The worldwide ITU dimension to DTV standards

— the impossible took a little longer!

Stanley Baron and David Wood

This article describes the progress made in the ITU-R during the 1980s and 90s to prepare international standards for digital terrestrial television systems. The last ITU-R meeting on this project was held in November 1996 – almost 10 years ago – at which a set of Recommendations for digital broadcasting systems was agreed, laying the foundations for the global roll-out of DTV and HDTV terrestrial broadcast services.

In the late 1980s, standards for digital programme production had been developed [1] and were beginning to be used, but delivering digital television beyond the studio and into the home seemed "impossible". The bitrates needed were considered to be well beyond the capacity of any terrestrial, satellite or cable broadcast channels. A sequence of events – and the work of dedicated individuals – changed this as the early 1990s unfolded. By the mid-1990s, digital television broadcasting standards were in place for all delivery means: satellite, cable and terrestrial broadcasting. The impossible had been achieved in about three to four years.

Digital television was developed in parallel in several parts of the world, but the different groups came together under the umbrella of the International Telecommunication Union (ITU), an agency of the United Nations, which is charged with developing international agreements and *Recommendations* [1] for both wired and wireless communications. Specifically, they came together within *CCIR Study Group 11*, the part of the ITU concerned with television broadcasting. In the 1980s and 1990s, under the leadership of Prof. Dr Mark Krivocheev, CCIR Study Group 11 was the crossroads for the world's television broadcast technologies.

CCIR Study Group 11 (SG 11) brought together engineers and managers from across the world. Some came to propose ideas and encourage others to adopt them. Some came to assimilate knowledge to allow them to make the best decisions for their national television services. It was the great melting pot of ideas for broadcast technology. It was an inspiring time for those who participated, and the authors were fortunate in being able to do so.

This article [2] describes the evolution of digital terrestrial television (DTT) broadcasting standards in CCIR Study Group 11, connecting this with the evolution of digital television (DTV) standards development in different parts of the world. Late in 1991, SG 11 delegates recognized the momentous advancements being made in DTT broadcasting technology. They recognized that the time was ripe to work on Recommendations to support global DTV services. The work of the ITU was (and is) conducted in committees that are assigned specific areas or issues: in broadcasting these include

1. ITU technical standards are referred to as "Recommendations".
2. In the title of the article, "the impossible took a little longer!" comes from the traditional engineers' saying: "*the difficult we do immediately, the impossible takes a little bit longer*".

areas such as video, modulation, quality, etc. They work within umbrella groups, the *Study Groups*. The committees are called *Working Parties*.

In 1991, the Chairs of the Study Groups and Working Parties formed the *Coordination Group* of Study Group 11, working under the leadership of Study Group 11's remarkable Chair, Prof. Dr Mark Krivocheev, who had served as Chair of Study Group 11 since 1974. The "Coordination Group" of Study Group 11 spent much time considering how to arrange the studies for DTT broadcasting. The ground to be covered included much more than any one or even two of the Working Parties. Many of the issues were interrelated, and sometimes politically sensitive. Furthermore, the timetables for all the elements had to be synchronized, and the work had to be rapidly accomplished before the world's Administrations became committed to many local, proprietary systems. The only solution was to create a dedicated cross-disciplinary *Task Group*. Due to the urgency of the need to establish the new Task Group, the Australian Administration accepted the request of the Coordination Group to endorse a new Question and propose it for adoption by correspondence. The Australian proposal was supported by 20 Administrations. Thus, Australia is a "founding father" of ITU DTT standards.

The charge to the Task Group was to define the technology required to support DTV broadcasting services.

Launching the project

Task Group 11/3, its terms of reference, its Chairman and Vice-chairmen were approved in a ballot of the Member Nations in January 1992 [2]. Stanley Baron (USA) was elected as the Chairman. Terry Long (UK) and Osamu Yamada (Japan) were elected as the two Vice-chairmen.

Figure 1
Chair of TG 11/3, Stan Baron, opening the first meeting in December 1992

ITU procedures provide for a minimum period between the approval of an ITU Committee and its first meeting, to allow the Member Nations to prepare documents and appoint delegations. Therefore, the Task Group met for the first time in Geneva, 14 - 18 December 1992. The meeting was attended by more than 115 delegates representing 43 national Administrations and international organizations.

Prior to the first meeting, the Task Group Chairman suggested that organizing the work as a design and development project would expedite the Task Group's effort. Noting that the MPEG standard provided a broad set of tools from which a subset could be selected, the Chairman further suggested that the Task Group should set itself the goal of developing a set of Recommendations describing a set of tools that would eventually result in a single chipset, regardless of which subset of tools was adopted by a broadcaster. This suggestion recognized that the cost to the consumer would be inversely proportional to the volume of production. A single chipset would maximize the long-term benefits to both manufacturers and consumers and help the introduction and worldwide adoption of DTV. It was understood that exceptions might exist within Recommendations involving the modulation subsystem, which must accommodate the existing 6, 7, and 8 MHz broadcast channels, and in special unique services adopted by regional broadcasters.

The Chair worked with a team of five other individuals consisting of the two Vice-chairmen and Thomas Ryden (Sweden), Richard Barton (Australia) and David Wood (EBU/Chair of Working Party 11A) to create an *Outline of Work* [3]. The Outline of Work provided a systems model and a list of issues which the Task Group should consider in preparing its Recommendations. The document also presented a set of draft Recommendations for consideration, an outline of a report (or reports) to be generated either as annexes to Recommendations proposed by the Task Group, as reports to carry the work of the Task Group forward, or in the form of a possible tutorial report. The Outline was distributed in June 1992 and was intended to serve as a guide for Administrations, and other interested parties, preparing the documents for consideration at the first meeting of the Task Group in December 1992 in Geneva. In effect, the Outline allowed the Task Group to begin its work six months prior to the first meeting.

The systems model divided the project into areas of investigation and *Special Rapporteurs* were appointed by the Chair to develop each area. The Special Rapporteurs, who would serve as the Chairmen of the Task Group subcommittees, were appointed in June 1992 and approved at the first meeting. The system-model areas of investigation were:

1) ***Source Coding and Compression***;
2) ***Service Multiplex and Transport***;
3) ***The Physical Layer*** including channel coding parameters and the modulation scheme, and
4) ***Planning Factors*** (which included consideration of both the transmission and receiver environments) and implementation strategies.

The two Vice-chairmen of 11/3 also served as Special Rapporteurs. Terry Long (UK) served as Special Rapporteur on *Planning Factors*. Osamu Yamada (Japan) chose to lead the effort on the *Service Multiplex and Transport*.

Thomas Ryden (Sweden) was appointed as Special Rapporteur for *Audio Source Coding and Compression*. Brian Roberts (New Zealand) was appointed as Special Rapporteur for *Video Source Coding and Compression*. During 1993, Thomas Ryden became Chair of another group, TG10/3, and Brian Roberts assumed responsibility for all source coding in Task Group 11/3. The Outline plan focused early efforts on the subject of source coding, which was in a relatively advanced state of development, and would define the bit-capacity required by the transmission system.

Work on the *Physical Layer* was assigned to Richard Barton (Australia). Starting in 1993, Keith Malcolm (Australia) shared the responsibilities. This was the task with the longest planning cycle, since the science in this area was furthest from being proven.

David Wood (EBU/Working Party 11A) was asked to investigate methods for achieving a worldwide digital television broadcasting system and to document a minimum standards set.

The goal was to develop a set of DTV system tools that would allow broadcasters to provide a wide variety of services in an integrated and interoperable environment and embraced the following principles:

- ***Diversity of services:*** There should be no constraint on the types of imaging, sound and data services (limited only by the total bitrate or data capacity of the system).
- ***Interoperability:*** There should be no constraint on service flexibility. The DTV system should enable useful and cost-effective interchange of electronic images, sound and data among different applications and different performance levels.
- ***Extensibility:*** There should be no constraint on the ability to grow into new services, thus providing protection against obsolescence.

Initial challenges

Prior to the first meeting, there was general agreement that any new digital television broadcasting service should provide the capacity to carry wide-screen images of higher resolution than existing conventional television services, and to have multichannel sound capability.

But the legacy of analogue television was still strong and, in many parts of the world, much time and resources had been invested in developing multiplexed analogue component (MAC) broadcasting systems, which were seen as the “practical” way to deliver to the home the quality available from 4:2:2 digital programme production and HDTV. MAC systems, based partly on analogue and partly on digital technology, were implemented in several approaches to provide SDTV and HDTV services.

In the late 1980s, there was a development which was to have a major impact on all forms of all digital video, and was to significantly improve the efficiency of digital video compression. This was the development of integrated circuits that could perform practical ***Discrete Cosine Transforms*** (DCTs) in real time. It was this technological key, more than any other single element, which would transform the world of broadcast delivery from analogue to fully digital.

When, in 1987, the United States FCC Advisory Committee on Advanced Television Services (ACATS) published a request for technical proposals for the next-generation terrestrial broadcasting system, over two dozen systems were offered, the majority of which were based on MAC technology. There were, however, four proposals based on all-digital technology. The digital systems used various proprietary compression, coding and modulation technologies. After testing the proposals, the advantages of all-digital became clear and the proponents of digital systems were invited to reconcile their proposals into a single proposal for an all-digital HDTV-capable terrestrial broadcasting system, as documented by the Advanced Television Systems Committee (ATSC).

One of the four digital systems proposed to the ATSC was developed by the Advanced Television Research Consortium (ATRC). It was based on the MPEG-2 standard and utilized a multi-carrier modulation scheme. The ATRC system provided the first over-the-air digital HDTV simulcast in the Americas on 30 September 1992, proving that a digital DCT system based on the MPEG system could support the required services. Over the course of a week, NTSC versions of TV programmes were broadcast on WRC-TV channel 4 in Washington DC, while HDTV programming was simultaneously broadcast over a UHF channel from the WRC-TV antenna and received 68 miles (approx. 100 km) away.

The European industry had formed a consortium in the late 1990s to develop an analogue-hybrid-component HDTV satellite and cable broadcasting system, HD-MAC. In addition, two alliances of companies in the Eureka programme and RACE programme VADIS project investigated the use of DCT transforms for video compression which might be used for broadcasting SDTV or HDTV. The Nordic countries (Sweden, Norway, Denmark and Finland) fully developed a system (HD-DEVINE), based on all-digital technology and incorporating DCT compression technology.

Abbreviations

8-VSB 8-state Vestigial SideBand

ACATS Advisory Committee on Advanced Television Systems (USA)

ATRC Advanced Television Research Consortium (USA)

ATSC Advanced Television Systems Committee (USA)
http://www.atsc.org/

CCIR (ITU) International Radio Consultative Committee

COFDM Coded Orthogonal Frequency Division Multiplex

DCT Discrete Cosine Transform

DTT Digital Terrestrial Television

DTTB Digital Terrestrial Television Broadcasting

DTV Digital Television

DVB Digital Video Broadcasting
http://www.dvb.org/

DVB-T DVB - Terrestrial

FCC Federal Communications Commission (USA)

HDTV High-Definition Television

IEC International Electrotechnical Commission
http://www.iec.ch/

ISDB Integrated Services Digital Broadcasting (Japan)
http://www.dibeg.org/

ISO International Organization for Standardization
http://www.iso.org

ITU International Telecommunication Union

ITU-R ITU - Radiocommunication Sector
http://www.itu.int/ITU-R/publications/rec/index.asp

JTC (ISO/IEC) Joint Technical Committee

MAC Multiplexed Analogue Component

MPEG Moving Picture Experts Group
http://www.chiariglione.org/mpeg/

MUSE Multiple Sub-Nyquist sampling Encoding

NTSC National Television System Committee (USA)

PAL Phase Alternation Line

SDTV Standard-Definition Television

SECAM *Séquentiel couleur à mémoire*

SMPTE Society of Motion Picture and Television Engineers (USA)
http://www.smpte.org/

UHF Ultra High Frequency

Subsequently, the DVB project developed DVB-T in 1993 as a digital container for digital terrestrial broadcasting, both SDTV and HDTV.

The Japanese had in the early 1980s developed an advanced MAC-based system, MUSE, designed for satellite broadcasting of the 1125i/30 HDTV system. Later in the 1990s, the ISDB-T family was developed for all-digital broadcasting, after the completion of the work of Task Group 11/3.

One of the main advantages of all-digital technology was always understood to be the more efficient use of spectrum through digital compression. More efficient use of the spectrum allowed more services and more diversity in the services offered. Digital packetized communications systems, using headers and compression technology, provide flexibility, economy and compatibility across a broad range of distribution media, allowing development of new services and the practical possibility of a myriad of entertainment, education, information and transactional services.

Since the focus of the Task Group was on terrestrial broadcast standards, the principal challenge was due to terrestrial channels being the most constrained of the media delivery channels. Channel bandwidth is limited. The channels assigned to broadcast television services were (and are) limited to 6, 7, or 8 MHz bandwidth, depending on the region of the world. Furthermore, the channels were (and are) both noise- and interference-limited.

The DTV system

The Outline of Work included a model of a digital terrestrial television broadcasting system. The model was divided into four areas of interest with sub-groups assigned to develop the required Recommendations and Reports. Each sub-group was chaired by a Special Rapporteur. The Task Group used the model as the basis of its investigations. The four sub-systems of the system model were as follows *(see Fig. 2)*:

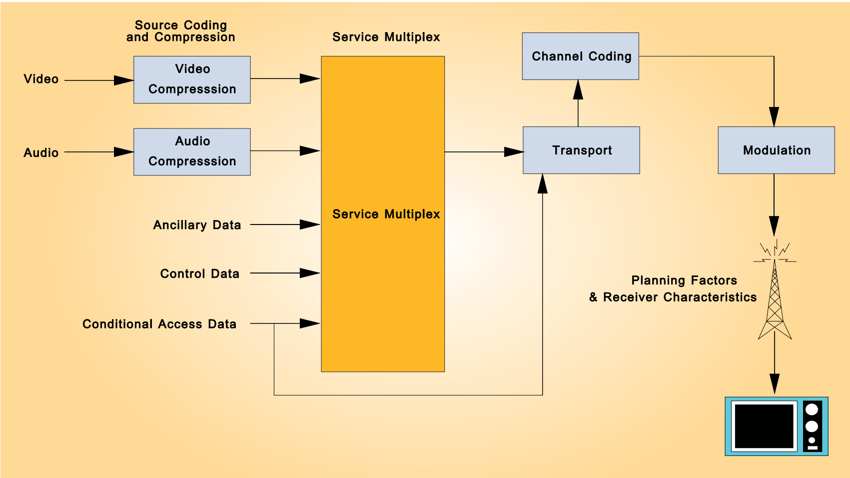

Figure 2
DTV systems model

In *Fig. 2*, the term *ancillary data* includes system control data, conditional access control data, or data associated with the programme audio and video services, such as closed captioning. Ancillary data can also refer to associated independent programme services such as still pictures or text used to provide additional information relating to the primary service.

Source Coding and Compression relates to coding methods that reduce the data stream created when images or sound are represented by a sequence of sample values (digitized) and which minimize the number of bits needed to represent the information. For image data, each pair of values represents the luminance and colour information contained within an individual sample or “pixel” (picture element). For sound data, each value represents a digital audio sample. In summary, the purpose of the source coder is to convert the audio and video into data and minimize the number of bits needed to represent the information.

The first function performed by the *Service Multiplex and Transport* is to divide the elementary digital data streams received from the source coders into packets of information, uniquely identifying each packet or packet type and its place in time. This module then multiplexes the video, audio and ancillary data-stream packets into a single programme or service data stream. The Multiplexer may also provide the capability of combining different programme data streams into a single broadcast channel for simultaneous delivery.

Through inputs from the worldwide community, the IEC/ISO JTC1 developed a timely standard, MPEG-2 [4], for the coding and multiplexing of high-quality video, audio and data signals, with the potential to be used for digital television systems. The MPEG-2 standard was developed, based on DCT, for television applications in which channel bandwidth or recording media capacity is limited and the requirement for an efficient transport mechanism is paramount.

The *Physical Layer* includes the channel coding and the modulation scheme. The *channel coder* takes the resulting compressed data bit-stream and adds additional information that can be used by the receiver to recognize and reconstruct the images, sound and ancillary data from the transmitted signal. Some of these additional bits may serve to assist in reconstruction when some of the data has been lost during transmission, due to noise in the channel of other forms of interference. The characteristics of the channel coder are selected to support the modulation scheme adopted for the system and the medium through which the data must be transported.

Modulation is a mechanism whereby the protected data stream is imposed on one or more carrier signals for transmission. These transmission systems are referred to as *single-carrier* and *multiple-carrier* schemes, respectively.

Planning Factors includes consideration of the characteristics of the transmission media and receiver environment, and discussions of strategies appropriate for the introduction and implementation of a digital terrestrial television broadcast service, taking into account existing broadcasting services.

Summary of Task Group Recommendations

Task Group 11/3 completed its work in November 1996 and produced a set of Recommendations and Reports that defined a digital terrestrial television broadcasting system. Task Group 11/3 based its work in many ways on both the work and the philosophy behind the MPEG-2 standard. The MPEG-2 standard provides a set of tools, from which a set can be selected. The approach to the work on the DTV Recommendations was similar. The set of Recommendations defined by Task Group 11/3 establishes a set of tools that can be used to provide DTV services.

In October 1994, Stan Baron [5] and David Wood [6] developed a Recommendation [7] that provided the basis for agreement on the minimum standards set for a digital terrestrial television broadcasting system. Two constrained subsets of the standard's set of tools were described in detail in the DTV Recommendations: ***System A*** (ATSC) and ***System B*** (DVB). The differences between the two subsets were minimized and harmonized with respect to the video and audio coding and transport levels so that there are no conflicts and single "plug-and-play" decoders were made possible. By constraining the syntax allowed in the ITU-recommended tool kit, Task Group 11/3 helped the development of a less complex, low-cost, consumer appliance for worldwide use.

A list of the international Recommendations and Reports produced by the Task Group are given in *Appendix A*.

Video coding

During the first year of the Task Group's effort, a consensus was reached to adopt MPEG-2 as a mechanism for video source coding for broadcasting applications [8].

A selection of the MPEG video-encoding profiles and levels was made. Of the 20 available, two were proposed. The number of included profiles and levels impacts the complexity and, therefore, the cost of the consumer appliance (receiver) and the cost of providing programme content for the international market. These two profile/levels were:

- the ***Main Profile at Main Level*** (MP@ML), which defines the consumer appliance for standard digital television services only;

- the ***Main Profile at High Level*** (MP@HL), which provides for a consumer appliance capable of decoding both HDTV and standard-definition DTV services.

The set of DTV video sub-system tools were defined in ITU-R BT.1208 and allow content producers to provide programming in conventional, wide-screen and HDTV formats. Task Group 11/3 recommended that emphasis be placed on systems employing MP@HL, thereby ensuring a “plug-and-play” environment for consumers. Recommendation BT.1208 states:

> ***“In order for a television receiver to be able to decode all these various television services it has to have functionality of the highest profile and highest level proposed for these services. This leads to the choice of the Main Profile at the High Level as the conformance point in the MPEG-2 standard.” [9].***

Prior to the final meeting of Task Group 11/3, four levels were being considered but, at the final meeting, agreement was achieved on the dropping of two profile/levels: the Main Profile at 1440 (MP@14) and the Spatially Scalable Profile at 1440 Level (SP@14).

The MP@14 profile/level was intended for use in interlaced 1080-line HDTV services that used only 1440 samples-per-line. However, because of the backward compatibility requirement of MPEG standards, the MP@HL profile/level described in the DTV standard could accommodate such services.

The Spatially Scalable (SP@14) profile had been considered for use in accommodating spatially- and temporally-scaled services, where an SDTV signal is broadcast together with a “top-up” signal when needed, to provide HDTV services. After an investigation, conducted primarily by the European Broadcasting Union (EBU), consideration of this profile was dropped, as spatially- and temporally-scaled services had been shown to be inefficient for use in terrestrial broadcasting.

Receivers capable of decoding the complete set of tools were defined in ITU-R BT.1208. This answered the request of the World Broadcasting Union for a system that can be accommodated by a single universal consumer appliance.

Audio coding

The selection of an audio source-coding system was controversial. There were two primary candidates, the MPEG-1/2 Level 2 system (MUSICAM) and the Dolby AC-3 system, both of which could provide three levels of audio performance (monaural, stereo or surround sound). MUSICAM was part of the MPEG-2 specification and in wide use. AC-3 was a more recent development and arguably a more efficient system. DVDs allowed for both systems.

After investigating how the MUSICAM and AC-3 systems worked, the Task Group chairman concluded that decoders for these two systems could be viewed as a collection of “resources” (arithmetic units and memory) under the control of one or more instruction sets. The appropriate instruction set could be selected for the service that was desired. Since the resources required to implement the two systems were very similar, a dual decoder would not require the building of two separate decoders, but could be implemented employing a single collection of resources with six resident instruction sets. After discussing this architecture with manufacturers of audio equipment, it was concluded that (licence fees apart), the cost to the consumer of purchasing a digital television receiver with a dual decoder would be less than a 0.25% increase over the cost of a receiver with a single system decoder capability. After some discussion, the Task Force approved a Recommendation providing for both MUSICAM and AC-3, thereby protecting the existing coded audio programmes.

The set of DTV audio sub-system tools were defined in ITU-R BS.1196 [10] and allow content producers to choose between both MPEG and AC-3 compression and coding tools. Single decoders, capable of decoding the complete set of tools for both MPEG and AC-3 coded sound as defined in ITU-R BS.1196, are widely used and chipsets are provided by multiple manufacturers.

Transport level

During the second year of the Task Group's effort, a consensus was reached to adopt a subset of the MPEG-2 standard as the mechanism for the service multiplex and transport. The work to fully define the modified transport and service multiplex consumed another two years.

MPEG-2 required some minor additions to allow for use in the broadcast environment. In order to facilitate the acceptance of these changes by the MPEG committee, the chairman of the MPEG committee, Dr Leonardo Chiariglione, was invited to participate in the Task Group meetings. Dr Chiariglione understood why changes requested by the Task Group were necessary, and he expedited work within the MPEG committee to incorporate the desired additions.

The service multiplex and transport that provides the foundation for the DTV system is a constrained subset of the MPEG-2 standard tool set and was defined in ITU-R Recommendation BT.1300 [11]. BT.1300 allowed for the development of a single decoder at the transport layer that can translate the service multiplex and transport layer, and extract the audio, video and ancillary data streams for any system that conforms to the DTV set of Recommendations. This established a “plug-and-play” environment for the consumer without the need to consider the specific coding subset used.

The assignment of packet identification as described in ITU-R DTTB System A and System B was harmonized to avoid the possibility of decoder errors. Systems which conform to the subset of the MPEG-2 transport defined in BT.1300, including the use of the Descriptor Tags and Table ID assignments, allow for the development of single devices capable of decoding the entire set of tools defined in BT.1300. Development of such decoders was made possible by the decisions taken at the final meeting of Task Group 11/3.

The existence of single decoders capable of decoding the entire set of tools defined in Rec. 1299 satisfied, once again, the request of the World Broadcasting Union for a set of broadcasting systems that meet regional broadcasting requirements but that can be accommodated by a single universal “plug-and-play” consumer appliance.

Physical layer

One of the major obstacles to agreement on a standard for the modulation system was the lack of uniformity in the use of the broadcast spectrum throughout the world. Countries that had adopted the NTSC system had developed spectrum plans employing 6-MHz channel bandwidth. Countries that had adopted the PAL and SECAM systems had developed spectrum plans with channel bandwidth that ranged from 6 MHz to 8 MHz. Therefore, the maximum available bit-capacity of the systems would vary geographically (given the same assumptions about error protection in each case).

Furthermore, there are other infrastructure differences which need to be accommodated. Sometimes national broadcasters produce and distribute programmes nationally to local service providers, but allow for local insertion of commercials and locally-generated programming. At other times, broadcasters provide a unique service regionally or nationally. In these environments, broadcasters produce and distribute programmes that are broadcast nationally or regionally without local modification. These broadcasters needed a system that allowed for the use of a single frequency from multiple transmitters that was impervious to reflections.

Recommendations concerning the DTV physical layer (channel coding and modulation scheme) were defined in ITU-R Recommendation BT.1306, which considered the existing 6, 7 and 8 MHz allocation of channel assignments and the need to accommodate differing environments and planning factors. The set of Recommendations and Reports can be viewed as providing a single compatible system solution for DTV within the practical physical limitations of the current worldwide channel-assignment environment.

Recommendation BT.1306 provided for 8-VSB, a single-carrier modulation technique, and COFDM, a multi-carrier modulation technique. COFDM was found to be less susceptible to multipath interference and facilitates single-frequency networks. 8-VSB was found to be slightly more bit-efficient (carried more bits per MHz) and required less power for fixed antenna reception, given low multipath interference. The difference in modulation technique employed depends greatly on local planning factors, which are dependent on the bandwidth of the channels used in various parts of the world and on local environmental conditions.

Multi-programme capability and interoperability with other media

The application of digital compression technology to television signals enables multi-programme transmission in the existing channels. Compressed digital television systems offer the prospect of considerable improvements in service quality while appreciably improving spectrum utilization as compared with analogue transmission methods. Use of MPEG-2 compression technology can be exploited to deliver three or more television programme channels in the spectrum currently assigned to one analogue television programme channel. Television service providers have a choice of delivering multiple digitally-compressed television programmes instead of a single conventional, enhanced or high-definition programme. These digitally-compressed television signals can be accompanied by digital high-quality sound, coded conditional-access information and ancillary data channels. Task Group 11/3 paid particular attention to constructing a digital architecture that could accommodate both high-definition television (HDTV) and conventional television (SDTV) services in the terrestrial broadcasting environment and that was interoperable with cable delivery, satellite broadcasting and recording media.

Different modulation schemes may necessarily exist for use with cable, satellite or recorded media to optimize the use of those channels. A common transport stream used as a transport “container” produces a universal data stream after demodulation in the consumer receiver or playback appliance and facilitates the interoperability of the signal through different delivery media. The existence of a common data stream simplifies the complexity of the consumer receiver appliance.

HDTV

During the final meeting of the Task Group in 1996, several nations indicated an interest in the 1080-line system as the basis of international agreement on an HDTV standard for programme interchange. Content producers, particularly those with global markets, obviously benefit from common standards. The HDTV standards proposed in the 1980s – the then current 1152-line interlaced/ 50 Hz (Europe) and 1035-line interlaced/60 Hz (Japan/USA) standards – were close and could be married together in the 1080i format. The advantages of the 720-line progressive/60 SMPTE standard were not yet proven. Only the 1080-line interlaced standard – existing in both 50 Hz and 60 Hz versions – provided the prospect for international agreement [3] [12]. The parameter values of the 1080-line system were documented in ITU-R Recommendation BT.709, Part II [13]. This was prepared in the early 1990s by CCIR Working Party 11A, chaired by David Wood [4].

Assignment completed

The final meeting of Task Group 11/3 was held in Sydney, Australia, in November 1996. At this meeting, international agreements defining a complete digital broadcasting system were finalized. Given the Australian initiative that launched the Task Group, it was appropriate that the final meeting be held in Sydney.

3. In practice, this meant the 1080 interlaced system, since the 1080p system was outside the specification of MPEG-2 encoding at 50 Hz and 60 Hz frame rates.
4. At that time, the only technology available for home display was the CRT, to which 1080 interlaced scanning was well suited.

Figure 3
The ITU handbook on digital terrestrial television, one of the important fruits of the work of TG 11/3

The Task Group produced a set of Recommendations that went beyond providing for digital terrestrial television services. It offered the ability to construct a digital highway into the home that allowed for a range of digital services. The set of Recommendations could be used to transmit an HDTV service with surround sound and supporting data, or multiple SDTV services, or provide a data path to download text, still pictures and other information.

At the final meeting, the Task Group also provided for continuation of the work by standing ITU Working Parties with specific suggestions for future maintenance. The Task Group recognized that technical standards are never "finished", and its work should be viewed as the beginning of an evolutionary process.

The concept of viewing the DTV system as a set of compatible modules was proven by the fact that some Administrations adopted the set of System A (ATSC) parameters while others adopted the set of System B (DVB). Other Administrations, such as Australia, adopted a mixture of the two.

Much has happened in the ten years since the work of Task Group 11/3 was completed in 1996. DTV is available across the world, though its establishment in the developing countries has been slower than we thought it would be ten years ago. There are now new and more efficient compression schemes and progressively-scanned flat-panel HDTV displays. The development of standards is truly never complete.

Many things stand out from the work of TG 11/3. The standards themselves have been widely used and drawn upon, and the concept of standards which are tool kits from which to draw "profiles" is now universally applied. The idea of single receivers with a worldwide market may have been ahead of its time, but it remains a valuable long-term vision and, step by step, we will get there. If applied earlier, it might have accelerated the growth of DTV in the developing world.

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Stanley Baron obtained BSEE and MSEE degrees from New York University and was involved in the design and development of digital television systems over four decades, beginning in 1962. He was the inventor of the first commercially-available digital graphics generator for television applications. In 1980, he described a digital sampling structure and equipment interface for television that was compatible with existing 50 Hz and 60 Hz television broadcast standards. His proposal became the basis of the international standards for component 4:2:2 digital television.

Mr Baron retired at the end of 1998 as Managing Director, Television Technology for the National Broadcasting Company (NBC) in New York where he was responsible for the investigation, evaluation and implementation of new television technology. He served as Chairman of the Advanced Television Systems Committee, Technology Committee, (ATSC-T3), charged by the FCC with responsibility for documenting the digital Advanced Television System standard, and was elected by the member nations as Chairman of the ITU's Task Group, ITU/R-TG11/3, charged with responsibility for developing international agreements on digital terrestrial television broadcasting.

Stan Baron is a past-president of the Society of Motion Picture and Television Engineers (SMPTE). He also served two terms as SMPTE Engineering Vice President with responsibility for supervising approximately 100 projects and approximately 600 professionals involved in developing US and international technical standards. He has been elected a Fellow of the Royal Television Society (UK), a Fellow of the SMPTE, a Fellow of the IEEE, and a Fellow of the BKSTS (UK).

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Within the EBU, Mr Wood works with the Digital Strategy Group of the Administrative Council, and a number of other groups involved with HDTV and new media.

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ITU-R, 1995.

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ITU-R, October 1997.

[12] ITU-R Doc. 11-3/78: **Report on the Third and Final Meeting of Task Group 11/3**
ITU-R, 1 Dec. 1996.

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ITU-R, October 1997.

Continued ...

Appendix A:
Task Group 11/3 Reports and Recommendations

Area of Interest	Document
System:	
Digital Terrestrial Television Broadcasting in the VHF/UHF Bands (2002)	Handbook
Rec: *The Basic Elements of a Worldwide Family of Common Systems for Digital Terrestrial Television Broadcasting*	ITU-R BT.1299
Video coding and compression:	
Rec: *Video Coding for Digital Terrestrial Television Broadcasting*	ITU-R BT.1208
Audio coding and compression:	
Rec: *Audio Coding for Digital Terrestrial Television Broadcasting*	ITU-R BS.1196
Service multiplex and transport:	
Rec: *Service Multiplex Methods for Digital Terrestrial Television Broadcasting*	ITU-R BT.1209
Rec: *Service Multiplex, Transport, and Identification Methods for Digital Terrestrial Television Broadcasting*	ITU-R BT.1300
Rec: *Data Services in Digital Terrestrial Television Broadcasting*	ITU-R BT.1301
Rec: *Data Access Methods for Digital Terrestrial Television Broadcasting*	ITU-R BT.1207
Physical layer:	
Rec: *Error Correction, Data Framing, Modulation and Emission Methods in Digital Terrestrial Television Broadcasting*	ITU-R BT.1306
Rec: *Spectrum Shaping Limits for Digital Terrestrial Television Broadcasting*	ITU-R BT.1206
Rec: *Planning Criteria for Digital Terrestrial Television Broadcasting Services in the VHF/UHF Bands*	ITU-R BT.1368
Report: *Guidelines and Techniques for the Evaluation of Digital Terrestrial Television Broadcasting Systems*	ITU-R BT.2035