

HDTV emission systems approach in North America

by R. HOPKINS and K. P. DAVIES

1. Introduction

Television engineers in the United States and Canada are immersed in a study which could lead to the development of HDTV emission standards for North America in the next three years. The primary force, to date, has been the terrestrial broadcasting industry which has made clear its intent to compete with other forms of media – cable, broadcast satellite, video cassette, video disk – for television viewers of the future. Organizations have been formed in the United States and Canada to address the issues.

While other regions plan extensive use of satellite broadcasting for HDTV, this is not the case in North America where there is a very strong emphasis on terrestrial delivery. The North American approach will be more easily understood if the broadcasting structure and the relationship between the different forms of the media are understood. This article explains first these structures and then the processes which are being used to define the appropriate technical systems for HDTV broadcasting. Technical proposals which have been made will then be summarized.

2. The broadcasting structure in North America

Compared to other regions, the structure of broadcasting in the United States and Canada is unique, being a complex interconnected web of over-the-air, cable, and satellite delivery media programmed by numerous competing sources, many independent of the delivery mechanism. North American viewers are well served, most having access to 10 or 12 channels and many with access to 30 or more. Over 50% of the viewers in the United States, and even more in Canada, receive their television on cable. Over 50% of viewers in both countries use VCRs for viewing rented and time-shifted programmes. About two million homes in the United States and a similar percentage in Canada directly

receive satellite signals used to distribute programmes to broadcast terrestrial stations and cable-head ends. In the United States the FCC has granted construction permits for high power DBS but systems are not yet operational. The introduction of the medium power satellite *ANIK-E* in 1990 will add a number of new television services by satellite for the Canadian viewers.

The introduction of HDTV into North American broadcasting will be subject to many forces – technical, economic, and political. The technical standards must take these forces into account and, at the same time, enable the introduction of consumer products -- receivers, VCRs, disks, etc. – that are economical and capable of displaying both current and HDTV services.

In the North American television industry, three clear motives can be seen in the introduction of HDTV services:

- Enhancement of current services

Existing terrestrial broadcasters, many of which are relatively small and independent, may take this approach to improve market share or to enhance business viability in the face of new competing services. Constraints of spectrum, investment, and market may lead to HDTV systems compatible with current NTSC receivers even if there is loss of potential quality.

- Provision of new services

New service providers, especially those with access to cable or satellite delivery, may press to establish HDTV services at a higher-quality level with a lower level of NTSC compatibility. Tape and disk distribution may be significant.

- Launching of new distribution technologies

High-power DBS and B-ISDN are examples of this approach. The new wideband technology will create new competitors for the viewers' screens. Standards affecting the viewers' terminals are an important consideration.

In the United States, television broadcasting is governed on a media basis by the FCC which regulates, among other things, the technical

aspects of broadcasting, including the use of spectrum. FCC regulation is most pronounced for terrestrial broadcasting and less so for cable and satellite broadcasting. State and local jurisdictions are also involved in the regulation of cable and common carriers (potential B-ISDN suppliers). The FCC is currently concentrating on spectrum matters related to terrestrial broadcasting of ATV¹.

In Canada, television broadcasting is regulated on a service basis, essentially neutral to delivery media, by the Department of Communications (DOC) and the Canadian Radio and Telecommunications Commission (CRTC). Interest in HDTV is thus broadly based, taking account of all potential delivery media.

Both the United States and Canada have considerable sharing and overlapping of television services and thus the question of HDTV services and standards has an international aspect to it. Practical considerations dictate similar standards throughout North America. It will take time to resolve this complex issue in a way that is acceptable to the many diverse participants in the discussion.

3. The search for HDTV broadcasting systems

Several organizations are now in place in North America and involved in the search for the most appropriate HDTV emission systems. Many different factors are being investigated in this search. This section will review events of the past several years which are seen as elements leading to the present situation.

The Society of Motion Picture and Television Engineers (SMPTE) established a Study Group on High Definition Television in 1977. The Study Group held seven meetings and issued its report in the February and March issues of the *SMPTE Journal* in 1980. The principal findings of the Study Group were that the appropriate line rate for HDTV is approximately 1100 lines per frame, that the frame rate should be 30 frames/second interlaced, that aspect ratio should not be less than 5:3, that luminance and chrominance should be kept separate, and that the luminance bandwidth should be about 25 MHz.

In 1982 the United States Advanced Television Systems Committee (ATSC) was formed by the United States television industry (broadcasters, cable industry, satellite operators, consumer electronics manufacturers, professional equipment manufacturers, motion picture industry) to coordinate and develop standards for ATV systems. Its founders² established the ATSC in the belief that

1. ATV has been defined by the FCC to include all advances in television ranging from simple improvements in the NTSC system to full HDTV, generally regarded as meaning twice the horizontal and vertical resolution of current systems, a wide aspect ratio, improved colour rendition, and high-quality multiple channel sound.

2. The founders and Charter Members of the ATSC are the Electronic Industries Association (EIA), the Institute of Electrical and Electronics Engineers (IEEE), the National Association of Broadcasters (NAB), the NCTA and SMPTE.

the prompt, efficient and effective development of a co-ordinated set of national standards (and of a single national position in the development of international standards) for ATV was essential to the United States' ability to foster a new generation of domestic television service.

The ATSC work on HDTV initially was in the area of production. In 1986 a group was formed to co-ordinate and develop standards for the distribution of HDTV programmes to the public. This group initiated a testing programme in 1987 to determine propagation characteristics in the UHF and other bands for two-channel systems (some proposed systems would broadcast NTSC in one channel and an augmentation signal in a second non-contiguous channel) and for wideband systems.

In 1987 the Canadian Advanced Broadcast Systems Committee (CABSC) was formed by the Canadian Government, Canadian Broadcasting Corporation (CBC) and other broadcasters, cable television operators, and industry to provide a national forum for the development of standards and introduction strategies for HDTV broadcasting. Two sub-committees were formed, the Strategy Sub-Committee which is to identify the best schemes for coherent implementation of advanced broadcast systems and the Technical Sub-Committee which is to investigate technical issues related to advanced broadcast systems and make recommendations on inputs to other national and international organizations. Current activities are directed towards the establishment of introduction strategies appropriate for the Canadian situation and the definition of HDTV emission systems suitable for the terrestrial, cable, and satellite facilities. As a part of the effort to arrive at a common solution, a high level of co-operation and collaboration exists with the FCC and testing laboratories in the United States. Canadian work has concentrated on the characterization and simulation of the delivery channel to the consumer and this will form the basis of testing in both countries. Future work will test the performance of candidate systems, both in simulation and in practical tests, as part of the screening process. The current Canadian view is that it will be difficult to find a single system that meets the diverse needs of the delivery mechanisms currently in use. Consequently, a related family of systems may be chosen that results in a common receiver design and fully exploits the capability of the various delivery mechanisms.

In January 1987 the Association of Maximum Service Telecasters (MST) and NAB jointly demonstrated the feasibility of HDTV terrestrial broadcasting in Washington, DC using UHF channels 58 and 59 as a single channel.

Also in early 1987, the FCC was considering a request from non-television interests to re-allocate some spectrum in the UHF television band to non-broadcast applications. MST coordinated the efforts of more than 50 broadcasters to petition the FCC to first consider the impact of HDTV on the terrestrial broadcasters. It was asserted that the broadcasters may need additional spectrum to broadcast HDTV. Further, it was claimed that other forms of media would be able to deliver HDTV programmes to the public and the terrestrial broadcasters would have a competitive disadvantage if they could not deliver HDTV to their viewers.

In July 1987, the FCC adopted a "Notice of Inquiry" to consider the technical and public policy issues surrounding the use of ATV technologies by terrestrial broadcast licensees. The primary focus of the proceeding is the initiation of terrestrial broadcast ATV service.

In November 1987, the FCC formed an Advisory Committee on Advanced Television Service to advise it "on the facts and circumstances regarding ATV systems for Commission consideration of the technical and public policy issues" (see annex). The scope of activity is to "develop recommendations regarding the introduction of terrestrial ATV service" and includes "technical, economic, legal and regulatory issues". The Advisory Committee is composed of a panel of industry leaders representing diverse viewpoints.

On September 1, 1988 the FCC adopted a "Tentative Decision and Further Notice of Inquiry". Several tentative findings were made. They were as follows:

- providing for terrestrial broadcast use of ATV techniques would benefit the public;
- the benefits of ATV technology can be realized most quickly if existing terrestrial broadcasters are permitted to implement ATV;
- any spectrum capacity needed for terrestrial broadcasting of ATV must be obtained from the spectrum now allocated to terrestrial broadcast television (VHF and UHF);
- existing terrestrial broadcast service to viewers using NTSC receivers must be continued at least during a transition period either by broadcasting ATV signals that can be received directly by NTSC receivers or by simulcasting NTSC and ATV signals on separate channels;
- the need for NTSC compatibility and the scarcity of spectrum lead to the conclusion that systems requiring more than 6 MHz to broadcast a signal non-compatible with NTSC receivers will not be authorized for terrestrial broadcast service;
- it is in the public interest not to retard the independent introduction of ATV in other services or on non-broadcast media, although sensitivity is expressed to the benefits of compatibility between equipment associated with the various video delivery methods.

The FCC set forth four alternative methods for accommodating ATV in the terrestrial broadcasting service. Each terrestrial broadcaster would:

- provide an NTSC compatible³ ATV service within the current 6 MHz assignment;

3. In this article, "NTSC compatible" means the broadcast signal can be received and displayed with normal quality on a conventional NTSC receiver without any converters.

- be provided with an additional 3 MHz for an augmentation signal;
- be provided with an additional 6 MHz for an augmentation signal;
- be provided with an additional 6 MHz for a simulcast⁴ non-compatible ATV signal.

The FCC is seeking comments on its Tentative Decisions, on the options for accommodating ATV service, on ATV systems being designed for terrestrial broadcast service, on how technical standards should be established for ATV, and on possible scenarios for distributing supplemental spectrum if it is decided to do so.

Many other organizations have formed task groups to study HDTV from different perspectives. Several terrestrial broadcasters formed the Advanced Television Test Center (ATTC). The ATTC plans to test the systems proposed for broadcasting ATV and submit its test results to the different organizations involved. The cable industry formed the Cable Television Laboratories to conduct research on HDTV relevant to the cable industry. Congressional Committees have held inquiries to examine the possibility of increasing the competitiveness of American industry in manufacturing HDTV consumer electronics.

4. Techniques under consideration

Development of ATV systems is advancing rapidly with tests of picture quality, spectrum performance and certain other parameters planned in the period 1990-1991. In this development a number of trends can be noted:

- NTSC-compatible proposals, which include a wide-screen format, are strongly supported. Prototype demonstrations have taken place. These proposals are, of necessity, based on analog modulation techniques and, as a result, their performance is constrained by the well-known impairments of terrestrial broadcasting channels.
- A growing level of support has been seen for simulcast proposals. Such systems are believed to offer improvements in performance over NTSC-compatible systems due to the use of digital techniques to make more efficient use of the available bandwidth.
- Proposals that make use of augmentation channels, in addition to a basic NTSC-compatible channel, are losing support.

4. In this article, "simulcast" means that programmes are broadcast simultaneously in the NTSC format in one 6 MHz channel and in a "non-NTSC compatible" ATV (or HDTV) format in a second 6 MHz channel.

Because of the interest in both NTSC-compatible and simulcast systems, the introduction of ATV services may be a two-step process. The first step would be the introduction of a wide-screen format with improved quality of sound and picture in a fully compatible manner. The second step would be the introduction of high-definition, channel-compatible, receiver-incompatible, simulcast systems.

It is also possible that the two steps will be pursued in parallel. That is, some broadcasters may choose to broadcast the NTSC-compatible system while others choose to move directly to the simulcast system. In such a scenario, consumers would likely be provided with a choice of receivers operating at both levels.

5. Conclusions

In contrast with other regions, there is great interest in North America in terrestrial broadcasting of HDTV. Several systems have been proposed for terrestrial, cable, and satellite broadcasting. Organizations are in place and are proceeding to examine the proposed systems and define the technical standards. The introductory date of HDTV services in North America is difficult to predict. Many questions remain concerning business, economic, and technical aspects. In addition, consensus has not been reached on the level of quality required for the services to be viable.

ANNEX

The FCC Advisory Committee on Advanced Television Service

The Advisory Committee on Advanced Television Service was established by the FCC to advise it on the facts and circumstances regarding ATV systems for Commission consideration of the technical and public policy issues. In the event the Commission decides that adoption of some form of advanced broadcast television is in the public interest, the Committee would also recommend policies, standards and regulations that would facilitate the orderly and timely introduction of ATV services in the United States.

The scope of activity includes all steps necessary to assemble and analyze information, deliberate upon appropriate policies and actions, and develop recommendations regarding the introduction of terrestrial ATV service.

The Advisory Committee reports to the Chairman of the FCC and is composed of about 25 television industry leaders selected to represent diverse viewpoints. Three Sub-Committees report to the Advisory Committee.

1.0 Planning Sub-Committee

The objective of the Planning Sub-Committee is to plan the attributes, or desired features, of terrestrial ATV service (picture quality, population served, costs to broadcasters/consumers/manufacturers, relationship to existing broadcast service, relationship to non-broadcast services) and recommend planning factors for ATV service (coverage area, quality of service, frequency reuse criteria, receiver quality, spectrum allocations).

Seven Working Parties and two Advisory Groups report to the Planning Sub-Committee.

1.1 Working Party on Technology Attributes and Assessments

This Working Party has to define and list the desirable attributes of terrestrial transmission systems for ATV. The list of basic issues of interest will be used by other Working Parties as a guideline for gathering data and describing and evaluating various systems under consideration.

1.2 Working Party on Testing and Evaluation Specifications

This Working Party has to develop specifications for the testing and evaluation of proposed ATV systems and develop a draft schedule for testing and evaluation to be performed by the Systems Sub-Committee. The specifications shall include measurements related to the attributes developed by the Working Party on Technology Attributes and Assessments.

1.3 Working Party on Spectrum Utilization and Alternatives

This Working Party has to carry out studies on the availability of spectrum to support various ATV schemes for terrestrial broadcasting using modelling techniques in connection with a number of spectrum utilization scenarios. Scenarios will be based on a series of assumptions including coverage, bandwidth, allocations, other radio service considerations, taboos, international agreements and projection ratios.

1.4 Working Party on Alternative Media Technology and Broadcast Interface

This Working Party has to establish a point of reference or baseline for designers of broadcast ATV systems so that a user-friendly interface is achieved whenever broadcast signals interface with alternative media. It is to be a focal point for other Working Parties to obtain information on the operational, technical and environmental aspects of alternative media. Alternative distribution technologies include satellite, fiber optics, cable television, microwave, VCR and video disk. This Working Party will develop the tests required to determine the suitability of proposed ATV systems for transmission through and between the alternative media.

1.5 Working Party on Economic Factors and Market Penetration

This Working Party shall identify the economic factors which will influence the development and penetration of ATV services and the impact on programme providers, programme distributors, and consumer equipment manufacturers, provide a methodology for economic evaluation, define the economic issues and identify the factors involved in consumer acceptance of ATV in terms of time and cost. Special attention will be given to the probable incremental cost to consumers.

1.6 Working Party on ATV Systems Subjective Assessment

This Working Party is to identify system characteristics in need of subjective assessment and recommend test methods for the subjective assessment of picture and sound quality of proposed ATV distribution systems. Topics in need of specification may include viewing conditions, test methods, data analysis, and subject populations. It shall propose guidelines for the production of subjective test material with static and moving scenes. In accordance with CCIR Recommendation 500, the test material "shall be critical, but not unduly so".

1.7 Working Party on Audience Research

This Working Party is to define, plan, and execute audience research which will lead to an understanding of viewer preference in the field of HDTV programmes viewed in the home. It shall investigate the types of programmes most appreciated in HDTV, the types of viewers who most appreciate HDTV programmes, the willingness of viewers to pay a premium for HDTV display, and the willingness of viewers to pay a premium for HDTV service in the home.

1.8 Advisory Group on Creative Issues

This Group is to assess the views of the creative community in relationship to the development and implementation of a terrestrial ATV transmission system in the United States.

1.9 Advisory Group on Consumer/Trade Issues

This Group is to identify the consumer and trade issues that must be resolved before a set of recommendations can be forwarded to the FCC.

2.0 Systems Sub-Committee

The objective of the Systems Sub-Committee is to specify the transmission and reception facilities appropriate for providing ATV service. The Sub-Committee is to provide advice on the parameters of systems, and evaluate (technical and economic) and recommend systems under development as candidates for implementation. This Sub-Committee may specify the design of an appropriate system. It will also advise on the appropriate transmission/reception technical standards and spectrum requirements for the recommended system(s). Four Working Parties report to the Systems Sub-Committee.

2.1 Working Party on Systems Analysis

This Working Party is to analyze the various candidate systems proposed for the distribution of ATV using the attributes developed in the Planning Sub-Committee. The transmission media shall include terrestrial broadcast, satellite broadcast, CATV, fiber optic distribution and hybrid systems composed of the above technologies.

2.2 Working Party on Systems Evaluation and Testing

This Working Party is to evaluate the transmission performance of various ATV distribution systems based on objectives developed by the Planning Sub-Committee. Extensive subjective and objective performance testing shall be conducted.

2.3 Working Party on Systems Economic Assessment

This Working Party shall establish estimates of the costs associated with the distribution of ATV by various systems, with inputs from the Planning and Implementation Sub-Committees. An assessment of the technological viability and economic feasibility of each system will be established.

2.4 Working Party on Systems Standard

It shall recommend standards for the transmission of ATV.

3.0 Implementation Sub-Committee

The objective of the Implementation Sub-Committee is to establish a scheme for implementation of advanced television service in the

United States. This Sub-Committee is to provide advice on policies, regulations and standards and develop a transition scheme for implementation of ATV service. It will also recommend appropriate FCC policies and regulations to oversee implementation of advanced television service and develop guidelines for industry activities. Two Working Parties report to the Implementation Sub-Committee.

3.1 Working Party on Policy and Regulation

The task of this Working Party is to define and address the policies and regulations appropriate to guide the implementation process.

3.2 Working Party on Transition Scenarios

The tasks of this Working Party is to critique the transition process for various generic system concepts in order to evaluate their implementation requirements and identify generic classes of ATV service. For each class, it shall develop reasonable implementation scenarios and determine requirements for implementation at each stage of the system (production, distribution, transmission, reception, display). It shall also consider impact on terrestrial and alternative media technology and develop an implementation plan for the selected system.

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Authors

Robert Hopkins is the Executive Director of ATSC. Prior to joining ATSC in 1985, he was the Managing Director of RCA Jersey Limited, Jersey Channel Islands (United Kingdom), an overseas subsidiary of RCA that manufactured professional television equipment for a world-wide market. He was also employed by RCA at the David Sarnoff Research Center and the Broadcast Systems Division. He is a fellow of the SMPTE and past Chairman of SMPTE's Standards Committee, Committee on New Technology, and Working Group on Digital Video Standards. He received the BSEE from Purdue University in West Lafayette (Indiana); PhD from Rutgers University, New Brunswick (New Jersey); and attended the Harvard Business School Program for Management Development.

Kenneth P. Davies is a graduate in Electrical Engineering of McGill University, Montreal. He has been involved in television broadcasting since graduation in 1957 in equipment design, planning and technical operations with both equipment suppliers and television broadcasters. He is presently Associate Director of Strategic Engineering at CBC responsible for technical research and development. He also serves as Director of TV Engineering for SMPTE and as Chairman of the NSG for CCIR Study Group 11 in Canada. He is a fellow of the SMPTE and a member of the IEEE.