Towards HDTV
DVB vs. ATSC

By
Rita Brennan
Apple Advanced Technology Group, U.S.A.

A Brief History of Television

The history of pyschovisual studies probably began during ancient civilization. The architectural plans for the Greek Parthernon show that viewers could best take in the Parthenon if it were built at a 5:3 aspect ratio, or 1.6666. It's no surprise then that when MUSE, the first HDTV system, was built, the Japanese based their new television screen on this ancient standard.

In the early part of the 20th Century, when David Sarnoff and his contemporaries were building television, they chose a similar aspect ratio, 1.3333 or 4:3; which later became the aspect ratio for the American National Television Systems Committee or NTSC. Early Hollywood movies adhered to the 4:3 aspect ratio, but unlike TV, they fluctuated among several aspect ratios over the years. Disney showed many films in 5:3 (the Greek allure thing again), other studios shot movies in 16:9 because it was complementary to both 4:3 and 5:3. Today, especially thanks to famous directors such as Steven Spielberg and digital HDTV supporters, 2:1 is gaining in popularity.

Beyond aspect ratio, the technologies that comprise HDTV are many. Many important decisions have been made in the HDTV world such as what broadcast transmission formats are necessary, how many pixels per second and pixels per line are captured and displayed, how interlace is sampled for a digital output, how progressive scan images are captured and displayed, to name a few.

This article attempts to compare and contrast the most significant advanced television standards committees' Recommendations for HDTV. In the U.S. the Advanced Television Standards Committee (ATSC) has championed HDTV, and in Europe, the Digital Video Broadcasting Committee, with support from the EU, has standardized their own versions of advanced television. I warn the reader now that this paper is acronym and concept loaded, so for further definition of acronynms in this paper, see the Glossary at the end.

What is Digital Video Broadcasting or DVB?

DVB, Europe's contemporary answer to advanced television, looks a lot like standard U.S. television in a digital bottle: 4x3 aspect ratio, interlaced, non-square pixels (sampling lattice), which has been adopted by several national administrations. The thrust and future direction of DVB is digital and 16:9 but perchance not HDTV, as defined in the U.S. by ATSC and developed by the Grand Alliance. ATSC (the acronym for the U.S. originated Advanced Television Systems Committee), in its high definition formats, is square pixel, wide aspect ratio and mostly progressive scan (14 out of 18 formats). ATSC also includes a number of SDTV formats to accommodate legacy material. The European-standardized DVB standard has portions relating to terrestrial, satellite, cable, MDS, and even disk and Internet. The U.S ATSC is almost exclusively written from the terrestrial perspective. MPEG compression plays a key role in each. From an MPEG perspective, DVB is MPEG 2 Main Profile @Main Level (MP@ML) compliant. So is ATSC's HDTV, but here's where many differences come into play.

How DVB contrasts with standards chosen for ATSC

- audio: MPEG 1 audio vs. Dolby AC-3.

- screen aspect ratio: 4:3 vs. 16:9

- modulation scheme: COFDM (used in DVB-T) vs. VSB (for U.S. terrestrial broadcast). COFDM is a modulation scheme based on Orthogonal Frequency Division Multiplexing (i.e., a multicarrier modulation). OFDM transmits many streams of data simultaneously, with each one occupying only a small portion of the total bandwidth. VSB stands for vestigial side band.The Federal Comuniations Comission (FCC) has mandated the ATSC ATV standard be 8-VSB for terrestrial broadcasts, with an enhanced 16-VSB for data only applications.

• MPEG-2 Profiles: MP@ML only vs. MP@ML & MP@HL (high level)

• Vertical line resolution: Maximum active vertical lines of 1152 vs. 1080 (although 1080 will most likely become the world-wide common format). DVB specifies 1152, while ATSC specifies 1080 maximum. Note that DVB adopted 1080 under pressure to accept a common world-wide format. The vertical line resolution of 1080 was a compromise solution put together by the CCIR 601 folks. It favored neither MUSE (an analog interlace format of 1125 lines at 60hz) from the Japanese, nor the MPEG encoded 1440 x 1035 standard, which is the digital raster of MUSE, nor the 1250 line standard from Europe, which is based on a 2048 x 1152 square pixel raster. Hence, the 1920 x 1080 line, square pixel standard was accepted as it seemed to favor no one. The promoters of this format also believed this would be accepted by the computer industry, because it is square pixel, and it fit into a 2M pixel screen memory buffer, which wouldn't cause grief in the computer industry. Note that SMPTE has defined 1920 x 1080 to be the Production Aperture. The production aperture is the size of the full image acquired by the taking device.

• Pixel format: interlaced/non square pixel centric vs mostly progressive/square pixel formats.

Employing only MP@ML may be a backward looking vision of digital television. While claiming to employ MPEG-2 Transport Stream, DVB essentially makes limited use of MPEG-2, not employing MP@HL or the High 1440 profile also defined by MPEG-2. High 1440 in DVB has little to offer that we are not already taking full advantage of here in the U.S. via DBS, digital cable and perhaps soon via DVD video and DVD-ROM.

DVB employs only the MP@ML subset of the standard, while ATSC also includes MP@HL. HL enables true HDTV resolutions. Note that the current ATSC specification does not include the H-1440 profile either. Many would say that DVB is not really backwards looking for digital television in general, but rather the difference between SDTV and HDTV. DVB's primary goal was DTV, not HDTV.

It is primarily DVB's MP@ML that is competing with the proposed ATSC standard for digital world television. By incorporating it into the standard we have increased the risk that this is the only format that will be adopted by the people who really matter...the consumers who pay for new receivers or digital decoders. Migration upwards is always costly.

Who Uses and Endorses DVB?

The European DVB standard (which is MPEG-based) is employed by Echostar. DSS, which is the Hughes acronym for Digital Satellite Service is a trademark of Hughes, and refers only to the system that they and USSB use, which is not DVB.

Echostar (aka DISH Network) and Alphastar are both based on the DVB standards, with the requisite modifications in vertical pixel counts and picture rates to suit NTSC receivers. Both of these digital direct-to-home satellite TV services have highlighted DVB Standards compliance in their marketing. General Instrument is a DVB member. Most of the major Japanese manufacturers are, too. Thomson Consumer Electronics and Philips are members as well. Thus, the satellite services using GI equipment may be complying with DVB.

Divicom supplies the encoders and muxes for The DISH network (Echostar) and they are DVB "compliant." The reason I put quotes around compliance is that, unlike MPEG, there is no published conformance document so there is no real way to prove compliance. In practical terms, this typically means that the DVB equipment manufacturers need to do system level integration tests to prove inter-operability. This may prove detrimental to PC TV convergence and support when the time comes, as PC industry TV specifications will be MPEG-2 compliant.

What's DSS and Does it Support DVB or HDTV?

DSS is not based on DVB standards (audio and video are MPEG, transport and transmission are proprietary). It loosely conforms to Table 3 of the ATSC HDTV standard and conforms closely to

MP@ML. These days complete home systems for digital TV via satellite can be bought for less than $200. Although this price requires a year-long subscription to a programming package, the low cost helps explain why over 2 million digital satellite systems have been sold in the US in the last 11 months. Hughes, the company that sells the DirecTV system, has also begun offering DirecPC, a satellite system that lets PC users link to the Internet via satellite. This satellite-based system grabs the Internet IP packets, throws it 22,300 miles into space to a satellite, bounces it back down to a 21" dish on your roof, and sends it straight into your PC. Up to 400 kbps. 28 times faster than the average modem. 3 times faster than ISDN lines. These systems, however, are still priced over $500 and are limited to receiving data at 400 Kbs.

Implications/Opinions: Digital satellite systems such as DirectTV are being adopted at a much faster pace than originally expected. Consequently, cable companies now have to scramble to find the funds to upgrade their systems to digital.

DSS Has Internet Potential

But DSS also has important implications as a means of access to the Internet. It is widely acknowledged that the current 28.8 kbps analog modem speed is at least an order of magnitude slower than most home users would like. But the various wired alternatives to the plain old telephone system (POTS)--ISDN, cable modems, and ADSL--all appear to have significant drawbacks, such as limited coverage and multiple standards, that will prevent rapid and ubiquitous implementation. By contrast, 18" satellite antennas can be placed in almost any geographical location and satellite receivers don't have a plethora of standards. I suspect that this sheer simplicity and the low cost of DSS could overcome many of the obstacles faced by the other technologies to merge home TV and home Internet/Web.

Note though that satellite receivers aren't cheap enough yet. But they will be soon since they leverage high-volume digital TV satellite technology. And if a pricing model similar to that of DirecTV or the cellular phone industry is adopted, i.e., subsidize the equipment cost through subscription fees, a sub-$200 price point will be easily achievable. The biggest barrier to widespread adoption of digital satellite technology for Internet access in the home will then be its "receive only" format. But the fact that a satellite can receive at high speed but must depend on POTS to send data back upstream should not be a problem for the majority of users since Internet surfing is inherently asymmetric. Most users just want to browse, so much of what goes upstream consists of short strings of text. But high bandwidth is usually needed in the downstream direction for receiving multimedia content.

In the final analysis, low cost DSS should prove to be very attractive to most home users, with the exception of those who need good quality videoconferencing capability.

Data Broadcasting

The ATSC recently organized a working group to address users' data needs. Data broadcasting was identified as the way to support data such as email, interactive channel guides, etc. A Data Broadcast study group (T3/S13) was established to address DB issues. They focus on applications requirements, profiles, and transport protocol support. So far they are looking to use the MPEG DSM-CC specification (Digital Storage Media - Command and Control) which defines a data carousel application to support a streaming data profile.

DVB on the other hand, has no concept of profiles, but has defined four classes of data broadcasting: data piping, data streaming, multi-protocol encapsulation and data/object carousel. DVB treats each each of these categories separately and not as profiles of a single defined transport standard as ATSC T3 does. The DVB-SI-DAT group has completed the final draft standard for data broadcasting (including IP-based) over MPEG-2 Transport Stream. This is based on several of the protocols specified in International Standard ISO/IEC 13818-6, MPEG-2 Part 6: Digital Storage Media Command and Control (DSM-CC). Defined within DVB SI is a Data_Broadcast_Descriptor. The ATSC is currently working on a proposal to be entirely compatible with DVB. It has been suggested that the Data_Broadcast_Descriptor could provide clear distinction between DVB vs. ATSC streams. Each of the types of broadcast may be indentified by examining the Stream Type - ATSC uses 0x0B &

0x05. DVB data carousel uses 0x0B as well - all others use other stream types. This means that one of the first steps used by a decoder to find data services is to examine the stream type in the PMT & filter on 0x0B and 0x05 (depending upon what is being looked for). This will automatically filter out all but the ATSC & the DVB data carousel.

The ATSC T3/S13 also addresses data carousel by defining a profile for using one. This most likely will also be based on DSM-CC's Data Carousel, User-User Object Carousel, User-Network Download, and MPEG-2 Transport Stream protocols (although the work effort is still in progress). These DSM-CC protocols enable, for example, the downloading of software, the delivery of Internet-type services over broadcast channels and interactive TV over MPEG-2 Transport Stream based networks, such as the systems defined by ATSC and DVB.

> Note that DSM-CC includes many other protocols which address other related areas. The concepts and protocols of DSM-CC provide the general capability to browse, select, download, and control a variety of bit stream types. DSM-CC also provides a mechanism to manage network and application resources through the concept of a session. A Session is an associated collection of resources required to deliver a Service. Examples of resources are MPEG-2 Transport Stream packet identifiers and network bandwidth. The Session complements a "Service Domain," which is a collection of interfaces to browse and select services, and control the delivery of bit streams.

The ATSC effort is more preliminary than that of DVB.

More on the DVB Project

The Memorandum of Understanding was signed in 1993. There are now more than 200 members worldwide. The first standard, for satellite, DVB-S, was issued within a few months. The cable standard, DVB-C, came next. Then came the SMATV version, DVB-CS, completed in 1994. The terrestrial system took longer and was specified just before the end of 1995. The MDS system was not yet finalized as of September, 1996. There are two versions: one for use below 10 GHz and one for use above. The Service Information system (something like an embedded viewers' guide), DVB-SI, was recently completed, as have DVB-Text (a teletext extension) and DVB-CI (conditional-access common interface). A return-channel interactive system is under development.

Standards are confirmed in ETSI and, sometimes, CENELEC. HDTV has been considered, but, since no one has put forth a business plan for it, it has not yet been acted upon, although DVB just recently adopted the 1080 active line ATSC format which may finally enable a world-wide common resolution format for HDTV.

Everything seems to be common up to the modulation systems. DVB-S uses QPSK, DVB-C uses QAM, DVB-T uses OFDM.

The terrestrial version is not yet on the air but is expected to be by 1998 at the latest. It uses COFDM instead of ATSC's VSB. A group of European broadcasters met at IBC in September to confirm plans for DVB-T (the terrestrial version).

Here are the existing, ratified standards:

ETS 300421 DVB-S
ETS 300429 DVB-C
ETS 300468 DVB-SI
ETS 300472 DVB-Text
ETS 300473 DVB-CS

The Digital TV Wrap-up

Digital TV provides an extraordinary improvement in picture and sound quality. It also offers the potential for vastly expanded broadcast formats, interactive services and the eventual return to the public domain of large amounts of the analog spectrum currently used by broadcasters. Advances in compression have also made digitally based NTSC, PAL and SECAM more efficient. Note that NTSC video used to require something on the order of ~160Mbits/s to transmit digitally whereas now it only requires ~8Mbits/s; down by a factor of 20. So, as transmission quality and efficiency go up, laying the ground work for advanced interactive services, the requirement for bandwidth for the traditional TV services is going down. I recently heard an MPEG expert from Samsung say that with advances in algorithms and compression, digital TV (e.g., with a wide screen aspect ratio of 1080x1920) will require a bandwidth of less than 48bits/s. Today, ATSC defines a bandwidth of 18.5Mb/s for video including the 1080 format.

If broadcasters want better digital television they must commit to broadcasting high-end digital television. Picture quality is only one of many factors in designing a new digital mass media standard. The current vision of digital television, embodied in both the proposed ATSC and DVB standards, is both inadequate and too aggressive. It fails to deliver many of the potential benefits of a digital mass media standard, while it seeks to deliver levels of picture quality that are not currently economically viable in the marketplace.

Globally, we should strive to provide a better, more affordable, more interoperable vision of digital television. There is now an opportunity to develop a robust MPEG-2 Profile that supports the baseline all-progressive scan format that the FCC provisioned in their landmark decision regarding the ATSC formats on December 23, 1996. The ATSC's call for layered coding is the first step in this direction. One can only hope that DVB will follow suit and worldwide compatibility will follow.

Glossary

ATSC Advanced Television Systems Committee; Founded in 1983 to develop standards for advanced television in the United States. ATSC also develops implementation strategies for advanced television.

ATV Advanced Television; The acronym commonly prescribed to discussions of digital and advanced analog television.

COFDM see OFDM

DBS Digital Broadcast Satellite

DirecTV a proprietary digital satellite system from Hughes.

DVB Digital Video Broadcasting; a multi-national European standard for digital television. The short term vision and solution to high definition television in Europe. Digital PAL at 50Hz.

DVB-C	DVB for cable systems.
DVB-CI	conditional access common interface for DVB-C
DVB-CS	the SMATV cable version of DVB-C
DVB-S	DVB for satellite
DVB-SI	Service Information channel
DVB-T	the DVB teletext extension

ETSI European Telecommunications Standards Institute. The force behind European DVB standardization.

FCC Federal Communications Commission (in the U.S.). The governent body that oversees the work of high definition television.

HDTV High Definition Television. Originated in Japan with the first HDTV proposal by NHK (Nippon Hoso Kyokai, or Japan Broadcasting Corporation), which was analog. Later, several U.S. based organizations forged the Grand Alliance to promote all digital proposals for HDTV. The acronym HDTV stuck for the high end digital television proposals using MPEG-2's Main Profile at High Level Profile (MP@HL) for ATV. All data packets would be 188 bytes long, with 4 bytes of header/descriptor and 184 bytes of payload. Same as MPEG-2 Transport Stream packets.

IBC European International Broadcast Consortium

MDS Multipoint Distribution System. Also known as MMDS (Multichannel Multipoint Distribution System) or wireless cable, uses microwaves to deliver signals to the home. Like satellite, MDS utilizes a dish placed on the roof, connected via cable to a set top unit in the home. However, unlike satellite, the transmitter is ground based. Also, the dish required is much smaller (e.g. 20-30 cm (8-12 inches). In some cases, a dish is not required, only an antenna.

MPEG Moving Pictures Experts Group; An international standards committee established as a joint technical committee of the International Standards Organization and the International Electrotechnical Commission, specifically, ISO/IEC JTC1/SC29/WG11.

MPEG-1 ISO/IEC 11172. A five part International Standard developed by ISO/IEC JTC1/SC29/WG11 for the coded representation of moving pictures and associated audio for digital storage media at up to about 1.5Mbit/s. Note though that the data rate is not limited to 1.5Mbits/s. It's just the one most commonly stated as used. However, 2.048Mbit/s is the common rate in Europe (for the E1 line - PDH network in Europe). MPEG-1 is published in five partsof which four are of interest. Part 1 - Systems - specifies the system coding layer of the standard. It defines a multiplexed structure for combining audio and video data and means of representing the timing information needed to replay synchronized sequences in real-time. Part 2 - video - specifies the coded representation of video data and the decoding process required to reconstruct pictures. Part 3 -audio - specifies the coded representation of audio data and the decoding process required to reconstruct audio. Part 4 - compliance specifies procedures to determine characteristics of coded bitstreams and to test compliance of bitstreams and decoders with the requirements specified in Parts 1,2 and 3.

MPEG-2 ISO/IEC 13818. A ten part International Standard developed after MPEG-1 to accommodate compression in digital media supporting advanced media services such as DBS, DVB and ATV, and notably, HDTV, and support the real-time delivery of said information in lossy environments. Again, like MPEG-1, bitstream rates are not limited at the upper bound. Bitstream rates can be as high as 100Mbits/s. As specified in ISO 13818-2 (Video), MPEG-2 stream rates are defined as 15 Mbits/s at MP@ML, 80 Mbit/s for MP@HL, and 100Mb/s for the base layer of HP@HL. In the ATSC advanced television specification, a maximum MPEG-2 Transport Stream bit rate of ~19.3 Mbit/s is given. Frame rates are 60 Hz (fields if interlaced, else frame), 30 Hz, and 24 Hz. Other parts of the standard of interest are Part 1 Systems, Part 3 Audio, Part 4 Compliance, Part 6 Digital Storage Media Command and Control, and Part 7 Advanced Audio Coding (non-backwards compatible audio extension for more efficient multi-channel audio).

MP@HL Main Profile at High Level (to accommodate HDTV television screens with at least 720 x 1280 lines of resolution on a 16:9 aspect ratio screen with frame rates of 24, 30 and 60 Hz progressive.

MP@ML Main Profile at Low Level (to accommodate digital NTSC and PAL / DVB).

OFDM Orthogonal Frequency Division Multiplexing. Several parallel channels with low bitrate whose carriers are overlapping but orthogonal. This is an efficient way of having several subchannels in a fixed bandwidth. The subcarriers are not separated by a distance corresponding to their bandwidth but are overlapping. The spacing between the subcarriers are arranged such that they become orthogonal, hence the name OFDM. Apart from the bandwidth efficiency, you get a fast implementation with FFT, which is used as a digital modulator/demodulator of each subchannel.

QAM Quadrature Amplitude Modulation. Amplitude modulation in which two signals modulate on in-phase (0 degrees) and quadrature (90 degrees) carriers, thus doubling the information carried in an amplitude-modulated (AM) system. QAM is used by the Cable TV industry instead of VSB for coax or HFC DTV.

QPSK Quadrature Phase Shift Keying. 4 phase digital modulation. Two data channels modulate the carrier. Transitions in the data cause the carrier to shift by either 90 or 180 degrees. This is the binary version of QAM. This allows customers to transmit two discrete data streams, identified as I channel (In phase) and the Q channel (Quadrature) data. Digital Dolby AC-3 has an encoded bitstream using (QPSK) modulation.

SDTV Standard Definition Television: digital NTSC.

SMATV Satellite Master Antenna Television. Paid wireless TV service where a small antenna is placed on the roof of the building receiving the television service.

USSB U.S. Satellite Broadcasting (company)

VSB a transmission method developed by Zenith, whereby a part of the lower AM sideband is filtered out before transmission leaving a vestige of the sideband remaining. The purpose of VSB is to reduce the frequency band needed for the video modulation in the picture signal. This makes it possible to use the 6-Mhz TV broadcast channel instead of the 8 MHz or more that would be needed for the double sidebands of a 4 MHz modulation. The Grand Alliance plans on competitive testing of the 4-VSB, 6-VSB and 32-QAM broadcast modulation systems and their related, higher-data-rate cable modes. Early choices by the Grand Alliance included the 16-VSB broadcast scheme. VSB is based on a form of linear QAM coding with 4 instead of 16 bands in the AM carrier wave signal matrix. Zenith is a member of the U.S. Grand Alliance. Note that the FCC has mandated the ATSC ATV standard be 8-VSB for terrestrial broadcasts, with an enhanced 16-VSB for data only applications.