Government of Canada Gouvernement du Canada

Ottawa, Canada

High Definition Television Colloquium

La télévision à haute définition Colloque

'85

Volume 2 of 2
Volume 2 de 2

Canada

High Definition Television
Colloquium 85

Télévision à Haute Définition
Colloque 85

2/

Second international colloquium on new television systems: HDTV '85 :

Ottawa, Canada, May 13-16, 1985 =

Deuxième colloque international sur les nouveaux systèmes de télévision: TVHD '85 :

Ottawa, Canada, du 13 au 16 mai 1985

1./International Colloquium on new Television Systems: HDTV '85 (2nd : 1985 : Ottawa)

POSTCONFERENCE PROCEEDINGS

LES ACTES DU COLLOQUE

Additional copies of the Colloquium Proceedings are available at $30 Canadian per two volume set. Please make cheques or money orders payable to **CBC/HDTV'85** and send your request to:

Elmer H. Hara
Chairman,
HDTV Colloquium Program Committee

Department of Communications
Room 638
300 Slater Street, Ottawa, Ontario
Canada, K1A 0C8

On peut se procurer des exemplaires supplémentaires des actes du colloque à raison de 30$ canadiens pour la série des deux volumes. Veuillez établir votre chèque ou mandat à l'ordre de **CBC/HDTV'85**. Les commandes doivent être adressées à:

Elmer H. Hara
Président
Comité du programme du colloque de la TVHD

Ministère des Communications
Bureau 638
300, rue Slater, Ottawa, Ontario
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SECOND INTERNATIONAL COLLOQUIUM
ON
NEW TELEVISION SYSTEMS: HDTV'85

Ottawa Congress Centre

- All Abstracts and Workshop Summaries are in English and French.
- Simultaneous English-French interpretation will be provided for the presentation of papers.
- Papers with an asterisk (e.g. 2.10* F. Delmas, "Colour Slide ...") are written in French.
- Papers with two asterisks (e.g. 3.5** E. Dubois & S. Ericsson, "Digital Coding ...") are written in both English and French.
- Papers with three asterisks are included in the Post-Colloquium Proceedings which also contains the Workshop Summaries.

PROGRAM

Monday, May 13, 1985

07:30 - 09:30	**REGISTRATION**
OPENING SESSION	Chairperson K. Davies, CBC
09:30 - 09:40	**OPENING ADDRESS** *** K. Hepburn, Assistant Deputy Minister (Technology & Industry), Department of Communications
09:40 - 10:05	**KEYNOTE SPEAKER** *** G. Gougeon, Vice President of Engineering, Canadian Broadcasting Corporation
SESSION 1. NEEDS	Chairperson D. MacLean, DOC
10:05 - 10:30	1.1*** T. Fujio, "The Present State of HDTV: What it takes and what should be done." NHK, Japan
10:30 - 10:50	**COFFEE BREAK**
10:50 - 11:15	1.2*** W. Habermann, "The HDTV-Studio Standard Project: Status of Discussions and Position in Europe", Chairman of EBU Working Group V1-HDTV
11:15 - 11:40	1.3*** J. Flaherty, "HDTV Standardization Activities in the United States", CBS, USA
11:40 - 12:05	1.4 F. Spiller, "The Content of HDTV: A New Creative Challenge", Francis Spiller Associates, Canada
12:05 - 13:00	**LUNCH**

SESSION 2-A. TECHNOLOGY; Psychophysics Chairperson D. Phillips, DOC

13:00 - 13:20	2.1	W. Glenn & K. Glenn, "HDTV Colorimetry", New York Institute of Technology, USA
13:20 - 13:40	2.2***	P. Hearty, "Limitations of Current Psychophysical Approaches to Display Evaluation", Department of Communications, Canada
13:40 - 14:00	2.3***	D. Kline & H. Mathias, "A Comparison of Film and Television Capture Characteristics - A Progress Report", Panavision Inc. USA
14:00 - 14:40	2.4***	A. Kaiser & D. Morss III, "Direct Comparison of 35 mm Film and High Definition Television", CBS Technology Center & CBS Engineering and Development, USA
14:40 - 15:00	**COFFEE BREAK**	

SESSION 2-B. TECHNOLOGY; Cameras and Displays and Recorders Chairperson S. Quinn, CBC

15:00 - 15:20	2.5	B. Stanski, "Some Noise Aspects of HDTV Cameras", University of Dortmund, FRG
15:20 - 15:40	2.6	G. Mahler, "The Display Problem of HDTV", HHI, FRG
15:40 - 16:00	2.7***	K. Morita & T. Kataoka, "Color Picture Display System for High-Definition Television", Matsushita Electric Industrial Co., Ltd., Japan
16:00 - 16:20	2.8	K. Takashasi, M. Umemoto, Y. Etoh, S. Mita, S. Nagahara, H. Noguchi, H. Ogiwara & M. Greenwood, "Color Television and Digital VTR for High Definition Television Use", Central Research Laboratory, Hitachi; Hitachi Denshi, Japan & Canada
16:20 - 16:40	2.9	G. Smith, "Recording HDTV - Present and Future", SONY, USA
16:40 - 17:00	2.10**	F. Delmas, J. Chambaut, M. Artigalas & M. Favreau, "Colour Slide Scanners for High Definition TV", Thomson-Video Equipment, France
18:00 - 20:00	**TOUR & RECEPTION**	(Optional: only a limited number of tickets are available.)

Tuesday, May 14, 1985

SESSION 2-C. TECHNOLOGY; Systems Chairperson L. Cheveau, CBC

08:45 - 09:05	2.11*	R. Melwig, "HDTV: A Slow Revolution", CCETT, France
09:05 - 09:35	2.12***	G. Broussaud, B. Nabati, "Using a Videodisc as a Medium for High-Resolution Fixed Images", Centre Mondiale Informatique et Ressources Humaine, France
09:35 - 10:05	2.13	J. Gaspar, "Interlace Scan Artifacts", McDonnel Douglas Astronautics Co., USA
10:05 - 10:25	**COFFEE BREAK**	

SESSION 3-A. SYSTEMS; Scanning and Coding Chairperson M. Akgun, DOC

10:25 - 10:50	3.1	N. Tanton, I. Childs & C. Sandbank, "Compatibility Consideration for HDTV Sources and Displays", BBC, UK
10:50 - 11:15	3.2	C. Billotet, H. Sauerberger & L. Stenger, "HDTV - Alternatives in Fieldrates and Conversion to 50 Hz", Deutsche Bundespost, FRG
11:15 - 11:40	3.3***	B. Wendland, "A Scanning Scheme for a New HDTV Standard", University of Dortmund, FRG
11:40 - 12:05	3.4	G.M.X. Fernando, D. Parker & P. Saraga, "Investigations on Raster Conversions for HDTV Displays", Philips, UK
12:05 - 12:30	3.5**	S. Ericsson & E. Dubois, "Digital Coding of High Quality TV", INRS, Canada
12:30 - 13:30	**LUNCH**	

SESSION 3-B. **SYSTEMS & DELIVERY; EDTV, HDTV** Chairperson G. Chouinard, DOC

13:30 - 14:10	3.6**	H. Mertens & D. Wood, "The European Approaches to Better Quality in Television", Technical Centre, EBU
14:10 - 14:30	3.7	G. Crowther, "European MAC: A Component Maker's Viewpoint", Mullard, UK (This paper was cancelled at the request of the author).
14:30 - 14:50	3.8***	J. Lowry, "The Evolution of B-MAC into a fully Compatible EDTV System", Digital Video Systems/Scientific-Atlanta, Canada
14:50 - 15:10	3.9	C. Rhodes, "The Further Evolution of B-MAC Signal Format for HDTV Broadcasting", Scientific-Atlanta, USA
15:10 - 15:30	3.10***	R. Morcom, G. Tonge & M.D. Windram, "Enhanced C-MAC: The Evolutionary Approach", IBA, UK
15:30 - 15:50	COFFEE BREAK	

SESSION 3-B. **SYSTEMS & DELIVERY; EDTV, HDTV** (continued) Chairperson D. Garforth, CBC, Canada

15:50 - 16:10	3.11	G. Reitmeier & C. Carlson, "An Adaptive Extended-Definition MAC Television System", RCA, USA
16:10 - 16:30	3.12	Y.S. Kao & L.N. Lee, "An Evolutionary Approach to HDTV based on Motion-Adaptive Image Processing Techniques", COMSAT, USA
16:30 - 16:50	3.13***	J. Kumada, "Developmental State of Various HDTV Equipment", NHK, Japan
16:50 - 17:10	3.14***	J. Nadan, "Two-Channel NTSC-Compatible HDTV Transmission Methods", Philips, USA
18:30 - 22:30	**BANQUET**	Reception Area

Wednesday, May 15, 1985

SESSION 3-C. **SYSTEMS & DELIVERY; Optical Techniques** Chairperson M. Sablatash, DOC

08:45 - 09:10	3.15	G. Heydt, "Optical Fiber Networks with HDTV Capability", HHI, FRG
09:10 - 09:35	3.16	R. MacDonald & D.K.W. Lam, "Photoconductive Broadband Switching for HDTV", Department of Communications, Canada
09:35 - 10:00	3.17***	C. Darling, "Towards Higher Definition Television", Nordicity, Canada
10:00 - 10:20	COFFEE BREAK	

SESSION 4. **POLICY, STANDARDS & IMPACT** Chairperson K.Y. Chang

10:20 - 10:45	4.1	Y. Tadokoro, "High-Definition Television: Towards a Worldwide Standard", NHK, Japan
10:45 - 11:10	4.2***	K. Powers, "High Definition Production Standards: How broad their application?", RCA, USA
11:10 - 11:35	4.3***	H. Payne, "Heroics in Policy Advising: The Australian experience in planning broadcasting services by national satellites." DOC, Australia
11:35 - 12:00	4.4***	P. Lyman, "HDTV: Who pays for the dream?", Nordicity, Canada
12:00 - 13:00	LUNCH	

COLLOQUIUM WORKSHOPS

Wednesday, May 15, 1985

WORKSHOP 1.
13:00 - 17:00

APPLICATIONS AND OPERATIONAL NEEDS Moderator M. Blandford, CBC, Canada

"HDTV: Who Needs It?"

- addressing the wide range of possible applications of HDTV, user expectations compared to present systems, economic implications on operations.

WORKSHOP 2.
13:00 - 17:00

SYSTEMS AND STANDARDS Moderator R. Zavada, Eastman Kodak, USA

"Evolution or Resolution?"

- addressing the emerging forces in systems and standards, approaches to a common standard, its urgency, whether the 1125 line system will become the de-facto standard.

WORKSHOP 3A.
13:00 - 15:00

TECHNICAL - PRODUCTION Moderator E. Zwanewald, NFB, Canada

"Practicality vs. Creativity"

- addressing how end-use impacts on production techniques, technical bottlenecks, impact of new equipment requirements, production costs, training costs, impact on small operations.

WORKSHOP 3B.
15:00 - 17:00

TECHNICAL - DISPLAY Moderator W. Habermann, IRT, FRG.

"Image of the Future"

- addressing needs for various applications, impact of digital processing, prospects of competing technologies, psychophysical aspects, impact of sound, the "ideal" in commercial and home systems.

18:30

SPEAKERS' DINNER National Arts Centre Restaurant

Thursday, May 16, 1985

WORKSHOP 3C.
9:00 - 11:30

TECHNICAL - DISTRIBUTION Moderator V. Reed, Skyline Cablevision, Canada

"Which Way to the Viewer?"

- addressing cable, broadcast and DBS technologies, impact on compatibility, stereo-sound, whether fibre optic transmission is the prerequisite for mass distribution.

WORKSHOP 4.
9:00 - 11:30

SOCIO-ECONOMIC Moderator P. Lyman, Nordicity Group, Canada

"HDTV: Who Pays for the Dream?"

- addressing the market for HDTV, perception of HDTV's value and its relative cost, the importance of compatibility, impact on consumer video products, on cinemas, whether EDTV is good enough or all that can be afforded.

CLOSING PLENARY SESSION Chairperson O. Roscoe, Telestat Canada
13:30 - 15:00

DEUXIÈME COLLOQUE INTERNATIONAL
SUR
LES NOUVEAUX SYSTÈMES DE TÉLÉVISION: TVHD 1985

Centre des congrès d'Ottawa

- Tous les résumés et les compte-rendus des ateliers de travail sont en versions française et anglaise
- Une traduction simultanée en anglais et en français sera disponible lors des conférences
- Les articles indiqués par un astérisque (e.g. 2.10* F. Delmas, "Les Analyseurs...") sont en version française.
- Les articles indiqués par deux astérisques (e.g. 3.5**, E. Dubois et S. Ericsson, "Codage numérique...") sont en version française et anglaise.
- Les articles indiqués par trois astérisques sont inclus dans les Actes qui contiennent aussi les rapports soumis par les ateliers.

PROGRAMME

le lundi 13 mai 1985

0730-0930	INSCRIPTION
OUVERTURE DU COLLOQUE	(Modérateur: K. Davies, Société Radio Canada)
0930-0940	MOT DE BIENVENUE *** K. Hepburn, sous-ministre adjoint (technologie et industrie), Ministère des Communications
0940-1005	TÊTE D'AFFICHE *** G. Gougeon, Vice Président, Ingénierie, Société Radio Canada
SESSION n° 1. LES BESOINS	(Modérateur: D. Maclean, Ministère des Communications)
1005-1030	1.1*** T. Fujio, "État actuel du système TVHD - Necessités et imperatifs." NHK, Japon
1030-1050	PAUSE CAFÉ
1050-1115	1.2*** W. Habermann, "Projet de norme sur les studios de TVHD: État des discussions et position en Europe." Rapporteur du groupe de travail V1-HDTV de l'UER

1115-1140	1.3*** J. Flaherty, "Activités de normalisation de la TVHD aux États-Unis." CBS, E.-U.
1140-1205	1.4 F. Spiller, "Contenu de la TVHD: nouveau défi à la créativité." Francis Spiller Associates, Canada
1205-1300	DÉJEUNER
SESSION n° 2A	**TECHNOLOGIE: la psychophysique** (Modérateur: D. Phillips, MDC)
1300-1320	2.1 W. Glenn et K. Glenn, "Colorimétrie en Télévision a Haute Définition." New York Institute of Technology, E.-U.
1320-1340	2.2*** P. Hearty, "Limites des méthodes psychophysiques actuelles d'évaluation de l'image." MDC, Canada
1340-1400	2.3*** D. Kline et H. Mathias, "Aperçu des caractéristiques du cinéma par rapport aux besoins de TVHD dans la production commerciale (États-Unis)." Panavision, E.-U.
1400-1440	2.4*** A. Kaiser et D.F. Morss III, "Comparaison directe du film 35mm à la Haute Définition (TVHD)." CBS Technology Center & CBS Engineering and Development, E.-U.
1440-1500	PAUSE CAFÉ
SESSION n° 2B	**LA TECHNOLOGIE: les caméras, les écrans et les enregistreuses**
	(Modérateur: S. Quinn, Société Radio Canada)
1500-1520	2.5 B. Stanski, "Caractéristiques de bruit des caméras de TVHD." Université de Dortmund, RFA
1520-1540	2.6 G. Mahler, "Problématique des écrans de TVHD." IHH, RFA
1540-1600	2.7*** K. Morita et T. Kataoka, "Système d'affichage en couleur pour la télévision à la Haute Définition." Matsushita Electric Industrial Co., Japon
1600-1620	2.8 K. Takahashi, M. Umemoto, Y. Etoh, S. Mita, S. Nagahara, H. Noguchi, H. Ogiwara., M. Greenwood, "Caméra de télévision couleurs et magnétoscope numérique pour la télévision à haute définition." Laboratoire central de recherche, Hitachi Ltée., Hitachi Denshi, Japon et Canada
1620-1640	2.9 G. Smith, "Enregistrement de la TVHD - Présent et avenir." Centre technologique Sony Inc., E.-U.
1640-1700	2.10** F. Delmas, J. Chambaut, M. Artigalas, M. Favreau, "Les analyseurs de diapositives couleurs à haute définition." Thompson Vidéo Equipement, France
1800-2000	VISITE ET RECEPTION (Optionel: nombre limité de billets disponibles)

le mardi 14 mai 1985

SESSION n° 2C	**LA TECHNOLOGIE: systèmes** (Modérateur: L. Cheveau, SRC)
0845-0905	2.11* R. Melwig, "La TVHD: Une révolution lente." CCETT, France
0905-0935	2.12*** G. Broussaud, B. Nabati, "Utilisation d'un vidéodisque comme support d'images fixes de haute résolution." CMIRH, France
0935-1005	2.13 J. Gaspar, "Défauts associés au balayage entrelacé." McDonnell Douglas Astronautics Co., EU
1005-1025	PAUSE CAFÉ

SESSION n° 3A		**SYSTÈMES: balayage et codage** (Modérateur: M.B. Akgun, MDC)
1025-1050	3.1	N.E. Tanton, I. Childs, C.P. Sandbank, "Considérations liées à la compatibilité des sources et des supports de présentation." BBC, U.K.
1050-1115	3.2	C. Billotet, H. Sauerberger et L. Stenger, "TVHD - nouvelles fréquences de trame et conversion à 50 Hz." Deutsche Bundespost, RFA
1115-1140	3.3***	B. Wendland, "Système de balayage pour une nouvelle norme TVHD." Université de Dortmund, RFA
1140-1205	3.4***	G.M.X. Fernando, D.W. Parker et P. Saraga, "Recherches sur la conversion de trame pour présentation sur écran de télévision à haute définition." Philips, U.K.
1205-1230	3.5**	E. Dubois et S. Ericsson, "Codage numérique des signaux de télévision de haute qualité." INRS, Canada
1230-1330		DÉJEUNER

SESSION n° 3B		**SYSTÈMES ET DISTRIBUTION: EDTV, HDTV** (Modérateur: G. Chouinard, MDC)
1330-1410	3.6**	H. Mertens et D. Wood, "Les voies européenes vers la télévision de meilleur qualité." Centre Technique, UER
1410-1430	3.7	G. Crowther, "Système MAC européen: Point de vue d'un fabricant." Mullard, U.K. (Cette communication a été retirée à la demande de l'auteur)
1430-1450	3.8***	J. Lowry, "Évolution du B-MAC vers un système de TVHD totalement compatible." Digital Video Systems/Scientific Atlanta, Canada
1450-1510	3.9	C. Rhodes, "Évolution supplémentaire de la structure des signaux B-MAC pour radiodiffusion TVHD." Scientific Atlanta, E.-U.
1510-1530	3.10***	R. Morcom, "Système C-MAC amélioré - Conception progressive." IBA, U.K.
1530-1550		PAUSE CAFÉ
		SYSTÈMES ET DISTRIBUTION: EDTV, HDTV (suite)
		(Modérateur: D. Garforth, SRC)
1550-1610	3.11	G. Reitmeir et C. Carlson, "Système adaptable de télévision à composantes analogiques multiplexées et a extension de definition." RCA, E.-U.
1610-1630	3.12	Y.S. Kao et L.N. Lee, "Conception progressive d'une norme TVHD basée sur les techniques de traitement de l'image avec compensation de mouvement." COMSAT, E.-U.
1630-1650	3.13***	J. Kumada, "État du développement de différents systèmes TVHD." NHK, Japon
1650-1710	3.14***	J. Nadan, "Méthodes de transmission TVHD à deux canaux, Compatible NTSC." Philips, E.-U.
1830-2230		BANQUET - Salle de reception

le mercredi 15 mai 1985

SESSION n° 3C	**SYSTÈMES ET DISTRIBUTION: techniques optiques**
	(Modérateur: M. Sablatash, MDC)
0845-0910	3.15 G. Heydt, "Réseaux à fibres optiques à capacité de TVHD." IHH, RFA
0910-0935	3.16 R. MacDonald et D.K.W. Lam, "Commutation à large bande par photo-conduction pour télévision à haute définition." MDC, Canada
0935-1000	3.17*** C. Darling, "Vers une télévision à haute définition." Nordicity Canada
1000-1020	PAUSE CAFÉ
SESSION n° 4	**POLITIQUE, STANDARDS ET IMPACT** (Modérateur: K.Y. Chang)
1020-1045	4.1 Y. Tadokoro, "Télévision haute définition: vers une norme internationale." NHK, Japon
1045-1110	4.2*** K.H. Powers, "Normes relatives à la production haute définition: Quelle est l'étendue de leur champ d'application?" RCA, E.-U.
1110-1135	4.3*** H. Payne, "Visées audacieuses: l'expérience de l'Australie dans la planification de services de radiodiffusion par satellites domestiques." MDC, Australie
1135-1200	4.4*** P. Lyman, "La TVHD: Qui paie la note du rêve?" Nordicity, Canada
1200-1300	DÉJEUNER

ATELIERS DU COLLOQUE

le mercredi 15 mai 1985

ATELIER 1
1300-1700

Applications et besoins (Modérateur: M. Blandford, SRC, Canada)

"La TVHD: Pourquoi?"

- Toutes les applications possibles de la TVHD, les attentes de l'utilisateur par rapport aux systèmes actuels, les implications économiques.

ATELIER 2
1300-1700

Systèmes et normes (Modérateur: R. Zavada, Eastman Kodak, E.-U.)

"Evolution ou résolution?"

- Les nouveaux développements en matière de systèmes et de normes, les possibilités d'une norme commune, la nécessité de s'entendre rapidement; le système de 1125 lignes deviendra-t-il la norme?

ATELIER 3a
1300-1500

Technique - Production (Modérateur: E. Zwanewald, ONF, Canada)

"Aspects pratiques vs. créativité"

- Les répercussions sur les techniques de production, les impasses techniques, l'impact des nouveaux besoins d'équipement, les coûts de production et de formation et l'impact sur les petites exploitations.

ATELIER 3b
1500-1700

Technique - Affichage (Modérateur: W. Habermann, IRT, RFA)

"L'image de l'avenir"

- La nécessité des diverses applications, l'impact du traitement numérique, les perspectives des technologies concurrentes, les aspects psychophysiques, l'impact du son, le système "idéal" pour l'équipement commercial et grand public.

1830 DINER DES CONFÉRENCIERS - Restaurant du Centre Nationale des Arts

le jeudi 16 mai 1985

ATELIER 3c 0900-1130

Technique - Distribution (Modérateur: V. Reed, Skyline Cablevision, Canada)

"Comment atteindre le téléspectateur"

- Le câble, la diffusion traditionelle, la diffusion directe par satellite, l'impact sur la compatibilité, le son stéréo; la fibre optique est-elle la condition préalable à la distribution à grande échelle?

ATELIER 4 0900-1130

Socio-économie (Modérateur: P. Lyman, Nordicity Group, Canada)

"La TVHD: qui paie ce rêve?"

- Le marché de la TVHD, la perception de sa valeur et de son coût relatif, l'importance de la compatibilité, l'impact sur les produits vidéo grand public, sur le cinéma; la EDTV convient-elle ou est-ce seulement un pis-aller?

le jeudi 16 mai 1985

SÉANCE PLÉNIÈRE DE FERMETURE (Modérateur: O. Roscoe, Telesat Canada) 1330-1500

OPENING ADDRESS

K. Hepburn

Assistant Deputy Minister (Technology and Industry)

Department of Communications

Good morning ladies & gentlemen. On behalf of the Government of Canada, on behalf of the sponsors of this second colloquium on high definition television, I would like to welcome you to what I am sure will be an interesting and rewarding four days. I should also compliment the organizing committee for having chosen this time of year. I do hope all our visitors to Ottawa will have the opportunity to enjoy its "Festival of Spring."

This colloquium has been organized to build upon the results of the first colloquium held in 1982. At that time it was recognized that there was a need to follow the development of HDTV and other forms of enhanced definition TV.

New communications technologies are having profound global effects - they are creating more efficient, world-wide distribution systems which are bridging national markets and cultural boundaries. Enhanced and high definition television systems will be integral parts of this new environment and they could represent potentially important economic and cultural opportunities.

The development of these systems has progressed significantly since our last colloquium. However, there remain important areas of development for researchers and manufacturers before these systems become commercially successful. We must not forget that, as with all technological innovations, the success of new TV technologies will ultimately depend on a variety of factors: technology, marketing, and programming that meets viewer demands are all crucial. The speakers at this colloquium will be addressing these areas in the next few days.

As you will have observed, the colloquium includes workshops and technical demonstrations as well as a full program of papers.

The papers have been organized around five major themes. These are "Needs for EDTV & HDTV," "The Basic Technologies," "Overall Systems and Approaches to Delivery," Industrial and Social Impacts," and finally "The Policy, Regulatory and Standards Matters."

The objective of the workshops is to encourage an open discussion of key issues and. of course, the objective of the demonstrations is to show the improved picture quality that can be achieved by using these technologies.

I am sure that all countries represented here today are attempting to keep abreast of the technological developments and develop strategic responses. We hope that this colloquium will assist them in this important task.

Once again, I would like to say how pleased we are to welcome all the delegates who are here with us today. I hope that the next few days will prove to be both pleasant and helpful.

The second international colloquium on new television systems is now open and I would like to call on CBC Vice-President Guy Gougeon to speak.

MOT DE BIENVENUE

K. Hepburn
Sous-ministre adjoint (technologie et industrie)
Ministère des Communications

Bonjour Mesdames et Messieurs. Au nom du gouvernement du Canada et des organisations parrainant ce deuxième colloque sur la télévision à haute définition, je vous adresse la bienvenue à cet événement de quatre jours qui se révélera, j'en suis sûr, à la fois intéressant et utile. J'aimerais aussi féliciter le Comité organisateur pour avoir choisi ce moment de l'année. J'espère vivement que les participants pourront assister au " Festival du printemps " qui se déroule en ce moment à Ottawa.

Nous sommes ici aujourd'hui pour donner suite au premier colloque du genre tenu en 1982. Il avait été reconnu à l'époque qu'il fallait suivre le développement de la TVHD et d'autres formes de télévision à définition améliorée.

Les nouvelles technologies des télécommunications ont des répercussions profondes à l'échelle du globe en ce sens qu'elles entraînent la création de systèmes de distribution mondiale plus efficaces qui rapprochent les marchés nationaux et éliminent les barrières culturelles. Les systèmes de télévision à haute définition et à résolution améliorée constitueront des parties intégrantes du nouvel environnement et pourraient procurer d'importantes possibilités économiques et culturelles.

Le développement de ces systèmes a considérablement progressé depuis le dernier colloque. Il reste toutefois des domaines critiques que les chercheurs et fabricants devront défricher pour assurer la viabilité commerciale de ces systèmes. Nous ne devons pas oublier que malgré toutes les innovations techniques, la percée des nouvelles technologies de télévision dépendra de nombreux facteurs : la mise au point d'une technologie satisfaisante, la commercialisation et la programmation d'émissions qui répondent aux demandes des auditeurs joueront un rôle crucial. Les conférenciers aborderont ces questions au cours des prochains jours.

Comme vous l'avez sans doute remarqué, le colloque comprend des ateliers, des démonstrations techniques et un programme complet de présentation de mémoires. Les mémoires ont été regroupés sous cinq thèmes principaux qui sont : " Les besoins ", " Les technologies de base ", " Systèmes et distribution ", " Impacts industriels et sociaux " et " Politique, standards et impact ".

Les ateliers ont pour objectif d'encourager la discussion ouverte de questions clés, alors que les démonstrations ont naturellement pour but de montrer quelle qualité d'image peut être obtenue à l'aide des technologies qui nous intéressent.

J'ai la certitude que tous les pays ici représentés aujourd'hui s'efforcent de demeurer à la pointe du progrès technologique et de trouver des solutions en matière de stratégie à suivre. Espérons que ce colloque les aidera dans la poursuite de ces tâches.

Encore une fois, j'aimerais dire qu'il nous fait plaisir d'accueillir tous les délégués qui sont des nôtres aujourd'hui. J'espère que les quelques jours à venir seront à la fois utiles et agréables.

Le deuxième colloque international sur les nouveaux systèmes de télévision est maintenant ouvert et je demanderais à Monsieur Guy Gougeon, vice-président à la société Radio-Canada de nous adresser la parole.

KEYNOTE SPEAKER

G. Gougeon

Vice President of Engineering

Canadian Broadcasting Corporation

Mr. Hepburn, Mr. Chairman, distinguished delegates and co-organizers of this 1985 colloquium on high definition television, ladies and gentlemen:

Please allow me to begin by saying two "thank yous ". To you, Ken, for your kind introduction, and to your organizing committee for inviting me here today.

I make no apologies for my enthusiasm in the subject at hand, simply because this week presents us with a golden opportunity to address what I believe is the most important question facing the television world today.

The Canadian Broadcasting Corporation is proud to join with the National Film Board of Canada and the Department of Communications in sponsoring this colloquium. The next few days will give us all the opportunity to learn about the latest developments in TV technology, to discuss their impact, and to see how we may best apply this knowledge to form new television systems. We will also have an opportunity to see some of the equipment in operation.

1985 is an appropriate time for this colloquium, because we are in a critical year for the development of standards for high definition television. Many of you are active in various working groups and committees in CCIR, EBU, ATSC, SMPTE and in industry, all searching for a studio standard for HDTV that will be of worldwide application. Canada strongly supports these worthwhile initiatives, and we offer the colloquium as a forum to aid this work.

Great progress has been made in TV technology since the 1982 colloquium here in Ottawa. Many of the questions raised at that time, and the ones in Don Fink's historic closing address, have now been answered in technology terms. What we must now do is to re-examine those questions, along with a critical examination of the essential needs for new television systems.

In doing so, we must not lose sight of the need for lower costs in production, post-production and distribution, so we can fill the ever-expanding pipelines to our diverse array of viewers. We have developed a number of useful technologies leading us in this direction, and our confreres in NHK and others have proposed parameters for a new HDTV system.

We must note the need to receive new services from satellite, cable, disk or tape usable with equipment that will also display current services, and computer-related data. It would be useful if the reverse compatibility also existed, allowing for the continued use of current equipment with new services, perhaps with low-cost adapters. The designers of transmission systems and receivers have a large task ahead of them to meet these objectives, and at costs that may be viewed as reasonable from both the users and the suppliers viewpoints.

A new high definition television system must clearly meet the needs of the major participants in the global television sphere, be they the users, the program producers, the broadcasters, the equipment suppliers or governmental administrations. What do they really want individually from HDTV?

Let us first consider the needs of the users, the millions of people who watch the programs we produce for education, for information, entertainment and advertising. With the latest technological developments, we can put together the systems and services that they now demand, or can be expected to demand in the near future. Some already feel that in addition to higher quality programs, there is a need for better, brighter and broader pictures, and yes, stereo sound.

The viewers certainly do not want a number of incompatible receivers, or a collection of set-top adaptors that will be mute, expensive monuments to our current difficulty in defining an adequate family of new TV services.

What of the broadcasters in these discussions, be they the conventional ones using terrestrially based transmitters, or the later arrivals using cable, communications satellites, broadcasting satellites, tape or disk to reach the viewers homes? They need to see systems introduced that can reach their target audiences, of various sizes and distribution, at affordable costs. Systems that offer the services necessary for their activities, and that will be viable for a number of years when television technology is changing rapidly, and which will avoid the "chicken-and-egg" situation of "who goes first, - the broadcaster, the receiver manufacturer, or the users?"

We note that the viewpoints of these various broadcasters are somewhat divergent, yet we must define TV systems that can be used with receivers and displays that are common to all the services they offer.

Program producers of all kinds are also eagerly looking forward to a new studio standard that will give them television pictures with improved resolution, colour, brightness and size, along with greatly improved sound. This new television standard will have to be capable of producing a wide range of production effects, without compromises, and it will have to be convertible to all the current and potential distribution media worldwide, simply, effectively, and without compromising its basic high quality.

The program producers, the broadcasters, and the users of TV services are not the only groups with an interest in new television systems.

Clearly, manufacturers of both professional and consumer level equipment have strong desires to develop new markets, and their interests seem best serviced by the development of strong standards and recommendations, based on wide areas of application, commonality of components, and compatiblity of services. No organization today can afford the luxury of markets divided and sub-divided by incompatibility, and by standards based on narrow nationalistic concerns.

Governments and national administrations also have a considerable interest in the development of new television systems and services. What modern country does not epouse the goals of a healthy high-technology industry based on strong electronic industries, viable exports of goods and services, and high-class domestic television services meeting national cultural needs?

While some governments are not direct players in the drive for new television systems, we are sure they all share at least some of these goals, and they would be ill-served if incompatibility impacted negatively on their current national investment in services.

In my view, we all share a common need to develop new television services, and I would like to suggest that the following eight criteria be used in the evaluation of the proposals put forward from the laboratory.

First--quality

Any new TV service must provide from the very beginning a worthwhile increment of quality-improvement that is clearly discernable and, in addition, one that must have the potential for further enhancement in the future.

Second--timing

At the time of its introduction, it should push current technology limits, but not so unreasonably as to jeopardize its success.

Third--the risk factor

It would be unwise to base our new system on a single technology break-through that may never happen, or on data that is not widely proven. We need to spread the risk by developing fall-back positions, and by seeking other applications that can share the development of these new technologies.

Fourth--cost

The cost of new services must bear a reasonable relationship to their benefits, taking account of a short start-up period. We can ill afford to develop services that threaten the viability of the current services, which must in turn bear the cost of these developments.

Fifth--production

New television systems must be cost-effective, add extra capability, and not introduce new limitations to our program producers.

Sixth--display

At the display level, a reasonable amount of two-way compatibility with existing services must exist, so economic bi-directional converters can be implemented. This would allow the consumers to introduce these new services in their homes, in a way that will expand the capability, rather than replace it.

Seventh--transmission

It is clear that in the transmission area, compatibility with the current planning for new services will certainly speed their introduction, reduce the introductory cost, and establish a situation where they can grow in the most effective manner.

Eight--incentive

Any new system will flourish more easily if the benefits that it offers are not confined to a single group, and all parties to the discussion come away with something of value. Certainly a system that has the effect of working a hardship on one or more of the partners, is not likely to be successful.

In our deliberations at this colloquium, it might be useful to keep some of these ideas in mind as a yardstick to gauge the value of the proposal that we are discussing.

HOW DO WE GET THE ANSWERS

Up until now I have addressed the questions concerning new television systems. It is time now to look at the technology answers that we have to work with. During this colloquium we will be examining recent major developments, and we have been fortunate in obtaining a very well qualified group of speakers from around the world to present the work that is currently in progress. They will participate in our discussions concerning future development and directions, and will present some new ideas on the applications of this new technology.

We have divided the program into six major technology sections, and we have also added a session on the critical area of policy and standards. You will find the details in your program. I know you will find these sessions informative, and I hope that they will provide you with a chance to ask questions of the experts.

We have also arranged, in conjunction with NHK and industry, some demonstrations of new television systems in such a way that comparison becomes possible between the various proposals. This will be an excellent chance for you to form your own conclusions regarding the desired and achieved quality, and it may also give you some insight into the production and distribution capability of these systems.

Towards the end of the colloquium, the workshop sessions will bring together all of the elements, and attempt to establish some joint viewpoints concerning new television systems, their application and their impact. I am sure that this week will at least keep you busy.

It is also our desire that this colloquium be a vehicle to move us all forward towards new television systems of wide application, high quality, and capable of future growth. Can we really afford the development of several competing systems to do the same job? I believe we all share a responsibility--designers, manufacturers and users alike--to leave behind us a firm and solidly based foundation for the future.

In 1985, we have the technology and the opportunity to establish a new television standard of worldwide application. Let us be sure that we don't lose this chance to move ahead by confusing the answers and the questions.

It is indeed unfortunate that we do not have with us today that distinguished colleague, scholar and leader of so many television activities, Dr. Christos Siocos, to guide us in this endeavour. His death last January left such a gap in the colloquium organization and in the many other organizations he served so enthusiastically and capably. His quiet diplomacy in bringing diverse groups together to arrive at solutions that were sound and viable - technically, economically and politically, will be sorely missed.

May I now ask Ken Davies, the Chairman of the Organizing Committee and of this morning's session to introduce our first distinguished speaker.

Thank you.

TÊTE D'AFFICHE

G. Gougeon
Vice-président, Ingénierie
Société Radio-Canada

M. Hepburn, M. le président, distingués délégués, co-organisateurs de ce colloque de 1985 sur la télévision à haute définition, mesdames et messieurs.

Avant de débuter, j'aimerais remercier Ken de ses bons mots de présentation et son comité organisateur d'avoir eu l'amabilité de m'inviter.

Je ne cache pas mon enthousiasme à l'endroit du sujet qui nous réunit tous aujourd'hui parce que cette semaine, nous aurons une magnifique occasion de traiter de ce qui, à mon avis, constitue la question primordiale actuellement dans le monde de la télévision.

La Société Radio-Canada est heureuse de s'associer à l'Office national du film du Canada et au ministère des Communications pour parrainer ce colloque. Au cours des prochains jours, nous aurons l'occasion de connaître les derniers développements technologiques en matière de télévision, de discuter de leurs impacts et de voir comment nous pourrions les adapter, le plus efficacement possible, aux systèmes de télévision de demain. Nous aurons également la chance de voir fonctionner quelques-uns de ces nouveaux appareils.

Le colloque de 1985 arrive à point car nous avons maintenant atteint une étape critique dans l'élaboration de normes relatives à la télévision à haute définition. Nombre d'entre vous font partie de divers groupes de travail ou de comités au sein de l'industrie et d'organismes tels que le CCIR, l'UER, l'ATSC, la SMPTE, tous souhaitant l'élaboration d'une norme de studio, d'application mondiale, régissant la TVHD. Le Canada encourage fortement ces initiatives louables et nous offrons ce colloque dans le but de faire avancer ces efforts.

La technologie de la TV a évolué de façon très significative depuis le colloque tenu à Ottawa, en 1982. Plusieurs des questions soulevées à cette occasion, surtout celles abordées par Don Fink dans son allocution de clôture historique, ont déjà reçu leur réponse au plan de la technologie. Notre tâche consiste donc à revoir ces questions et à faire un examen critique des besoins essentiels des nouveaux systèmes de télévision.

Ce faisant, nous ne devons pas perdre de vue la nécessité d'abaisser les coûts de production, de post-production et de distribution, de façon à pouvoir alimenter le nombre toujours croissant de canaux qui desservent notre large gamme d'utilisateurs. Nous avons mis au point un éventail de technologies pratiques nous permettant d'aller de l'avant dans cette direction et nos confrères de la NHK et d'ailleurs ont proposé les paramètres d'un nouveau système de TVHD.

Il convient que nous tenions compte de la nécessité de recevoir les nouveaux services dispensés par satellites, câbles, disques ou rubans et pouvant être utilisés avec des appareils capables d'afficher en outre les services courants et les données de nature informatique. Il serait aussi utile de réaliser la compatibilité inverse, et ainsi permettre l'utilisation de l'appareillage actuel avec les nouveaux services, peut-être par le biais d'adaptateurs peu coûteux. Une lourde tâche attend ceux qui conçoivent les systèmes de transmission et les récepteurs et qui devront atteindre ces objectifs à des coûts raisonnables, tant du point de vue de l'utilisateur que celui du fournisseur.

Un nouveau système de télévision à haute définition doit pouvoir clairement répondre aux besoins des principaux intéressés à savoir les utilisateurs, les radiodiffuseurs, les producteurs d'émissions, les manufacturiers d'appareils ou encore les gouvernements et grandes administrations nationales. Quels sont leurs besoins individuels face à la TVHD.

Penchons-nous d'abord sur ceux des utilisateurs, c'est-à-dire les millions de téléspectateurs à qui sont destinés les émissions d'information, de divertissement, de publicité et éducatives que nous produisons. Les dernières découvertes technologiques nous permettent de réaliser les systèmes et les services qu'ils exigent actuellement ou qu'ils devraient logiquement exiger dans un proche avenir. Quelques-uns croient qu'en plus d'émissions de plus grande qualité, il existe un besoin pour des images plus belles, plus claires et plus grandes et même pour la stéréophonie.

De toute évidence, les téléspectateurs s'objectent à une multiplication d'appareils incompatibles ou à une collection d'adaptateurs montés sur les appareils, témoins muets de notre difficulté actuelle à définir une famille adéquate de nouveaux services de télévision.

Dans tous ces échanges, qu'advient-il des radiodiffuseurs conventionnels qui desservent leurs utilisateurs par le biais de stations terrestres ou de ceux plus à l'avant-garde qui utilisent le câble, les satellites de communication, les satellites de radiodiffusion, les rubans ou les disques ? Ils espèrent voir la naissance de systèmes capables d'atteindre les diverses catégories de téléspectateurs, de toutes tailles et en tous lieux, à coûts raisonnables. Des systèmes bien adaptés à leurs besoins, pouvant durer plusieurs années dans un monde où la technologie évolue si rapidement et qui leur éviteront la question classique de " l'oeuf ou de la poule " c'est-à-dire qui, du diffuseur, du fabricant de téléviseurs ou de l'utilisateur sera privilégié en premier lieu ?

Nous avons noté certaines divergences de points de vue entre les divers radiodiffuseurs. N'empêche qu'il nous faut définir des systèmes de télévision qui puissent utiliser les récepteurs et les moyens d'affichage communs à tous les services qu'ils dispensent.

Les producteurs d'émissions de toutes sortes attendent impatiemment l'avènement d'une nouvelle norme de studio qui leur assurera des images TV dont la résolution, les couleurs, la brillance, la taille et le son seront grandement améliorés. Cette norme de télévision devra permettre de réaliser une vaste gamme d'effets de production, sans compromis, et pouvoir s'adapter à tous les moyens de distribution actuels et potentiels, à l'échelle mondiale, de façon simple et efficace et sans mettre en péril la haute qualité fondamentale du système.

Les producteurs d'émissions, les radiodiffuseurs et les utilisateurs de services de télévision ne sont pas les seuls que les nouveaux systèmes de télévision intéressent.

Les manufacturiers d'appareils destinés aux consommateurs comme aux professionnels ont, de toute évidence, intérêt à développer de nouveaux marchés et à voir leurs intérêts servis au mieux par le biais de nouvelles normes et recommandations fermes, basées sur un large éventail d'applications, l'inter-changeabilité des composantes et la compatibilité des services. De nos jours, nulle organisation ne peut se payer le luxe de desservir des marchés fractionnés et balkanisés par l'incompatibilité et par des normes reposant sur des conceptions nationalistes étroites.

Les gouvernements comme les grandes administrations nationales ont grand intérêt à voir se développer de nouveaux systèmes et services de télévision. De nos jours, les pays sont tous intéressés par la vitalité d'une industrie de pointe florissante reposant sur les industries électroniques, des exportations de biens et de services favorables et des services de télévision domestique de première qualité axés sur la satisfaction des besoins culturels nationaux.

Bien que certains gouvernements ne soient pas directement dans la course aux nouveaux systèmes de télévision, nous sommes certains qu'ils partagent tous au moins quelques-uns de ces buts et que leur investissement national actuel serait nettement défavorisé par l'incompatibilité de leur système.

Selon moi, nous avons un but commun et c'est de mettre au point de nouveaux services de télévision et je voudrais donc, à cet égard, avancer huit critères qui pourraient servir à l'évaluation des propositions formulées par les chercheurs.

D'abord, la qualité

Tout nouveau service de télévision doit, dès le départ, offrir une amélioration de qualité significative en plus d'assurer des possibilités d'amélioration éventuelles.

Deuxièmement, l'à-propos

Au moment de son lancement, le système devrait pouvoir repousser les limites actuelles de la technologie sans toutefois mettre son succès en jeu.

Troisièmement, le facteur risque

Il serait peu prudent d'asseoir notre nouveau système sur une seule percée technologique qui pourrait ne jamais voir le jour, ou sur des données insuffisamment éprouvées. Il nous faut étaler le risque en établissant des positions de repli et en recherchant d'autres applications susceptibles de partager la mise au point de telles technologies de pointe.

Quatrièmement, le facteur coût

Ces nouveaux services doivent être caractérisés par un rapport qualité/coût raisonnable, compte tenu d'une courte période de rodage et de mise en route. Nous n'avons pas les moyens de créer des services qui pourraient mettre en péril les services actuels auxquels ces coûts de développement seront imputés.

Cinquièmement, la production

Les nouveaux systèmes de télévision doivent être rentables et capables d'étendre les possibilités et d'éviter de soumettre nos producteurs d'émissions à des contraintes nouvelles.

Sixièmement, l'affichage

Pour ce qui est de l'affichage, il est normal d'espérer un niveau raisonnable de compatibilité avec les services actuels, pour rendre possible l'utilisation de convertisseurs bi-directionnels. Ceci permettrait aux consommateurs d'introduire ces nouveaux services dans leurs foyers, de façon à étendre le service plutôt qu'à le remplacer.

Septièmement, la transmission

Au plan de la transmission, il est clair que la compatibilité avec les nouveaux services prévus à l'heure actuelle aura certainement pour effet d'accélérer la pénétration de ces derniers, d'abaisser les coûts inhérents et de créer une situation qui leur permettrait de se développer le plus efficacement possible.

Huitièmement, l'aspect stimulant

Tout nouveau système prospérera d'autant plus facilement que les avantages qu'il offre ne sont pas restreints à un seul groupe et que toutes les parties prenantes y trouvent leur profit. Il va sans dire qu'un système qui pénaliserait un ou plusieurs des partenaires est voué à l'échec.

Lors de nos délibérations, il pourrait être intéressant et utile d'utiliser quelques-unes de ces idées pour évaluer les propositions qui nous sont soumises.

COMMENT OBTENIR LES RÉPONSES

Jusqu'ici je n'ai parlé que des questions relatives aux nouveaux systèmes de télévision. Il est maintenant temps d'aborder les solutions technologiques que nous devons apporter. Au cours du présent colloque, nous nous pencherons sur les derniers grands développements. À cet égard, nous sommes privilégiés de pouvoir compter sur l'apport de conférenciers très compétents qui nous entretiendront de l'état de la technologie. Ils participeront à nos discussions relatives aux développements qui s'annoncent et aux voies à suivre et nous feront part de quelques nouvelles idées quant aux applications de cette nouvelle technologie.

Nous avons scindé le programme en six grandes sections technologiques et aussi ajouté une session portant sur le secteur critique des politiques et des normes. Vous en trouverez les détails au programme qui vous a été remis. Je suis certain que ces sessions sauront vous captiver et j'espère que vous aurez l'occasion d'interroger les experts.

Nous avons également organisé, avec la collaboration de la NHK et de l'industrie, quelques démonstrations de systèmes de télévision de façon qu'il vous soit possible de comparer les diverses propositions. Le colloque vous fournira ainsi une excellente occasion de vous former une opinion quant à la qualité visée et celle obtenue et vous permettra en outre d'évaluer les possibilités de production et de distribution des systèmes en démonstration.

Vers la fin du colloque, les ateliers de travail tenteront de faire la synthèse des divers éléments et de dégager certaines lignes directrices concernant les nouveaux systèmes de télévision, leurs applications et leurs impacts. Je suis assuré que vous n'aurez pas le temps de vous ennuyer cette semaine.

Nous souhaitons en outre que ce colloque puisse nous rapprocher tous de l'avènement des nouveaux systèmes de télévision multi-usages, de grande qualité et évolutifs. Pouvons-nous nous permettre le luxe de développer plusieurs systèmes concurrents visant à dispenser les mêmes services ? Je crois que nous, concepteurs, fabricants et utilisateurs, partageons une même responsabilité, celle de poser une assise de développement solide et saine.

En 1985, nous disposons de la technologie et des possibilités d'élaborer une nouvelle norme de télévision d'application mondiale. Faisons en sorte de ne pas rater cette occasion de faire un grand pas en avant en évitant de confondre les questions et les réponses.

Afin de nous guider dans cette entreprise, nous aurions aimé avoir à nos côtés aujourd'hui M. Christos Siocos, collègue de grand renom, savant et chef de file en matière de télévision. Son décès survenu en janvier dernier laisse un vide énorme non seulement auprès de l'organisation du colloque mais également auprès des nombreuses organisations pour lesquelles il s'est dévoué avec tant d'enthousiasme et de savoir-faire au fil des ans. Ses talents de diplomate et son aptitude à réconcilier des groupes d'opinions divergentes et à les mener à des solutions saines et viables sur les plans technique, économique et politique seront regrettés de tous.

Je cède maintenant la parole à Ken Davies, président du comité organisateur et de la session de ce matin, qui vous présentera le prochain conférencier invité.

Merci

THE PRESENT STATE OF HDTV - WHAT IT TAKES AND WHAT SHOULD BE DONE

Takashi Fujio
Director General of Research

NHK Science & Technical
Research Laboratories

1.1

ABSTRACT

In the information society of the future television will be assigned to an ever more important position as an imaging system and a video communication system fundamental to the information industry. After the digitization of TV signals was achieved, extensive picture processing, including in the temporal frequency domain, has become possible by manipulation of TV signals. All the future imaging systems would be based on television technology. From this point of view, an HDTV system proposed by NHK was designed to make it a total broadcasting system from program production and transmission to reception in homes, bearing in mind the all-round system which will be able to create a future image culture.

Presently, all the HDTV equipment including a receiver with 40-inch CRT has been completed by NHK. Early in 1984, the MUSE signal system was developed for DBS and it is used for experimental HDTV broadcasting at the Tsukuba Exposition site. A quality system converter from the HDTV with 60 Hz field to existing TV with 50 Hz field was also developed and demonstrated successfully in January of this year at the IWP 11/6 in Tokyo.

NHK has done all this to realize an ultimate TV broadcasting with single standard throughout the world, which promises the unification of the world into one "television community" in the next generation. Engineers of today are responsible to hand over a splendid video system to engineers of tomorrow. Broadcasters of the eighties should cooperate and direct their effort to the establishment of a unified HDTV system without sticking on conventional ideas which will obstruct an advance and progress of the system in the future.

ÉTAT ACTUEL DU SYSTEME HDTV - NÉCESSITÉS ET IMPÉRATIFS

Takashi Fujio,
Directeur général de la recherche
Laboratoire de recherche scientifique et technique de la NHK

RÉSUMÉ

Dans la société consommatrice d'information de l'avenir, la télévision se verra accorder un rôle de plus en plus important comme système d'imagerie et systèmes de communication vidéo essentiel à l'industrie de l'information. Après la numérisation des signaux de télévision, la manipulation de ces signaux, y compris dans le domaine temporel, rend possible le traitement détaillé de l'image. Tous les systèmes d'imagerie éventuels seraient basés sur la technologie de la télévision. De ce point de vue, un système HDTV proposé par le laboratoire de la NHK a été conçu pour en faire un système de radiodiffusion intégral comprenant la production, la transmission et la réception au foyer des programmes, tout en tenant compte d'un ensemble de facteurs qui permettront la création de la culture de l'imagerie de l'avenir.

Tout le matériel de HDTV a déjà été mis au point par le laboratoire de la NHK, y compris un récepteur comportant un TRC de 40 pouces. Dans les débuts de l'année 1984, le système MUSE a été mis au point pour la radiodiffusion directe par satellite et il est utilisé à titre expérimental pour la radiodiffusin de TVHD à l'exposition de Tsukuba. Un convertisseur de système de grande qualité permettant le passage de la trame TVHD 60 Hz à la trame TV 50 Hz a été également mis au point et a fait l'objet d'une démonstration réussie en janvier de l'année courante dans le cadre des travaux du groupe de travail intérimaire 11/6 à Tokyo.

Le laboratoire de la NHK a effectué tous ces travaux pour obtenir un système de télévision basé sur une seule norme internationale promettant l'unification des cultures pour former une seule "communauté télévisuelle" dans la prochaine génération. Les ingénieurs d'aujourd'hui sont tenus de remettre aux ingénieurs de demain un système vidéo splendide. Les radiodiffuseurs des années 80 doivent coopérer et diriger leurs efforts vers l'établissement d'un système TVHD unifié sans s'accrocher aux idées conventionnelles qui bloquent les progrès éventuels du système.

The Present State of HDTV

- What it takes and what should be done -

1.1

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1. Introduction

It is almost 15 years since the research into high-definition television, HDTV, was started at NHK. As a result of wide-ranging studies, a provisional standard was proposed by NHK and today, in Japan, technological development has been pushed ahead according to this provisional standard. Television of the future must be a most precious medium by which to create the 'image culture' of the future. In order to bring about a world that is more peaceful than the one in which we live, television of tomorrow must be something that provides the countries of the world with a common system to link them together.

The HDTV system, as its technical development advances further, will be introduced rapidly into various fields of 'image' industry - such as, movie, printing, photography, teleconference and medicine.

The broadcasters of the world must thoroughly understand and grasp the current situation and, at the same time, must keep their eyes on the future society and think seriously as to what should be done now. And we certainly would like to play a meaningful part as the engineers of the present generation, cooperating closely with one another with our aim set on the development of a video system that we can hand over with much pride to the next generation.

2. HDTV for Future Imaging System

2.1 Function of Future Television

During the last 30 years, television has been playing a major role in extensive fields of people's life and information society.

With the development of sound multiplex technology in television broadcasting, it has become possible for the description of scenes by sounds and voices. This has developed television into a medium that can be fully enjoyed by people with some handicap in eyesight. The functions of television have been further expanded in such a way as to make television a medium which, by means of teletext service, is capable of conveying the content of conversations to the viewers who are hard of hearing.

After the digitization of television signals has been achieved and large-capacity video memory device can be introduced into the broadcasting system, the picture processing, including in the temporal frequency domain, difficult with optical technology, can be freely performed by the manipulation of television signals.

Such processing holds great potential for conventional imaging systems, such as those used in printing, photography, and the cinema. In the information society of the future, all imaging systems are likely to be based on television technology, i.e. on video technology.

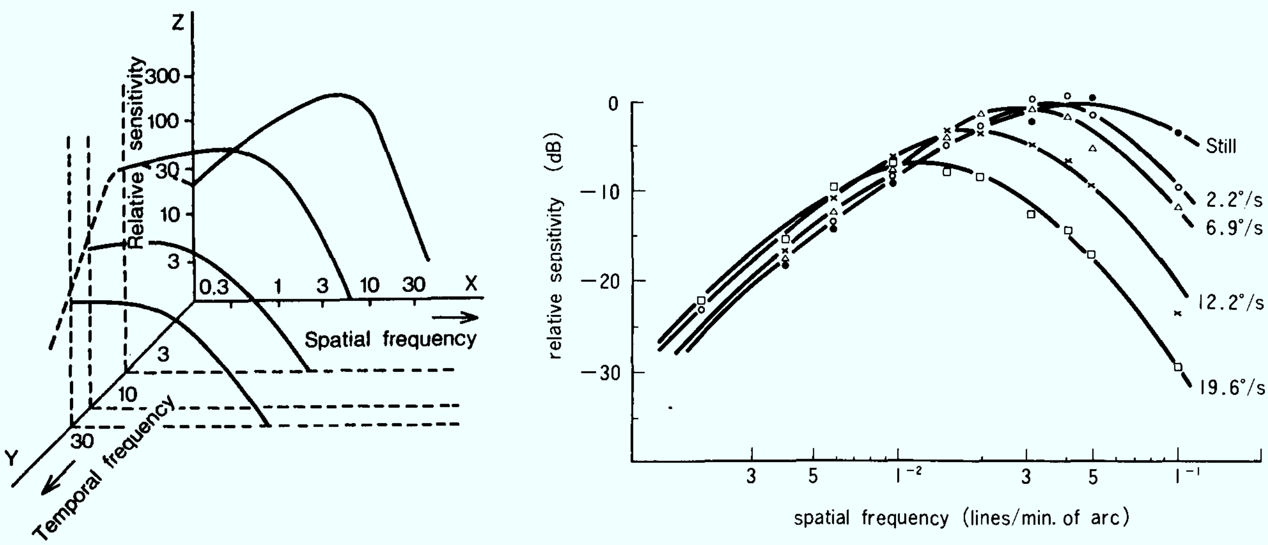
For this reason, a new TV system which will be acceptable to the future information society is desirable to enhance its ability to become a medium so that it may convey ample and rich information both in volume and content.

And, future TV system must be designed not only for broadcasting but also for other applications to all imaging systems which create image culture of the coming generation.

2.2 HDTV System for the Future

Considering the above-mentioned requirements for becoming a new television of the future, NHK has been doing comprehensive studies of the standards of performance and characteristics from various point of view such as the amount of information that is most suitable for human vision, and the conditions required to produce appropriate psychological effects.

Fig. 1 (a) show tempo-spatial frequency characteristics of the human visual system when viewing television. The characteristics both in temporal and spatial frequencies are of LPF type. Fig. 1 (b) shows the relative sensitivity of the visual system for luminance measured with a drifting spatial sine-wave.(1) The visual response in the high spatial frequency range decreases as the temporal frequency becomes higher.



(a) Spatio-temporal

(b) Sensitivity for different drifting velocities

Fig. 1 Response of the human visual system

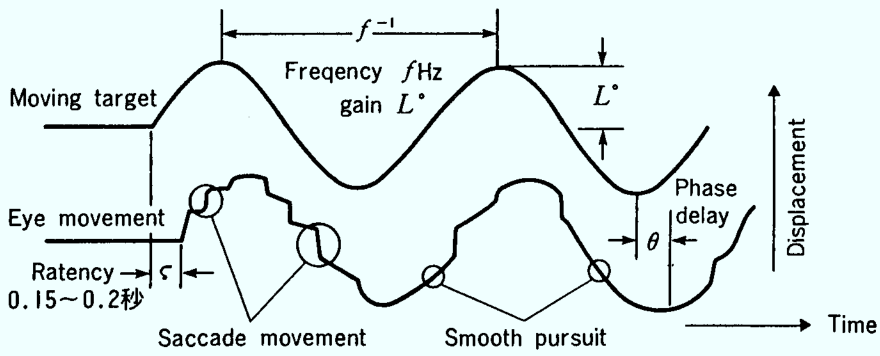


Fig. 2 Tracking behavior of the eye

Table 1 Provisional standard for HDTV

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

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

Fig. 2 shows the tracking behavior for moving object of the human visual system.(2)

So that, desirable watching condition of TV which is an imaging system of moving objects will be decided from Fig. 2. Based on the watching condition, desirable number of scan lines and number of picture elements can be obtained from Fig. 1 (a). Fig. 1 (b) will give a suggestion of scan system for television.

The most important thing for determination of standard of television which conveys moving pictures is the matching and balance between picture information and the human visual characteristics, both in the spatial domain and in the temporal domain.(3)

The HDTV standard shown in Table 1 was determined and designed on the basis of long and extensive studies at NHK to make it a total broadcasting system from program production to reception in homes. The HDTV has such performances as described in the following,

(1) It is capable of reproducing video pictures of high resolution, with five times the information content of conventional television pictures;

(2) Each television frame can take the form of an 8-by-11-inch page of 10.5-point characters (2.6 mm x 2.6 mm each) and pictures of fine detail;

(3) The picture quality is equivalent to that of a 35-mm transparency, and superior to that of a 35-mm motion picture film;

(4) An HDTV picture displayed on the screen with a wider aspect ratio of 5:3 and a larger size of 40 inches - 60 inches produces psychological effects such as sensation of reality and an impact which cannot be produced by current TV systems.

3. Present State of the Development of HDTV Equipment[4] [a]

NHK has been making every effort to develop a high-definition television equipment of 1,125 scanning lines system. Various experimental equipment had been already developed, such as TV cameras, laser telecine, VTR, color encorder, laser film recorder and receiver for satellite FM transmission, display devices and high-resolution color monitors as shown in Fig. 3.

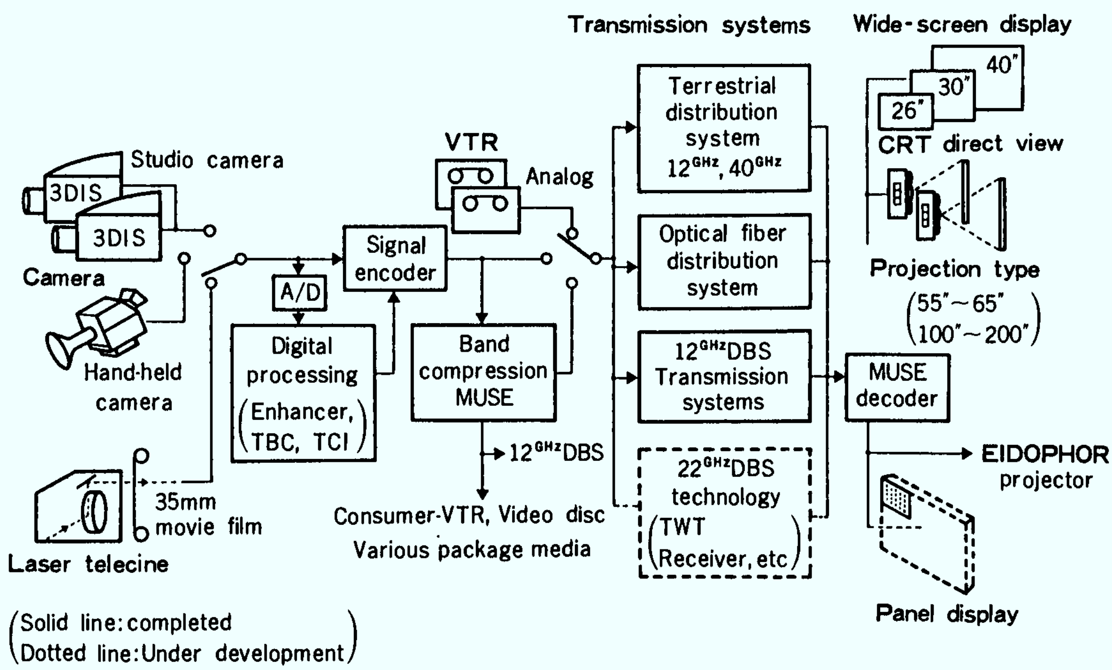


Fig. 3 Various HDTV equipment developed by NHK

They 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.

Recently, the HDTV research and developmental work is being concentrated on the performance improvement, small size and light weight. Since the development of the MUSE signal system, applications of HDTV equipments to package media have been active by many Japanese manufacturers. Some recent HDTV equipments are briefly given in the following.

3.1 Camera

At the NHK Science and Technical Research Laboratories, research and development of a new short-length 1-inch Saticon tube for HDTV has been carried out based on novel design concepts. It has an excellent performance of high resolution as well as low-lag characteristics. Also a 2/3-inch Saticon tube for HDTV has been developed using the same principle as that for the 1-inch tube.

Fig. 4 Portable camera for HDTV

A new type of cameras using these tubes with static deflection and magnetic focusing have been designed. The one is a 1-inch portable camera (Fig. 4) and the other is a 2/3-inch self-contained portable camera. The weight of the former camera including a lens is about 13 kg and that of the latter is about 8.5 kg.

3.2 Telecine and Film-recording Devices Using Scanned Laser Beams

Telecine and film recorder for HDTV are using advantageous features of laser beams to the fullest extent. An accurate deflection technique for laser beams with rotating polygonal mirrors was developed to perform these devices.

In 1981, a laser telecine for 70 mm movie film was developed.

Furthermore, a telecine for 35 mm film with a new contour corrector using an additional readout by means of a defocused laser beam, has been developed and HDTV signals with an exceptionally high S/N ratio and an excellent resolution have been obtained by this telecine. These devices will be all available at the Tsukuba Exposition now being held in Japan.

It is possible to transfer a 35 mm slide picture independently from the transmission of motion picture film after the deflected beam being partly separated and scanned. Fig. 5 shows an external view of a newly developed laser telecine device for 35 mm film, installed at the NHK Laboratories.

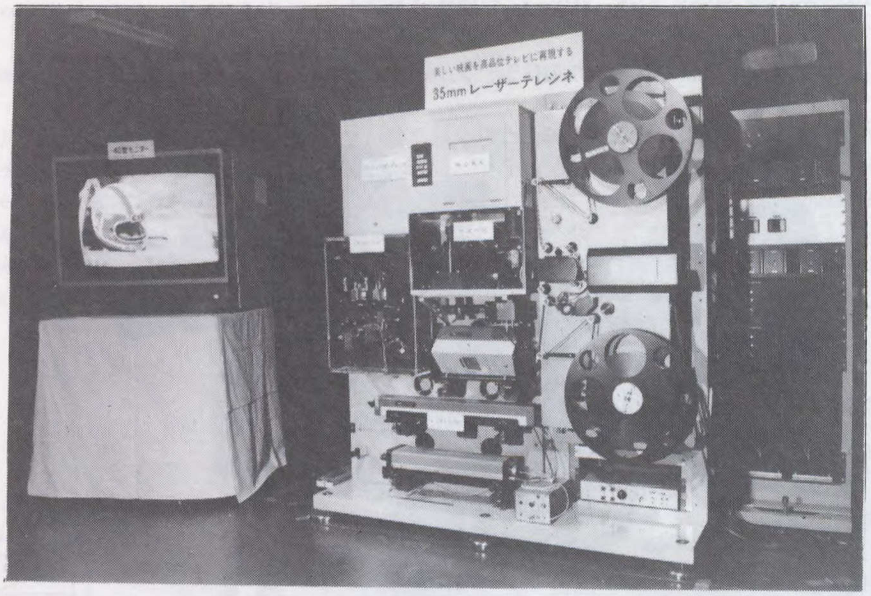
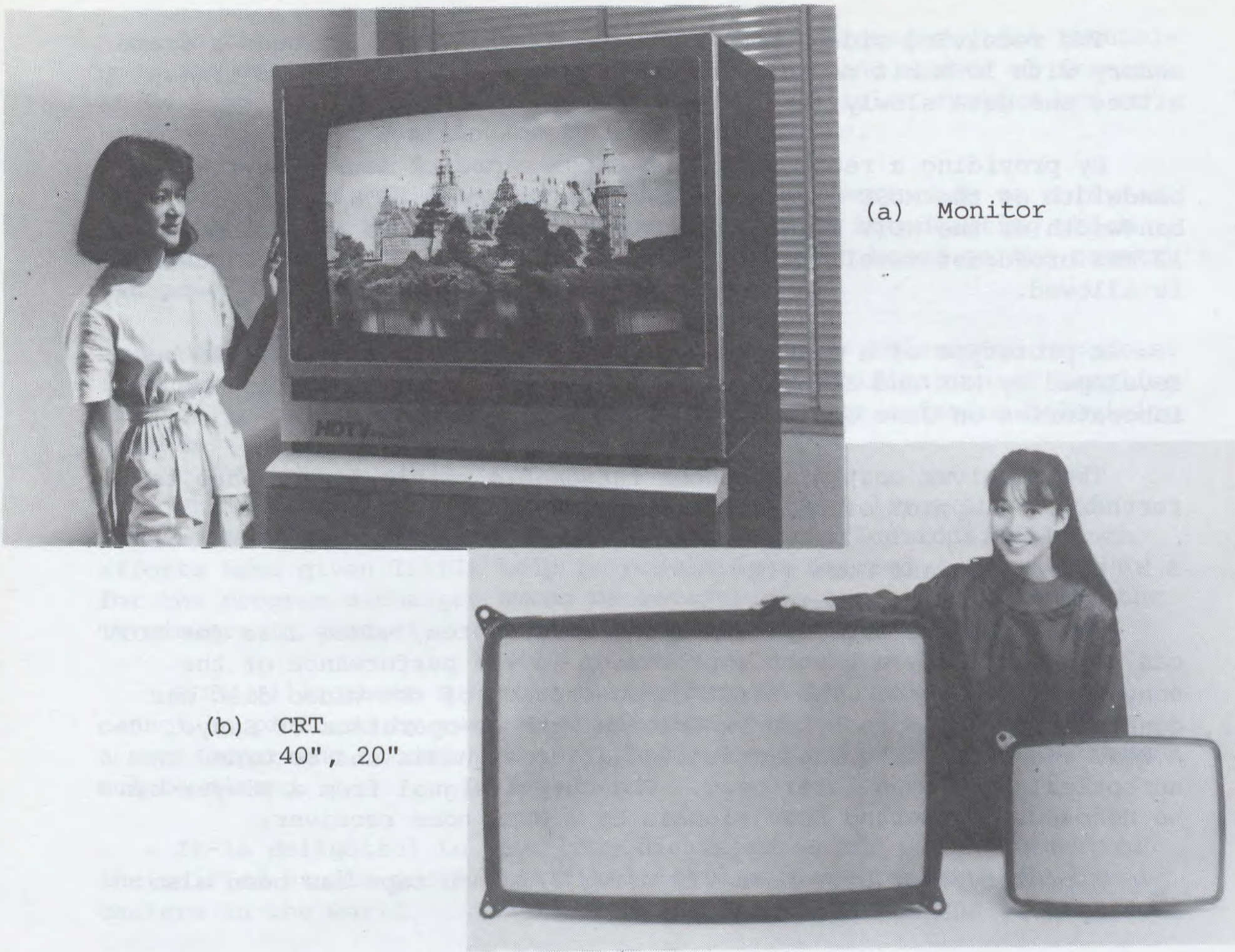


Fig. 5 35mm laser telecine

A prototype of laser-beam recorder has been developed by NHK. It can transfer HDTV pictures onto 35 mm films without any noticeable degradation of image quality. Some programs were recorded with this system and demonstrated the results at the International Television Symposium, Montreaux, in 1983, and at the SMPTE winter-conference, San Francisco, in 1985.

3.3 Display

Many types of display for the HDTV have been developed in Japan by several manufacturers: 26-inch, 30-inch monitors using direct view CRT and projection type display from 55-inch size to 120-inch size. A novel type of 40-inch monitor was also developed by NHK with cooperation of Matsushita, Mitsubishi, Toshiba and Asahi-Glass Companies. A 40-inch CRT for the HDTV with aspect ratio of 5:3 covered with a shadow mask of 420 μm fine pitch was developed for this monitor. Fig. 6 shows an external view of the 40-inch monitor and its CRT, the largest in the world.



(a) Monitor

(b) CRT 40", 20"

Fig. 6 40" size monitor and CRT for HDTV

A 200-inch and a 400-inch displays are now being developed for theater projection. The employ 10-inch Schmidt-type CRTs. The 400-inch display is being used at Expo'85.

As for flat pannel displays which are considered to be most promising system for HDTV in the future, research and development on gas-discharge pannels are being conducted in NHK. A pulse-driven DC-pannel having a memory function and a color AC-pannel were developed, and the 525-line TV picture was successfully displayed on them. Further efforts are being made for improvement in efficiencies and implementation technologies to realize larger pannels for use in HDTV.

3.4 MUSE System and HDTV Home Receiver

In order to broadcast HDTV from a broadcasting satellite operating in 12 MHz band, the bandwidth of the base-band signal needs to be compressed substantially.

Early in 1984, NHK developed and made public the signal system called the 'MUSE (Multiple sub-Nyquist Sampling Encoding) system'. The MUSE system transmits a picture frame by first separating it into 4 fields each having picture elements spreading sparsely both in vertical and horizontal directions.

The receiving side, then, reproduces HDTV signal through a frame memory with 10 M bit capacity from the MUSE signal which had transmitted the data slowly, taking time.

By providing a receiver with a large-capacity memory device, the bandwidth of the MUSE signal can be made narrower to 8 MHz from 20 MHz bandwidth of the HDTV signal. And the signals may be broadcast from a 12 MHz broadcast satellite if a little degradation in picture quality is allowed.

A prototype of a home receiver for the MUSE system has also been developed by NHK and demonstrated at the open house exhibition of NHK Laboratories on June of 1984.

The receiver cost will become reasonable within 5 years due to further development of LSI fabrication technology.

3.5 Video Disc and Home VTR

Thanks to the development of the MUSE system, video disc for HDTV can be achieved by a slight improvement in the performance of the conventional device. The first demonstration of the video disc was done at the 1984 open house exhibition with co-operation of Sanyo. A MUSE signal is frequency-modulated after emphasis and recorded on an optical disc by a laser beam. The output signal from a player can be decoded to wideband HDTV signals by a MUSE home receiver.

A prototype of HDTV home VTR using 2/3-inch tape has been also developed by NHK and demonstrated.

3.6 HDTV Experimental Broadcasting Using 12 GHz Band

Transmission tests of HDTV satellite broadcasting is scheduled at the end of this year by BS-2 broadcast satellite. Presently, experimental test to determine transmission parameters is progressing in the Laboratories.

The broadcast system will employ a MUSE signal using one broadcast channel of 12 GHz satellite with 27 MHz. Toward the HDTV broadcast, the signal form and transmission standards will be discussed at the Radio Technical Council of Japan from this year. HDTV programs are being demonstrated at Tsukuba Expo'85 which also includes an experimental 12 GHz terrestrial broadcasting. Regular HDTV broadcast will begin by using BS-3 broadcast satellite which will be launched in 1989. HDTV home receivers should be manufactured in time at reasonable cost.

4. HDTV Standardization

4.1 Significance of Single Standardization

The world is currently going to be united into one communication community, through the rapid advance and expansion of communications technology. It is therefore necessary that television, the leading format in the information industry, should receive single standardization.

In the movie industry, whose long history precedes video technology, the entire world is standardized film size and number of frames at 24 frames per second. However, current television systems are not uniform either in scanning or in signal standards.

In the past, at every opportunity, efforts were made to unify as much as possible the standards and systems of TV broadcasting which was originally started by various countries, each based on the country's own power frequency for broadcasting of its own.

For example, the scanning standard for color television broadcast in Europe was unified into 625/25 and a global unification of sampling frequency was achieved in the digital standard for existing television systems.

While a great deal of time was consumed by a large number of engineers in accomplishing the work for such unifications, all such efforts have given little help in providing a unified system, either for the program exchanges among broadcasting organizations or for the TV viewers in general.

HDTV will create a system that offers an attractiveness which cannot be produced by current television systems. It will present a most opportune occasion for single standardization, one which should not be missed.

It is delightful to have been discussed on the establishment of the unified studio production standard in cooperation with all broadcasters in the world.

4.2 Single Standardization of HDTV(10)

The approach to the following three standards as shown in Fig. 7 has to be considered when a complete broadcast system for HDTV is envisaged:

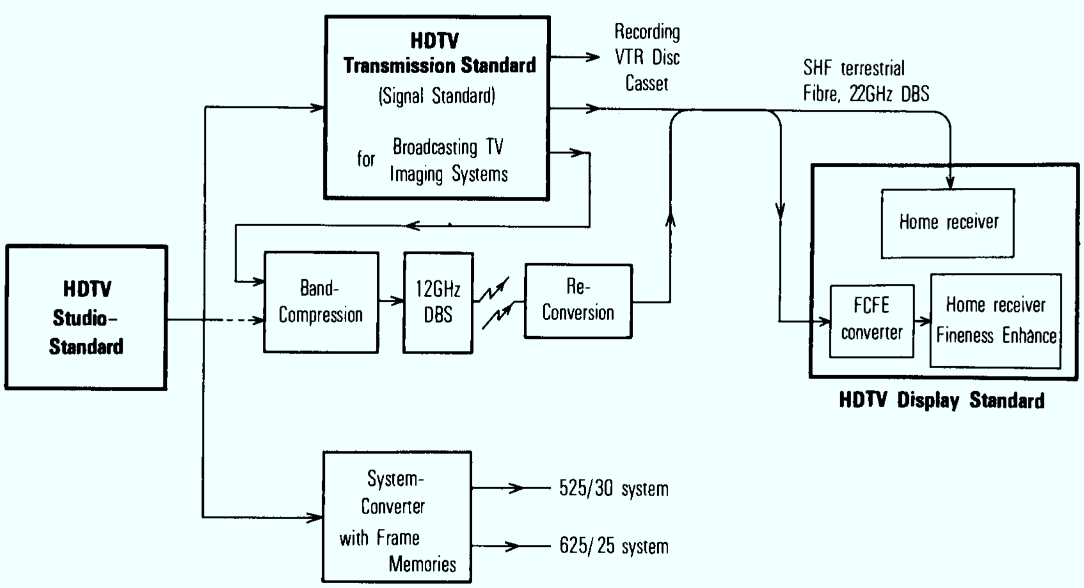


Fig. 7 Standards for HDTV broadcasting system

(1) Studio standards for program-production;

(2) Transmission standards for distribution;

(3) Display standards for picture reproduction.

Standard (1) is for studio-production for HDTV program production and for international program exchange. Presently, works for the unification of single standard are progressing at the Interim Working Party on HDTV which was established in 1983 under the Study Group 11 of the CCIR.

Standard (2) is for signals for transmitting information to homes and for signal transmission system. Standard (3) is for reproducing HDTV pictures by processing the received signals.

The display standards at the receiver determines the signal quantity of information to be transmitted. Display standards affect the signal and transmission standards, because they involve questions of the quantity of information and the types of signals to be transmitted in HDTV. Therefore, display standards are important.

The display standard should be decided following the studio standard before determining the transmission standard.

5. Creation of Video Culture by HDTV

The HDTV 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 production of high-quality motion picture, printing, transmission of picture with fine detail and so on.

A prototype of laser-beam recorder developed by NHK can transfer HDTV pictures onto 35 mm films from video without any noticeable degradation of picture quality.

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.

We are now looking into the possibility of using this HDTV for 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.

In Japan, introduction of HDTV technologies is progressing into such systems for movie production and printing industries, and new medical diagnostic systems.

The video system for the Tsukuba Expo Center is operated entirely with the HDTV system. HDTV programs are distributed and displayed in various parts of Japan. Projection-type large-screen display with 8.0 m x 4.8 m and direct-view type 40-inch CRT display was developed for the EXPO. Terrestrial broadcasting test using a MUSE signal system is also being carried out at the Tsukuba EXPO site. Transmitting frequency used is 12 GHz, and transmitting power is 0.5 W.

6. Duties of Broadcasters

6.1 Technical Establishment of HDTV

The advanced system of the future should not be such a system of compromise as the existing television. Rather than merely picking up information, the present advanced technology has become capable of handling information with rich volume and content in the process of transmission and display as well.

We, video-engineers must work to build the most efficient TV system which matches well the human visual system using advanced technologies.

Even if a system is capable of conveying a large volume of information, it cannot be called a good imaging system as long as the information is conveyed disregarding its matching with the visual system. For the high-definition TV system of the future, it is necessary to ensure better matching with the characteristics in various domains of the visual system, such as, chromaticity and luminance or spatial and temporal, and to develop a good system by distributing the required information to each of the above-mentioned domains.

In the psychological aspects, also, efforts must be made to develop an imaging system that satisfies the viewers on a sophisticated psychological level.

Furthermore, it is essential to overcome limitations and shortcomings of the existing TV system[11] for developing a new HDTV system. Advanced new technologies of today have reached the level with which such shortcomings can be solved. Colorimetiric design of the HDTV is also an important item we should consider to unify taking primaries of the system and to decide the transmission primaries.

In the Appendix, colorimetric design studied by the author and the provisional standard of the NHK's HDTV are listed for reference.

6.2 Toward the World's Single Standardization

If we, broadcasters were to miss this opportunity of establishing a unified system for HDTV, the chance of achieving the unification of TV standards would be lost forever and our hope of bringing the whole world into a Television Community would remain an eternal dream.

In the field of movie or of photography, they have a technical system that functions under a single standard common to countries all over the world. In the field of television, therefore, an electronic imaging system that is responsible for creation of an 'image culture' to be handed on to the next generation, we should avoid adhering to the century-old power frequency as the basis on which to think about the HDTV system. This is because it is the engineers themselves that are fully aware of its being the most clumsy way to choose.

Many engineers in the world know a number of methods of improving the existing system. However, none of such methods would contribute to the next generation if that method deviates from the ultimate objective of further developing new techniques with which to create the new society of the next generation, or if that method ends up merely as a stop-gap device, something like a patch-work done to the roof to stop the leaks.

In order to realize the unification of HDTV standards, the broadcasters and video engineers of the world should never remain a group of people who have lost sight of the substance of the question, preoccupied only with the idea of relating the unified standard to that of the present television.

And the system to be built up through our efforts should be something that we can hand over with pride to the people in the next generation.

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APPENDIX

Transmission Signal for HDTV

(1) Basic stimulus and luminance signal

Primary color (phosphor)	NTSC primaries			NTSC primaries	NTSC primaries	New primaries		
	R	**G**	**B**			**R**	**G**	**B**
	x = 0.67 / y = 0.33	0.21 / 0.71	0.14 / 0.08	ditto	ditto	0.686 / 0.314	0.174 / 0.739	0.150 / 0.025
Basic stimulus (CIE colorimetric system)	Illuminant C $x_w = 0.310$, $y_w = 0.316$			9300°K + 27MPCD $x_w = 0.281$, $y_w = 0.311$	D_{65} white $x_w = 0.313$, $y_w = 0.329$	Illuminant C $x_w = 0.310$, $y_w = 0.316$		
Stimulus values between CIE and color TV colorimetric systems	$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \overset{*}{\begin{pmatrix} 0.607, & 0.173, & 0.201 \\ 0.299, & 0.587, & 0.114 \\ 0.0\ , & 0.066, & 1.117 \end{pmatrix}} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$			$a_{ik} = \begin{pmatrix} 0.495, & 0.186, & 0.223 \\ 0.244, & 0.629, & 0.127 \\ 0.0\ , & 0.071, & 1.241 \end{pmatrix}$	$a_{ik} = \begin{pmatrix} 0.589, & 0.179, & 0.183 \\ 0.290, & 0.605, & 0.105 \\ 0.0\ , & 0.068, & 1.020 \end{pmatrix}$	$a_{ik} = \begin{pmatrix} 0.620, & 0.166, & 0.201 \\ 0.284, & 0.683, & 0.033 \\ 0.0\ , & 0.080, & 1.103 \end{pmatrix}$		
Remarks	*: a_{ik} , In use tentatively from 1976					Should be discussed on adaptabilily for imaging systems		

(2) Transmission primary signals (basic stimulus: illuminant C)

Chrominance components	Transmission system of chroma components of fine and coarse chromaticity axes	Transmission systems focussed on system stability (across the ucs diagram at right angle)			Transmission system to improve flesh tints
		I axis of NTSC as a reference	Fine chromaticity axis as a reference	Coarse chromaticity axis as a reference	
Transmission primaries (UCS colorimetric system)	C_W' : $\begin{pmatrix} u = -2.42 \\ v = 0.0 \end{pmatrix}$ C_N' : $\begin{pmatrix} u = 0.19 \\ v = 0.0 \end{pmatrix}$	I_W : $\begin{pmatrix} u = -0.363 \\ v = 0.0 \end{pmatrix}$ I_N : $\begin{pmatrix} u = 0.368 \\ v = 0.0 \end{pmatrix}$	C_W : $\begin{pmatrix} u = -2.42 \\ v = 0.0 \end{pmatrix}$ C_N : $\begin{pmatrix} u = 0.24 \\ v = 0.0 \end{pmatrix}$	C_W : $\begin{pmatrix} u = 6.08 \\ v = 0.0 \end{pmatrix}$ C_N : $\begin{pmatrix} u = 0.24 \\ v = 0.0 \end{pmatrix}$	Λ : $\begin{pmatrix} u = -0.31 \\ v = 0.0 \end{pmatrix}$ Φ : $\begin{pmatrix} u = 0.21 \\ v = 0.0 \end{pmatrix}$
Stimulus values between taking primaries and transmission primaries	$\begin{pmatrix} Y \\ C_W' \\ C_N' \end{pmatrix} = \begin{pmatrix} 0.30, & 0.59, & 0.11 \\ 0.61, & -0.52. & -0.09 \\ -0.03, & -0.38, & 0.41 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$	$\begin{pmatrix} Y \\ I_W \\ I_N \end{pmatrix} = \begin{pmatrix} 0.30, & 0.59, & 0.11 \\ 0.59, & -0.30, & -0.29 \\ 0.21, & -0.52, & 0.31 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$	$\begin{pmatrix} Y \\ C_W \\ C_N \end{pmatrix} = \begin{pmatrix} 0.30, & 0.59, & 0.11 \\ 0.63, & -0.47, & -0.16 \\ -0.03, & -0.38, & 0.41 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$	$\begin{pmatrix} Y \\ C_W \\ C_N \end{pmatrix} = \begin{pmatrix} 0.30, & 0.59, & 0.11 \\ 0.61, & -0.52, & -0.09 \\ -0.14, & -0.30, & 0.44 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$	$\begin{pmatrix} Y \\ \Lambda \\ \Phi \end{pmatrix} = \begin{pmatrix} 0.30, & 0.59, & 0.11 \\ 0.58, & -0.47, & -0.11 \\ 0.25, & -0.57, & 0.32 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$
Y/C encoding system	•Quadrature phase modulation of half-line offset subcarrier •HLO-PAL system •PAF system	ditto	ditto	ditto	Very useful for the quadrature phase modulation
Remarks			Decided as transmission primary signals in 1976.		Retransmission

T. Fujio Sept. 1976.

The HDTV-Studio Standard Project
Status of Discussions and Position in Europe

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ABSTRACT

In September 1984 the CCIR IWP 11-6 had received for consideration various proposals - originated by the EBU, Japan and USA - on potential choices of parameters to be included in a CCIR Recommendation possibly agreed upon at the CCIR Final Meeting October 1985. The most controversial item contained therein was the field rate, where differing requirements, in particular the mandatory conversion to existing standards set diverging priorities. The level of quality reached in standards conversion from one particular HDTV-standard candidate into the conventional standards was considered to be the fundamental and decisive attribute for its acceptance.

Among the variants in question the conversion of a 60 Hz field rate into 50 Hz found particular attention. Combined efforts in Europe, Japan and USA were made to provide the appropriate program material and the sophisticated hardware for arranging the conversion itself and demonstrations and subjective tests on the quality achieved. The paper will give a survey of these activities intended for the beginning of 1985, present the results of the tests and possibly enlarge on conclusions drawn from them.

PROJET DE NORME SUR LES STUDIOS DE TVHD

ÉTAT DES DISCUSSIONS ET POSITION EN EUROPE

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RÉSUMÉ

En septembre 1984, le Groupe de travail intérimaire 11-6 du CCIR avait reçu pour fins d'étude diverses propositions formulées par l'Union européenne de radiodiffusion (UER), le Japon et les Etats-Unis concernant les paramètres susceptibles d'être inclus dans l'avis du CCIR que pourrait arrêter la Réunion finale du CCIR en octobre 1985. L'élément le plus controversé du document était la fréquence de trame. En effet, la divergence des besoins sur ce plan - en particulier la conversion obligatoire aux normes existantes - fait que les priorités sont différentes pour les uns et pour les autres. Le niveau de qualité de la conversion entre une certaine proposition de norme de télévision à haute définition (TVHD) et les normes classiques a été jugé l'élément fondamental et décisif de l'acceptation de cette norme de TVHD.

Parmi les variantes proposées, la conversion d'une fréquence de trame de 60 Hz à 50 Hz a particulièrement retenu l'attention. Des efforts concertés ont été faits en Europe, au Japon et aux Etats-Unis pour fournir la programmation utile et le matériel sophistiqué nécessaires à la conversion proprement dite et aux démonstrations et essais subjectifs de la qualité obtenue. Le document passera en revue ces activités qui sont prévues pour le commencement de 1985; il présentera aussi les résultats des essais et s'étendra possiblement aux conclusions qui en sont tirées.

The HDTV-Studio Standard Project
Status of Discussions and Position in Europe

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As one of the earliest reactions on the request for the submission of relevant contributions put forward by the CCIR Interim Working Party 11-6 the EBU had set up mid 1984 a "Draft framework for a HDTV Production Standard". This document specified and defined a number of significant parameters which seemed to be feasible in commencing the international discussion on that topic:

Number of active lines	1035
Aspect ratio	5:3
Samples per active line (Y;U;V)	1800; 900; 900
Bits/sample	8
Total number of lines (8 %V-Blk)	1125
Interlace	2:1

Although the parameter set was rather restricted and not exhaustive in the sense of a comprehensive specification this proposal already showed a "sampled representation" of the signal this way linking it to the "Digital Studio Interface" as outlined in CCIR Rec. 601. Furthermore reference was made to "family members" employing progressive scan which, although bandwidth consuming, could prove preferable for certain operational reasons.

The matter of field rate was still handled "open-minded" in this proposal. Possible figures were optionally 50, 60 and 80 fields/s the latter showing priority since it was not only considered to improve motion portrayal - at the expense of increased bandwidth and reduced camera sensitivity - but to serve as a reasonable basis for conversion down to 60 and 50 fields/s without introducing unacceptable impairments.

In response to the EBU proposal Japan from the very beginning expressed its dissent. The U.S. position, although affirmative initially, changed as well. It was recognised that a HDTV-Standard based on the well established 60 Hz field rate would prove advantageous in terms of compatibility with existing services, featuring acceptable temporal resolution without burdening the bandwidth account excessively and providing at virtually no additional expense an unobjectionable flicker-free receiver presentation. Furthermore one was aware of the quality impairment one would have to cope with if a deviating field rate were chosen whether it be 80 or 50 Hz. Not surprisingly very quickly it was stated that discussions on a worldwide HDTV-Standard should be restricted only to systems based on a 60 Hz field rate and that there was no evidence at all to succeed in negotiating on other figures within the U.S. broadcast community.

As easy it is to implement a HDTV standard into an existing environment if the field rates conform, as difficult it may prove to solve this task if the contrary does apply. Within the working groups of the EBU concerned, in particular in Specialist Group V1/HDTV it was realised that the proceeding intended at the beginning - to select a set of parameters as a common source-standard in which HDTV production could be performed and to consider subsequently the way down to separate emission standards, compatible to the existing ones - would fail. It became obvious that the possibility of a worldwide standard based on 60 Hz was to be taken into account and that the consequences for 50 Hz countries would have to be studied carefully.

Differing TV field rates in a telecommunication community make mandatory field rate conversion somewhere. However the complexity to be employed in the equipment and the degree of quality artifacts that are produced by the process and have to be tolerated finally depend on the location of the linking spot within the system. It is commonly agreed that even the highest order of sophistication in real-time conversion - there is some feeling that elaborate non-real-time procedures will enable the goal to be reached more closely in future - will never achieve a completely satisfactory result of conversion quality at the HDTV level. Consequently the field rate within the HDTV domain should be left unchanged from the signal source through transmission, processing, emission until the receiver. Converted signals should merely appear at the link to conventional services.

Here the exising CCIR documentation outlines the expected quality margin: Conversion into present standards should provide a quality at least as good as that available from signals generated directly in these standards.

Although specialists in this field point out that this request is hardly to be accomplished and any field rate conversion process will to some degree suffer from more or less susceptible artifacts making in particular motion portrayal worse than that experienced in standard television, this request was formulated so strongly. It reflects the judgement the motion portrayal obtained in present-day standards conversion being well acceptable occasionally in current affairs services; however to use it day-by-day in all kinds of program the remaining artifacts even if reduced may prove annoying.

In this context the achievable maximum quality of the conversion into the conventional standard becomes a decisive - if not at all the most important - factor for the acceptability of a potential standard, more specifically for the acceptance of a 60 Hz field rate in a 50 Hz environment.

The most critical point in HDTV/60-625/50 standards conversion is the change of the field rates since the respective provision of motion samples (at 50 resp. 60 instants/s) is nearly equal and a certain amount of conversion losses can always be anticipated. Because the temporal sampling instants are not coincident in 60 and 50 Hz systems, the missing information ought to be deduced by interpolation from temporally and/or spatially adjacent pixels. As long as the information does not change significantly with time (e.g. in still pictures or at very low motion speed) the information can be restored without impairment.

As the speed increases the Nyquist limit is surpassed - our present television systems even for quite moderate motion speeds prove to be temporally sub-sampled -, any principle employing pure interpolation processes - these only applicable below the Nyquist criterion - will fail and discontinuous motion presentation results. New principles have to be brought into action; motion has to be sensed as such and depending on motion magnitude and direction differing algorithms are applied.

The NHK had offered to provide a new converter concept employing motion adaptive algorithms. One could assume this concept to set a landmark in terms of circuitry sophistication and picture quality. The question remained open whether the result could even cope with the CCIR request. It was evident a meaningful evaluation could only be obtained by subjective assessment and having this in mind a test within the EBU was agreed upon.

The test material was carefully selected and produced in HDTV 1125/60 and PAL 625/50 in parallel. The material was converted in two ways:

- Conversion HDTV 1125/60 into PAL 625/50 using the new NHK Standards Converter
- Conversion HDTV 1125/60 into NTSC 525/60 employing merely line conversion

In a second step this latter material was processed further into PAL 625/50 via the ACE-Converter of the BBC to allow for comparison with present-day conversion quality.

After the final editing - all copies were composed straight from the master tapes (from the original resp. from the converted tapes) in order to keep down the number of generations - the tests were carried out in February 85 at the premises of seven EBU member organisations. It should be pointed out that carrying through these tests as well as their organisation and preparation required a considerable amount of international cooperation which was undertaken by all parties and individuals involved with great willingness.

12 scenes were presented in the test, each of them in 3 variants:

- In direct PAL it represented the quality target aspired to ("upper anchor")

- Converted through NTSC into PAL the today's conversion quality level was established ("lower anchor")

- Elsewhere in between - perferably close to direct PAL - the result of the NHK Converter was expected.

The scenes were selected in order to provide a widespread variety of all kinds of motion: unidirectional (camera panning; captions), multidirectional (rotating objects), periodical (swinging objects). They included artificial test patterns as well as natural scenes as they happen in daily practice: Show, interview, sports event, traffic scene.

The observers - their number in total amounted to some 500 - were kept to restrict their assessment to the presentation quality of motion. A special test method was developed since none of the existing procedures showed up to be applicable to the assessment of motion portrayal defects without change. The proceeding followed in general the principles of the EBU assessment method, however the presentation itself was arranged according to the CCIR "Single stimulus method using the quality scale with high and low indirect anchoring".

Because evaluation of motion portrayal artifacts requires some viewing time, the display period was adapted accordingly.

It was remonstrated that the "lower anchor" chosen and the instruction and motivation given to the observers was inappropriate. This reproach will certainly be investigated. I am personally convinced, poor motion portrayal represents an artifact which cannot be compensated by other items shown in the most excellent condition. Motion defects may prove even more annoying if the other quality parameters perform to their best. Bearing in mind the weak point of conversion <u>is</u> motion portrayal the assessment of related artifacts rather than overall picture quality to me seems reasonable. Furthermore I still stick to the decision using the ACE converter quality as the lower anchor. Although people tend to assign to both anchors the ends of the grading scale such rating the ACE quality as "poor" or "bad" (which should not be taken in the words' true sense) this proceeding has put a magnifying glass to the conversion problem showing where the state-of-the-art is between the earlier developed converters - now in regular operation - and the direct PAL-quality aspired to.

By the way: The diverging opinions experienced here have made evident the need for a commonly agreed practice for the assessment of temporal processes in picture transmission - at present a gap in the relevant documentation.

The consistency of the test result was remarkably good not only within one organisation but also in comparison to the other participating EBU member-organisations. Obviously the selected method has proven reliable.

The test results show up two groups of sceneries. In the first majority group, as expected, the NHK conversion was estimated between ACE and direct PAL or the latter is even reached if the temporal resolution in the original is limited. As compared with ACE the NHK-Converter shows dominating judder and less temporal integration. Although judder is usually felt more annoying, the motion adaptive process improves considerably the behaviour. Even critical sceneries like sporting events are judged about 1 grade better. However a difference of rather the same size remains relativ to PAL. The target of a quality equal to conventional TV is not yet reached in the average.

The other group of scenes contrasts in the result with the first one: Here the NHK conversion is equal or even worse than the ACE conversion. A large difference to "direct PAL" exists. This group contained scenes employing critical rotational and lateral motion.

In appraising the overall situation of field rate conversion as it appears from the test result one has to envisage the fact that even the high sophisticated design employed by NHK has at the time of the test not yet reached the final goal, as it is outlined in the CCIR documentation. Moreover it is unlikely to achieve ever unimpaired PAL quality and one has to envisage a certain allowance for quality reduction in conversion.

Besides the dominant criterion of an acceptable conversion quality the experts of Specialist Group V1/HDTV have figured out six other items of concern, which if considered separately do not show up as much significant; however they might prove decisive in combination:

Postprocessing of converted material. In general postprocessing of picture material should be carried out at the highest possible quality level, i.e. in the source signal configuration. In practical operation however it sometimes becomes indispensable to process further downstream signals which - if those signals have allready undergone temporal processing like conversion - will no more be possible without impairment. A typical example is stop-motion of sportsevents when the critical goal-kick cannot be shown either because the soccer ball - as a consequence of interpolation - disappears or is shown threefold in the selected picture. Similar constraints may evolve in bit-rate reduction for transmission links or with temporal processing in receivers for display enhancement.

Effect of emission principles. In Region 1 there exists a shortage of emission channel capacity in general and even more there is at present no evidence for the availability of wideband channels appropriate for baseband HDTV signals. NHK has developed and shown in operation the MUSE system which permits emission of much of the HDTV studio quality through a single WARC satellite channel (appr. 8 MHz basebandwidth). Since bandwidth reduction is achieved in this system by spatial/temporal subsampling artifacts are experienced in motion performance. The EBU Specialist Group V1/HDTV is convinced, that in order to achieve unobjectionable HDTV transmission one cannot force down bandwidth requirements to less than, say, two WARC transmission channels. One of these channels then has to provide compatible reception for standard 625/50-receivers. It is unlikely to reach this goal with a hybrid 50/60 Hz solution on the two channels. The request for compatibility here makes a 50 Hz emission almost mandatory and would imply a conversion in the HDTV level at the studio output if a 60 Hz production standard were to be used - according to the experts' opinion on unsolveable problem.

Interference mains frequency/fieldrate. If field and mains frequency differ they may interfere and beat-frequency flicker may be caused in scene lighting. Present-day technology provides the means to overcome this problem either by suitable installation or largely by complementary signal amplitude modulation (flicker eliminator). But besides the higher investment costs one has to take into account these lighting conditions and means not being available everywhere in outdoor shooting using existing light installation, at least for a certain transitional period.

Large area flicker and interline twitter. On 50 Hz displays employing wide viewing angles large area flicker is a disturbing effect on CRT displays and would require storing devices in the receiver to increase the field rate beyond the verge of flicker-sensitivity of the human eye. Other display principles (light valve, plasma etc.) might improve the situation in that their duty-cycle is increased such diminuishing flicker effects.

With 60 Hz satisfactory results can be achieved without added circuitry.

Interline twitter always occurs at half the field frequency and is visible with 50 and 60 Hz almost equally. Progressive scanning in the receiver removes this artifact - again at the expense of increased circuit complexity.

Motion continuity and dynamic resolution. 50 or 60 motion phases are both adequate for the portrayal of a continuous motion. Dynamic resolution however is increased with decreasing exposure time (insofar higher field rates prove to be advantageous). CCD-Cameras will improve the situation. Furthermore shuttering could be used however at the expense of reduced S/N ratio. It is not clear how shuttering would facilitate or render more difficult conversion.

Conversion to and from film. Program material produced electronically and converted to 24 pictures/s film stock would be subject to the same kind of quality limitations as the conversion from 60 to 50 fields/s. To relinquish 24 pictures/s in electronically produced films would be a matter of discusssion, and would certainly increase the potential of the film to become a true storing device for HDTV. The investigation of a progressive 60 Hz HDTV-standard, put forward dominantly by motion picture industry and mentioned in the latest U.S. CCIR draft recommendation could prove a first step in that direction. In theatrical release the compatibility problem could be solved most likely at the projector side without inducing insolveable constraints.

Theatre films, shot originally at 24 pictures/s and used as a HDTV programm source would - scanned at 60 field/s - suffer from judder somewhat more annoying than the strobing at a slightly increased picture rate experiened by European viewers nowadays.

Based on the test results and after consideration of the other items of concern the EBU has consolidated their position on the occasion of their Technical Committee meeting in Sevilla, April 1983 and formulated a CCIR contribution. Therein the general support is confirmed the EBU gives to the efforts on achieving a worldwide production standard. It is however stated there is not sufficient technical evidence at present to advocate for a standard based on 60 Hz. The major issue is still field rate conversion where further investigations have to prove whether and how a tighter approach to the CCIR-agreed criterion is possible. (It is explicitely said - and I feel myself obliged to underline it - that this result should in no way devaluate the outstanding success achieved by the NHK development.) Besides the conversion issue there are, as I explained before, some other items of concern supplemented by certain economic and operational factors which collectively seen may become decisive as well.

The EBU course of action is to continue the initiated work towards an internationally agreed HDTV production standard and to investigate in this context the feasibility of a 60 Hz field rate. Although not in a position to contribute a firm proposal now the EBU will carefully observe the activities put forward by other parties and ensure their conformity with the earlier EBU submissions.

In the unfortunate case the result of the intended studies will show up the use of a HDTV-Standard based on a 60 Hz field rate within the European 50 Hz environment unsuitable, as a fall-back position the EBU will pursue to apply the principle of CCIR Recommendation 601 to the HDTV domain, i.e. coexistence of a 50 and a 60 Hz standard related to each other in terms of equal sample rates. The EBU does not continue to endeavour for an 80 Hz proposal at present since it is unlikely the advantages of a higher field rate will outweigh the constraints it may cause. There is no evidence a successful discussion of it could be initiated in the international field now.

The present situation and the deadline given by the CCIR meeting schedule promises a busy summer for all parties involved. In order to resolve the matter of possible economic and operational implications an Action Committee was formed in liaison with ATSC and NHK. This Committee will report straight to the Technical Bureau of the EBU before September 85 - the latest date an EBU position could be forwarded to CCIR Study Group 11 in this study period. In parallel as outlined earlier in this paper the relevant groups in the EBU are charged to clear up the field of motion portrayal-assessment and to propose a suitable criterion for the level where remaining conversion artifacts could be accepted. The NHK was asked to intensify any investigation of improving the conversion quality beyond that already achieved. If they succeed in a substantially improved result new tests should be carried out before mid-August. An overall appraisal was stimulated what conversion quality could be asymptotically expected taking into account the technologigal progress in the on-coming years.

I might assume, that this very concise survey has made obvious the considerable and costly efforts performed by a great number of organisations and individuals aiming at composing a HDTV-Standard applicable worldwide without in the course of time leaving the feeling of having better abstained from it.

The topic of this paper was the situation in Europe and up to now I only have dealt with the EBU. As a matter of fact the EBU is considered often by non-broadcast parties in Europe as a reliable spokesman or a high-handed dictator depending on their respective opinion. Evidently the EBU is devoted to the broadcasters needs. Consequently the output from the EBU does emphasize on items of concern in broadcasting. In the general HDTV discussion outside the broadcast domain I frequently found no understanding for including at all in the deliberations the 60 fields/s issue and this is still happening today. If one analyzes the background one must concede that the main interest in a common HDTV-standard and in particular in a single field rate is derived from the necessity of program exchange, a matter of priority exclusively for broadcasters. This matter is the more important as here as well applies the request for conversion at the HDTV-level if differing HDTV-field rates were used worldwide and this is - as already said - a rather insolveable problem. Where program exchange does not count, the 60 field issue appeares in the 50 Hz environment merely as an incentive for implications. This final remark should help to understand the diverging opinions one might discover today in Europe.

This report ends without a conclusion which was deliberately omitted. The paper represents merely a snapshot of a situation in evolution. It should outline the enormous work that was done and has to be done. It should demonstrate the differing opinions and the in each case understandable reasons for them. It should encourage all those involved to proceed onwards in reaching the intended goal.

HDTV STANDARDIZATION ACTIVITIES IN THE UNITED STATES

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ABSTRACT

Since there is wide spread agreement in the U.S. for the need for a single world wide HDTV production standard, the Advanced Television Systems Committee (ATSC) was formed in May, 1983, to study high definition, enhanced, and improved television systems. This work towards a high definition television production standard has been conducted by the ATSC. The ATSC has been coordinating its efforts with those of the EBU and other broadcasting unions throughout the world in order that a worldwide HDTV production standard may be achieved.

The ATSC recently adopted recommendations for a high definition production standard. These recommendations have been submitted to the U.S. State Department in preparation for the final meetings of CCIR Study Group 11 to be held in Geneva in October, 1985.

The recommendations of the ATSC will be reported and their implications on a worlwide HDTV standard will be considered. The need for such a standard in the mass communications environment of the 21st Century will also be discussed.

ACTIVITÉS DE NORMALISATION DE LA TVHD AUX ÉTATS-UNIS

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RÉSUMÉ

Etant donné qu'on s'entend généralement aux États-Unis sur la nécessité d'établir une seule norme mondiale de production TVHD, le Advanced Television Systems Committee (ATSC) Comité d'étude des systèmes de télévision avancés) a été créé en mai 1983 pour étudier les systèmes de télévision à haute définition, améliorés et avancés. L'ATSC a dirigé les travaux susmentionnés visant la formation d'une norme de production de télévision à haute définition. Il a coordonné ses efforts avec ceux de l'Union européenne des radiodiffuseurs et d'autres unions de radiodiffusion du monde entier en vue d'en arriver à une norme mondiale de production TVHD.

Dernièrement, l'ATSC a présenté au ministère d'État des États-Unis des recommendations sur une norme de production de télévision à haute définition, en prévision des réunions finales de la Commission d'études du CCIR qui se tiendront à Genève en octobre 1985.

Dans sa commission, M. Flaherty décrit les recommendations de l'ATSC et leurs implications sur une norme TVHD mondiale. Il traite aussi de la nécessité d'adopter une telle norme dans le milieu des communications de masse du 21ième siècle.

HDTV STANDARIZATION ACTIVITIES IN THE UNITED STATES

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I am very pleased to have been invited to speak here today. The last lecture that I was honored to deliver in Canada was 11 years ago on the occasion of my receiving the David Sarnoff Gold Medal in 1974.

In retrospect, it seems that those days saw a "technological tranquility" which was perhaps a precursor to today's "technological churn".

In 1974 the color service had become routine. Two inch quadruplex video tape was still king, and E.N.G. was well off the launching pad in the United States with over 100 television stations and all three commercial networks rapidly extending their E.N.G. arsenals.

In the intervening years, one inch video tape was conceived and has virtually replaced two inch video tape; E.N.G. has swept the world; the digital domain spawned a whole new set of technical tools; and we saw the achievement of the world compatible digital video standard in CCIR Recommendation 601. Today electronic graphics and animation systems are bursting on the scene from every direction and a plethora of new small format video tape systems are competing for attention and acceptance.

The newness and importance of these post-1974 developments notwithstanding, it was actually four years before the appearance of these commonplace technologies, in 1970, that NHK began its modern day development of High Definition Television.

Yes, 15 years ago! Perhaps the longest gestation period for any television technology to date.

At that time NHK began extensive research and psychophysical testing as ground work for choosing a scanning format, an aspect ratio, and an entirely new electronic imaging system.

From 1970 through 1977 technical papers were published around the world discussing subjective evaluation of picture quality, the response of the human visual system to increased line scanning, the visual effects of interlace scanning, and the chromatic spatial frequency response of the human visual system. One 1973 paper by NHK described an 1125 line camera, while another reported on a high definition color CRT display.

Thus, there is nothing new about HDTV except our awareness of it. In fact, it was as far back as 1977 that the SMPTE Study Group on High Definition Television was formed, and began its work.

It was just one year later in 1978 that a paper entitled "A Study of High Definition TV System in the Future", was published by Dr. Fujio of NHK in the IEEE Transactions on Broadcasting.

In 1980 the SMPTE Journal published the report of the SMPTE Study Group on HDTV. It is perhaps ironic that in the same issue of the SMPTE Journal an article entitled "Worldwide Color Television Standards -- Similarities and Differences" was published. This article compared NTSC, PAL, and SECAM and the 13 variations of these systems recognized by the CCIR. Today's chaos was indeed documented with chilling accuracy.

Nevertheless, the SMPTE Study Group report was timely and valuable.

One premise of their study was:

> "The appropriate standard of comparison is the current and prospective optimum performance of the 35mm release print as projected on a wide screen."

This Study Group also concluded that:

> "The appropriate line rate for HDTV is approximately 1100 lines per frame," and "the frame rate should be 30 per second, interlaced two-to-one . . . "

The first North American demonstration of the NHK HDTV System was at the 1981 Winter SMPTE Conference in San Francisco. Two weeks later a demonstration was conducted in Washington D.C. for the FCC and other U.S. Government bodies.

Subsequently, a small mobile production unit was assembled to record a variety of programs. CBS Recorded an NFL football game and the 1982 Rose Parade. Glen Larson of Glen Larson Productions then used the unit "on location" with the "The Fall Guy", and Francis Ford Coppola produced two single camera cinematographic pieces in HDTV.

These sample productions along with several others, were shown in demonstrations throughout the United States during 1982.

Following the productions in the United States six European television organizations produced HDTV demonstrations for the Montreux International Television Symposium in May 1983. Swiss TV produced segments of the Montreux Jazz Festival, Austrian TV (ORF) produced the opera "The Magic Flute" in Salzberg, the French TV production organization, SFP, produced "A Tour of the Monuments of Paris", and Russian TV recorded the Kirov Ballet production of "The Sleeping Beauty" in Leningrad. The BBC recorded a variety show in HDTV, and Italian TV (RAI) produced a single camera cinema style vignette in Venice -- photographed by the famous cinematographer Vittorio Storraro.

During these original HDTV demonstrations the equipment available throughout the world was in short supply. However, by 1984, those who attended the NAB Convention saw the beginning of an explosive growth in HDTV production tools and the infrastructure to support them. Two styles of HDTV cameras were shown -- Ikegami's studio-style camera and Sony's Electronic Cinematography camera -- and a second generation video tape recorder. Three manufacturers showed CRT monitors measuring from 13 inches to 30 inches diagonally. Sony introduced a 120 inch projector and a switcher with wipes, dissolves, chroma-key and matte generator.

This year the 1985 NAB Convention witnessed a still more impressive array of HDTV equipment. A third manufacturer, Hitachi, introduced an HDTV camera. Hitachi also showed an experimental digital HDTV VTR. In addition to new, larger monitors, new tools were added to the HDTV infrastructure. Grass Valley demonstrated an experimental HDTV production switcher with full pattern generator based on the 300 series conventional switcher. Ultimatte introduced an HDTV matte keyer, and Rank Cintel demonstrated a prototype HDTV flying-spot telecine.

Even before the NAB Convention had opened, two other manufacturers had announced new HDTV equipment which was in development. Sony has built a prototype 200 inch flat screen projector. This new unit will require no special screen and will, in fact, display an HDTV image on a normal movie screen. Quantel announced that they are developing an HDTV paint box.

This mushroom cloud in the growth of the HDTV production infrastructure stands to underscore the need for a worldwide HDTV production standard before it is too late to achieve one.

Actually, work on the standard began in my reference year -- 1974. In that year, the CCIR recognized the need for a coordinated standards effort and Study Group 11 adopted Question 27/11 which stated:

> "The CCIR UNANIMOUSLY DECIDES that the following question should be studied: what standards should be recommended for high-definition television systems intended for broadcasting to the general public?"

While research continued and technical contributions were addressed to that study question, it was nine years later, in March 1983, at the Fourth Conference of the World Broadcasting Unions that the need for a worldwide HDTV standard was reiterated. In the final report of that meeting the World's Broadcasting Unions unanimously adopted the following resolution:

> "Considering:
>
> "That high definition television systems will require a resolution which is approximately equivalent to that of 35mm film and corresponds to at least twice the horizontal and twice the vertical resolution of present television systems;
>
> "That the advantages of a single HDTV worldwide standard include lower equipment costs for broadcasters and viewers, easier exchange of programs and technical information, and encouragement to the ideal of international solutions to common technical problems;
>
> "That multiple different standards will cause difficulties among broadcasters in the future;

"The Conference recommends:

> "That the Broadcasting Unions should encourage their members to carry out studies on the preferred characteristics of a uniform world standard for a high definition television system;
>
> "That the Broadcasting Unions should concentrate these studies at first on a single HDTV production standard . . ."

The nine organizations adopting this resolution were:

ABU	ASIA-PACIFIC BROADCASTING UNION
AIR	ASOCIACION INTERAMERICANA DE RADIODIFUSION
ASBU	ARAB STATES BROADCASTING UNION
CBU	CARRIBEAN BROADCASTING UNION
EBU	EUROPEAN BROADCASTING UNION
NANBA	NORTH AMERICAN NATIONAL BROADCASTERS ASSOCIATION
OIRT	INTERNATIONAL RADIO AND TELEVISION ORGANIZATION
OTI	ORGANIZACION DE LA TELEVISION IBEROAMERICANA
URTNA	UNION OF NATIONAL RADIO AND TELEVISION ORGANIZATIONS OF AFRICA

NANBA represents the CBC and CTV in Canada, and ABC, CBS, The Corporation for Public Broadcasting, NBC, National Public Radio, and PBS in the United States. All unanimously agreed on this goal!

Thus the conference gave the World's Broadcasting Unions a clear indication of their responsibility: To determine the parameters of a uniform world standard for a High Definition Television System. The conference further agreed that these efforts should be directed toward an HDTV production standard; recognizing that a production standard is the first step toward achieving a world communications system which will allow the nations of the world to communicate among themselves.

In the United States, it was recognized that this standard was so fundamental as to affect the entire industry from the producer in the studio, through the broadcaster, cable operator, VCR manufacturer, to the professional exhibitor and the home consumer.

Thus, in May 1983, the Joint Committee on Inter-Society Coordination (JCIC), made up of:

EIA	ELECTRONIC INDUSTRIES ASSOCIATION
IEEE	INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS
NAB	NATIONAL ASSOCIATION OF BROADCASTERS
NCTA	NATIONAL CABLE TELEVISION ASSOCIATION
SMPTE	SOCIETY OF MOTION PICTURE & TELEVISION ENGINEERS

formed the United States Advanced Television Systems Committee, or ATSC, under the able chairmanship of Mr. William Henry, an attorney and former chairman of the FCC.

The ATSC charter states:

> "Purpose. The purpose of the Committee is to explore the need for and, where appropriate, to coordinate development of voluntary national technical standards for Advanced Television Systems. For purposes of the Committee's work, Advanced Television Systems shall include systems for the generation, distribution and reception of improved NTSC, enhanced 525-line and high definition television."

The ATSC is also charged with responsibility for international coordination of standards activities. The charter states:

> "The Committee shall also develop a national position for presentation by the Secretariat to the Department of State for purposes of developing a United States position within the Consultative Committee of International Radio (CCIR) and with other international organizations as appropriate."

This organization represents the full scope of United States interests in High Definition Television. It is currently composed of 51 full member companies and 19 observers.

Later that same year, in September 1983, CCIR Study Group 11 established Interim Working Party 11/6. This IWP was given the following instructions:

> "Considering:
>
> > "That High Definition Television (HDTV) is a subject of intense current interest and activity in the world;
> >
> > "That it would be clearly beneficial to broadcasters and to the public alike, if the CCIR could recommend the adoption of a single, worldwide standard for high definition television;
> >
> > "That prompt action in this respect is required, to avoid the establishment of one or several de-facto standards;
>
> "Decides:
>
> > "That an Interim Working Party (11/6) should be set up . . .
> >
> > "to prepare within the present study period, a draft recommendation for a single worldwide high definition television standard for the studio and for international program exchange, to be submitted to Study Group 11."

It is significant that the statements from both the Fourth World Conference of Broadcasting Unions and CCIR Study Group 11 recognized the benefits to be gained from a single worldwide standard for HDTV. Both bodies agreed that benefits are to be realized by broadcasters and viewers alike. Equally, both bodies agreed that the establishment of multiple different standards should be avoided.

These agreements should not be taken lightly. They represent a consensus among broadcasters from every part of the world.

Nor should it be considered that we can delay this standard beyond the current CCIR study period. To do this is to invite the precise situation which the Fourth World Conference of Broadcasting Unions and the CCIR sought to avoid -- the establishment of multiple different standards.

As this standard developed the ATSC came ever closer to agreement with the EBU and in June 1984 the EBU produced a statement recognizing this. I would like to read that to you today.

> "In 1983 the world's nine Broadcasting Unions were signatories to a recommendation to work toward worldwide standards for high definition television (HDTV). This, in itself, did not imply that high definition television services will be broadcast in the near future in all parts of the world, but was rather a recognition of the need to coordinate studies from the early stages. Events in the past have shown that this is the only way to ensure that all interests are taken into account, and to ensure worldwide agreement.
>
> "The EBU has undertaken studies in support of the 1983 Inter-Union Recommendation on HDTV, and with a timescale following the declared wishes of CCIR Study Group 11 -- the appropriate standards body of the International Telecommunications Union (ITU). Equally, the Advanced Television Systems Committee (ATSC) in the United States is studying the subject. CCIR Study Group 11 has asked that a first objective should be a standard for high definition television studio production.
>
> "At recent technical discussions between the EBU and the ATSC (Vienna, June 1984), it became clear that the results of their respective studies and experiments have led to common technical conclusions about the appropriate parameters for a high definition television production standard. The common conclusions relate to specific parameter values in certain cases, and in other cases to the range of values within which the most appropriate value should be chosen, after experimental results have been obtained.

> "The fact that the two studies have yielded common conclusions gives confidence in the technical arguments involved, and can be seen as a source for considerable optimism that a worldwide HDTV production standard can indeed be achieved, in the timescale envisaged by the CCIR.
>
> "The timescale envisaged by the CCIR, which the ATSC and EBU are endeavouring to work towards, is for the HDTV television production standard to be agreed at the final meetings of CCIR Study Group 11 in October 1985."

Let me point out that the CCIR Study Group 11 resolutions were agreed upon in 1983. By June of 1984, almost a year ago, the EBU had confirmed that the standard could very likely be achieved.

In January of this year, CCIR Interim Working Party 11/6 met in Tokyo. At that time a provisional draft recommendation was adopted. The key parameters, scanning rate, scanning format, aspect ratio and temporal rate, are:

Number of Scanning Lines:	1125
Field Rate (Hz):	60
Aspect Ratio:	5:3
Interlace System:	2:1

Two months later, on March 19 of this year, the ATSC High Definition Technology Group adopted a recommended HDTV Studio Standard. The parameters of that recommendation are:

Number of Scanning Lines:	1125
Field Rate (Hz):	60
Aspect Ratio:	5.33:3
Interlace System:	2:1

This is essentially the same as the provisional draft recommendation adopted by IWP 11/6. Only the aspect ratio differs.

On April 3 of this year, the ATSC Executive Committee unanimously approved the recommendation of the High Definition Technology Group. This recommendation was submitted to the U.S. State Department in preparation for the Final Meetings of CCIR Study Group 11 to be held in Geneva this October. Recently, the State Department submitted that document to CCIR Study Group 11 as the official U.S. position.

Two weeks after the meeting of the ATSC Executive Committee, at the meeting of the EBU Technical Committee in Seville, Spain, the EBU concluded that it would:

> "Continue to work with specialists from CCIR Regions 2 and 3 towards the establishment of a CCIR Recommendation for a worldwide standard based on 60 Hz."

This standard cannot yet be recommended, but intensive work is underway.

As the EBU has stated:

> "The major problem remains, fundamentally, standards conversion, which . . . cannot yet be considered to provide unimpaired movement portrayal . . ."

This is the issue upon which hangs the standard's future! Little else is of consequence, and time is of the essence. The CCIR four year study cycle concludes this October, scarcely five months from today.

And if we miss this cycle -- ?

Many who have labored for years in the CCIR vineyard believe that it is "now or never". Mr. Dick Kirby, the Director of the CCIR, has said that, in his professional judgement, if the HDTV production standard is not achieved in this study cycle at least three de-facto standards will emerge -- never again to be reconciled!

Some believe it is still too soon to take this standard -- the high quality results and 15 years of work notwithstanding. Yet if it is too soon -- consider the alternative. The alternative is "Too Late"! "British Teletext, French Teletext, and North American Teletext" is too late. "Beta and VHS" is too late. "Betacam and M format" is too late. "Quarter-Cam and Quarter Recorder" is too late. "B-format and C-format video tape" is too late. Too late means we do not set standards, we document the chaos! Unhappily, in this latter endeavor we are amassing an impressive record.

This world has failed twice to set a single television standard. It failed after the second world war in monochrome. It failed again, for less valid reasons, in 1965.

In the beginning the alibi was "there is no video tape" -- the only program exchange was on film. Later the excuse was "there is no high band tape and there are no communications satellites".

Today we have no such handy excuses. There are at least 350 transponders distributing television signals worldwide and three competitors trying to put more satellite links across the oceans. Moreover, video tape is at its highest state of development.

Whatever you believe of Marshall McLuhan's "Global Village" or Naisbitt's "World Economy" and the on-rush of the "information society", this much you must understand: Mass communications is the vanguard of these changes, and broadcasting is the vanguard of mass communications.

If we engineers fail to lay the technological foundations for a single worldwide television standard and doom this world to enter the 21st Century with today's technological Tower of Babel, we deserve the condemnation which will most certainly fall upon our heads.

As we ponder these problems over the next few days, we might also reflect on the 16th Century words of Sir Francis Bacon who said:

> "He that will not apply new remedies must expect new evils; for time is the greatest innovator."

LIMITES DES MÉTHODES PSYCHOPHYSIQUES ACTUELLES D'ÉVALUATION DE L'IMAGE

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RÉSUMÉ

Au cours du développement de systèmes de communication améliorés tels la télévision à haute définition (TVHD), il est d'usage d'employer une forme quelconque d'évaluation psychophysique qui guidera les décisions relatives à la conception. Les méthodes d'évaluation employées varient bien entendu d'une étude à l'autre. Dans certains cas, par exemple, des mesures de la perception humaine du contraste servent à orienter les décisions touchant la meilleure résolution. Dans d'autres cas, des mesures de la satisfaction du spectateur sont utilisées pour établir le rapport de largeur à hauteur d'image optimal.

Bien que ces analyses psychophysiques varient en genre, en complexité et en schèmes perceptuels, toutes consistent en un test précis comportant des combinaisons particulières de mesures, de spectateurs, de stimulations et de conditions. Par conséquent, la signification et la portée des résultats sont forcément restreintes. Malheureusement, ceux qui lisent ces rapports ne saisissent pas toujours ces limites.

Le présent document examine plusieurs sujets de recherche en conception de la télévision à haute définition et il résume les constatations des études produites à leur propos. Dans cette optique, il relève les points forts et les limites des diverses mesures et méthodes psychophysiques et montre le genre de conclusions qu'elles sont susceptibles de fournir.

Il brosse également les grandes lignes d'une nouvelle approche théorique et en examine l'utilité pour comprendre les schèmes humains de perception et de jugement. Cette approche diffère des autres en ce qu'elle accorde un sens particulier aux questions soulevées dans la discussion des mesures et des méthodes psychophysiques. En conclusion, l'article aborde certaines applications de cette approche dans la recherche sur l'évaluation de l'image.

LIMITATIONS OF CURRENT PSYCHOPHYSICAL APPROACHES TO DISPLAY EVALUATION

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ABSTRACT

In developing improved communications systems, such as high-definition television, it is common practice to use some form of psychophysical assessment to guide design decisions. The assessment procedures used, of course, vary from study to study. In some cases, for example, measures of human sensitivity to contrast are used to guide decisions about optimum resolution. In other cases, measures of viewer satisfaction are used to guide decisions about optimum aspect ratio.

Although these psychophysical studies vary in type, complexity, and visible formality, each is a specific test involving particular combinations of measure, viewer, stimulation, and circumstance. Consequently, the meaning and generality of study outcomes are implicitly limited. Unfortunately, these limitations are not always clear to those reading the study reports.

The present paper examines several research issues in high-definition television design and summarizes the results of existing studies that relate to these issues. In this context, it explores the strengths and limitations of various psychophysical measures and methods and demonstrates the kinds of conclusions they can support.

The paper then outlines a new theoretical approach and explores its implications for understanding human perceptual and judgemental processes. This approach differs from others in that it is particularly sensitive to the issues raised in the discussion of psychophysical measures and methods. In closing, the paper develops some of the implications of the approach for research in display evaluation.

INTRODUCTION

The design standard for current television reflects compromises made to accommodate the limitations of electronics technology decades ago. The all too evident consequences of these compromises have resulted in dissatisfaction with the quality of current television systems and in a growing determination to replace the current standard with one more conducive to satisfactory viewing (e.g., Fujio, 1982).

Efforts to develop improved television systems have been influenced by specific symptoms of the inadequacy of current systems. Although the symptoms most commonly addressed are inadequate spatial and temporal resolution, current constraints on screen sizes and unattractive screen aspect ratios are also being considered.

The determination to alleviate these symptoms is not, however, without reservation. Proposed technological enhancements (e.g., enhanced spatial resolution) are costly. Moreover, the cost of an enhancement increases dramatically with its extent. For this reason, those working to improve television design are concerned with establishing the possible impacts of proposed enhancements.

To accomplish this, researchers have turned to psychophysics, a field of perceptual enquiry concerned with establishing the perceptual impacts of variations in the magnitude of external stimulation. The logic here is straightforward--technological enhancements that have no perceptible impact are not worth implementing.

The goal in enhancing television technology, however, should be to improve the overall quality of television viewing, not to introduce perceptible changes in particular dimensions that characterize television displays. Subject to certain limitations, psychophysical studies estimate the perceptibility of changes in particular display dimensions; they do not reveal the importance of these dimensions in television viewing. It is only through knowledge of the importance of a dimension for television viewing, however, that changes shown to be perceptible can be used to estimate the viewing value that would be added by by a proposed refinement.

An intuitively appealing alternate approach to solving the value-added estimation problem would be to vary television parameters and to ask viewers for their opinions of the resulting displays. At first glance, this would appear to finesse the problem of determining the importance of particular dimensions for viewing. Unfortunately, this procedure is problematic due to the complex and treacherous nature of the perceptual judgement process.

The present paper will attempt to cover the issues raised thus far. First, it will show how psychophysical data can be used to estimate the perceptual impacts of changes in particular display dimensions. Second, it will deal briefly with the limits to the applicability of such data. Third, it will present a new theoretical approach for understanding perceptual processing in complex tasks such as television viewing and, thus, for determining the importance of particular display dimensions to task performance. And, finally, it will apply this approach to viewer judgement and demonstrate how viewer judgements can be used meaningfully in determining the viewing value added by particular changes.

PSYCHOPHYSICAL RESEARCH AND TELEVISION

Given a display dimension that contributes to viewing value, there are two ways that psychophysical data can be used to select a design target on that dimension. One approach is to determine the absolute limit of sensitivity to that dimension and to use this as a design target. Obviously, refinements beyond this limit would be pointless as their consequences could not be detected by viewers. Alternately, if the limit cannot be matched technologically, relative sensitivity to the dimension can be determined and the point at which sensitivity diminishes below some criterion can be selected as a target. The logic here is that progress towards the ultimate limit would be achieved.

In this section of the paper, two television design questions, spatial and temporal resolution, will be presented. Each will be addressed using both approaches to apply relevant psychophysical data. The purpose of the presentation is to illustrate the use of psychophysical research to determine design targets and to demonstrate some of the techniques involved in the research.

Spatial Resolution

The question for television design concerns the spatial resolution to use in television recordings, broadcasts, and displays. In design terms, the question for study concerns the perceptibility of changes in horizontal and vertical spatial resolution. In practice, however, it is usually assumed that the two resolutions will be equivalent and, thus, the question is usually expressed in terms of visible scan lines (vertical resolution).

Sensitivity Limit

The question here concerns the display resolution beyond which viewers would be unable to perceive further "improvements". To access the relevant psychophysical data, however, it is first necessary to refine the question. Thus, one might consider the size of the smallest detail that can be detected by the visual system. In addition, one might consider the size of the smallest separation between details that can be resolved by the visual system.

In studies of detection acuity, viewers are asked to detect the presence of a single target as its projected (angular) size on the retina is varied. In a typical study, a dark line is presented on a bright background and its projected thickness is varied until the minimum thickness at which the target is reliably detected can be estimated. The results of such studies have shown that projected thicknesses as small as 0.5 seconds of arc (e.g., 0.005 mm at 2 metres) can be detected (e.g., Hecht & Mintz, 1939).

In studies of separation acuity, viewers are asked to detect separations among targets as the projected sizes of targets and separations are varied. In a typical study, two parallel dark lines are presented on a bright background and the projected sizes of the targets and their separation are varied until the minimum separation that is reliably detected can be estimated. The results of such studies have shown that projected separations as small as 30 seconds of arc (e.g., 0.291 mm at 2 metres) can be detected (e.g., Craik, 1939).

If a television display were designed with these limits in mind, one might take the detection acuity limit as the maximum dark interval between adjacent scan lines. This would tend to eliminate the possibility that viewers would perceive the line structure of the display. In addition, one might take the separation acuity limit as the maximum interval between the closer edges of a scan line and its next-but-one neighbour (this interval would, of course, include one scan line and two scan-line intervals). This would tend to preserve the opportunity for viewers to perceive the finest separations among objects and details that they are capable of seeing. The approach is illustrated in Figure 1.

Taking the detection acuity limit, θ_D, as the maximum angular size of the intervals between scan lines and the separation acuity limit, θ_S, as the maximum angular size of one scan line and two scan-line intervals, the minimum number of lines, N_L, for a display of height, H, viewed at distance, D, would be:

$$N_L = \frac{\dfrac{H}{2D} + \tan\dfrac{\theta_D}{2}}{\tan\dfrac{\theta_S - 2\theta_D}{2} + \tan\dfrac{\theta_D}{2}}$$

Thus, for a screen 0.5 metres high viewed at a distance of 2 metres (four times the picture height), the minimum number of visible scan lines would be about 1748.

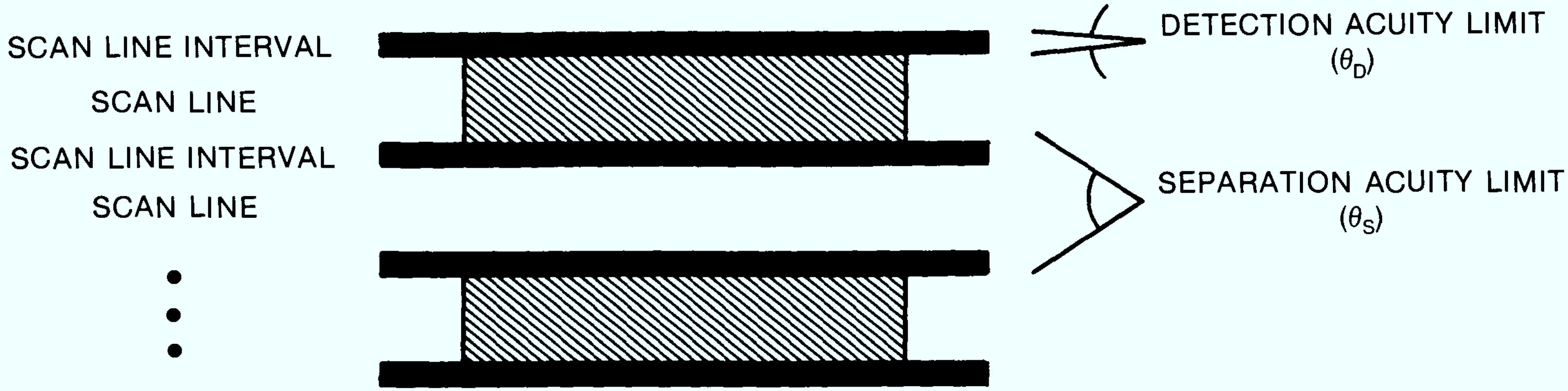
This estimate may seem extreme as it was derived from acuities assessed in optimal conditions. Indeed, it considerably exceeds those commonly suggested [for similar circumstances, Fujio (1982) suggests 940 and Mitsuhashi (1982) suggests 975 or 1125]. More will be said later of the validity of estimates.

Relative Sensitivity

If it is not feasible to match the spatial resolution of the television system to the upper limit of human spatial acuity, the relative sensitivity approach can be followed. Here, there is an attempt to capitalize upon any diminishing sensitivity revealed as the human visual system approaches its upper spatial limit.

In a typical study, relative spatial acuity is assessed in terms of the minimum light-to-dark contrasts necessary for viewers to resolve sinusoidally modulated luminance patterns of various spatial modulation frequencies (e.g., Schade, 1956). Studies of this sort have shown that the human visual system is most sensitive to spatial frequencies between 1 and 10 cycles per degree of retinal projection and is much less sensitive to spatial frequencies appreciably outside this interval (e.g., Campbell & Green, 1965). Two idealized relative spatial sensitivity functions are shown in Figure 2.

As the idealized functions suggest, the perceptual system is relatively insensitive to high spatial frequencies. In fact, sensitivity is extremely low for spatial frequencies above 40 cycles per degree of retinal projection. Thus, if a screen 0.5 metres high were viewed at 2 metres (visual projection = 14.2 degrees), viewers are unlikely to detect increases in the number of visible scan lines beyond about 1136 (assuming a sampling rate of two scan lines per cycle).



$$N_L = \frac{\frac{H}{2D} + \tan\frac{\theta_D}{2}}{\tan\frac{\theta_S - 2\,\theta_D}{2} + \tan\frac{\theta_D}{2}}$$

WHERE: N_L is minimum scan lines

H is screen height (metres)

D is viewing distance (metres)

θ_D is detection acuity (degrees)

θ_S is separation acuity (degrees)

FIGURE 1. The use of spatial acuity limits in determining scanning requirements.

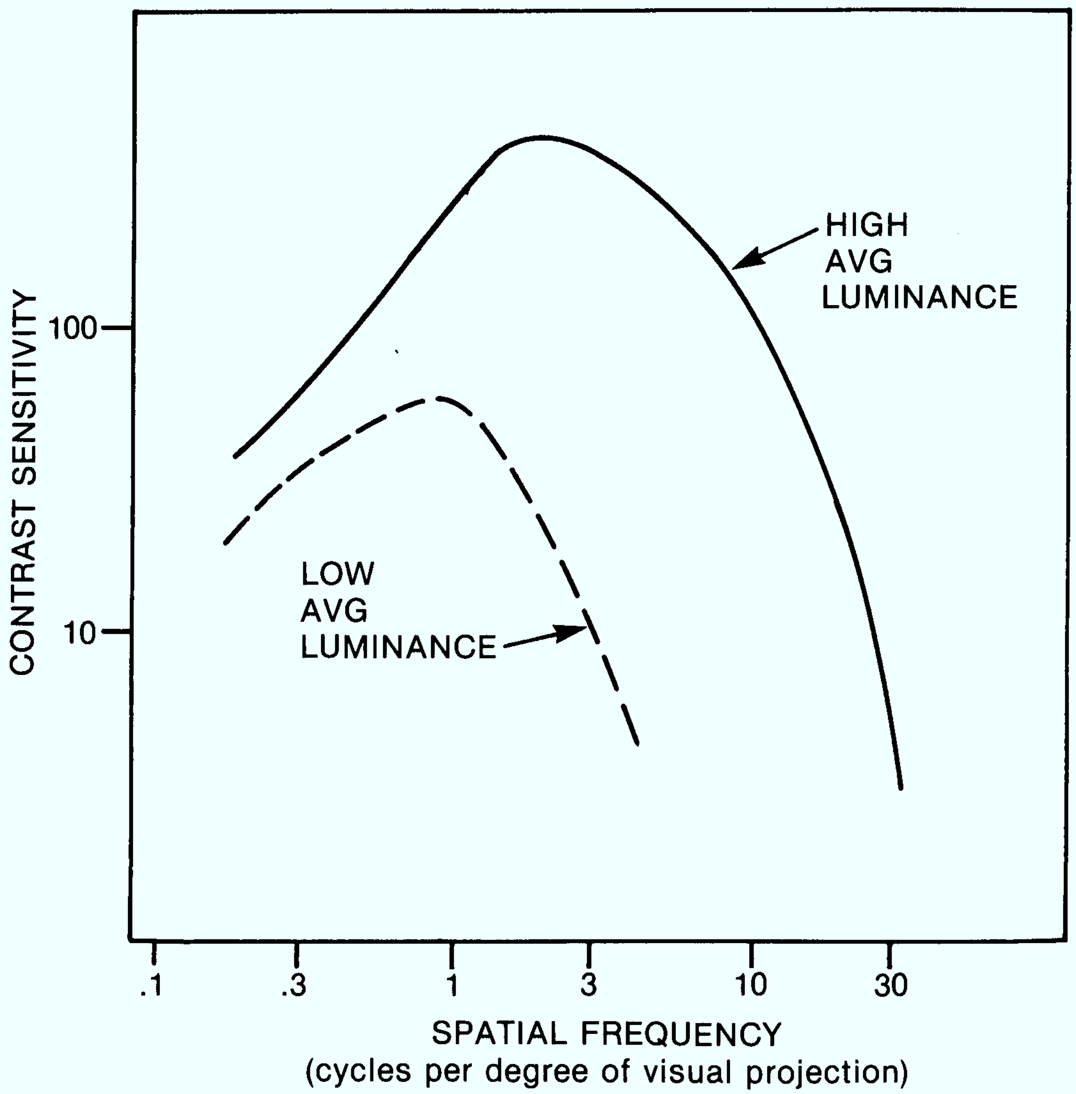


FIGURE 2. Contrast sensitivity (arbitrary units) as a function of spatial frequency for two average luminance levels.

Such experiments, however, do not give a precise estimate of perceptual reactions to changes in screen resolution. The simplest study to address the issue directly would adjust the sizes of increments in display resolution (i.e., scan lines) and gather viewer judgements as to whether changes in resolution (or sharpness) were perceived. If both base resolutions and resolution increments were varied appropriately, increments in display resolution could be related to increments in perceived resolution. This is the classical Method of Constant Stimuli and has been used by psychophysicists to determine difference thresholds (e.g., Fechner, 1860; Weber, 1834).

Carlson and Cohen (1980) have reported a study of this sort. They assessed the minimum increase in 50% modulated spatial frequency necessary for a perceived increment (or just noticeable difference) in image structure. Their data indicate that, as the base pattern frequency (in cycles per degree of visual projection) increases, the size of the increment required increases dramatically. For a screen 0.5 mm high viewed at 2 metres (visual projection = 14.2 degrees) and with a minimum sampling rate of 2 lines per cycle, their data suggest the following very rough bases and perceptible increments: 284 lines (jnd = 15 lines), 568 lines (jnd = 43 lines), 994 lines (jnd = 175 lines), and 1420 lines (jnd = 2130 lines).

The relative sensitivities approach suggests a lower requirement in display resolution than the sensitivity limit approach. The results of relative acuity studies suggest that display resolutions of about 1100 lines may be adequate.

Temporal Resolution

Another question in television design concerns the display frame/field rate to adopt. One of the concerns here is to remove the possibility that artifactual luminance flicker will be seen when scenes that change abruptly in luminance are presented in discrete temporal samples. As in the case of spatial acuity, the question will be addressed using both the sensitivity limit and the relative sensitivity approaches.

Sensitivity Limit

The question here concerns the frame/field rate beyond which viewers would be unable to perceive further "enhancements". As with the spatial question, however, this question must be refined further to access relevant perceptual data. Thus, one might consider the temporal display rate beyond which luminance flicker would be imperceptible.

In studies of flicker sensitivity, viewers indicate whether an objectively intermittent light source is perceived as intermittent or continuous. In a typical study, the light source is modulated in a sinusoidal or rectangular fashion and the modulation frequency is varied until the the minimum frequency at which fusion (the appearance of continuity) occurs reliably can be estimated [see Christman (1971) for a fuller description]. The results of such studies have shown that, with intensely modulated light sources, the fusion frequency can be 60 cycles per second or greater (e.g., Hecht, Shlaer, & Pirenne, 1942).

These findings would tend to suggest a display rate of 60 Hz or more. This would reduce the possibility that flicker would be induced as an artifact of the television system. However, the fusion frequency data also suggest that viewers may be capable of perceiving real changes in scene luminance at cyclical rates of 60 Hz. Thus, to preserve the opportunity for viewers to perceive real changes in scene luminance at the greatest rate of which they are capable, it would appear that the sampling rate should also be 60 Hz or greater. Thus, a 60 Hz display rate with progressive scanning may be needed.

Relative Sensitivity

If it is not feasible to match the upper limit of the temporal resolving power of the visual system, the relative sensitivity approach can be followed. Here again, there might be an opportunity to capitalize upon such diminishing sensitivity as the visual system may reveal when its limit is approached.

In a typical study, relative temporal sensitivity is assessed in terms of the minimum modulation amplitude required to induce the perception of flicker as a steady state light is subjected to modulation at various frequencies. The results of such studies have shown that the visual system is most sensitive to flicker at modulation frequencies between 5 and 20 Hz, less sensitive at lower frequencies, and pronouncedly less sensitive at high frequencies (e.g., DeLange, 1958). Two idealized relative temporal sensitivity functions are illustrated in Figure 3.

Thus, as with the spatial case, the relative sensitivity approach may yield a less demanding estimate of temporal requirements for television. For example, the low acuity of the visual system to high temporal frequencies may permit a lower sampling rate than the sensitivity limit data suggested. Perhaps, then, the 30 Hz sampling rate in current television systems is sufficient.

LIMITS TO THE APPLICABILITY OF PSYCHOPHYSICAL DATA

The results of psychophysical studies are often taken to reveal the functioning of immutable sensory operations. In part, this reflects a belief that there is a very close relation between perceptual data and the neurological substrates of perception. Unfortunately, this belief is not always justified.

Before study results are applied, it is prudent to recognize that there are always limits to the applicability of study results. In this section of the paper, three classes of factors that affect the applicability of psychophysical data will be discussed. These concern responses and measures, observer samples, and several situational factors.

Responses and Measures

Responses

In every psychophysical experiment, one or more responses are taken as indices of the real perceptual states of the observer. However, these responses vary in the extent to which they can be verified objectively. Some responses refer to externally observable states (e.g., detection decisions) and, thus can be scored unambiguously as either correct or incorrect. Other responses are presumed to reflect internal, nonobservable states (e.g., subjective magnitudes, subjective judgements) and, thus, there is always an element of uncertainty with regard to their precise meaning. When applying data from studies that involve such subjective responses, it is wise to temper any conclusions drawn in recognition of the uncertainty implicit to the response. More will be said later of the nature and meaning of subjective responses.

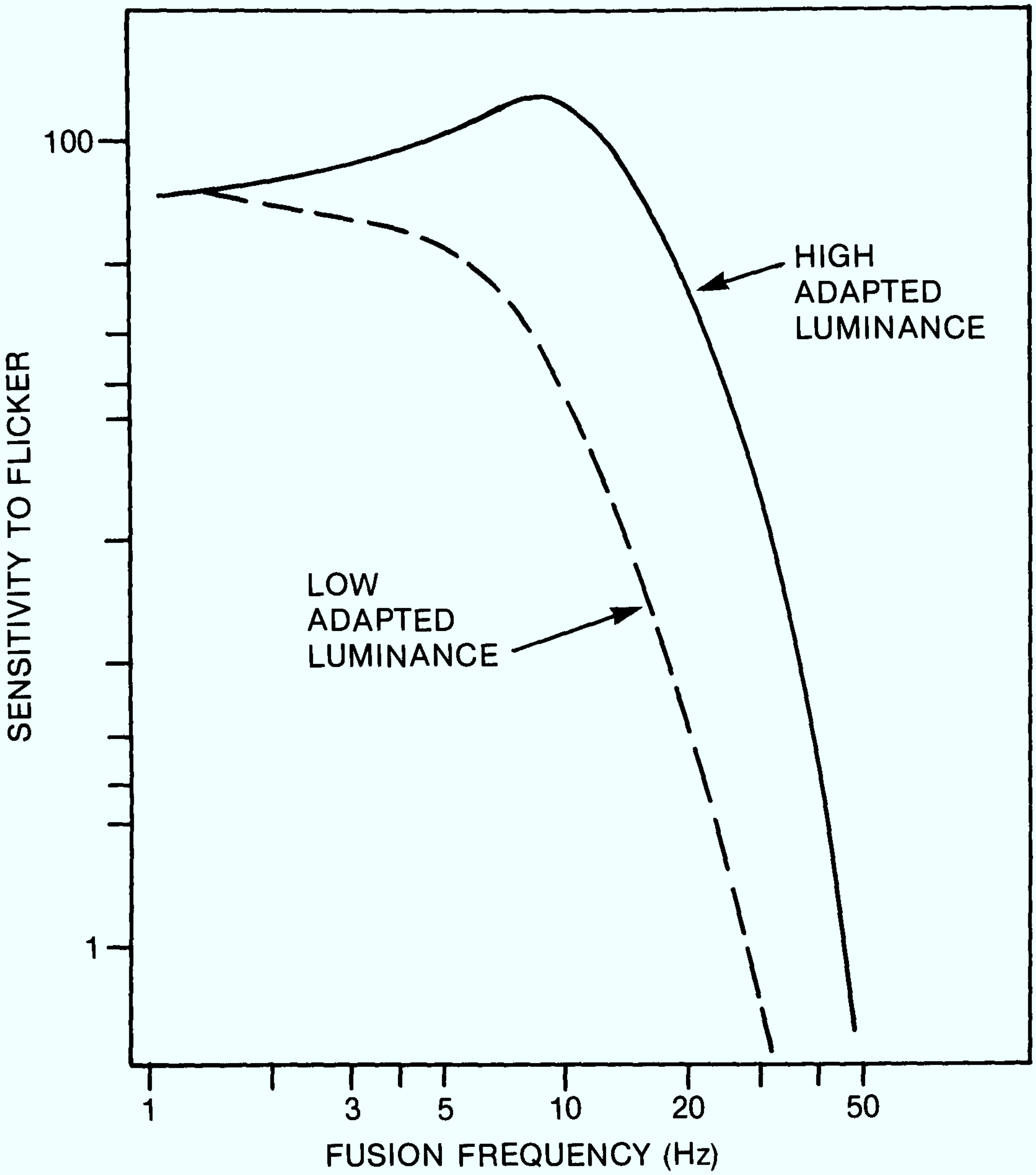


FIGURE 3. Flicker sensitivity (arbitrary units) as a function of luminance modulation frequency.

An additional point to remember about perceptual responses is that, to some extent, they are specific. That is, the observer is responding to a question posed explicitly or implicitly by the experimenter. Thus, the observer uses perceptual experience to respond to a particular question. There is no assurance that a similar response would be made, even to identical stimulation, if this question were not asked. For example, when asked to do so, a viewer might remark on the perceptibility of scanning structure in a display. When simply watching television, however, the viewer may fail to notice scanning structure. Thus, to apply such perceptual data, it is necessary to have some assurance that not only the viewing situation but also the situational requirements are similar.

Measures

Once the responses have been collected, one or more measures are taken. These are used to summarize and to analyze the effects of conditions. A great many measures have been used in perceptual studies. Some are counts of particular responses, some are the means of values given as responses (e.g., Stevens, 1974), and some are complex estimates of internal subjective values [see, for example, Allnatt (1979) and Thurstone (1927)]. In every case, however, the measurement explicitly assumes that certain classes of operations on the perceptual response are appropriate. Before the results of psychophysical studies are applied, it is wise to ensure that the assumptions made in measurement are acceptable.

With one class of subjective response, there is a particularly difficult measurement problem. Consider the categorical judgement task. There, observers are asked to express their current perceptual state or opinion by selecting one of a set of ordered judgement categories (e.g., very bad, bad, fair, good, and excellent).

Various methods have been used to treat such responses. Some count the number of times each response alternative was selected (e.g., Cavanaugh & Lessman, 1971) or the number of times responses at or above a criterion response were selected (e.g., Hearty & Treurniet, 1985). Others attempt to estimate the internal values upon which response selection was presumably based (e.g., Thurstone, 1927). In all cases, however, there is the residual uncertainty that arises from not knowing exactly how observers made their decisions.

There is one method of dealing with categorical responses that has a high potential for misleading those interested in application. Here, consecutive real numbers are applied to the *n* response alternatives and a mean opinion score is computed. In assigning the real numbers to the response alternatives and in performing multiplicative operations on these numbers, one assumes quantitative properties in a response that need have only ordered qualitative properties (see Kirk, 1978). Thus, although one might have assigned the numbers 1 to 5, the numbers 1, 56, 57, 65, and 1000 might have been more appropriate indices of the internal values upon which responses were based.

Observers

Perceptual studies are usually designed to compare conditions rather than to estimate population parameters or to establish the generality of effects at a population level. Thus, an attempt is made to preserve the *a priori* equivalence of conditions but little or no effort is devoted to selecting observers that, in some sense, represent the population at large.

The consequences of this tactic are acceptable for theoretical work but may be less acceptable when perceptual data are applied to the design of systems to be used at population or at near population levels (e.g., television). For example, the acuity studies described previously involved small samples of observers that likely were drawn from an undergraduate class. The perceptual acuities of these observers are unlikely to represent those of the overall population.

A sample can be considered to represent a targeted population if it is large enough to be stable statistically and if every member of the population had an equal opportunity of being selected. Representative samples are normally constructed by sampling randomly from the targeted population [see Tull & Albaum (1973) and Wood (1974) for descriptions of procedures commonly used].

Given a representative sample, however, one problem still remains. It is necessary to select an appropriate population criterion to use as a design goal. Of course, the estimated population mean could be used as the criterion but this would result in system parameters that relate only to the hypothetical centre of the targeted population. For example, if mean population acuity were used to determine television resolution, the system would meet or exceed the acuities of only half the population. A better approach would be to determine the extent to which members of the targeted population vary and to adopt as criterion a value that would be inappropriate for only a small proportion of the population [the anthropometric approach--see Hertzberg (1972)]. Note the logical similarity to the relative sensitivity approach discussed previously.

Situational Factors

Just as responses, measures, and observers affect the applicability of the data from psychophysical experiments, so also do aspects of the situations in which the data were collected. In this section, test conditions, test stimuli, and test tasks will be discussed.

Test Conditions

Psychophysical performance can vary widely as a function of test conditions. For example, spatial acuity is affected by luminance contrast between target and background and by overall target area luminance (Thomas, 1975) and flicker sensitivity is affected by the size, intensity, and degree of modulation of the test light (Christman, 1971). Thus, psychophysical results may not generalize to conditions appreciably different from those of the initial test. Successful application of results requires the knowledge that the conditions likely to exist in the targeted application are, in some sense, perceptually equivalent to those in the initial test.

Successful application is complicated by the fact that psychophysicists exert rigorous control over test conditions in order to eliminate ambiguity in the interpretation of study outcomes. Thus, the initial test conditions are not likely to be reproduced exactly in real settings. This problem is even more pronounced with studies of perceptual sensitivity. There, the extreme conditions used in the test are unlikely ever to be encountered in practice.

Test Stimuli

Psychophysicists exercise great care in the selection and creation of test stimuli. The intent is to eliminate possible contamination of perceptual activities by extraneous aspects of stimuli. Thus, the goal is often to create stimuli either that involve one perceptual dimension only or that vary in one perceptual dimension only (e.g., intensity). Success in such goals results in stimuli that are impoverished relative to those normally seen. Thus, it may be difficult to apply the data derived from such stimuli to the stimuli that will be seen in real settings.

Another consideration concerns possible contextual effects of the set of stimuli used in the experiment. The ways that observers describe and judge stimuli are affected by the range the stimulus set occupies in the perceptual dimensions involved (e.g., Helson, 1964) and by the way the stimuli are distributed over this range (e.g., Parducci, 1974). Thus, even if individual stimuli are similar to those to be seen in the applications setting, it may be difficult to apply the perceptual data.

Test Tasks

Psychophysical data reflect the performance of a particular task (e.g., detect lines) or of a particular set of tasks. As a result, the suggestions that study outcomes provide about the perceptual importance of particular stimulus dimensions must be considered specific to the task or tasks studied. Thus, it may be improper to apply knowledge gained during the performance of one task to situations that involve the performance of another.

The critical point here is that the demonstrated importance of a factor to the performance of one task says nothing about its importance when that task is not being performed and, thus, nothing about its importance to the performance of other tasks. More will be said of task effects in the next section of this paper.

A "NEW" APPROACH TO PERCEPTUAL THEORY

In enhancing television technology, the goal is to improve overall viewing quality and, thus, to add value to viewing. To this end, psychophysical data, subject to the limitations previously discussed, provide insight into the extent to which proposed changes in particular dimensions may be discriminated by the viewer. To determine the importance of a dimension and to estimate the viewing value that might be added by the discriminable change, however, it is necessary to have a thorough understanding of the processing involved in television viewing. Unfortunately, there is no perceptual theory that is currently capable of explaining the performance of a task as complicated as television viewing.

A first step towards such a theory is presented in the next section of this paper. The approach adopted is based upon three major theoretical assumptions. First, perceptual activities can be analyzed as sequences of operations that acquire, transform, and use information [the information processing approach, see Neisser (1967) and Haber & Hershenson (1973)]. Second, the perceptual system adapts its activities to meet the requirements of the particular task environment at hand. Here, the system is considered to be problem solving and, thus, is assumed to exhibit structural and functional similarities to other problem-solving systems (e.g., Newell & Simon, 1972). And, finally, the perceptual system performs any complex task by the combined performance of appropriately selected, more basic tasks. The latter is the basis of the system's adaptability; it permits the system to deal with complex and varied tasks by using a relatively small set of well learned, more basic tasks.

An Adaptive Perceptual Processing System

How would this adaptive perceptual system work? A conceptual overview of an adaptive perceptual processing system is presented schematically in Figure 4 (the schematic is a more detailed version of one presented by Hearty, 1983). In the diagram, the large rectangular enclosure refers to the perceptual system. Elements outside the enclosure are external events that can be observed (e.g., stimulus and response) or inferred with some confidence (e.g., perceptual task). Elements within the enclosure refer to perceptual operations (labelled arrows) or to the materials and products of processing (boxes).

Conceptually, the approach is straightforward. On receiving a perceptual task (at the beginning of time epoch 1), the system engages in a sequence of processing activities that culminate (during epoch 2) in the acquisition, interpretation, and use of data from a perceptual stimulus. Note that, logically as well as temporally, the task precedes the stimulus. Each of the proposed processes and components will now be described in the presumed order of their occurrence during perceptual processing.

First, the perceptual system acquires a perceptual task. This task may be assigned explicitly (e.g., the instructions in a perceptual experiment) or may be inferred by the system from situational context. Alternately, the task may be generated internally (e.g., from interest). The perceptual task may be "simple" (e.g., to identify an object) or it may be complex (e.g., to view a television program).

The task is then PARSEd. Here, the task is analyzed into smaller, familiar components or sub-tasks which, together, form an internal representation of the task. Possible sub-tasks include "identify object" and "locate object". The PARSE operation normally would render a task into a number of sub-tasks. In some cases, however, there might be relatively few lower order components (e.g., in the very basic tasks of perceptual studies). Note that there is an implicit assumption here that the PARSE operation "knows" how to partition tasks into appropriate sub-tasks.

The sub-tasks in the internal task representation are then used to SELECT perceptual processing procedures from an existing repertoire. These procedures are the fundamental operations of perceptual processing and involve activities such as contour detection and integration, form identification, and the like.

Once the relevant procedures have been SELECTed, they are ORGANIZEd into a working configuration. This working configuration is effectively the "program" by which all subsequent perceptual processing is accomplished. Once the working configuration has been formed, the perceptual system is in a state of readiness.

The working configuration is then ENACTed. Its constituent procedures govern the attack and processing of perceptual stimuli. Some procedures may poll sensory apparati for state changes attendant upon stimulus onset (note that the Theory of Signal Detectability is subsumed). Others may govern the way that the external stimulus is examined [e.g., by controlling eye movements (Yarbus,

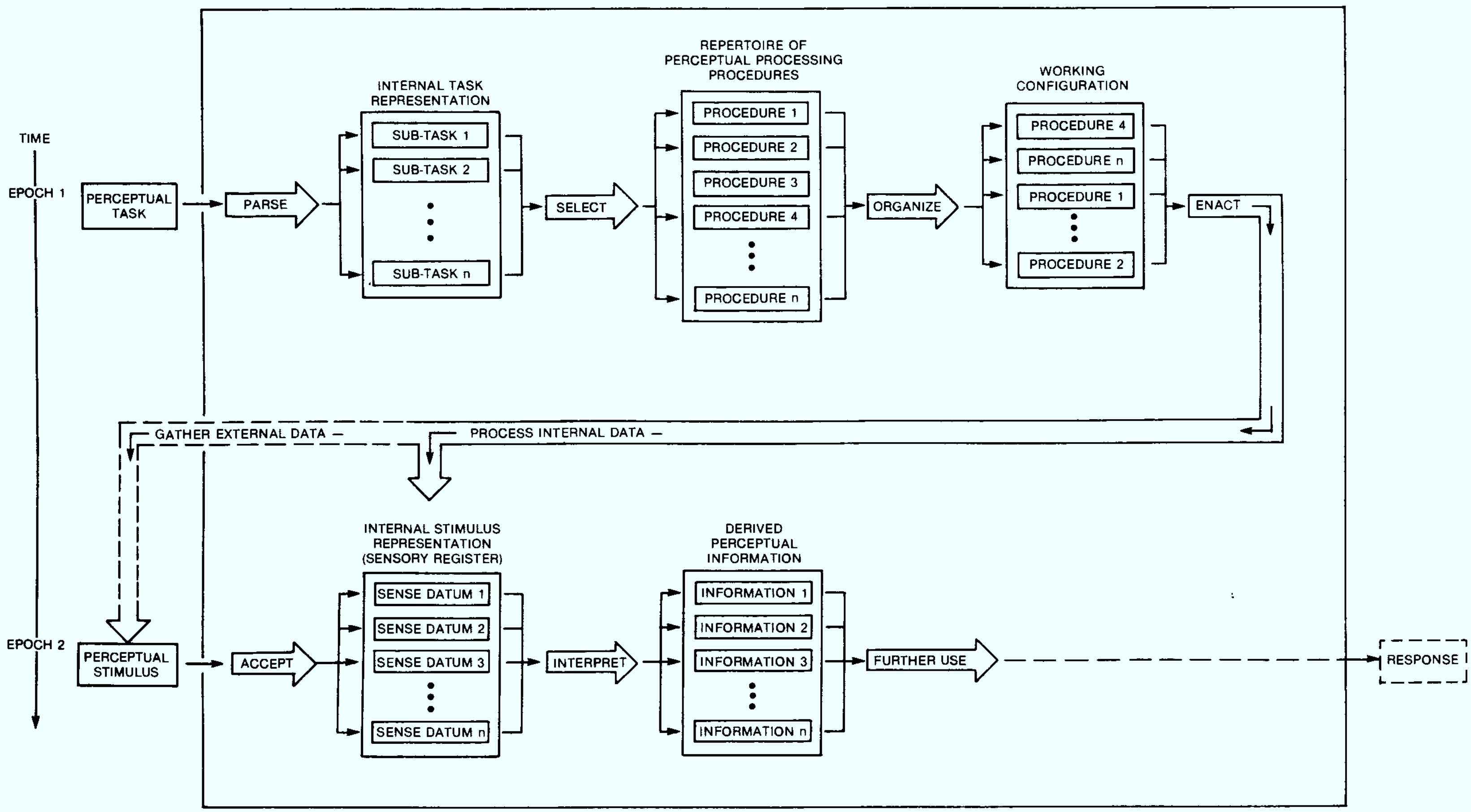


FIGURE 4. A schematic representation of an adaptive perceptual processing system.

1967)]. Note that part of attentional theory is subsumed by the latter type of operation.

In any case, the stimulus is ACCEPTed into the sensory register and an internal stimulus representation is formed. This can be considered to consist of a collection of relatively unanalyzed sense data. Some of the procedures from the working configuration are then used to collect (attention again) and to INTERPRET these sense data. Once the perceptual information has been derived, it is then subjected to FURTHER USE in accordance with the further requirements of the task. Sometimes, this culminates in an observable external response.

Implications for Perceptual Theory

The foregoing might seem an inordinately involved way of saying that the perceptual system can perform a wide variety of processing tasks. The proposed structure, however, does far more than that. Although it is not yet specified in detail (implementation is in its initial stages), the structure shows how the perceptual system could deal with a variety of complex tasks in a controlled and economical fashion.

The proposed structure offers the opportunity to integrate our knowledge of perceptual processing in the diverse tasks used in perceptual research. Certain explanatory models already, in some sense, have been subsumed and others, no doubt, will follow. In addition, the problem solving solving nature of the structure offers the prospect of convenient integration with similar models of cognitive activity.

Even at this point, the structure relates to important and topical issues in perception. Relevance to attention and signal detection has already been noted. Other issues include, but are not confined to: perceptual skill (better PARSing and more appropriate procedures), apparent automaticity (the formation of procedures), perceptual learning (development of the structure and of the procedures as well as acquisition of the knowledge needed to PARSE and to INTERPRET), and learning transfer (PARSing to permit use of old procedures in new circumstances).

Implications for Research Methodology

The proposed structure is sensitive to the factors previously presented as limiting the applicability of perceptual data. In the structure, a response is a behaviour whose form is specified by the task and whose value is determined by the interaction of the perceptual stimulus with the procedures ENACTed to meet the requirements of the task as PARSEd. Thus, a response need have no validity as an index of anything outside the restricted domain of the task performed.

The structure allows for variability among observers. In addition to differences in the sensitivity of sensory apparati, the structure permits variation in the PARSE operation (according to differences in task relevant knowledge), in the nature and number of available procedures, in the INTERPRET operation (knowledge differences again), and in the integrity and capacity of the overall system. Thus, the perceptual activities of one observer need not predict those of another.

Test conditions, stimuli, and tasks all contribute either explicitly or implicitly to the overall perceptual task. Thus, according to the structure, they will determine the ultimate form of the working configuration and, thus, the nature of the perceptual processing. Consequently, perceptual factors that are important in one situation need not be important in another; they need be important only in those situations with working configurations that subsume or are equivalent to that of the original test.

Implications for Television Design

At first glance, appropriate application of perceptual data to television design might appear an intractable problem. That is, if the perceptual system is different to some extent in every circumstance, how can perceptual knowledge be applied? The answer to the latter question lies in the analytic approach fundamental to the structure. If the processing involved in television viewing can be predicted from the knowledge of which sub-tasks are involved and of how these sub-tasks are combined and carried out, the structure (specified more fully) would be a vehicle for the principled application of perceptual data.

The problem is to determine the perceptual sub-tasks involved in television viewing. Some can be derived on logical and introspective grounds (e.g., object and person identification, word and utterance comprehension, etc.). Others will be identified by further research. Still others will emerge as obvious needs (i.e., gaps) as the structure becomes further specified and applied to television viewing.

The point to remember is that much of perceptual enquiry (including psychophysics) has been devoted to studying primitive perceptual tasks that might approximate the sub-tasks of television viewing. This research will provide not only examples of possible sub-tasks but also some understanding of how they are carried out and of the input dimensions important to their performance. It remains for the structure to subsume the sub-tasks and their input requirements such that their relative importance in television viewing can be established formally and the viewing value added by proposed input changes estimated.

The proposed structure offers the opportunity to develop a perceptual theory that is sufficient to handle perceptual processing as complex as that involved in television viewing. With further refinement and development, it may prove capable of determining which television system dimensions are important for television viewing and, thus, of predicting which changes are likely to add viewing value. This would improve significantly upon the tenuous logic of current application practice (i.e., correcting symptoms of the inadequacy of current television systems without a clear understanding of what is really needed to add television viewing value).

Implications for Display Evaluation

Observer judgements of subjective values (e.g., acceptability) are often used as the basis for decisions concerning system design parameters. It has already been mentioned, however, that there is always an element of uncertainty about the meaning of subjective responses. Consider, for example, the case of categorical judgement. Here, there is usually some uncertainty as to which perceptual dimensions are used in making judgements and there is always some uncertainty about how decisions among the response alternatives are made.

The structure previously presented, now applied to categorical judgement, is shown in Figure 5. Note that some components of the structure (procedures repertoire and working configuration) have been left blank. Other components (task representation, stimulus representation, and perceptual information) have been specified in a rudimentary fashion. And others still (weighted perceptual values, overall internal value, and internal value to response mapping) have been added as examples of how scaling could be done.

Initially, the perceptual system acquires a perceptual scaling task. Most likely, this task was assigned by an external source as formal scaling is not a normal activity of the perceptual system. The scaling task is then PARSEd into its principal sub-tasks. In the figure, these are shown as: represent stimulus on n-point scale [scale (1-n)] and acquire/use values of perceptual factors [e.g., value(a)]. These sub-tasks would reflect stated or implied aspects of the instructions. Other relevant aspects of the instructions would include the name of the scale and the verbal descriptors of response alternatives.

The sub-tasks lead to the SELECTion, ORGANIZation, and ENACTment of various processing procedures, some of which may control the way that the stimulus is examined. The stimulus is then ACCEPTed and an internal stimulus representation consisting of sense data corresponding to the targeted perceptual dimensions is formed. The sense data are then INTERPRETed and derived perceptual values for the targeted dimensions determined.

Next, the processing procedures carry out the scaling sub-task. The figure shows a proposed series of scaling operations. First, the derived values are WEIGHTed according to the relative importance of their perceptual dimensions for the judgement. The weighted values are then INTEGRATEd by simple summation to form an overall internal value. And, finally, the internal value is MAPped onto the response scale by comparison to a set of decision criteria established over the range of possible internal values. These criteria serve as choice points between adjacent response alternatives but need only loosely reflect supplied response alternative labels. Once the decision has been made, the observer RESPONDs in the fashion dictated by the task instructions.

The assertion that scaling is an example of perceptual problem solving and, thus, is a task governed activity has important implications for scaling theory. First, it provides insight into the origins and natures of internal scale values and of response decision criteria. And, second, it facilitates comprehension of the range and frequency effects alluded to previously [e.g., Helson (1964) and Parducci (1974)]. Because the range and distribution of stimuli are important aspects of the problem solving situation, they should affect the nature of the processing involved in performing the scaling task.

In the proposed structure, a perceptual judgement reflects a situationally appropriate selection and weighting of the values of particular perceptual factors. Expressed judgements, therefore, are meaningful only within the confines of the task induced sub-task structure and can be applied only to situations with identical sub-task structures.

Recall, however, that the television viewing task induces its own sub-task structure. Thus, to acquire subjective assessments that relate to television viewing value, it is necessary to ensure that the assessment is done with a sub-task structure equivalent to that of television viewing.

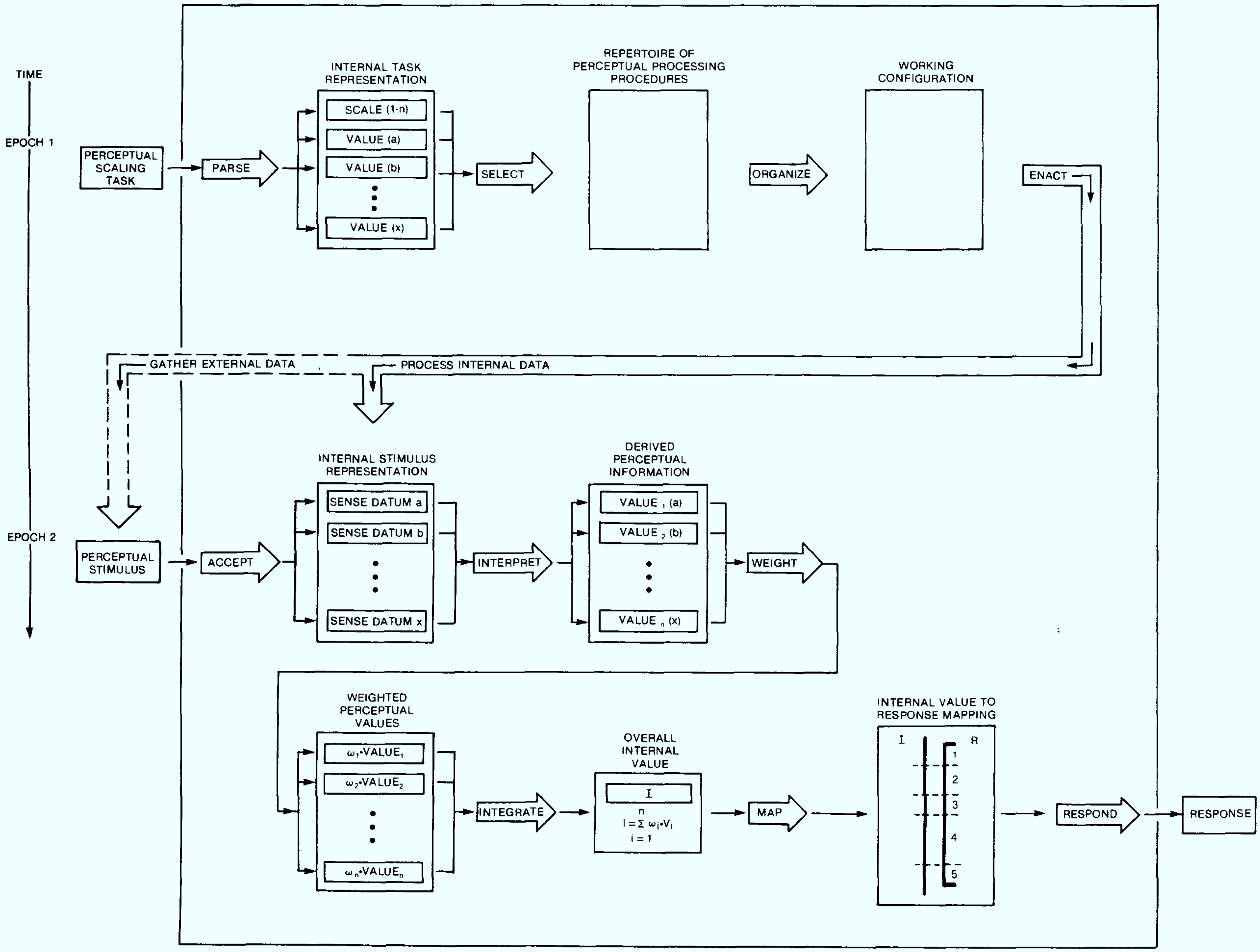


FIGURE 5. The adaptive approach applied to perceptual scaling (categorical judgements).

One way of attempting to ensure this equivalence is to gather display assessments during real television viewing. To the extent that the viewing task dominates the ensuing sub-task structure, then, assessment data might reflect television viewing value.

However, to some extent (at least by including the scaling sub-task and at most by emphasizing display factors that are unimportant in normal viewing), the assessment will affect visual processing. Thus, it might be more appropriate to require an unexpected single assessment immediately following a period of normal viewing. The reasoning here is that, for a short time at least, the period of normal viewing would leave its bias towards critical viewing dimensions. The problem, of course, is to ensure that the final assessment is really unexpected; otherwise, viewers might alter their viewing in order to find display factors upon which to base the anticipated assessment.

An alternate approach is to use the unexpected final assessment procedure for each of the television viewing sub-tasks separately. This would result in estimates of the importance of changes in particular display dimensions for particular sub-tasks involved in normal viewing. Once assessments (and performance) in each of the sub-tasks were gathered, the model of television viewing would then weight the various assessments according to the relative importance of the associated sub-tasks for normal viewing and would derive estimates of the viewing value that would be added by particular changes in display. This approach would have two advantages. First, it would minimize the problem of convincing observers that that they are not there to assess a television system; they would be there, for example, to participate in a study of face recognition. And, second, the performance measures collected would be an extra source of information for interpreting subjective assessments.

ACKNOWLEDGEMENTS

I wish to thank Steve Lupker and Brian Shelton for many discussions about perceptual scaling. As well, I wish to acknowledge their role in supplying the weight-summation procedure used to express concretely one way that perceptual data that are differentially important to the task can be combined.

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A LOOK AT THE CHARACTERISTICS OF FILM IN RELATION TO THE NEEDS OF HDTV FOR THEATRICAL PRODUCTION, USA

2.3

Don Kline & Harry Mathias

ABSTRACT

In order for HDTV to more nearly provide the viewing experiences of film, it needs to satisfy more criteria than simply achieving equivalent resolution.

This paper looks at some of those considerations, such as; dynamic range, comparative gamma and temporal effects.

APERCU DES CARACTÉRISTIQUES DU CINÉMA PAR RAPPORT AUX BESOINS DE TVHD DANS LA PRODUCTION COMMERCIALE (ÉTATS-UNIS)

Don Kline et Harry Mathias

2.3

RÉSUMÉ

Pour procurer des sensations visuelles plus proches de celles du cinéma, il ne suffit pas que la TVHD offre strictement une résolution équivalente. Elle doit satisfaire à bien d'autres critères.

Le présent document examine un certain nombre de ces aspects, entre autres: la gamme dynamique, la gamma relatif et les effets temporels.

A COMPARISON OF FILM AND TELEVISION CAPTURE CHARACTERISTICS 2.3

A PROGRESS REPORT

By Don Kline, Panavision Inc. Tarzana, California

and

Harry Mathias, Cinematographer and Consultant

The questions are often asked. "What is the film look ? When capturing images for television, how and why does film give a different viewing experience than when video is the source"?

Much has been written on such important aspects as spatial resolution, color rendition, lighting and composition practices.

This paper is a progress report on continuing work at Panavision in the areas of contrast reproduction, temporal resolution and dynamic range.

These subjects are being investigated in order to more fully understand the requirements for a high definition video image in the production of dramatic material, possibly for large screen display.

In traditional broadcast oriented video production, gamma is thought of as gamma correction; the nonlinear processing of a linear signal to compensate for the reproduction characteristics of a television monitor. To a certain extent gamma in film can also be considered as a correction to adapt the photographic image to the viewing conditions of a large screen in a dark room. Cinematographers and emulsion makers working with gamma view the contrast reproduction problem in additional ways.

In addition to a fairly low contrast and uniform response portion, negative film has a compressed toe and shoulder. It is sometimes assumed that a more desirable photographic film, if it could be created, would be one with linear response from the darkest blacks to the brightest highlights. In fact this is not desirable, and most cinematographers consider the shoulder and toe portions of the curve to be valuable tools, allowing them flexibility in determining the reproduction of a given scene and creation of a mood or style.

Print film has entirely different requirements. When viewed on a large screen in a darkened room, a film print should show the cinematographer's intended depiction of the original scene, and be capable of black blacks and white highlights. The overall response is what video engineers have recently referred to as an "S" shaped curve.

During investigation of our results, interviews with motion picture laboratories and cinematographers have provided information that might dispel a widely held belief. The assumption has always been that film has a wider latitude than video, which indeed it does, and that video would simply have to be made equal in order to duplicate the so called film look. It turns out, however that motion picture scenes do not often simultaneously utilize every part of the negative's exposure latitude. Cinematographers routinely use the ends of the negative's range in order to tailor the reproduction capabilities of motion picture print film. In other words, the negative is an adjustable contrast compression or expansion tool, and the desired effect can be had by simply placing the exposure higher or lower on the negative's characteristic curve. It is desirable for high definition television to have the ability to select a gamma characteristic based on the intended use of the final image. We must give some thought to the selection of a gamma specification that provides more photographic versatility than our present practice.

Let's contrast this with the situation that currently exists in video. The pickup tube has a linear gamma with a sharp toe, and may be clipped at the white shoulder. Attempts to lift or round the black portion of the curve, through black stretch, frequently result in added noise and black shading problems. The reproduction of over exposed highlights is the most obvious indication of the video look, and beam pooling or comet tailing are considered undesirable in a video image. The Ikegami EC 35, the Panacam and other cameras have tried, by soft compression techniques, to reproduce the shoulder of the film curve.

Our investigation of this problem began with a comparison of film to current video gamma. In order to avoid obvious errors of direct comparison between two dissimilar media, we used a method that would rely on their commonalities instead of their differences.

We also hoped to examine examples of high definition video cameras, but none were available. Ikegami was very generous in providing information, and these cameras appear to be quite similar to standard practice. The slight differences were given as a somewhat reduced initial slope in the black, for noise reduction purposes, and an overload capability limited to two or possibly three stops.

GREY SCALE REPRODUCTION

We are all familiar with this first slide, a waveform monitor presentation of a video camera viewing a standard grey scale transparency. An opaque patch has been added to show a true black level, here set to 7.5 units. The darkest chip is between 4 and 5 percent of the transmission of the brightest chip, and the scale is logarithmic. Camera gamma was set for a crossover slightly less than 50 units, which represents a typical practice.

In this experiment we are concerned with reflectance values below 100 percent, and the camera soft clip is not in use.

For the second slide, we have taken the same grey scale, and photographed it with Eastman 5247 negative film stock, with a Panavision camera and lens. The cinematographer was asked to expose the film as if the brightest chip represented 100 percent diffuse reflectance, and was shown a chip area of 18 percent relative grey as a cross check. Development and printing were done at Technicolor. A standard print, and a print on low contrast stock were made from the negative. Instructions were to use normal procedures in all cases.

The film was now taken to Ruxton, Ltd. for transfer to tape on a Rank Cintel telecine. Ruxton personnel were asked to contribute their great experience and judgement to adjust the telecine to average best practice for that type of film, with the extreme blacks and whites set as in the first slide.

We see that the logarithmic grey scale has been corrected to an almost linear slope. The most striking differences compared to video are in the blacks, with the "5 percent" chip at almost twice the video level, and the crossover at about 60 units. The higher crossover can be simulated by resetting the video camera gamma control in each channel, and an R-G-B black stretch function would appear to better simulate negative stock, to the extent permitted by noise considerations. This ability to see into the shadows is quite apparent when viewing negative telecine transfers, and is similar to human visual perception of the original scene.

Slide number 3 is conventional print stock, made from the previous negative. Here, within the range of normal scene reflectance we see black and white compression together with a mid grey stretch. I should emphasize that this result is for telecine transfers, and does not necessarily apply to human viewing under theatrical conditions. Although there is no longer a distinction between the black reference and the darkest chip, the mid grey stretch might give added life to flat lit scenes and the general appearance of the televised image is of higher contrast than from a video source. This kind of video grey scale rendition is presently available from commercial processing boxes and post production services. We believe it could easily be incorporated into camera designs, and would fit well with soft clip.

In slide 4 we see the result of low contrast print stock. In the print, both the black reference and the dark chip are raised in level by similar amounts. Telecine adjustments return the overall result to something roughly similar to the standard print.

Quantitative data, together with other print medias, such as inter positive and inter negative films have been omitted from this first study. They will be included in a future report.

TEMPORAL RESOLUTION EFFECTS

A notion has been advanced that the temporal or motion update rate is an important subliminal clue to determine program origin and perception of quality. The perceived quality theory can be simply stated: Lower motion update rates are unconsciously regarded as "film like" and assigned a higher quality level. It is a learned response. In order to test this theory and to determine if these lower rates are adequate for certain images another experiment was made.

A Panavision Panacam video camera was modified to scan at a vertical rate of 30 Hz. The line rate, color subcarrier and all image processing remained unchanged. The video output is a composite signal of 525 lines, 30 noninterlaced frames a second, progressively scanned. The Apert Herzog company made available a specially modified frame store to accept the composite progressive signal and convert it to N.T.S.C. interlaced output. A direct conversion process would destroy the phase continuity of the 3.58 MHz. subcarrier, so a means was devised to periodically invert the subcarrier phase into the camera encoder to complement the conversion effect.

The camera can be operated in both conventional and modified modes by an interchange of circuit cards.

In addition to the altered motion portrayal, several other changes were observed:

We saw less beam discharge lag at low light levels.

Registration appeared to be better.

And for still scenes:

The vertical modulation transfer function improved.

The vertical limiting resolution increased by about 25%.

Aliasing appeared in the vertical direction.

Some observers felt that the adjacent line vertical image enhancement was more pleasing than the conventional alternate line method.

Although these tests were conducted with a 525 line system, I believe the principals and results apply equally to high definition television.

For the experiment, a half silvered mirror was arranged so that a motion picture film camera and a television camera could simultaneously view the same scene. Identical lenses were used on both cameras. Exposures were set from 100 % and 18 % cards in a manner similar to the grey scale experiment.

Soft clip was used on the video camera.

Film was transferred from the negative by Ruxton, Ltd. on a Rank Cintel set up in a way similar to that in the grey scale experiment.

VIDEO AND FILM TESTS

The first shots compare the motion portrayal of film and conventional television for continuous movement.

We now show some 30 frame film and 30 frame progressive scan television.

So far so good, and perhaps acceptable where the motion rates are low. Now let's see some faster action with more motion discontinuity. Some feel that the blur on the hoofs and in the background contributes to the artistic effect. Others disagree. What do you think?

The next shot is another common type of scene, an open pan. The negative film black stretch is quite visible in these last two takes.

Now for a 3-way comparison: These similar scenes were taken in different ways; conventional television, progressive television and film. Can you correctly identify them?

This sequence compares still frame capabilities. In progressive scan, adjacent pixels are captured close together in time. Full vertical resolution is possible without suffering from flutter.

Let's take a look at the static resolution improvements I mentioned earlier. We first see a standard resolution chart in interlaced scan. Vertical resolution is about 350 lines. In progressive scan, 400 lines are quite clear, and some claim 425 to 450. Aliasing is visible in repetitive patterns but not on edges. The radial resolution chart also shows vertical improvements. Group 1-6 can now be read, as compared group 1-3 before. Little aliasing is visible. Since horizontal resolution in the progressive camera is somewhat limited by the 14 MHz. sampling rate of the frame store, the standard system was adjusted to match. Actual measurements were: 100 % to 3MHz., 70 % at 4 MHz. and 50 % at 5 MHz. Vertical M.T.F. was set to 100 % at 200 lines in both cases. Greater amounts of vertical detail caused outlining, but no increased limiting resolution in the conventional camera and a slight gain in resolution and additional aliasing in the modified camera. We did not observe any significant outlining in the modified unit.

CONCLUSION

In situations where there is some control of scene motion a reduced motion sampling rate may be possible. Well known shooting techniques have enabled the film industry to cope with the motion problem, and even use it for artistic effect. Subliminal learned responses may impart perceived value to material captured in this way. It has been demonstrated that 30 frame progressive scan motion artifacts are similar to those of film.

This method permits the known advantages of adjacent pixel image capture pertaining to still frames, digital picture manipulation, bandwidth reduction processing and improved sensor performance. Beam discharge tube lag seems to be reduced. 30 frame progressive is compatible with existing and proposed high definition and standard 60 Hz. systems.

Dual mode camera operation is possible, and may be desirable.

New camera designs would benefit from more flexibility in the the rendition of grey scales. Grey stretch, black stretch and white compression offer artistic and operational benefits which to date have only been available in film.

The digital storage system required for sequential to interlaced conversion may also be useful for other tasks, such as noise reduction to make increased black stretch practical. Reduced lag and noise will also help increase the dynamic range and sensitivity of the video camera.

Thank you for your attention.

DIRECT COMPARISON OF 35mm FILM AND HIGH DEFINITION TELEVISION

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2.4

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ABSTRACT

In January 1985, CBS will conduct a test at the CBS film studios in Studio City, California to produce the first direct comparison of 35mm film and High Definition Television. Over the course of a week, a variety of objective test material and subjective scenes will be shot simultaneously on a high quality 35mm camera and on a HDTV system operating at 1125 lines, 60Hz., 2:1 interlace, and 5:3 aspect ratio.

Each scene will be set up so that horizontal and vertical sizes will be identical for both images when projected. In addition, the director of photography will adjust the film and HDTV cameras to achieve identical image characteristics such as depth of field.

Comprehensive test material as well as scenic material representative of a broad range of cinematographic circumstances will be photographed during the production.

The results of the production will be used for direct comparative evaluation using film and electronic projection systems. The material will also be used for the evaluation of the ongoing development of HDTV film recording systems and HDTV telecines.

This paper will report on the methods used to produce the test material and the results obtained.

COMPARAISON DIRECTE DU FILM 35 mm
A LA TÉLÉVISION À HAUTE DÉFINITION (TVHD)

Arthur Kaiser
Centre technologique de CBS

2.4

Dwight F. Morss III
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RÉSUMÉ

En janvier 1985, CBS procédera à un essai dans ses studios de cinématographie de Studio City (Californie), afin d'obtenir la première comparaison directe entre film 35 mm et télévision à haute définition (TVHD). Pendant une semaine, des scènes devant servir à des essais objectifs et subjectifs seront filmées simultanément par une caméra 35 mm de grande qualité et par un système TVHD qui produira une trame de 1 125 lignes, à 60 Hz avec entrelacement de 2/1 et rapport d'image de 5/3.

Chaque scène sera tournée de manière que les dimensions horizontales et verticales des deux images soient identiques au moment de la projection. En outre, le directeur de la photographie réglera les caméras 35 mm et de TVHD de manière à obtenir des caractéristiques d'image identiques, par exemple la même profondeur de champ.

Des scènes types de toutes sortes ainsi que des scènes illustrant une vaste gamme de prises de vues de cinéma seront filmées pendant la production.

Les résultats serviront à une évaluation comparative directe au moyen de systèmes de projection cinématographique et de projection électronique. La matière sera aussi utilisée pour évaluer le développement actuel des systèmes d'enregistrement cinématographique de TVHD et les systèmes de télécinéma TVHD.

Le rapport fait état des méthodes employées pour produire la matière des tests et des résultats obtenus.

DIRECT COMPARISON OF 35mm FILM AND HIGH DEFINITION TELEVISION

2.4

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In late January of this year, CBS produced a 35mm motion picture film and an 1125 line high definition videotape simultaneously, and of identical scenes, to permit the first direct comparison of the two production media to be made. During this colloquium, you will have an opportunity to attend the first public showing of this vehicle. You may sit back, relax, and enjoy the show; just as if you had bought a ticket at your neighborhood movie theater. The judgments will be entirely yours to make.

For many years 35mm film has been the benchmark of image quality. This was recognized from the earliest industry-wide deliberations on the subject of HDTV, commencing with the SMPTE Study Group on HDTV which was formed in 1977 under the chairmanship of Donald Fink. The report of that Study group noted that: "The appropriate standard of comparison is the ... performance of the 35mm release print as projected on a wide screen".[1]

The study of the performance of motion picture film is not new to CBS. Since 1966, CBS has had an ongoing concern with the resolution characteristics of film and has done extensive work in this area. In 1972, these efforts were directed to high-resolution film production for electronic video recording. In 1978, such activities were spurred by the promise of electronic cinematography for television viewing. Since 1980, HDTV has been the focal point, and CBS has set out to answer two fundamental questions:

1) How good must HDTV be to match 35mm film as viewed in the theater?

2) How close has HDTV come to that standard of 35mm film?

To answer the first question, an intensive review of literature was undertaken -- to no avail. Unambiguous, definitive information on the end-to-end resolution performance of 35mm motion picture film has not been published. For that reason, early in 1984 CBS produced a test film, using a television resolution chart, to obtain the result from the "live scene" to the "wide screen". The results of this work have been published in the June 1985 issue of the SMPTE Journal.

CBS then carefully investigated the entire process of film duplication for the distribution of release prints. Figure 1 shows the normal process for producing thousands of release prints of a feature production. The camera produces an exposed color negative, e.g. 5247, which must be developed and from which one or more master positives, e.g. 5243, are produced by printing. Master positives are then used to print many duplicate negatives, e.g. 5243, which are used for producing the numerous release prints, e.g. 5384. Each release print is then used for projection in the theater. The film which will be shown today was made by this sequence of steps.

The process of producing intermediates impairs the achievable resolution and, by direct observation, CBS has concluded that a limiting resolution of approximately 700 TVL is the most that can be expected. In a recent paper by engineers of Eastman Kodak, this statement appeared:

"A 1.85:1 aspect ratio theatrical print with an 11.3 mm aperture height was assumed. Assuming the limiting resolution occurs at about 5-10% response, we see that while the camera negative has a resolution of about 1600 lines/picture height, the screen image resolves only about 700 lines/picture height."[2]

So we have the answer to the first question -- 700 TVL on the theater screen.

PRODUCTION OF CBS 35mm TEST FILM

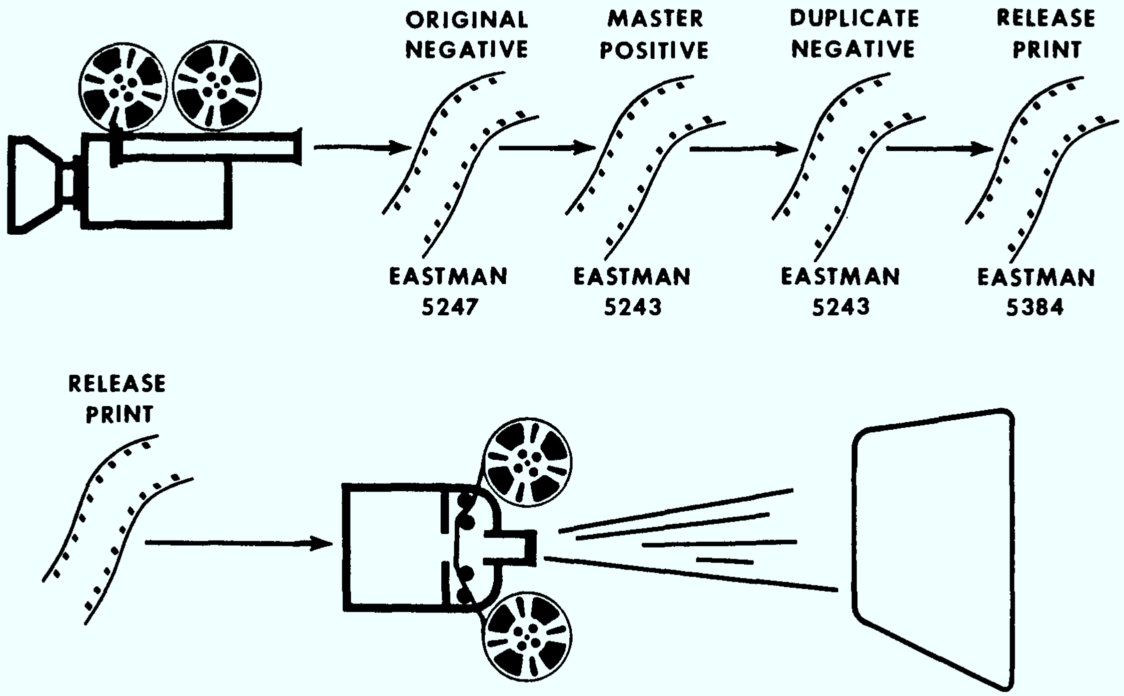

FIGURE 1

To determine how close HDTV has come to meeting the performance of 35mm wide screen motion picture film, one need only measure the system. On a waveform monitor or on a picture monitor of adequate performance, the requisite resolution is achieved. But, how would the general public view the results? To determine this, CBS produced the comparison you will shortly be able to view.

The production was done at CBS/MTM Studios in Studio City, California. The film camera was a Panavision Panaflex - X equipped with a 20-100mm zoom lens. Eastman 5247 and 5294 color negative stocks were exposed. The video camera was a Sony HDC-100 with 12-84mm zoom lens. A Sony HDV-100 video tape recorder was also used.

The two cameras were mounted together on a specially built pan head. This arrangement allowed shots to be matched as closely as possible while minimizing parallax. The cameras are shown in Figures 2 and 3.

The production personnel included a professional film crew and Director of Photography. The Director of Photography established the illumination level based on the film stock in use. He then set the film camera aperture for the depth of field which would normally be used for each shot. This done, the high definition video camera iris was set to achieve equal depth of field. The video level was then adjusted using the camera gain controls and, when necessary, neutral density filters. Figure 4 shows the production staff preparing to shoot a scene.

The high definition video camera has a fixed aspect ratio of 5:3 or 1.66:1. The film camera was adjusted so that the field of view for both media would be identical at the time of projection.

Follow focus technique was employed for both cameras just as it would be for a normal film production.

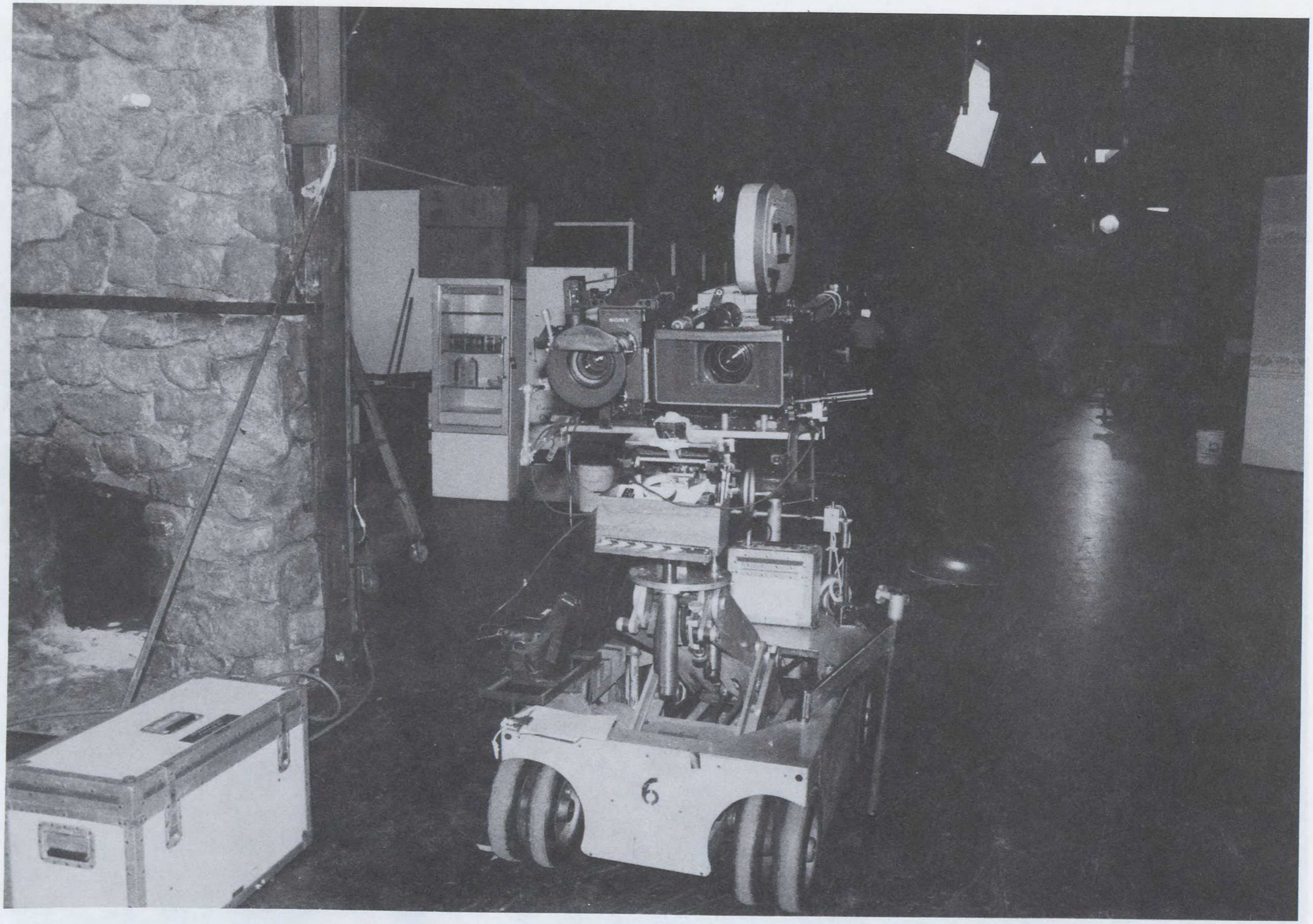

FIGURE 2

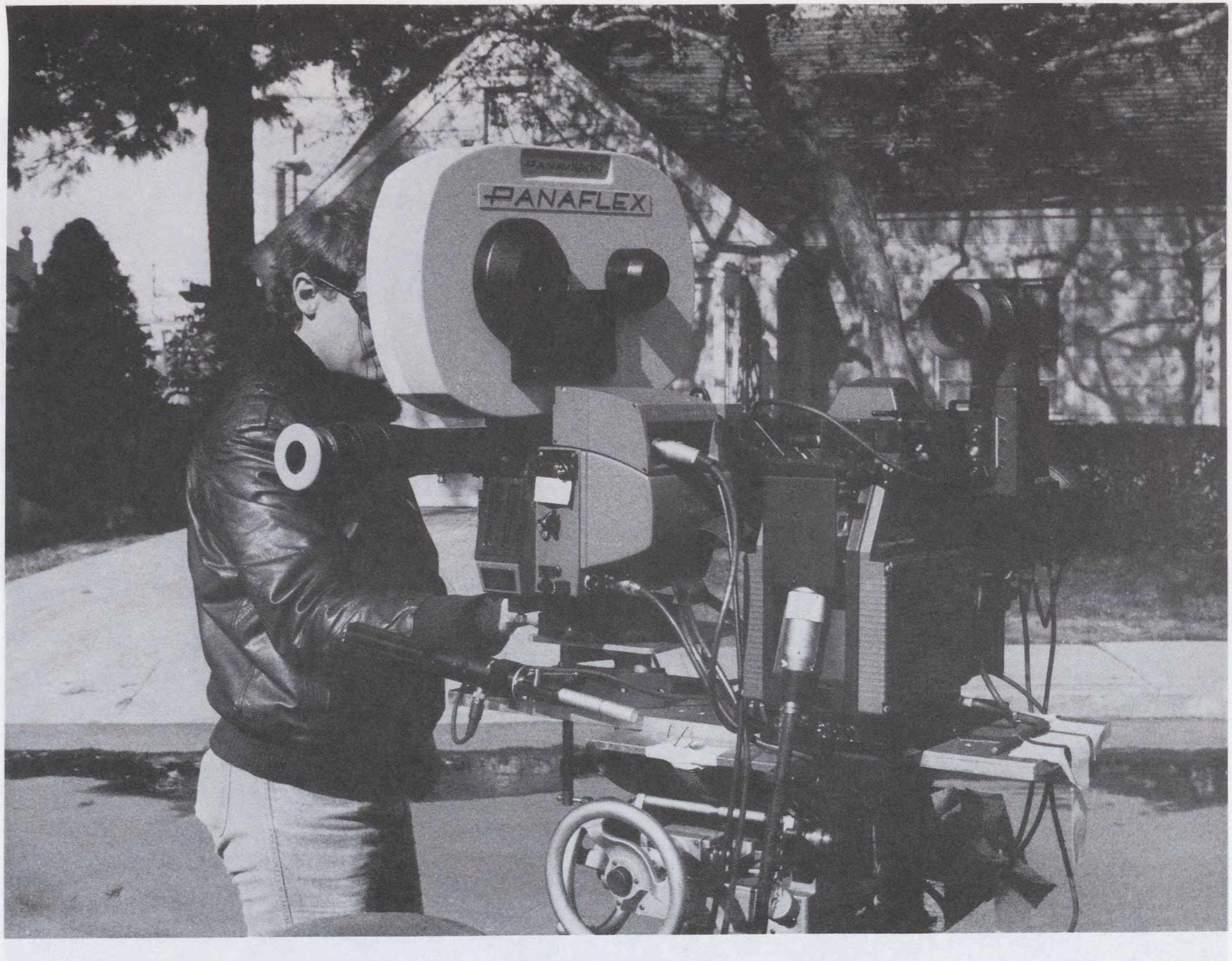

FIGURE 3

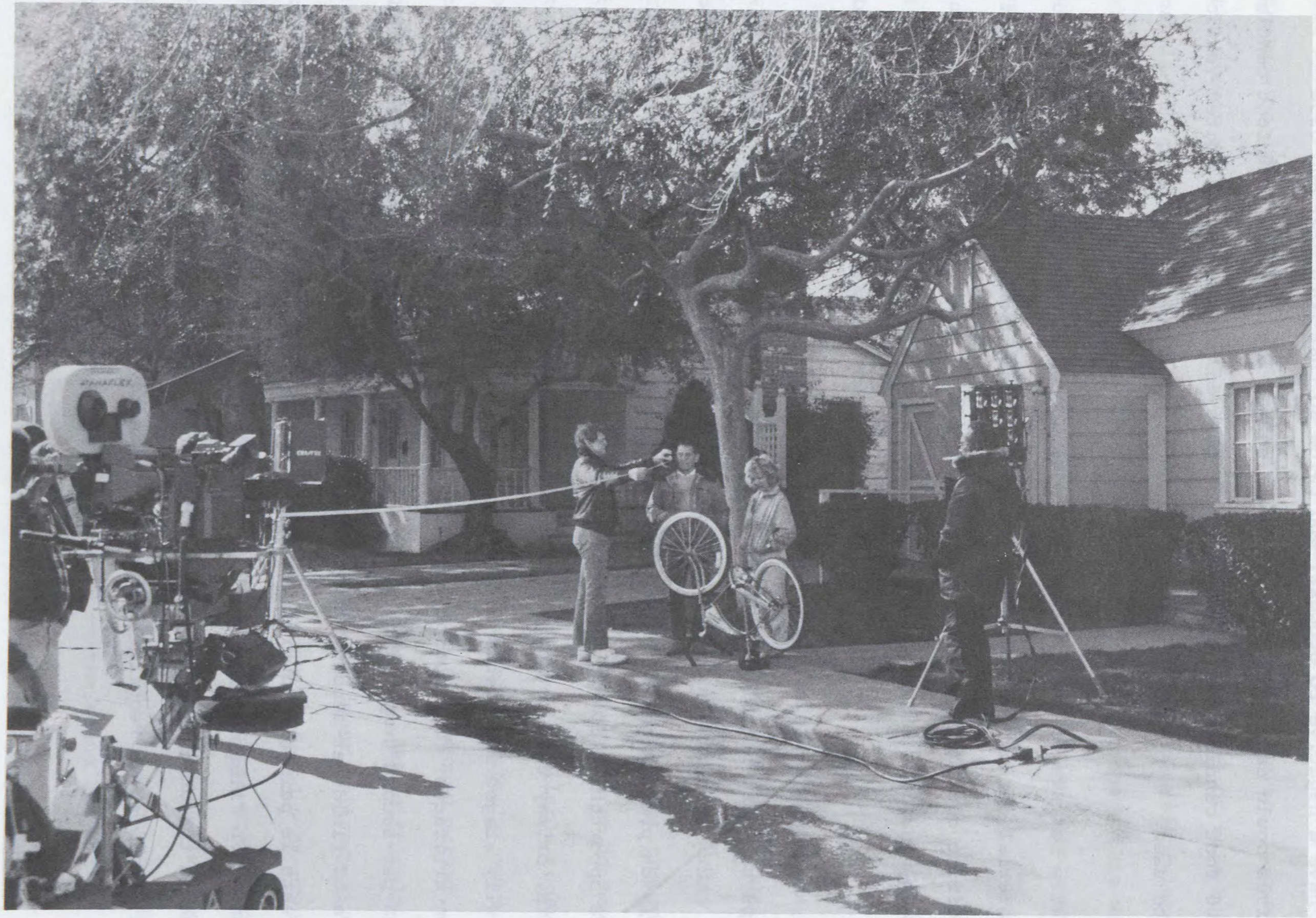

FIGURE 4

Each scene was shot four times, twice so that both Deluxe General and CFI would have a negative to process, and twice so that both 5247 and 5294 negatives could each be exposed at their normal light levels; 200 foot candles and 100 foot candles, respectively. For this demonstration, an edited version will be used.

The daily reviews of the previous day's shooting, and the subsequent review of all material during the selection process, served to make those connected with this effort confident that a genuine milestone in program production had been achieved.

There are some facets of this comparison which merit particular attention. Perhaps the most notable is motion portrayal.

Television professionals are accustomed to shooting live events which offer little opportunity for production control. These professionals may be unaware, or may tend to forget, that motion picture production must be carefully staged for scenic action to prevent the introduction of annoying motion artifacts. The motion artifacts which occur at the 24 frames-per-second temporal rate of films are essentially absent in television with a 60 field-per-second temporal rate. The existence of the film motion artifacts is painfully obvious to anyone who has attempted to shoot live action. NFL Films, a firm which produces films of the National Football League in the United States, shoots wide angle shots at 32 frames-per-second while narrow shots require 48 frames-per-second.

During the production of this comparison the Directors of Photography staged all action as would normally be done for film. Thus, most of the scenes include no action which would produce motion artifacts. However, in one scene the viewer will note a spinning bicycle wheel. The portrayal of this motion on film is as expected; the wheel appears to be spinning backwards relative to the actual direction of motion. The viewer is invited to compare this with the same scene as portrayed on video; the motion is smoother and the wheel at no time appears to be spinning backwards.

In all scenes the viewer is invited to compare the relative sharpness and image stability of the two media.

When observing the demonstration of these films and tapes the viewer should bear in mind that he is not witnessing some kind of anachronistic oddity of the distant future. The 120" HDTV projection system used here for the video is a production model, not a prototype. A 200" flat-screen system is now a reality. It is well known that satellite distribution is available today for both wideband and encrypted service. Many are also very painfully aware of the present-day pirating of films for showing in the underground market, costing producers untold millions of dollars in revenues. How difficult can it be, therefore, to recognize the value of an entertainment delivery system to a theater with a receive-only satellite dish on its roof and a de-cryption device feeding the projection system; with multilingual digital stereophonic sound and the potential for showing feature productions <u>plus</u> real time events such as sports and public affairs? It truly does <u>not</u> require a crystal ball to envision this; all one need do is look around -- the means are all at hand.

Author's Note

The presentation of this paper was followed by five demonstrations of the 35mm film and video tape described in the text. The HDTV projection screen and the film screen were identical in size and aspect ratio.

The authors believe that the demonstration provided convincing evidence that HDTV has indeed proved to be a production media which is equivalent, and in some ways superior, to 35 mm film.

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COLOR PICTURE DISPLAY SYSTEM FOR HIGH-DEFINITION TELEVISION

2.7

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ABSTRACT

The wide screen, high-definition television produces a crisper and higher resolution picture aiming at presenting a more attractive impression of "realism" to viewers thereby attempts to satisfy to the demands of the coming video generation. Research and development works in high-definition television (HDTV) system have been carried out at Matsushita Electric for thirteen years under the guidance of the NHK Science and Technical Research Laboratories (Japan Broadcasting Corporation). Comprehensive technological developments made to date include a high-definition camera with high-resolution Plumbicon pick-up tubes, a wide band contour corrector, a color encoder and decoder for composite signal transmission (HLO-PAL), a color encoder and decoder for Y-C components separate transmission, a high-definition video tape recorder, an SHF television receiver for DBS, a MUSE (Multiple Sub-Nyquist Sampling Encoding) decoder, and a variety of high-definition picture displays.

A picture display is one of the key components of a television system, because a viewer evaluates the television system he watches through the display. In this paper, details of recently developed displays for HDTV are described. Following a short review of our technological development in the field of high-definition picture displays, a 110 inch front-type projection display, a 55 inch rear-type projection display, and a 40 inch CRT display are described. Developmental displays made by Matsushita have been mainly used for visual evaluation of actual pictures in experimental HDTV systems. Relatively few numbers of developmental displays have been offered for systems investigation in high quality video transmission by optical-fibers, for computer video image composition, for use as a video display for electronic cinematography, and for educational use in closed circuit networks. Incidentally, there is the International Exposition, Tsukuba, 1985 (Tsukuba Expo '85), going on in Japan, where several displays are used to experiment broadcasting in HDTV.

SYSTÈME D'AFFICHAGE EN COULEUR POUR LA TÉLÉVISION À HAUTE DÉFINITION

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RÉSUMÉ

La télévision à grand écran et à haute définition produit une image plus nette, de meilleure définition, visant à donner une meilleure impression de "réalisme" aux téléspectateurs et essaie ainsi de satisfaire aux demandes de la génération vidéo montante. Des travaux de recherche et de développement sur la télévision à haute définition (TVHD) sont menés depuis treize ans à la compagnie Matsushita Electric, avec les conseils des laboratoires de recherche scientifique et technique de la NHK (Société de radiodiffusion du Japon). Les importants développements technologiques réalisés jusqu'ici comprennent une caméra à haute définition utilisant des tubes de captage Plumbicon de haute résolution, un correcteur de contours à large bande, un codeur et un décodeur pour la transmission de signaux composites (HLO-PAL), un codeur et un décodeur couleur pour la transmission séparée des composantes Y-C, un magnétoscope à haute définition, un récepteur de télévision SHF pour le service de radiodiffusion directe par satellite, un décodeur MUSE (sous-échantillonnage avec compensation de mouvement) et divers écrans d'affichage à haute définition.

L'affichage est l'un des éléments clés d'un système de télévision, car le spectateur évalue le système de télévision par l'image qu'il voit. La communication décrit en détal les écrans d'affichage récemment mis au point pour la télévision à haute définition. Après une courte revue de nos développements technologiques dans le domaines de l'affichage à haute définition suit une description d'un écran d'affichage de 110 pouves à projection par l'avant, d'un écran de 55 pouves à projection par l'arrière et d'un affichage à TRC de 40 pouces. Les écrans d'affichage mis au point par Matsushita ont été principalement utilisés pour l'évaluation visuelle d'images réelles dans les sytèmes en transmission vidéo de haute qualité par fibres optiques, pour la composition d'images vidéo par ordinateur, pour l'utilisation comme affichage vidéo pour la cinématographie électronique et pour des fins éducatives, dans des réseaux en circuit fermé. Il est à signaler que l'exposition internationale de Tsukuba (Expo 85), au Japon, montre l'utilisation de divers écran d'affichage pour la radiodiffusion expérimentale de télévision à haute définition.

COLOR PICTURE DISPLAY SYSTEM FOR HIGH-DEFINITION TELEVISION

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1. INTRODUCTION

A picture display is one of the key components of a television system, because a viewer evaluates a television system through the display. Research and developemnt in high-definition television (HDTV) system have been carried out at Matsushita Electric for thirteen years under the guidance of the NHK Science and Technical Research Laboratories (Japan Broadcasting Corporation). Details of recently developed displays for HDTV are described in this paper.

Following a short review of our technological development in the field of high-definition picture displays, a 40-inch CRT display, a 110- inch front-type projection display, and a 55-inch rear-type projection display are described.

Developmental displays made by Matsushita have been mainly used for visual evaluation of actual pictures in experimental HDTV systems. A number of developmental displays have been offered for systems investigation in high quality video transmission by optical-fibers, for computer graphics, for use as a video display in electronic cinematography, and for edicational use in closed circuit networks. Incidentally, there is Tsukuba Expo '85 going on in Japan where several displays are used in receiving experimental HDTV broadcasting.

2. History of HDTV picture display

Development activities on HDTV picture displays at Matsushita Electric were initiated by request from the NHK Laboratories. A number of developmental displays were used at the NHK Laboratories in their visual evaluation of pictures in the system. Table 1 shows provisional standards for the high-definition television of NHK.

〔I〕 CRT displays

In Table 2 specifications for high-definition CRT displays are shown.

(1) 22-inch display with an aspect ratio of 4 : 3

In 1972, the first high-resolution picture display with a 22-inch fine shadow mask pitch CRT was developed. This CRT had a shadow mask pitch of 0.31mm, which is less than half the pitch in conventional CRTs. A high resolution electron gun of a new design was used in a large diameter neck. MTF data for this CRT are shown in Fig. 1. The resolution of CRT generally depends on the frequency response of the space sampling by the shadow mask pitch and on the electron beam spot size.

(2) 26-inch three-tube display

Because wider screen displays were in demand, a 26-inch three-tube display was developed in 1975, which had a screen of 0.5 meter by 1.0 meter. Its structure is shown in Fig. 2. Each CRT had a shadow mask pitch of 0.44 mm. High-resolution electron guns were used. Each tube displays one-third of the picture. Three portions of the picture are combined through a half mirror. For smooth picture continuity from one portion to the next, the video signals near the border are composed of fading-out in one CRT and fading-in in the other.

The display gave an impressive, beautiful picture on the screen.

(3) 30-inch display with a 5 : 3 aspect ratio

A 30-inch wide screen CRT with an aspect ratio of 5 : 3 was developed in 1977. A 30-inch display is shown in Fig. 3. This display has a screen size of 64 cm by 38 cm ; almost twice the area of a conventional 20-inch CRT picture screen.

This tube has a high-resolution electron gun in a large neck of 36 mm diameter. The shadow mask pitch is chosen to be 0.34 mm to reduce moire patterns. A black matrixed phosphor screen is used. In Fig.4, a 30-inch wide screen CRT is shown in comparison with a 20-inch conventional CRT.

(4) 26-inch CRT display

This display was developed to meet the need for a reliable, easy-to-handle CRT display at moderate cost. Fig. 5 shows this display.

The 26-inch high-definition CRT has a wide field of applications including character and /or graphic displays for computer terninals and picture displays in high-definition television systems. The CRT has an aspect ratio of 4 : 3 , but a modification mask panel can be attached from outside for 5 : 3 aspect ratio operation.

〔II〕 Projection displays

Table 3 shows specifications of HD projection displays, developed for larger sized display applications.

(1) 55-inch Sehmidt lens type projection display

A large size wide screen display is in demand to give viewers a strong visual impact and enhanced presence.

A 55-inch HD projection display was developed in 1978 using a newly developed double D-type projection tube with a Schmidt lens in triplet. Three projection tubes for R.G.B. are positioned in line to get a brighter picture without color shading. Velocity modulation of the electron beam for picture improvement and an improved electro-magnetic focus system were introduced.

(2) 55-inch refractive lens projection display

A new 55-inch HD projection display using direct refraction through optical lenses was developed in 1980.

A refractive lens system gives wider freedom in screen sizes or projection distances than a Schmidt system does. Design modifications can be made in the case of refractive lens system much easier than in the case of Schmidt lens. Adjustments during operation, to improve focus or color aberration, are not difficult in the case of refractive lens system.
Fig. 6 shows the 55-inch HD projection display.

〔III〕 Recently Developed Displays for High-Definition Television

A direct view 40-inch CRT display has been developed recently. On the other hand, 100-inch or wider front-type projection displays have come into being and been demonstrated by several manufacturers.

Development activities in 40- to 60-inch rear-type projection displays have been also pursued. Rear-type projection displays are considered to be promissing for home television applications, and efforts are being paid to improve the contrast ratio and to enlarge the viewing angle of the rear projection screen.

A large Schmidt lens type projection CRT (with meniscus lens), developed for professional giant screen displays, projects its images on a 400-inch rear screen. To ensure high brightness and high picture quality, images projected via 12 monochrome tubes are superposed. An automatic resistration is performed with a camera.

Details of three types of displays recently developed at Matsushita Electric Industrial Co., Ltd. are described below. These three are a 40-inch CRT display, a 110-inch front type projection display, and a 55-inch rear type projection display. Table 4 shows specification for these displays.

(1) 40-inch CRT display

Conventionally, direct view CRT displays were used for 30-inch or smaller screen sizes, whereas projection displays were used for 50-inch or larger screen sizes. However, the former are superior in picture quality to the latter in a number of ways, resulting in a strong demand for the development of large-sized CRTs. In April 1984, we succeeded in developing a 40-inch CRT whose display area is 1.8 times that of a 30-inch CRT. In May of the same year, a 40-inch display for HDTV, the first one in the world, was completed and demonstrated at the NHK Laboratories.

In Tsukuba Expo '85, which is now under way, our 40-inch displays for HDTV are used for receiving MUSE system experimental broadcasting. Fig. 7 shows an external view of this display.

a) Development of 40-inch CRT

In the development of 40-inch CRT display, the most difficult task was to develop its CRT. The progress of manufacturing techniques for shadow masks and glass envelopes contributed much to the development of this CRT. In particular, computer simulation using the finite element method was made in mechanical design calculations of the glass envelope of the CRT with an aspect ratio of 5 : 3. Table 5 shows specifications for this CRT. The CRT, which has a deflection angle of 90° and a neck diameter of 36.5 mm, measures 76 cm in length and weights approx. 90 Kg. Including the weight of this CRT, the total display weight amounts to 170 Kg.

The shadow mask pitch is one of the significant factors to determine the resolution of a CRT. The pitch was chosen to be 0.45 mm so that the resolution would be 1,000 TV lines and the moire pattern will be minimized.

Another factor affecting resolution is the beam spot size. Since the 40-inch CRT requires beam current approx. 2 times that in a 30-inch CRT, HI-BPF electron gun incorporating an impregnated cathode was developed to improve the beam spot response characteristics. Fig. 8 shows beam spot response characteristics of the 40-inch CRT. The resultant resolution is 1,000 TV lines (-10 dB) at an average brightness of 60 cd/m².

b) Electric circuit system

There have been a number of improvements in components and circuitry to be used with this 40-inch CRT. The deflection coil is wound on a dual section deflection yoke, permitting easy convergence correction and desirable beam landing. The deflection circuit, which is required to drive the deflection coil, employs a separate system in which the horizontal deflection circuit and the high voltage circuit are independent of each other. The high voltage circuit, incorporating a feedback loop, generates stabilized anode voltage at 32 kV.

The video output circuit driving the CRT has a fairly flat frequency response characteristic. A cascode type amplifier is used for the output stage to ensure a sufficient output voltage swing. As a result, video signal output of 100 Vpp at a band width of 0~30 MHz has been attained.

c) Digital convergence

In a high resolution large screen display, the accuracy of convergence is required to be rather high. Although convergence circuits were conventionally of analog type in most of CRT displays, a digital convergence system has been employed for this 40-inch CRT display. This new convergence circuit which handles both analog and digital waveforms together has contributed to high picture quality attributable to a smooth convergence correction as well as easy adjustment.

The convergence yoke, which has static and dynamic coils separately, is designed for low power consumption. It also has dynamic blue lateral coil windings. Consequently, convergence adjustment over the entire screen down to four corners can be accurately made. Fig. 9 shows a block diagram of the digital convergence. The number of adjustment points is 11 horizontally and 9 vertically. The number of digitized bits used is 8.

(2) 110-inch front-type projection display

A 110-inch projection display was developed with an objective of attaining both a large screen and a high luminous flux. The size of a front projection curved screen to be used with this display is fixed to 110-inch size. The size of a flat screen, however, can be chosen between 70 and 120 inches, either front or rear projection.

In the 110-inch display, a screen gain of 10 permits 50 ft-L brightness. The contrast ratio is 60 : 1. Use of a scan converter permits this display to display NTSC pictures as well. An automatic switching function is provided, which changes over the number of scanning lines from 1,125 to 1,050. The aspect ratio of the screen can be automatically changed over from 5 : 3 to 4 : 3. Details of this display are described below.

a) Projection lens

We have developed a refractive lens system, composed of 7 spherical glass lenses, to attain a projection lenses with a large relative aperture. The F-number is 1.45 and the focal distance is 265 mm. The MTF, which determines the resolution, is 65% at the central part and 40 % at the circumferential part for 800 TV lines. As a result, the lens meets requirements for HDTV applications.

Two types of projection lens have been developed for curved and for flat screens. The projection lens for curved screen is exclusively used for 110-inch displays, while the projection lens for flat screen is applicable to 70- to 120-inch displays.

b) Projection CRT

A 12-inch flat face projection CRT has been developed to ensure a high screen brightness on a large screen. It is essential in HDTV applications to make beam spot narrow at high peak current.
The beam current in this projection CRT goes up to 3 mA or more.
This unit uses an electron gun of electro-magnetic focusing method which minimizes the deterioration of beam spot diameter. The magnetic lens is of electro-magnetic focusing coil type, which is mounted on the neck.
A dynamic focusing coil is provided to attain a resolution of 1,000 TV lines over the entire screen including corners. Fig. 10 shows schematically the structure of 12-inch flat face projection CRT.
This projection CRT, which has a neck diameter of 29.1 mm and a deflection angle of 90°, is designed to reduce power consumption.

Fig. 11 shows the beam spot size as a function of beam current when the anode voltage is 30 kV. When the CRT is operated in high-current conditions, the heat dissipation will cause stress to be produced on the face plate. For this reason, an ion exchange strengthening method is applied to the face plate of this valve.

c) Electric circuit system

In the video amplifier circuit, the frequency response extends to 30 MHz and the maximum output voltage is 100 Vpp or more. In this projecter, the deflection circuit can be switched over from front projection mode of operation to rear projection mode and adjustments can be done for color shading correction circuit.

(3) 55-inch rear projection display for HDTV

Although a front type projection would be preferred for most of large screen applications, a rear type projection display has the following advantages :

i) With a flat screen installed, the appearance can be made similar to that of a conventional television receiver.

ii) External dimensions can be made relatively compact to make the display acceptable for home television applications.

iii) A screen reflectivity as small as a few % of less minimizes the drop of contrast ratio ; the display can be used in a brightly lit room.

The above mentioned advantages were included in the design objectives in the development of this rear projection display which measures 55 inches in screen size and 78 cm in depth.

Fig. 12 shows schematically the internal structure of 55-inch rear projection display. An exterior view is shown in Fig. 13.
Reflections occur two times on surface mirrors, each with a reflectivity of 95%, resulting in a reduced depth of enclosure. Key components vital to the success of this rear projection display include a compact high-performance projection CRT, a high aperture ratio projection lens, and a screen with a high directivity.

a) Projection lens

A compact high aperture ratio projection lens system composed of 9 glass lenses have been developed to attain high brightness pictures.

The F-number is 1.2 and the MTF of the lens is 80 % (when the resolution is 900 TV lines) . The object distance is as small as 1,688mm. The reduced optical path makes total enclosure dimensions compact. Multiple lens coatings prevent contrast degradation.

b) Projection tube

A 7-inch projection tube with high brightness and high resolution has been developed. It has a neck diameter of 29.1 mm and a deflection angle of 70° An electromagnetic focusing method attains high-resolution throughout the screen area from the center to four corners. The beam spot diameter is 0.22 mm at a beam current of 1 mA resulting in a resolution of 1,000 TV lines or more. The outer surface of the face plate of the projection tube is flat, while the internal phosphor screen is curved to ensure better optical focusing. Like the lens, the face plate of the CRT is multi-coated to improve the contrast ratio.

c) Rear screen

In the development of a rear type projection display, the most vital unit is the screen. Nowadays a variety of screens have become available. Screens with large viewing angles or with black stripes have been put into practical uses for NTSC. In general, the rear screen consists of a diffusing layer and a Fresnel lens to improve circumferential brightness. In the earlier developmental models, both a diffusion surface and a Fresnel lens were made from one piece of acrylic plate. With this structure, the screen gain was 5 and the viewing angle was $\pm 23^\circ$.

A lenticular lens system was added on the opposite side of the Fresnel lens of the diffusion plate to widen the horizontal viewing angle.

In this screen, the pitch of the lenticular lens is chosen to be 0.7 mm and the Fresnel lens has a pitch of 0.5 mm, resulting in a reduced moire patterns. The horizontal viewing angle has been improved to 30° or more. Fig. 14 shows characteristic curves for this screen.

As a result, a brightness of 100 ft-L at white peaks is attained for viewing in a room not darkened. The lenticular lens pitch should better be further reduced ; a lenticular lens pitch of 0.5 mm or less would be required for a 40-inch screen. In a rear type projector, the optical coupling between the lens and the CRT plays an important role in improving contrast.

Conclusions

A short histrical review of high definition desplays is given followed by descriptions on more recently developed direct view CRT displays and projection displays. Development works on high-definition home television receivers based on MUSE system are now under way intended for reception of HDTV broadcast expected in

1990s.

Since most signals in MUSE decoders are digitally processed, rapidly progressing LSI technology and digital processing technology will permit much of the now bulky circuitry to give way to a small number of LSIs, resulting in a reasonable cost of the receiver for home entertainment applications.

For making high definition displays really practical and competitive, a number of tasks are facing us. In direct view CRT displays, brightness is to be increased and performances are to be further stabilized. With regard to projection displays, it is vitally necessary to improve their brightness and contrast ratio. For rear-type projector, a more compact optics and a higher performance screen would be desirable. Continued efforts will be paid for research in and development of display systems, components and devices appropriate to HDTV applications.

Future applications of HDTV will not be limited to home entertainment applications. There will be theatres, teleconferences and other professional applications for which a variety of displays for HDTV will have to be developed to meet specific requirements for each application.

Bringing large-sized flat panel type displays into practical reality is indispensable for wider acceptance of HDTV. Recent announcements include NHK Laboratories' plasma panels and RCA's flat CRTs. Developmental MDS (Matrix Drive and Deflectiona Systems) type flat CRT panels have been demonstrated by Matsushita Electric Industrial Co., Ltd. These announcements suggest future possibilities for direct view screen sizes of 40 inches or larger, though it would be not easy to bring picture quality competitive with that of conventional CRTs.

For the time being, direct view CRT type and CRT projection type displays will continued efforts in research and development of displays for HDTV will be paid with objectives of coming up with a more pratical answer to future needs.

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The authors wish to thank to all members who co-operated with their development works of high-definition picture displays.

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Natl. Conv. of ITE Japan 12-5. 1983.

10) Y. Suzuki et al., "40-inch CRT Display"
ED 832, Vol.8, No.39, ITE Japan, Dec. 1984.

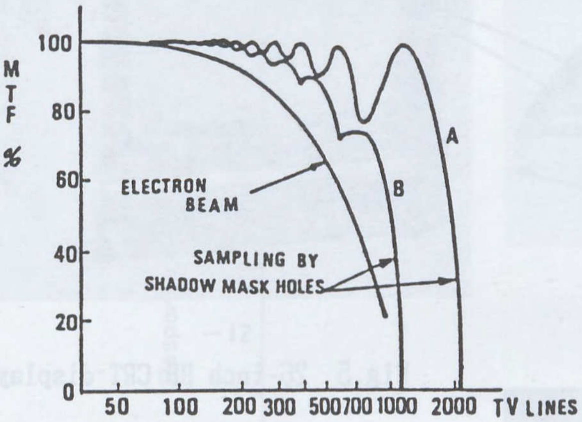


Fig.1 MTF of 22-inch HD color CRT.

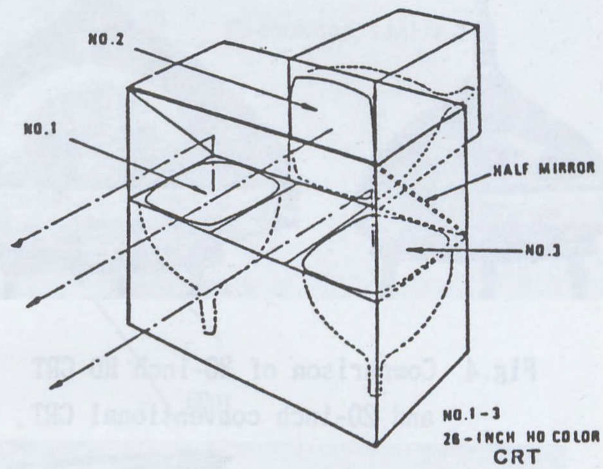


Fig.2 Structure of a three-CRT display.

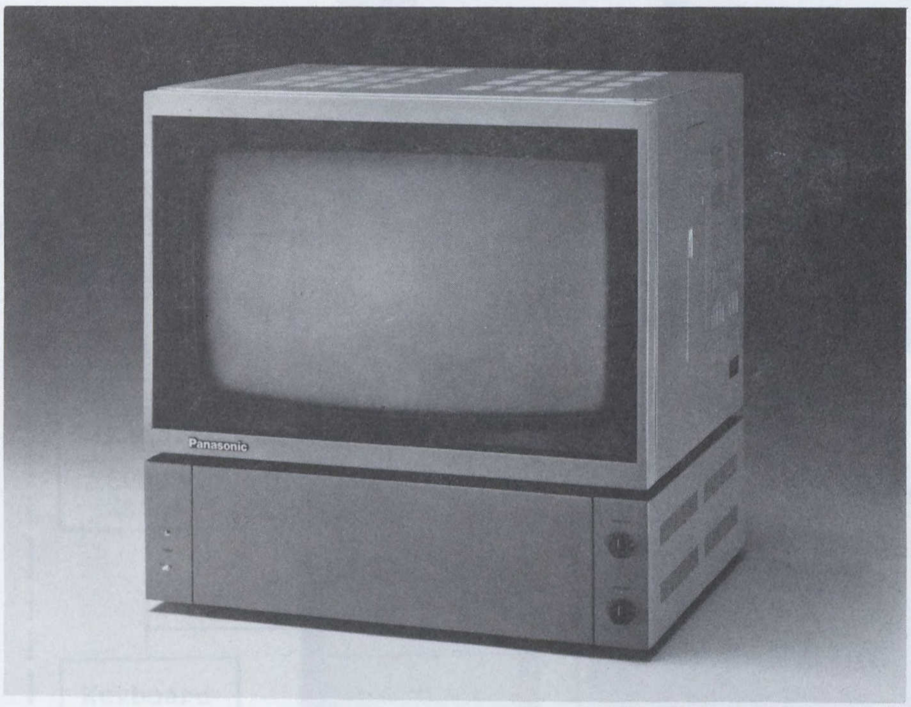


Fig.3 30-inch HD CRT display.

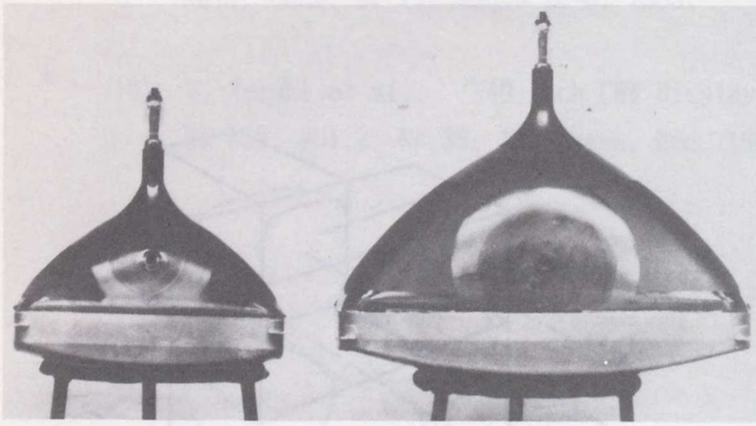


Fig.4 Comparison of 30-inch HD CRT and 20-inch conventional CRT.

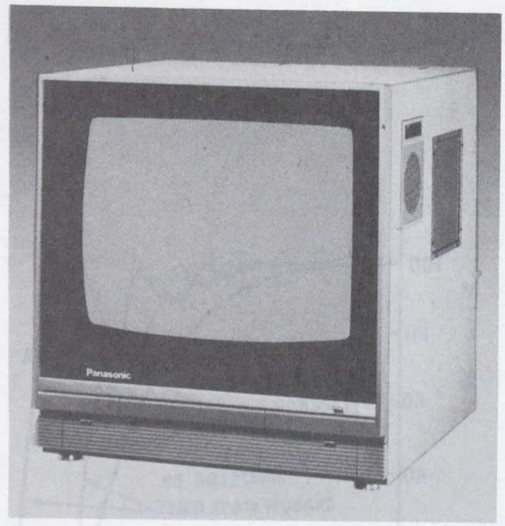


Fig.5 26-inch HD CRT display.

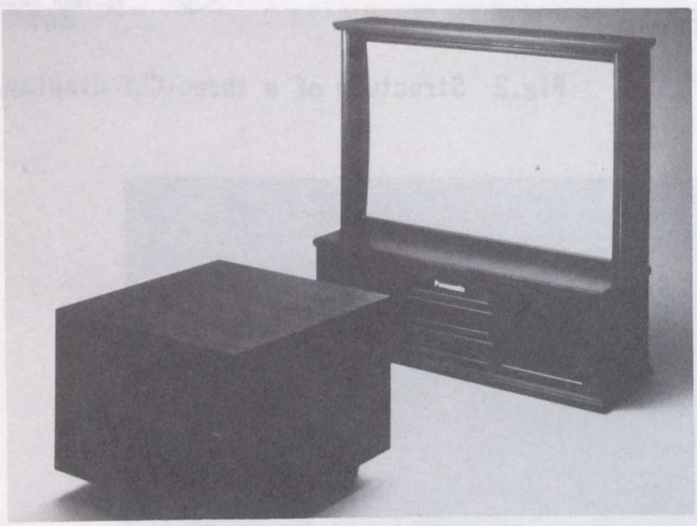


Fig.6 55-inch HD projection display.

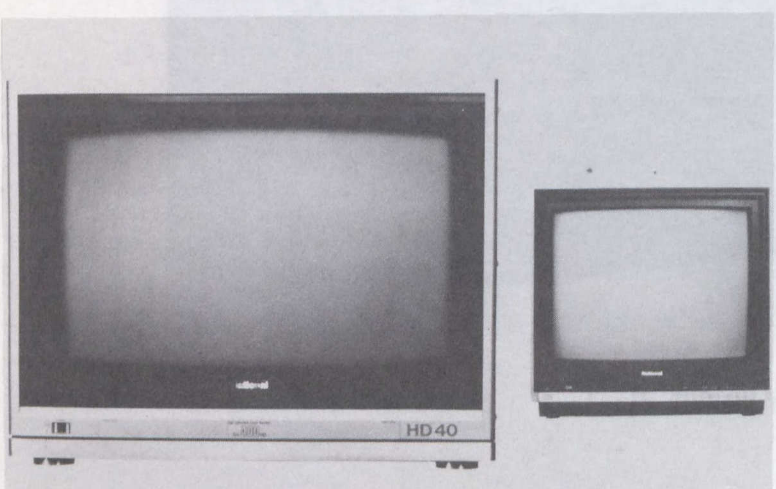


Fig.7 Comparison of 40-inch HD CRT display and 20-inch conventional display.

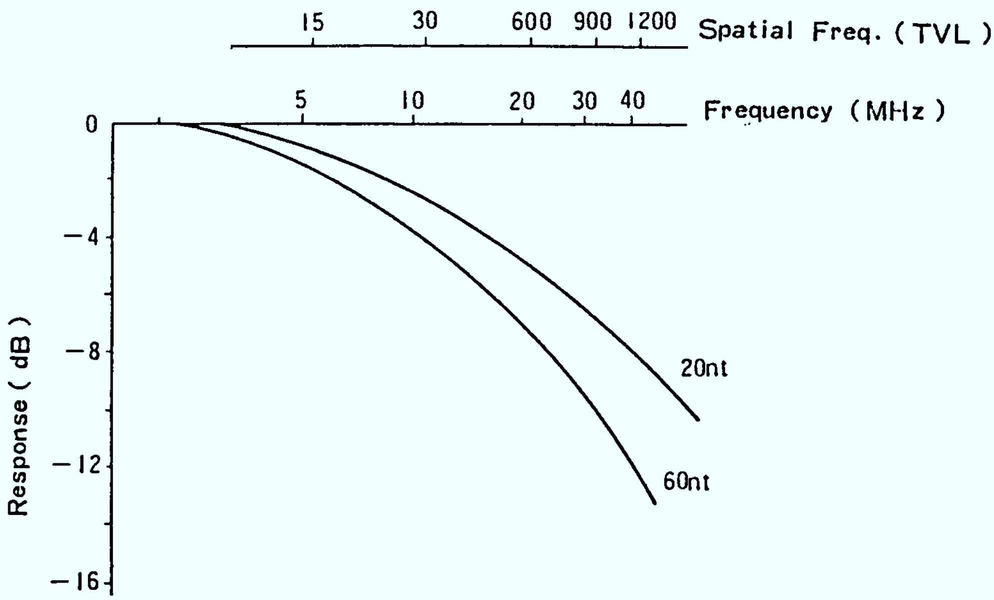


Fig.8 Response characteristics of 40-inch CRT.

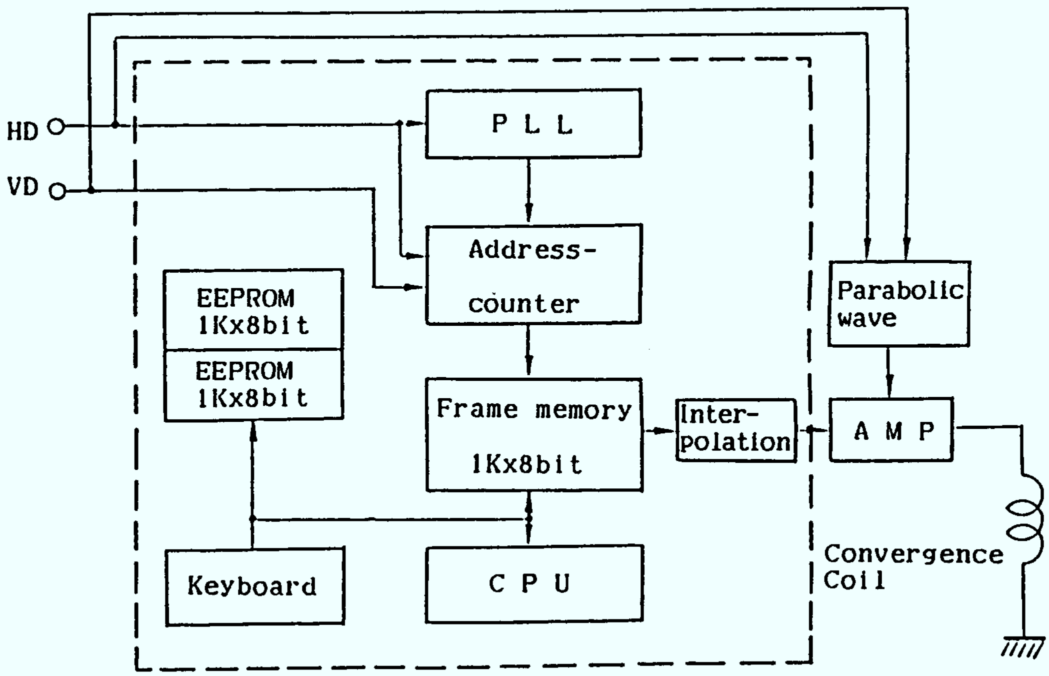


Fig.9 Block diagram of digital convergence.

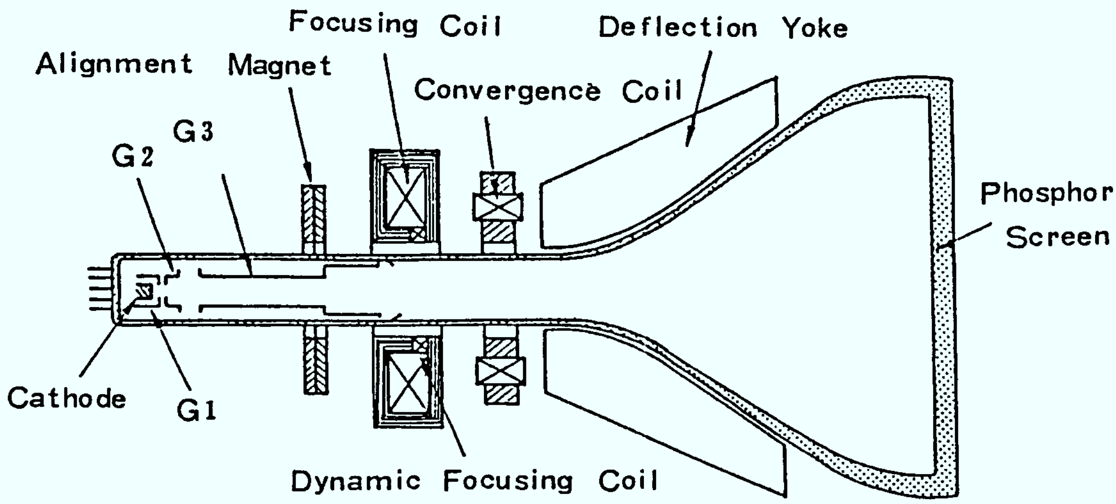


Fig.10 Structure of magnetic focusing projection tube.

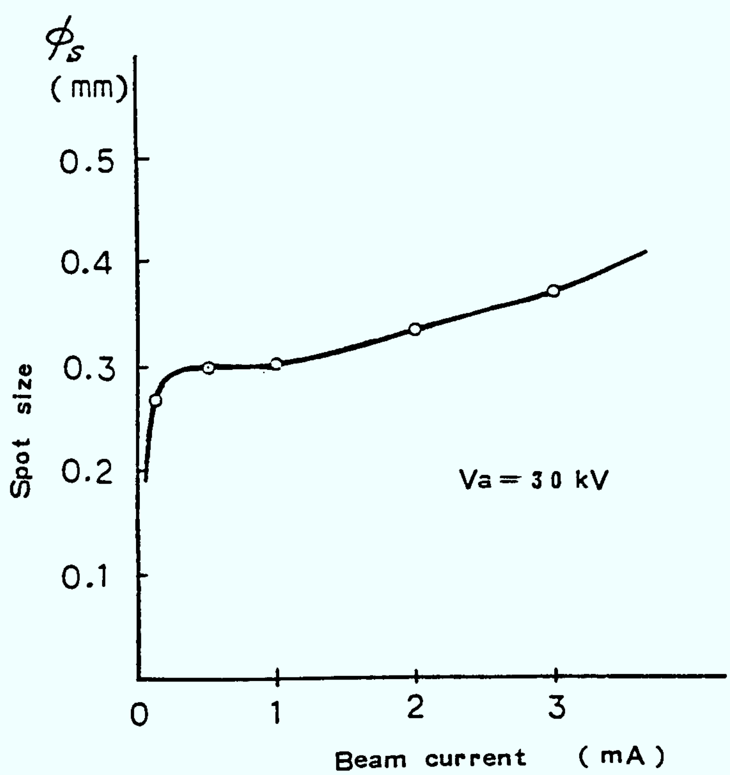


Fig.11 Spot size of 12-inch projection tube.

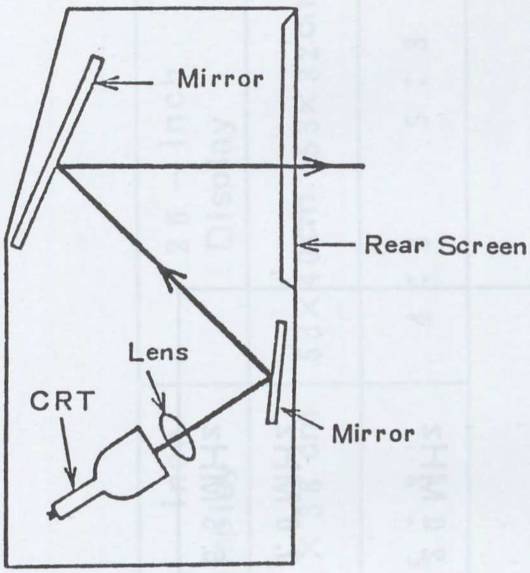


Fig.12 Structure of rear projection.

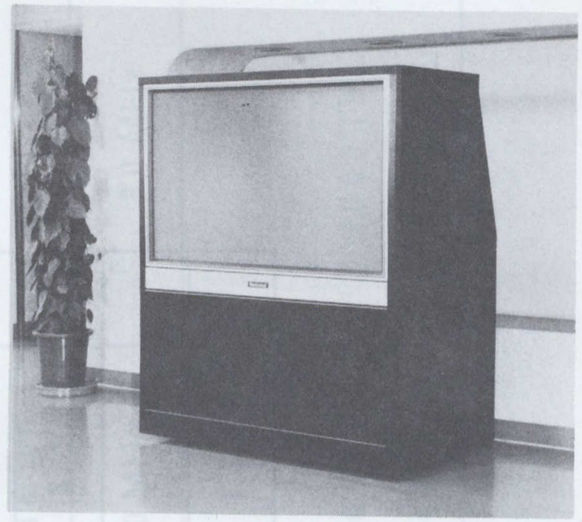


Fig.13 55-inch rear projection display.

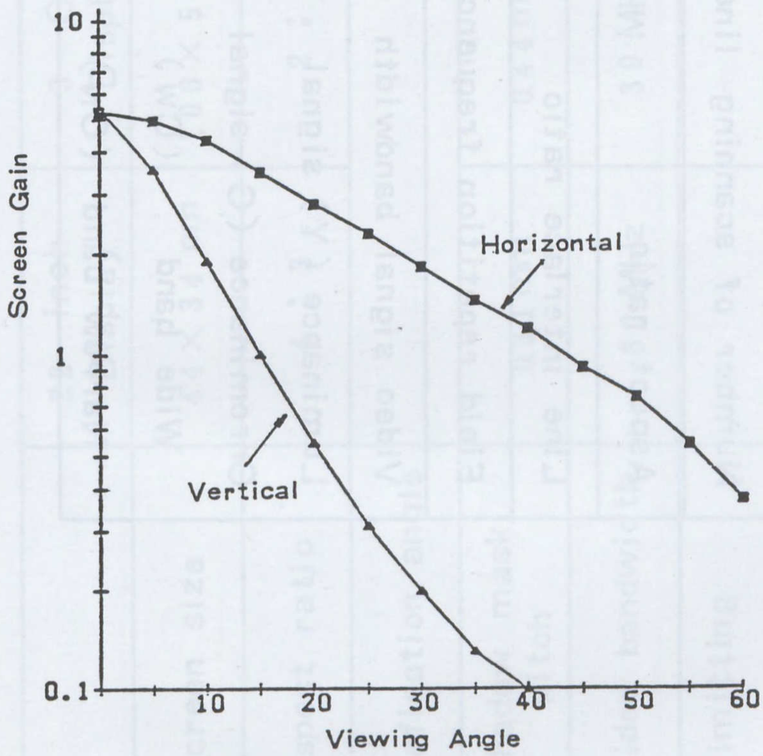


Fig.14 The screen gain vs. viewing angle characteristics of rear screen.

Table 1 NHK's provisional standards for HDTV

Number of scanning lines	1,125
Aspect ratio	5 : 3
Line interlace ratio	2 : 1
Field repetition frequency	60 Hz
Video signal bandwidth	
Luminance (Y) signal	20 MHz
Chrominance (C) signal	
Wide band (Cw)	7.0 MHz
Narrow band (CN)	5.5 MHz

Table 2 Specifications for high-definition CRT display

	22 - inch Display	3 - CRT Display	30 - inch Display	26 - inch Display	
Screen size	44 × 34 cm	100 × 50 cm	64 × 38 cm	53×40cm	53×32cm
Aspect ratio	4 : 3	2 : 1	5 : 3	4 : 3	5 : 3
Deflection angle	90 degree				
Shadow mask pitch	0.31 mm	0.44 mm	0.34 mm	0.36 mm	
Video bandwidth	30 MHz	30 MHz	30 MHz	30 MHz	
Limitting resolution					
Horizontal	1,000 TVL	1,000 TVL	1,000 TVL	1,000 TVL	
Vertical	750 TVL	750 TVL	750 TVL	750 TVL	

Table 3 Specifications for high-definition projection display

	55-inch Schmidt system	55-inch refraction sysem
Method of projection	Schmidt lens system	Refractive lens systm F/f = 1.4/136 mm
Light sources	Projection CRT × 3 (with Schmidt lens)	7 - inch CRT × 3 (55 degree deflection)
Screen size	120 × 71 cm	
Applicable viewing angle Horizontal Vertical	 ± 30 degree ± 10 degree	 ± 60 degree ± 10 degree
Video bandwidth	30 MHz	30 MHz
Limitting resolution Horizontal Vertical	 800 TVL 750 TVL	 800 TVL 750 TVL

Table 4 Specifications for recently developed displays

type		Direct View CRT	Front-projection	Rear-projection
		40-inch type	110-inch type	55-inch type
Picture Size (5:3)		83×49 cm	240×145 cm	120×71 cm
CRT	Size Deflection Angle	40 inch 36.5 mm 90 degree	12 inch × 3 29.1 mm 90 degree	7 inch × 3 29.1 mm 70 degree
	Focusing Anode Voltage	electrostatic 32 kv	electromagnetic 30 kv	electromagnetic 30 kv
Brightness (at peak white)		150 cd/m²	170 cd/m² (Gs = 10)	330 cd/m² (Gs = 5.4)
Screen		shadowmask pitch: 0.45 mm	curved screen	flat screen
Projection lens			F: 1.45/265 mm	F: 1.2/143 mm
Horizontal resolution		1,000 TVL	1,000 TVL	1,000 TVL
Convergence		Digital+Analogue	Digital	Digital

Table 5 Specifications for 40-inch CRT

1. Dimension	
Glass bulb	1,013 mm (diagonal) (40 inch)
Length	775 mm
Neck	36.5 mm dia.
Deflection angle	90 degree
Weight	90 kg
2. Phosphor screen	
Picture size	940 mm
Aspect ratio	5 : 3
Phosphor dot	Delta (Black matrix)
Dot-trio pitch	0.46 mm
Phosphor	P22
3. Electorical spec.	
Heater voltage	6.3 v (0.57 A)
Anode voltage	32 kv

USING A VIDEODISC AS A MEDIUM FOR HIGH-RESOLUTION FIXED IMAGES

Bahman Nabati

Centre Mondial Informatique et
Ressources Humaines

2.12

ABSTRACT

Limited as they are to a spatial resolution of about one micron, the videodiscs that have so far been developed have a transmission bandwidth of less than 5 MHz.

While this is adequate for reproducing good-quality images that meet present commercial standards, it does not permit much higher resolutions to be achieved, such as those required for archival purposes for many documents (manuscripts, lithographs, prints...).

The author will describe the system that he developed at the Centre Mondial to overcome this limitation in the case of fixed images for which a number of tracks of a videodisc can be used to store information relating to a single document.

To achieve this, the initial image is broken down into elemental blocks of 170 kilobytes, each corresponding to the capacity of a low-resolution image.

These blocks are then reconverted into analog form and recorded on a tape, which is the medium capable of transferring them, as they are, onto a videodisc.

To restore the image to its original state, the process is reversed: selection of partial images, digitalization, memorization, reconstruction and analog reconversion.

At each stage, the information stored in the memory is limited to the useful part of the image, excluding synchronization signals.

The model that will be described pertains to a 1,125 line monochrome image that uses six tracks of a LASERVISION videodisc. The same principle could be applied to colour images and to much higher resolutions.

UTILISATION D'UN VIDÉODISQUE COMME SUPPORT D'IMAGES FIXES DE HAUTE RÉSOLUTION

Bahman Nabati

2.12

Centre Mondial Informatique et Ressources Humaines

RÉSUMÉ

Limités qu'ils sont à une résolution spatiale voisine du micron, les vidéodisques développés à ce jour ont une bande passante inférieure à 5 MHz.

Cette performance, suffisante pour la restitution d'images de bonne qualité aux standards commerciaux actuels, ne permet pas d'atteindre des résolutions nettement supérieures, comme celles qui sont réclamées par l'archivage de nombreux documents (manuscripts, lithographies, gravures...).

L'auteur décrira le dispositif qu'il a réalisé au CENTRE MONDIAL pour dépasser cette limitation dans le cas d'images fixes pour lesquelles plusieurs spires d'un vidéodisque peuvent être utilisées pour le stockage des informations relatives à un même document.

A cette fin, l'image initiale est d'abord digitalisée pour être décomposée en blocs élémentaires de 170 koctets, compatibles chacuns avec la capacité d'une image de basse définition.

Ces blocs sont reconvertis ensuite sous forme analogique puis enregistrés sur une bande magnétique qui est le véhicule capable de les transférer tels quels sur un vidéodisque.

La restitution est effectuée par le processus inverse: sélection des images partielles, digitalisation, mémorisation, reconstruction et re-conversion analogique.

A chaque stade, les informations stockées en mémoire sont limitées aux seuls parties significatives de l'image, à l'exclusion des signaux de synchronisation.

La maquette qui sera décrite est relative à une image monochrome de 1.125 lignes, occupant 6 spires d'un vidéodisque LASERVISION. Son principe vaut aussi pour des images couleurs et des résolutions beaucoup plus élevées.

UTILISATION D'UN VIDEODISQUE COMME SUPPORT D'IMAGES FIXES DE HAUTE DEFINITION

2.12

Georges BROUSSAUD
Bahman NABATI

CENTRE MONDIAL INFORMATIQUE ET RESSOURCE HUMAINE

1- IDEES DIRECTIVES

Jusqu'à un passé récent, la conservation du patrimoine culturel en est restée, pour l'essentiel, aux concepts et aux méthodes des siècles passés, à savoir la consultation locale directe des objets (manuscrits, livres, tableaux...) qui composent les collections.

Pour des raisons technologiques évidentes, le patrimoine "dynamique" des sons et des images animées est resté longtemps hors de la mission des Bibliothèques et des Musées, de même que la téléconsultation de leurs archives.

Or il est de fait que l'importance croissante des collections (7 kilomètres linéaires par an à la Bibliothèque Nationale de Paris) pose de très difficile problèmes de stockage et d'accès. Si l'on veut bien considérer aussi que la dégradation naturelle des supports classiques commence dès maintenant à poser problème, force est de convenir qu'il importe de trouver, dans l'arsenal des technologies modernes, de nouveaux modes de stockage, mieux adaptés que leurs devanciers à la conservation et à la diffusion du patrimoine culturel.

Et c'est tout naturellement vers l'électronique que l'on va se tourner pour cela.

2- INTERET DU VIDEODISQUE

Conçu à l'origine (vers la fin des années 60) comme un nouveau véhicule de diffusion domestique de programmes linéaires conventionnels, du type films de cinéma, le vidéodisque a rapidement dépassé ses objectifs initiaux pour atteindre de nouveaux domaines de la communication, inenvisageables avant lui.

Rappelons-en ici quelques unes de ses caractéristiques essentielles.

1. Un vidéodisque c'est, d'abord, une mémoire de masse dont la densité de l'information stockée dépasse d'un facteur 30 celle de ces compétiteurs magnétiques les plus performants.

2. C'est aussi, fondamentalement, une mémoire d'image exceptionnelle autant par ses facilités de lecture et d'accès que par son aptitude à la téléconsultation.

3. C'est enfin, la mémoire la plus apte à assurer la pérennité de son contenu.

En contre partie, les images stockées sur un vidéodisque conventionnel (il y en a 54000 sur chacune de ses faces) sont limitées en définition à celle de la télévision commerciale, qui est de 575 lignes utiles au standard Europe, et 485 lignes au standard américain.
Acceptable lorsqu'il s'agit d'image animées courantes, cette définition s'avère bien souvent insuffisante dans le cas d'images fixes, et tout spécialement dans le cas de gravures, de photographies ou des tableaux.

Il est heureusement possible de pallier cet inconvénient en distribuant sur plusieurs images du vidéodisque (chaque image occupe une spire) le contenu d'une seule image fixe de plus haute définition. Naturellement, la capacité globale du disque restant inchangée, le nombre d'images ainsi stockées se trouve réduit d'autant; mais, disposant 54000 spires par face, le nombre de document qui peuvent ainsi trouver place sur un disque reste néanmoins impressionnant.

3. VIDEODISQUE HAUTE DEFINITION

Les figures 1 et 2 sont la description schèmatique du dispositif conçu au CENTRE MONDIAL, dont une maquette probatoire a permis de vérifier la parfaite validité opérationnelle.

La figure 1 est relative à l'enregistrement.
La partie gauche regroupe les fonctions analogiques, économe en bande passante et qui permettent de ce fait une densité de stockage importante.
La partie droite est significative des fonctions logiques, mieux adaptées au traitement de l'information.

3-1 Enregistrement

L'image de haute définition, par exemple 1.125 lignes et 15 MHz de bande passante, est d'abord convertie sous forme numérique puis débarassée de ses éléments non significatifs et stockée enfin sur une mémoire vive (RAM) de 900 Kilooctets seulement. La mémoire est organisée en 6 blocs de 150 Kilooctets chacun, dont le contenu informationnel est significatif d'une image de télévision standard, que nous qualifirons désormais "basse définition". Chacun de ces blocs est retranscrit ensuite en analogique, sous la forme d' "image" de basse définition (625 lignes), et de 3 MHz de bande passante. (Le mot image a été écrit entre guillemets pour indiquer que l'entité informationnelle correspondante n'aura pas, obligatoirement, de signification visuelle directement interprétable sur un écran de télévision). Ainsi dispose t-on de 6 "images" aux normes usuelles, que l'on peut enregistrer successivement sur une bande magnétique, exactement comme s'il s'agissait d'image normales de télévision.

A chaque image de haute définition, on a fait correspondre ainsi une séquence de 6 "images" de basse définition dont le report sur le vidéodisque peut être effecué sans aucun problème, aux norme maintenant bien définis du standard LASERVISION.

3-2 Lecture

Le disque une fois pressé et son contenu répertorié spire par spire, l'ordre est donné au lecteur d'aller rechercher telle séquence de 6 "images" de basse définition correspondant à une image de haute définition déterminée.

ces "images" élementaires sont lues comme des images normales, et leurs contenus respectifs convertis successivement en un signal numérique fait de 6 blocs de 150 Kilooctets chacun qui prennent place sur une mémoire électronique convenablement dimensionnée.

Ces blocs sont analysés alors 25 fois par second et leur contenu global converti à nouveau en un signal analogique (1.125 lignes, 15MHz), directement adressable sur un moniteur de haute définition.

3-3 Description générale

La figure 3 montre le schèma synoptique général du système.

Le même appareil peut être utilisé à la fois pour la saisie des images hautes définitions et pour leur reconstitution.

3-3-1 Saisie haute définition

Dans la position 1 (mode haute définition) du commutateur électronique K, c'est l'image de l'analyseur qui passe par le convertisseur analogique numérique (CAN), lequel reçoit l'horloge d'échantillonnage adéquate.

La commande de mémorisation est envoyée manuellement à travers le clavier du micro-ordinateur. La mémorisation dure 40 ms à partir de la première synchro trame paire détectée.

Après la mémorisation le commutateur reste sur la position initiale et l'image haute définition est visualisée sur l'écran HD.

3-3-2 Enregistrement magnétique

Dans la position 2 (mode basse définition) la mémoire passe en mode lecture basse définition. Son contenu peut être lu de deux manières différentes:

1-Lecture récursive de la séquence de 6 "images".

Dans ce cas, l'enregistrement de la séquence de 6 "images" sur la bande magnétique peut se faire d'un coup, à condition qu'une synchronisation stricte entre le début de la séquence de 6 "images" et l'instant de l'enregistrement soit établi. Ceci est une opération très difficile à cause du temps de "prerol" du magnétoscope.

2- Lecture "image" par "image".

Dans ce cas l'enregistrement se fait image par image à l'aide d'une programmation apropriée. Aucune synchronisation n'est nécessaire, mais le temps d'enregistrement est très long (environ 1 minute par image HD. Toujours à cause du temps de "prerol" du magnétoscope).

Une troisième solution au mode opératoire simplifié peut également être envisagée.Elle consiste à enregistrer au hasard deux séquences successives de 6 "images". Ainsi au moment du montage de la bande Mère, il est possible de repérer une séquence complète ordonnée. Ceci exige malheureusement l'utilisation d'une génération supplémentaire.

3-3-3 Restitution haute définition

Dans la position 2 du commutateur K, le système est prêt pour recevoir le signal sortant du lecteur de vidéodisque ou de toute autre source au même standard (625 lignes). Le micro-ordinateur envoie l'ordre au vidéodisque de rechercher la séquence N et de se mettre en mode de lecture (play). La mémoire passe en mode d'écriture à partir de la première synchro trame paire rencontrée. Le CAN reçoit le signal d'échantillonnage adéquat et les 6 "images" ainsi analysées seront stockées successvivement à des endroits pré-determinés de la mémoire. Après la mémorisation, le système passe automatiquement en mode HD, et l'image de la séquence demandée sera visualisée sur le moniteur haute définition (une lecture de la mémoire 25 fois par seconde).

Remarques:

1- pour simple qu'il soit dans son principe, le "processus total" décrit ci-dessus n'en implique pas moins de 4 conversions (analogique/numérique et numérique/analogique) et plusieurs transferts. De nombreuses précautions doivent donc être prises pour que le racord des "images" partielles sur l'image restituée globale ait lieu au pixel près, sans que rien ne puisse rappeler sa décomposition initiale.

2- pour des raisons de commodité à court terme, la source d'image utilisée à ce jour a été une caméra Siemens type K100 dont fréquence d'analyse des images est de 25 Hz. Du fait que nous nous intéressons seulement à des images fixes, cette caractéristique constitue une difficulté supplémentaire, puisqu'elle oblige à effectuer la digitalisation du signal à une fréquence de 30 MHz, ce qui exige l'emploi de composants coûteux et sensiblement moins performants que leurs homologues fonctionnant à plus basse fréquence.

Les prochaines versions de notre système utiliseront, au lieu d'une caméra, un analyseur d'image fixe (AIF), construit autour d'une barette CCD de 2048 points par ligne, et dont la fréquence d'analyse verticale à 3 Hz n'exigera pas des circuits d'échantillonnage une fréquence supérieur à 6,75 MHz.

3-4 Cas particulier des images en couleur

Dans tout ce qui précède, nous avons implicitement admis que l'on avait à faire à des images monochromes.

Le cas des images couleurs s'en déduit aiseément:

A l'enregistrement, le document original est exploré 3 fois, chacune de ces passes successives correspondant à l'une des 3 couleurs fondamentales qui sont le rouge, le vert et le bleu.

Trois images numérisées qui sont ainsi dérivées de l'image originale, seront stockées dans 3 mémoires distinctes (ce qui conduit à multiplier par 3 la capacité des plans de mémoires qui reçoivent les blocs élémentaires significatifs des "images" de basse définition).

La conversion des blocs numériques en "images" de basse définition analogiques est effectuée de façon à délivrer au magnétoscope des signaux codés PAL, ou SECAM, ou NTSC, qui rassemblent à l'intérieur de la même bande passante la totalité des informations indispensables à la reconstitution des trois composantes chromatiques d'une image couleur.

De cette façon, 6 spires du disque suffisent à l'enregistrement d'une image couleur de 1.125 lignes, comme c'était le cas pour une image Noir et Blanc.

A la lecture le mode opératoire inverse permet de remonter la chaîne des opérations précédentes.

Chacune des séquences de 6 "images" couleur de basse définition est lue séquentiellement, décodée en ses 3 composantes primaires (R,V,B), puis stockée à l'endroit imparti dans les plans de mémoire.

Trois convertisseurs Numérique/Analogique transforment les signaux numériques provenant des 3 plans de mémoires en signaux analogiques, lesquels sont directement adressables sur les entrées R,V et B d'un moniteur haute définition.

3-5 Considérations générales

Le système esquissé ci-dessus, qui est celui actuellement en démonstration en version monochrome, constitue seulement un exemple de mise en oeuvre du principe général qui est à la base de ce procédé.

En distribuant l'image sur davantage de spires du disque, il est facile d'augmenter sa définition, qui n'est limitée que par les performances des systèmes de prise de vue et de visualisation.

Dans l'état actuel de la technologie des tubes "couleur", il ne semble pas que l'on ait de réel avantage à aller au delà des 1.125 lignes de l'actuel prototype.

Mais si l'on devait se limiter à des images Noir et Blanc, il n'y aurait pas de difficulté à pousser jusqu'à 2.000 lignes, et un autre projet est en cours de réalisation qui traitera des images à 1.691 lignes, dont 1.641 seront effectivement affichées sur l'écran.

4- DISQUE OPTIQUE NUMERIQUE VS VIDEODISQUE

Dès lors que l'ensemble du traitement proposé a lieu sur des images numériques, la question vient tout naturellement à l'esprit de savoir s'ils ne serait pas plus coherent de renoncer au vidéodisque (analogique) au profit de son dérivé numérique qui vient de commencer sa carrière commerciale .

Les considérations qui suivent montrent qu'il n'en est rien.

4-1 Caractéristiques

Les disques optiques numériques (désignés en France sous le sigle DON) ont été dévelopés pour satisfaire aux exigences de l'archivage en général et de bureautique en particulier.

Conçus comme des périphériques d'ordinateur, ils possèdent en outre les caractéristiques suivantes:

(i) ils sont inscriptibles par l'utilisateur,
(ii) ils sont organisés en pistes et en secteurs,
(iii) ils exigent l'utilisation de codes auto-correcteurs qui permettent de passer des quelques 10E-5 qui mesurent leur taux d'erreur intrinsèque aux 10E-12 indispensables au traitement numérique des données.

D'où un certain nombre de contraintes relatives notamment:

(i) à la complexité et au coût de ces machines qui n'ont d'ailleurs pas encore entamé leur carrière industrielle,
(ii) à une réduction de 20% de leur capacité pour y loger les adresses de chacun des différents secteurs,
(iii) à une réduction de 10% supplémentaire qui est le prix payé pour la protection apportée par l'emploi d'un code auto-correcteur.

4-2 Capacité

Dans les conditions décrites ci-dessus, la capacité utile d'un DON de 30 centimètre de diamètre est de l'ordre de 1 Gigaoctets.

A raison de 1.200 Kilooctets par image de haute définition, ce disque est donc limité au stockage de 833 clichés.

Encore ne s'agit-il là que des images monochromes.

Sauf à disposer, de moyen techniques, capables de réduire le nombre d'informations à enregistrer (ce point va être abordé plus loin), l'enregistrement d'une image couleur exige l'enregistrement successif de ses 3 composantes chromatiques élémentaires.

De sorte que la capacité d'un DON se trouve réduite à 277 images couleurs (32 fois moins que sur le vidéodisque haute définition précédemment décrit).

La décomposition d'une image polychrome en ses 3 composantes primaires, si elle conduit à une représentation satisfaisante de l'image initiale, est une solution excessivement rigoureuse puisqu'elle conduit à traiter davantage d'informations élémentaires que l'oeil humain ne peut en percevoir sur le document en question. Ceci du fait que la résolution chromatique de notre rétine est sensiblement inférieure à sa résolution photométrique globale.

C'est le souci de limiter la bande passante du signal vidéo au strict minimum utile à la perception d'une image couleur qui a conduit des techniciens de la télévision à définir des systèmes de codage (NTSC, PAL ou SECAM) qui dissocient la fonction luminance de la fonction chrominance. Avec comme caractéristique essentielle de n'affecter à la chrominance que la moitié (voire le quart) de la bande passante allouée à la luminance qui représente la version Noir et Blanc de l'image ainsi codée.

En allouant la moitié de la bande passante du signal luminance aux signaux "différence couleur" (DR et DB), on peut déjà réduire de moitié la place en mémoire nécessaire pour stocker ces signaux, sans pour autant trop compliquer la réalisation du système. Ainsi la capacité de stockage des images couleurs (1125 lignes) sur le disque optique numérique peut-elle être ramené 416 images par face.

On peut aussi envisager d'autres procédés de codage mettant à profit la correlation spatialo-temporelle des images pour éliminer une certaine quantité de redondance sur celles-ci, et par la suite gagner davantage de place sur le DON. Mais ceci étant au prix d'une complexité énorme du système et d'une augmentation considérable du coût de revient.

En tout état de cause, la capacité d'un DON en image restera toujours nettement inférieur à celle de son homologue analogique.

4 -3 Temps d'accès

Le temps d'accès à l'image sur un vidéodisque est composé de 2 termes :

1- un temps d'accès "mécanique" qui est relatif au temps de positionnement radial de la tête de lecture.

2- un temps d'accès "électrique" qui est relatif à la lecture de l'image enregistrée.

Les DON ont un temps d'accès "mécanique" moyen de 0,2 seconde qui est beaucoup plus court que celui des disques analogiques (4 secondes).

Le temps d'accès "électrique" est fonction du débit de la tête de lecture. Par exemple le Gigadisc de THOMSON a un débit maximum de 3,83 Megabits (utiles)/seconde. Ainsi le temps d'accès "électrique" à une image monochrome sera de l'ordre de 2,5 secondes. Contre 240 milisecondes (6 fois 40 ms) pour celui du vidéodisque haute définition.

Sur une image couleur, si aucune compression n'est envisagée, ce temps atteint 7,5 secondes pour le DON, tandis qu'il est inchangé pour le vidéodisque haute définition, si l'on mémorise simultanément les 3 composants R,V et B (utilisation de 3 C.A.N. en paralèlle).

Mais pour réduire le coût de revient du système, il est préférable d'analyser 3 fois chaque "image" et mémoriser séquentiellement ses 3 composantes. Le temps d'accès "électrique" est alors 0,72 seconde, soit encore 10 fois moindre que celui d'un DON.

4-4 Coût

Le prix d'un système de DON est environ 150.000 francs, contre 6 à 10.000 francs pour un lecteur de vidéodisque analogique doté de toutes les fonctions nécessaires à l'utilisation qui en est proposée comme sources d'images de haute définition.

A quoi il faut ajouter le prix du décodeur, constitué essentiellement d'une mémoire d'image et d'un convertisseur analogique/numérique (CAN).
A l'exclusion du CAN, il n'y a pas à priori, de raison pour que cette interface diffère sensiblement avec la solution adoptée (DON ou vidéodisque analogique).

5-CONCLUSION

Nous avons, en cours des pages qui précédent, abordé des différents problèmes posés par le recours à l'image électronique pour le stockage du patrimoine culturel et nous avons été conduit à privilégier le vidéodisque de haute définition comme banque d'images.

Comparé à son dérivé numérique (le DON), le vidéodisque analogique permet en effet un gain de 30 sur le nombre d'images stockées.

Il permet aussi le recours à des matériels éprouvés et relativement peu coûteux dont le signal de sortie peut être acheminé sur tous les canaux traditionnels de la télévision comerciale.

Sur la maquette qui a été réalisée par le CENTRE MONDIAL, 6 spires du disque ont été utilisées pour répartir sur 6 "images" de basse définition, de 3 MHz chacune de bande passante, la totalité de l'information contenue dans une image de haute définition.
Ce choix, qui n'utilise pas la pleine largeur de bande disponible sur le vidéodisque, résulte de l'emploi d'un magnétoscope 3/4 pouce comme vecteur du signal analogique codé.

Avec un magnétoscope au standard prfessionnel d'un pouce la bande passante des "images" peut être portée à 4 MHz, de sorte que 4 spires du vidéodisque suffisent alors au stockage de chacun des documents enregistrés.

Ainsi la capacité du vidéodisque se trouve t-elle portée à 13.500 images fixes de 1.125 lignes par face, au lieu de 9.000 précédemment.

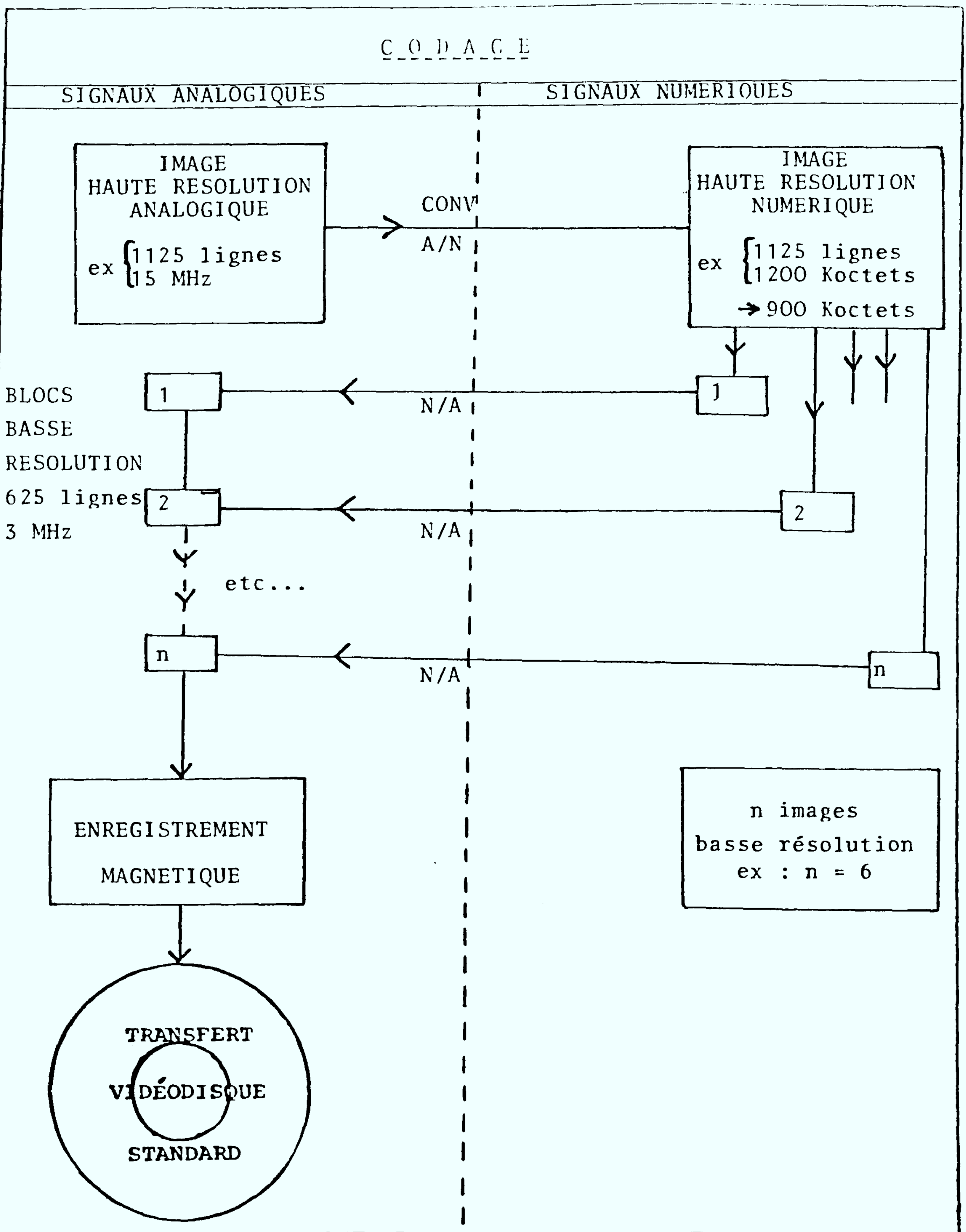
Cette densité accrue du support disque peut être mise à profit pour en faciliter l'accès.

Si une 5éme spire est utilisée pour l'enregistrement basse définition (625 lignes) de tous les documents réunis sur le disque, il est possible de charger le décodeur de 4 quelconques

l'itinéraire des visiteurs à l'intérieur d'une banque d'images donnée.
Un dialogue est alors possible au travers des touches réelles ou virtuelles directement associées à l'écran.

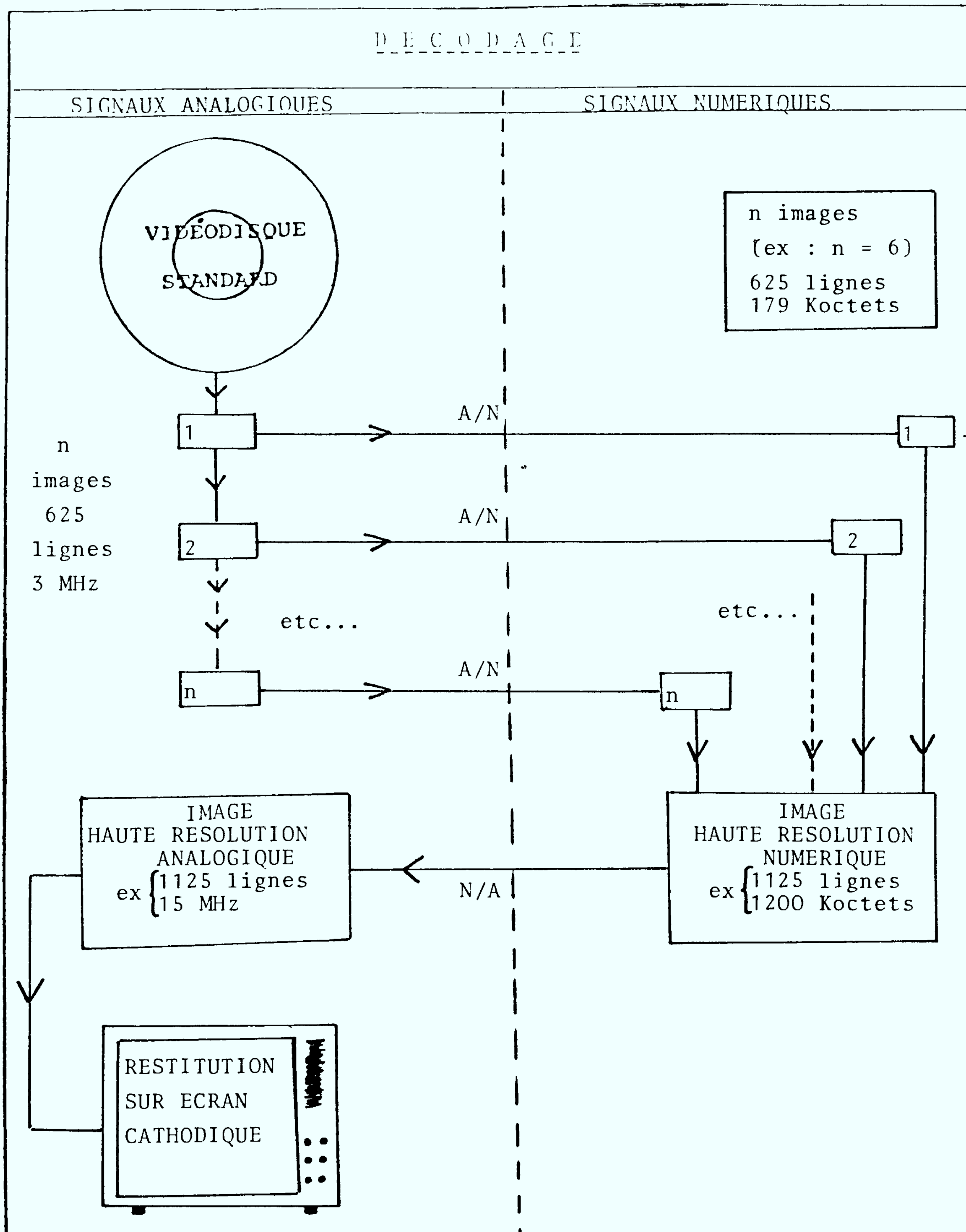
Dans cette condition, la capacité d'une face d'un vidéodisque serait de 10.800 images, avec un temps d'accés moyen égal à 4 secondes qui est appelé à être réduit de moitié sur les lecteurs institutionnels de second génération.

Ajoutons enfin, pour conclure, que le mêm disque peut contenir aussi des séquences animées de basse définition, et qu'il n'y a pas de difficulté de principe à disposer de moniteurs bi-standards à commutation automatique, comme il en existe déjà pour les différents standards exploités commercialement.



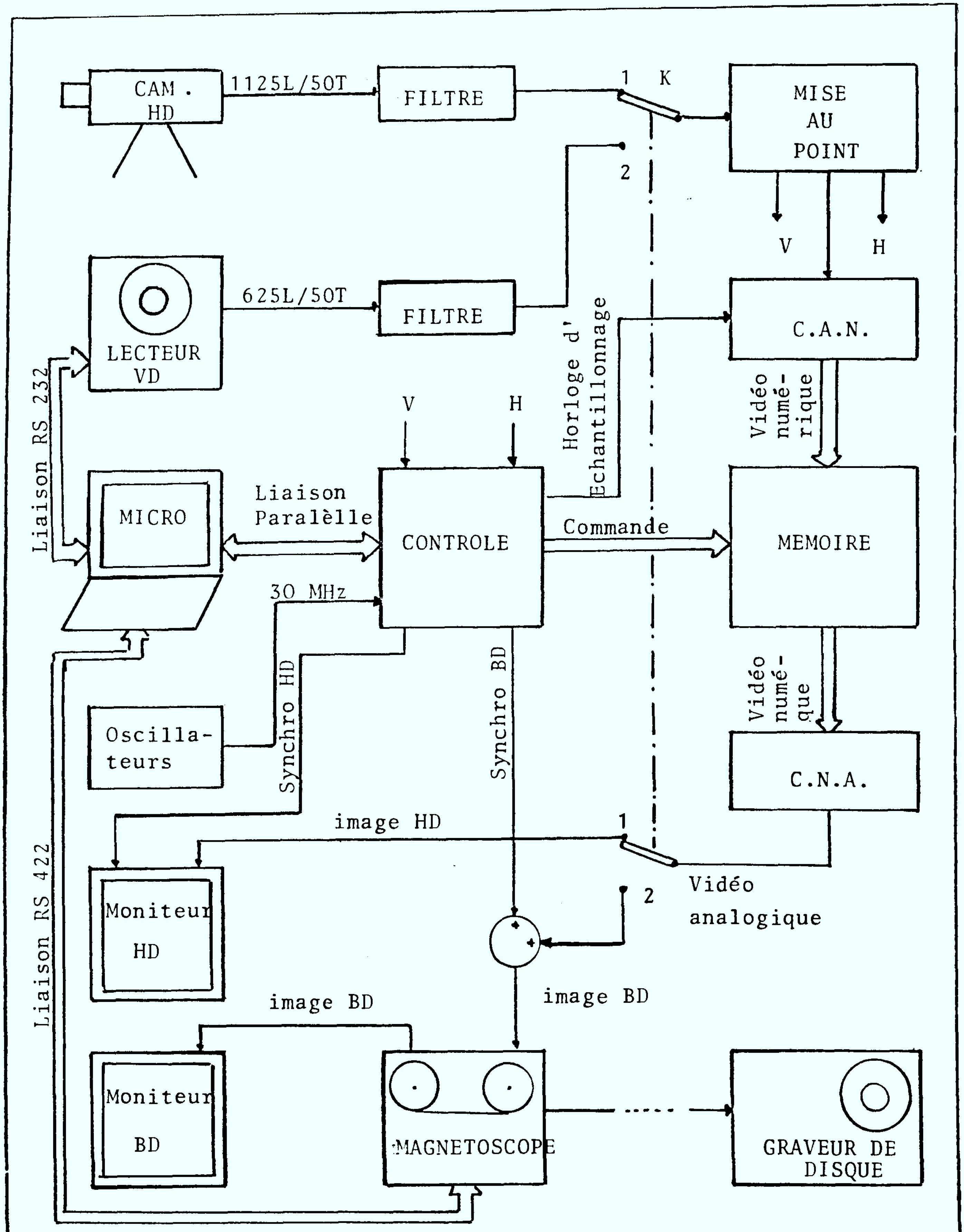
N = numérique - A = analogique

FIGURE 1



N = numérique - A = analogique

FIGURE 2



SYNOPTIQUE DU SYSTEME

FIGURE 3

A SCANNING SCHEME FOR A NEW HDTV STANDARD

3.3

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ABSTRACT

The progress of VLSI-techniques and digital signal processing makes feasible television systems with pre- and postprocessing, by this obtaining higher picture quality. Therefore, there are good reasons to think about a new HDTV standard taking into account the progress of signal processing for EDTV systems.

Results have been published on several proposals to improve picture quality such as

- progressive scan reproduction,
- vertical pre- and postfiltering,
- diagonal pre- and postfiltering.

By these methods impressive improvements of picture qualities can be achieved, which have been assessed by subjective tests comparing with the standard TV-system as well as with a high line number system.

As a main result it comes out that progressive scan reproduction is a powerful method to improve picture quality. Line flicker is overcome and the impression of resolution and sharpness is improved. This can be achieved by motion-adaptive progressive scan reproduction at the receiver end. But then there still remain heavy aliasing effects in moving picture parts due to the coarse line pattern of the field scanning. This can only be avoided by a progressive scan in the camera. Therefore, for a new HDTV standard field aliasing and the implementation cost for a motion controlled HDTV frame store can be avoided by a progressive scan production standard.

Another result out of the subjective tests is, that there is no Kell-factor for progressively scanned (natural) pictures. Therefore, to get a harmonic distribution of resolution, there is a demand for a higher horizontal resolution as it is in standard television systems. That means we need a bandwidth e.g. equal to the checkerboard frequency. This is a very important fact for a new HDTV standard.

Finally it was shown, that diagonal pre- and postfiltering is the best processing for a given video bandwidth or channel capacity. This is due to the fact, that diagonal processing is better matched to human eye and the distribution of contours in natural pictures.

From these results we can conclude that a new HDTV-standard could have the following properties

- progressively scanned signals
- harmonic resolution in horizontal and vertical directions,
- offset sampling and diagonal signal processing

This proposal will be presented at the conference.

SYSTÈME DE BALAYAGE POUR UNE NOUVELLE NORME TVHD

3.3

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RÉSUMÉ

Les progrès des techniques VLSI et des méthodes de traitement des signaux numériques rendent possibles des systèmes de télévision comportant le pré-traitement et le post-traitement, permettant ainsi une qualité d'image supérieure. Par conséquent, il est tout naturel de penser à une nouvelle norme TVHD qui tiendra compte des progrès du traitement des signaux pour les systèmes EDTV.

Des résultats ont déjà été publiés concernant plusieurs propositions pour améliorer la qualité de l'image, par exemple:

- balayage progressif de l'écran,

- pré-filtrage vertical et post-filtrage vertical,

- pré-filtrage diagonal et post-filtrage diagonal.

Ces méthodes permettent des améliorations appréciables de la qualité de l'image, d'après les évaluation qui ont suivi à l'aide de tests subjectifs comparant ces méthodes avec le système de télévision conventionel et un système de télévision comportant un grand nombre de lignes. Le principal résultat de ces tests confirme que la reproduction du balayage par lignes contigues (balayage progressif) constitue une puissante méthode d'amélioration de la qualité de l'image. Le scintillement des lignes est éliminé et l'impression de définition et de netteté est améliorée. Le résultat voulu s'obtient par reproduction du balayage par lignes contigues avec compensation de mouvement au récepteur. Mail il reste encore des effets de repliement importants dans les zones en mouvement en raison de la configuration grossière des lignes de balayage de trame. Cela ne peut s'éviter que par le balayage par lignes contigues à la caméra. Par conséquent, dans le contexte d'une nouvelle norme HDTV, il est possible d'éviter le repliement et les coûts d'implantation d'une mémoire de trame TVHD avec compensation de mouvement, en ayant recours à une norme de production de balayage par lignes contigues.

Les tests subjectifs ont également montré qu'il n'y a pas de coefficient Kell dans le cas des images (naturelles) balayées par lignes contigues. Par conséquent, pour obtenir une distribution harmonique de la résolution, une meilleure résolution horizontale est nécessaire comme dans le cas des systèmes de télévision conventionels. Cela signifie que nous avons besoin d'une largeur de bande égale à celle de la mire en forme d'échiquier. Il s'agit là d'un fait très important dont if faut tenir compte pour établir une nouvelle norme TVHD.

Finalement, il a été montré que le pré-filtrage diagonal et le post-filtrage diagonal constituent le meilleur traitement possible pour une largeur de bande vidéo donnée ou une capacité de canaux donnée. Cela est dû au fait que le traitement diagonal est mieux adapté à l'oeil humain et à la distribution des contours des images naturelles.

A partir de ces résultats, nous pouvons conclure qu'une nouvelle norme TVHD pourrait comporter les caractéristiques suivantes:

- signaux balayés par lignes contigues;

- résolution harmonique dans les sens horizontal et vertical;

- échantillonnage avec compensation de mouvement et traitement diagonal des signaux.

Cette proposition sera présentée à la conférence.

A Scanning Scheme for a New HDTV Standard

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3.3

Abstract

In this paper parts of the work on EDTV Systems at the University of Dortmund are reported. Results are described on several proposals to improve picture quality such as

- progressive scan reproduction,
- vertical pre- and post-filtering,
- diagonal pre- and post-filtering.

By these methods impressive improvements of picture qualities can be achieved, which have been assessed by subjective tests. From the results out of these tests a new HDTV scanning scheme can be concluded with the following properties

- progressively scanned signals
- harmonic resolution in horizontal and vertical directions,
- offset sampling and diagonal signal processing

This proposal is described in this paper with some detail

1 Introduction

In 1985 a remarkable step could be done towards a new worldwide HDTV production standard. To support this, increasing efforts all over the world can be recognised.

Within this discussion this paper is to describe experiences and results on enhanced TV systems. This seems to be very useful considering a new HDTV-standard.

The progress of VLSI-techniques and digital signal processing makes feasible television systems with pre- and postprocessing, by this obtaining higher picture quality. Therefore, there are good reasons to think about a new HDTV standard taking into account the progress of signal processing for EDTV systems.

Furthermore, taking into account the progress of EDTV systems it is possible to conclude a real HDTV standard avoiding some restrictions of standard TV e.g. interlace distortions.

2 On Picture Quality

Since 1979 at the University of Dortmund a group of engineers is active in the field of "High" and "Enhanced Definition Television". Several proposals and experimental results have been published previously. Some of the methods to improve picture quality by signal processing have been investigated as to their effects on subjective picture quality. These methods, listed in Figure 1, are:

(s) Standard television system (5MHz, 625ℓ, 2:1 interlaced, 50 fields/s)
(p) Progressive scan reproduction of standard TV signals [1-4]
(v) Vertical pre- and post-filtering-approach [5-6]
(d) Diagonal pre- and post-filtering approach [5-6]
(h) High line number (HDTV) System [7] (20 MHz, 1249ℓ, 2:1 interlaced, 50 fields/s, aspect ratio: 4:3)

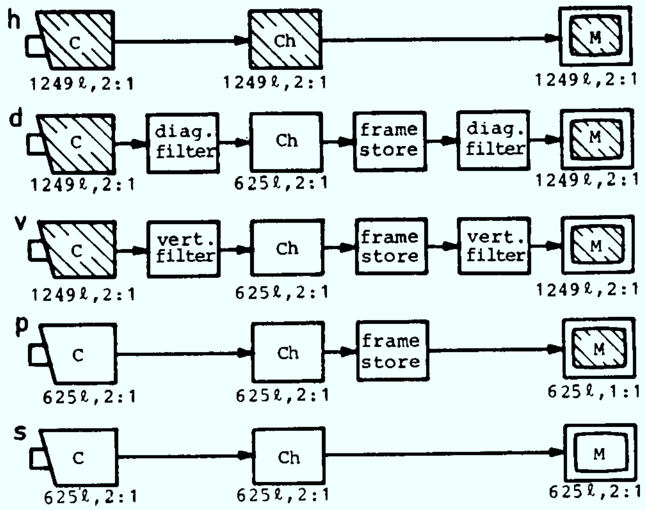

Figure 1: Transmission schemes for different TV systems.

The resolution boundaries for the various television systems shown in Figure 1 are given in Figure 2 For the standard interlaced television system (s), a vertical resolution boundary of

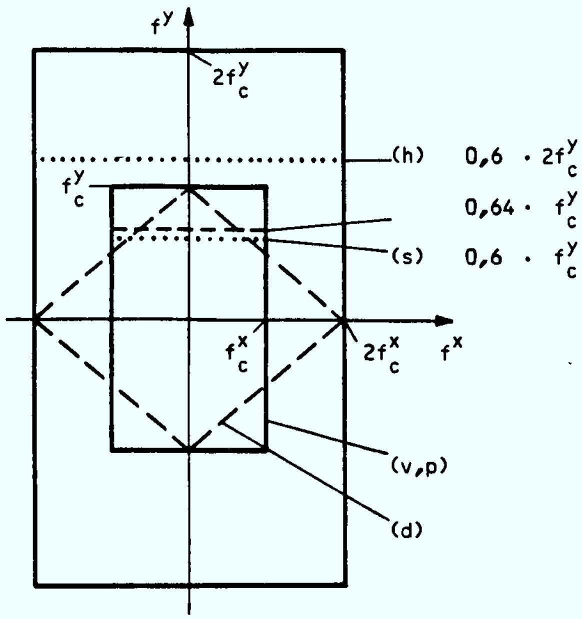

Figure 2: Resolution boundaries for different TV systems corresponding to Figure 1

$\approx 0.6 \cdot f_c^Y$ is assumed. By vertical pre- and postfiltering (v), the vertical resolution boundary is increased up to f_c^Y.

Applying progressive scan reproduction (p) by frame store techniques, the resolution boundary usually is assumed - in accordance to the literature with a Kell factor of 0.64 - to be $0.64 \cdot f_c^Y$. However, as a result from some previous work [6], which is briefly summarized below, it comes out, that in the case of progressive scanning the vertical resolution boundary is f_c^Y.

An interlaced high line number system (described by Fujio [7]) has a vertical resolution boundary of about twice that found in the standard system: $\approx 0.6 \cdot 2f_c^Y$.Its horizontal resolution boundary is also doubled to $2f_c^X$. The same horizontal resolution boundary in connection with a diagonal band limitation can be achieved within the given basic standard by means of diagonal pre- and postfiltering. The vertical resolution boundary then is given by f_c^Y.

To determine the subjectively weighted improvements of picture quality with the different signal processing concepts, a series of subjective tests was performed [8]. Out of this work Figure 3 shows the assessed improvements of (still) picture quality (by 12 experts, using the CCIR comparison scale, viewing distance: 3 picture heights) for the described concepts for two picture examples.

These processing concepts were compared with the standard system with 2:1 interlace. As the improvements depend on picture content, the results for two pictures with very different structures are shown for different criteria such as sharpness, resolution, flicker reduction, and total impression. The tests showed that, in the

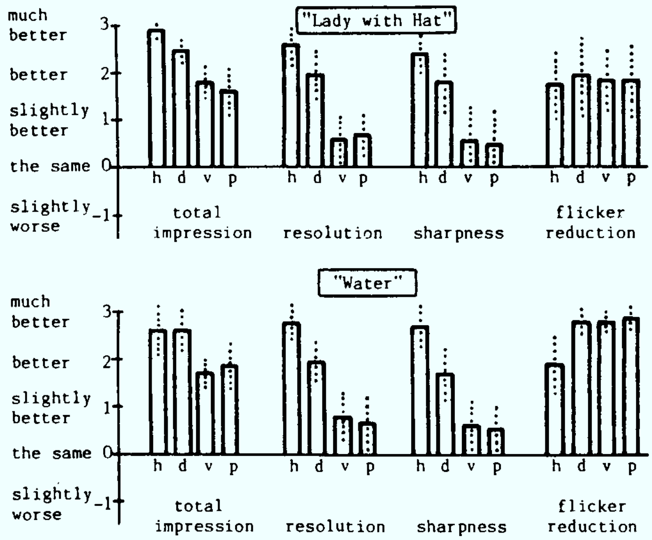

Figure 3: Comparison of picture quality of improved systems to the standard system [8].

cases with compatibly improved picture quality, flicker reduction by use of picture framestores gives impressive improvement. Further, vertical pre- and postfiltering, although producing impressive improvement for the reproduction of horizontal contours or lines, gives nearly the same resolution and sharpness as does progressive scanning.

This is important because if the same modulation transfer function is applied in the horizontal and vertical directions, we get the same resolution or sharpness in these directions. In a two-dimensionally bandlimited system, with the same cutoff frequencies, $f_c^y = f_c^x$, there is no reason to reduce f_c^x by a Kell factor. Because of this and the fact that without vertical pre- and postfiltering there is a subjective impression of somewhat greater sharpness, we should never reduce horizontal bandwidth by a Kell factor if we apply progressive scanning at the receiver.

In all cases, diagonal pre- and postfiltering gives the best picture quality for a given standard and bandwidth.

As a main result, it can be concluded, that progressive scan reproduction is a powerful method to improve picture quality (nearly 2 grades of the CCIR comparison scale). By this line flicker distortion is overcome and the subjective impression of resolution and sharpness is improved.

Therefore, progressive scan reproduction (by motion controlled picture frame store techniques) is well suited for future television receivers with improved picture quality. These frame store techniques can also be applied to overcome large area flicker by increased vertical frequency which is important especially for TV standards with 50 Hz vertical frequency.

3 Motion Adaptive Processing for Compatible High Quality Television

Flicker Free Television Reproduction

One of the most disturbing effects in TV systems is the flicker due to TV line interlace techniques, i. e. line flicker, line crawl, heavy 25 Hz flicker on horizontal contours of high contrast, etc.

Moreover, the subjective improvement in resolution of an interlaced television system with 625 lines compared to a non interlaced system with 312 lines is very poor and does not exceed 25 to 30 %. This was well known by Prof. Schröter, who first introduced line interlace into electronic video systems [9] in Europe. Although the improvement is poor, the line interlace technique is applied all over the world causing all the flicker effects mentioned above.

In addition, for 50 Hz television standards large area flicker is also an annoying distortion. This is true especially for large screens with high brightness. Therefore, to eleminate line flicker and large area flicker several proposals have been published[1-4, 10-12]. In general most of these proposals are based on a receiver structure shown in Figure 4, which has been introduced in Refs. (1), (4).

The incoming video signal is first split into a first (n-1) and second (n) field of the same frame. By intra-/interframe processing e. g. progressive scan readout we get a high quality reproduction without irritating line structures and line flicker out of the upper path in Figure 4. This processing is obtained for still picture areas or slowly

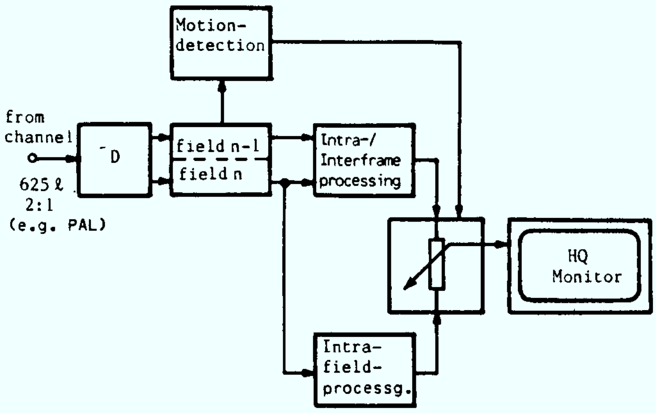

Figure 4: Motion adaptive high quality television reproduction

moving picture parts, generating a reproduction standard well matched to the HQ (high quality) monitor.

Under control of the motion detector the lower path in Figure 4 is switched on (soft decision to avoid busy edges) for faster moving areas. In this path, the incoming signal is transformed by an intra field processing to the same standard considered for the HQ monitor.

The latter intra field processing is performed only within the lines out of the actual field. This restricts spatial resolution to the information content of just one field - which is the standard resolution for moving objects. However, the temporal resolution is given by 50 Hz field frequency without motion blur.

Using this general concept, the resolution is switched softly from high spatial and low temporal resolution (25 Hz) to high temporal resolution (50 Hz) and lower spatial resolution. The first is applied for still and slowly moving picture parts, the latter for rapidly moving parts.

It should be mentioned here that by motion adaptive high quality reproduction, as described, a flicker free reproduction can be achieved. However, there remains field aliasing [3] in moving parts, which cannot be overcome by simple signal processing at the receiver end.

A Concept for Aliasing Free Preprocessing

One of the most annoying effects of line interlace techniques is caused by field aliasing in moving parts of a picture. This results because the line distance in one field is twice the line distance in a full frame. Achieving good vertical resolution that is well matched to the line number of a full frame results in heavy field aliasing in every field. For still pictures and with complete integration, the field aliasing of one field cancels the aliasing of the adjacent field and vice versa because of the line offset position of adjacent fields [5]. If there is a time variation in the spatial spectrum of the transmitted picture, however, the field aliasing of one field can no longer cancel that of the adjacent field exactly. The content of every field comes from another time instant, and in a moving scene residual field aliasing occurs.

This defect in a line-interlaced picture is well known especially in connection with vertical moving parts in a picture (line crawl, artifacts by field aliasing). The human eye is highly sensitive to this aliasing, so the visibility already starts at a detail velocity of about 0.1 pel/field, a very low velocity. This field aliasing in moving areas, caused by line interlace, also takes place in the case of offset sampling for increased horizontal resolution [5]. This case of offset sampling seems to be more critical because the same sensitivity to very low horizontal velocities leads to new artifacts, unknown in the standard technique.

Therefore, even for the standard techniques with line interlace, there is also a demand for a means of avoiding field aliasing in moving areas. A concept [3] for motion-controlled pre- processing with errorfree scanning producing high spatial resolution for still pictures, but lower spatial resolution in moving parts avoiding field aliasing, is shown in Fig.5

Beginning with an HQ camera with 1249 lines/2:1 interlace, the video signal is stored in two fieldstores distributed by the demultiplexer (D). Because of the limited resolution of the HDTV cameras that will be available in the near future, we only have a

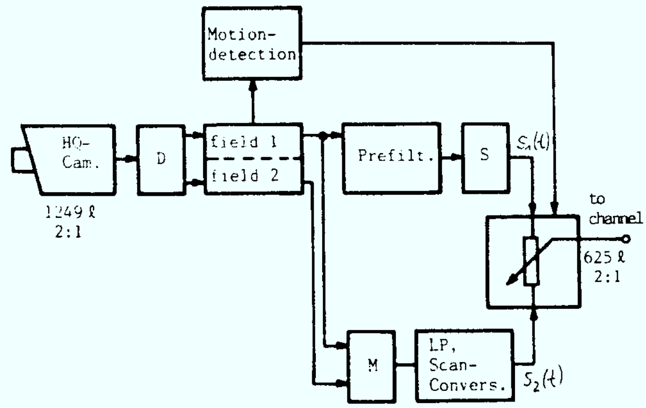

Figure 5: Motion-controlled preprocessing for compatible improved standard signals.

small amount of frame aliasing and limited field aliasing in moving parts of the high-line-number signal. A diagonal or vertical pre-filter can therefore be used to get input fields with 625 lines without aliasing for still pictures or very slow motion. This technique has been discussed before and is shown in some more detail in Refs 5.

This pre-filtering allows field scanning with 625 lines without aliasing for still pictures or very slow motion. In moving parts however, this pre-filtering will produce jerkiness. Therefore, for high temporal resolution, the signal is also fed to a second path in which there is no real line interlace.

However, to avoid field aliasing, there is an interpolating low-pass filter. This filter produces (in connection with a multiplexer, M) bandlimited output fields in $s_2(t)$. In this way, out of the input fields of the 1249-line/2:1 interlace signal, we get output fields that produce standard signals, $s_2(t)$, with 625 lines/2:1 interlace, which are free of field aliasing and motion blur. On the other hand, this high temporal resolution for moving parts (50 Hz) is accompanied by reduced vertical resolution, i.e., 312 lines/picture height for every output field.

To get maximum spatial resolution for still pictures or for slowly moving parts of a picture in the upper path, just one pre-filtered field of the high-line-number system is used. Out of field 1 of the high-resolution signal, two synthetic output fields are constructed by the selector S to build up a signal $s_1(t)$ with 625 lines/2:1 interlace.

For optimum matching to the scene and optimum usage of the transmission channel, still avoiding motion blur and field aliasing, we can adaptively choose by means of the motion detector between:

- Overall maximum spatial resolution within the standard with only 25-Hz temporal resolution for still pictures or slower moving parts in a picture (velocities up to about 2 pel/frame are allowed), and
- Maximum temporal resolution (50 Hz) with reduced spatial resolution (restricted to the resolution of only one field of the output signal.

Using this concept, because of the synthetic output fields from one high-resolution input field, no motion problems are caused by cancelling the field aliasing in the output signal $s_1(t)$. Every two fields come from a single time instant and thus fit together. This is also true for the motion problems associated with increased horizontal resolution caused by offset sampling and diagonal spatial pre- and post-filtering. On the other hand, for rapidly moving parts, every output field is free of aliasing because of the interpolation (two-dimensional low-pass filtering) in the lower path (Fig. 5).

4 Recommendations for a New HDTV Scanning Scheme

(1) Progressive Scan

As a main result out of the described work on subjective quality, it comes out, that progressive scan (reproduction) gives an impressive improvement of picture quality. Therefore, one of the essentials for an HDTV system is to apply progressive scanning at least at the receiver end.

However, field aliasing at the picture source can only be overcome by proper camera processing. A motion adaptive processing scheme has been described above to achieve pictures free of field aliasing. The price for this improvement is a reduced vertical resolution for moving picture parts on the other hand a somewhat complex processing scheme. This processing scheme has to be implemented with motion detectors at the receiver and at the transmitter end. Both detectors have to work dependently with shifted thresholds against each other. The threshold is to make sure that intraframe processing at the receiver end is only then performed if intraframe processing is applied at the transmitter end.

This concept seems to be a good solution for an enhanced TV system compatibly improved with respect to standard receivers. However, for a new worldwide HDTV standard, which should be a convention for a long time period, a real progressive picture pick-up should be applied [13,14]. This is strongly recommended with respect to picture quality and processing complexity as well and it is recommended just because of the experiences on EDTV systems.

Besides the very important improvement of picture quality by overcoming field aliasing there are other important advantages of a progressive HDTV standard, especially for the display.

To achieve a total flicker free reproduction with a 60 Hz standard no HDTV-picture frame-store is necessary at the receiver. This reduces receiver costs. In the case of a 50 Hz HDTV standard, which could become a european convention, a progressive standard gives the opportunity to overcome large area flicker by a receiver frame-store. No motion adaptive signal processing, no additional bandwidth and no increased line frequency is necessary to overcome line flicker distortion.

In addition there are other advantages of a progressive scan standard for postproduction processes, which have been reported by K. Powers [14]:

- image manipulation and special effects,
- aperture correction, MTF enhancement,
- spatio-temporal-filtering,
- editing (1 field editing),
- chroma key,
- slow motion (CCD-camera!),
- standard conversion,
- film recording.

Considering bandwidth requirements it comes out from [3, 14] that for equivalent resolution a progressive standard requires 1.3 times the bandwidth of that of an interlaced standard. This is due to the so called "interlace factor" of about 0.65. This factor describes the loss of vertical resolution of an interlaced reproduction compared with a progressive reproduction, assumed the same spatial line number and doubled bandwidth for the progressive standard.

This means, doubling the line number on the basis of interlaced standards e.g. from 625 (2:1) to 1249 (2:1) doubles the vertical resolution. To get the same vertical resolution by progressive scanning only 1.3 times the line number is necessary. So, a progressively scanned system with 625 . 1,3 ≈ 813 lines would have nearly the same vertical resolution as given for a system with 1249 lines, 2 : 1 interlaced.

It should be mentioned that this calculation is based only on the visibility of line structures [15] which has been investigated for 50 Hz systems [8]. Results are shown in Figure 6.

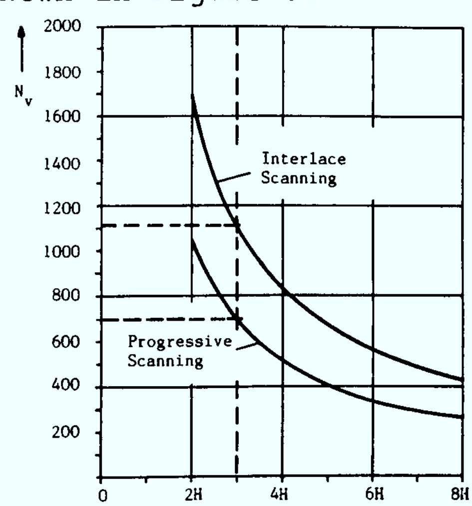

Figure 6: Visibility of line structure for interlaced and progressive reproduction (N_v - number of active lines)

It comes out that for non visible line structure at a viewing distance of 3 times the picture height an interlaced standard should have about 1100 lines whereas a progressive standard requires about 700 lines.

However, this describes only line structure visibility. There are several much stronger distortions due to interlace scanning such as line flicker at horizontal contours and field aliasing. Both are visible and disturbing at much higher viewing distances and can be overcome by a progressive scan picture pick-up.

(2) Increased Horizontal Resolution

It has been pointed out in chapter 2 as a result of our studies on picture quality that in the case of progressive scan no Kell factor should be applied to reduce horizontal bandwidth. There is the same impression of resolution for natural pictures in the case of either progressive scan or vertical pre- and postfiltering.

The latter processing yields a continously perceived signal also in vertical direction, just like a non sampled signal, as it is given in horizontal direction.

Therefore, to get a harmonic distribution of resolution in horizontal and vertical direction we should never reduce the bandwidth below checkerbord frequency. It is therefore recommended to choose a bandwidth which yields a horizontal resolution equal to the resolution given by the checkerboard frequency.

(3) Offset Sampling and Diagonal Filtering

The superiority of offset sampling and diagonal pre- and postfiltering has been described in chapter 2. An improvement of about 2.6 grades on the CCIR comparison scale can be achieved. A doubled line number system yields an improvement of 2.8 grades.

Therefore, it is recommended to apply offset sampling and diagonal filtering for an HDTV transmission. By this a remarkable amount of bandwidth can be saved.

Compared with a progressive HDTV scanning scheme with n lines and a bandwidth equal to the checkerboard frequency, by offset sampling and diagonal filtering half the bandwidth can be saved. This is a very interesting advantage of diagonal processing approach.

5 Comparison of HDTV Scanning Schemes

To get a better insight in some properties of the described recommendations further tests on subjective picture quality have been performed along with different scanning systems and signal processing described below. The resolution boundaries of some different HDTV-Systems are shown in Fig. 7.

A conventional HDTV-system similar to the 1125 lines system of NHK[7] may have a resolution boundary in vertical direction of f_c^y, wherein f_c^y in "cycles per picture heights" (cph) is given by f_c^y = 1/2 number of lines.

The subjective detail resolution in vertical direction is somewhat distorted by line interlace and may be reduced to about 0.6 . f_c^y (interlace factor of

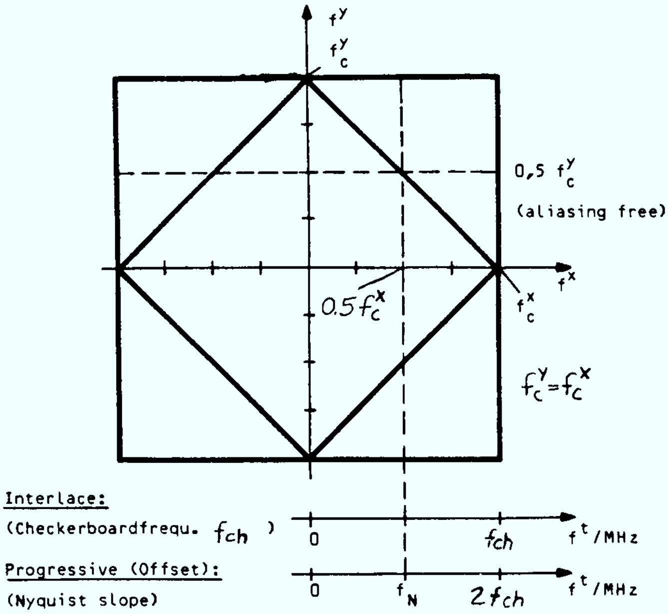

Figure 7 Resolution boundaries of HDTV systems, Aspect ratio 5 : 3

about 0,6). But it has to be mentioned, that this reduction stronly depends to brightness and picture content.

In addition, in moving parts there occur heavy field aliasing and moving defects. For a system without field aliasing and moving defects the vertical resolution boundary is reduced by proper prefiltering and cannot exceed 0.5 f_c^y (dashed line in Fig. 7).

For an harmonic distribution of resolution boundaries for both horizontal or vertical direction the horizontal resolution boundary also may be bandlimited to 0.5 f_c^x, wherein $f_c^x = f_c^y$ is the resolution boundary of an harmonic system with optimum horizontal and vertical pre- and postfiltering as mentioned in chapter 2. (After the scanning process f_c^x is equivalent to the so called "checkerboard frequency f_{ch}").

Taking into account the considerations mentioned above several different HDTV-Systems can be defined:

(S): standard HDTV-system with line interlace 2 : 1. Vertical resolution: about 0.6 f_c^y, horizontal resolution boundary: 0.5 f_c^x.

(S_e): extended standard system with increased bandwidth. Vertical resolution: ≈ 0.6 f_c^y, horizontal resolution boundary: $f_c^x = f_c^y$ (bandwidth = checkerboard frequency).

(V_e): vertically and horizontally pre- and postfiltered system, progressively scanned. Vertical resolution boundary: f_c^y, horizontal resolution boundary: $f_c^x = f_c^y$.

(D): diagonally pre- and postfiltering system, progressively scanned. Resolution boundaries: f_c^x, f_c^y, (diamond shape).

To compare the picture qualities along with these different systems and scanning schemes some subjective tests have been performed. Out of practical reasons and because of the existing equipment, only 50 Hz systems have been tested. The tests have been performed by computer simulations with 12 experts, using the CCIR comparison test scale. Only still pictures were used. Viewing distance was 3 picture heights, related to a 1249 lines system. The test results for two picture examples are shown in Fig. 8.

The reference system for all comparisons is the standard HDTV-

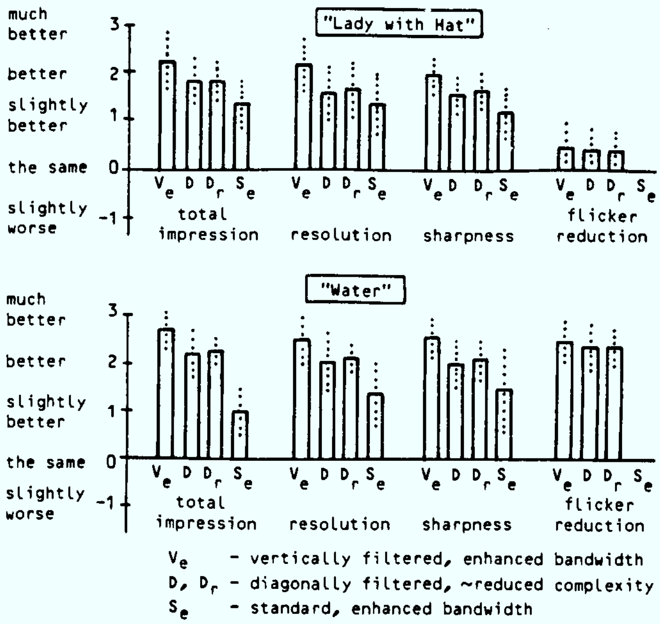

Figure 8: Subjective picture quality of various HDTV-standards

system (S) mentioned above (similar to [7]). The (D_r)-system is a system with pre- and post-filtering but reduced complexity. Test results:

(S_e) Increasing the bandwidth of the interlaced system to the checkerboard frequency gives an improvement of about 1 grade.

(V_e) Avoiding line interlace defects and aliasing by pre- and postfiltering and progressive scanning improves picture quality by about 2,3 grades; depending on picture content.

(D),(D_r) Diagonally pre- and postfiltering with diamond shape of the resolution boundary inside the square given by $|f_c^x| = |f_c^y|$ = const gives a somewhat smaller, but still high improvement of quality of about 2 grades (depending on the picture content).

From these results it comes out, that diagonal pre- and postfiltering (in connection with an offset sampling scheme) [5] is a superior picture processing scheme, because of the fact, that for a (D)-system we only get half the data rate of that in (V_e).

Conclusion

Out of the reported results the following recommendations for a new HDTV-system can be developed:

(1) Progessive scanning should be applied to avoid field aliasing and all moving artifacts.

(2) The system bandwidth should be extended to checkerboard frequency. (No Kell-factor should be applied).

(3) To save transmission bandwidth offset sampling and diagonal pre- and postfiltering should be applied. This processing is well matched to the human eye (oblique effect) and to the statistics of natural pictures. In connection with a sampled signal (such as in a MAC-system) and with a proper nyquist slope about half the bandwidth can be saved.

Taking into account these three recommendations a new HDTV-standard with progressive scanning is possible, which for the same sampling rate (or bandwidth) as for a line interlace system has the following advantages:

- no field aliasing or line flicker effects,
- increased vertical resolution, and
- high temporal resolution without moving defects.

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ENHANCED C-MAC: THE EVOLUTIONARY APPROACH

3.10

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ABSTRACT

The EBU-recommended standard for DBS in Europe, C-MAC/Packets, was designed very much with future developments in mind. This paper describes one method of implementing an Enhanced C-MAC signal which allows transmission of wider-aspect-ratio, higher-definition pictures suitable for large-screen displays and reduced viewing distances. The extra information required for the aspect-ratio increase is carried in parts of the signal not normally used for picture information in the standard C-MAC/Packet format. This technique allows full compatibility between the Standard and Enhanced signals. Owners of DBS receivers or set-top converters for the standard C-MAC/Packet system would receive a high-quality 4:3 aspect-ratio picture when tuned to the Enhanced C-MAC channel, while those who owned Enhanced C-MAC receivers would gain the advantages of the new signal (wider aspect ratio and increased resolution). The signal requires only one WARC satellite channel.

This evolutionary approach to higher definition television transmission achieves the resolution increase required without using new, incompatible line scanning standards for transmission. Horizontal and vertical resolution increases are achieved by using the satellite channel bandwidth to the full and by "upconverting" in the Enhanced C-MAC receiver, to a sequentially-scanned display with 625 lines every fiftieth of a second. The subjective picture quality improvements obtained by this technique are discussed.

Enhanced C-MAC can provide a means of transmitting higher-definition television in a single WARC satellite channel in a way which is compatible with existing television sets and studio equipment. It does not require new studio equipment or a new receiver to start the service as do other DBS HDTV systems. This feature is seen to be very important in ensuring the market penetration and rapid growth required for such a high-risk venture.

SYSTEME C-MAC AMÉLIORÉ - CONCEPTION PROGRESSIVE

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3.10

RÉSUMÉ

La norme recommandée par l'UER pour la radiodiffusion directe par satellite en Europe, c'est-à-dire la transmission par paquets CV-MAC, a été conçue en tenant compte des développements éventuels. Le présent document décrit une méthode de matérialisation du signal C-MAC amélioré permettant la transmission d'images à plus haute définition, a un rapport de dimensions plus grand et de qualité convenable pour affichage sur grand écran et visionnement à distance réduite. L'information supplémentaire nécessaire à l'amélioration du rapport des dimensions est transmise dans certaines parties du signal qui ne sont pas normalement utilisées pour l'information d'image dans le système normalisé de transmission par paquets C-MAC. Cette technique donne une comptabilité intégrale entre les signaux normalisés et les signaux améliorés. Les propriétaires de récepteurs de radiodiffusion directe par satellite ou de convertisseurs adaptés aux téléviseurs pour le système normalisé de transmission par paquets C-MAC recevraient une image de haute qualité de rapport 4:3 sur la voie du système C-MAC amélioré, tandis que les propriétaires de récepteurs du système C-MAC amélioré tireraient profit des avantages du nouveau signal (rapport de dimensions plus grand et définition améliorée). Le signal ne nécessite qu'une seule voie de satellite CAMR.

Cette conception progressive de la transmission d'images télévisées de meilleure définition obtient le résultat voulu sans faire appel pour la transmission à de nouvelles normes incompatibles de balayage lignes. L'amélioration de la résolution horizontale et de la résolution verticale s'obtient en utilisant toute la largeur de bande de radiodiffusion par satellite et en effectuant une "conversion ascendante dans le récepteur du système C-MAC amélioré pour produire un affichage à balayage séquentiel comportant 625 lignes à tous les cinquantièmes de seconde. Le présent document traite également des améliorations de la qualité subjective de l'image obtenue par cette technique.

Le système C-MAC amélioré peut donner un moyen de transmettre des images télévisées de définition supérieure sur une seule voie de satellite CAMR d'une façon qui reste compatible avec les téléviseurs et l'équipement de studio existants. Contrairement à d'autres systèmes de radiodiffusion TVHD par satellite, il n'est pas nécessaire de changer l'équipement de studio et les récepteurs actuels pour utiliser ce système. Cette caractéristique est jugée très importante dans le contexte de la pénétration du marché et du développement rapide nécessaires à une entreprise comportant de si grands risques.

ENHANCED C-MAC - THE EVOLUTIONARY APPROACH

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3.10

INTRODUCTION

Looking to the future for television there is a growing conviction that there will be a place for a higher quality broadcast service, based on a wider aspect ratio display and improved picture quality. Such a service could be broadcast via Direct Broadcast Satellite (DBS) or cable, with material also being available to the viewer in a pre-recorded form. Despite this, conventional terrestrial transmission is likely to remain the dominant mode of broadcasting into the twenty first century. Any new higher quality service which is planned within this timescale should therefore take adequate account of the current broadcast situation, both at the domestic receiver and in the studio.

In the context of DBS for Europe, the C-MAC/packet system has been developed with the current situation in mind as well as providing a doorway to enhancements to meet future needs. Current scanning standards (ie 625 lines, 50Hz field rate, 2:1 interlace) are maintained while future enhancements are facilitated by having a flexible format with analogue component video and digital sound and data. This provides the means for an evolutionary approach to future higher quality television. The option for viewers to 'upgrade' their receivers is provided without rendering existing equipment obsolete. Furthermore at the studio an enhanced service could be started on the basis of modifying existing equipment.

This paper describes some enhancements to the 'basic' C-MAC/packet system and discusses the quality of the pictures produced. The practicability of the evolutionary approach is contrasted with a 'revolutionary' philosophy which tends to take little account of existing standards.

ENHANCED C-MAC

The basic technical details of the system have been described in detail elsewhere (refs. 1,2,3). Enhanced C-MAC has been developed as one of a family of compatible extensions to the C-MAC/packet system for DBS. The objectives identified in this development were:-

a) an increased aspect ratio in the region of 5:3.

b) resolution should be such as to permit viewing on large screens in a home environment. Reasonable estimates of screen size and typical living room layout suggest a viewing distance of around 4 times picture height.

c) there should be the option of picture processing at the receiver to improve picture quality.

d) extra complexity should occur in the enhanced definition display and not in the conventional 4:3 aspect ratio display.

e) there should be total compatibility with the existing C-MAC specification and no loss of quality of the C-MAC service when the enhanced system is used.

Engineers at the Independent Broadcasting Authority have developed and built a system which meets these objectives. The new signal format - 'Enhanced C-MAC' has an aspect ratio of at least 4.7:3 and possibly up to around 5:3, while retaining total compatibility with the standard 4:3 aspect ratio C-MAC/packet signal. The main features of the system are shown in figures 1 and 2. Figure 1 shows the transmitted frame for a standard C-MAC signal, with a full length data burst and capacity of up to 8 sound channels. Figure 2 shows the transmitted frame of an enhanced C-MAC signal in which the data burst has been reduced in duration to carry 2 sound channels plus additional data for over-air addressing, conditional access, etc. The extra luminance information for the picture edges is carried in the place of the data which has been removed, while the extra chrominance information is carried in the vertical blanking period. This trade off of data with vision preserves the full quality of the 4:3 aspect ratio picture. Other systems which retain the data capacity but reduce the vision quality of both the 4:3 and 5:3 aspect ratio pictures at the receiver are under study elsewhere and are not described here. Fig. 2 represents something of a simplification since C-MAC can be transmitted in scrambled form. A detailed description of Enhanced C-MAC must take account of this as discussed in References 1 and 2.

The standard C-MAC receiver ignores the extra information shown in Fig. 2 and decodes the signal normally as a 4:3 picture. The Enhanced C-MAC receiver joins on the extra portions invisibly to form the wider aspect picture. The joining is accomplished in a similar way to that required in the 4:3 picture descrambling process and is resistant to channel imperfections such as noise and non-linearity.

With Enhanced C-MAC, the capacity of the satellite channel is more fully explored. It has been found from current work within the IBA that a compressed video bandwidth of around 11 MHz can be considered. This allows an uncompressed video bandwidth of the order of 7.3 MHz for both the 4:3 aspect ratio part of the picture and the edges if the same compression ratio is used. It should be noted that an increase of compression ratio of the edges only by a factor of 3:2 will reduce the edge bandwidth only to 4.9 MHz and give a picture aspect ratio of 5:3. This option is currently under study.

It may be important that the standard-aspect-ratio viewer sees the 'correct' portion of the wider-aspect-ratio picture - that is the part containing the subject of interest at the time. For this reason the amounts of left and right hand 'side' of picture transmitted in the Enhanced C-MAC signal can be variable although the total is constant. The proportions of left and right extended picture being transmitted can be signalled in the TDM control line (line 625) for use by the Enhanced C-MAC receiver. The C-MAC receiver only processes the 4:3 ratio picture and would therefore ignore this control.

SCAN CONVERSION

In conjunction with Enhanced C-MAC, receiver processing can take advantage of the capabilities of the current line scanning standards to give a performance approaching closely to that of an incompatible "HDTV" standard. Scan conversion processing provides for a display employing more lines than are present in the transmitted signal. The effect of this is to offer many of the benefits of a system employing more lines, but without increasing the number of lines in transmission.

Scan conversion can provide a number of benefits. Conversion from 625 line 50 Hz interlace to 625 line 50 Hz sequential scan produces significant improvements in picture quality by removing interline flicker and by reducing line visibility. Conversion to a higher field rate is also possible in order to remove large area flicker, but this has not yet been the subject of the present study.

In addition to the development of the enhanced C-MAC coder and decoder, a scan converter to convert 625 line interlace scanning to 625 line 50 Hz sequential scanning has been built.

The main function of the scan conversion equipment is to provide additional 'new' (or 'interpolated') lines in the gaps left by 2:1 interlace. The input and output line structures are as illustrated in Fig. 3. With interlace each field contains only half the complete number of lines, i.e. 312½ for 625 line systems. The non-interlaced output however carries a full 625 lines in every field. Because of this the output line-rate is not the conventional 15.625 kHz but rather 31.25 kHz. Similarly the output line time is 32 μs rather than the input 64 μs. Thus the scan-conversion equipment not only calculates new lines but also applies time-compression to all lines by a factor of two. This increases output bandwidth requirements by the same factor.

The conversion equipment calculates, or interpolates, the new lines by taking weighted sums of nearby input lines. For static areas of picture the most appropriate interpolation method is to take into account only lines from the same vertical position as the 'missing' line. This involves taking the average of lines from the previous and subsequent fields, requiring field storage. This interpolation method removes interline flicker effects and hence gives the desired increase in apparent vertical resolution. In moving picture areas however this method is unsatisfactory since a 'multiple-image', or severe blurring effect can occur. The conversion process therefore needs to be motion adaptive. A movement detector is employed which controls the method of interpolation according to some objective measure of scene motion. In completely static picture areas the interpolation method described above ('temporal interpolation') is selected. In clearly moving areas an interpolation method taking into account only lines from the same field as the 'missing line' is employed ('vertical interpolation'). The transition from temporal to vertical interpolation (and vice versa) is currently achieved via several compromise modes.

A block diagram of part of the scan conversion equipment is shown in Fig. 4 with specific reference to the movement processing. The area of motion adaptation has been the subject of considerable study and optimisation (Ref. 3, 4) and here only a brief description will be given. In the interpolation of the 'missing lines' for the luminance, an interpolation filter is selected from a number of possibilities by means of a control signal generated by the movement processor (Fig. 4). For the chrominance a fixed vertical interpolation is used. The movement processing is derived from a frame difference signal. The subsequent modification of this is illustrated in simplified form in Fig. 4. The 'spatial filter' provides a data-rate-reduced 'block' format (eg 3 lines x 6 samples) by first averaging the signal over larger overlapping blocks (eg 6 lines x 12 samples). The 'field delay' is configured as a recursive loop to provide 'lag' on the control signal in order to overcome detection difficulties with critical pictures such as electronically generated moving captions. The provision shown of combining this processed signal with the basic frame difference signal (which has incidentally had some noise removed) is in fact not used in the current equipment configuration. This approach has been found to work well in all circumstances encountered so far.

PICTURE QUALITY CONSIDERATIONS

In considering the quality aspects of any television system, it is necessary to define the target. If the target is that of cinemas with a large audience and a very large screen then we can expect that the optimum scanning parameters might be different from those for a display on a screen of say 1 metre x .6 metres viewed in a typical living room. The target for enhanced C-MAC is clearly identified as that of broadcasting to the home. A screen size of 1m x 0.6m coupled with a typical home viewing distance of around 2.4m gives an anticipated relative viewing distance of four picture heights. This coincides with what has been identified as a desirable relative viewing distance taking into account motion difficulties with closer viewing (Ref. 5).

Enhanced C-MAC improvements

C-MAC itself provides major improvements, notably freedom from cross-luminance and cross-colour. It also provides increased chrominance and luminance resolution over composite systems because of the absence of the sub-carrier 'notch' necessary to reduce cross effects on the display. Enhanced C-MAC provides a further increased horizontal resolution and an increased aspect ratio.

A 4.7:3 aspect ratio is available with uniform resolution. The definition of resolution in MHz must be considered with care as this is affected by aspect ratio and horizontal scan frequency as well as absolute spatial resolution. C-MAC uses a satellite channel baseband bandwidth of 8.4 MHz and has a horizontal resolution for luminance of 5.6 MHz for a 4:3 aspect ratio picture based on a compression ratio of 3:2. The increased satellite channel bandwidth of 11MHz with enhanced C-MAC gives a luminance resolution for the 4:3 aspect ratio picture of 5.6 x 11/8.4 = 7.3 MHz. For fixed active line duration, the increased aspect ratio gives a luminance resolution of 7.3 x 4.7/4 = 8.6 MHz (Note that scan conversion can increase this value to 17 MHz by doubling the line scanning frequency as described earlier). The predicted resolution performance of the enhanced C-MAC coder, modulator, demodulator and decoder has been confirmed experimentally. It is interesting to note that in full system tests including professional camera and projection equipment, horizontal resolution is limited at present by the source and display devices and not by the enhanced C-MAC channel.

Reference has been made earlier to the possibility of a further increase in aspect ratio to around 5:3 by using increased compression on the picture edges. The edge compression being used in present experiments is increased by a factor of 3:2 on that of the 4:3 part of the picture, corresponding to a total compression for luminance at the edges of 2.25:1. Initial results indicate that while the loss of resolution of the edges is visible for artificial test material such as the full amplitude circular zone plate, it is not perceived under normal viewing conditions with conventional picture material as sourced for example by a modified (wideband) telecine.

For uniform horizontal resolution, the effect of noise can be predicted directly from the performance of C-MAC. Because the picture edges are transmitted as additional information and not by increased compression, there is no noise penalty due to the increased aspect ratio for either the conventional or the Enhanced C-MAC receivers. The increased satellite channel baseband exploited by

Enhanced C-MAC gives increased resolution with a penalty of around 1.5 dB in subjective noise for those receivers which take advantage of this resolution.

For non-uniform resolution, the effect of satellite channel noise on the different compression ratios for different parts of the 5:3 aspect ratio picture requires careful study. Preliminary results suggest that at normal satellite carrier to noise ratios (around 16 dB) the difference in noise is not noticed, but that at lower carrier to noise ratios down to around 11 dB, the noise difference of the edges is visible, although at even lower carrier to noise ratios the difference is masked by the overall high noise level. It should be noted however that the picture edges do not form part of the 'conventional' C-MAC vision signal, so that techniques such as adaptive or non-linear pre- and de-emphasis (Ref.6) can be applied to these parts of the picture to equalise the noise in the different parts of the picture.

The effects of satellite channel interference have been studied theoretically, but not yet practically for both 4.7:3 and 5:3 aspect ratio pictures. As no spectrum folding techniques are involved in Enhanced C-MAC, studies both at the IBA and elsewhere (Ref.7) suggest that interference both into and from other satellite channels will not be a problem. However, because of the complexities and subjective nature of interference, full subjective tests will be carried out on this aspect.

Scan Conversion Improvements

Scan conversion improves the display of the 625 line interlaced transmission. Nevertheless the fundamental question remains: Are 625 lines sufficient for the target picture size of approximately 1 m x 0.6 m with a viewing distance of around 4H?

A display with 575 active lines viewed at 4H has an angular line pitch of 1.5 minutes of arc, which is close to the threshold of detectability by the eye. This suggests that the line structure should not be obtrusive. Furthermore we have argued previously that the theoretical resolution capabilities of 575 active lines are sufficient (Ref. 8).

We will present here some preliminary results of subjective assessments of picture quality using 625 line sequential scan conversion after enhanced C-MAC coding and decoding. Fuller results will appear shortly (Ref. 9). Four test conditions were studied in order to assess the merits of interlaced versus sequential scanning in the display. These were:-

i) 625 line sequential scan with temporal interpolation
ii) 625 line sequential scan with vertical interpolation
iii) 625 line 2:1 interlaced scan
iv) 312 line sequential scan derived via temporal interpolation

Each of the above scanning standards used a 50 Hz field rate and were shown on the same 50 cm monitor. It is intended to perform similar tests at a later date on a larger screen display. A single stimulus method of presentation was used with a five-point quality scale. Five test slides were used. Four of these were EBU test slides (Crawley Tree, Girl with Toys, Formal Pond and Young Couple) while a fifth (Latin Text) contained fine detailed text.

The slides were scanned in a high resolution flying spot telecine providing a 625 line 2:1 interlaced output. All other standards were derived from this after enhanced C-MAC coding and decoding. The tests were carried out with two monitor brightness settings: "Full brightness" (70 cdm^{-2} as specified in CCIR Rec. 500) and "Half brightness" (approx. 30 cdm^{-2}). Viewing distances of 4H and 6H were used.

The mean grades for each scanning condition and both brightness conditions are presented in Table 1. It is interesting to note that both the interline flicker effects of interlace (and vertical interpolation sequential) and the static aliasing effects of 312 line sequential were more objectionable at the higher display brightness. The influence on results of the quality of the upper anchor (best picture) is also evident. It is rare under normal conditions for a wide bandwidth low noise component picture to be given a grade of around 3 (fair)! This does point out however that the viewers (mainly non-expert) saw the scan conversion procedure as providing a very worthwhile improvement on static scenes.

	$B = 30cd/m^2$	$B = 70cd/m^2$
625/50 sequential (temporal interpolation)	4.7	4.7
625/50 sequential (vertical interpolation)	3.5	3.0
625/50 2:1 interlace	3.5	2.9
312/50 sequential	2.7	2.2

TABLE: Mean quality grades for subjective assessments of scan conversion for two display brightness conditions.

An important remaining topic is that of picture quality with scene movement. A significant factor here is whether adaptive scan conversion processing can be successfully implemented. Recent experience with the motion adaptive scan converter developed at the IBA has shown no significant cases for which the adaptive processing has failed.

Overall tests of Enhanced C-MAC with scan conversion and a large screen projected display have confirmed our initial conclusions of the adequacy of 625 lines as a transmission standard to the home. For 35 mm film, for example, the overall impact is that of watching a film, rather than that of watching a television presentation of a film. As indicated earlier, limitations are now not in the transmission channel but in the source and display equipments although they are themselves of professional standard.

PRACTICABILITY OF THE EVOLUTIONARY APPROACH

Why evolutionary? Why not consider a revolution in the TV standards for higher quality television? In the United Kingdom, the existing four television channels provide a coverage of around 99.5% of the population. These channels, sourced at studios in many different parts of the country, will continue to provide the main television services in the United Kingdom into the twenty first century.

If satellite broadcasting develops alongside terrestrial broadcasting, then a revolutionary standard based on a different field rate poses problems both at the studios and in the home. The problems in the studios of standards conversion are being well considered in the CCIR and EBU. Evidence to date indicates that even a single standards conversion with the most advanced converter is not adequate in performance. Multiple standards conversion as could be necessary in a complex multiple studio national network as used for example in Independent Television could be disastrous. The problems of operating studios undergoing revolutionary change would be considerably higher than those of operation in the evolutionary change to digital technology which in itself posing many difficult problems and has been the subject of much discussion. In the home, we can expect a single display to be required to present pictures from all sources, whether terrestrial or satellite in origin. Complex standards converters are likely to be too expensive for many years for home use and simpler conversion while remaining expensive may well be inadequate in performance.

The evolutionary approach of Enhanced C-MAC is illustrated in Fig. 5. It provides for the possibility of studios providing programmes to both the terrestrial and the Satellite Broadcast systems in a compatible manner, and for an evolutionary approach to the home receiver without the need for expensive field standards converter. In this approach, it will be possible for existing terrestrial programmes also to be enhanced in quality by adaptive decoding and scan conversion to be presented on the same large screen display as enhanced C-MAC.

At the source, our experiments so far have concentrated on using modified conventional equipment. A studio colour television camera has been simply modified to give 5:3 aspect ratio and a wider bandwidth. A flying spot telecine has been more extensively modified to scan the film sequentially and to convert to conventional interlace in a frame store with 10MHz bandwidth in RGB. The results of this work are encouraging, especially with the telecine which can produce an excellent picture quality. Experiments are also under way using an HDTV studio colour camera scanning with 625 lines, 50Hz field rate and sequential scan. Downconversion to 625 line interlace is currently by alternate line omission.

In the early years of satellite broadcasting, large screen displays are unlikely to be widely available. The use of simple set top converters or sets with built in MAC receivers (not requiring frame storage or complex image processing) will provide a route by which satellite broadcasting can achieve sufficient market penetration to be a financially viable service. The evolutionary approach of Enhanced C-MAC ensures that all complexity is put in the more expensive large screen display equipment and not in the simpler 4:3 aspect ratio small screen display. The revolutionary route with its cost penalties in complexity in all receivers does not appear to offer the same rapid market penetration and is therefore not seen as attractive for satellite broadcasting.

CONCLUSIONS

Enhanced C-MAC, a member of the C-MAC/packet family of systems, provides an evolutionary route to higher quality television. The system provides an aspect ratio of around 4.7-5:3 and the quality achieved is considered to be well suited to viewing on displays of around 1 m x 0.6 m, a size which is practical in most homes.

The evolutionary approach to Higher Quality television seems to be the most realistic way ahead. By keeping an eye on both the future and the present, an improved wide aspect ratio high quality service can be introduced in a way which is both economic for the programme provider and attractive to the viewing public.

ACKNOWLEDGEMENTS

We wish to acknowledge the work of our colleagues in the Independent Broadcasting Authority. Without their major efforts in developing and building the C-MAC and Enhanced C-MAC systems, this paper would not have been possible. We wish to thank the Director of Engineering for permission to publish this paper.

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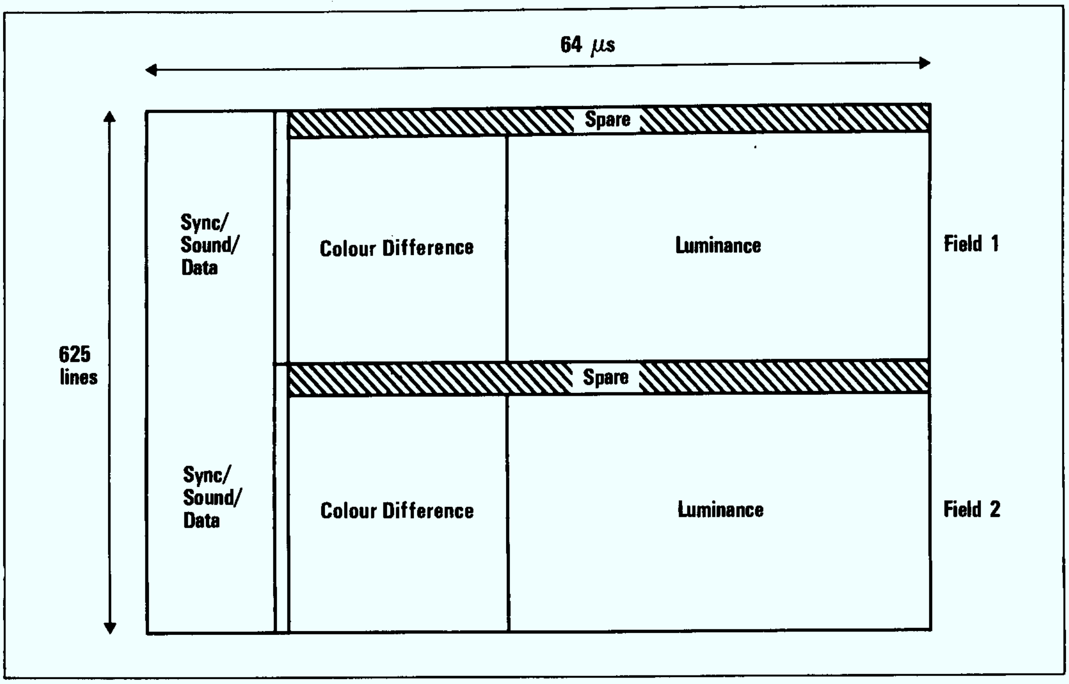

Fig. 1 Transmitted frame for the EBU Satellite Broadcast standard "C-MAC packets".

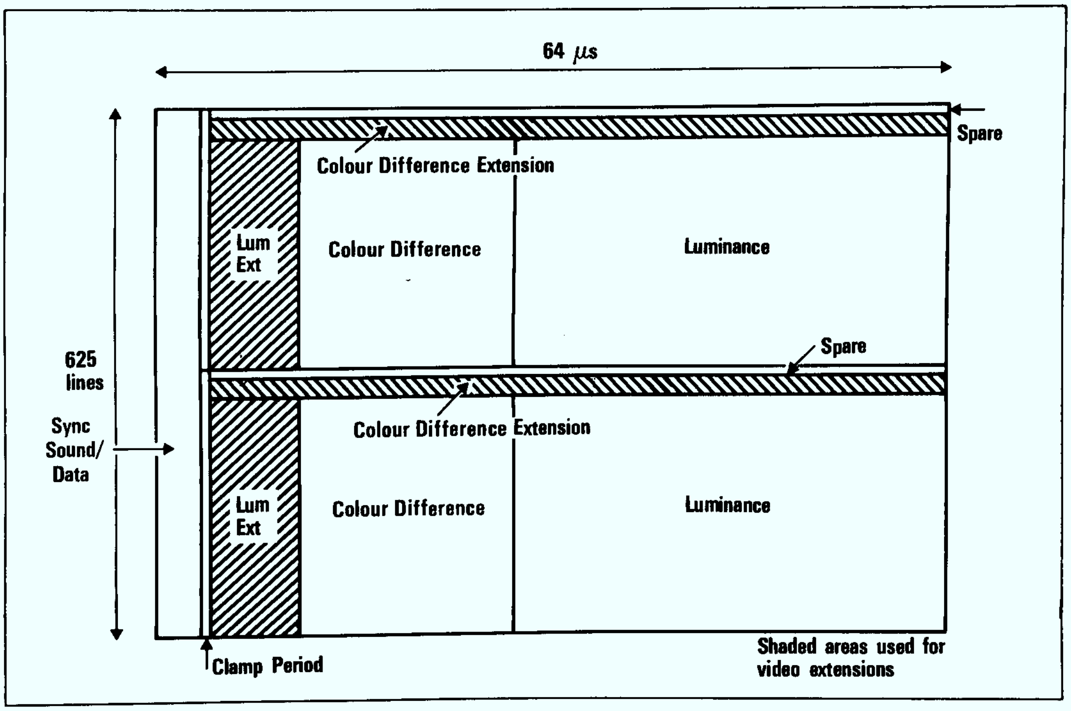

Fig. 2 Transmitted frame for the Enhanced C-MAC system.

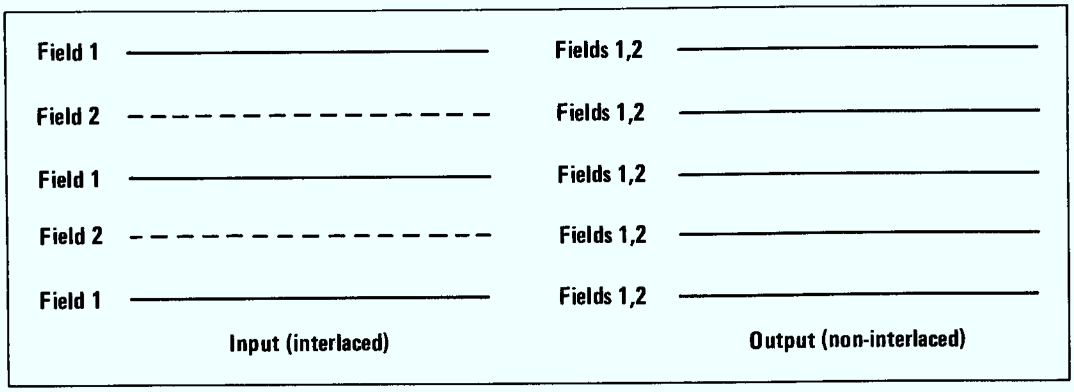

Fig. 3 Input and output line structures for interlaced to non-interlaced scan conversion

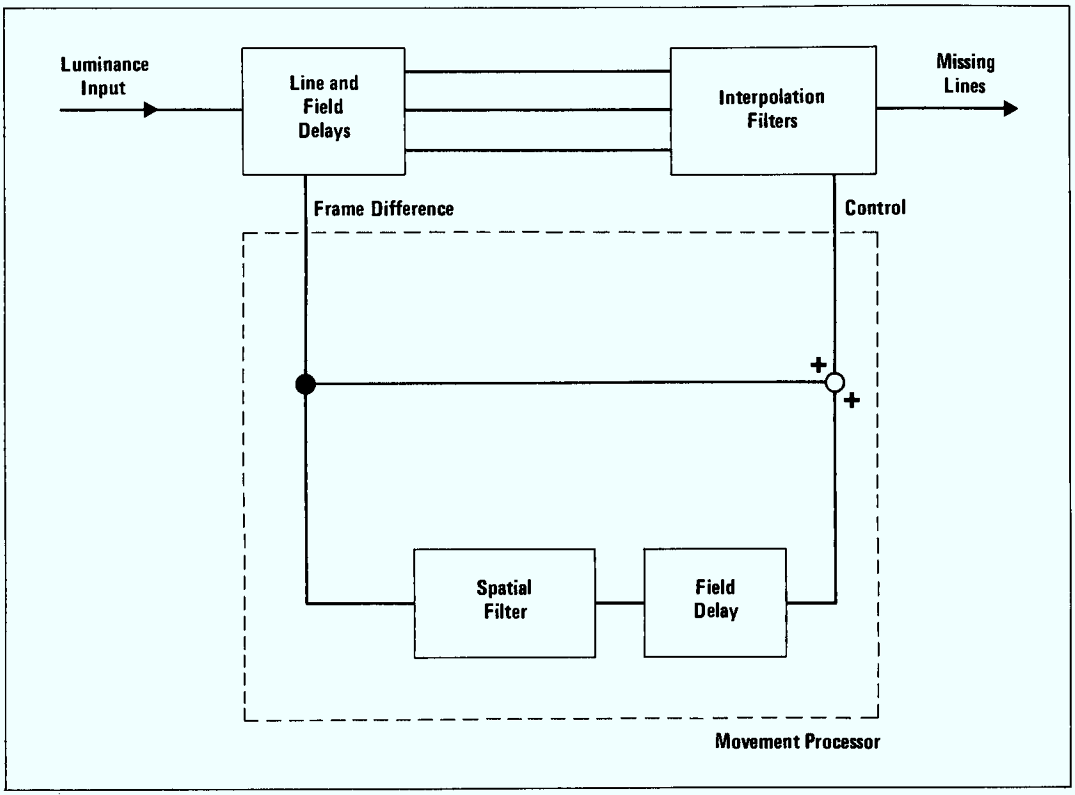

Fig. 4 Interpolation of missing lines in the scan converter

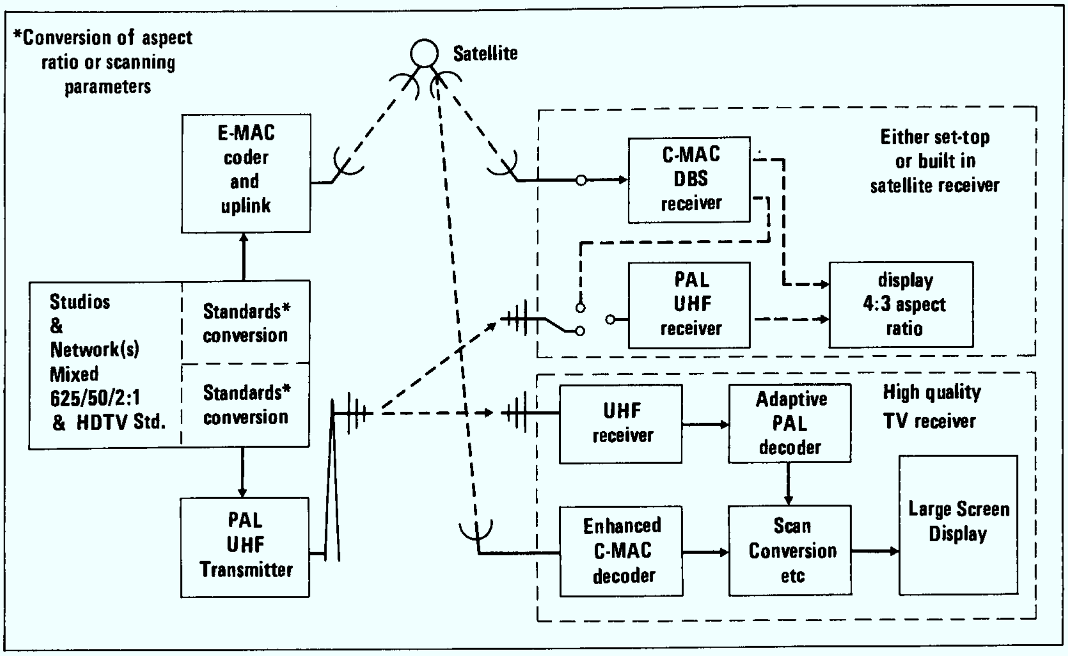

Fig. 5 Block diagram showing inter-relation of satellite broadcasting, terrestrial broadcasting and high quality television.

DEVELOPMENTAL STATE OF VARIOUS HDTV EQUIPMENT INCLUDING THE MUSE SYSTEM

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ABSTRACT

Fifteen years have passed since the research and development of HDTV were started at the Science and Technical Research Laboratories of NHK. In three years, various HDTV studio equipment and signal processing equipment have been developed such as TV camera, telecine, VTR, laser-beam film recorder, CRT, projection-type display, TCI system (Time Compression Integration), and MUSE system (Multiple Sub-Nyquist Sampling and Encoding). Recently, a system converter for converting HDTV signal to NTSC or PAL signal was developed.

Using the MUSE system which reduces the HDTV signal bandwidth to about 1/3, it has become possible not only to broadcast the HDTV signal through one channel of a broadcast satellite, but also to record the HDTV signal on a consumer VTR or an optical video disc, so that the MUSE opens the way to new package media.

System converter which is essential for an exchange of programs between HDTV and conventional TV plays an important role in considering the unified worldwide standard of HDTV.

Using these equipment, a lot of programs of HDTV have been produced and they are experimentally broadcast at Tsukuba Exposition now being held in Japan.

ÉTAT DU DÉVELOPPEMENT DE DIFFÉRENTS SYSTEMES DE TVHD, Y COMPRIS LE SYSTEME MUSE

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RÉSUMÉ

Quinze années ont passé depuis le début des travaux de recherche et développement du matériel de TVHD au Laboratoire de recherche scientifique et technique de la NHK. Cette période a connu le développement de différents équipements de studio et de traitement des signaux de TVHD comme les caméras de télévision, le matériel de télécinéma, de magnétoscopie (VTR), les enregistreurs de film à laser, le TRC, l'affichage par projection, le système ICT (intégration par compression du temps) et le système MUSE (sous-échantillonnage avec compensation de mouvement). Un convertisseur de système a été mis au point récemment pour la conversion des signaux de TVHD en signaux NTSC ou PAL.

Grâce au système qui réduit la largeur de bande du signal de TVHD à environ 1/3, il est devenu possible non seulement de radiodiffuser le signal de TVHD sur une seule voie de satellite de radiodiffusion mais aussi d'enregistrer ce signal de TVHD sur un magnétoscope domestique ou un vidéodisque optique. Le système MUSE ouvre donc la voie à de nouveaux supports d'information.

Le convertisseur de système qui est essentiel dans l'échange des programmes entre le système de TVHD et le système de télévision classique joue un rôle important dans les considérations relatives à la norme unifiée internationale de TVHD.

A l'aide du matériel de TVHD, bon nombre de programmes TVHD ont été produits et ils sont radiodiffusés à titre expérimental à l'exposition de Tsukuba tenue actuellement au Japon.

DEVELOPMENTAL STATE OF VARIOUS HDTV EQUIPMENT

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NHK has proposed an HDTV standard of 1125 lines, 60 fields per second and 2:1 interlaced scanning system. On-going development of equipment based on this standard is continueing and being used in HDTV program production of which some are being converted into NTSC and broadcasted on the NHK channel.

The MUSE system was developed, using bandwidth reduction techniques able to transmit an HDTV signal through one satellite channel of 24 or 27 MHz width. The MUSE system points the way to a realization of the HDTV broadcasting service.

Introduction

High Definition Television, which has recently been attracting interest as a future television system, is now reaching the practical application stage, as most of the studio use equipment have already been developed. For example, hand-held one-piece type cameras along with the standard and portable type cameras are all available with post signal processors, as is also the analog VTR system, while an experimental proto-type digital system has been developed. Laser beam usage, having superior ability in the transfer system between video and film, is employed in the telecine and film recorder. Also CRT color monitors ranging in size from 14 inches to 40 inches are being used in many ways, as well as projection type displays of from 50 inches to 400 inches. All equipment for HDTV studio use except ENG is available, such as the video switcher, DVE, FPU, optical fiber system, computer graphics, steal picture files and so on.

Many programs have been produced using these kinds of equipment with some of them being converted into NTSC and being broadcast on the NHK channel. For this purpose, an HDTV to NTSC standard converter has been developed, as well as a new HDTV to PAL converter.

The MUSE system using bandwidth reduction techniques by which HDTV can be broadcast on a single satellite channel has been developed and as a result the HDTV broadcasting service has become more realistic. Using the MUSE system, an experimental broadcasting service is currently being carried out at Expo. '85 now being held in Japan, where HDTV systems are being utilized in many ways with signals being transmitted through optical fiber networks to other cities up to distances of several hundred kilometers. As the MUSE system reduces HDTV signal bandwidth to the extent of 1/3, HDTV signals can be handled by such things as consumer VTRs, and therefore this MUSE system has versatility for the new package media.

All the above mentioned equipment has been developed using the standard of 1125 line 60 field 2:1 interlaced system which NHK has proposed. The developmental state of HDTV equipment in Japan is described in the following.

1. Cameras

Since the first HDTV color camera, the 3DIS type capable of practical usage was developed in 1980[1], such cameras have been developed with some enjoying market availability. These types consist of those using either 1-inch MM DIS[2] (Magnetic focusing Magnetic deflection Diode operation Impregnated cathode SATICON) or 1-inch MS DIS (Magnetic focusing Static deflection), portable cameras featuring small, light head unit using 1-inch MS SATICON, and a smaller one-piece type camera using 2/3-inch MS DIS of which development has made it possible to pickup pictures at various angles just as conventional cameras. Features of these cameras are listed in Tab. 1.

In the following, various characteristics of HDTV cameras are considered.

1-1 Resolution

Fig. 1 shows the resolution characteristics of the pickup tubes used in the above cameras. These characteristics can be approximated with Gaussian curves in equation (1).

$$Ar(x) \simeq \exp\{-(x/a)^2\}$$

x indicates spatial frequencies, Ar(x) amplitude response at x, and 'a' the spatial frequency given by Ar(x) = 1/e. The approximation (1) as to the DIS tubes holds within an error amount of several percent. Assuming the equation (1), the resolution of pickup tubes can be expressed in one parameter 'a' which also applies to the expression of resolution. The arrows in Fig. 1 show the parameter 'a' of each pickup tube.

Resolution can be improved by two-dimensional aperture correction applied to the output signal from the pickup tube, while the SNR (Signal to Noise Ratio) is reduced. Fig. 2 shows the noise increase ratio with applied aperture correction which compensates completely the resolution up to the maximum spatial frequencies transmissible in the 1125 line system (1035 TVL: equal to the number of active scanning lines). In Fig. 2 the parameter 'a' is normalized by the maximum spatial frequency. The noise increase ratio decreases with the large value of 'a', and increases rapidly with the value of 'a' below unity. It is desirable for the pickup tube used in HDTV cameras to have a response of more than 35% at 1000 TVL, and as the parameter 'a' of the 1-inch MM DIS is about 0.9 (950 TVL), it satisfies the above requirement, although the 1-inch MS and 2/3-inch MS tubes need improvement in resolution.

The resolution of the lens with full aperture reaches the same level as the resolution of the 1-inch MM DIS, therefore, the lens is a factor which limits camera resolution. The deterioration of resolution and the lack of light in the picture corners are noticeable when the lens is operated at the full aperture. To keep satisfactory characteristics as the HDTV camera, it is necessary that it is used at least in one lens stop down operation.

1-2 Signal to Noise Ratio

Though the video signal bandwidth of the luminance signal (Y) is set to 20 MHz in the provisional HDTV standard, the camera provides a bandwidth of 30 MHz in order to prevent degradation of picture quality caused by bandwidth limitation. The triangular noise* in the camera signal indicates that the noise power increases in proportion to the third power of bandwidth, and that the system with 30 MHz has greater noise power of some 26 dB compared to the conventional systems of 4.2 MHz.

The SNR should be taken into account in developing an HDTV camera, because of the above fact. As the signal current of pickup tubes used in these cameras is set at 2 $\sim$ 4 dB greater than conventional ones, the SNR shows improvement to the corresponding amount. "Parcival's circuit" which has not been used in conventional cameras, is useful in bringing about an improvement of SNR by 3 $\sim$ 5 dB in HDTV cameras. To increase the SNR in proportion to the number of amplification elements, a low noise distributed amplifier has also been developed.[3]

In the 1125 line system, the detectable threshold of noise in Y signal at the viewing distance of three times picture height, is said to be 37 dB expressed in SNR. Although these cameras exceed the threshold, they may fall short of it when the aperture correction is applied, while also greater improvement of SNR would be desirable.

1-3 Sensitivity

The HDTV cameras when compared with conventional types, have lower sensitivity of about a half lens stop because of large signal current and poor utilization** of incident light.

Pickup tubes have generally a reverse-correlation between the maximum signal current and the resolution, while higher resolution tubes have a smaller current and vice versa. The reverse-correlation of DISs is shown in Fig. 3. This reverse-correlation shows that the resulting SNR does not always show improvement due to the large noise increase ratio combined with the aperture correction which is necessary for the corresponding decrease in resolution even when trying to improve the SNR by means of increased signal current. Conversely, even with reduced signal current, the resulting SNR may show improvement due to the corresponding higher resolution along with lower aperture correction. Fig. 4 shows the highest resulting SNR given with the parameter 'a' at about unity.

The parameter 'a' of actual pickup tubes is less than unity and therefore it is possible to improve the resulting SNR as well as sensitivity corresponding to

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* The r.m.s. amplitude of triangular noise increases in proportion to frequencies.

** Assuming the diagonal lengths are the same, the scanning area is smaller with a 5:3 aspect ratio compared with 4:3.

the reduction of signal current when its reduction with increase of resolution is achieved.

1-4 Lag

The lag after three fields in these cameras is 1% $\sim$ 3%. Lag can be removed by the enhancement of higher frequencies on temporal domain using field memories, even though the resulting SNR would deteriorate. This would not be a problem as the deterioration would only be of 2 $\sim$ 3 dB for the above value of lag. With this in mind, dvelopment of a lag remover based on this method is being carried out.

The integration effect along with lag is an important factor of degrading dynamic resolution. At the present technical level, there is no alternative but to use mechanical shutters with loss in sensitivity. A new improved method without sensitivity loss and with low SNR deterioration is necessary.

1-5 Registration

Mis-registration not only causes deterioration of mis-convergence in the reproduced picture but also luminance signal resolution composed of R, G and B signals. The mis-registration should be less than 0.4 times the distance between scanning lines in order to keep deterioration within -3 dB.

A precise registration correction circuit named DRC (Digital Registration Correction) has been developed to keep severe accuracies in registration. The picture area is divided into a large number of regions in order to be able to adjust the registration of each region independently, while a similar technique is applied on the convergence system of the displays. This kind of technique is one of the basic approaches required for good picture quality of HDTV equipment.

1-6 Auto-setup

The auto-setup system concerning to the black and white balance well-established in conventional TV cameras, has no adverse effect in its application in HDTV camera.

The auto-setup of DRC is performed as follows. First, the camera shoots either a pattern generator equipped in the zoom lens or a special picture, for example a picture where the V marks are arranged corresponding to the DRC regions. Second, the mis-registration in each region is measured, after which the measured value is subtracted from the DRC data of each region. This sequence continues until the mis-registration of the entire regions becomes less than the prescribed value or until the number of the sequence exceeds the prescribed amount.

The time necessary for the DRC auto-setup is about one minute per channel $\sim$ for example in the 3DIS Camera $\sim$ even though there are some differences in setup time depending on the measuring method of mis-registration, the number of divided regions or the primary mis-registration.

2. VTRs

The video signal bandwidth of HDTV signals is five times that of the conventional one, and in order to record these wide bandwidth signals on tape it is necessary to widen the frequency characteristics of the video head or signal process unit along with the necessity of high density recording. There are two approaches in realizing wide bandwidth recording. One is a high speed wide band recording with a higher head running speed, while the other is a multi-channel low speed recording where the signal bandwidth of each channel is reduced to the extent which conventional VTRs are able to handle. Although the above methods have their own advantages and disadvantages, the result has been that two kinds of VTRs have been developed correspondingly to these two approaches. Of these the former is the Y-C two channel system where the luminance signal Y of 20 MHz bandwidth and the line-sequential color difference signal of 7 MHz bandwidth are recorded respectively(4). The latter is the R-G-G-B four channel system having 10 MHz bandwidth per channel, which is presently available on the market and enjoying various usages.

In the multi-channel system, signal kind allocation to each channel should be considered, in other words the SNR distribution among three components of the color signal (Y and two Cs). The R-G-G-B system has higher SNRs of 5.5 dB in Y and 1.7 dB in R-Y but slightly worse in B-Y respectively, compared with the case of recording Y, R-Y and B-Y signals through each channel respectively. In view of the noise of the color difference signal being unnoticeable to the human eye plus the merit of being able to use the same hardware for each channel, the R-G-G-B system is considered the proper one in the four channel system format.

In order to record the Y signal of the 20 MHz bandwidth, the following signal processes are carried out. After the input R, G and B signals are limited to a bandwidth of 10 MHz, the higher frequency component from 10 MHz to 20 MHz in the Y signal is added to the G signal. Through the process of time expansion by two times, the G signal is divided into two channels ∿ G1 and G2 ∿ with each signal having a bandwidth of 10 MHz, after which these four signals are recorded on tape by FM. In the play back mode, following the G1 and G2 signals time compression by two times, they are then synthesized into one signal where the original G signal is reproduced. Fig. 5 shows the functional block diagram of the VTR while its characteristics are listed in Tab. 2.

3. Displays

HDTV displays having screen sizes of more than fifty inches in diagonal, are desirable with them being as thin as possible for home usage. The gas-discharge type flat pannel display could be utilized, however present technology has not reached the level needed for this kind of HDTV display. Displays(5) only suitable for usage in HDTV are the direct-viewing CRT and the projection type monitors having high brightness CRTs. Some of these direct-viewing CRT displays are listed in Tab. 3.

As there is a limit to the size of CRT monitors due to problems of intensity and weight of the glass tube used, there is no alternative but to use the projection type in making large size displays of over 40 inches. In projection type displays, each CRT for R, G, and B cannot function properly when used together, for example when the CRT for G channel is set in the center axis of the screen, the CRTs for

R and B become off axis which results in serious mis-convergence on the screen occurring. Most projection type displays for HDTV provide circuits similar to the DRC in cameras in which they are able to correct the mis-convergence accurately. Tab. 4 lists several projection type displays.

The 400-inch type being used at Expo. '85 in Japan, has four projection tubes for each R, G and B channel in order to obtain sufficient brightness on the large screen. In such a case, slight mis-convergence in the same color channels ∿ perticularly in G channels ∿ causes serious deterioration of resolution on the screen. The convergence accuracy of 0.02% is required to keep sufficient resolution for HDTV. As it is difficult manually to adjust the convergence accurately, an automatic convergence control system consisting of several conventional 525-line CCD cameras equipped in the system which shoot the picture on the screen, was developed to overcome this problem. Mis-convergence of each divided region is measured using the CCDs' video signals, after which the mis-convergence is corrected accurately.

The compact 55-inch type display was developed as a model for home usage while many others have been produced and are being used in many ways.

4. Telecine

The motion picture film is one of the most important and attractive program sources for HDTV. In order to transfer film pictures to HDTV video signals without degradation of picture quality, laser telecine equipment has been developed(6), having advantages hardly obtainable with other types of telecine. As the film is directly scanned by the laser beam concentrated into a small spot with high intensity, characteristics such as high resolution and high SNR can be obtained without any degradation caused by blooming, flare or lag.

The configuration of the laser telecine is shown in Fig. 6 and consists of three separate laser beams for the R, G and B channels which are then combined into one beam and deflected horizontally. Vertical scanning is mainly carried out by the continuous running of the film while sub-deflection is used to adjust slightly the vertical position on the film corresponding to its running speed or format, as the running speed can vary continuously from 3 to 120 frames per second. In this method, the laser beam passing through the film is separated into R, G and B components, each of which are converted to electrical signals by a photo-multiplier, with the video signals controlled to optimize the picture color through the frame-by-frame color corrector in the video processor.

The frame rate conversion (24 fps to 30 fps) as well as the progressive to interlaced scanning conversion are carried out in the frame memories.

By combining the frame memories and sub-deflector, the conversion from film to video is achieved, regardless of film running speed, running direction and film format.

This equipment is able to operate in 35 mm and 16 mm film formats and at present is being used practically at Expo. '85 in Japan.

5. Film Recording

An immediate application apart from broadcasting of HDTV is electro-cinematography, in which motion picture films can be produced using the television system. In order to realize electro-cinematography, various video-to-film transfer systems have been developed, among which is the laser film recorder(7).

For conventional kinescope, it is difficult to achieve both high-brightness and high-resolution requirements of CRTs and to perfectly match spectral characteristics of CRT's phosphors to the spectral sensitivity of the film. Although slow-speed film provides high resolution and fine grain, it cannot be used due to the insufficient light output of CRTs. However, excellent picture quality can be obtained by utilizing the characteristics of the laser beam, such as its extreme brightness, sharp directivity and good monochromacity.

Fig. 7 shows the configuration of the laser film recorder for HDTV which consists of laser light sources, optical modulators, an optical deflector, a recording camera, a frame rate converter, video processors, etc. with the operating principles of the recorder being as follows.

The R, G and B laser beams are intensity-modulated by optical modulators in accordance with the R, G and B video signals respectively, and are combined into a single beam by dichroic mirrors, after which the beam is deflected horizontally by the rotating optical deflecting mirror and focused on the 35 mm film continuously running in the recording camera. The signal recorded on the film should be in the form of 25 frames per second with progressive scanning lines, and more additional scanning lines are also necessary in order to match the vertical blankings between the HDTV signal and film format due to the film having a larger blanking than the video signal. Using three field memories, the standards converter works in such conversions with output signals being in the exact forms of 23.68 frames per second and 1425 lines per frame.

6. MUSE System(8)

NHK is proposing to broadcast the 1125-line HDTV picture on one broadcast satellite channel using a 24 or 27 MHz width channel with the HDTV receiver tuned to the channel the same as with the 525-line receiver.

NHK has considered and examined several bandwidth-compression techniques, and is tentatively specifying the following for HDTV transmission:

- Luminance and color information to be sent by TCI (Time Compressed Integration) signal;
- Color information to be sent by time-compressed line-sequential color component signals;
- Time-compression of the color-difference signal to be by a factor of four;
- The TCI signal to be bandwidth-reduced using the three- dimentional phase-alternating sub-sampling method with the processed signal bandwidth being about 8 MHz.

◦ A digital audio signal to be multiplexed with the video signal.

The bandwidth-compression method is called MUSE (Multiple Sub-Nyquist sampling Encoding), being a motion-compensated sub-sampling system, and is currently in use at Expo. '85 in Japan where at the same time HDTV broadcast services are being carried out experimentally.

6-1 Sampling and Interpolation in the MUSE System

Tab. 5 shows the most important characteristics of the MUSE system, while Fig. 8 the sampling pattern of the system of which the cycle of the sequence is in a period of four fields. Fig. 9 illustrates the original picture and also the four transmitted pictures of each field.

For a stationary picture area (portion of the field where the picture is stationary), an HDTV picture can be reconstructed by temporal interpolation using samples of signals from all four fields. Fig. 10 shows a transmissible region of the spatial frequency domain for a stationary picture area. The total number of samples used in reconstruction are one half of the original ones with the reconstructed picture being slightly different from the original picture. However as illustrated in Fig. 9(b) and (c), the difference is slight and picture quality is better compared to the case as shown in Fig. 9(a), where the total number of samples are the same as one half of the original but are only sub-sampled horizontally.

For a moving picture area, the final picture is constructed by spatial interpolation using signals sampled from a single field. If the signals of two or more fields were used to reconstruct a moving area, the technical quality of the picture would be degraded because of multi-line blur. By using spatial interpolation, the transmissible region is narrowed as shown in Fig. 10(b).

In the case of movement caused by panning or filting, blur is more noticeable and so to avoid this effect of spatial interpolation, the usage of motion-compensation is introduced. A vector representing the motion of a scene is calculated for each field at the encoder and the vector is transmitted to the decoder using the vertical blanking period. In the receiver, the position of sampled picture elements of the preceding field are shifted according to the motion vector. Together with this motion-compensation, temporal interpolation can be applied to panning and tilting with no resulting blur.

6-2 System Construction

The block diagram of the MUSE transmitter and receiver are shown in Fig. 11 with the signal flow being as follows. First, the video signal is encoded into a TCI signal with a sampling frequency of 64.8 MHz. Prior to the signal being sub-sampled at 16.2 MHz, different pre-filters (anti-aliasing filters) are applied according to whether the portion of the picture is moving or stationary, with ideal characteristics for these two filters being shown in Fig. 10(a) and (b) respecively. The mixing-ratio for the output of the two filters corresponds to the motion of the picture, which is detected pixel-wise. Certain control signals, like motion vectors, are transmitted in the vertical blanking interval, while in the receiver, the output of two interpolators is employed according to whether the portion of the picture is moving or stationary with the motion detection being done pixel-wise.

6-3 Band-Reduction Rate of the MUSE System

As mentioned earlier, the MUSE transmits half the number of samples of the original picture and divides them into two fields, resulting in a transmitting rate a quater of the original. Theoretically the bandwidth of HDTV signals should be able to be reduced to 5 MHz due to the original signals having 20 MHz width. While the FM transmission system using 24 or 27 MHz bandwidth of one satellite channel can transmit a baseband signal of about 8 MHz. The most important aspect of the MUSE is of course to transmit HDTV signals on one satellite channel, so therefore in the MUSE, the sampling frequency of 64.8 MHz was chosen due to the needed requirement of the band-reduced signal having an 8 MHz bandwidth.

Ideally it will be possible for the MUSE to transmit a horizontal resolution of 32.4 MHz for stationary areas as well as 16.2 MHz for moving picture areas which will result in the horizontal resolution being only slightly lower compared to the primary resolution of 20 MHz.

6-4 Applications of the MUSE System

The HDTV broadcast system conception is as shown in Fig. 12 with many kinds of peripheral equipment and systems to be included in this practical system.

Several kinds of peripheral equipment have been developed, such as consumer VTRs, optical video disc recorders and an adapter which converts the MUSE signals to conventional video signals for standard receivers. A simple encoder for the HDTV home-use VTR has also been developed, where the 3/4-inch cassette type VTR is able to record and replay a program up to an hour's duration with usage of the 1/2-inch cassette type also being possible. The video disc unit has a 30 cm laser disc format on which 30 minutes of MUSE signal can be stored on either side.

Combined with these and other kinds of equipment, the MUSE has potentiality to give versatility not only to the broadcasting service but also to the new package media.

7. Standards Converter[9]

It will be inefficient for a future TV station to have separate studios for both HDTV and conventional TV as programs can be produced with HDTV equipment even if the program is for conventional TV. In electro-cinematography ∿ one of the HDTV applications ∿ the frame rate conversion from the TV frame rate to the film rate of 24 fps is needed.

A conversion from 1125 line/60 field/2:1 interlaced HDTV signal to NTSC is easily performed in principle by a two-dimensional low-pass filtering in spatial frequency domain, while conversion to PAL or film requires to convert frame rates. These conversions have been carried out mainly by techniques using a linear interpolation, which however is unable to give satisfactory resulting picture quality because of blur and jerkiness in the moving picture area.

A new technique of advanced motion-compensation used in the MUSE system has been developed. The proto-type is able to converte the 1125/60/2:1HDTV signal to 625/50/2:1PAL signal, and was demonstrated successfully at the CCIR IWP 11/6 meeting held in Tokyo in January 1985 with the possible adoption of single world-wide HDTV standard. The same technique can of course be applied in the video to film converter.

The new converter concept is as follows with Fig. 13 showing the configuration of the equipment. The system consists of three blocks being PLSC (Progressive Line Scanning Converter), LIFC (Linear Interpolation Frame Converter) and MCFC (Motion Compensated Frame Converter).

PLSC consists of line and field memories and a motion detector with line conversion being carried out using inter-field interpolation in the stationary picture area but using intra-field interpolation in the moving area, with an output signal of 625 line 60 field non-interlace. The output signals from the motion detector controls which interpolation is to be used.

LIFC is made up of a frame memory and linear interpolation frame circuitry for basic frame conversion employing the same construction as existing standards converters. The linear interpolation frame circuitry produces the weighted average of the combined current and previous frame signals according to frame order, which results in a linear interpolated frame signal.

MCFC is made up of frame memories, motion-compensation circuits and a detector which performs motion vector using the current frame and previous frame signals. After the magnitude adjustment of the motion vector is carried out according to frame order, the vector controls the picture position of the motion compensater output. In other words the read-out address of the frame memories is shifted according to the vector.

The output signal of the LIFC ∿ with an edge signal in the moving area added on by the edge signal generator ∿ and the output signal of MCFC are selected by the motion signal which discriminates between the stationary area and the moving area. Finally the signals undergo non-interlace to interlace conversion with an output signal of 625/50/2:1.

Conclusion

In the previous sections, the development of HDTV equipment in Japan has been described. The characteristics of various HDTV equipment will continuously improve, with existing TV equipment also benefitting from the new technology which has been developed to overcome technical difficulties in realization of HDTV, such as the precise registration correction system in cameras or the motion compensation used in the MUSE system.

From the aspect of HDTV program production, the main subject of experimental production is now turning to the artistic side rather than the technical one, in other words, to what can be best expressed by HDTV. NHK is moving to produce some twenty to thirty programs this current year, thus showing the practical ways that HDTV is being used. In this situation, it is very urgent to decide the most acceptable world-wide HDTV standard.

The author hopes that this paper will be of any help in the development of the HDTV system.

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	3 DIS	MS Standard	Portable	Hand-held
Developed in	1980	1984	1983	1984
Configuration	with CCU	with CCU	with CCU	One-piece type
Tube used	1-inch MM DIS	1-inch MS DIS	1-inch MS	2/3-inch MS DIS
Limiting resolution *1	1600 TVL	more than 1200 TVL	more than 1200 TVL	more than 1000 TVL
SNR *2	44 dB	44 dB	41 dB	38 dB
Sensitivity (at 2000 lx)	F : 2.8	F : 3.2	F : 3.2	F : 2.8
Lag	1 %	1 %	3 %	1 %
Registration (entire picture area)	less than 0.025 %	less than 0.04 %	less than 0.04 %	less than 0.3 %
Weight of the CHU	48 Kg	41 Kg	9.6 Kg	6 Kg
Camera cable length	200 m	1 Km with optical fiber cable	1 Km with optical fiber cable	—
Others	Auto setup Fine regi. correction Different scanning line operation capabilities	Auto setup Fine regi. correction Market availability	Auto setup Fine regi. correction Market availability	Battery operation capability Prototype only

*1 Without band limiting filter

*2 Bandwidth of 30 MHz

Table 1 Features of typical HDTV cameras

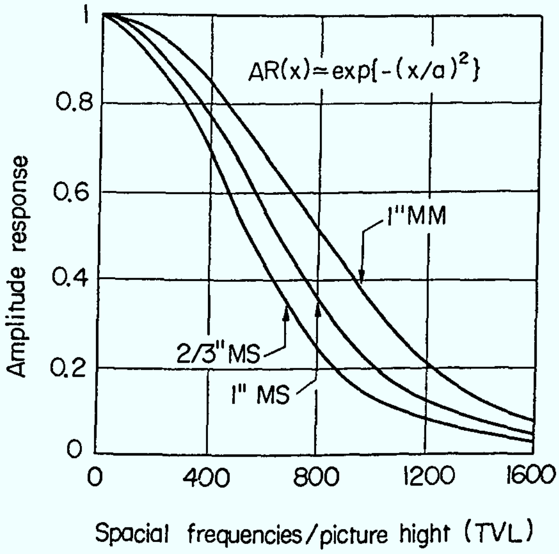


Fig. 1 Resolution characteristics of some pickup tubes

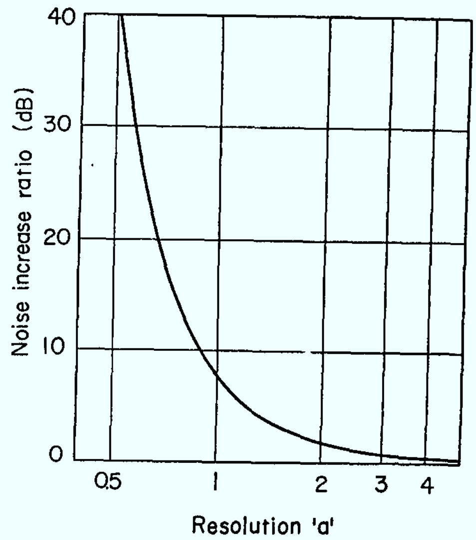


Fig. 2 Noise increase ratio with applied aperture correction

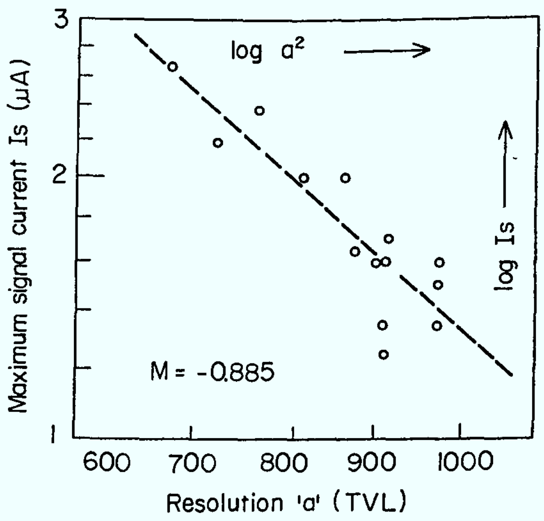


Fig. 3 Reverse-correlation between signal current and resolution of the DISs

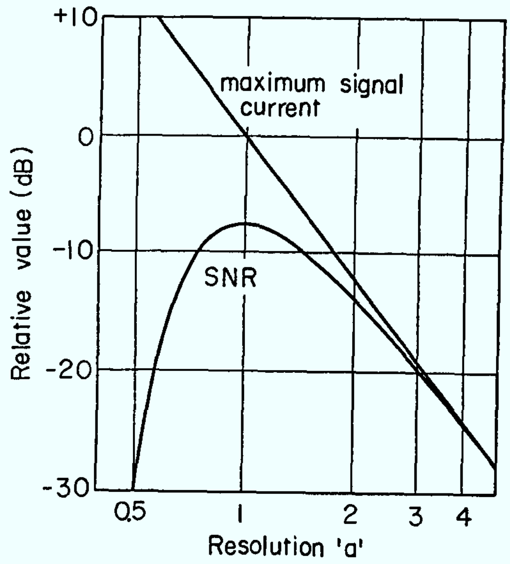


Fig. 4 Relation between signal current and resulting SNR

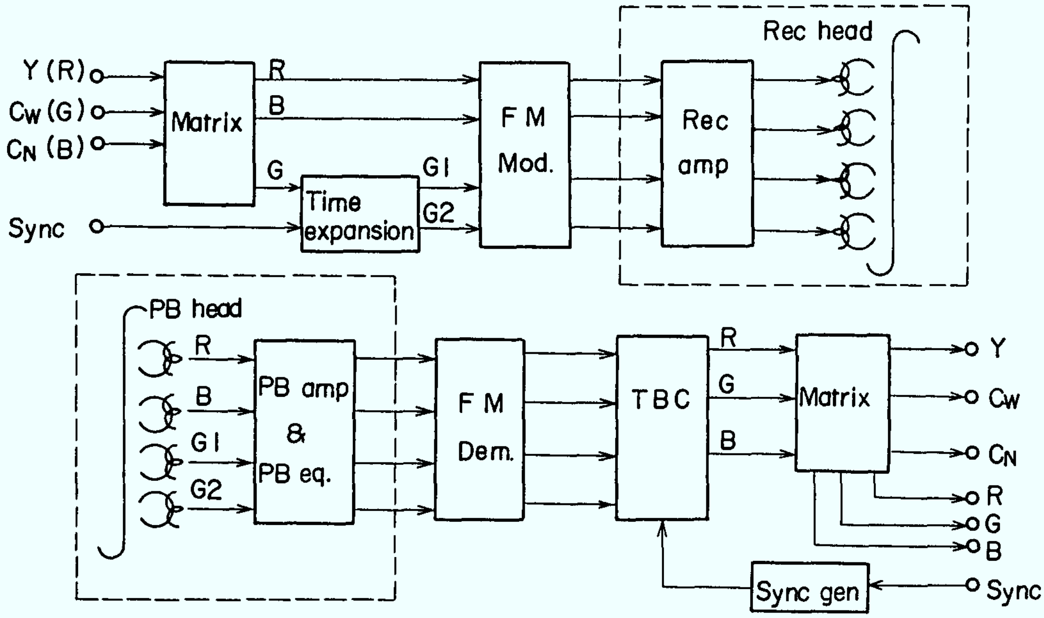


Fig. 5 Functional block diagram of four channel VTR

Signal bandwidth	Luminance Chrominance	DC ~ 20 MHz, +0.5dB ~ -3dB DC ~ 10 MHz, +0.5dB ~ -3dB
SNR		more than 42 dB
DG		less than 5 %
Residual time base error		±5 nsec
Y/C delay		less than 5 nsec
Tape running speed		483.1 mm/sec
Writing speed		25.58 m/sec
Maximum recording time		63 min

Table 2 Characteristics of four channel VTR

	26-inch	30-inch	40-inch
Developed in	1981	1977	1984
CRT used (aspect ratio)	26-inch (4:3)	30-inch (5:3)	40-inch (5:3)
Shadow-mask pitch (mm)	0.37	0.34	0.46
Weight of CRT	22 Kg	35 Kg	85 Kg
External size (WxHxD cm)	61x54x61	76x56x65	100x85x85
Peak luminance	150 cd/m^2	100 cd/m^2	100 cd/m^2
Limiting resolution	1000 TVL	1000 TVL	1000 TVL
Convergence system	Analog	Analog	Digital with auto setup

Table 3 Features of typical CRT monitors

	55-inch	110-inch	400-inch	Eidophor
Projection system	3 tubes rear projection	3 tubes front projection	12 tubes rear projection	3 tubes front projection
Light source	7-inch CRT	12-inch CRT	10-inch CRT	Xenon lamp 4.2Kw
Light output	90 lumen	180 lumen	1800 lumen	5800 lumen
Screen size (WxH mm)	1180 x 708	2400 x 1450	8000 x 4800	4770 x 2862
Screen gain	5.5	10	4	3.5
Peak luminance	150 cd/m^2	150 cd/m^2	50 cd/m^2	150 cd/m^2
Observable region vertical	± 15°	± 10°	± 10°	not limitted
Observable region horizontal	± 30°	± 30°	± 40°	± 30°
Limiting resolution	1000 TVL	1000 TVL	800 TVL	800 TVL
Convergence system	Digital	Digital	Digital with auto setup	Analog
Remarks	For home use	For mini-theater	Used at Expo.'85	

Table 4 Features of typical projection type displays

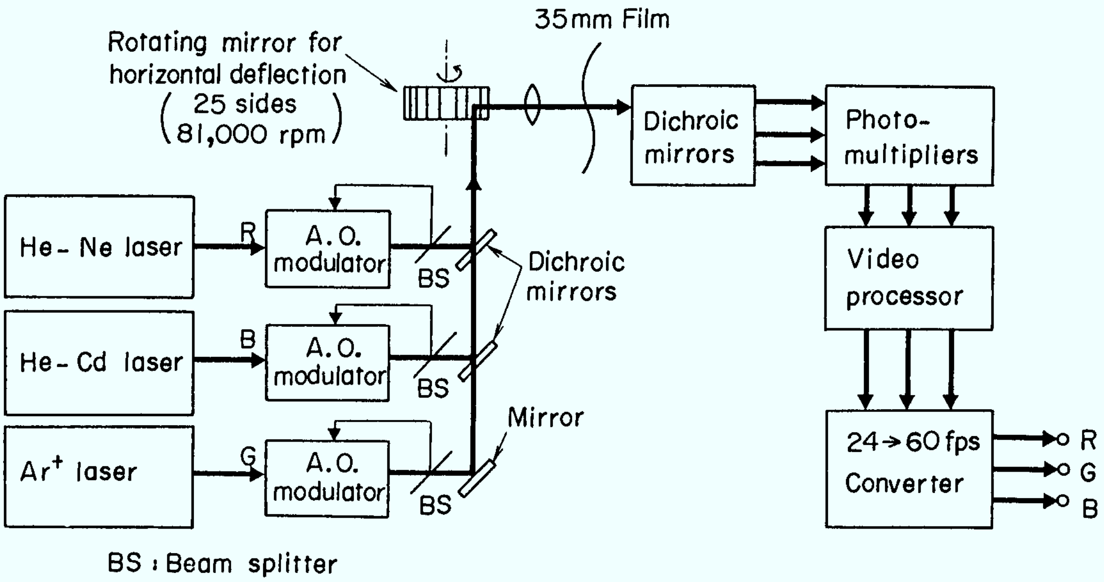


Fig. 6 Configuration of laser telecine

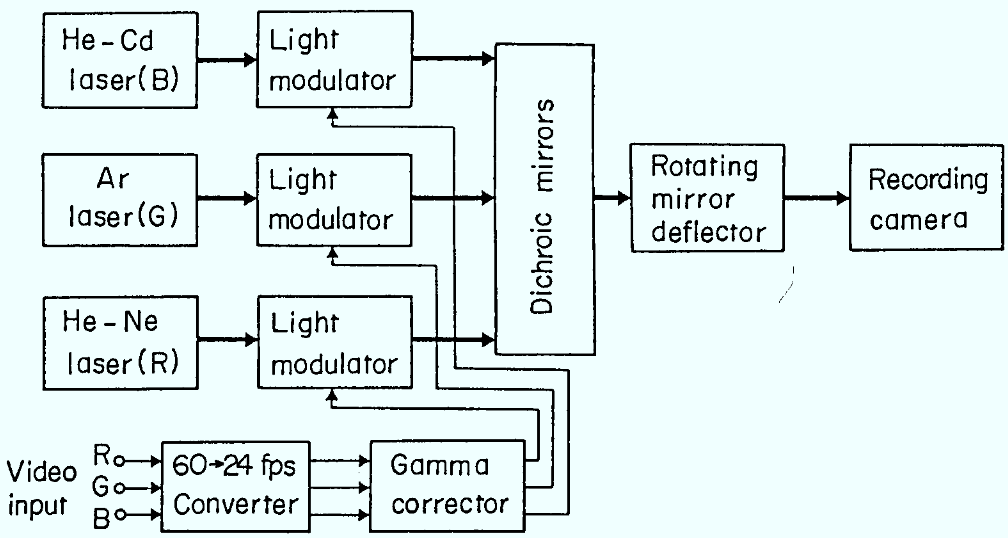


Fig. 7 Block diagram of laser film recorder

System		Motion-compensated multiple subsampling system (Multiplexing of C signal is TCI fromat.)
Scanning		1125/60 2:1
Bandwidth of transmission baseband signal		8.1 MHz (-6 dB)
Resampling clock rate		16.2 MHz
Horizontal bandwidth	(Y)	20~22MHz(for stationary portion of the picture) 12.5 MHz*(for moving portion of the picture)
	(C)	7.0MHz(for stationary portion of the picture) 3.1 MHz*(for moving portion of the picture)
Synchronization		Positive digital sync
Audio and additional information		PCM multiplexed in VBLK using 4ϕ DPSK (2048 Kb/s)

* Values of a prototype receiver: these values should be 16MHz and 4MHz, if a perfect digital two-dimensional filter could be used

Table 5 Characteristics of the MUSE system

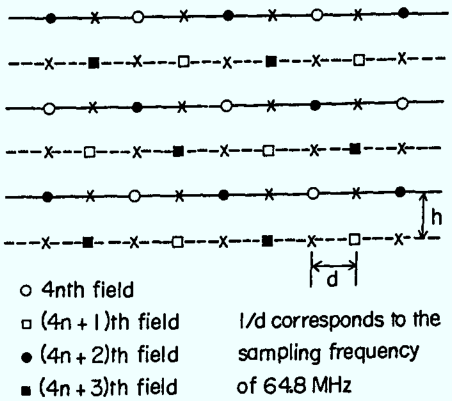


Fig. 8 Sampling pattern of the MUSE system

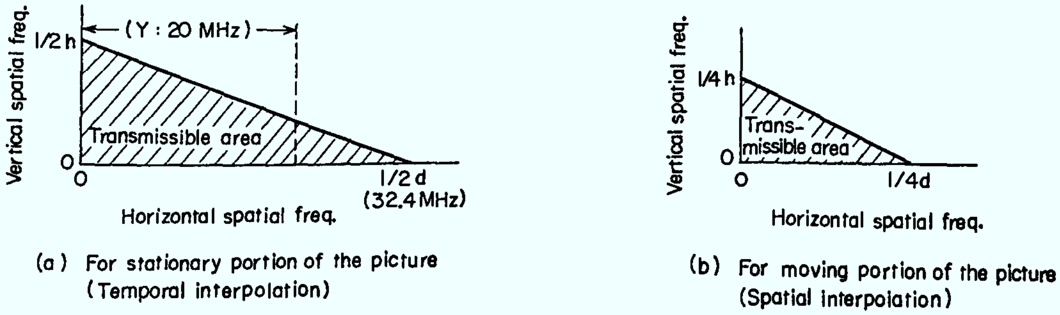
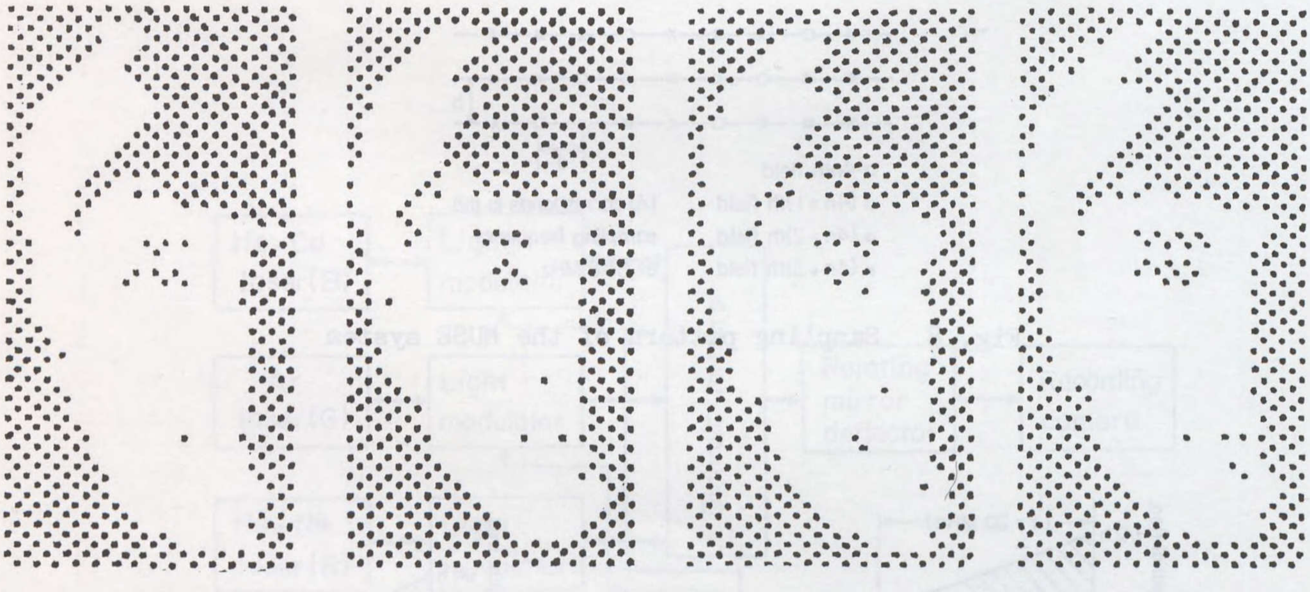


Fig. 10 Transmissible spatial frequency area of the MUSE system

(a) Horizotally sub-sampled picture (b) Original picture (c) Phase-alternating sub-sampled picture



(d) Transmitted in n-th field (e) Transmitted in (n+1)-th field (f) Transmitted in (n+2)-th field (g) Transmitted in (n+3)-th field

Fig. 9 Illustrations of the pictures transmitted in the MUSE system

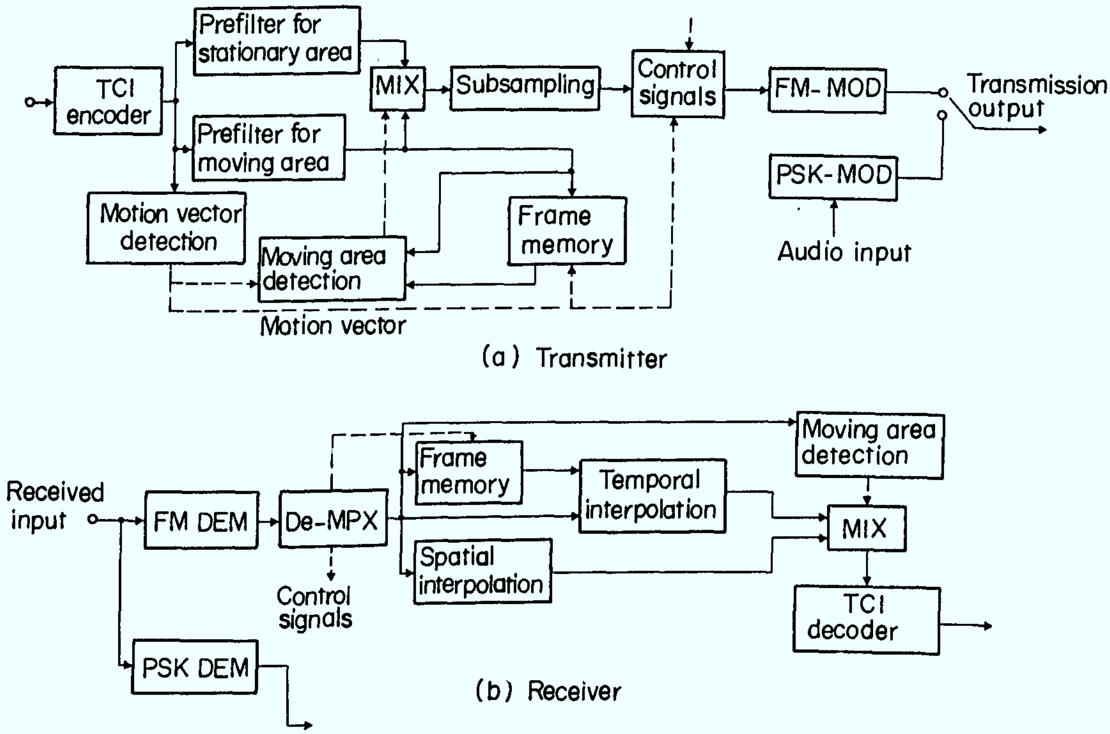


Fig.11 Block diagram of MUSE transmitter and receiver

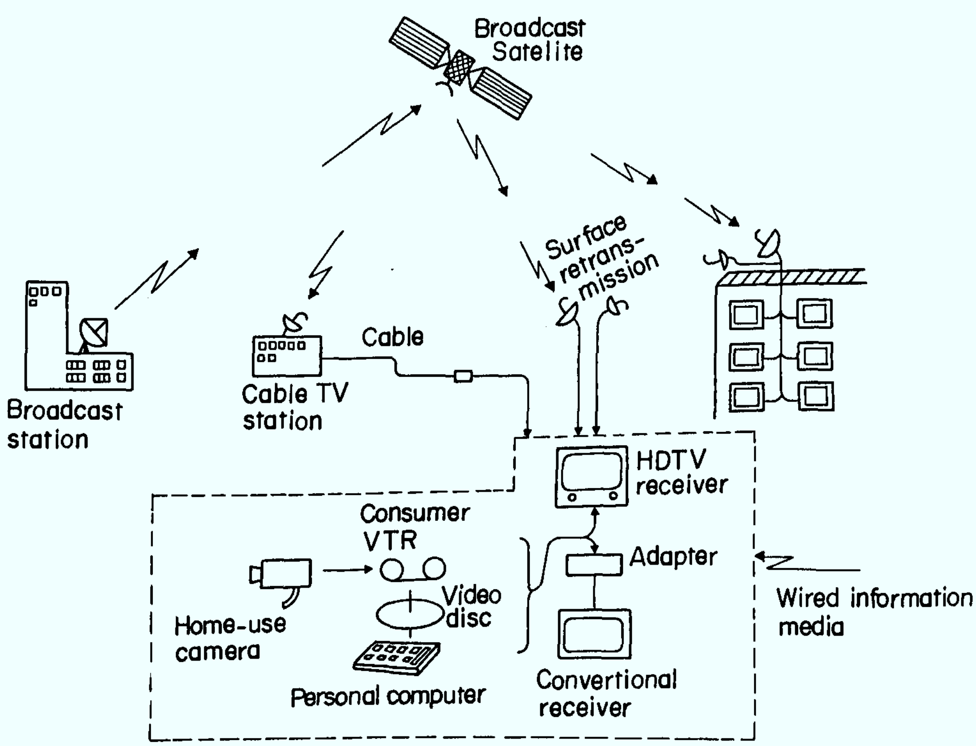


Fig. 12 Service image of the HDTV broadcast

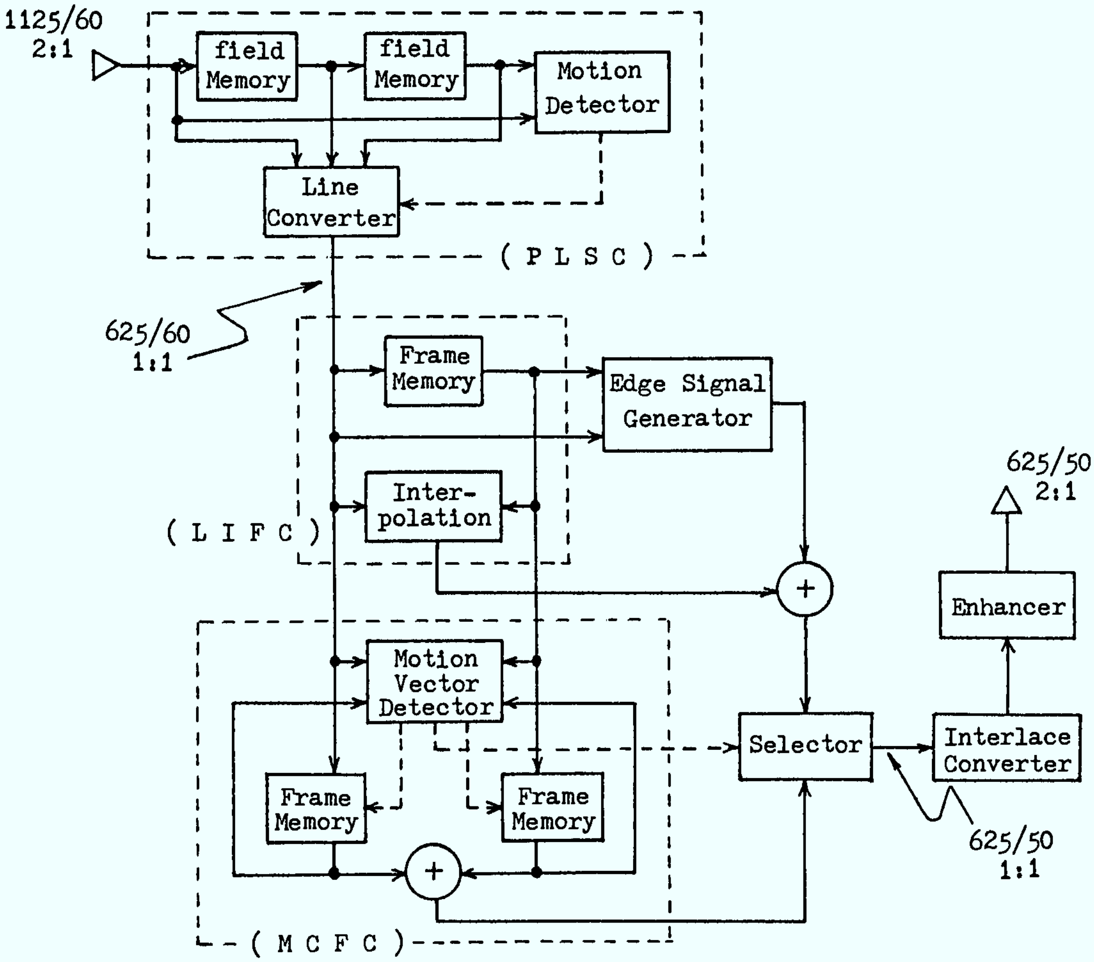


Fig. 13 Block diagram of the 1125/60 to 625/50 converter

THE EVOLUTION OF B-MAC INTO A FULLY COMPATIBLE EDTV SYSTEM

3.8

John D. Lowry

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Toronto, Ontario
Canada

ABSTRACT

For the past three years, Digital Video Systems in Toronto has been working on the development of a new format for delivery to the home of improved quality television pictures with up to six high fidelity digital sound channels combined with a range of text, data and access control features. The set of custom integrated circuits for implementation of a low cost consumer B-MAC decoder for operation in both 525 and 625 line standards, is now essentially complete.

While designed principally to optimize channel utilization for satellite distribution, the format also applies for terrestrial broadcast, cable TV, master antenna TV, multipoint distribution systems, etc.

The B-MAC format can provide for compatible distribution of 4:3 (1.33/1) and 16:9 (1.78/1) aspect ratios in the same channel, with selection by the viewer of the ratio appropriate to his display equipment. "Pan & Scan" for selection of the 4:3 portion of the total picture area will become a built-in feature of the home decoder, under frame by frame digital control from the broadcast centre.

This paper gives an overview of the B-MAC system, and details various parameters of the format that are related to the compatible wide screen technique.

The following paper by Charles Rhodes, discusses the utilization of a second distribution channel which can be added to this standard broadcast compatible channel for presentation of full high definition wide screen video, sound and data.

ÉVOLUTION DU B-MAC VERS UN SYSTEME DE TVHD TOTALEMENT COMPATIBLE

3.8

John D. Lowry

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RÉSUMÉ

Depuis trois ans, la Digital Video Systems de Toronto travaille à la mise au point d'un nouveau format pour la transmission à domicile de signaux d'image de télévision de meilleure qualité comportant jusqu'à six canaux audio numériques de haute fidélité et une gamme de fonctions d'affichage de textes, de transmission de données et de contrôle d'accès. La fabrication des circuits intégrés spéciaux que requiert un décodeur B-MAC grand public bon marché fonctionnant dans les standards 525 et 625 lignes est à toutes fins pratiques maîtrisée.

Quoique conçu pour optimiser l'utilisation du canal en distribution par satellite, le format convient aussi à la radiodiffusion de Terre, à la télévision par câble, à la télévision à antenne collective, aux systèmes de distribution multipoint, etc.

Le procédé B-MAC rend compatible la distribution, dans le même canal, de signaux ayant un rapport largeur-hauteur de 4/3 (1,33/1) et de 16/9 (1,78/1). Il appartient au téléspectateur de choisir le rappoirt qui convient à son appareil. Les décodeurs domestiques comporteront une fonction "panoramique et balayage" pour la sélection d'une partie de l'image totale en fonction du rapport 4/3. Cette fonction sera contrôlée par un signal numérique trame par trame, transmis par le centre de diffusion.

Le mémoire donne un aperçu du système B-MAC et décrit divers paramètres du format qui se rattachent à la technique grand écran compatible.

La communication suivante de M. Charles Rhodes examine l'utilisation d'un deuxième canal de distribution, lequel peut être ajouté au canal de diffusion compatible normal, afin de présenter sur grand écran des images de haute définition pour distribution vidéo, son et données.

THE EVOLUTION OF B-MAC INTO A FULLY COMPATIBLE EDTV SYSTEM

John D. Lowry
Scientific Atlanta

About three years ago Digital Video Systems and Scientific Atlanta embarked on an examination of the market requirements for distribution to the home of improved pictures, sound, and other services. While the principal thrust was satellite television, it was found that the format had to be capable of distribution on cable, through Master Antenna Television Systems for multiple family dwellings, and via VHF or UHF terrestrial broadcast.

Commercial considerations in many applications required controlled access with encryption of the audio and data, and hard scrambling of the video, combined with broad addressing and tiering capabilities, impulse pay-per-view, personal messages, teletext facilities, and, from the beginning, the potential expansion for extended definition television. Pricing to meet realistic market needs, and timely delivery of a proven product was mandatory.

A transmission format meeting these market needs was developed, and is compatible with both 525 and 625 line standards, NTSC, PAL and RGB. The decoding hardware has been reduced to a set of low cost integrated circuits.

The signals in use today for the transmission of broadcast television services are direct descendents of the original monochrome transmissions of the 1940s. The subcarrier method adopted for the addition of color was dictated by the requirement to be compatible with the early monochrome receivers, and by the technology then available. Since that time, of course, there have been significant advances in technology due in particular to the advent of large scale integration of electronic components.

B-MAC FORMAT

This new transmission format today provides compatibility with conventional television receivers by transcoding to the current NTSC and PAL transmission standards, using low cost LSI techniques in each decoder.

B-MAC is a hybrid system, which uses digital codes for the audio and data combined with analog component video. The B type Mac system was selected which time multiplexes the video with audio and data at baseband using a multilevel code during the horizontal blanking period. The bandwidth required for the compressed video is 1.5 times that of the luminance to be delivered.

COMPATIBILITY

By utilizing the wide dynamic range of the video transmission channel, the digital audio and data require less bandwidth than the video, while delivering 1.8 million bits per second utilizing the blanking periods. This provides a signal that can be used for satellite, cable, SMATV, terrestrial microwave, or broadcast without the need for decoding or reformatting at intermediate distribution points.

In Satellite Master Antenna Television applications, for example, the B-MAC signal can be received from the satellite and passed directly through a cable system within a building for subscriber access control at each individual television set. This provides the potential for high quality red, green and blue signals for the television display, combined with digital stereo audio and other services for each viewer.

Delivery to the home of RGB pictures approaching studio quality is now practical with this format. Through elimination of the traditional sync pulses and both the color and audio subcarriers, FM deviation in the channel, I.F. filters, and the pre-emphasis/de-emphasis networks, all can be optimized to yield excellent results. Smaller satellite receiving dishes, improved performance, or both is achieved. B-MAC is also unaffected by most non-linearities in the transmission channel.

HORIZONTAL MULTIPLEX

With the B-MAC format, the 52.5Us active line of luminance is time compressed to occupy 35Us. A period of 17.5Us per line is thereby made available, which is occupied by the time compressed, color difference signal. The remaining 11.5Us of each line is utilized for the B-MAC data system. A total of 1.86 Megabits per second of data accompanies the video, providing digital audio, control, and data services.

The data pulses consist of two or four level symbols during the blanking intervals. Of the 1.86 Mbits/sec available 1.573 Mbits/sec is provided by the horizontal blanking interval. The remainder is accommodated by the vertical blanking interval, and is employed for control, conditional access, and text services. Of the 1.573 Mbits/sec HBI data, a total of 1.510 Mbits/sec are absorbed by 6 channels of digital audio, and associated error concealment. The remaining 62.5 Kbits/sec provides a permanent utility data channel (See Figure 1).

The data channel is encrypted and made available to each user under control of the broadcaster. It may be used for delivery of a library of tele-software, or any other data service considered appropriate. Utility data is provided at a separate output port on the decoder. Any number of the digital audio channels may be re-assigned to utility data on a temporary basis to provide data services. Such re-assigned channels are separately decrypted, and provided to each individual user, again, under control of the broadcaster. Finally, the active video channel itself may be re-assigned to data, giving an additional capacity of about 10.8 Mbits/sec.

DOLBY DIGITAL AUDIO

The audio coding technique selected is the Dolby adaptive delta-mod system. It has demonstrated quality at least as high as an equivalent PCM system, and higher in terms of certain parameters such as dynamic range. Six channels of Dolby digital audio are provided in the transmission format. All can be available simultaneously in the decoder. Each channel has a frequency response of 20 Hz to 16 KHz $\pm$ 1/2 dB. It is down 3dB at 18 KHz and down 7dB at 20 KHz. Each channel requires a total of 251.7 Kbits/sec including error protection. The audio channels are separately decrypted. The audio coding is such that the 2 inner levels of the 4 level code can be eliminated. The resulting 2 level code carries three of the six digital audio channels.

The receiver is conceived in every respect as being micro processor controlled. It is responsible for the user input interface, for example, the remote keypad for infrared control, for conditional access to all services, and for message display. In the B-MAC format, text and data are integral to the design, there being a single clock and sync recovery system which serves for all data, text, digital audio, and video signals. Indeed, these signals are inseparable since line and field syncs are abolished, and carried digitally.

VERTICAL MULTIPLEX

All control data is carried by 2 level symbols, in the vertical blanking interval. This data is synchronized with and at the same symbol rate as the 4 level data in horizontal blanking. Lines 1 to 8 carry control data for clock and sync recovery, and subscriber control (See Figure 2). B-MAC sync is extremely rugged, yet it requires 0.2% of the total time as opposed to over 20% required for NTSC or PAL. Sync is carried on one line in the vertical interval as a digital word, and provides for receiver lockup at one dB carrier to noise.

TEXT SERVICES

Lines 9-13 contain teletext data. Each line carries a single row of 40 ASCII characters. A range of text services are available providing 200 pages with 20 second access. Text can be encrypted or sent in the clear. Film subtitles or closed captioning for the hearing impaired are provided in a box or superimposed over the picture. Template text pages are delivered with portions of the page supplied by the local microprocessor memory for applications such as parental access control, individual billing, and lists of pay-per-view specials watched. "Forced" messages which replace the viewed program can be delivered on an addressed basis in the case of weather warnings or other matters of urgent public interest. In less urgent circumstances, a message light is illuminated on the decoder. Messages can be addressed to a region, a city, town, street, or to an individual, providing an "electronic mail" capacity.

ADDRESSING

The addressing technique provides for up to 256 million addresses with redundancy for reliable reception. Addressing is at the rate of about one million per hour. Each decoder contains multiple addresses for independent access contol by various programers. Effectively instant access is provided to all authorized programs when the subscriber switches channels. The audio, data, text, and addresses can be encrypted to the level of the Data Encryption Standard (DES) with the decryption keys and codes changing 4 times per second.

SCRAMBLING

Line translation B-MAC scrambling is a time shifting process achieved by varying the amount of data accompanying each line unlike analog video. This digital information can be spliced without degradation or channel non-linearity problems (See Figure 3).

The data period is widened or narrowed by a few microseconds on successive lines to produce shifts in time of the active video (See Figures 4 and 5). This time shift varies up to a few microseconds on each line, but the effect is cumulative, slewing the picture in random patterns by up to one line (See Figure 6). This shift in time of transmission has no effect on the picture quality parameters regardless of non-linearities in the channel.

WIDE SCREEN FORMAT

This scrambling system with its line-by-line time displacement is integral to the wide screen B-MAC system. A compatible wide screen output is available with this format without further compression or re-arrangement of picture information.

With the prime sample rate of 14.3 MHz, a 16 by 9 aspect ratio is delivered. If 75% of the same video samples are read out of the line store at 10.7 MHz (.75 X 14.3 MHz), a 4 by 3 aspect ratio portion of the wide picture will be displayed (See Figure 7).

The C.C.D. implementation of the B-MAC system provides 4.2 MHz bandwidth for the 525 line 4 by 3 ratio. 6.4 MHz is available for the 16 by 9 ratio. 6.4 MHz is 89% of the Nyquist limit and can be achieved with low cost filters. The base band frequency required for the transmitted MAC signal is 9.6 MHz to deliver 6.4 MHz compatible wide screen images. In the future, wider bandwidths can be delivered while maintaining the essential backward compatibility with the basic transmission format and earlier systems in the field.

The 6.4 MHz wide screen signal costs between 2 and 3 dB in dish size compared with the 4.2 MHz 525 line requirement.

WIDE SCREEN PAN AND SCAN

Now that we have the choice of two ratios available from one decoder, pan and scan for cropping the wide aspect ratio is essential. As noted earlier, a line-by-line time shift is employed for scrambling. Pan and scan is the identical function but the time shift is at the frame rate (See Figure 8). The pan and scan framing delay off-set information is transmitted from the broadcast center as a digital code on line three, to each decoder. The descramble key controls both line and frame timing offsets.

Two C.C.D. line stores provide for B-MAC decoding, and descrambling, and pan and scan, for a simple low cost implementation. Frame stores are not required for this system, but offer great potential for B-MAC's future developments as frame store IC's become available at true consumer prices.

We are suggesting then, an evolutionary process...from black and white television in the 40's to compatible color in the 50's and 60's to compatible B-MAC today with its component video, and digital sound and other features, to be followed by, again compatible, wide screen B-MAC when the market is ready. Finally the wide screen B-MAC System can be expanded to embrace higher bandwidths and higher line standards in the future, while maintaining compatibility with today's hardware.

SUMMARY

In summary the B-MAC System is a format optimized for the F.M. satellite transmission environment but compatible in its channel requirements with terrestrial broadcast and cable. It has six channels of high fidelity digital audio and a high capacity for down loading data into home computers.

The audio, data and text can be encrypted and the video scrambled for controlled access. The addressing is effectively unlimited, providing for a broad range of tiering and personal messaging. The microprocessor system provides fully for impulse pay-per-view. The video is delivered in a component form providing NTSC or PAL and red, green, and blue for the newer television monitors.

The format provides for compatibility between standard 3 by 4 and wide screen aspect ratio broadcasts as the 16 X 9 ratio display devices become available.

The B-MAC decoder has been reduced to a set of custom integrated circuits and is available today.

During the past three years, thanks to Dr. Keith Lucas and his team of engineers in Toronto and Atlanta, and to the dedication of Plessey, this project has proceeded to completion, amazingly on schedule, with no features lost by the wayside, and many added. Ten custom IC's are now completed and working. Figure 9 is a photograph of the final consumer circuit board.

The best quality pictures and sound from any regular broadcast service in the world will be available in late 1985 using these IC's and circuit board in their first major system implementation. This super quality television won't be in New York, London, Paris, or Tokyo. It will be in the homes of the ranchers and farmers in the outback of Australia.

In September 1984 the Department of Communications in Australia was the first to announce selection of the B-MAC format. The Australains will use it for program distribution to TV stations and for the provision of a range of satellite services to individual homesteads and remote communities throughout the Country. B-MAC equipment deliveries began in March 1985.

June 4 1985

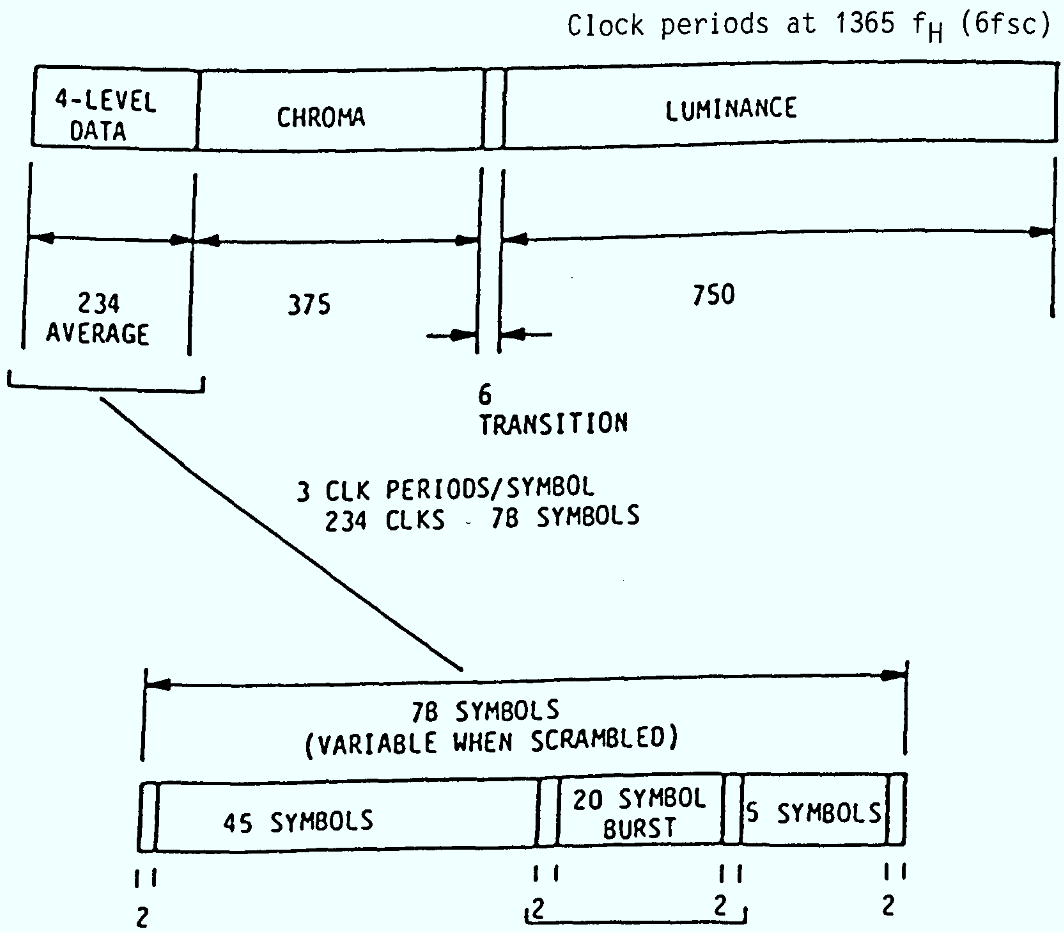

Fig. 1 B-MAC Horizontal Multiplex

LINE NO.	4 LEVEL DATA	2 LEVEL DATA/ACTIVE VIDEO (377 SYMBOLS)			
1	HORIZONTAL BLANKING INTERVAL (78 SYMBOLS) AUDIO AND UTILITY DATA	CLOCK RECOVERY LINE			VERTICAL BLANKING INTERVAL
2		SYNC RECOVERY LINE			
3		SEED/SYSTEM DATA			
4		USER ADDRESS	CKOM OR USER DATA	CRC	
5		USER ADDRESS	CKOM OR USER DATA	CRC	
6		USER ADDRESS	CKOM OR USER DATA	CRC	
7		USER ADDRESS	CKOM OR USER DATA	CRC	
8		USER ADDRESS	CKOM OR USER DATA	CRC	
9		TELETEXT PACKET			
10		TELETEXT PACKET			
11		TELETEXT PACKET			
12		TELETEXT PACKET			
13		TELETEXT PACKET			
14		SPARE OR TELETEXT			
15		SPARE OR TELETEXT			
16		SPARE OR TELETEXT			
17		RESERVED FOR B-MAC TEST SIGNAL OR TELETEXT			
18		RESERVED FOR B-MAC TEST SIGNAL OR TELETEXT			
19		RESERVED FOR B-MAC TEST SIGNAL OR TELETEXT			
20		RESERVED FOR B-MAC TEST SIGNAL OR TELETEXT			
21		QUIET LINE (MID-GRAY LEVEL)			
22		LUMINANCE BLACK REFERENCE (AGC)			
23		ACTIVE VIDEO (MESSAGE SENT DURING FULL-FIELD CKOM MODE ON LINES 21 - 58)			
58					
59		USER ADDRESS	CKOM OR USER DATA	CRC	THIS DATA IN FULL-FIELD MODE ONLY. OTHERWISE ACTIVE VIDEO.
60					
61					
62					
63					
64					
65					
66					
67					
68					
69					
70		USER ADDRESS	CKOM OR USER DATA	CRC	
		CKOM LINES ABOVE			
257		USER ADDRESS	CKOM OR USER DATA	CRC	
258					
259					
260					
261					
262		USER ADDRESS	CKOM OR USER DATA	CRC	

Fig. 2 B-MAC Vertical Multiplex

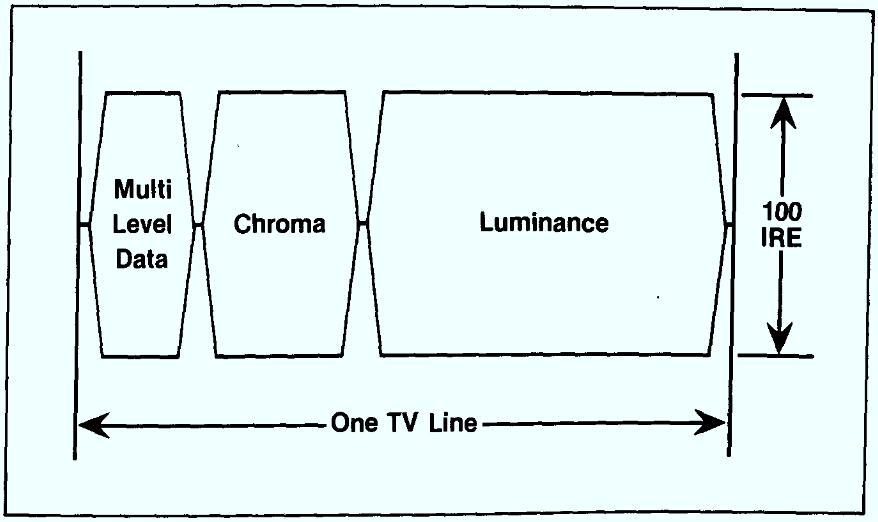

Fig. 3 Line Translation Scrambling of B-MAC
The multi level data portion of the line can be cut and spliced without degradation.

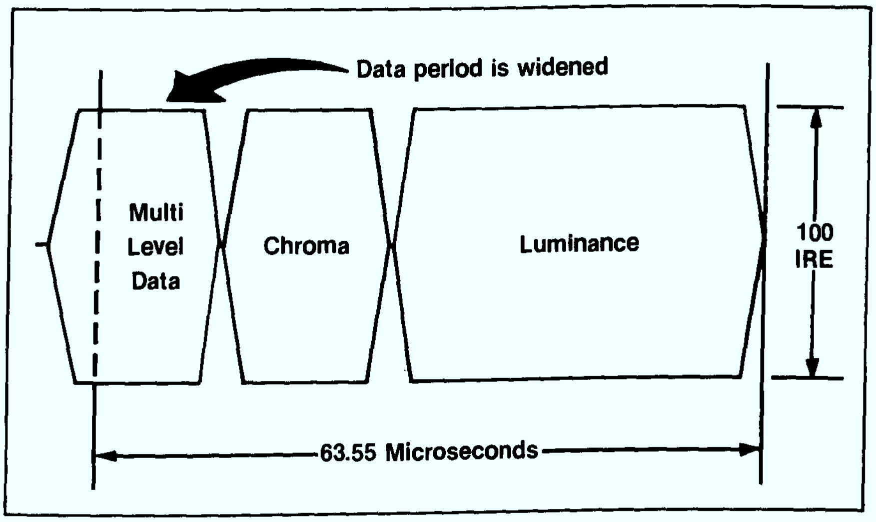

Fig. 4 Line Translation Scrambling
The data period can be widened by a few microseconds, delaying the active video.

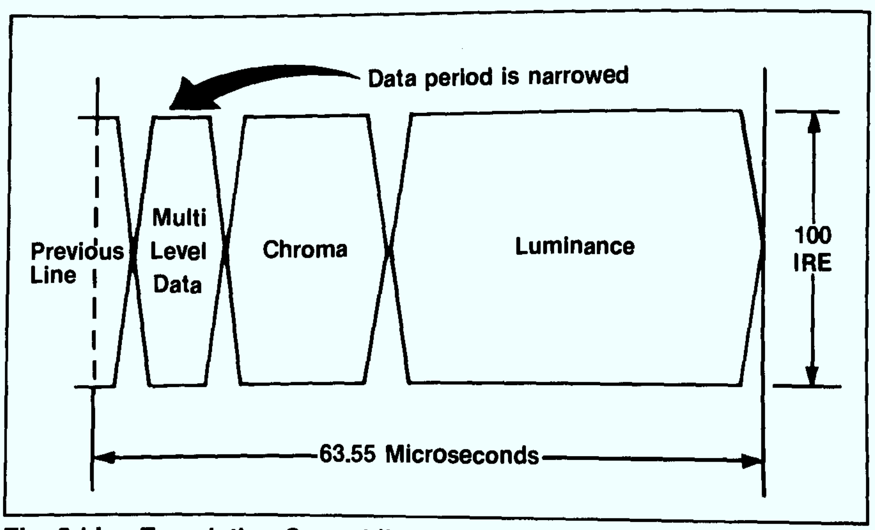

Fig. 5 Line Translation Scrambling
The data period is narrowed, advancing the active line.

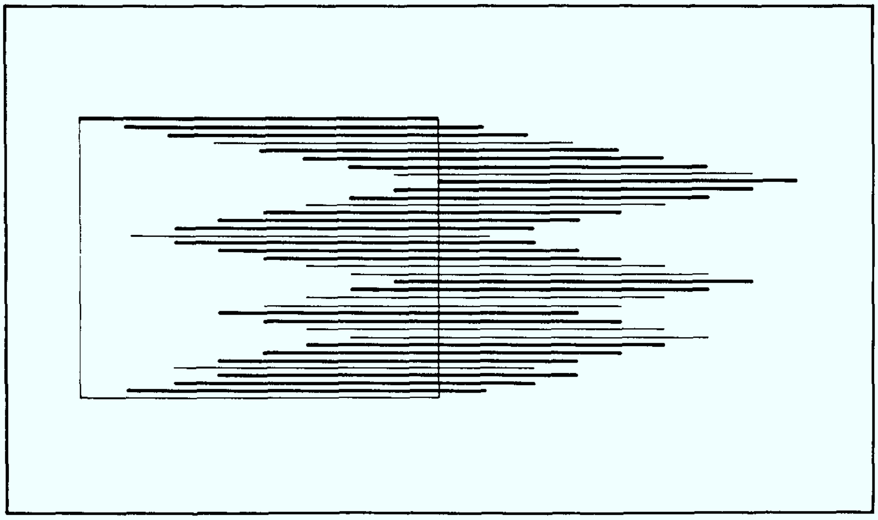

Fig. 6 Line Translation Scrambling
The cummulative effect of a few microseconds per line delay or advance.

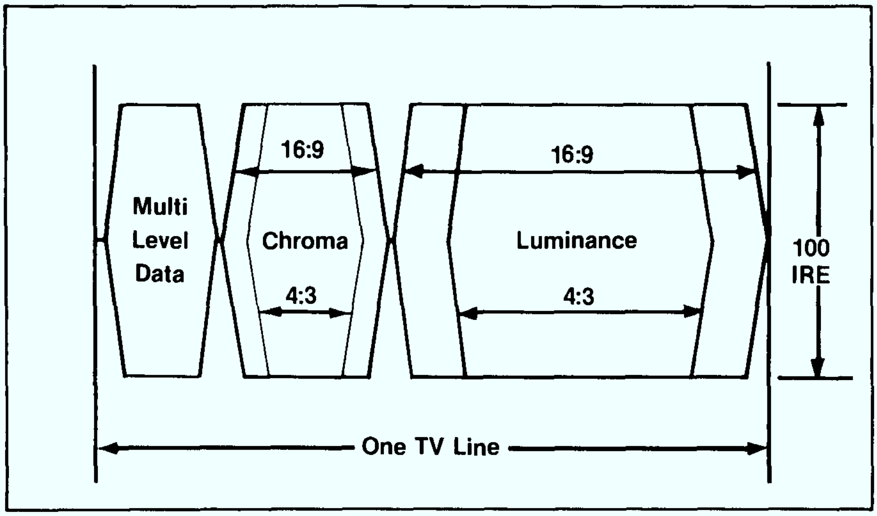

Fig. 7 Compatible 4:3 and 16:9 Aspect Ratios
Reading 75% of the samples from the active video at 75% of the standard 14:3 MHZ (10.7 MHZ) provides the 4:3 output.

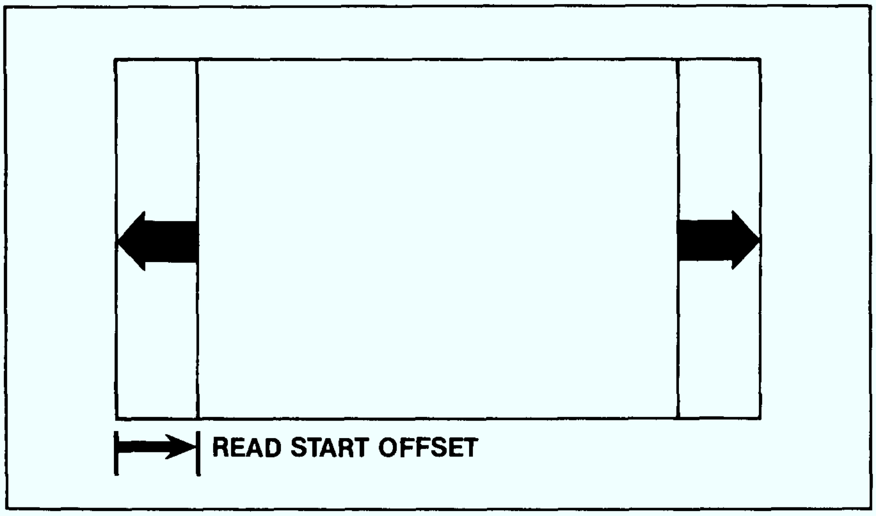

Fig. 8 Pan and Scan in Each Decoder Wide Screen
Pan and Scan is a frame rate timing offset effectively identical to the line rate offset for line translation scrambling.

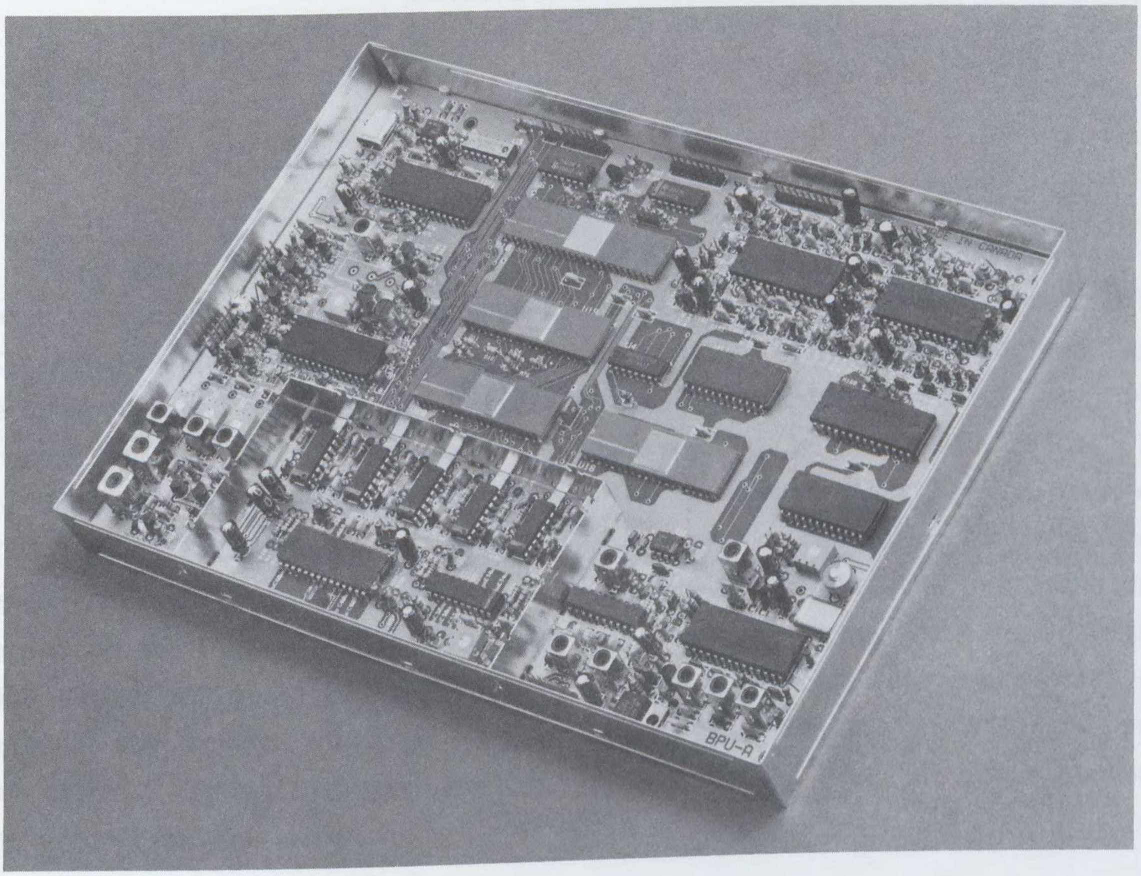

Fig. 9 B-MAC Consumer Decoder

TWO-CHANNEL NTSC-COMPATIBLE HDTV TRANSMISSION METHODS

Joseph S. Nadan

3.14

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ABSTRACT

This paper outlines the evolutionary path to HDTV in the home. It is based on consumer needs for an advanced television system and is shown to be NTSC-PIP-POP-pHDTV-HDTV. Pseudo-HDTV (pHDTV) is a market-driven and technology-based method of delivering most of the value of an HDTV production standard to the home of the consumer at an affordable price. By considering channelization options, it is shown that a two-channel NTSC-compatible method of pHDTV transmission optimizes the consumer benefit/price ratio. When desired, the consumer can purchase a frame-store option to achieve full HDTV. Methods of using the frame-store to increase both perceived vertical and horizontal resolution are reviewed. Issues relevant to converting from a production to transmission standard are considered. Several system options are presented, some of which support improved (digital) audio.

MÉTHODES DE TRANSMISSION TVHD A DEUX CANAUX COMPATIBLE NTSC

3.14

Joseph S. Nadan

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North American Philips Corporation

RÉSUMÉ

Le mémoire décrit les étapes successives de l'évolution de la TVHD dans le sens de sa commercialisation grand public, centrée sur le besoin du consommateur de disposer d'un système de télévision évolué, et basée sur un cycle de développement à cinq volets : Compatibilité NTSC, Insertion d'images (PIP), Surimpression d'images (POP), pseudo-TVHD et TVHD. La pseudo-TVHD (pTVHD) est une méthode réactive au marché et une technique qui permettent de fabriquer un produit de grande consommation à un prix abordable, d'une qualité proche de ce que donnerait une norme de production de TVHD. L'étude des options qui s'offrent en matière d'assignation de canaux démontre qu'une méthode de transmission de pTVHD compatible NTSC à deux canaux maximiserait le rapport bénéfice/prix. Le consommateur pourrait au besoin acheter en option un dispositif d'enregistrement d'images et profiter ainsi de tous les avantages de la TVHD. L'utilisation de mémoires à images en vue de raffiner la résolution verticale et horizontale est aussi examinée. L'auteur aborde également divers aspects de la conversion d'une norme de production à une norme de transmission et décrit plusieurs systèmes, dont certains améliorent l'ensemble de son (numérique).

TWO-CHANNEL NTSC-COMPATIBLE HDTV TRANSMISSION METHODS

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INTRODUCTION

It is now time to begin serious consideration, demonstration, and evaluation of cost-effective methods for the delivery of high definition television (HDTV) signals to the home of the consumer. This can happen if all segments of the television industry develop value from this endeavor. As illustrated in Figure 1, a model of television industry segments, if users value an advanced television system, they will supply the monies necessary to justify the substantial investment required by electronic equipment manufacturers, producers of programming, and providers of signal distribution. However, if any of the segments do not develop value from this endeavor, they will resist it and most probably successfully prevent its development.

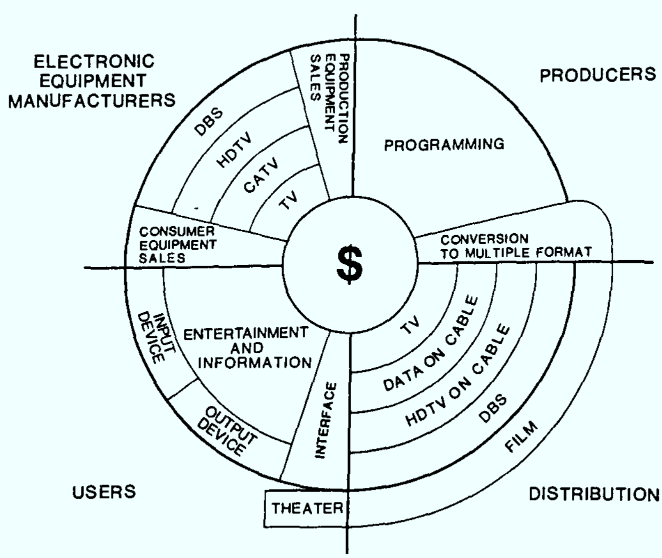


Figure 1. Model of television industry segments.

BACKGROUND

The beginning of a new advanced television service will require a production standard, a transmission standard, and an entry scenario. There are two HDTV production "standards" that are viable. The first is an 1125 line 2:1 interlaced 60.00 Hz system that has been developed and extensively demonstrated by NHK over a fourteen-year period. The second is a 750 line 1:1 progressive 60.00 Hz system that has only recently been proposed by RCA. Both require nominally 40 MHz bandwidth and can be operated in the 16:9 aspect ratio. Why then, if both nominally deliver an HDTV signal with twice vertical perceived resolution, twice horizontal perceived resolution, and a wider picture, is there so much discussion over selecting one worldwide HDTV production standard? The answer has two parts. First, trained video engineers in the 50 Hz world are not convinced that conversion, from a 60.00 Hz HDTV production standard to a 50 Hz compatible signal for existing (ordinary) PAL (or SECAM) receivers, is possible without introducing undesirable artifacts. Second, the 750 line progressive system has higher spatial resolution on motion. This is easily understood since the progressive system scans 750 lines in 1/60th second, while the 1125 2:1 interlaced system scans only 1125/2 = 562.5 lines in 1/60th second. Many worldwide video engineers believe that when high line number CCD imagers become available, camera lag will be reduced to the point where significant improvement may possibly be obtained by a progressive system having 33% more lines in every 1/60th of a second. In essence, camera tubes currently mask these problems. There is, however, considerable economic pressure on the part of producers of programming to begin replacing film by video production due to an estimated $400,000-per-program-hour savings attainable by this technology change.

THE HDTV ENGINE-CONSUMER VALUE

The preferred method of transmitting an HDTV signal to the home of the consumer should be based upon the HDTV production standard that is eventually adopted and selected in view of the perceived consumer values of an advanced television system. The values deliverable to a consumer by an advanced television system are not limited to only better picture quality, but also include improved sound and other features made possible by including small amounts of digital memory in the receiver. If an advanced television system is to be viable, then these consumer values will be the engine pulling it into existence. It is, therefore, important to identify these values and closely match the transmission standard to their needs.

While extensive marketing research is not available, it is generally believed that these values, listed in order of decreasing importance, are:

1. Wider picture.
2. Improved (digital) sound.
3. New memory features (e.g., PIP).
4. Reduced line structure visibility.
5. Improved resolution.
6. Reduced artifact content.

The most noticeable and valuable difference of an advanced television system is a wider picture most closely approximating the aspect ratio of all motion picture film. An aspect ratio of 16:9 = 1.78:1 is recommended, representing a 33% increase over the present 1.33:1 standard; this is explained later.

The possibility of transmitting improved (digital) sound will dramatically increase the impact of an advanced television system. This technically feasible service will threaten the existence of analog stereo broadcast by FM radio. We could all possibly have fun in twenty years explaining the ancient concept of "simulcast" to our grandchildren.

The reason for the relatively high value of this service may be understood from Figure 2a through 2c. Figure 2a represents the situation of today in which one (or two optionally for stereo) speaker(s) are usually located on the receiver console. Speaker separation is significantly less than that necessary for a maximum stereophonic effect. Regardless of where viewers sit in the room, they see and hear the program in the same location. If the consumer replaces the on-receiver speakers by off-receiver speakers (as shown in Figure 2b) in an attempt to increase stereo separation, then relative location problems occur. At location P1, both audio and video programming are perceived as originating from the center of

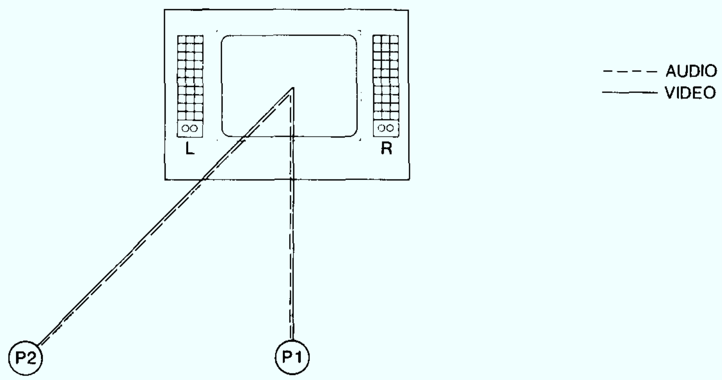


Figure 2a. Analog (stereo) sound with on-receiver speakers.

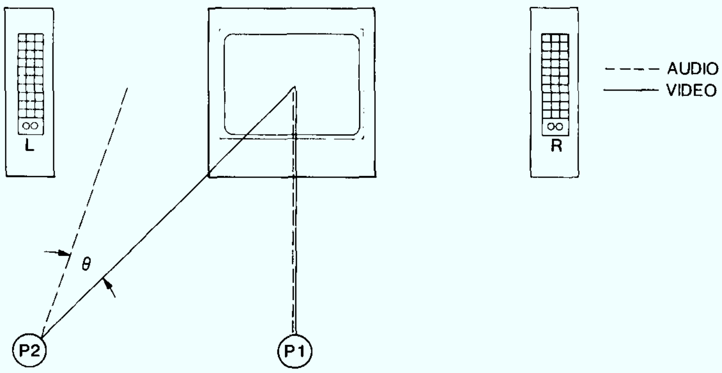


Figure 2b. Analog (stereo) sound with off-receiver speakers.

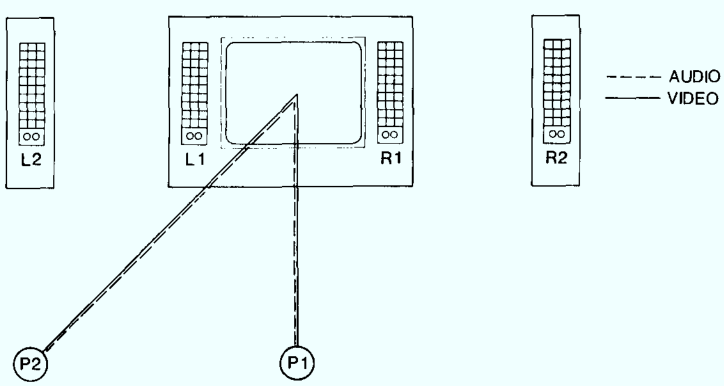


Figure 2c. Triphonic (quadraphonic) sound with both analog (stereo) sound to on-receiver speakers and digital stereo sound to off-speaker receivers.

the receiver. However, at location P2 there is a separation of angle θ between the perceived sources of audio and video. When this angle exceeds about 15° this effect is extremely annoying. Hence, speaker and viewer location become extremely critical. This difficulty may be overcome as illustrated in Figure 2c, where both on and off receiver speakers are used. By proper mixing of the triphonic (quadraphonic) sound, both separation and location effects may be solved. When desired, (digital) sound may be supplied only to the off-receiver speakers for true "concert-hall" type performance. The method for doing this is explained later.

It is possible to display more than one NTSC picture on a display, as illustrated in Figure 3, by placing a small amount (about 10K bytes) of digital memory in the receiver. This may be used to perform three distinct functions. First, when continuously watching two programs, the Picture-in-Picture (PIP) is used to <u>monitor</u> the smaller program. Second, when periodically (perhaps even five seconds) changing the smaller program to the next favorite channel, the viewer <u>scans</u> the programming availability. Lastly, the memory may be used to indefinitely <u>freeze</u> one subsampled (but properly filtered) field of an image. Maximum value may be delivered to the

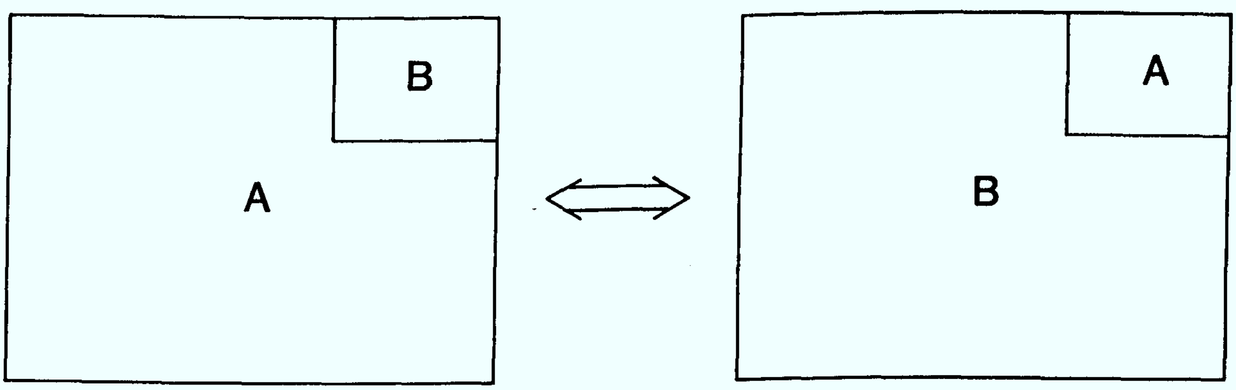


Figure 3. Picture-In-Picture (PIP) on 4:3 display.

consumer if these functions are easily implementable. This requires a second tuner-IF-decoder in the receiver such that functionality may be easily controlled. For example, rapid exchange of the PIP monitored and main programs should be possible when the PIP monitored programming becomes more interesting.

The PIP program replaces part of the main program in the 4:3 aspect ratio display. One Japanese manufacturer, therefore, gives the consumer the possibility of moving the PIP display by remote control to any of the four corners. Another approach, synergistically related to HDTV, is placing the second program outside the first program as illustrated in Figure 4a, Picture-Outside-Picture (POP). One 16:9 display may be used to display a movie, two 4:3 programs (16:9 = 5 1/3:3 = 4:3 + 3((4:3)/3)), or one centered 4:3 program, Figure 4b.

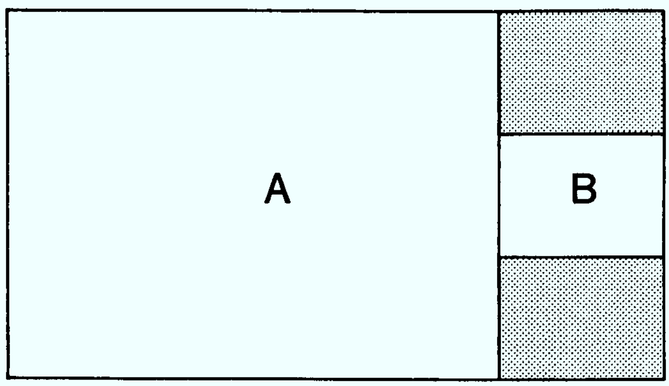


Figure 4a. Picture-Outside-Picture (POP) on 16:9 display.

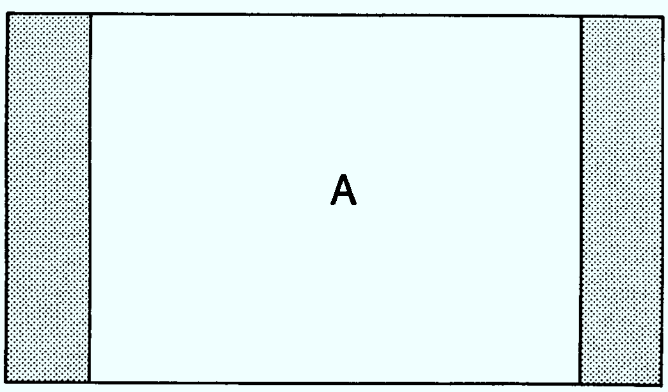


Figure 4b. Centered 4:3 on 16:9 display.

Significantly improved rear projection televisions are now becoming available. The improved contrast, brightness, convergence, resolution, and lack of color shift make rear projection, and not direct view CRT, the preferred display for viewing HDTV in the home. The most significant remaining artifact for NTSC transmissions displayed on these projectors is the visibility of line structure. While some (not most) consumers consider line structure as a positive indication of resolution, this artifact should be removed. This may readily be accomplished by progressive display and/or increasing the number of active lines displayed in each frame.

Toward the bottom of the ordered list of consumer values for an advanced television system are increased resolution and reduced artifact content. While it is generally agreed that increased resolution is important for the production standard, it should not be a major consideration in selecting a standard for transmission to the home of the consumer. A different standard may be required for transmission to a very large screen in a public theater. Cross effect artifacts can be reduced by combing at both the receiver and transmitter. Line flicker can be reduced by progressive display in the receiver.

THE PSEUDO-HDTV CONCEPT

The fundamental concept of pseudo-HDTV (pHDTV) is that an advanced television system should deliver most, but not all, of the value of HDTV to the home of the consumer at an affordable price. It will be shown that the best match to the ordered list of consumer values and the needs of the cable television system operator is a transmission standard using two standard NTSC signals and a receiver without a frame-store. Full HDTV, having both twice vertical and twice horizontal perceived resolutions can be achieved with a receiver frame-store option. This is summarized in Table 1.

The reason for not selecting a transmission standard that requires including a frame-store in every receiver is one of cost. The memory of an NTSC frame-store costs about $50 (480 lines x 720 samples/line x 1.5 bytes/sample x $1/10,000 bytes); the memory for an HDTV frame-store with 5 1/3 times the amount of information (R_V = 2 x R_H = 2 x R_W = 1.33)

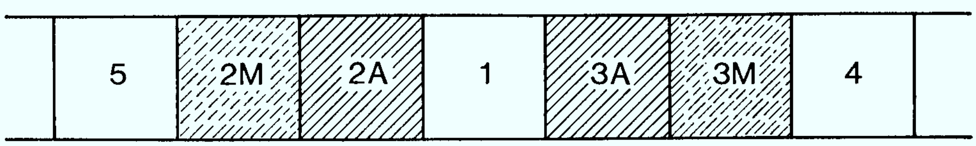
TABLE 1.

System	R_V	R_H	R_W	Comments
NTSC	1.00	1.00	1.00	30 years.
pHDTV	1.25-1.50	1.00	1.33	POP-10Kbytes memory.
HDTV	2.00	2.00	1.33	Frame-store option.

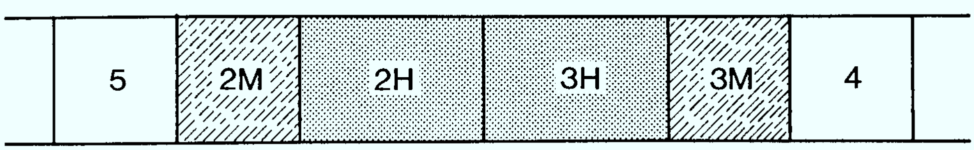
R_V: Perceived vertical resolution improvement factor.
R_H: Perceived horizontal resolution improvement factor.
R_W: Width improvement factor.

costs about $275. Conservatively estimating the cost of integrated circuits to control the HDTV frame store at $25 raises the total cost of the HDTV frame-store to about $300. The price of the frame-store option will, by the time it is sold to the consumer, be about $750. Now it is relatively certain that this price will decrease by using CCD rather than DRAM, further, time and competition will also force this price down. However, it will be many years before this option will exceed a just-valuable-difference for the consumer.

Another concern is the channelization of the cable television head-end. Consider two different channelization schemes for a head-end as shown in Figure 5. The first uses a two-channel NTSC-compatible method for



(a) Compatible HDTV.



(b) Non-compatible HDTV.

Figure 5. CATV channelization options.

transmitting HDTV while the second uses another HDTV transmission method requiring only one and one-half times the bandwidth of an NTSC channel. Programs 1, 4, and 5 are NTSC only and not available in HDTV. The NTSC compatible method of channelization gives a slight bandwidth advantage; in this example, one extra program being transmitted in the same bandwidth. Programs 2 and 3 are available in both NTSC and HDTV; the former being required in both channelization methods so that producers of programming will have sufficiently large audiences during the entry phase of HDTV broadcast. Of course, when desired, the NTSC compatible version can be eliminated and/or scrambled. Consumers with NTSC only receivers can display all channels of the compatible transmission including the auxiliary channel necessary to build the main channel into an HDTV signal. If recognizable, the auxiliary channel will serve as a form of continuous free advertising for the purchase of HDTV receivers.

The compatible method of channelization is more flexible than the incompatible method. When desired, the CATV operator can transmit NTSC only programming over channels 2A and 3A. To transmit NTSC only programming over channels 2H and 3H would require a change of equipment.

The compatible method of channelization and transmission does not require the CATV operator to purchase any new head-end equipment.

The compatible method of channelization and transmission allows the advanced television receiver to implement POP more completely and at a lower cost. Consider the receiver signal processing options, listed in Table 2, and given in order of increasing cost. With only one NTSC signal processing

TABLE 2.

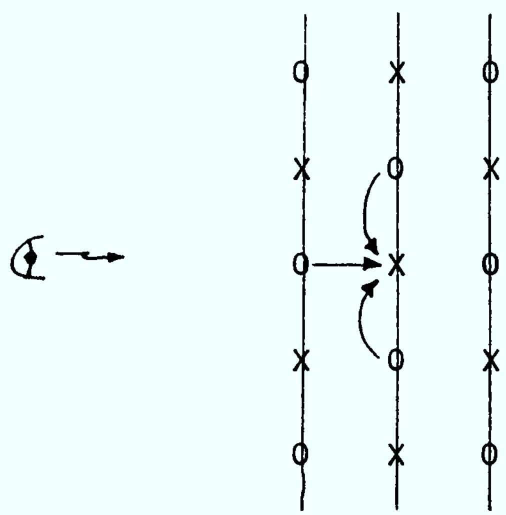
Signal Processing		Capability	
NTSC	HDTV Only	POP	HDTV
1	0	No	No
2	0	Yes	Yes
1	1	Limited[1]	Yes
2	1	Limited[2]	Yes
2	2	Yes	Yes

[1] only one NTSC one HDTV. [2] cannot POP two HDTV.

chain, the present situation in most receivers, PIP and HDTV signals cannot be displayed. With two NTSC signal processing chains both POP and HDTV can be displayed, even including a POP version of the first channel of an HDTV program. The next option, one signal processing chain of each type, displays HDTV and only a limited number of POP. The POP display for this option is usable only when one of the programs is HDTV and the other is NTSC. It cannot handle the cases of two NTSC or two HDTV programs. This may be overcome by adding more equipment in the receiver as indicated in the next two options. Clearly, <u>the two-channel NTSC-compatible option is the lowest cost implementation of total coverage POP</u>.

ATTAINING FULL HDTV WITH A FRAME-STORE OPTION

The methods of attaining full HDTV with a frame-store option is the subject of other papers [1,2] and will be reviewed briefly here. One could achieve twice perceived vertical resolution by doubling the number of lines transmitted; however, this requires an excessive amount of bandwidth. By transmitting a smaller number of interlaced lines and then performing an interlace to sequential scan conversion in the optional frame-store in the receiver, it is possible to gain about 60% in perceived vertical resolution. This is illustrated in Figure 6 and more fully explained in the paper of Fernando, Parker, and Saraga [1]. Hence, to accomplish twice vertical perceived resolution only requires a 25% increase in the number of lines (2 = 1.6 x 1.25).



Stills:	2 V
Motion:	1 V
Subjective mix:	1.6 V

Figure 6. Interlace-to-Sequential scan conversion.

As shown in Figure 7, for $R_W = 1.33$ and $R_V = 2.0$, the maximum attainable horizontal resolution improvement factor is $R_H = 1.2$, and not the required $R_H = 2.0$. This may be overcome by using a spatio-temporal

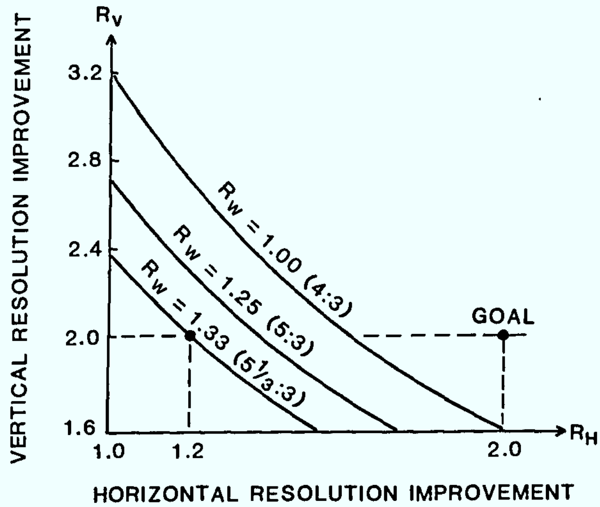


Figure 7. Two-channel design tradeoff.

exchange (STE), as illustrated by Figure 8. Sending the high frequency components of the video signal at a lower frame rate improves the communication efficiency since it better matches the signaling method to the psychophysical properties of human vision.

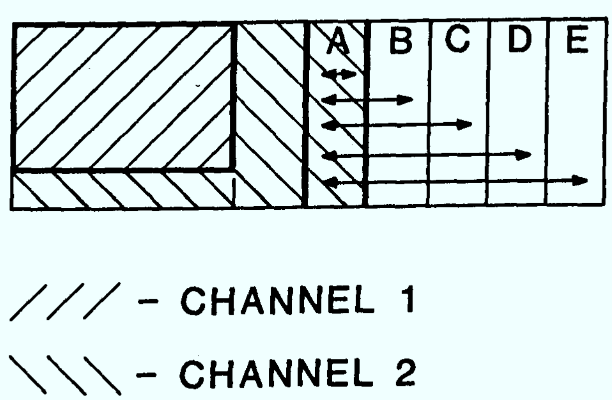


Figure 8. Spatio-temporal exchange.

TWO-CHANNEL REVERSIBLE DECOMPOSITION

A schematic representation of how a HDTV signal may be reversibly decomposed into two standard TV signals is shown in Figure 9. The "center" portion of the HDTV signal, between cuts C1 and C2, is scan converted from

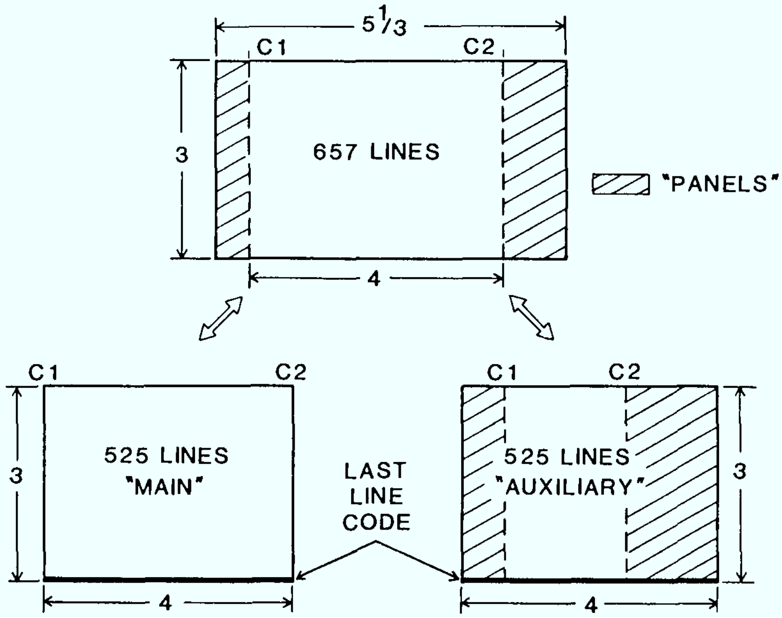


Figure 9. Two-channel reversible decomposition.

657 to 525 lines and sent as the "main" NTSC channel. In a manner analogous to the "Pan and Scan" operation in telecine conversion, cuts C1 and C2 may be positioned anywhere from the extreme left to the extreme right as required by the program content. The "panels" of the HDTV signal, outside the center region, are similarly scan converted and sent as the outside of the "auxiliary" NTSC channel. The remaining lines are suitably encoded and transmitted between the panels of the auxiliary NTSC channel. Reconstruction is accomplished in an inverse manner.

The last line in each NTSC channel is used to transmit information to aid the receiver in reconstructing the HDTV signal. This information includes the center region location, channel matching test patterns, sound controls, and a limited amount of motion data.

This process may be explained in further detail by considering sample allocations, Figure 10. The following simplified explanation illustrates how the pseudo-HDTV part of the HDTV signal is converted; it should be noted that the scan conversion method used in this explanation is not used in practice because it would degrade the quality of the main channel signal.

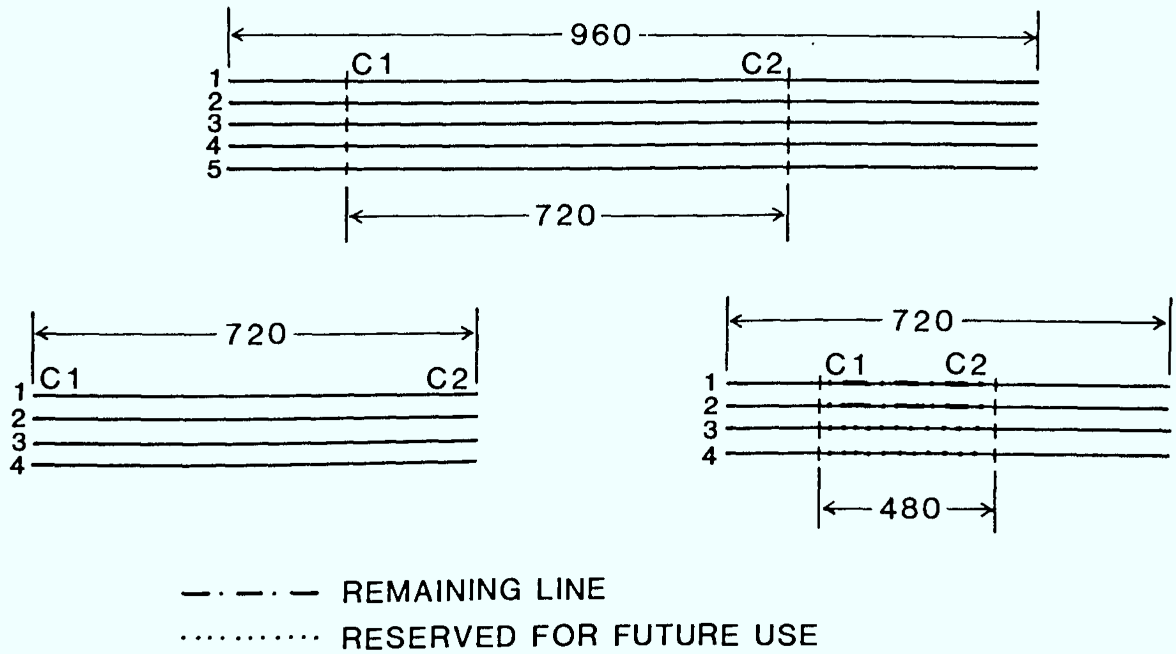


Figure 10. pHDTV sample allocation.

Consider five lines in the pseudo-HDTV signal sampled at four times subcarrier. Since the lines are one-third wider, and the horizontal resolution is to remain unchanged, the 720 samples of the normal width line are raised to (4/3) x 720 = 960 samples for the wider line. For the moment, consider only the first four lines. The "center" 720 samples are used to completely fill the main channel. The remaining 960 - 720 = 240 "panel" samples are used to fill the outside of the auxiliary channel. Each of the four lines of the auxiliary channel therefore have 720 - 240 = 480 remaining samples. The fifth remaining 960 sample line may be divided in two and used to fill two of the 480 sample partial lines of the auxiliary channel. This completes the decomposition of the pHDTV signals; the remaining two of the 480 sample partial lines are reserved for future use as explained later.

SYSTEM CHOICE

The unused portion of the auxiliary channel may be used in many different ways to improve the video and/or audio part of the programming. For example, a sixth line of 960 samples could have been used to fill the remaining two of the 480 sample partial lines. This would then result in a 750 rather than a 657 line pHDTV system. Alternatively, the remaining 2 x 480 = 960 samples represent one-third of the auxiliary channel bandwidth [(960/(4 x 720)) = 1/3]. This 1.4 MHz may be used to send compact disc quality digital sound over the auxiliary channel. Four possible transmission methods are summarized in Table 3 below.

TABLE 3.

System	Sound	Comment
525 s	0.4 MHz digital	1/2 LD 11.2/4.2
657 i	1.4 MHz digital	--
750 i1	Analog	--
750 i2	1.4 MHz digital	1/3 LD 8.4/4.2

The 525s system [3] requires that one of every two lines be line differentially encoded [4] with two-dimensional filtering corresponding to 11.2 MHz being low-pass filtered to 4.2 MHz. Since the attenuated spectrum is in the diagonal direction it may be possible to fully transmit the sequential signal without perceivable degradation. This would allow progressive display without a frame-store in the receiver. Detailed consideration of this signaling method reveals that 0.4 MHz would be available for signaling digital sound. If desired, a consumer could use a frame-store in the receiver to increase perceived horizontal resolution.

The 657i system represents a straight forward encoding of the pHDTV signal, does not require line differential encoding, and supports the transmission of full compact disc digital sound. The 750 i1 system is also a straight forward encoding of the pHDTV signal; however, it does not support the transmission of digital sound since all the samples have been used for the video part of the program. By using one of three line differential encoding, it is possible to create enough available bandwidth to transmit full compact disc digital sound.

It is not possible to select between the options on a purely technical basis.

PRODUCTION TO TRANSMISSION CONVERSION

One of the important considerations in selecting from among the above options is the choice of the production standard. This situation should be clearer in October 1985 after the CCIR meeting. Several considerations relevant to this decision are summarized below.

The conversion process usually involves a series of cascaded conversions that may be represented schematically as $I_1 \rightarrow S_1 \rightarrow S_2 \rightarrow I_2$. Each of the three conversion steps introduces artifacts which are to be held to a minimum. It is very difficult, if not impossible, to remove an artifact once it has been introduced. Hence, it is desirable to minimize the artifacts introduced at each conversion. The best way to do this is to eliminate as many of the steps as possible. For example, the NHK converter [5] process is (1125, 2:1, 60)→(625, 1:1, 60)→(625, 2:1, 50). A less expensive and higher performance conversion would be (750, 1:1, 60)→(625, 2:1, 50).

In an attempt to balance the risk between the 60 Hz and 50 Hz worlds in getting to one worldwide HDTV production standard, a choice was made to use 60.00 Hz as a field rate. This facilitates conversion to 50 Hz and creates difficulty in conversion to 59.94 Hz. This latter process has not, in this author's opinion, been sufficiently well investigated.

SUMMARY AND CONCLUSIONS

This paper has introduced a new concept for HDTV transmission to the home of the consumer. Pseudo-HDTV (pHDTV) delivers most, not all, of the value of HDTV at an affordable price. By using a frame-store option, consumers may, when desired, recover the entire HDTV signal at increased cost.

Consumer needs for an advanced television system have been identified and listed in order of preference. It has been shown that these needs can be addressed best by a two-channel NTSC-compatible method of transmitting the pHDTV signal.

Several two-channel pHDTV systems have been presented. The tradeoffs between video and audio performance have been discussed. Full compact disc digital sound may be transmitted by several of these systems.

Issues pertinent to the selection of a production and transmission standard have been outlined. It is this author's personnel opinion that a 750 line progressive production standard is preferable for two reasons; first, it has higher spatial resolution on motion, and second, it will introduce fewer artifacts in conversion for transmission.

Finally, it is widely agreed, that one worldwide HDTV production standard, which can be converted to NTSC/PAL/SECAM and the HDTV transmission standard(s) without introducing noticeable artifacts, is highly desirable. It is this author's personal opinion that one such system does not exist today. If it did exist, it wouldn't be needed; for if easy and artifact-free conversion between standards were possible, then it would be possible to have two or more such standards without any significant penalty. It should be noted that HDTV broadcast can begin before a production standard is globally adopted, using film as a source with telecine conversion to one or more transmission standards.

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VERS UNE TÉLÉVISION À HAUTE DÉFINITION?

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3.17

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RÉSUMÉ

Diverses opinions s'affrontent quant aux avenues praticables de développement visant l'offre de services de télévision améliorée et à haute définition. Elles varient des applications réalisables dans les normes de transmission NTSC aux approches appelant une modification radicale de l'équipement actuel de transmission et d'abonné.

Initialement présenté lors du vingt-huitième congrès annuel de l'Association canadienne de la télévision par câble, tenu en avril 1985, le mémoire traite de scénarios possibles de développement au Canada, de leur impact éventuel sur les systèmes de câblodistribution et de leur mise en oeuvre et, notamment, de l'évolution des récepteurs numériques, des systèmes à deux canaux NTSC, des composantes vidéo analogiques, des composantes vidéo analogiques améliorées et des systèmes de TVHD à largeur de bande réduite tels que les prototypes de CBS à deux canaux et MUSE de la NHK, au Japon.

TOWARDS HIGHER DEFINITION TELEVISION ?

By

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ABSTRACT

Currently, diverse opinions exist regarding the possible development paths towards enhanced and high definition television services. These approaches range from development options compatible with current NTSC transmission standards to those involving a complete change in current transmission and subscriber equipment.

This paper (initially presented at the Canadian Cable Television Association's 28th Annual Convention in April 1985) examines possible development scenarios in Canada as well as the possible impact on cable systems of several developments and implementation options including; the evolution of digital receivers, NTSC 2 channel sytems, analogue component video, enhanced analogue component video and bandwidth reduced HDTV systems such as the CBS 2 channel and the Japanese NHK MUSE proposal.

1. INTRODUCTION

Several schools of thought are currently being pursued for the development of possible enhanced and high definition television services. Opinions on the most likely outcome range from those of the most skeptical, who feel quantity not quality will inevitably remain the viewers preference - to those who believe delivery of full high definition television is just around the corner.

Where 'quantity' is currently a critical issue for cable operators in Canada (our recent survey of cable operators for the Canadian Cable Television Association indicates the average cable system capacity is currently 27 channels but expected to be 41 channels by 1990), improving 'quality' has in the past not been of primary importance. As receivers become increasingly more sophisticated, the potential exists for services providing the consumer with enhanced viewing options, which if packaged appropriately, could provide further impetus for the development of discretionary services.

2. ENTRY SCENARIOS - OR HOW DO WE GET THERE FROM HERE?

A strong force is currently underway both in Europe and Australia, where DBS is expected to be introduced using analogue component video transmission techniques, and in Japan, where a High Definition Television (HDTV) service trial is scheduled for launch in the fall of this year. It is a matter of continuing research as to when (and if) North Americans will succumb to the lure of increased image quality. As to how, within North America any one of the following development scenarios might occur:

1) Gradual introduction of enhanced definition services initiated either by a DBS service or the desire for hard scrambling and improved satellite transmission of discretionary services to cable head-ends - complemented by increasing sophistication in digital receivers;

2) Initiation of HDTV services for specialized uses (to bars, hotels, theatres, etc) (which could be provided through cable distribution), paralleled by the distribution of programming via "over the counter" higher definition tape or disc - leading finally to the gradual introduction of services designed for the household consumer;

3) A start up of HDTV services as a result of a successful introduction in Japan and the reduction in the cost of the receiver due to volume production for the Japanese market. This scenario becomes increasingly plausible if one assumes the new generation Japanese receivers would be capable of receiving both HDTV services as well as traditional NTSC signals.

Although offering an enhanced definition television service may not seem 'just around the corner' for cable operators, it is important that the cable industry be prepared for these market forces in order to take either pro-active or defensive action.

3. DRIVING FORCES AND THEIR IMPLICATIONS

3.1 Digital Receivers

Developments in digital receivers are well underway and to a large part inevitable. As memory capabilities become viable for not only line but field and frame storage, increasingly enhanced picture quality and more sophisticated features become possible.

Current 'digital receivers' now available in Europe, while containing digital chips in place of some linear integration circuitry, do not offer any noticeable improvement in picture quality. Receivers with sufficient line store memory and processing capability to eliminate 'ghosting' however, are expected to be in the marketplace by mid 1985.

Further removal of impairments inherent in the transmission of NTSC signals (or PAL or SECAM for that matter) will be achieved when receivers with field and ultimately frame storage capabilities become available. These sets could also offer additional features such as 'picture in picture', 'multi-picture in picture', 'still picture', 'store and recall picture' and 'zoom'. There is some fear that once the 'expected' impairments are corrected however, the disparity between off-air signals and poor quality transmission (and resulting 'un-expected' impairments) on some cable systems will be exposed. Thus, there will be perhaps a need for increased emphasis on cable maintenance programs.

A recent international Delphi survey of individuals involved in television technologies (conducted by Nordicity Group as part of a technological assessment on the future television technology for the

Department of Communications) indicates that receivers with field storage capabilities are already in the laboratory and can be expected to be widely distributed in the 1990 time- frame. These sets could possibly be bypassed or followed by receivers with full frame store.

This increased memory capacity offers the potential for even further image improvements and features when complemented by other transmission schemes.

3.2 NTSC 2 Channel Systems

One school of thought suggests that the one feature which viewers will find most attractive is an increase in the television screen aspect ratio from 4:3 (of current systems) to 5:3 or 5.33:3 (approaching "movie screen" proportions, generally of 2:1). Joseph Nadan of Philips Laboratories suggests that cable distribution of a two channel service based on NTSC may 'represent an acceptable compromise between value to the consumer and bandwidth cost'(1). The beauty of this proposal to cable operators is the complete compatibility with existing systems. In this scheme, the first channel carries the traditional NTSC signal with a second supplementary channel providing extra lines and 'side panels', so when combined at the receiving end the resulting image has 657 lines and a 5:3 aspect ratio.

Cost implications to the cable operator to offer the two channel NTSC service would be; the cost of the convertor required at the head end to convert an enhanced or high definition signal received into the NTSC two channel format (prices for the convertor are not yet quoted), the incremental costs associated with the use of an additional cable channel, and the investment in specialized decoders required only for those households where subscribers have 'fancy' sets with field storage capabilities and wish to obtain the full premium service.

3.3 Analogue Component Video

Analogue component video proposals originated with the desire to design a format which would be more closely optimized to the characteristics of FM transmission on satellite channels (as opposed to the lower frequency AM channels used in terrestrial broadcasting). Several 'Multiplexed Analogue Component' (MAC) schemes have been proposed. Two essential features of MAC are:

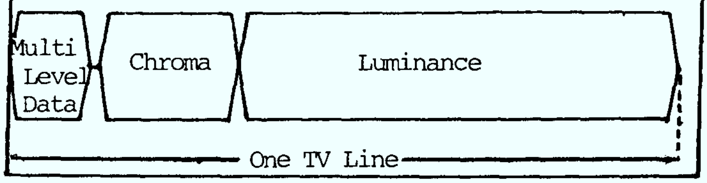
- it is a component system transmitting the luminance and chrominance information separately (rather than merging them into the same waveform as in NTSC);

- it uses time division multiplexing (TDM) techniques to separate the luminance and chrominance by transmitting them at different times.

Several MAC proposals have been put forward including C-MAC, D2 MAC and Scientific Atlanta's B-MAC recently adopted for DBS launch in Australia in September of 1985. The major difference in these proposals is in the schemes for the combining of audio and data with video.

Figure 1 shows the baseband waveform of one television line of the Scientific Atlanta B-MAC signal.

Figure 1[2]
Scientific Atlanta B-MAC Format
Baseband Waveform



The attractiveness of MAC delivery for the cable industry lies not only in its hard scrambling advantages and elimination of NTSC impairments, but in its potential to evolve into a higher definition service while maintaining compatibility throughout.

It is not expected that cable operators would want to offer all services with enhanced quality, but it might be attractive for that extra perk to stimulate subscription to a premium service. If a satellite service was delivered as a MAC signal, the cable operator would have the option to convert to NTSC for distribution, or to pass the MAC signal through the cable system and decode on the subscriber's premises. While MAC signals could be distributed through the cable system via AM (requiring approximately two cable channels), MAC is ideally suited to FM transmission which provides a signal clean of noise and echo interference which plagues AM transmission. An FM MAC signal can be provided over three contiguous high-band channels (ie. channels 30, 31, 32) resulting in a considerably improved image to subscribers with receivers having an RGB input. For subscribers with traditional NTSC receivers improvements in impairments such as 'trailers' will be realized. New generation CRT's with an RGB input and 'data grade' picture tubes will result in greatly improved image. Complemented with field store capabilities, further improvement can be realized with the elimination of interlacing impairments (currently lab models require 3 field stores for de-interlacing for NTSC).

The implications of FM transmission on cable systems raises concerns over increased signal to noise ratios due to wider bandwidth, thus a possible requirement for increased amplifier power. Some experts believe, however, that transmission can be achieved in the superband with even less energy required than for some AM single channels. Truncating energy at 18MHz by passing the signal through a filter will eliminate any sideband interference implications. Thus, assuming spare channel capacity exists, no major implication to the cable system - other than the major expense of head end equipment currently quoted around the $5000-$10,000 per channel range, high unit cost decoder replacement (currently priced around $140, also suitable for NTSC decoding needs), and the incremental costs associated with two additional channels - would be expected.

3.4 Enhanced Analogue Component Video

Enhanced Analogue Component Video could be the second evolutionary step in the development of premium television transmission already on the MAC path. While the signal maintains the same number of scanning lines as the basic approach, more bandwidth is provided, pre and post transmission filtering must be performed, and a wider aspect ratio can be provided. Current proposals suitable for cable transmission involving wider aspect ratio really fall under bandwidth reduced HDTV.

3.5 Bandwidth Reduced HDTV

Bandwidth reduced HDTV proposals range from two channel arrangements such as the CBS two channel analogue component proposal to the one channel digital compression schemes such as the Japanese Multiple Sub-Nyquist Sampling Encoding (MUSE) system.

3.5.1 Two Channel Proposals

The CBS two channel system proposal contains one channel containing a 525 line, 60 field, 4:3 aspect ratio, time multiplexed component (TMC) and a second channel carrying on additional 525 lines of video but with a 5:3 aspect ratio. (This is not the same as the previously discussed 2 channel NTSC proposal.) When these two channels are matrixed, an HDTV picture results containing 1050 lines and a 5:3 aspect ratio. Figure 2 provides a simplified scanning geometry for this proposal and Figure 3 outlines the baseband waveform for this format.

The two channel scheme is not necessarily restricted to the CBS proposal but with a little imagination can be extended to the other MAC schemes. Scientific Atlanta, for example, plans to unveil a family of services including evolution to a 2 channel transmission scheme providing image with a 5.33:3 aspect ratio. This scheme may only require one additional 5.4 MHz cable channel over the basic MAC proposals for full enhanced service delivery, with the initial (three cable channel) service still available to subscribers who have not yet upgraded to a new generation television set.

The evolution towards component television may enable customers to obtain decoders with the 'smarts' built in to decode any signal, complemented by an RGB input receiver and display device. These decoders would likely have the ability to pass either NTSC, MAC or enhanced MAC signals to the appropriate receiving device. For those customers with the deluxe television model, an image of essentially HDTV quality could be realized.

While this discussion has focussed around evolution in the home consumer environment, the potential also exists for the cable industry to be the primary distributing force for specialized services which may develop in the bar, hotel and mini theatre market. The two channel schemes - at least the bandwidth reduced variety - proposed will provide a large screen image approaching that of 35 mm quality.

3.5.2 MUSE Proposal

Since 1968, NHK (Japan Broadcasting Corporation) has been the driving force in the area of high definition television production research. The MUSE system provides one channel (8 MHz baseband) with 1125 line HDTV pictures with a 5:3 aspect ratio. This proposal offers the advantage to cable operators of reduced channel requirement with the disadvantage of lack of compatibility with existing receivers.

Four field frame stores are required at the receiving end, making production of initial receivers expensive. With government support in Japan, limited HDTV broadcast will commence in the fall of this year, and a full service scheduled via DBS in 1989. If successful take-up occurs in the Japanese market, the price of these receivers could fall considerably, making their entry into the international marketplace more plausible. If growth in North America occurs in a high-end market for high definition VCR or videodisc and display devices a base (of say over 1-2 million units) could be in place for the broadcast of a HDTV service with the addition of a receiver/decoder component. (Note that HBO is scrambling its signal after a base of 1 million TVROs in the US has been established.)

Although the MUSE signal is not readily compatible with traditional receivers, plans are to produce a decoder for conversion of the signal to a 525 line image. As the MUSE signal is somewhat of a different animal than the other proposed transmission schemes, it is not clear whether AM transmission on cable will be possible at suitable power levels or whether an FM scheme would be adopted. The mode of transmission on cable will depend on the data rate and modulation coding chosen. Although to date no AM scheme has been proposed, it will certainly be worth considering as the possibility exists for significant bandwidth savings. If AM is deemed unsuitable I expect FM transmission within three to four high band contiguous channels would be possible.

4. CONCLUSIONS - OR FOOD FOR THOUGHT

When discussing higher definition television it is easy to 'pooh-pooh' the thought of its introduction in a currently quantity driven consumer service environment. However, if one looks back at where a broadcaster might be if he had not chosen to offer a colour television service, or where those radio operators are who believed that FM radio would never amount to anything, it suddenly seems appropriate to consider some of the following questions:

1) Will the introduction of digital television of increasing sophistication expose cable delivery which may not be up to snuff?

2) Could an NTSC two channel system provide a suitable cable transmission compromise or perhaps an interim measure towards higher definition services?

3) With decoders due for periodic replacement anyway, should their replacement coincide with or be prepared for the introduction of some MAC or enhanced MAC discretionary services?

4) Would enhanced transmission provide an attractive perk for one or two premium services? (Particularly after 1990 when ample channel capacity should be available in most cable systems in Canada)?

5) With a possible market for specialized services to bars, mini theatres, etc. should cable operators in North America take a pro-active role in obtaining these services for delivery?

6) Should cable operators position themselves for an evolutionary approach to enhanced service offerings or await possible introduction of a Japanese type HDTV service?

In closing, I leave you with the question - Will the cable industry move 'Towards Higher Definition Television' ?

(1) Signal Processing for Wide Screen Television: The Smart Receiver, Joseph S. Nadan, Philips Laboratories, Richard N. Jackson, Philips Laboratories, pg. 301

(2) SMPTE, Television Image Quality, B-Mac, An Optimum Format for Satellite Television Transmission, John D. Lowry, Scientific-Atlanta Inc., Feb.10-11, 1984, page 220.

(3) CBS Technology Center, Stamford, Connecticut, A Compatible HDTV Broadcast System, John P. Rossi, A.A. Goldberg, R. H. McMann, Oct. 1984, page 5.

Figure 2[3]

CBS Two Channel Proposal
Simplified Scanning Geometry

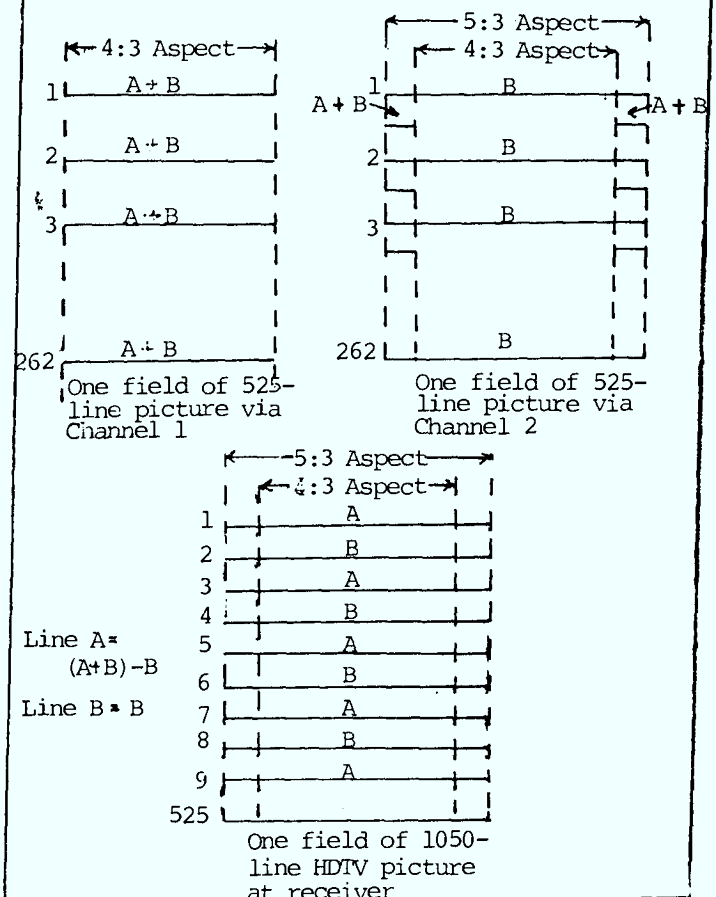
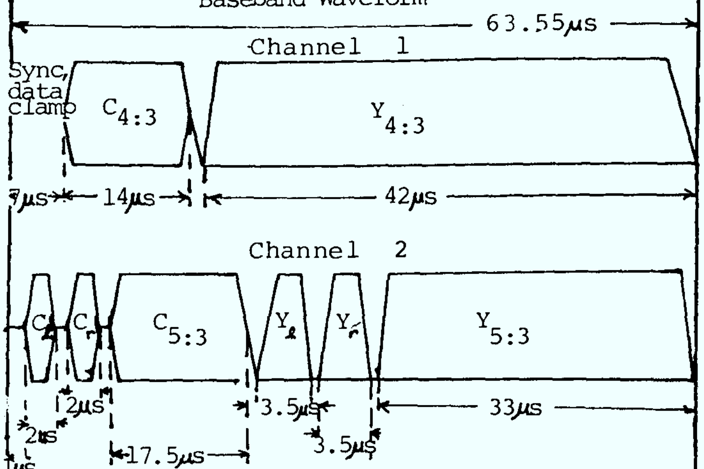


Figure 3[3]

CBS Two Channel Proposal
Baseband Waveform



C Chrominance
Y Luminance
C_l Chrominance left side panel
C_r Chrominance right side panel
Y_l Luminance left side panel
Y_r Luminance right side panel

HIGH DEFINITION PRODUCTION STANDARDS
How broad their application?

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ABSTRACT

The Broadcasting Unions of the world have called upon their members to work toward the achievement of a single worldwide high definition television production standard to achieve lower equipment costs and to ease exchange of programs internationally. The motion picture industry has been studying the possible application of HDTV technology to the production and post-production of feature films for theatrical release. Although historically the television and motion picture industries have been separate entities, the distinctions between their objectives and indeed between the participants themselves is becoming more cloudy.

The potential for achieving through the world standardizing bodies a common worldwide standard for both applications will be explored and the thorny issues requiring compromises on both sides will be discussed.

NORMES RELATIVES À LA PRODUCTION HAUTE DÉFINITION
Quelle est l'étendue de leur champ d'application?

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4.2

RÉSUMÉ

Les unions de radiodiffusion du monde entier ont enjoint à leurs membres de travailler à l'établissement d'une norme mondiale commune de production de télévision à haute définition (TVHD), afin de réduire le coût de l'équipement et de faciliter l'échange international des émissions. L'industrie cinématographique étudie l'applicaton possible de la technique de la TVHD à la production et à la postproduction des longs métrages destinés aux salles de projection commerciales. Par le passé, la télévision et l'industrie du film étaient deux entités bien distinctes. Toutefois, les divergences entre leurs objectifs et, à vrai dire, entre les participants mêmes, tendent de plus en plus à s'estomper.

Les possibilités d'en arriver, par le truchement des organismes de normalisation internationaux, à une norme mondiale commune à ces deux secteurs seront examinées et les questions épineuses au sujet desquelles il faudra en arriver à un compromis seront discutées.

HIGH DEFINITION PRODUCTION STANDARDS--
HOW BROAD THEIR APPLICATION?

4.2

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In 1983, the Broadcasting Unions of the world[1] and the CCIR[2] called for studies leading to an agreement within the current CCIR Study Period (1982-86) on a single worldwide HDTV standard for the television studio and for international program exchange. The standards for transmission and broadcast distribution are deferred to the 1986-90 CCIR Study Period. The CCIR formed an Interim Working Party for HDTV to accelerate progress on an agreement.

Figure 1 illustrates a concept that has become recently popular in which technology now permits us to deviate from the time-honored principle of synchronously scanning of the television rasters in camera and display. In the so-called Improved Composite Systems, transmission would use conventional NTSC or PAL standards, but field stores in the receiver will permit either a progressive scanning of the display or perhaps interpolation up to higher line numbers and higher field frequencies to reduce interline and large-area flicker. It will also be possible to derive from a high line-rate camera a further improved 525- or 625-line composite signal from a combination of progressive scanning and diagonal filtering as described in the paper by Professor Wendland.[3] Similarly, Figure 1 illustrates equally well new Enhanced- or Extended-definition transmission systems that might include wider bandwidth multiplexed-analog-component transmission and wider aspect ratio for further improvements beyond composite systems. We have heard several approaches for such systems at this Conference.

Finally, Figure 1 is also applicable to future High-Definition Systems in which the production and distribution employ different scanning standards. The display scanning is labeled a "nonstandard" because it is not clear that a need

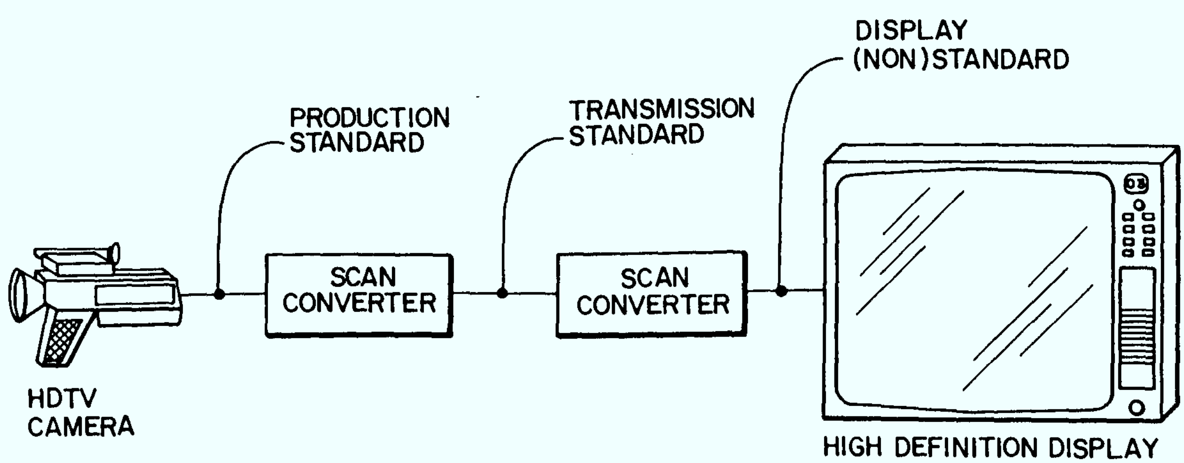

Figure 1

exists to specify how the received signal is to be displayed. Competitive environments should assure the consumer the best quality that can be achieved with the technology of the day.

In the same year that the broadcasting unions called for a single worldwide HDTV studio standard, the Society of Motion Picture and Television Engineers (the SMPTE) formed a Working Group on High Definition Electronic Production to determine the requirements for the production and post-production of motion pictures for theatrical as well as television release. This concept is illustrated in Figures 2-4. Image capture is assumed to be either on film or electronic, and the electronic production system should have sufficient flexibility that a decision of whether to shoot on film or tape is an economic one rather than a constraint of the standard. The post-production editing suite of Figure 3 takes inputs from either film or tape, herein designated as HDEP to emphasize use for theatrical as well as TV applications. The tape or film dailies are loaded through the production switcher to tape or disc buffers. Editing under computer control intercuts film clips, tape clips, computer generated graphics, animations, and special effects to produce a final edited HDEP master tape ready for replication and release to distribution. As HDEP productions are expected to be used as source materials for film and standard television release, standards conversions must be made for both film prints and, as shown here, for CCIR Recommendation 601 digital tapes for 525/60 and 625/50 release.

For EDTV or HDTV broadcast to the home or distribution to the electronic cinema, conversion from an HDEP replicated master to the selected EDTV or HDTV transmission standard is applied as shown in Figure 4. A film is delivered physically to the nonelectronic cinema. Obviously, a similar diagram for other distribution media, for example, VCR cassette, videodisc, and cable TV could be prepared.

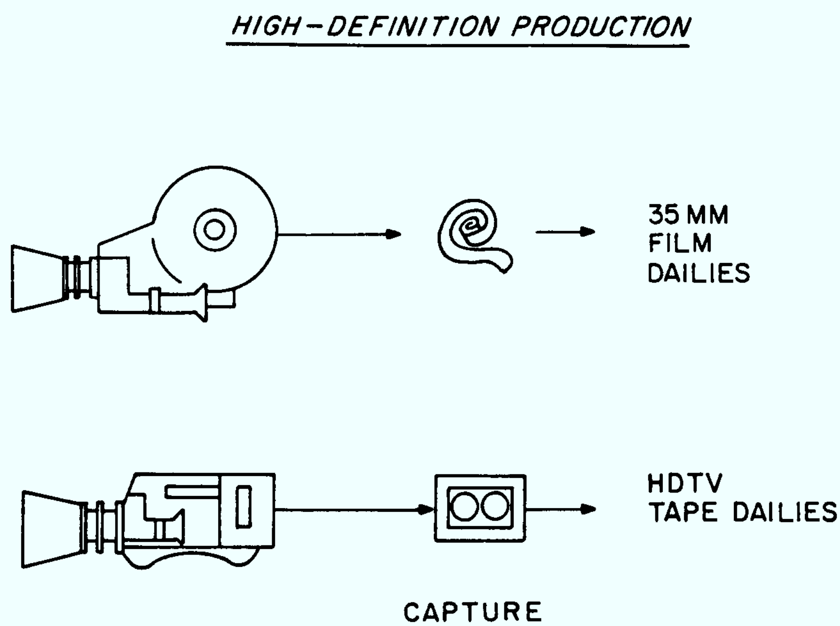

Figure 2

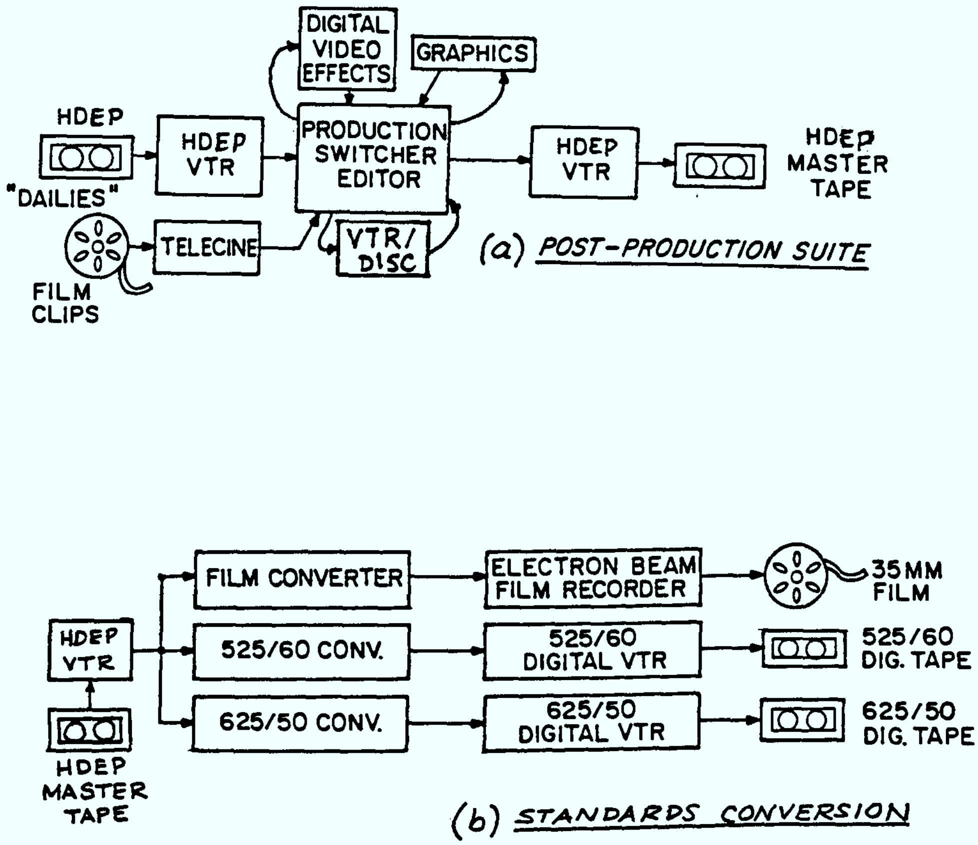

Figure 3. Post-Production

HIGH-DEFINITION PRODUCTION

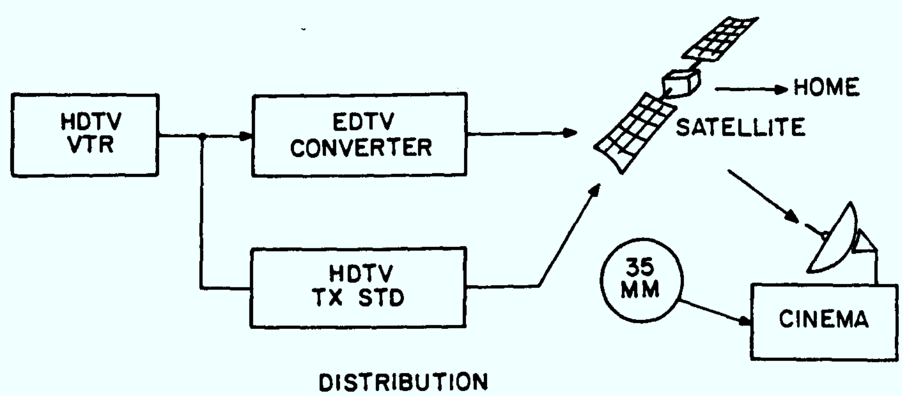

Figure 4

In the electronic production system being considered by SMPTE, the three parameters that were regarded at the outset to be most difficult to define were 1) a common aspect ratio, 2) a common frame rate, and 3) the interlace ratio. Previous work in SMPTE had already concluded the creatively preferred aspect ratio depends on subject matter, but, in general, is some unknown number between 1.5 and 2.5-to-one with a very broad optimum. Thus the selected standard should be determined not on creative preference but on the basis of maximum compatibility with current practice.

There appeared to be two options: 1) to select some compromise value (for example, 1.66:1) and try to encourage its use, or 2) to apply the concept of "shoot-and-protect" to provide flexibility in aspect ratio release. The "shoot-and-protect" concept has already largely replaced the need for pan-and-scan for film-to-tape conversions of modern-day wide screen films when converted for television viewing. Even though the scene might be artistically composed for cinema projection at 1.85 aspect ratio, the action is confined to a reticle of 1.33 aspect ratio to permit cropping of the sides without loss of critical content.

Figure 5 summarizes the end result of the SMPTE aspect ratio study. All of the commonly used values from 1.33 to the Cinemascope 2.35 are constructed as rectangles of equal area and superimposed on a common center. The intersection of all of the rectangles forms an inner reticle and their union is enclosed within

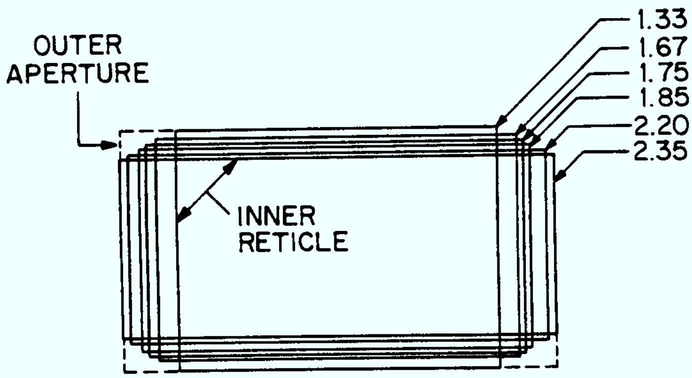

Figure 5

an outer aperture. These two rectangles (the inner and outer) turn out to have the identical aspect ratio of 1.77, the geometric mean of 1.33 and 2.35. This number is within ±6 percent of the values 1.66 and 1.85 that constitute an overwhelming majority of cinema release prints worldwide. Now if the scene is framed to confine the action to within the inner reticle and if superfluous intrusions (microphones, lights, crew, etc.) are excluded from the aperture space surrounding the reticle, then release prints can be derived at any aspect ratio ranging from 1.33 to 2.35 with a minimum of wasted film area. The number 1.77 was adopted and immediately rounded up by SMPTE to 1.7777 or precisely 5-1/3:3 or 16:9, to be more compatible with CCIR Rec. 601. For the theatrical application, this value permits the action to be framed in a <u>wide screen</u> format while still protecting a 4:3 release, instead of conversely. The new aspect ratio and its shoot-and-protect concept has been endorsed by several Hollywood cinematographers and has been adopted not only by SMPTE, but also by the ATSC, by NANBA and has been submitted by the U.S. as a position for the CCIR.

The question of common frame rate and interlace-versus-progressive scan have turned out to be not so easily resolved. Tests by SMPTE of frame rate conversions by use of a Videola machine as a picture sample-and-hold technique, have shown that there is no magic number in the entire range of 24 to 200 Hz that will allow judder-free conversion to both 50- and 60-Hz field rates and also to 24-Hz film. The conclusion reached was that frame-rate conversion algorithms substantially better than the temporal interpolations of state-of-art 4-field standards converters would have to be developed before good quality could be achieved in all potential release media.

On the question of interlace, the SMPTE Working Group expressed a strong preference for a progressively scanned standard because of its editing advantages in production and post-production but has not yet resolved the issue of the wider bandwidth implied. However, pressed for provisional recommendations to the ATSC for a U.S. position in the CCIR, the SMPTE expressed a willingness to accept a 60-Hz 2:1 interlaced television program exchange standard, if that be necessary to achieve a single world standard. The application of such a standard to theatrical film production would likely have to await a solution to the motion-adaptive frame rate conversion problem.

Figure 6 illustrates in chart form all of the television standards now existing and expected in the near and distant future that would be used for production/post-production, international program exchange, broadcast or distribution, and display. Currently all television broadcasts around the world use one of the

ADVANCED TELEVISION SYSTEMS

	PRODUCTION/ POST-PRODUCTIDN	INTERNATIONAL PROGRAM EXCHANGE	BROADCAST OR DISTRIBUTION	DISPLAY
NOW	FILM @ 24/25 NTSC PAL	FILM NTSC ➞ PAL/SECAM PAL ➞ NTSC/SECAM	NTSC PAL SECAM	R G B 525-LINE 625-LINE 2:1 INTERLACE
NEAR TERM	ABOVE PLUS 601 @ 525 601 @ 625	ABOVE PLUS 601 @ 525 ➞ 625 681 @ 625 ➞ 525	ABOVE PLUS E-525 E-625	ABOVE PLUS 525-PROGRESSIVE 625-PROGRESSIVE
LONG TERM	ABOVE PLUS HDEP	ABOVE PLUS HBTV	ABBVE PLUS EBTV-60 EDTV-50 MUSE 2 CH HBTV-60 2 CH HDTV-50	ABOVE PLUS 1050-PROGRESSIVE 1250-PROGRESSIVE 1125-PROGRESSIVE

Figure 6

thirteen variants of NTSC, PAL, and SECAM. These are displayed to the home viewer in a red-green-blue format in which the raster is either 525- or 625-line, 2:1 interlaced. For international program exchange, programs produced in NTSC must be standards converted to PAL or SECAM, and programs produced in PAL must be standards converted for NTSC or SECAM. Film at 24 frames per second constitutes a significant program exchange medium. Although such films require standards conversion by the 3-2 pull-down telecine technique for NTSC, they are simply run at 25 frames per second and scanned at two fields per frame for either PAL or SECAM systems. Although international program exchange on film is declining, film still constitutes the preferred production and post-production medium for about 80 percent of prime-time television. Dramatic series, on-location productions, and, of course, cinema films are all produced on film.

SECAM has been omitted from the chart as a production standard as there is growing use in Europe of PAL for production of material to be released in SECAM. In the near term, the implementation of the digital studio standard of CCIR Recommendation 601 will gradually begin to replace productions in NTSC and PAL. The chart does not include production in component analog video (CAV) which is essentially a serial analog equivalent of CCIR 601 and might be used as a nearer term alternative. Although the common worldwide digital studio standard has many parameters common to 525/60 and 625/50, it is a dual standard of two different frame rates that requires frame rate conversions between the 525 and 625 versions.

As the digital studio standard permits wider bandwidth luminance (up to about 6 MHz) and provides signals in component form, it is an ideal source for multiplex-analog-component transmission techniques. Thus in the near-term, NTSC, PAL, and SECAM will be joined by enhanced-525 and enhanced-625 as transmission standards. During the same time frame, the 2:1 interlaced displays will give way to progressively scanned displays that will substantially enhance the quality of the pictures presented to the viewer, whatever the transmitted signal may be.

In the long term, we expect to see introduction of high definition television productions that will permit broadcast or distribution in still higher quality, wide-screen extended-definition television (EDTV) signals, two-channel HDTV systems, and single-channel bandwidth-reduced HDTV systems, such as MUSE. Both HDEP and HDTV are indicated, respectively, as production and international program exchange standards although, of course, it would be conceptually desirable to have one standard for both. At the display, still higher quality pictures will be produced by progressive displays at 1050-, 1250-, or 1125-line scanning, depending on the progress of HDTV standardization.

A single worldwide international program exchange standard at 60 Hz represents a problem not only for PAL and SECAM conversions, but also for planned use of E-625 and EDTV-50 in 50-Hz countries. The compromises that will have to be made to achieve a single worldwide HDTV standard are now becoming clear. A recent CBS document[4] that was submitted to the CCIR Interim Working Party on HDTV states:

> "Some standards conversion footprints will need to be accepted, when programs generated in HDTV will need to be broadcast through conventional television broadcast channels; this is perceived as a comparatively modest price to be paid for the sake of a single HDTV studio standard because...this price will really only be paid

during a comparatively short transition period, namely from the time when an important number of programs will be produced in HDTV, to the time when HDTV broadcasting will become the primary service."

The implications of a single worldwide HDTV studio and program exchange standard impact not only the HDEP standard but also the HDTV broadcast standards that have been deferred for later agreement. It is clear that the studio standard and the broadcast standard, although possibly different, must at least employ the same field rate or the conversion footprints would negate the higher quality intended for HDTV.

There is currently only one HDTV studio standard under consideration, namely, the NHK 1125-line 60-Hz 2:1 interlace system. Both 50 Hz and 80 Hz have fallen by the wayside as well as all other alternatives that would require more time for evaluation. Accept it in October 1985, or forever suffer the consequences of multiple incompatible *de facto* standards. The time for decision is now.

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HEROICS IN POLICY ADVISING : THE AUSTRALIAN EXPERIENCE IN PLANNING BROADCASTING SERVICES BY NATIONAL SATELLITES

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ABSTRACT

A major emphasis in the decision of the Australian Government to establish a national communications satellite system was the removal of disadvantages in communications services of people in remoter areas of Australia.

The decision was founded on the capability of a satellite system of relatively modest size and cost to deliver television, radio, and telephony services to people who lacked some or all of the above services, or who were receiving sub-standard services. Successive Australian Governments have stressed the capacity of the satellite system to deliver these services to remote Australia.

The planning for the delivery of television and radio services to outback communities and homes, was that each of the higher powered transponders on the Australian satellites would deliver one television and at least two radio services. These radio services would be provided using SCPC signals in the same transponder as the PAL television. Tests over a period of years gave confidence that the PAL/SCPC approach was technically feasible and would provide an acceptable grade of service. Within twelve months of the planned introduction date of satellite services, ongoing investigation revealed that the successful introduction of PAL/SCPC was unlikely due to a combination of operational, technical and economic factors. The planners and policy advisers were then forced to either look at possible alternative technical solutions or to accept that the broadcasting services to remote areas would be restricted to one television service only.

VISÉES AUDACIEUSES:

L'EXPÉRIENCE DE L'AUSTRALIE DANS LA PLANIFICATION DE SERVICES DE RADIODIFFUSION PAR SATELLITES DOMESTIQUES

4.3

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RÉSUMÉ

La décision du gouvernement de l'Australie d'instaurer un système national de télécommunications par satellite visait principalement à améliorer le sort de la population des régions reculées de l'Australie en matière de communications.

Elle était motivée par la capacité d'un système à satellites de dimensions et de prix relativement modestes de distribuer des services de télévision, de radio et de téléphonie aux Australiens qui sont privés d'une partie ou de tous ces services ou qui reçoivent des services de qualité inférieure à la norme. L'un après l'autre, les gouvernements australiens ont souligné la capacité d'un système à satellites de fournir ces services jusqu'aux confins de l'Australie.

Selon le plan de distribution des services de radio et de télévision aux localités et aux foyers situés dans les terres intérieures, chacun des répéteurs de puissance plus élevée des satellites australiens transmettrait un signal de télévision et au moins deux signaux de radio. Ces services de radio emprunteraient des signaux à une seule voie par porteuse qui passeraient par le même répéteur que le signal de télévision PAL. Des essais menés au cours des années donnaient l'assurance que la méthode était réalisable sur le plan technique et qu'elle fournirait un service de qualité acceptable. Moins de douze mois avant la date prévue d'introduction des services par satellite, les recherches en cours ont montré qu'il était peu probable que la mise en oeuvre de la transmission de signaux PAL et de signaux à une seule voie par porteuse par un même répéteur réussisse à cause d'une combinaison de facteurs opérationnels, techniques et économiques. Planificateurs et conseillers en politique se sont alors vue contraints d'envisager des solutions techniques de rechange ou d'accepter que les services de radiodiffusion dans les régions reculées soient limités à un seul service de télévision.

HEROICS IN POLICY ADVISING : THE AUSTRALIAN EXPERIENCE IN PLANNING BROADCASTING SERVICES BY NATIONAL SATELLITES

4.3

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There are a variety of reasons why nations decided to establish domestic, and in some cases, regional communications satellite systems. The existence of the technology and the push for new export industries have no doubt been important factors in some instances, and other matters such as national pride and political interests have been apparent in some instances.

The case for establishing for Australia a national communications satellite system was argued almost singularly on the ability of satellite technologies to extend broadcasting, telephony and other communications services to a relatively small number of people living in remote parts of the nation and who could not otherwise expect to have access to such services for many years. There were degrees of support for a satellite communications system from some industry sectors, notably the national and commercial broadcasters and computer suppliers and users, while government authorities reliant on communications systems to maintain essential services such as aircraft navigation, air safety and public order, added their support to a Federal Government initiative to begin the planning of a commercial satellite network.

Predictably the strongest or most influential opposition to the proposal came from those parts of public administration which believe that they have special qualifications to censor any proposal for spending Government funds. In their opposition, even the principles of physics seemed liable to challenge and rewriting but that is perhaps a story for another day or a long winter's night.

As an attachment to this paper I have given some pertinent facts of Australian demography and geography and an outline of the present arrangements for providing telecommunications and broadcasting services in that country. The Australian decision to commit its reputation and a considerable amount of public funds to establish a national communications satellite system by late 1985, does not make sense unless it is seen in the context of more than 300,000 people without any television service, some 10,000 homes which could not expect to receive a telephone service through existing terrestrial technologies, in a prosperous nation where such services are readily available to other residents.

The decision to proceed with the satellite system proposal was really presented as a piece of altruism - urban Australians funding the cost of extending communications services to those living in the remoter parts of the continent.

In announcing the decision in the Australian Parliament in 1979 to proceed with planning for a national satellite system, the Minister then responsible for communications matters, (the Hon. A.A. Staley) stressed the advantages which a satellite system offered to people without adequate means of communicating and obtaining information in a modern society. The satellite system was seen as offering the means to provide services to unserviced areas, to upgrade services in areas where services are degraded, and providing the scope to change the method of delivery of health, education and other services to those who did not have ready access to them because of remoteness from more populous areas.

The above sentiments would have been well-known to Canadians in the 1970's when their government established Telesat and decided to proceed with the network of ANIK satellites. I am not suggesting that the imperatives which led the Canadian and Australian Governments to proceed with establishing national communications satellite systems were common throughout but both governments were impelled by the need to remove or reduce the disadvantages in access to communications of those people who live in the remoter areas of two very large nations of considerable wealth.

I acknowledge the debt which Australian policy advisers and technologists owe to their counterparts in the Department of Communications in Ottawa and to senior executives of Telesat. I accompanied Mr Staley on a visit in early 1979 to a number of countries which were playing leading roles in the development and use of communications services provided by geo-stationary satellites. I well remember standing in the bitter cold of Shelley Bay on a February morning while we were photographed with Canadian officials looking rapturously at an antenna which was used for experiments with the Hermes satellite.

It was the witnessing of those experiments which had a profound effect on the thinking of the Australian Minister about the merits of establishing an Australian satellite system to distribute television programmes direct to homesteads in the Australian outback.

Up to this time, the accepted wisdom was that high-powered transponders, of at least 100 watt output, were essential to provide the strength of signal on the ground which could be received by antennae of reasonable size for direct television reception in individual residences. Indeed, the need for very high-powered transponders to provide direct broadcasting services had been agreed by member states of the International Telecommunications Union when determining frequency allocations to regions for direct broadcasting purposes.

The significance of the Canadian experiments in the late 1970's was that they demonstrated that a much lower signal strength on the ground would provide an acceptable standard of television service when received through a domestic antenna of about 1.5 metres diameter.

From an Australian view, the Canadian research effort had changed, in a radical way, the economics of satellites for direct broadcasting purposes. Mr Staley and I arrived in Ottawa fresh from a visit to Japan where an experimental satellite was operating a direct broadcasting service using 100 watt travelling tubes and domestic antenna of 90 centimetres diameter.

Instead of dealing with a technology which offered the prospect of a direct broadcasting service using costly travelling wave tubes of 100 watts or more, which were unproven in space, and with a design life of about three years, we were now offered the alternative of satellites of using space-proven travelling wave tubes with a much smaller power output, with a far greater transponder capacity to provide a mix of communications services, while retaining the essential element of reception by low cost antenna of about 1.5 metres diameter.

Leaving Australia as a sceptic about the utility and cost of a domestic satellite system to meet Australia's needs, Mr Staley returned home with the conviction that Australia must decide in favour of establishing its own satellite system as soon as practicable.

Some of my dear friends in other parts of the Australian bureaucracy would delight in saying that this demonstrates the dangers of encouraging Ministers to travel overseas. Some engineering acquaintances would say that this showed the folly of the Minister taking a bloody lawyer with him rather than an engineer who could give a professional assessment of overseas developments in satellite communications systems.

I have always thought that the Minister was most wise in his choice of a travelling companion. That is a facetious comment but it does also hold a germ of truth. Subsequent to Mr Staley's visit, a strong relationship developed between the engineering elements of the Canadian and Australian counterpart organisations and any doubts or reservations about the efficacy of the Canadian approach in satellite system design were quickly removed. On the other hand, the potential of a satellite system to extend the coverage of communications services within Australia had to be argued/fought in the political environment. However noble of brow and deed our engineering brethren may be, policies are not fought and won by applying principles of physics or mathematical formulae.

I pause at this stage to recap the essential elements of the Government strategic thinking in endorsing the establishment of a national communications satellite system. I will have then set the scene for introducing the unlikely heroes of this dramatic story.

The Australian Government agreed to proceed on the basis that:-

1. a national satellite system had the capability to extend and upgrade domestic communications services;

2. this could be done using conventional and proven space technology;

3. estimates of system costs showed that the satellite system would not be a continuing drain on public moneys; i.e. that the system could operate as a commercial venture;

4. the satellite system would provide a direct broadcasting service to people in remoter areas by low-cost earth terminals with antenna about 1.5 metres diameter;

5. the likely cost of such an earth terminal, based on information from overseas, was in the order of $A1000 at current prices.

At various key points, Government agreement was sought and obtained to proceed with the phases of planning, including approval in 1980 of the conceptual design of two satellites in orbit and an on ground spare, each satellite to have four transponders of 30 watts and eleven transponders of 12 watts. The satellites would have a national beam and shaped or spot beams designed to divide Australia into 4 zones, with an additional spot beam also switchable to Papua New Guinea to meet that country's aspirations to introduce a direct broadcasting service in 1988.

The Australian Telecommunications Commission - commonly known as Telecom - and the Department of Communications had been experimenting with increasing the audio channels which could be used with a television channel in a satellite transponder. Telecom Research Laboratories had simulated a satellite transponder to demonstrate that two and possibly three additional audio channels could be provided with a television service through a transponder. Theoretically it was possible therefore to add two, or possibly three, radio services in addition to the direct television service to be available to remote homesteads and communities. Each of these radio services would be carried by separate carriers within the frequency band of that transponder.

The concept of providing radio services in conjunction with a television service was attractive to the Government and to the Australian Broadcasting Corporation (the ABC) which already provides a first and second radio network to many centres as well as an FM radio service for fine music which is being extended to a national service as funding and priorities permit.

To test the Telecom laboratory results, a team of Australian officials visited Fucino in Italy in 1980, and conducted a series of experiments involving the transmission of a television programme and a number of audio signals through a transponder of the European OTS satellite system. These tests did not wholly support the results obtained at the Telecom Research Laboratories but at least indicated that two monophonic radio channels could be transmitted by separate carriers within the bandwidth available on a transponder.

Through the co-operation of the Department of Communications in Ottawa, similar experiments were carried out in 1981, using a transponder of an ANIK B satellite. The experiments were repeated on a "bench test" in Los Angeles in 1983, with a 30 watt travelling wave tube identical to those to be fitted to the Australian satellites.

These tests demonstrated the technical feasibility of carrying additional radio channels but there was concern by engineers supervising the tests that there could be degradation of the television signal without proper control over the relative signal strength of the radio channels. As the transmission technique would be unique to Australia, there were also concerns about the cost of domestic earth stations designed specifically to meet the requirements of the small Australian market.

Over this period the Department of Communications had been trying to keep in touch with developments in satellite transmission technology occurring in other parts of the world. Other possible options for the transmitting system were not well advanced however and in February 1984 the Minister for Communications announced that the direct broadcasting service would comprise a PAL TV program and separate radio programs using single channel per carrier techniques.

There was continuing pressure to look at other possible systems and in June of that year, the Department originated a review of the system standards for the direct broadcasting service. There was great activity if not action as a result. Omitting a description of the activity, the major result of this standards review was the advice of AUSSAT Pty Ltd - the organisation equivalent to Canada's Telesat - not to proceed with single channels per carrier for the additional radio services.

The view of AUSSAT Pty Ltd was that removal of the single channel per carrier signals from the transponders would result in cheaper domestic earth stations and significant technical and operational benefits. The operation of the video carrier at saturation would improve the standard of the television service and the absence of inter-modulation noise between the video and the radio carriers should result in a greater operating margin in the television service.

If the Government persevered with separate carriers for the radio services, this would significantly increase the cost of AUSSAT major city earth stations, and the use of a highly complex and untried rain compensation scheme which provided uplink power control and balance between the separate video and audio carriers.

Even the calmest of those responsible for giving policy advice to the Minister were a little dismayed by this result. There was an expectation that the purchase of a small earth station would enable a household in rural Australia to receive the ABC television service and at least two ABC radio programs. To use a gentle word, it would be "awkward" for the Minister to announce at this late stage of endeavour that there had been a technological problem which required the planned broadcasting services to be significantly reduced.

The first reaction of the Department of Communications was to "accept the inevitable" and advise its Minister that the planned broadcasting services to remote areas would have to be reduced. The ABC reluctantly agreed with that position. While we knew of theoretical technologies of the various multiplexed analogue component systems, it was our assessment that the MAC technologies would not be proven with hardware available until well after the system design of the Australian satellite system had to be finalised. Engineers of the Department and the ABC believed that the future of direct broadcasting services by satellite was in using a MAC transmission mode but Western Europe was bickering over which of the MAC technologies should be used there, while the United States seemed to be concerned with using a MAC technology to encode or encrypt transmissions for some very uncertain proposals for subscription television services.

We had been in contact over a long period with an American corporation of high repute for its technical excellence in communications technology and which was putting considerable effort into developing a B-MAC system for use by one of the largest suppliers of subscription television services in the USA. While the research achievements were considerable and gave little room to doubt that a B-MAC technology and hardware would be available in the near future, the positive indicators were that this would be too late to be incorporated into the Australian system.

While we were pessimistic that a MAC system would be available in time for Australian purposes, the head of the Department of Communications decided that he should make a last sweep of Western Europe to determine whether there were any prospects of a MAC system being developed and agreed to as a standard in Europe within the near future. This took place in August 1984. While he was abroad representatives of Plessey Australia Pty Limited, a subsidiary of the large Plessey organisation in Britain, invited representatives of the Department of Communications to witness a demonstration of a B-MAC system at the Department's laboratory. This test was as convincing as any bench test of new technology can be, recognising that the laboratory can never reproduce actual field operation circumstances. Scientific Atlanta of the United States had developed the B-MAC technology and was proceeding with the design of a general custom integrated circuit for a low cost B-MAC decoder.

Meanwhile the Departmental head had visited the parent Plessey company in Britain and its research laboratories at Swinburn where chips for the integrated circuit were being designed. He was given assurances from the most senior level of the organisation that both it and its American partner, Scientific Atlanta, had a commitment to produce the integrated circuitry required for a proposed American direct broadcasting organisation, and that the components for the B-MAC system would be available to Australia for use with its first satellite.

A "safe course" would have been to adopt the position that the B-MAC technology could not be proven in time for implementation of the Australian satellite system and that we should remain with a PAL direct broadcasting service. Our problems were further complicated by advice from another American organisation that it would have a B-PAL system available in the near future. That system offered several digital audio channels in addition to a PAL television channel using one transponder. A positive attraction of this second proposal was that the system had been developed for a large organisation providing television programming via satellite and which had a need to protect those programs from casual interception. This proposal carried a prediction of a low cost domestic terminal because of the cost advantages derived from the support of a large US market.

The decision on the transmission technology to be employed for the television service was at the imperative stage. There was a commitment to the Australian manaufacturing industry that the Government would determine technical specifications for domestic earth station equipment by February 1985. This was seen as the latest possible date for industry to prepare for the manufacture of equipment in time for the scheduled commencement of the direct broadcasting service in October 1985.

I am not sure if there was a particular or single factor which tipped the balance in favour of proceeding with the B-MAC system offered by Scientific Atlanta and Plesseys. The additional audio channels in a B-MAC system were of course important.

A telling point was that a PAL television service would operate at or near the margin of a reasonable standard of service.

There is no experience in Australia of the effects of heavy rain on signals in the Ku-Band relayed from a satellite. Laboratory experiments of the B-MAC system gave reason for confidence that a B-MAC signal would hold up much better in adverse climatic conditions than a conventional PAL signal. The other authorities in the Communications portfolio with concerns for the standard of the direct broadcasting service - the ABC and AUSSAT - were supportive.

It is nice to have friends in a crisis but in a final analysis the Department has to take responsibility for advices to the Minister both on questions of policy and on technical specifications for the broadcasting system.

Unwillingly we had to make a decision on introducing a major technological development in advance of the world, and more precariously, in advance of the full design of the integrated circuits required to operate that system.

Papers went forward to the Minister for Communications in late 1984 recommending that he approve the adoption of B-MAC as the transmission system and in January 1985 technical specifications were approved. The detailed specifications for the direct broadcasting service were published in the following month.

At the time of writing this paper, we have the comfort that the integrated circuitry has been designed and that a prototype of the decoder required will be available in Australia for testing in June this year.

There are uncertainties about the cost of a domestic earth station with decoder for the B-MAC system. The Australian company which will manufacture the decoders considers that the over-run from the estimated cost of $1000 given in 1980, will be acceptable. Some proportion of the additional costs can properly be attributed to inflation over this period but I acknowledge that this sort of argument makes little impact on consumers who have a ready recall of the price first indicated and a healthy scepticism of reasons why costs and thus prices must increase in the economic circumstances of the preceding five years.

It needs hardly to be said that there must be co-ordination between the introduction of the direct broadcasting service and the availability of earth stations to intending consumers. Whether the HACBSS is acceptable as a community service will depend on the quality of that service, the cost of earth stations to receive the service, and the degree of difficulty in installing an earth station with the correct pointing to receive the signals from the satellite system.

Not long after the Australian decision to use the B-MAC system, there was an announcement that the European Broadcasting Union and manufacturers of electronic equipment in Western Europe had agreed on introducing a C-MAC system for direct broadcasting purposes. That decision did not shock or give us affront. It will be some time before prototypes for a C-MAC system will be available and it therefore offered no hope of a solution to the Australian problem.

The C-MAC initiative also seems to have been taken for entirely different reasons to those which caused Australia to look to a MAC system for direct broadcasting services. Western Europe seems to me to have little need or pressure for direct broadcasting services in the sense that we interpret "direct broadcasting" as a system in North America and Australia.

My understanding is that the Western European decision for C-MAC technology was largely inspired by the need for its domestic industries to remain competitive in markets which are now squeezed by the products and technologies of others. The signal compression which I am told is included in the technical specifications determined for the C-MAC will enable high definition television to be introduced at an appropriate time - certainly within the time-frame of 15 years - and will also enable a range of other services to be provided in conjunction with a video service. The most important feature of the thinking in Western Europe is that, while the video and other services would be distributed on a regional or national basis via a high-powered satellite system, the intention is that the services would be distributed to individual receivers by cable systems.

That might be the path which Australia will eventually take but it seems to me to be many years away. With over 5 million PAL television receivers operating, the introduction of high definition television will depend initially on the availability of a decoder at reasonable cost as an optional service. There is no Government commitment to even consider the development of cable systems for delivery of a range of Communications and information services. My guess is the development of cable systems to individual households will need the spurs provided by innovative operators offering to provide a cable system with entertainment and interactive information programs.

Perhaps only Canada and Australia among the developed countries will operate broadcasting services which are designed to go direct to home in the true sense.

Having reviewed in potted form the events leading to the decision to abandon one transmission system and decide on another about six months before the first satellite launch, I asked myself what lessons, if any, could be learned from the Australian experience.

I certainly believe that the engineering concerns about the need to control the level of signals of the proposed additional audio services should have been given greater prominence in

1983. There was a failure of management or communication at that stage and the technical doubts about that transmission system could have been resolved earlier than they were.

This failure did not, however, have any long term influence on later events. If we had known earlier that a PAL television service with single channels for two radio services through the one transponder had serious technical implications, we could not have made the switch earlier to a different transmission system because choices or options for alternative systems did not exist at that time. We would only have been uncomfortable for a longer period.

I think the moral of the Australian experience is that if a nation or an organisation is engaged in a project which is based on use of high technology, and which involves a lengthy period from the decisions to start and the finalisation of the project, it would be unwise to expect that the technological assumptions made at the time of the decision to proceed will remain constant throughout the life of the project. It follows from this that variations in the technical assumptions may require major modifications within the planning for the project and that the nerve and judgment of policy advisers may well be tested at critical stages of the project when the options are to accept or reject technical variants arising during the course of the project.

While it is said that some unlikely people become heroes and heroines who would expect that colourless and cautious people within a bureaucracy would have within their souls the capacity to perform acts of heroism?

BACKGROUND NOTES

People attending the colloquim may not be familiar with some features of Australian geography and demography and the arrangements for the delivery of communications services to the Australian community.

Area and Population

In area, Australia is 7.682 million square kilometres. By comparison, the area of Canada is 9.76 million square kilometres, that of the United States of America is 9.363 million square kilometres, and Europe is 4,936 million square kilometres. The population of Australia in 1982 was 15,276,000 with a natural increase of 0.83 and a net migration increase of 0.67, giving a total average annual rate of growth of 1.51% at that time.

At 30 June 1982 more than 10.6 million people - equivalent to 70.04% of the total population - lived in the 12 major Australian cities (those with populations in excess of 100,000). These cities are predominantly located on the south and east coasts of the continent, thus giving an unusual demographic population spread of pockets of concentrated population with vast areas of the interior only sparsely inhabited.

Telecommunications Services

Telecommunications services within Australia are provided predominantly by the publicly-owned telephone network which is operated and maintained by the Australian Telecommunications Commission. The Commission is a statutory authority of the Federal Government and has a statutory monopoly to establish communications facilities for public use.

External telecommunications services are provided through another public-owned Federal authority - the Overseas Telecommunications Commission (Australia) - which has a de facto monopoly in respect of international telecommunications services.

A national satellite communications network will commence with the targetted launch in August 1985 of the first domestic communications satellite, to be followed by the launch of a second satellite in October 1985 and with the possibility of a third operational satellite being launched in mid-1986. The satellite communication facilities are owned by a company, AUSSAT Pty Ltd. This is a proprietary company i.e. its shares cannot be traded through a Stock Exchange, in which the Australian Government owns 75% of the issued shares, with the Australian Telecommunications Commission (Telecom Australia) holding the balance of the shares.

Television Services

Television services are provided by a network of national and commercial services. The national services are provided by the Australian Broadcasting Corporation, a statutory authority which is totally-owned and funded by the Australian Government. It provides a television service of one channel which is received by some 96% of the population through a network of 84 main transmitting sites and 204 translator stations. Some local program material is originated by ABC studios in each of the six capital cities but for the most part, the ABC provides a single television program which is distributed throughout Australia.

Commercial television services are provided by 50 licenced commercial stations which are funded by advertising revenues. Through main transmitting stations and over 130 translator stations, approximately 92% of the community receives at least one commercial television service. Four of the capital cities receive three commercial television stations. Other major cities have one or two commercial stations licensed to serve those areas.

Additional to the above, the Special Broadcasting Service provides separate radio and television services which are designed to meet the special needs of ethnic groups in a multicultural society. The Special Broadcasting Service is established as a statutory authority which is funded entirely by the Government. At present it provides a radio service in two capital cities and a television service in three capital cities. Planning is proceeding to extend the television service to other capital and major cities in the near future.

Radio Services

The Australian Broadcasting Corporation provides two radio programs (Radios 1 and 2) in eight principal cities and one radio service to other areas through 80 stations. These services are received by nearly 100% of the total community. The ABC also provides a fine music station in 36 regions, with the service being gradually extended to a true national service. The ABC also provides a popular FM station in Sydney and planning is advanced to introduce a second regional network as funding permits.

There are 138 commercial radio services. These stations operate in the medium frequency band except for 7 FM services which service capital cities. The largest growth area in licensed services is in the public broadcasting area. Non-profit organisations are licensed to provide a particular category of radio service to a defined community area. At present there are 53 licenced public radio stations, most of which operate within areas of principal cities.

The AUSSAT Satellite System

Each AUSSAT satellite will provide telecommunications facilities through 15 transponders, 4 of which are designed with travelling wave-tubes of 30 watt output. The satellite antenna are designed to provide a national beam to cover the Australian continent and spot beams to one of four zones into which Australia has been divided for the provision of direct television services. A spot beam on each satellite is switchable to Papua New Guinea while other transponders are switchable as between the Australian beam and spot beams.

A recent design modification to the third of the AUSSAT satellites provides for a switchable beam to service Papua New Guinea and other South Pacific countries, with the intention of offering satellite communications services to the small nations in that area which have poor communications facilities.

"HDTV: WHO PAYS FOR THE DREAM?"

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4.4

ABSTRACT

"HDTV" is likely to be introduced first through digital receivers and second via new bandwidth compressed formats of television distribution and display (E-MAC, MUSE, etc.). Interim stages will consist of tape or disc to home player/display devices and specialized services to mini-theatres, hotels, and bars. By the late 1990s, HDTV could become a mass market home entertainment product and service.

Technological development paths toward HDTV can be identified, but more difficult is to determine the combination of investment and consumer interest that will lead to the world-wide introduction of HDTV. Past consumer behaviour in receiver and analogous product purchases help project likely demand given the appropriate price/performance characteristics of HDTV receiver/display products and above all the programming available.

While the origin of the critical mass of investment for Japan and Western Europe is relatively clear, who will take the initiative in North America is not easy to predict. The likely driving forces are the major programming producers seeking higher margins and the incremental investment of, first, direct-to-home and, second, satellite-to-cable delivery systems.

La TVHD : Qui paie la note du rêve?

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Selon toute vraisemblance, la télévision à haute définition (TVHD) sera implantée initialement au moyen des récepteurs numériques, mais elle empruntera ensuite de nouveaux formats de distribution et de présentation de télévision par compression de la largeur de bande (E-MAC, MUSE, etc.). Les étapes intermédiaires comporteront l'exploitation sur bandes ou disques pour des dispositifs de reproduction et d'affichage domestiques et la prestation de services spécialisés destinés aux petites salles de cinéma, aux hôtels et aux bars. Vers la fin des années 90, la TVHD pourrait bien devenir un marché de masse comme produit et service de divertissement à domicile.

Il est possible d'entrevoir les avenues de développement technique de la TVHD. Par contre, il est plus difficile d'identifier l'heureuse combinaison prix/intérêt du consommateur qui conduira à l'essor mondial de cette technique. Le comportement antérieur des consommateurs face à l'acquisition de récepteurs et de produits semblables aide à extrapoler la demande probable, compte tenu d'un rapport qualité/prix approprié pour les récepteurs et les supports de présentation de TVHD et, surtout, du contenu offert.

Si l'on se doute d'où viendra la masse critique des investissements au Japon et en Europe Occidentale, il n'est pas aussi facile qui relèvera le défi en Amérique du Nord. Les forces agissantes les plus probables seront les grands producteurs d'émissions, qui cherchent à accroître leur marge de bénéfices, et l'investissement marginal connexe dans les systèmes de diffusion directe à domicile, puis dans les systèmes de transmission satellite-câble.

WHO PAYS FOR THE DREAM?

By

Peter Lyman
Managing Partner

Nordicity Group Ltd.
Ottawa, Ontario

In this session on policy, standards, and impact, I want to focus on the impact of HDTV.

In terms of impact of HDTV, the most pertinent interests affected are those of the television and program production industry itself - ie, the broadcasters, cable operators, carriers, program and movie production industries, and their equipment suppliers. In this paper, I will comment briefly on the impact on those elements of the television industrys as well as the perspective of Canada.

The impact of HDTV depends on when and how HDTV will arrive on the world scene and within each national broadcasting system. Therefore, to put the impact within a framework, I will present the highlights of preliminary findings of our research into the when and how question.

Our company, Nordicity Group Ltd. was engaged by the Canadian Department of Communications to undertake a technology impact assessment of future TV technologies, including HDTV. As part of the study, we conducted an international Delphi survey involving some 35 experts.

The purpose of the survey was to forecast the probability of certain events occuring within a specified timeframe - we used 1990, 1995 and 2000. Exhibits 1 to 4 show the highlights of the survey results. Note that in these exhibits the probability is signified by the Roman numeral for an event occurring in 1990, 1995 and 2000. A Roman numeral "I" indicates that the median forecast of the experts was 50-75% probability for that event to occur by that year. A "II" denotes 76-90% median probability and III is 91-100%, ie, virtual certainty.

Japan

Note that in the case for Japan (Exhibit 1), 'smart' receivers, with field or frame store capabilities are likely, according to the experts, to be on the market by 1990 or before, ie. the median probability is 50-75% for that 'event' to occur. HDTV cameras and other studio equipment are even more likely to be available by 1990 (75-90% probability), while their extensive use by major TV program producers is more than 50% probable by 1995.

In terms of HDTV services available to the home consumer, by 1990 there is a 50-75% probability that there will be 1 to 2 of them available to Japanese households equipped with appropriate HDTV receivers and display systems. As might be anticipated, experts feel that the transmission format would be MUSE bandwidth reduced HDTV distributed via DBS/SMATV. Delivery via cable was judged to be more problematic in that timeframe and not more than 50% likely until 1995.

A result that was anticipated by the project team was the forecasted concurrent arrival in the marketplace of HDTV VCRs and projection display systems. The median probability of 50-75% occurs in 1990 for VCRs - for projection displays it is 5 years later in 1995. Our own view is that projection display systems are very important to the consumer's interest in high quality image and wide aspect ratio. We also believe that the home video distribution medium has an immediate practical attraction in that it does not have to wait for broadcasting distribution systems throughout the world to establish HDTV transmission (much like compact disc in audio). Thus, in this case we would take some exception to our own Delphi results and predict an earlier date of introduction for the combination HDTV projection display system and HDTV VCRs.

Western Europe

The Western European and North American forecasts are similar to Japan in the 'system independent' areas, eg. marketplace availability of improved NTSC/PAL receivers, HDTV VCRs, projection display systems, and studio equipment. Therefore, we concentrate on the areas of difference between Western Europe and the results just shown for Japan. Unlike the Japanese timetable, the experts projected the advent of HDTV services in Western Europe well into the 1990s, ie, about 5 years after Japan (see Exhibit 2). There is a 50-75% median probability of 1-2 services by 1995 and the same probability for more than 2 services being available only by 2000.

The transmission format believed most likely for Western Europe was of course analog component video, which was believed likely to start by 1990. As you can see, experts seem to have somewhat greater confidence in UK services beginning by 1990 than the rest of Western Europe. Enhanced analog component video was believed to be the logical transition to HDTV services, with a 50-75% median probability of occurrance by 1995. This was consistent with the expectation that 1 - 2 HDTV services would start by 1995. It should be noted that bandwidth reduced HDTV was given a chance by the year 2000, indicating that Enhanced Analogue Component is a step in the evolution of HDTV, or perhaps it is the experts' hedge against the possibility that enhanced "MAC" systems would be bypassed in Western Europe.

North America

In the US and Canada, as Exhibit 3 shows, HDTV services will start in about the European timeframe, in the experts' opinion. However, a multi-service start-up was thought to be a strong possibility in the US. Canada is projected to lag behind the US, which reflects the normal historical pattern for broadcsting services - as in the transition to colour and in the authorization of pay-TV and specialty television channels. This is not the case for Home Video and cable distribution however, and does not necessarily have to be the pattern for HDTV - but that's what the experts reported.

The experts seemed to have failed to reach a consensus as to transmission format in the US and Canada, illustrated by the year 2000 timeframe for a 50-75% median probability for both bandwidth reduced and enhanced analogue component video transmission formats. However, there is some consensus that an analog component service would be available by 1990 on a satellite to cable basis. Unlike Western Europe, where DBS/SMATV and cable appeared to vie for distribution popularity among experts, the satellite to cable combination is the favoured distribution system in Canada and the US.

Australia

With Australia pioneering the implementation of analogue component video systems, we were curious about expert opinion about how Australia would develop - mind you with only a couple of Australian experts included in our survey. Again, as Exhibit 4 shows, the timeframe for HDTV services approximates that of Western Europe and North America, with a somewhat more definite DBS preference for Australia than in North America.

Thus, we have a general situation of HDTV services beginning in a 5 to 10 year timeframe with different transmission formats and distribution strategies. While the survey involved primarily technical people, we ask when products or services would be available in the marketplace, not just when they would be technically feasible. The experts' probabilities and timeframes seem to us to pass the test of reasonableness.

Market Penetration of HDTV Receivers

With that overall timeframe established for the introduction of HDTV services, we then projected the consumer impact in North America to the year 2000 - ie, how many households would have HDTV receivers by then. The factors we considered in making these forecasts were the following:

1. growth of market, including households, colour TV penetration and, most importantly, the number of sets per household;

2. TV receiver replacement timeframe changes, assuming the availability of 'smart' digital receivers with frame stores;

3. various start-up dates of HDTV services and how they would be distributed, ie, primarily via cable;

4. various penetration rates of HDTV receivers depending on receiver/display retail prices and availability of programming.

While there are obviously many assumptions that could be debated extensively, the results of these demand forecasts for Canada and the US are shown on Exhibits 5 and 6.

In Canada, the two scenarios shown are for HDTV full programming services start dates of 1992 and 1995. They also assume:

- that smart digital receivers with frame store have already been introduced;
- that HDTV receivers are priced at a declining premium over smart digital receivers;
- that the receiver replacement cycle is 6 years, not 11 years as at present, and;
- that TV sets/household grows from the current 1.45 to 1.77 by 2000 - which still makes it less than Japan.

The result of these assumptions is the market projection of 900 thousand receivers by 2000 on a 1992 multi-service start date, and about 550 thousand for a 1995 start date.

For the US we began with slightly different assumptions, ie.

- a 1992 multi-service start date and slow growth of HDTV receivers because of an assumed premium price over high end receivers;
- a 1995 multi-service start date and more rapid growth of receivers assuming a relatively low price differential between NTSC and HDTV receivers.

The results from these two scenarios show a spread of about 4 to 10 million housholds in the US by 2000. The lower figure happens to represent the approximate growth rate of VCR households in the US eight years after their introduction in the marketplace - not that VCR growth is a valid surrogate for HDTV receivers. In fact, we could determine no approximate historical service or product analogy that would fit the characteristics of HDTV.

Again, there are many assumptions behind these estimates which can be debated. Critical to these HDTV household projections is the judgement about whether viewers would buy an expensive receiver/display device to receive HDTV. There is very little direct market research evidence of the degree to which TV viewers will be interested in HDTV, at least that is publicly available. However, there is one Japanese survey of high income business people about the HDTV concept that is very interesting. In that Japanese survey of 1000 potential viewers, there was a high degree of awareness of HDTV (88%) and about 65% response rate for those viewers who would acquire an HDTV receiver - after the price was down to the equivalent of $1200 US and after HDTV broadcast had begun.

Our view is that HDTV will become a mass market medium, more like the growth of FM radio than colour TV. It will <u>not</u> simply be a minority market service similar to hi-fi recordings, but will become the dominant TV format 10-15 years from now. In making this statement we assume that bright, large and wide screen receiver/displays will be available at no more than a 25% premium over conventional receivers.

The critical factor is ample programming in HDTV format, which will take vision, entrepreneurship and investment to make happen.

<u>HDTV Start-Up</u>

Investors, of course, will not be gambling hundreds of millions of dollars on the totally unaccountable views of consultants. In North America, at least, we have to explore how HDTV could get started at the least possible financial exposure to its sponsors.

One way to start up HDTV is to follow the presumably earlier timeframe of NHK in Japan. Once the Japanese service is up and running, North American entrepreneurs could provide similar services based on the bandwidth reduced transmission of NHK and the HDTV production/reception systems developed for it. The first customers would likely be a mix of conspicuous consumers and public places like bars and hotels, which could afford the early high cost of HDTV receivers.

A second start-up scenario for North America is to piggy-back on existing or proposed programming services and transmission systems. If HDTV programming could be grafted on to a TV service which was already financially covered by NTSC receivers, then the HDTV investment could be minimized.

In North America DBS appears to be entering a more realistic start-up phase than had been the case a few years ago. DBS now seems to be based on the coalescence of key existing satellite-to-cable programming services around single satellites. These services would start scrambling their existing programming, and then market their services to potential customers on a direct-to-home basis. Such is the concept of company "X" promoted by Telesat Canada, which has proposed the use of the 14/12 Anik C service at full rather than half power for a group of programming services already available to cable subscribers. This means that DBS is a marginal cost concept, not a new venture whose full programming costs have to be amortized over DBS customers.

Let us take the example of Telesat's concept a little further, to determine how it could ease into HDTV services delivery. Telesat or another DBS entrepreneur could select a transmission format that could be readily upgraded to EDTV services, and make the transition into EDTV at a low investment to itself and TV viewers. The logical chance could be an analogue component video system, which can be converted into an enhanced version without much cost penalty - though there may be other alternatives.

Without a major power penalty, Telesat could broadcast an enhanced version of an analogue component service at the outset, and install decoders compatible with the enhanced version from the beginning. Some programming suppliers, for example, the premium movie channels, could insert HDTV programming into its schedules for the small number (initially) of viewers equipped to receive it. These viewers could be bars and hotels at first, in view of the high initial cost of wide screen, projection display receivers. Individual TV households, with high disposable incomes, might also 'subscribe' to the HDTV service. More and more of the programming schedule, likely extending into sports programming could be made available in this format, thus ushering in the HDTV era over the next several years.

The practical problem is that Telesat and other DBS service proponents who will have to converge on a DBS scrambling standard, have their hands full solving more pressing problems - like getting enough DBS customers for the NTSC service. However, they should at least be contemplating the longer run potential for HDTV delivery.

The DBS scenario could easily be substituted by different delivery media, for example, satellite-to-cable. The two channel HDTV schemes designed for cable systems demonstrate the technical paths for this approach. The practical problem of these approaches is to obtain the collaboration of major cable MSOs. Unfortunately, cable operators recoil at the thought of adding more expensive decoders in people's homes, especially if tv viewers also have to purchase new format receiver/display systems.

The more likely start-up path for HDTV in North America is for people to vote with their feet - and acquire HDTV programming off-the-shelf - as they have done in NTSC home video and 6/4 GHz dishes. Again, it is the programming which will drive the tv viewer to part with his disposable income. It may even be in the interest of movie producers and distributors to arrange for the early, early release of the wide screen home video rights prior to conventional home video. Once the projection tv set owner tires of the limited quality of NTSC format movies, he will be ripe for the HDTV variety - and note that the 1 million mark of projection tv set owners will be soon surpassed in the US.

The point is not to predict exactly how HDTV will come about in North America, but to show how it could be implemented without an enormous risk being taken by investors or other entrepreneurs. It has to be a piggy-back service of some kind, over satellite, satellite and cable or over the counter.

The Impact

Finally, let us address the impact. In one way or another let us assume that HDTV will become a reality and examine who benefits, who pays. Let's begin with those already in the business:

First, the programming suppliers, ie. Hollywood majors, independent producers throughout the world and broadcasters with extensive production operations. At the outset it is Hollywood with its inventory of wide aspect ratio, 35MM product which will benefit. However, Los Angeles metaphorically could become a 'smokestack' industry town if it does not heed the transition to electronic cinematography. New centres of production not bound by the film and animation factories of the past may supplant the traditional production centres. Major broadcasters are also more likely to incorporate HDTV production as they undergo conversion from analogue to digital in any event.

Second, broadcasters have an enormous stake in over-the-air delivery which will not be a viable medium for HDTV. Over the next 5 to 10 years broadcasters are going to have to face up to the decline in the value of their spectrum property. It will still be highly efficient as a delivery system, but for what? Certain categories of programming? Data broadcasting? In any event, broadcasters will have to get used to the notion that alternative delivery/display systems for the home will provide a superior product.

Third, we have discussed how satellite to cable programming services and cable systems themselves can become the instigators of the HDTV era. Alternatively, they can be bypassed by HDTV-based DBS or more likely home video systems. The recent success of Beta's hi fi VCR combined with prerecorded stereo movie product demonstrates a frightening scenario for cable and cable dependent programming services - they might also be caught in the inferior service trap as home video bypasses them even more effectively than at present. Cable systems will have to plan very carefully the correct paths to follow to remain competitive in service offerings and quality of service.

Besides the impact on different elements of the television system, there is the national impact to consider. As far as nations are concerned, the challenge for a country like Canada is to benefit from new tv systems and not simply get caught with an enormous infrastructure upgrade cost. Canada's television system is mainly a large investment in transmission and distribution capacity, with a lesser stake in program production, and almost none at all in consumer electronics. The main economic impact of HDTV introduction in Canada would be the following:

1. Potentially an incremental $500-800 million in tv receiver imports a year by 2000 assuming an early start-up scenario.

2. A greater utilization of the extensive satellite, optical fibre, and cable plant in the country, some of which is under-utilized at present - and a possible re-utilization of the UHF/VHF spectrum.

3. A major opportunity or threat to Canadian studio and transmission equipment suppliers, depending on how well they convert to digital and make shrewd product development decisions.

4. A major program production opportunity, provided the program production industry takes some initiative in becoming proficient in electronic cinematography.

There are many other economic and institutional ramifications to the introduction of HDTV to Canada, not the least of which is the potential role of the CBC. The point is that middle power countries like Canada have to adapt to HDTV, since we have little real opportunity to shape its development. As a country, we had better get on with the effort to seek some advantage in the long change-over to HDTV.

In regard to the production standards issue, Canadian interests, like those of other middle level countries, would be well served by the timely adoption of world standards. Programming exchange on an international basis could boost Canadian production and co-production opportunities. As well, world standards would ultimately result in lower cost, higher performance production equipment.

The only caveat is that the achievement of world production standards should not be at the possible expense of greater downstream costs in transmission and reception. That would represent a high cost for Canada. However, production standards do not necessarily dictate transmission and reception standards. We should strive for world standard - since relative chaos of de facto standards is perhaps a greater evil than an imperfect world standard.

Conclusion/Summary

HDTV will present a transformative change to the world of broadcasting, affecting most entrenched interests. While HDTV is coming, it is far enough away for all interests affected - broadcasters, cable operators, etc., as well as countries - to embrace HDTV rather than get steamrolled by it.

As to the original question of who pays for the dream, it is all of us or none of us. It will remain a dream and perhaps a wonderful but essentially dead-end distraction enjoyed by few - unless we can make the programming and its presentation such good entertainment value that it truly develops the economies of a successful mass medium. Let us hope that the HDTV Colloquium brings us a step closer to that fundamental goal.

Exhibit 1

TV Technology Forecast Highlights - **Japan**

TELEVISION PRODUCT/ SERVICE	PROBABILITY OF AVAILABILITY IN MARKETPLACE		
YEAR	**1990**	**1995**	**2000**
Receivers			
- Field/frame Storage	I	II	III
Purchase of HDTV Equipment for HDTV Production			
- HDTV Cameras	II	III	III
- Use of HDTV Equipment by Major Television Producers		I	III
Number of Hidef Services			
- 1-2 services	I	II	III
- More Than 2 services		I	III
Distribution of Higher Definition Television			
- MUSE via DBS/SMATV	I	III	III
- HDTV VCRS	I	II	III
- HDTV Projection Display		I	II

LEGEND: Delphi forecast median probabilities:

I - 50-75%
II - 76-90%
III - 91-100%

Exhibit 2

TV Technology Forecast Highights - **Europe**

TELEVISION PRODUCT/ SERVICE	PROBABILITY OF AVAILABILITY IN MARKETPLACE		
YEAR	**1990**	**1995**	**2000**
Number of Hidef Services			
- 1-2 services		I	II
- More Than 2 services			I
Distribution of Higher Definition Television			
- Analogue Component Video (ACV)			
- DBS/SMATV	I I	II I	III - UK II - Eur
- Satellite to Cable (Converted to Conventional Signal)	I I	I I	II - UK I - Eur
- Satellite to Cable (ACV Distributed Directly to Consumer)		II	II
- Enhanced Analogue Component Video			
- DBS/SMATV		I	II
- Satellite-to-cable distributed directly)			I
- Bandwidth Reduced HDTV			I

LEGEND: Delphi forecast median probabilities

I - 50-75%
II - 76-90%
III - 91-100%

Exhibit 3

TV Technology Forecast Highlights - **North America**

TELEVISION PRODUCT/ SERVICE	PROBABILITY OF AVAILABILITY IN MARKETPLACE		
YEAR	**1990**	**1995**	**2000**
Number of Hidef Services			
- 1-2 services		I I	III - US I - Can
- More Than 2 services		I	II
Distribution of Higher Definition TV			
- Analogue Component Video			
- DBS/SMATV		I	I - US I - Can
- Satellite to Cable (Converted to Conventional signal)	I	I	II - US I - Can
- Satellite to Cable (Analogue Component Video Distributed Directly to Consumer)	I	I	II - US I - Can
- Enhanced Analogue Component Video			
- DBS/SMATV			I
-Bandwidth Reduced HDTV			
- DBS/SMATV			I
- Satellite-to-cable (distributed directly)			I - US - - Can

LEGEND: Delphi forecast median probabilities:

I - 50-75%
II - 76-90%
III - 91-100%

Exhibit 4

TV Technology Forecast Highlights - **Australia**

TELEVISION PRODUCT/ SERVICE	PROBABILITY OF AVAILABILITY IN MARKETPLACE		
YEAR	1990	1995	2000
Number of Hidef Services			
- 1-2 services		I	II
- More Than 2 services			I
Distribution of Higher Definition Television			
- Analogue Component Video			
- DBS	I	II	III
- Satellite to Cable (Converted to Conventional signal)	I	I	II
- Satellite to Cable (Analogue Component Video Distributed Directly to Consumer)		I	II

LEGEND: Delphi forecast median probabilities:

I - 50-75%
II - 76-90%
III - 91-100%

Exhibit 5

Projected Demand of Hidef Receivers - Canada

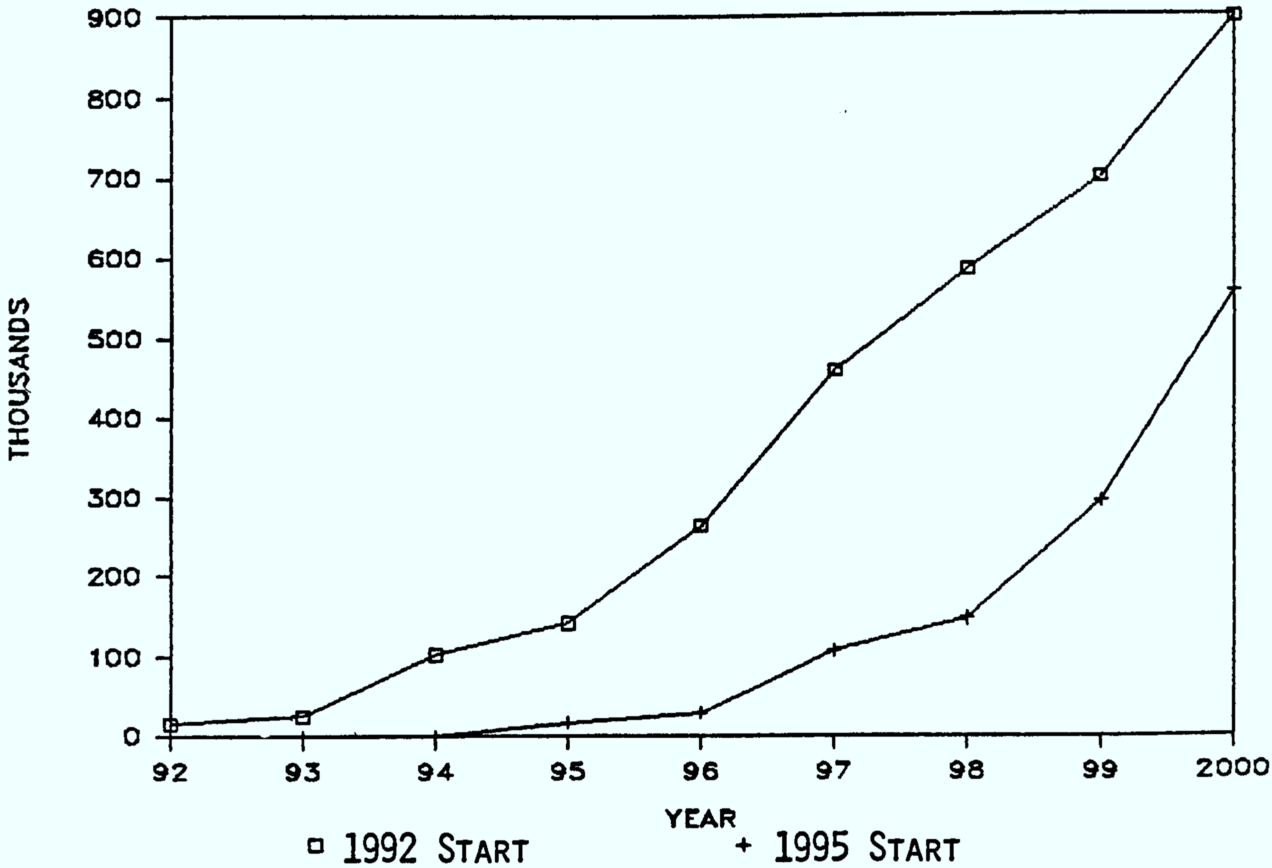
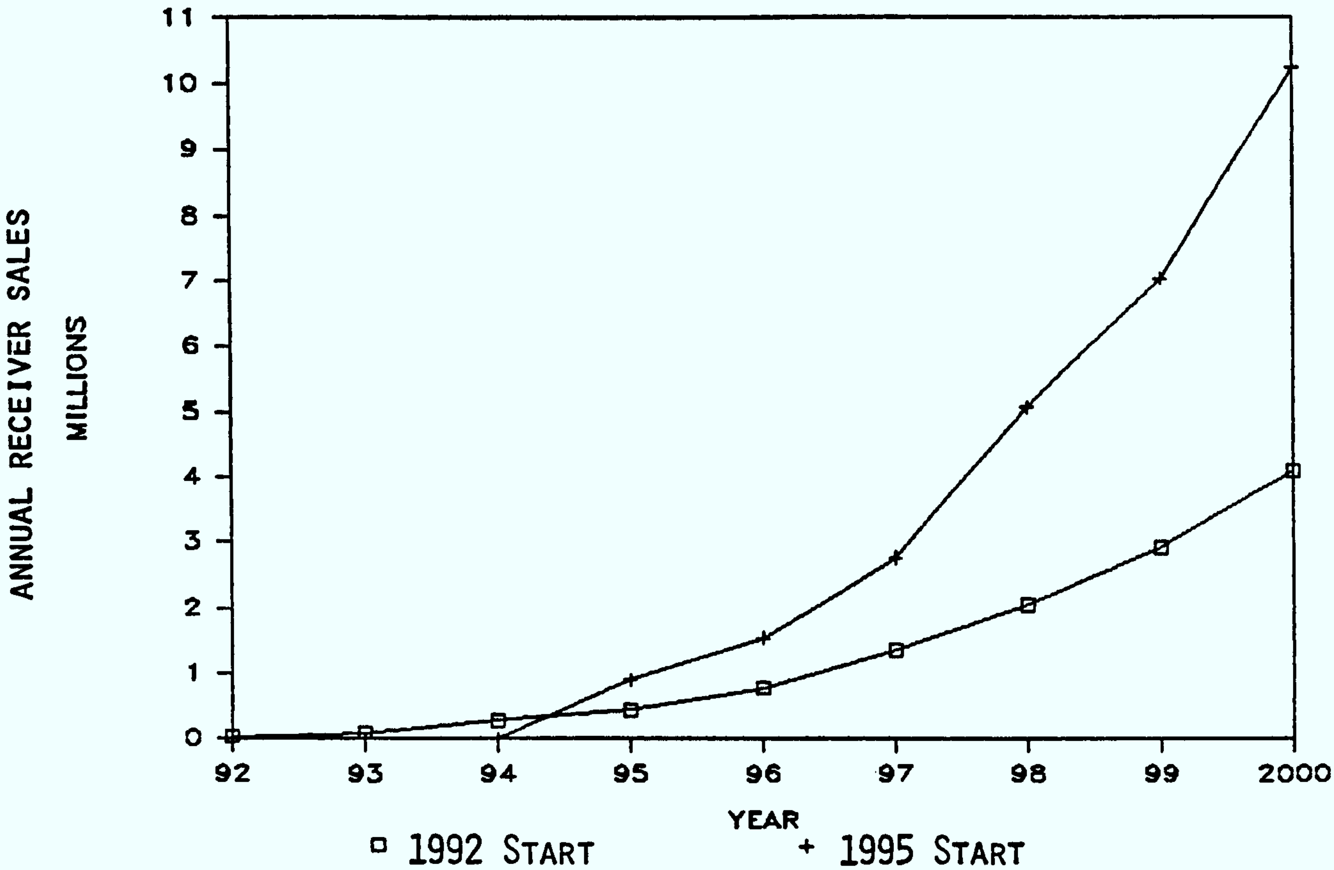


Exhibit 6

Projected Demand in US HDTV Receivers Sales



HDTV COLLOQUIUM WORKSHOPS

WORKSHOP NUMBER 1

<u>Topic</u>: <u>Application and Operational Needs</u>
"HDTV: Who Needs It?"

<u>Moderator</u>: Mark Blandford, CBC, Canada

<u>Panelists</u>: W.M. O'Farrell, Crawley Films, Canada;
L. Thorpe, Sony Corporation, Canada;
M. Paradis, National Film Board of Canada;
J. Gaspar, McDonnel-Douglas, U.S.A.

Introduction:

Workshop discussion quickly categorized applications into three main areas; non-broadcast applications, film industry applications and broadcast users.

Non-Broadcast Applications

Non-broadcast applications involve users such as medical, imaging, retail, military, teleconferencing, simulation and computer graphics.

Simulators (from aircraft to train applications) need the degree of realism that high definition can give them. The simulator industry is not very cost-conscious, as they save a great deal of money for their clients anyway. Anything that increases the realism is worth the expenditure.

The computer graphics industry is also very interested in HDTV. They want to show the results of their work (that is, the computer screen) to the people who either could not be present, or who were not close enough to the screen to see the detail required. HDTV will provide a medium to record and playback the information, or to project the small (terminal) screen on a larger screen for an audience.

The computer industry will adopt HDTV devices, rather than develop their own, because, historically, the industry has been too fragmented to get together and develop their own standards, and hence, display systems.

The retail industry can save a lot of money by using HDTV (the idea is to show the high quality of your product) for marketing and training applications.

This is true even though HDTV equipment presently costs two to three times as much as conventional professional TV equipment.

Film Applications

The movie industry will become a large user of HDTV systems. The main impetus will be to reduce the cost of production. This cost reduction will not be due to less expensive equipment, or to lower cost materials. The cost savings will be realized through lower manpower costs. "Takes" on videotape can be reviewed instantly and most special effects at least previewed on the spot. This will eliminate the delay (one night to several days) between the actual shooting and the first review of the final product. Crews will not be kept "on call" or will not have to be assembled for a new take, if the first one is not satisfactory.

HDTV has the same aspect ratio as film (nearly) so that the videotape can either be used directly, or can be used to make an artistic judgement that immediately reflects the state of the simultaneously shot film.

The movie industry will experiment with HDTV for at least 7 years. Special effects are probably one of the first areas to make the transitions to HDTV because of speed and flexibility.

The NFB sees a gradual transition from 16/35 mm film to HDTV. They already use video for animation, checking titles etc. Higher frame rates would be useful in animation effects.

It was pointed out that present HDTV equipment is still cumbersome. Electronic cameras are not as good as film cameras, though they will improve.

Film will always be used for some applications (for example, documentaries).

Broadcast Users

The conventional broadcaster will be the last to start using HDTV, because of the problems of distributing an HDTV signal. The problems are in transmitting the signal and in displaying the wide-screen image in the home.

The main appeal to the consumer will not come from the "high definition" aspect of the system, but from the wider screen, and high quality, multichannel sound. (There should be at least 3 and maybe 5 separate sound channels.) The wider screen gives movie producers a similar, familiar medium to work with. Cinematographers are free to use their artistic talents to create moods and impressions that are very difficult with conventional 4:3 television.

All this will create a "visible difference" for the potential HDTV buyer.

Material produced in HDTV format for release in wide and normal screen formats should have a control signal encoded along with it. This will allow artistic control of which part of the image will be discarded for presentation on standard TV screens (so-called "pan and scan" methods).

An HDTV screen being used for a 4:3 image has a side panel that can be used to display 3 additional (compressed) 4:3 images. The viewer can pick whichever source he wants for the "full size" image.

Frame rate conversions between 60, 50 and 24 frames per second are a major unsolved technical problem.

Domestic HDTV equipment must be convenient to use or it will suffer the fate of the 16 and 8 mm home-movie market.

The "wide screen" - not just the sheer size of the screen - will create the market. A huge screen could in fact be a drawback, because of the difficulty of fitting it into the home environment. There must be enough increase in resolution to conceal the scanning artifacts that would otherwise become apparent at the reduced viewing distances needed to get the benefits of the wider screen. The entertainment market - not the non-broadcast market - will provide the money to develop HDTV.

Market Factors

Only one market survey has been published to date. A survey among high-income ($40,000 U.S. median) Japanese businessmen showed wide product awareness. More than 50% of the sample were willing to buy a receiver at less than $1,200 U.S. if there was one station on air. This was felt to be quite an optimistic set of results. Others are doing market research, but have not published their results. Sony stated that it is in HDTV because it believes in the product, and is confident of an eventual return on its investment. They see some immediate returns from the non-broadcast industry, but HDTV will eventually have to become established in the consumer market.

Standards from an Applications Viewpoint

There was a good deal of discussion about HDTV standards from an applications perspective. The general feeling was that several "de-facto" standards would be detrimental to the HDTV consumers and manufacturers. A worldwide production standard should be agreed on by October 1985, in the opinion of some of those present. Finding a standard that would be acceptable to "the 50 Hz countries," however, will probably be difficult. As was mentioned previously, satisfactory frame rate conversion between 60, 59, 94, 50 and 24 frames per second is still a major problem.

Once the production standard is established, the secondary standards, such as tape format and transmission standards, can be worked on.

WORKSHOP NUMBER 2

Topic: Systems and Standards
"Evolution or Resolution?"

Moderator: R. Zavada, Eastman Kodak, U.S.A.

Panelists: R. Hopkins, ATSC, U.S.A.; L. Cheveau, CBC, Canada; G. Tonge, IBA, U.K.; R. Rossi, CBS, U.S.A.

Introduction:

This workshop was well attended, some sixty people participated in the lively and fruitful discussions which focused on the question of an HDTV standard for use in production and program exchange, although other aspects of HDTV systems were touched on in presentations and comments.

The salient points associated with the standards question were reviewed by the panelists, beginning with background on the organization of the Advanced Television Standards Committee by the five member organizations of the Joint Committee for Intersociety Coordination of television issues. The work of the 3 sub-groups of ATSC - (1) Improved NTSC, (2) Enhanced NTSC, and (3) HDTV, was explained, as was the mandate of ATSC to consult with the JCIC member organizations.

The urgency was addressed of achieving a standard within the current cycle of CCIR for the basic parameters of the 1125-line, 30-frame, 2:1 interlace system. Preliminary specification was felt necessary to address the next phase which would include colorimetry, gamma, and blanking interval specifications.

From a policy viewpoint, one of the panelists expressed concern about whether it would be possible to continue national policies to provide equitable service to all citizens; for example, would it be possible to provide HDTV to all Canadians, as the CBC is mandated to do with present day television?

There has been far too little effort directed to the needs of non-broadcast applications and whether or not HDTV would be compatible for these uses.

The need to consider the inter-relationships of other standards with HDTV standards was also noted. A particular example was the recent effort on CCIR 601 (digital component specifications) and the value of this effort in the light of the HDTV proposed standards. The lack of provision for HDTV in the 12 GHz DBS allocation was also noted. This lack of a defined delivery system weakened the need for studio compatibility, although a universal electronic production approach was considered desirable.

Development of an HDTV standard in Europe could probably take place in an evolutionary manner. Europeans supported the desire for a common standard, but in practice recognized that delivery must be based on 50 Hz and therefore dual 50/60 Hz standards were a fallback position. Either approach is based upon significant compromises, one being a compromise for conversion quality, and the other a compromise for dual specifications and continued studio conversion between systems. An example was the problem that would be created during ENG takes (for 60 Hz systems) by flicker from 50 Hz lighting. In the long term however, the CCIR 601 component approach might alleviate differences. In general, there appeared to be significant merits in continued study of progressive scan systems.

Finally, the great difficulty in developing worldwide common standards was noted, and on the benefits that would accrue if some strong force could decree a common specification. Undoubtedly there would be imperfections or limitations in any selected single system but the great force of future common engineering would, in the long run, justify the common standard. This was well recognized, and, worldwide, all broadcasting unions had voted in favour of the desirability of a single common HDTV standard and the economic advantages of compatible equipment.

Prompt action was urged by one panelist for the current proposed 1125-line specification, who cautioned that evolution would never lead to a common single standard.

Following the panel presentations, a series of possible questions were tabled and, by voting, were reduced to the three which provided the focus for the remainder of the workshop discussions.

Question 1: "Must HDTV de downward compatible?"

The question was interpreted to mean convertible but not necessarily compatible. It was, however, pointed out that a convertible but non-compatible standard adds another complexity to the growing list of distribution complexity - noting the addition of component digital and now HDTV.

Several people noted that the system is not fully defined; first, electronic production, second, electronic conversion for program exchange with questioned transparency, and third, the future problem of 50/60 Hz delivery.

The current compatible motion picture film as the dominant prerecorded origination medium was discussed as a system ideal. It was noted that most broadcast airing of film-originated programming is from tape transferred by non-broadcast speciality facilities contracted by the producer. This type of compatibility and system transparency represents a goal for a production standard.

There are uncertainties about the effectiveness of conversion to 525/30/60 and 625/25/50. What are the penalties of conversion? Some believed that with interlace we are constrained until technology would permit a 100% improvement to 1125-line progressive scan which would then allow equal horizontal and vertical resolution. It was also noted that more transparent conversion is possible when starting with progressive scan as against interlaced origination.

The acceptable level of degradation introduced by less than 100% transparency of conversion systems was discussed. The degraded quality of colour transmissions viewed on monochrome receivers using the NTSC system was noted. Flicker in 50 Hz receivers was discussed and related to the adaptability of the human visual system. The capability of up-converted displays to overcome this flicker was pointed out.

Others believed that motion adaptive techniques could be improved to make the system conversion transparent within the limited of viewing and the human visual response characteristics.

Finally, it was pointed out that if, in the near future, transcoding could achieve virtual transparency, then there was less need for a single worldwide standard.

A vote on the question showed 38 in favour, 1 against and the rest uncommitted.

Question 2: "Does a HDTV studio standard need to be achieved immediately?"

At the start of the discussion it was noted that the desire by CCIR to arrive at a standard at the 1986 Plenary Session meant that Interim Working Party 11/6 must agree on a recommendation at its final meeting, planned for June 15/16, 1985 (subsequently scheduled for October 1986).

There was a discussion of historical precedents, attempting to identify examples of prematurely set standards. The case of the FCC/CBS standard for colour TV was discussed. Its "recall" was attributed to its non-compatability with existing monochrome receivers, raising again the question of whether convertibility alone is enough.

It was pointed out that the question was really whether we are prepared to accept an "imperfect" standard or will insist on perfection, and that, while waiting will usually produce improvements in the standard or increase its acceptability, we cannot wait forever.

Questions were raised, and points made, about the advantages and disadvantages of delay. Was there real pressure from broadcasters for immediate standardization? How much investment is planned for, say, the next four years, which might be spent differently if the standard was agreed on now? Would taking due time over the standardization question allow the opportunity and benefits of a total system approach? Are there hidden risks, unknown/unidentified new technologies, or unexplored current technologies (CCD camera, progressive scan, signal coding, etc.) which should be fully explored before a standard is agreed? Is the proposed standard fully exploiting our current technological capabilities? Is the "now-or-never" syndrome an overreaction to the momentum of the 1125-line NHK proposal?

It was pointed out that the consequences of not agreeing to a standard soon were that most likely three systems (at least) would be developed or deployed in the near future -- (1) Japan (and possibly others) will go ahead with the 1125-line/60 Hz system (NHK will be broadcasting within 5 years), (2) a progressive scan system will be developed, probably at 750 lines, and (3) Europe would adopt a (locally) compatible 1250-line/50 Hz system.

Throughout the discussion, the importance of non-engineering factors was noted.

The vote on the question indicated 11 favouring immediacy, 14 favouring delaying and the balance choosing not to voice an opinion.

Question 3: "Will the 1125/60, 2:1 system become the defacto standard?"

At the start of the discussion it was pointed out that there is unlikely to be only <u>one</u> defacto standard, although the NHK system would certainly be one of several. However, proponents of the latter felt strongly that there was no need for a defacto approach, the system being based on many years of extensive technical and psychophysical research. It was considered by many to be superior to 35 mm film, and that energy should now be directed to the step-by-step standardization process.

The defacto (i.e., no standard) approach was noted as destroying the opportunity and the motivations to immediately start work on the next stage where colorimetry, gamma, and general system aspects would be considered.

The question was voted on in two forms: "would 1125 become _a_ defacto standard" (17 voted YES); and "would 1125 become _the_ defacto standard" (no one in support!).

Conclusions:

1. A future HDTV system must be convertible with transparency, or undetectable artifacts, to current systems.

2. The present CCIR cycle does not allow adequate evaluation of progressive scan counter proposals to 1125/60 2:1. We need more time - but not necessarily 4 years!

3. If the 1125/60 2:1 standard is to become the single worldwide common standard, then it must be formally adopted now, otherwise fallback positions will most likely allow for three different systems.

WORKSHOP NUMBER 3A

Topic: Technical - Production
"Practically vs. Creativity"

Moderator: E Zwanevald, NFB, Canada

Panelists: D. Kline, Panavision, U.S.A.;
M. Auclair, CBC, Canada;
J. Galt, CJOH-TV, Canada.

Introduction:

The moderator opened the workshop by reviewing the mandate and objectives of the workshop which were to identify and formulate joint viewpoints regarding appropriate and necessary production tools for HDTV, by identifying end uses and their impacts on production, identifying quality assurance parameters and requirements, suggesting guidelines on ways in which the production tools should stabilize or reduce production costs for the targeted end uses, and identifying the incentives for program producers to use HDTV techniques.

Panel Discussion

One of the panelists outlined three main areas of concern with the production aspects of HDTV which were:

- The reliability and stability of the camera source,
- The problems of analogue tape recorders, and
- The inherent instability of colour monitors.

Another panelist offered comments concerning the difference in viewing psychology with respect to HDTV. From a practical production viewpoint, he suggested that the maintenance of correct focus will be further complicated with higher resolution HDTV cameras, and the filtres and lighting will be even more important to the production process with the advent of HDTV. He also felt that the distribution of HDTV will probably not be performed by terrestrial systems, but by other more technically advanced means, which may cause market fragmentation.

The final panelist commented on some of the limitations of HDTV for production purposes. In the production process, the use of HDTV cameras will reduce the depth of field for the cinematographer and therefore limit his creativity. Even with the advent of HDTV systems, film will most likely still be used as an entertainment medium. Thus the problem of integration and cross-compatibility is an issue requiring further study.

The moderator then asked for questions from the workshop attendees:

In response to a question concerning the format of switchers (digital or analogue), panelists stated that digital switchers are still in the prototype stage. In addition, current analogue switchers are performing better and better every year, with accompanying increases in equipment reliability. It was concluded that the use of digital switchers as a useful production tool is still many years in the future.

On the subject of the use of film versus HDTV systems (when they become available), it was stated that film is the predominant medium for commercial and high-quality television production in North America. This is due mainly to the traditional use of film as well as the perceived artistic freedom that film affords. It was felt that HDTV systems would initially be used in news broadcasting. It was emphasized that HDTV technology would only be used by producers if it proved to provide more production freedom. As TV producers worked under more stringent technical constraints than film producers, HDTV would have to remove or at least reduce some of these constraints. Otherwise, it would not be considered an effective production tool.

With respect to the film industry, the concerns about HDTV technology include reliability, maintainability, and quality.

On the question of the cost of distribution, it was thought the electronic mode will most likely prove to be the less expensive. From the consumers' viewpoint, the desire is to be able to decide what he will watch and when he will watch it. This is, in part, the reason for the success of the consumer VCR. It was suggested that if HDTV services are to be a success, then this fact must be clearly recognized.

With respect to the question of what would be the best vehicle for the introduction of HDTV, it was indicated that high fidelity television services, coupled later with pre-recorded leased VCR material, would be the best approach.

It was further suggested that the use of HDTV in closed-circuit entertainment or sports events, coupled with satellite distribution, would be another method. Small movie theatres were another possible alternative identified.

WORKSHOP NUMBER 3B

Topic: Technical - Display
"Image of the Future"

Moderator: W. Haberman, IRT, Germany

Panelists: F. Benedikt, CBC, Canada;
K. Powers, RCA, U.S.A.,
H. Schroder, Dortmund, Germany.

Introduction:

The moderator opened the workshop by surveying some of the items to be discussed, which included the psychophysical aspects of HDTV, viewing conditions, equipment adaptability to users' homes, and standards compatibility.

Panel Discussion

Panelists voiced concerns about the compatibility of HDTV equipment as well as the problems of integrating this equipment into consumers' homes. The display was probably more important than the final HDTV standard, and current commercially available displays were not good enough for HDTV.

On the topic of the psychophysical aspects of HDTV, it was emphasized that the issue of immediacy was one of the most important characteristics of any future HDTV displays. The advent of HDTV technology will move the viewer from the "keyhole" viewing of current television systems to a "window" effect.

The issue of aspect ratio was then discussed with the common consensus being that the viewing distance is fixed at approximately three meters. The aspect ratio is a function of the wider screen displays afforded by HDTV technology. One panelist suggested that any HDTV display, in order to provide the necessary requirement of immediacy, had to approach the limits of human peripheral vision.

On the subject of the audio services that will be required with the improved resolution of HDTV displays, it was stated that the minimum number of audio channels should be three, with higher numbers being suggested by panel members (possibly up to six in accordance with the film industry). The general opinion of the workshop was that the audio services would have to be of very high quality in order to successfully augment the improved video service.

In discussion on the level of ambient light required for the viewing of HDTV displays, it was noted that HDTV displays presently provide a lower brightness level than conventional television sets.

With respect to the topic of colorimetry, the importance of the camera filtre standard as well as the chrominance/luminance balance was underlined.

With regard to display technology, it was indicated that the maximum line rate and minimum retrace time was, in the view of the display manufacturer, a direct function of economics. Any system over 35 kHz would probably have a cost impact on the price of HDTV displays.

On the topic of integratability with the home environment, it was stated that the foldaway or rollaway screen, although perhaps a solution to the problem of large HDTV display size, was not technically appropriate due to the requirements of geometry and surface accuracy. Plasma and flat-pack screens were also mentioned, but were considered as being currently inappropriate. The weight of the flat-pack screen was mentioned as one of its more important detractions. In the view of one of the panelists, the most effective display currently in use is the rear projection screen, as it accommodates the wide-area viewing requirements of HDTV as well as minimizing, to as great a degree as possible, the occupied display space.

On the topic of HDTV compatibility with existing services, it was generally agreed that the P.O.P. (Picture Outside Picture) concept with a wide aspect-ratio was the most acceptable. Discussion emphasized that both forward and backward compatibility is essential to any successful display design. It was further indicated that future displays will be capable of improved NTSC performance, thus minimizing the technical and financial jump to full HDTV services. It was estimated that, when available, HDTV displays would cost less than ten per cent more than existing displays, as the latter will have had the required capability, through frame stores and other techniques, already built in.

With respect to the cost of digital technology required to effect HDTV services, it was indicated that the cost of the semiconductor devices bore no relation to the complexity of the circuit, but to the volume of the production run. The initial costs may be high, but will reduce as HDTV display devices achieve more market penetration.

WORKSHOP NUMBER 3C

Topic: Technical - Distribution
"Which Way to the Viewer?"

Moderator: V. Reed. Skyline Cablevision, Canada

Panelists: B. Read. TV Ontario, Canada;
D. Weese, Telestat. Canada;
R.I. MacDonald, Communications Research Centre, Canada.

Introduction:

The workshop opened with the moderator explaining the purpose of the workshop and was followed by introductory statements of the panel members, covering all possible transmission media. During the discussions, with participation from the floor, essentially four subjects relating to distribution were discussed:

1. potential of various transmission media to distribute HDTV signals,
2. possible HDTV service offerings,
3. key features to launch HDTV services, and
4. the Japanese approach to introducing HDTV services.

The following is a summary of the discussions in these four subject areas.

Potential of Various Transmission Media to Distribute HDTV Signals

The capabilites of coaxial-cable CATV networks, fibre optics networks, the presently existing VHF/UHF broadcast television networks and satellite-based systems were discussed.

a) Coaxial-Cable CATV Networks

Coaxial-cable CATV networks that were built to provide 12. 20 or 35 channels would probably not be capable of transmitting HDTV services, since their spectrum capacity has already been used to provide existing programming and non-programming services. However, newer systems which are now being built are designed to provide a capacity of 50 to 70 channels and will provide excess capacity in the near term, part of which could be used to provide HDTV services. Since many older systems in Canada are being rebuilt now, or will be in the near future, CATV networks are considered very likely to play a vital role in the distribution of HDTV services to the general viewing public. It was also stated that HDTV services would probably be considered a premium service and should preferably be charged to the user on a pay-per-view basis. The technology for measuring and billing viewing times is already available, although it has not been introduced into CATV networks in any significant manner.

Since the quality requirements and bandwidth of HDTV signals are not known at this time, the impact of such signals on CATV networks and the adequacy of present network quality standards were not discussed.

b) Fibre Optic Networks

Fibre optic technology could provide in the future, the preferred distribution medium for not only HDTV, but other broadband signals as well. This technology is particularly suited for the transmission of digital signals. It has a very wide bandwidth and therefore, no signal processing would be required in order to reduce the bandwidth of the HDTV signal. For technical reasons, fibre optic distribution networks are more suitable for centrally switched star configurations. Such networks have the advantage of providing access to a virtually unlimited number of programs since the distribution network to the end user does not have to carry all programs simultaneously.

It was noted, that at the present and in the near term, fibre optic networks are not expected to play a major role in the distribution of HDTV signals because of their unavailability and still relatively high cost. The opinion was expressed that the introduction of fibre optic networks could be accelerated through integration of voice, data and video services on a single system. Although current ISDN efforts point in this direction, it was noted that emerging standards may be inadequate for such networks to handle high quality video signals.

c) Present VHF/UHF Television Broadcast Networks

Present VHF/UHF television broadcast networks are not considered to potentially become a distribution medium for HDTV signals. The inability is not due to technical inadequacy, but rather because of the practical consideration that the spectrum allocated to the present TV services is already heavily used, in particular, the VHF bands. HDTV is not seen as a replacement of existing TV services, but as an addition. It would therefore require the allocation of new spectrum.

An analogy was drawn to the situation of the introduction of FM radio broadcasting, which did not replace already existing AM broadcasting, but was in addition to it. New spectrum was allocated to this service.

d) Satellite Systems

Satellites were seen as having the largest potential for distribution of HDTV services. Satellites could be used to distribute signals to cable system headends or low-power transmission stations in remote and sparsely populated areas, which in turn, would deliver the programs to the ultimate users. The other alternative to using this technology is Direct Broadcast Satellites (DBS).

The advantage of satellites is seen in the single retransmission required in the satellite transponder, thereby reducing signal quality degradation, which would for example, be present in a terrestrial microwave system. Another advantage is the large coverage provided by satellites, thus reducing the distribution cost per subscriber.

In North America, the 12 GHz band and the current generation of satellites could be used immediately to distribute HDTV signals. Initially, no satellites would be designed to provide HDTV only. Assuming an EIRP of 48 dbw, a high signal-to-noise ratio of S/N = 54db estimated to be required for high quality HDTV, can be achieved with receiving antennas of 4.5 to 7.0m in diameter. Channel bandwidth of 27 MHz or 54 MHz could be used, depending on requirements.

The European view is that satellite distribution would primarily be via DBS systems. Since the available channel numbers for each country in the 12 GHz band are limited, use of the 22 GHz band for HDTV DBS services is foreseen. Currently, no consideration is given to reserve the 22 GHz band exclusively for TV services only. 48 GHz, the next higher band reserved for satellite use, was considered unsuitable for TV broadcast distribution, due to the very severe attenuation caused by rain absorption at these frequencies. The 22 GHz band was therefore considered the highest usable band for TV broadcast distribution and its reservation for exclusive TV usage was urged.

HDTV Service Offerings

There was general agreement among the attendees that HDTV would find at least two distinctly different applications, each of which could place different technical requirements on the system.

a) Limited Special Services

One possible HDTV service could be the distribution of feature films by HDTV in electronic form. The distribution would use satellites with movie theatres providing the necessary reception facilities, including the satellite receive-only terminals. Distribution of movies could either be done in real time, which would perhaps put excessive demands on satellite capacity, or transmission of movies could be done during low usage times of satellite for other purposes. The programs would electronically be recorded by the movie theatres for future showings.

It was pointed out that present HDTV recording equipment is very expensive and also that the recording capacity is too short to be suitable for feature-length films. One remedy, to at least the cost, is seen through centrally recording movies and locally distributing it to the individual theatres by a fibre optic distribution network.

A second special application for HDTV could be the distribution of one-time live events, such as opera performances, sports events, rock shows, etc., to movie theatres.

Since both applications are new and do not have an installed base of equipment to consider, compatibility of the transmission format is not an issue. However, high quality and high availability of the distribution system are very important. As an example, it was mentioned that the reduction of the S/N ratio from 54db to 44db may be tolerable for only 30 minutes during one year.

b) General Broadcast Service

Under this subject, the distribution of HDTV services to residences and the general public was discussed. In North America, and particulary Canada, because of the high penetration of CATV systems in urban/suburban areas, the distribution system would likely include satellite distribution of HDTV programs to cable system head ends, with cable systems providing the final distribution to individual homes. In remote areas with low population densities, transmission of HDTV signal via low-power transmitters may be considered. DBS systems were considered less likely in North America.

The European view on the other hand, is that DBS systems will be the primary distribution network for HDTV services. Even if in the foreseeable future, fibre optic distribution networks would become cost-competitive, it was estimated that it would not reach more than 60-70% of the potential viewers. Such networks could therefore not provide the up to 98% coverage that DBS systems are expected to be capable of.

Some form of compatibility with the existing base of receivers was seen as an important consideration in the introduction of HDTV as a general broadcast service. Necessity for compatibility was recognized for both the upward as well as the downward direction. However, there was no consensus how that could best be achieved. In this context, it was also recognized that the achievement of compatibility is more an economic problem rather than a technical one.

One suggested method was the transmission of HDTV signals in two channels. One of the channels would transmit a signal which would be compatible with present TV standards, such as NTSC, PAL or SECAM. The second channel would transmit additional information for higher resolution and the different aspect ratio. This approach would provide for downward compatibility. Nothing explicit however, was mentioned with respect to how a HDTV receiver would receive a conventional TV signal. The two-channel "compatible" HDTV transmission method generally found supporters from European and North American workshop attendees. This route was also seen as an evolution of the currently proposed various MAC-Systems into HDTV Systems.

One interesting suggestion that was offered towards the solution of the compatibility problem was the simultaneous transmission of the same program in HDTV and conventional format. This way the cost of conversion would be placed at a central point, thereby eliminating the cost of this process for the viewer, and also provide both upward and downward compatibility. It was recognized that this approach would reduce the overall available TV transmission spectrum. However, since compatibility would only be required for a transition period until most of the viewers would have replaced their conventional receivers with HDTV receivers, the burden on transmission capacity would also only be temporary.

A different approach to the problem of compatibility is being considered in Japan. Transmission of HDTV programs are planned for 1989 using the MUSE system via DBS. Upward and downward compatibility would be achieved by using adapters. An HDTV receiver could receive conventional TV signals using an adapter, and a conventional TV receiver could receive HDTV signals using yet another adapter. In essence, no compatibility of the transmitted HDTV signal with conventional TV signals is considered.

Key Features to Launch HDTV Services

There was considerable discussion with respect to which features would be most important for marketing HDTV services to the consumer. It was stated that the main feature would be the aspect ratio. Larger displays and high-quality sound channels were also viewed as requirements with HDTV. The higher resolution offered with HDTV was not viewed as the main selling point of HDTV. It was, however, recognized that it may be needed with larger displays to mask the line structure.

The issue of compatibility with present systems was also discussed in relation to the marketability of HDTV. It was stated that due to the large investment of consumers in present equipment, compatibility between the two systems was desirable. If not achieved, broadcasters may have to broadcast in both formats simultaneously.

The Japanese Approach to Introducing HDTV Services

Discussion took place concerning the Japanese approach to the introduction of HDTV services. NHK has developed the MUSE system, which reduces the HDTV bandwidth to 8 MHz. Dr. Fujio of NHK Research Laboratory, stated that NHK is planning to introduce an HDTV service using the MUSE system, by 1989. The cost of an HDTV receiver, consisting of a display and a MUSE decoder, excluding the satellite receiver antenna and tuner, was estimated at approximately $2,500 (U.S.). Compatibility will be achieved through converters. MUSE to NTSC, and NTSC to MUSE converters will be available.

There was also considerable discussion regarding the costs of a direct introduction of HDTV versus that of a gradual introduction, which would preserve system compatibility. The possibility of transmitting HDTV on two channels, one carrying the NTSC information, and a second one carrying the high-definition information was raised. Dr. Fujio stated that although the details of the transmission of HDTV programs had not yet been decided, it was a possibility that NHK may broadcast programs simultaneously in HDTV (MUSE) and in NTSC.

With respect to the signal-bandwidth-reducing MUSE system, Dr. Fujio stated that it uses a motion compensation technique. The system provides good quality pictures, without any degradation for slow movements. High-speed motions are however affected by the band compression process.

Some information was also provided on the range of displays being considered for HDTV. It was indicated that NHK has developed direct-view CRT's from 26 to 40 inches, projection type displays from 55 to 65 inches and plasma device flat panels. The size of the latter is dependant upon the smallest cell size. Panel sizes from 1.2 to 1.5 metres have been developed by NHK. They are planning to have a 1 metre panel on the market in four years.

Conclusions

Although varying views were expressed on a number of subjects during this workshop, some consensus was reached on certain items:

On the basis of these discussions, it appears that no distribution medium can be ruled out for HDTV transmission, at least on a technical basis. They will rather play different roles, depending whether they are more suitable for general broadcast to the end user, or as a primary distribution means of HDTV programs to feed subscriber distribution systems.

Coaxial-cable-based CATV networks. particularly in North America, and DBS systems appear to have the greatest potential for HDTV broadcast. Present VHF/UHF television broadcast networks may also be used provided a new channel plan is developed and additional spectrum is provided, since HDTV broadcast is not seen as replacing existing TV broadcast, but rather as an additional service. Since DBS is a new technology, and makes heavy use of signal processing, it will be most likely the first distribution medium for HDTV or EDTV broadcasting. Fibre optics is not expected to play a major role in the distribution of HDTV, for practical and economical reasons. Satellites were also identified as having an excellent potential for primary distribution of HDTV.

The issue of compatibility with present TV broadcast standards was also a major concern during the workshop. Although there was a general consensus that compatibility was highly desirable, it was felt that 100% compatibility with existing standards may not be achievable. The questions to what degree compatibility could be achieved, what the best approach would be and what cost could be considered reasonable, were, however, left open.

Another issue, also on which no consensus was reached, was whether HDTV would best be achieved through an evolutionary process or a revolutionary single step.

WORKSHOP NUMBER 4

Topic: Socio-Economic
"HDTV: Who Pays for the Dream?"

Moderator: P. Lyman, Nordicity Group, Canada

Panelists: K. Lager, AD Systems Inc., U.S.A.;
W. Vivian, Kalba Bowen Associates, U.S.A.;
C. Darling, Nordicity Group, Canada.

Introduction:

The workshop opened with an introduction by the chairman where he stressed that the successful introduction of HDTV would require concentration on the definition of user needs and on a mass marketing approach. The panelists indicated that there is an immediate market for HDTV in the areas of simulation, computer graphics, and military applications; that vision and imagination at this time are more important than market research data to the successful implementation of HDTV; that the development capabilities and cost of smart receivers are the stumbling blocks to the successful introduction of enhanced/high definition TV to the consumer marketplace; and the universal introduction of EDTV/HDTV in Canada would result in the cost being shared by all TV viewers, whereas the introduction by an entrepreneur would result in the cost being covered by individual subscribers.

A discussion ensued regarding the availability and cost of HDTV receivers. EDTV/HDTV can now be transmitted via cable utilizing two channels at a minimal additional cost to each viewer. Studio equipment is available, albeit at a high cost; hence, the main stumbling block to the early introduction (3 to 4 years) of HDTV into the consumer marketplace is the display. The general consensus was that an HDTV receiver and display that is in an acceptable consumer price range (i.e., about 1.25 times the cost of an NTSC receiver) could be available in about 7 years. It would be virtually impossible for industry to develop and manufacture this product at an acceptable cost to the consumer in a shorter time period.

The question of the evolutionary versus revolutionary introduction of HDTV to the marketplace was discussed. An announcement was made at the Conference that NHK would start broadcasting HDTV via the BS3 satellite in 1989. Receivers incorporating MUSE decoders will be available at a projected cost of $2500. NTSC TV will still be available to consumers via terrestrial means. It was generally agreed that the introduction of HDTV in Europe and North America would be in more of an evolutionary nature starting with EDTV that is NTSC compatible, and evolving, perhaps, to HDTV. EDTV at its best is very good, and the "just noticeable difference" in going to HDTV may be inadequate to convince the consumer that HDTV is required. Entry to the market of EDTV could be via digital NTSC-type receivers with a 5:3 aspect ratio and a picture-in-picture capability. The growth of EDTV/HDTV in the marketplace is very difficult to project because a viable surrogate is not available. Correlation with the growth of VCRs and colour TV has been done; however, the credibility of this correlation is questionable. It was, however, suggested that the growth of projection displays may be a viable surrogate. A survey conducted in Japan indicated that the end-user requirements for HDTV would be 60% HDTV broadcasting and 40% high-definition graphics.

It was proposed that a discrete high-definition display with a built-in VCR and a diagonal screen size of 40 inches be made available at twice the cost of a 19-inch NTSC TV, with movies available on tape or disc. The question was posed to the workshop regarding who would buy the system. There were 3 yes votes, 23 no votes, and 3 abstentions. The type of system to be made available was somewhat modified, whereby training/educational material would be made available and the system would have an interactive capability. The purchase was again voted on, resulting in 6 yes votes, 21 no votes, and 2 abstentions. The proposed system was further modified, whereby it would replace the present NTSC TV/VCR with enhanced quality (not necessarily high definition) and all available programming could be received and displayed. The vote on purchase resulted in 20 yes votes, 6 no votes, and 3 abstentions. It would therefore appear, at least as far as the workshop attendees were concerned, that compatibility with the present NTSC/PAL/SECAM system is an important factor.

CLOSING PLENARY

Concluding Remarks

Chairman: O.S. Roscoe, Telesat Canada

In concluding the workshops portion of HDTV '85, I would like to thank the moderators for doing such a good job of keeping stimulating discussions going in their particular workshops, and then, on short notice, making such comprehensive reports at this plenary session. One of the opening papers posed the question of whether HDTV should be looked at from a pixel or a perspective viewpoint. In fact, the colloquium has dealt with both. Some papers treated specific technical aspects in great detail. Others took broad overviews. Particularly in the workshops, some of the issues of perspective were well aired, and we are very pleased that the participants were so forthcoming with their opinions.

From a technology development perspective, I have some personal observations comparing the status of HDTV technology as discussed and described at this colloquium, compared to the first colloquium held in 1982. There has been a very considerable amount of advance since HDTV '82. At that time, the NHK 1125-line system was the only HDTV system. A major issue was the lack of downward compatibility. There were not any schemes at that time for a downward-compatible system, one which would permit HDTV to be receivable, albeit with reduced definition, by today's conventional NTSC/PAL/SECAM receivers, of which several hundred million are in operation worldwide.

At this colloquium, and in other fora, at least half a dozen or more schemes for downward-compatible HDTV have been identified. This is significant progress in the two and half years between HDTV '82 and HDTV '85.

At HDTV '82 all of the components in the string between the camera and the display were not yet available. Now they are, with most actually seen here in the demonstration hall. Perhaps not all are yet suitable for practical use in an operational environment, but I don't expect that it will take very long to carry out the necessary refinements.

At HDTV '82 the multiplexed analogue-component systems were at the laboratory state. We have come a long way since then. Now, they have been recommended for DBS use in Europe, and have, in fact, been adopted by Australia. We heard a paper on the policy reasons for the Australian adoption of MAC. Consumer equipment is being delivered for service in Australia beginning this fall.

One of the big questions at HDTV '82 was the quest for a single worldwide standard, and I think that this is still with us. That is very obvious from the discussions at the workshops. It appears that an attempt to reach a single worldwide standard is coming up at the CCIR session on the subject this fall, and from the straw vote taken at one of the workshops, it seems that some feel that this will perhaps even be the last chance for a single worldwide standard. Others do not seem to think that there is a need for a rush. The question of whether the NHK 1125-line standard will become the defacto standard, or a defacto standard, was being asked at HDTV '82 and still is being asked. Perhaps, Dr. Fugio's statement today that NHK will begin HDTV broadcasting in 1989 via direct-broadcasting satellite to high-definition receivers incorporating MUSE decoders and targeted to sell for $2500 is a strong clue to the answer to that question.

Finally, on behalf of the sponsors of this colloquium, the Canadian Broadcasting Corporation, the Department of Communications, and the National Film Board, I would like to thank all of those who contributed to its success. This includes the authors, the chairpersons, the moderators of the workshops, the rapporteurs, and especially you, the participants. I think that we have all collectively benefitted from the presentations as well as the discussions, both in the workshops and in the corridors. The demonstrations were a particular highlight of this colloquium. Again on behalf of the sponsors, I would also like to thank NHK and all the other organizations and corporations who provided the equipment to make the demonstrations possible, and did so in a non-commercial manner. The organizers of the demonstrations, I think, did an outstanding job of making sure, through the assembly of all the equipment from many sources, and through the provision of a special set with appropriately attired models designed to show up artifacts in television pictures, that we had the opportunity to compare all of the ranges of video technology that are available today, and I think that they also deserve our thanks.

Now, it only remains for me to wish you all a safe trip home, and to declare this colloquium adjourned. Thank you.

ATELIERS DU COLLOQUE SUR LA TÉLÉVISION À HAUTE DÉFINITION

ATELIER 1

Sujet : Applications et besoins
" La TVHD : Pourquoi ? "

Modérateur : Mark Blandford, Société Radio-Canada, Canada

Invités : W.M. O'Farrell, Crawley Films, Canada;
L. Thorpe, Sony Corporation, Canada;
M. Paradis, Office national du film, Canada;
J. Gaspar, McDonnel-Douglas, États-Unis.

Introduction

On s'empresse de classer les applications de la TVHD en trois grandes catégories : applications autres qu'à la radiodiffusion, applications à l'industrie cinématographique et applications à la radiodiffusion.

Applications autres qu'à la radiodiffusion

Ces applications touchent des domaines comme la médecine, l'imagerie, la vente au détail, les manoeuvres militaires, la téléconférence, la simulation et l'infographie.

Pour créer l'impression de réalité nécessaire, les simulateurs (qu'ils soient appliqués aux aéronefs ou aux trains) ont besoin de la haute définition. L'industrie de la simulation ne se préoccupe pas tellement des prix, étant donné qu'elle permet à ses clients de réaliser d'importantes économies. Il semble opportun d'investir dans toute technique qui contribue à accroître l'impression de réalité.

De même, la TVHD intéresse beaucoup l'industrie de l'infographie. Grâce à elle, même les personnes qui ne peuvent assister à un événement ou qui ne se trouvent pas suffisamment près de l'écran peuvent admirer les produits de l'infographie dans leurs moindres détails. En effet, la TVHD permet d'enregistrer et de visionner l'information ou de projeter les images d'un petit écran (terminal) sur un grand écran.

L'industrie de l'informatique préfère adopter les appareils de TVHD plutôt que d'en fabriquer elle-même, parce qu'elle a toujours été beaucoup trop fragmentée pour qu'il lui soit possible d'établir ses propres normes et, par conséquent, ses propres systèmes d'affichage.

Les détaillants, pour leur part, peuvent économiser beaucoup en utilisant la TVHD (pour démontrer la qualité supérieure d'un produit) à des fins de commercialisation et de formation et ce, même si le matériel de TVHD coûte encore de deux à trois fois plus cher que l'équipement professionnel de télévision en usage.

Applications à l'industrie cinématographique

L'industrie cinématographique deviendra un grand utilisateur des systèmes de TVHD. Son principal objectif est de réduire les coûts de production, non pas par la réduction du coût de l'équipement ou du matériel, mais par les économies réalisées au titre de la main-d'oeuvre. Les enregistrements sur bande vidéo peuvent être visionnés immédiatement et, à tout le moins, un premier examen de la plupart des effets spéciaux peut se faire sur-le-champ. On élimine ainsi la période d'attente (allant d'une nuit à plusieurs jours) entre le tournage proprement dit et le premier visionnement du produit final. L'équipe n'a pas besoin d'attendre ni de se réunir pour une nouvelle prise de vue si la première n'est pas satisfaisante.

Le rapport largeur-hauteur de l'image dans le cas de la TVHD est le même qu'en cinématographie (ou presque), si bien que la bande vidéo peut être utilisée comme telle ou servir de base à une évaluation artistique dont on peut immédiatement tenir compte dans le tournage simultané du film.

L'industrie cinématographique mettra la TVHD à l'essai pendant au moins sept ans. Les effets spéciaux constituent probablement l'un des premiers domaines dans lesquels s'effectuera le passage à la TVHD, pour des raisons de vitesse et de souplesse.

L'Office national du film prévoit un passage graduel du film 16-35 mm à la TVHD. Il utilise déjà la vidéo en animation, en vérification, en titrage, par exemple. Il serait utile d'augmenter la fréquence d'image pour les effets d'animation.

On signale que l'équipement de TVHD demeure encombrant. Les caméras électroniques ne sont pas d'aussi bonne qualité que les caméras 35 mm, mais elles seront améliorées.

Le film sera toujours utilisé dans certaines applications (comme les documentaires).

Radiodiffusion

Le radiodiffuseur traditionnel sera le dernier à utiliser la TVHD, en raison des problèmes que pose la distribution d'un signal de TVHD. Il s'agit en fait d'un problème de transmission du signal et d'affichage de l'image sur l'écran de l'abonné.

Le consommateur ne sera pas attiré de prime abord par l'aspect " haute définition " du système, mais par la largeur de l'écran et la qualité supérieure du son multivoie. (Il devrait y avoir au moins trois, et peut-être cinq, voies sonores distinctes.) Le grand écran de la TVHD constitue pour les producteurs de films un outil de travail qui leur est familier. Les cinéastes peuvent exploiter leur talent artistique pour créer des atmosphères et des impressions qui sont très difficiles à produire au moyen d'un écran de télévision traditionnel de format 4:3.

Tous ces facteurs permettront à l'acheteur éventuel de services de TVHD de noter une différence marquée.

Un signal codé de contrôle devrait être attribué aux oeuvres produites suivant le format de la TVHD destinées à des écrans de grande dimension et de dimension normale. Ce signal permettrait de déterminer artistiquement quelle partie de l'image sera supprimée durant la projection sur un écran de télévision ordinaire (fonction " panoramique et balayage ").

Un écran de TVHD utilisé pour une image 4:3 comporte un panneau latéral pouvant servir à afficher trois images supplémentaires (comprimées) 4:3. Le téléspectateur peut alors choisir l'image précise qu'il souhaite voir au complet à l'écran.

La conversion d'une fréquence d'image entre 60, 50 et 24 images par seconde demeure un important problème technique à résoudre.

L'équipement de TVHD utilisé à domicile doit être pratique, sinon il subira sur le marché le même sort que celui des films 16 et 8 mm. C'est la largeur de l'écran, pas simplement sa dimension, qui créera le marché. Un écran énorme pourrait en effet présenter des inconvénients, car il s'intégrerait difficilement au reste du décor. La résolution de l'image doit être suffisamment améliorée pour qu'il soit possible de dissimuler les défauts de balayage, qui autrement deviendraient visibles à la distance réduite qu'il faut maintenir si l'on veut bénéficier des avantages de l'écran élargi. Le marché du divertissement - et non le marché des autres applications que la radiodiffusion - procurera les fonds nécessaires à la mise au point de la TVHD.

Facteurs relatifs au marché

Une seule étude de marché a été publiée à ce jour. Une enquête menée au Japon auprès de gens d'affaires à revenu élevé (revenu moyen de 40 000 $ ÉU) montre que le produit est bien connu. Plus de 50 p. 100 des personnes interrogées seraient prêtes à acheter un récepteur qui coûterait moins de 1 200 $ ÉU si une station offrait la TVHD. Ces résultats sont jugés plutôt encourageants. D'autres études de marché ont été effectuées, mais les résultats n'ont pas été publiés. Sony a indiqué qu'elle se lance dans la TVHD parce qu'elle a confiance dans le produit, et elle est persuadée d'atteindre un seuil de rentabilité. Elle croit pouvoir tirer des profits directs de l'industrie autre que de la radiodiffusion, mais il faudra que la TVHD finisse par percer le marché du consommateur.

Normes du point de vue des applications

Les participants discutent longuement des normes de TVHD du point de vue des applications. Ils estiment en général que plusieurs normes de facto porteraient préjudice aux consommateurs et aux fabricants de la TVHD. De l'avis de certains, une norme mondiale de production devrait être approuvée d'ici octobre 1985. Cependant, il sera probablement difficile d'établir une norme qui conviendra aux pays utilisant la fréquence d'image de 50 Hz. Comme il a été mentionné précédemment, la conversion de la fréquence d'image entre 60, 59, 94, 50 et 24 images par seconde pose encore un problème majeur.

Une fois que la norme de production aura été établie, on pourra travailler à l'élaboration de normes secondaires concernant, par exemple, le type de bande magnétique et la transmission.

ATELIER 2

Sujet : Systèmes et normes
" Évolution ou résolution ? "

Modérateur : R. Zavada, Eastman Kodak, É.-U.

Invités : R. Hopkins, ATSC, É.-U.;
L. Cheveau, Société Radio-Canada, Canada;
G. Tonge, IBA, R.-U.;
R. Rossi, CBS, É.-U.

Introduction

Les participants à cet atelier sont nombreux. Une soixantaine de personnes prennent part aux débats animés et fructueux qui portent sur l'établissement d'une norme de TVHD applicable à la production et à l'échange d'émissions, tandis que d'autres aspects des systèmes de TVHD sont examinés dans le cadre des exposés et des commentaires.

Les invités passent en revue les principaux points concernant les normes, en commençant par l'historique du comité d'étude des systèmes de télévision avancés (Advanced Television Standards Committee) établi par les cinq organisations membres du comité conjoint de la coordination intersociétés des questions relatives à la télévision (Joint Committee for Intersociety Coordination of Television Issues). On explique les travaux des trois sous-groupes du Comité d'étude - (1) amélioration (" Improved NTSC ") (2) perfectionnement (" Enhanced NTSC ") et (3) TVHD, ainsi que le mandat du Comité, tenu de consulter les organisations membres du comité conjoint de la coordination intersociétés.

On parle de la nécessité d'établir sans tarder, à l'intérieur du cycle d'étude actuel du CCIR, une norme concernant les paramètres fondamentaux du système à 1 125 lignes ayant une fréquence image de 30 Hz et un rapport d'entrelacement de 2:1. On estime qu'il sera nécessaire d'établir des spécifications préliminaires lors du cycle d'étude suivant, applicables à la colorimétrie, au gamma et aux intervalles de suppression de ligne et de trame.

Un des invités se demande s'il serait possible de continuer d'appliquer les politiques nationales visant à fournir un service équitable à tous les citoyens; par exemple, s'il serait possible de fournir la TVHD à tous les Canadiens, ainsi que la Société Radio-Canada en a le mandat dans le cas de la télévision ordinaire.

On n'a pas suffisamment cherché à examiner le bien-fondé des applications autres qu'à la radiodiffusion, ni à déterminer si la TVHD serait compatible avec ces utilisations.

On signale également la nécessité de tenir compte des liens entre les autres normes et les normes de la TVHD. On cite en particulier les efforts déployés récemment dans l'élaboration de l'avis 601 du CCIR (spécifications concernant les composants numériques) et la répercussion de ce concensus sur les normes proposées de TVHD. On indique aussi qu'il n'est pas prévu de fournir un service de TVHD dans la bande de 12 GHz attribuée au service de radiodiffusion directe par satellite. Faute d'un système défini de transmission, il devient moins nécessaire d'assurer la compatibilité des studios, bien que l'on juge souhaitable d'adopter une méthode universelle de production électronique.

L'établissement d'une norme TVHD en Europe pourrait probablement se faire progressivement. Les Européens sont en faveur d'une norme commune mais, en pratique, reconnaissent que la transmission doit être assurée sur la fréquence de 50 Hz et, par conséquent, qu'une double norme de 50/60 Hz serait une solution de réserve. Les deux solutions supposent des compromis considérables; dans un cas, des concessions quant à la qualité de l'image et dans l'autre, des concessions pour l'établissement d'une double norme et la conversion des systèmes d'un studio à l'autre. On cite l'exemple du problème que poserait, au cours des enregistrements de reportages électroniques (dans le cas des systèmes de 60 Hz), le papillotement produit par un éclairage de 50 Hz. Grâce à l'avis 601 du CCIR, cependant, les différences pourraient à la longue être atténuées. En général, il semble très avantageux de poursuivre l'étude des systèmes à balayage progressif.

Enfin, on signale la grande difficulté d'établir une norme commune mondiale et les avantages que l'on obtiendrait si une autorité puissante pouvait en décréter une. Certes, on reconnaît que le système choisi comporterait des imperfections ou des limites, mais les grandes possibilités offertes par l'utilisation d'une future technique commune justifieraient, à long terme, la norme commune. Toutes les unions de radiodiffuseurs ont voté en faveur d'une norme TVHD unique et reconnu les avantages économiques de l'utilisation de matériel compatible.

De l'avis d'un des invités, il faut adopter sans tarder la norme proposée concernant le système 1 125 lignes, car l'on n'aboutira jamais à l'établissement d'une seule norme commune.

Les invités ayant terminé leurs exposés, les participants soulèvent une série de questions, parmi lesquelles on en choisit trois pour orienter la discussion.

Question 1 : La TVHD doit-elle être compatible avec des systèmes moins perfectionnés (compatibilité vers le bas) ?

La question est comprise au sens de " conversion " mais pas nécessairement de " compatibilité ". Cependant, on signale qu'une norme assurant la conversion mais non la compatibilité ajoute à la complexité déjà importante de la distribution : ajout des composantes numériques et, maintenant, de la TVHD.

Plusieurs font remarquer que le système n'est pas entièrement défini en ce qui concerne, premièrement, la production électronique, deuxièmement, la conversion électronique pour l'échange d'émissions (quant à la transparence de cette conversion) et troisièmement, le problème futur de la transmission à 50/60 Hz.

Les participants sont d'avis que le long métrage compatible serait l'outil idéal à utiliser comme principal support pré-enregistré du système. On signale que dans la plupart des cas, la diffusion de films se fait à partir de bandes qui ont été transférées par des services spécialisés autres que de radiodiffusion à la demande du producteur. Ce type de compatibilité et de transparence doit s'inscrire dans les objectifs d'une norme de production.

On met en doute la qualité de la conversion à 525/30/60 et à 625/25/50. Quels sont les inconvénients de la conversion ? Certains estiment qu'en ce qui concerne l'entrelacement, nous sommes limités jusqu'à ce que la technologie permette une amélioration à 100 p. 100 du système pour obtenir un balayage progressif de 1 125 lignes, qui assurerait alors une résolution horizontale et une résolution verticale égales. On signale également qu'une conversion rendant le système plus transparent est possible en utilisant le balayage progressif plutôt que le balayage entrelacé.

On discute de ce qui serait un niveau acceptable de dégradation dans le cas où la conversion des systèmes n'assurerait pas une transparence complète. On note la qualité inférieure des émissions en couleurs projetées sur des écrans monochromes utilisant le système NTSC. On discute du papillotement des récepteurs 50 Hz, question liée à la capacité d'adaptation de l'oeil du téléspectateur. Un écran plus perfectionné est capable de réduire considérablement ce papillotement.

D'autres estiment que les techniques d'adaptation du mouvement pourraient être améliorées pour permettre la transparence du système eu égard aux limites de visionnement et aux caractéristiques de l'oeil humain.

Enfin, il est mentionné que si, dans un proche avenir, le transcodage pouvait assurer une transparence virtuelle, il ne serait plus aussi impérieux d'établir une norme mondiale.

Un vote sur la question donne les résultats suivants : 38 personnes répondent oui; une seule, non; et les autres s'abstiennent.

Question 2 : Faut-il établir immédiatement une norme sur les studios de TVHD?

Au début de la discussion, on signale que si le CCIR désire établir une norme à la séance plénière de 1986, cela suppose que le Groupe de travail intérimaire 11/6 devra formuler un avis à sa dernière réunion, prévue pour les 15 et 16 juin 1985 (subséquemment remise à octobre 1986).

On évoque l'expérience du passé, en essayant de trouver des exemples de normes établies prématurément. On parle du cas de la norme FCC/CBS concernant la télévision en couleurs. Son " rappel " est attribué au fait qu'elle n'était pas compatible avec les récepteurs monochromes existants, ce qui soulève une fois de plus la question de savoir si la capacité de conversion est suffisante en elle-même.

Il s'agit en fait de déterminer si nous sommes prêts à accepter une norme " imparfaite " ou si nous tenons à la perfection; nous admettons que la norme a des chances d'être améliorée ou de devenir plus acceptable dans l'intervalle, mais nous ne pouvons pas attendre indéfiniment.

Les participants soulèvent des questions et fournissent des arguments en ce qui concerne les avantages et les inconvénients de reporter l'adoption d'une norme. Les radiodiffuseurs exercent-ils véritablement des pressions pour qu'une norme soit établie immédiatement ? Combien d'argent est-il prévu d'investir durant les quatre prochaines années, par exemple, qui pourrait être dépensé différemment si la norme était approuvée dès maintenant ? Le fait de prendre tout le temps nécessaire pour examiner la question de la normalisation procurerait-il les avantages d'une approche globale ? Y a-t-il des risques cachés, des techniques inconnues ou des techniques existantes inexplorées (caméra à dispositif de transfert de charge, balayage progressif, codage du signal, etc.) qu'il faudrait examiner de près avant d'adopter une norme ? La norme proposée exploite-t-elle entièrement les capacités technologiques actuelles ? Le syndrome du " maintenant ou jamais " serait-il une réaction excessive à l'importance que prend la norme NHK 1 125 lignes proposée ?

Si une norme n'est pas adoptée sous peu, trois systèmes (au moins) seront vraisemblablement établis ou déployés dans un proche avenir - (1) le Japon (et peut-être d'autres pays) adoptera le système 1 125 lignes/60 Hz (la NHK diffusera d'ici cinq ans); (2) un système à balayage progressif sera mis au point, probablement à 750 lignes; et (3) l'Europe adoptera un système (local) compatible 1 250 lignes/50 Hz.

Tout au long de la discussion, on signale l'importance des facteurs non techniques.

Les résultats du vote sur la question sont les suivants : 11 personnes favorisent l'adoption immédiate d'une norme; 14 sont en faveur d'un report et les autres préfèrent s'abstenir.

Question 3 : Le système 1 125/60, 2:1 deviendra-t-il la norme de facto ?

On signale d'abord qu'une norme de facto unique est peu probable, même si le système NHK en sera assurément une parmi d'autres. Cependant, les défenseurs de cette hypothèse estiment fermement qu'il n'y a pas lieu d'adopter une norme de facto, étant donné que le système est fondé sur de nombreuses années de recherches techniques et psychophysiques poussées, que beaucoup de personnes le jugent supérieur au film 35 mm et que les efforts devraient être maintenant axés sur une normalisation progressive.

On estime qu'en adoptant une approche de facto (c'est-à-dire aucune norme), on aura ni la chance ni l'envie d'entreprendre immédiatement la prochaine étape, où seraient examinés des aspects comme la colorimétrie, le gamma et les caractéristiques générales du système.

La question est formulée de deux façons : lorsqu'on demande si le système 1 125 lignes deviendra <u>une</u> norme de facto, 17 répondent oui, et lorsqu'on demande si le système 1 125 lignes deviendra <u>la</u> norme de facto, tous répondent dans la négative !

Conclusions

1. Un système futur de TVHD doit pouvoir être converti aux systèmes existants de façon transparente ou en produisant des défauts imperceptibles.

2. Le cycle d'étude actuel du CCIR ne permet pas une évaluation adéquate des propositions concernant le balayage progressif allant à l'encontre de l'adoption du système 1 125/60 2:1; il nous faut plus de temps, mais pas nécessairement quatre ans !

3. Si la norme 1 125/60 2:1 doit devenir la norme mondiale commune, elle doit être adoptée officiellement dès maintenant; autrement, à défaut de mieux, trois systèmes différents seront fort probablement introduits.

ATELIER 3A

Sujet : Techniques - Production
" Aspects pratiques vs créativité "

Modérateur : E. Zwanevald, ONF, Canada

Invités : D. Kline, Panavision, É.-U.
M. Auclair, Société Radio-Canada, Canada
J. Galt, CJOH-TV, Canada

Introduction

Le modérateur passe en revue les objectifs de l'atelier : cerner les points de vue des participants concernant les outils de production nécessaires à la TVHD, en déterminant les applications ultimes et leurs répercussions sur la production, en définissant les paramètres et les exigences quant aux garanties de qualité, en proposant des lignes directrices sur la façon dont les outils de production devraient stabiliser ou réduire les coûts de production aux fins visées, et en trouvant des moyens d'inciter les producteurs d'émissions à utiliser les techniques de TVHD.

Discussion entre les invités

L'un des invités définit trois grandes sources de préoccupation quant à l'aspect production de la TVHD :

- la fiabilité et la stabilité de la caméra;
- les problèmes que posent les magnétoscopes analogiques;
- l'instabilité des écrans couleurs.

Un autre invité fait des observations sur l'aspect psychophysique, différent dans le cas de la TVHD. Du point de vue pratique de la production, il sera à son avis plus compliqué d'effectuer la mise au point avec les caméras de TVHD à haute résolution, et les filtres et l'éclairage seront encore plus importants pour la production dans le cas de la TVHD. Il estime également que la TVHD ne sera probablement pas distribuée par des systèmes terrestres, mais par d'autres moyens techniques plus avancés, ce qui risque de fragmenter le marché.

Le dernier invité parle des limites de la TVHD aux fins de la production. En cours de production, l'opérateur d'une caméra de TVHD voit la profondeur de champ réduite et est donc limité dans sa créativité. Même lorsque les systèmes de TVHD seront bien établis, les films continueront vraisemblablement d'être utilisés comme divertissement. Il convient donc d'étudier de plus près le problème de l'intégration et de la compatibilité.

Le modérateur invite ensuite les autres personnes présentes à poser des questions.

En réponse à une question à propos du type de commutateur (numérique ou analogique), les invités indiquent que les commutateurs numériques sont encore à l'étape du prototype. Les commutateurs analogiques existants sont de plus en plus efficaces et leur fiabilité augmente parallèlement. On en conclut que les commutateurs numériques ne seront pas utilisés avant de nombreuses années comme outil pratique de production.

À propos de l'utilisation du film par opposition aux systèmes de TVHD (lorsqu'ils seront disponibles), on indique que le film est le principal moyen utilisé en Amérique du Nord pour la production d'émissions de télévision commerciales de haute qualité et ce, principalement en raison de l'utilisation traditionnelle qui en est faite et de la souplesse artistique qu'il permet. On estime que les systèmes de TVHD serviraient d'abord à la radiodiffusion des nouvelles. On souligne que les producteurs utiliseraient les techniques de la TVHD seulement si elles permettaient une plus grande liberté en matière de production. Étant donné que les producteurs d'émissions de télévision doivent respecter des contraintes techniques plus rigoureuses que les producteurs de films, la TVHD devrait supprimer, ou du moins réduire, certaines de ces contraintes. Autrement, elle ne sera pas jugée efficace comme outil de production.

Pour sa part, l'industrie cinématographique se préoccupe de la fiabilité, de la durabilité et de la qualité de la TVHD.

A propos du coût de la distribution, on estime que le mode électronique s'avérera vraisemblablement le moyen le plus économique. Le consommateur, quant à lui, souhaite pouvoir décider de l'émission qu'il veut regarder et du moment auquel il la regardera. C'est ce qui explique en partie le succès du magnétoscope. Il faut en tenir compte si l'on veut favoriser la percée des services de TVHD.

Quant au meilleur moyen d'introduire la TVHD, ce serait d'établir des services de télévision à haute fidélité et d'y joindre plus tard des bandes magnétoscopiques louées et pré-enregistrées.

Une autre méthode serait d'utiliser la TVHD pour la diffusion en circuit fermé de spectacles ou d'événements sportifs, associée à la distribution par satellite. Les petites salles de cinéma seraient également une autre solution.

ATELIER 3B

Sujet : Technique - Affichage
" L'image de l'avenir "

Modérateur : W. Haberman, IRT, Allemagne

Invités : F. Benedikt, Société Radio-Canada, Canada
K. Powers, RCA, É.-U.
H. Schroder, Dortmund, Allemagne

Introduction

Le modérateur ouvre l'atelier en passant en revue certaines des questions à examiner, y compris les aspects psychophysiques de la TVHD, les conditions de visionnement, les possibilités d'adapter l'équipement au domicile de l'utilisateur et la compatibilité des normes.

Discussion entre les invités

Les invités parlent de l'inquiétude que suscite la compatibilité de l'équipement de TVHD, ainsi que des difficultés que pose son intégration au domicile du consommateur. L'écran constitue probablement un problème plus important que celui de l'adoption d'une norme définitive de TVHD, et les écrans mis actuellement sur le marché sont de qualité insuffisante pour la TVHD.

À propos des aspects psychophysiques de la TVHD, on souligne que l'une des caractéristiques les plus importantes de tout écran de TVHD doit être la capacité de produire un effet proche de la réalité. Grâce à la technologie TVHD, le téléspectateur aura l'impression de regarder le monde non plus

" par le trou d'une serrure ", comme dans le cas des systèmes de télévision actuels, mais " par la fenêtre ".

On discute ensuite du rapport largeur-hauteur, et tous sont d'avis que la distance entre le téléspectateur et l'écran doit être d'environ 3 mètres. La largeur de l'écran est une caractéristique de la technologie TVHD. L'un des invités estime que tout écran de TVHD, pour produire l'impression de réalité nécessaire, doit être de dimension proche des limites du champ de vision du téléspectateur.

A propos des services audio que nécessitera la résolution améliorée des écrans de TVHD, on indique qu'il devrait y avoir au moins trois voies audio, certains proposant un nombre plus élevé (éventuellement jusqu'à six selon l'industrie cinématographique). En général, les participants à l'atelier sont d'avis que les services audio devraient être de haute qualité pour réussir à améliorer le service vidéo.

En discutant de l'intensité de la lumière ambiante nécessaire dans le cas des écrans de TVHD, on indique que ceux-ci ont une brillance plus faible que les écrans des téléviseurs traditionnels.

A propos de la colorimétrie, on souligne l'importance de la norme concernant les filtres de la caméra et de l'équilibre chrominance-luminance.

Pour ce qui est des techniques d'affichage, on indique que la fréquence de ligne maximale et le temps minimal de retour du faisceau d'électron constituent de l'avis des fabricants d'écrans, des facteurs directement liés au coût. Tout système de plus de 35 kHz aurait probablement des répercussions sur le prix des écrans de TVHD.

A propos de la facilité d'intégrer le système dans le reste du décor, on indique que l'écran pliant ou roulant, bien qu'il puisse être une solution au problème des grands écrans de TVHD, n'est pas approprié du point de vue technique en raison des exigences de géométrie et de surface. On parle également des écrans à plasma et à panneaux plats qui demeurent cependant inadéquats pour l'instant. Le poids de l'écran à panneaux plats est l'un de ses principaux inconvénients. L'un des invités estime que l'écran le plus efficace qui soit en usage est l'écran à projection par l'arrière, étant donné qu'il répond aux exigences de la TVHD quant à sa surface potentielle et qu'il nécessite un minimum d'espace.

A propos de la compatibilité de la TVHD avec les services existants, on reconnaît en général que la juxtaposition d'images (picture outside picture) et un grand rapport largeur-hauteur constituent des caractéristiques fort appréciées. On souligne que tout écran, pour percer sur le marché, doit être compatible avec toute la gamme de systèmes de télévision, du système actuel à 525 ou 625 lignes à la TVHD. On ajoute que les écrans futurs donneront une meilleure reproduction des image NTSC, facilitant ainsi le passage, des points de vue technique et financier, au service intégral de TVHD. On estime que les écrans de TVHD coûteront sur le marché moins de 10 p. 100 de plus que les écrans existants, étant donné que ces derniers seront déjà dotés de capacité améliorée, grâce entre autres à des techniques de mémorisation d'images.

En ce qui concerne le coût des techniques numériques nécessaires aux services de TVHD, on indique que le coût des appareils à semi-conducteurs n'est nullement lié à la complexité du circuit, mais plutôt au volume de production. Le coût initial pourra être élevé, mais il baissera au fur et à mesure que l'écran de TVHD percera sur le marché.

ATELIER 3C

Sujet : Technique - Distribution
" Comment atteindre le téléspectateur ? "

Modérateur : V. Reed, Skyline Cablevision, Canada

Invités : B. Read, TV Ontario, Canada
D. Weese, Télésat, Canada
R.I. MacDonald, Centre de recherches sur les communications, Canada

Introduction

Le modérateur explique l'objet de l'atelier et cède la parole aux invités qui, dans leur exposé d'introduction, présentent tous les moyens de transmission possibles. Au cours de la discussion, à laquelle prennent part les personnes présentes, quatre principaux points sont soulevés concernant la distribution :

1. possibilité des divers moyens de transmission pour distribuer les signaux de TVHD;
2. services possibles de TVHD;
3. principaux attraits des services de TVHD;
4. introduction au Japon des services de TVHD.

Suit un résumé des discussions sur ces quatre sujets.

Possibilité des divers moyens de transmission pour distribuer les signaux de TVHD

On discute de la capacité des réseaux de télédistribution par câble coaxial, des réseaux à fibres optiques, des réseaux de radiotélévision VHF/UHF et des systèmes de télécommunications par satellite.

a) Réseaux de télédistribution par câble coaxial

Les réseaux de télédistribution par câble coaxial construits pour fournir 12, 20 ou 35 voies seraient vraisemblablement incapables de transmettre les services de TVHD, parce que leurs fréquences sont déjà utilisées pour fournir des services d'émissions et des services auxiliaires. Cependant, les nouveaux systèmes sont conçus de manière à fournir une capacité de 50 à 70 voies et fourniront sous peu une capacité supplémentaire, dont une partie pourrait servir à la prestation de services de TVHD. Étant donné qu'au Canada un grand nombre de systèmes plus anciens sont remis à neuf, on s'attend à ce que les réseaux de câblodistribution jouent un rôle essentiel dans la distribution de services de TVHD au grand public. On indique que le service de TVHD serait vraisemblablement considéré comme un service offert en prime qui, de préférence, devrait être facturé à l'utilisation. On dispose déjà de la technique nécessaire pour mesurer le temps d'écoute et facturer le service en conséquence, mais elle n'a pas tellement été utilisée dans le cas des réseaux de câblodistribution.

Étant donné que l'on ne connaît pour l'instant ni la qualité ni la largeur de bande requises pour ce qui est des signaux de TVHD, on préfère ne pas discuter des répercussions de ces signaux sur les réseaux de câblodistribution, ni de la pertinence des normes actuelles concernant la qualité du réseau.

b) Réseaux à fibres optiques

La technique des fibres optiques pourrait constituer à l'avenir le moyen privilégié de distribution non seulement de la TVHD, mais aussi d'autres signaux à large bande. Cette technique convient tout particulièrement à la transmission des signaux numériques. Elle nécessite une très grande largeur de bande et, par conséquent, il n'y aurait pas lieu de traiter les signaux pour réduire la largeur de bande du signal de TVHD. Pour des raisons techniques, les réseaux de distribution à fibres optiques conviennent davantage aux réseaux en étoile, dotés d'un central. Ces réseaux ont l'avantage de fournir l'accès à un nombre pratiquement illimité d'émissions, étant donné que le réseau de distribution n'a pas besoin de transmettre toutes les émissions simultanément aux utilisateurs.

On signale qu'à l'heure actuelle et à court terme, les réseaux à fibres optiques ne joueront pas un rôle prédominant dans la distribution des signaux de TVHD parce qu'ils sont rares et que leur coût demeure assez élevé. L'introduction des réseaux à fibres optiques peut être accélérée par l'intégration en un seul système des services de transmission de la voix, de données et de signaux vidéo. Bien que les travaux menés sur le RNIS ouvrent des perspectives dans ce sens, on signale que les nouvelles normes pourraient ne pas convenir à la distribution des signaux vidéo de haute qualité par ces réseaux.

c) Réseaux de radiotélévision VHF/UHF

Il ne semble pas que les réseaux actuels de radiotélévision VHF/UHF puissent devenir un moyen de distribution des signaux de TVHD, non pas pour des raisons d'ordre technique mais pratique, plus précisément parce que les fréquences attribuées aux services de télévision sont déjà largement utilisées, en particulier les bandes VHF. La TVHD n'est pas perçue comme un remplacement des services existants de télévision, mais comme un ajout. Il faudrait donc que d'autres fréquences lui soient attribuées.

On donne l'exemple de la radiodiffusion FM, qui n'a pas remplacé le service de radiodiffusion AM, mais s'y est ajoutée. De nouvelles fréquences ont effectivement été attribuées à ce service.

d) Systèmes de télécommunications par satellite

On considère que les satellites sont les plus susceptibles d'assurer la distribution des services de TVHD. Ils pourraient être utilisés pour distribuer les signaux aux têtes de ligne des systèmes de câblodistribution ou aux stations d'émission de faible puissance dans les régions éloignées ou peu peuplées, stations qui, à leur tour, transmettraient les émissions aux utilisateurs ultimes. L'autre solution serait d'utiliser les satellites de radiodiffusion directe.

Les satellites offrent l'avantage d'une retransmission simple assurée par le transpondeur du satellite, réduisant ainsi la dégradation de la qualité du signal, comparativement à la dégradation que produirait, par exemple, un système terrestre à micro-ondes comprenant plusieurs circuits en tandem. Un autre avantage est la grande couverture assurée par les satellites, qui réduit le coût de la distribution par abonné.

En Amérique du Nord, la bande de 12 GHz et la génération actuelle de satellites pourraient servir dès maintenant à la distribution des signaux de TVHD. Au départ, aucun satellite ne serait conçu pour fournir uniquement un service de TVHD. Avec une PIRE de 48 dBW, on pourrait obtenir un rapport signal-bruit élevé de 54 db, nécessaire à un service de TVHD de haute qualité, au moyen d'antennes de réception de 4,5 à 7 mètres de diamètre. Une largeur de bande de canal de 27 MHz ou de 54 MHz pourrait être utilisée, selon les besoins.

En Europe, on considère que la distribution par satellite se ferait essentiellement au moyen des satellites de radiodiffusion directe. Étant donné que le nombre de voies disponible pour chaque pays dans la bande de 12 GHz est limité, il est prévu d'utiliser la bande de 22 GHz pour les services de radiodiffusion directe de TVHD par satellite. Présentement, il n'est pas envisagé de réserver la bande de 22 GHz aux services de télévision exclusivement. On trouve que la bande de 48 GHz, bande supérieure suivante réservée aux satellites, ne convient pas à la distribution des services de télévision, étant donné que la pluie atténue sensiblement le signal à ces fréquences. Il semble donc que la bande de 22 GHz est la bande la plus élevée pouvant servir à la distribution des services de radiotélévision, et qu'il faudrait sans tarder la réserver exclusivement à la télévision.

Services possibles de TVHD

Les participants reconnaissent en général que la TVHD trouverait au moins deux applications distinctes, dont chacune supposerait une utilisation technique différente du système.

a) Services spéciaux limités

L'un des services de TVHD possibles pourrait être la distribution électronique de longs métrages. Les satellites assureraient la distribution, tandis que les salles de cinéma fourniraient les installations de réception nécessaires, y compris les stations de réception des signaux de satellite. La distribution des films pourrait se faire en temps réel, mais cela surchargerait peut-être la capacité du satellite. L'autre possibilité serait de distribuer les films pendant les périodes de faible utilisation des satellites. Les salles de cinéma enregistreraient les émissions par voie électronique pour les présenter ultérieurement. On signale que le matériel d'enregistrement de THVD est très coûteux et que la durée possible d'enregistrement est trop courte pour un long métrage. L'une des solutions au problème que pose le coût, tout au moins, serait d'enregistrer les films dans un emplacement central puis de les distribuer à chacune des salles de cinéma de la localité au moyen d'un réseau à fibres optiques.

La TVHD pourrait également servir à la distribution en direct dans les salles de cinéma d'émissions spéciales comme des concerts d'opéra, des événements sportifs ou des spectacles rock.

Étant donné que ces deux applications sont nouvelles et qu'il n'existe aucun matériel de base que l'on peut envisager d'utiliser, la compatibilité du mode de transmission ne pose aucun problème. Cependant, il est très important que le système de distribution soit de qualité supérieure et largement disponible. Par exemple, on mentionne que la réduction du rapport signal-bruit de 54dB à 44dB peut être tolérée pendant 30 minutes seulement par an.

b) Service général de radiodiffusion

On discute de la distribution publique et privée des services de TVHD. En Amérique du Nord, et en particulier au Canada, vu la grande étendue des systèmes de câblodistribution dans les régions urbaines et les banlieues, le réseau comprendrait vraisemblablement la distribution par satellite d'émissions de TVHD aux têtes de ligne des systèmes de câblodistribution, ces derniers assurant la transmission des signaux aux résidences. Dans les régions éloignées moins peuplées, on pourrait envisager d'utiliser des émetteurs de faible puissance pour transmettre les signaux de TVHD. L'utilisation des systèmes de radiodiffusion directe par satellite est moins probable en Amérique du Nord.

En Europe, par contre, les systèmes de radiodiffusion directe par satellite constitueront le principal mode de distribution des services de TVHD. Même si, dans un proche avenir, les réseaux de distribution à fibres optiques offraient des prix compétitifs, on estime qu'ils n'atteindraient pas plus de 60 à 70 p. 100 des téléspectateurs éventuels. Ces réseaux ne pourraient donc pas assurer la couverture allant jusqu'à 98 p. 100 que l'on attend des systèmes de radiodiffusion directe par satellite.

Une certaine compatibilité avec les récepteurs existants est considérée comme un facteur important dans l'introduction de la TVHD en tant que service général de radiodiffusion. La compatibilité vers le haut aussi bien que vers le bas est jugée nécessaire. Mais on ne s'entend pas sur la façon dont elle pourrait être assurée. On reconnaît que la compatibilité pose davantage un problème d'ordre économique que technique.

L'une des méthodes proposées est la transmission des signaux de TVHD sur deux voies. L'une des voies acheminerait un signal qui serait compatible avec les normes de télévision actuelles, comme les NTSC, PAL ou SECAM. La deuxième voie transmettrait des données supplémentaires pour permettre une résolution supérieure et un rapport largeur-hauteur différent. La compatibilité vers le bas serait alors assurée. Cependant, rien n'est mentionné explicitement quant à la façon dont un récepteur de TVHD capterait un signal de télévision ordinaire. La méthode de transmission sur deux voies de signaux de TVHD compatibles est généralement approuvée par les Européens et les Nord-Américains présents à l'atelier. Ce cheminement est également perçu comme une évolution des divers systèmes MAC projetés aux systèmes de TVHD.

Pour résoudre le problème de la compatibilité, une proposition intéressante serait de transmettre simultanément la même émission en mode TVHD et en mode traditionnel. De cette manière, le coût de la conversion serait appliqué à un point central, si bien que le processus ne coûterait rien aux téléspectateurs, et la compatibilité vers le haut et vers le bas serait possible. On reconnaît que cette façon de procéder réduirait la partie du spectre pouvant servir à la transmission des signaux de télévision. Cependant, étant donné que la compatibilité ne serait nécessaire que pendant la période de transition, jusqu'à ce que la plupart des téléspectateurs aient remplacé leur récepteur traditionnel par des récepteurs de TVHD, la forte utilisation de la capacité de transmission ne serait elle aussi que temporaire.

Au Japon, le problème de la compatibilité est envisagé d'une manière différente. Il est prévu de transmettre en 1989 les émissions de TVHD au moyen du système MUSE, par l'entremise de satellites de radiodiffusion directe. La compatibilité vers le haut et vers le bas sera assurée au moyen d'adapteurs. Un récepteur de TVHD pourra recevoir des signaux de télévision conventionnelle à l'aide d'un adapteur, et un récepteur de télévision ordinaire pourra capter les signaux de TVHD au moyen d'un autre adapteur. Essentiellement, on n'envisage pas de rendre le signal de TVHD compatible avec les signaux de télévision conventionnelle.

Principaux attraits des services de TVHD

On discute longuement des aspects les plus importants de la commercialisation des services de TVHD. On indique que le principal attrait du système sera le rapport largeur-hauteur. Le grand écran et les voies audio de haute qualité sont également considérées comme éléments essentiels de la TVHD. La haute résolution qu'offre la TVHD n'est pas jugée comme le principal facteur de vente de la TVHD. Cependant, on reconnaît qu'elle pourrait être nécessaire dans le cas des grands affichages pour camoufler la structure de ligne.

On discute également de la question de la compatibilité de la TVHD avec les systèmes existants par rapport à la commercialisation. Parce que le consommateur investit beaucoup dans le matériel existant, il est souhaitable que les deux systèmes soient compatibles. Autrement, les radiodiffuseurs devront peut-être transmettre les émissions simultanément dans les deux modes.

Introduction au Japon des services de TVHD

On discute de la méthode utilisée par le Japon pour introduire les services de TVHD. La NHK a développé le système MUSE, qui réduit à 8 MHz la largeur de bande de la TVHD. M. Fujio du laboratoire de recherche de la NHK indique que la NHK prévoit d'introduire, d'ici 1989, un service de TVHD utilisant le système MUSE. Le coût d'un récepteur de TVHD, composé d'un écran et d'un décodeur MUSE, exception faite de l'antenne de réception des signaux de satellite et du dispositif d'accord, a été établi à environ 2 500 $ ÉU. La compatibilité sera assurée au moyen de convertisseurs. En effet, des convertisseurs MUSE à NTSC et NTSC à MUSE seront mis sur le marché.

On discute également du coût de l'introduction directe de la TVHD comparativement à une introduction graduelle qui assurerait la compatibilité des systèmes. On mentionne la possibilité de transmettre les signaux de TVHD sur deux voies, l'une acheminant l'information suivant la norme NTSC, l'autre les données permettant la haute définition. M. Fujio indique que même si l'on n'a pas encore décidé en détail de la façon dont les émissions de TVHD seront transmises, il se pourrait que la NHK diffuse simultanément en modes TVHD (MUSE) et NTSC.

En ce qui concerne le système MUSE où la largeur de bande du signal est réduite, M. Fujio précise qu'il utilise une technique de compensation du mouvement. Le système fournit des images de bonne qualité, sans dégradation des mouvements lents. Le processus de compression de la bande influe cependant sur les mouvements accélérés.

On fournit quelques renseignements sur les divers écrans que l'on envisage d'utiliser pour la TVHD. On indique que la NHK a mis au point des écrans à visionnement direct de 26 à 40 pouces, des écrans à projection de 50 à

65 pouces, des écrans à plasma et des écrans à panneaux plats. La dimension de ces derniers varie selon la taille de la plus petite cellule. La NHK a mis au point des panneaux dont la dimension varie entre 1,2 et 1,5 mètres. Elle prévoit de mettre sur le marché d'ici quatre ans un panneau d'un mètre.

Conclusions

Bien que des opinions divergentes aient été exprimées, les participants s'entendent sur certains points :

Tous les moyens possibles de distribution semblent pouvoir convenir à la transmission des signaux de TVHD, du point de vue technique tout au moins. Chacun jouera un rôle différent, selon qu'il convienne davantage à la radiodiffusion directe à l'intention des utilisateurs ultimes ou à la distribution des émissions de TVHD pour alimenter les systèmes d'abonnés.

Les réseaux de télédistribution à câble coaxial, notamment en Amérique du Nord, et les systèmes de radiodiffusion directe par satellite semblent convenir mieux que tout autre à la transmission des signaux de TVHD. Les réseaux existants de radiotélévision VHF/UHF peuvent également être utilisés, à condition qu'un nouveau plan d'attribution des fréquences soit établi et que des fréquences supplémentaires soient attribuées, puisque la TVHD n'est pas perçue comme un remplacement du service de télévision, mais comme un service supplémentaire. Étant donné que la radiodiffusion directe par satellite constitue une nouvelle technologie et utilise largement le traitement des signaux, elle sera vraisemblablement le premier moyen de distribution de la TVHD ou de la TVDA (télévision à définition améliorée), pour des raisons d'ordre pratique et économique. Les satellites ont également d'excellentes chances de devenir le principal moyen de distribution de la TVHD.

La question de la compatibilité avec les normes actuelles de radiotélévision constitue une grande source de préoccupation. Bien que l'on admette en général que la compatibilité entre les systèmes est très souhaitable, on estime qu'une compatibilité entière avec les normes existantes n'est peut-être pas possible. Cependant, on n'a pas encore déterminé dans quelle mesure la compatibilité pourrait être assurée, quelle serait la meilleure façon de procéder ni quel coût serait jugé raisonnable.

On ne réussit pas non plus à déterminer s'il serait préférable que la TVHD découle d'une évolution graduelle ou d'une révolution générale.

ATELIER 4

Sujet : Socio-économie

" La TVHD : qui paie ce rêve ? "

Modérateur : P. Lyman, Groupe Nordicité, Canada

Invités : K. Lager, Ad Systems Inc., É.-U.

W. Vivian, Kalba Bowen Associates, É.-U.

C. Darling, Groupe Nordicité, Canada

Introduction

Le président ouvre l'atelier en soulignant que l'essor de la TVHD dépend du soin que l'on mettra à définir les besoins des utilisateurs et la méthode de commercialisation à adopter. Les invités indiquent qu'il existe déjà une demande de TVHD dans les domaines de la simulation, de l'infographie et des applications militaires; qu'il est plus important à l'heure actuelle de faire preuve de clairvoyance et d'imagination que de mener des études de marché pour réussir la mise en oeuvre de la TVHD; que les possibilités de développement et le coût des récepteurs intelligents font obstacle à la percée de la télévision à définition améliorée ou à haute définition sur le marché du consommateur; et que l'introduction universelle de la TVDA/TVHD au Canada en fera partager les frais entre tous les téléspectateurs, tandis que son introduction par un entrepreneur en imposerait les coûts aux abonnés.

Il s'ensuit une discussion concernant la disponibilité et le coût des récepteurs de TVHD. La TVDA/TVHD peut maintenant être transmise par câble au moyen de deux canaux, moyennant un coût supplémentaire minime pour chaque téléspectateur. Le matériel de studio nécessaire existe déjà, bien qu'il soit coûteux; en conséquence, l'affichage constitue le principal obstacle à la mise en marché accélérée (trois à quatre ans) de la TVHD.

Tous sont d'avis en général qu'un récepteur et un écran de TVHD pourraient être offerts sur le marché d'ici environ sept ans, à un prix abordable (c'est-à-dire, par exemple, 1,25 fois plus élevé qu'un récepteur NTSC). Il serait pratiquement impossible pour l'industrie de mettre au point et de fabriquer ce produit à un coût raisonnable à plus bref délai.

On discute de l'introduction de la TVHD sur le marché, à savoir s'il est préférable de la présenter comme une évolution ou une révolution. Il a été annoncé à la Conférence que la NHK commencerait, en 1989, à diffuser les signaux de TVHD au moyen du satellite BS3. Les récepteurs comportant des décodeurs MUSE seront offerts au coût prévu de 2 500 $. La télévision NTSC continuera d'être offerte aux consommateurs au moyen d'installations terrestres. On s'entend en général pour dire que l'introduction de la TVHD en Europe et en Amérique du Nord aurait davantage l'aspect d'une évolution si l'on commençait par établir une TVDA compatible avec la télévision NTSC pour peut-être aboutir à la TVHD. La TVDA, dans les meilleures conditions, est très efficace, et la " différence à peine perceptible " qu'offre la TVHD pourrait ne pas suffire à convaincre le consommateur de la nécessité de la TVHD. La TVDA pourrait être mise sur le marché par l'introduction des récepteurs numériques de type NTSC ayant un rapport largeur-hauteur 5/3 et une capacité d'insertion d'images (pictures inside pictures). Il est très difficile de prévoir la croissance de la TVDA/TVHD sur le marché, faute d'un point de comparaison valable. On a établi des rapports avec la croissance des magnétoscopes et des téléviseurs couleurs, mais la valeur de ces rapports reste discutable. Cependant, il pourrait être utile d'établir des comparaisons avec la croissance des écrans de projection. Selon une enquête menée au Japon, les utilisateurs ultimes emploieraient la TVHD pour obtenir, dans 60 p. 100 des cas, un service de radiodiffusion à haute définition et, dans 40 p. 100 des cas, des graphiques à haute définition.

On propose de mettre sur le marché une unité d'affichage spécialisée à haute définition dotée d'un magnétoscope et un écran de 40 pouces de diagonale, à deux fois le prix d'un téléviseur NTSC de 19 pouces; des films seraient offerts sur bande ou sur disque. Les participants à l'atelier ont été invités à indiquer s'ils achèteraient le système : trois répondirent oui, vingt-trois non, et trois s'abstinrent. En modifiant quelque peu le type de système envisagé, de manière qu'il soit possible de l'utiliser pour l'affichage des documents de formation ou didactiques et que le système ait une capacité d'interaction : six des participants répondirent oui, vingt-et-un, non, et deux s'abstinrent. On modifie une fois de plus le système proposé, de manière qu'il remplace la télévision et le magnétoscope NTSC existants en en améliorant la qualité (sans qu'il s'agisse nécessairement de haute définition) et qu'il puisse recevoir et afficher toutes les émissions possibles. Les résultats du vote furent les suivants : vingt participants répondent oui, six non, et trois s'abstinrent. Il semble donc, du moins en ce qui concerne les participants de l'atelier, que la compatibilité avec le système NTSC/PAL/SECAM constitue un facteur important.

ASSEMBLÉE PLÉNIÈRE DE CLÔTURE

Allocution de clôture

Président : O.S. Roscoe, Télésat Canada

En conclusion des ateliers du Colloque de 1985 sur la TVHD, j'aimerais remercier tous les modérateurs pour avoir su soulever des discussions intéressantes au sein de leur groupe respectif et pour avoir pu présenter, à très bref délai, des rapports aussi détaillés au cours de cette séance plénière. L'un des tous premiers mémoires présentés a abordé la question de savoir si la TVHD devait être examinée du point de vue d'élément d'image ou sous un angle perspectif. De fait, le colloque a traité des deux points de vue. Quelques mémoires ont étudié en détails des aspects techniques particuliers. D'autres ont été plus généraux. Au cours des ateliers, certaines questions de perspective ont été bien débattues et nous avons éprouvé beaucoup de plaisir à voir les participants exposer aussi nettement leurs opinions.

En ce qui a trait au développement technologique, je ferai une comparaison personnelle sur l'état de la technologie de TVHD tel que discuté et décrit ces derniers jours par rapport au premier colloque tenu en 1982. Il y a eu, depuis, un avancement très considérable. À l'époque, le système TVHD NHK à 1 125 lignes était le seul du genre. L'un des problèmes les plus importants rencontrés était le manque de compatibilité avec les systèmes plus simples. Il n'existait pas non plus de plan de création d'un système compatible qui aurait permis la réception de la TVHD, malgré une définition réduite, par les récepteurs conventionnels d'aujourd'hui de type NTSC, PAL ou SECAM, dont plusieurs centaines de millions sont aujourd'hui en opération.

Durant ce colloque et au cours d'autres conférences, au moins une demi-douzaine ou plus de projets de systèmes de TVHD à compatibilité avec les systèmes plus simples ont été identifiés. Il s'agit là d'un progrès notable réalisé au cours des deux années et demie écoulées entre 1982 et 1985.

En 1982, tous les composants de la chaîne de produits entre la caméra et le dispositif d'affichage n'étaient pas encore disponibles. Ils le sont maintenant et la plupart d'entre eux ont pu être vus dans la salle de démonstration. Ils ne sont peut-être pas encore adaptés à une utilisation en situation opérationnelle, mais je ne pense pas qu'il s'écoulera beaucoup de temps avant que tous les perfectionnements nécessaires soient apportés.

En 1982, les systèmes à composantes analogiques multiplexées étaient encore au stade du laboratoire. Un long chemin a été parcouru depuis. Ces systèmes ont été recommandés pour la télédiffusion directe en Europe et ont, de fait, été adoptés en Australie. L'un des mémoires a porté sur les motifs politiques de l'adoption par l'Australie de la norme MAC. La distribution de l'équipement grand public a commencé dans ce pays pour permettre l'entrée en service des systèmes au début de l'automne.

L'une des grandes questions soulevées lors du colloque de 1982 a été l'établissement d'une norme unique mondiale. Le problème demeure entier aujourd'hui, comme l'ont montré les discussions tenues dans les ateliers. Il semble que des efforts seront faits pour adopter une telle norme au cours de la prochaine assemblée du CCIR, cet automne. Le sondage d'opinion pris dans l'un des ateliers laisse présumer que ce sera là la dernière occasion à saisir pour établir une norme universelle. D'autres croient qu'il n'y a pas lieu de précipiter les événements. La question de savoir si le standard NHK à 1 125 lignes deviendra le standard de fait ou une simple autre norme a été abordée au colloque de 1982 et s'est encore posée ici. Peut-être faudrait-il voir un élément certain de réponse dans la déclaration de M. Fugio voulant que la NHK introduise la transmission TVHD en 1989 par le moyen d'un satellite de télédiffusion directe, dont les signaux seraient captés directement dans les foyers par des récepteurs à haute définition dotés de décodeurs MUSE qui se vendraient à environ 2 500 $.

Pour conclure, j'aimerais remercier, au nom des organisateurs de ce colloque, de la Société Radio-Canada, du ministère des Communications et de l'Office national du film, tous ceux et celles qui ont contribué à la réussite du colloque. Ces remerciements vont aux auteurs, aux présidents, aux modérateurs des ateliers, aux rapporteurs et, tout spécialement, aux participants. Je pense que nous avons tous collectivement profité des présentations ainsi que des discussions tenues dans les ateliers comme dans les corridors. Les démonstrations ont constitué un point saillant de ce colloque. Je tiens à remercier la NHK et les autres organismes et sociétés qui ont fourni l'équipement nécessaire aux démonstrations, sans prétention commerciale. Les organisateurs des séances de démonstrations méritent aussi nos remerciements pour l'excellent travail accompli afin de nous permettre de comparer toute la gamme des technologies vidéo disponibles aujourd'hui grâce à l'assemblage de tout l'équipement provenant de plusieurs sources et à la présentation d'un montage scénique avec deux modèles conçus spécialement pour montrer les divers défauts de reproduction d'image de travail sur les images-télévision.

Il ne me reste plus qu'à vous souhaiter de retourner sains et saufs dans vos foyers et de déclarer ce colloque clos. Merci !

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