

## WORLDWIDE HDTV STANDARD FOR BROADCASTING AND ELECTRONIC CINEMA

*For the anniversary of an outstanding Scientist  
and International leader Prof. Ilija Stojanović*

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**Abstract.** In Dubrovnik from 12 to 23 May 1986 the XVIth Plenary Assembly of CCIR took place, headed by the Chairman Prof. I. Stojanovic. On this Assembly the problem of HDTV perspective system standardization was for the first time generally discussed by CCIR.

The Assembly approved the report of CCIR SG 11 (TV broadcasting) chairman on this problem and adopted a number of important documents which contributed to its effective solution, including the Resolution to hold an Extraordinary meeting of SG 11 on HDTV.

The author provides a brief historical overview, focusing on the development of HDTV standard taking into account the progress of digital technologies, using CCIR and ITU-R documents as the basis of the study. On SG 11 meeting in June 1999 an improved Recommendation for HDTV was unanimously approved. It was a worldwide HDTV standard for broadcasting, international programs exchange and electronic cinema. So a very important stage of long work on creating the basic standard of society information in XXI century was reached

### 1. Introduction

In 1972, the ITU began a study on a new high-definition television (HDTV) service. The goals for this high-definition service included viewing at approximately three times picture height, such that the system would provide images that are virtually transparent to the quality of portrayal perceived in the original scene by a discerning viewer with normal visual

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acuity. This implied the development of a system with improved motion portrayal, perception of depth, and colorimetry with respect to the current 525- and 625-line television broadcast standards. Such a system would allow viewing on large, wider aspect ratio displays that would leave the viewers with the perception that they were surrounded by the images. The system was also seen as providing a common tool for use in electronic film production and special effects for the cinema, printing, computer imaging, television photography, and a vast array of applications in education, medicine, video conferencing, scientific work, and so forth.

The system was based on the use of new technologies with a heavy dependence on the application of digital technology and has had a radical impact on all aspects of the television chain from program-generation facilities through program distribution and the television receiver itself. A new era in television broadcasting was brought about by developments in digital television originally conceived to meet the challenges of implementing HDTV service.

Efforts to achieve international standards for high definition television (HDTV) were greatly influenced by the various implementation scenarios adopted in different regions of the world. In the area of broadcasting, some countries envisaged the use of direct broadcast satellites as the primary delivery medium, whereas others envisaged terrestrial broadcasting and cable distribution schemes.

The CCIR, the International Radio Consultative Committee, as part of the International Telecommunications Union (ITU) concerned with broadcasting standards, provided the initial leadership in the field of HDTV. Subsequently, this work of the CCIR was assigned to the ITU Radiocommunications Sector (ITU-R) after the reorganization of the ITU in 1993.

The work of the CCIR and ITU-R in the field of high-definition television was assigned to Study Group 11 (television broadcasting). The assignment was the following:

- *Define* the parameters (digital and analog) of a single HDTV standard for studio production and for the international exchange of HDTV programs,
- *Study* the methods of emission of HDTV signals for terrestrial and satellite broadcasting.

The CCIR is the only international organization working on HDTV standardization on a worldwide basis. Although the CCIR has dealt with high-definition television since 1972, activities intensified after the XVth

CCIR Plenary Assembly in Dubrovnik (May 1986) to study and to develop HDTV techniques. Studies cover all aspects of HDTV, both analog and digital: program production, transmission and emission of signals in terrestrial or satellite services, transcoding to the traditional television systems and also the technical links to other existing or forthcoming media. The studies aim at standardization in the interest of the public, of telecommunication administrations and broadcasting organizations.

The effort to develop a new high-definition television service was initiated by a Japanese Proposal for a New Study Program - High Definition Television. CCIR Document 11/31, 17 March 1972.

Work on high-definition television began within the CCIR with the adoption of Question 27/11. The adoption of Question 27/11 subsequently led to a number of Questions, Study Programs, Resolutions, and Decisions regarding HDTV. Within Study Group 11, two Study Programs were created: 27A/11, concerned with HDTV compatibility with existing standards and broadcast channel assignments; and 27B/11, concerned with display technologies. The study programs led to Decisions which provided a structure for the investigation of this new service. The Decisions included:

- Decision 58, which established Interim Working Party (IWP) 11/6, charged with the study of HDTV;
- Decision 60, which charged IWP 11/7 on digital television to investigate the application of digital technology within HDTV;
- Decision 66, which charged IWP 11/4 on subjective assessments to investigate the means of assessment of HDTV system performance; and
- Decision 59, establishing a cooperative effort with Study Group 10, to investigate the means of video recording.

## **2. First step towards a global standard: XVI Plenary Assembly of the CCIR**

The XVIth Plenary Assembly of the International Radio Consultative Committee (CCIR) which met in Dubrovnik from 12 to 23 May 1986, devoted considerable attention to High-Definition Television (HDTV). HDTV was a subject of intense current interest and activity in the world of television programme production and broadcasting and was the subject of study within the work carried out by the CCIR since 1972 at the Study Group 11.

Study Group 11 on the eve of CCIR XVIth Plenary Assembly was engaged in comprehensive studies on the technical aspects of television broadcasting. It worked under the terms of reference adopted by the XVth Plenary

Assembly<sup>1</sup>. They include the following:

- the study of the technical aspects of the broadcasting service (television), including the use of satellites;
- the study of standards for motion-picture films intended for television and for all forms of television recording relevant to the international exchange of programmes.

IWP 11/6 was set up under Decision 58 (Document 11/239) to study the basic parameters of a high-definition television system. The Chairman was Mr. Tadokoro (Japan), and the Vice-Chairmen were Mr. Green (United States) and Mr. Habermann (Federal Republic of Germany). The IWP held meetings in Switzerland, the United Kingdom and Japan. High-definition television systems were demonstrated. As a result of its activities, IWP 11/6 developed: "Proposal for a new Recommendation (Document 11/499(Rev.1), and amendments to Report 801: "The present state of high-definition television" (Document 11/1008).

The situation with regard to high-definition television (HDTV) deserved particular attention. This problem was widely discussed (see Document 11/532) and a text was unanimously adopted for inclusion in the report of the Chairman of Study Group 11 the forthcoming CCIR XVI Plenary Assembly, as well as the first "Proposal for a new Recommendation - Parameter values for signal generation in HDTV studios and for international exchange of HDTV programmes".

The text referred to (Document 11/495 (Rev.1)) is reproduced below.

#### **STATUS REPORT ON HDTV CURRENT POSITION OF STUDY GROUP 11 ON HDTV**

##### **Introduction**

*In 1983 a CCIR Interim Working Party was established with the aim, as a first step, of establishing a draft Recommendation for a single world-wide HDTV studio production standard.*

*The members of CCIR Study Group 11 are united in their wish for a single world-wide HDTV standard, and all recognize the positive benefits of this. There is general agreement among all administrations regarding the need for a single system of approximately twice the horizontal and vertical resolution of existing television systems and having a wide aspect ratio. In addition, agreement exists on the use of components, expressed in both analogue and digital form, the latter to be closely related to Recommendation 601 "Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios". There remains, however, discussion about the precise parameter values, such as those concerning scanning, appropriate to achieve this aim.*

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<sup>1</sup>See Volume XI-1, page XXIII.

There are, at the time of the 1985 CCIR final meetings, a number of different perspectives, each of which is founded on genuine concerns and studies.

First point of view

The 1125/60/2:1 parameters were submitted for consideration as the basis for a single world-wide standard. Many administrations in both 525/60 and 625/50 countries support this proposal which was an output document (excluding the reservation note) of IWP 11/6 (11/399) following two years of intensive study. Extensive technical evidence, based on both objective and subjective testing shows that this proposal meets the requirements of a single world-wide HDTV studio standard outlined in the terms of reference establishing IWP 11/6. These administrations argue that the benefits of a single world-wide standard achieved in a timely manner are clearly preferable to the emergence of multiple standards. These administrations support the proposed for a new Recommendation (Document 11/499 (Rev.1) is given below.

Second point of view

Many other administrations, using the 625/50 standard, have reservations about, and are not able to accept, the 1125/60/2:1 parameter values at this time; there are a number of issues to be studied before a commitment is made to this, or any other, set of parameter values. One of the major and as yet unresolved issues is how the 1125/60/2:1 system will fit into the future broadcasting and transmission systems to be used in a 50 Hz environment, and secondly, what its relationship is to Recommendation 601. The first point is in line with Study Programme AK/11, and a similar approach is indicated for stereoscopic television in Study Programme AK/10-11. These administrations support the note of reservation contained in the proposed new Recommendation:

PROPOSAL FOR A NEW RECOMMENDATION  
PARAMETER VALUES FOR SIGNAL GENERATION IN HDTV STUDIOS  
AND FOR INTERNATIONAL EXCHANGE OF HDTV PROGRAMMES

The CCIR,

CONSIDERING

- (a) that an HDTV Studio Standard must provide pictures with approximately twice the horizontal and vertical spatial resolution of, and a larger aspect ratio than studio sources using existing standards;
- (b) that there exists a broad range of applications for HDTV;
- (c) that there has been substantial progress made in high definition television technology for production equipment;
- (d) that multiple different standards will cause difficulties among broadcasters in the future;
- (e) that the advantages of a single HDTV world-wide standard include lower HDTV equipment costs for broadcasters and viewers, easier exchange of programmes and technical information, and encouragement to the ideal of international solutions to common technical problems;
- (f) that HDTV studio signals will also be used as sources for current and currently proposed broadcast television systems;
- (g) that conversion to existing 625/50 and 525/60 composite standards can be provided with good quality;

- (h) that an HDTV studio standard must be specified in digital form with a simple relationship to Recommendation 601;
- (i) that the transfer to and from film can be provided with adequate quality,

#### RECOMMENDS

that the following standard parameters be used for generation of signals in high definition television studios and for the international exchange of high definition television programmes:

Number of scanning lines:	1125
Number of active lines:	1035
Field rate:	60.00 Hz
Scanning method:	2:1 interlace
Aspect ratio:	Horizontal 16 to vertical 9
Samples per active line:	1920 for luminance 960 for colour difference

*Note.* A number of administrations using the 625/50 standard have reservations about the parameter values above, and at this time are not able to accept these as a basis for a single world-wide HDTV studio and international exchange standard. They believe that reconsideration of some values may be needed. Every effort will be made to work in accordance with Decision 58.

#### Conclusion

The discussion is continuing in a spirit of mutual understanding. Administrations are aware of the urgent need expressed in some parts of the world to make use of an HDTV studio standard and they are conducting studies on HDTV parameter values as rapidly as possible.

This question was discussed at the XVIth Plenary Assembly. Matters relating to high-definition television were also considered in Report 801-1 (Document 11/1008): "The present state of high-definition television" and Report AC/10-11 (Document 10-11/1010): "High-definition television by satellite".

At that time had place such a position: Distribution of HDTV signals will occur either through wideband channels or through one or more WARC-77 or RARC-83 channels. In cases where bandwidth compression must be introduced, this is likely to cause some impairment to picture quality (see Report 801 and Report AC/10-11). Scan conversion at the display may not be necessary with HDTV, although in principle a further improvement in picture quality could be obtained with this technique.

A major problem in considering HDTV emission was the limited radio frequency spectrum available. For these reasons the WARC-ORB-85 charged the CCIR with the task of carrying out studies to find out, preferably on a

world-wide basis, the technical parameters and the frequency bands appropriate for HDTV transmissions by satellite.

The discussions which took place in Dubrovnik on HDTV related to the parameters which HDTV might have at the studio level and did not, at this stage, explicitly include the aspects of transmission and reception. It is obvious, however, that these issues had some impact on the deliberations.

A total of 19 proposals on the subject were made by participating administrations and organizations. To assist the Conference in reconciling the positions expressed through these proposals and with a view to coming to an agreement, as proposed by the Chairman of the Plenary Assembly Professor I Stojanovic, an Ad Hoc Group chaired by Prof. Dr. Krivocheev Chairman of SG 11 was established.

In the course of its work, the Ad Hoc Group amended report 801 (Document 11/1008 (rev 1)) which constituted the only consolidated CCIR report on HDTV, to include the developments which had taken place after November 1985 so as to reflect the current position as regards the standardization of HDTV. The amendments took into account that:

progress has resulted in the availability of HDTV production equipment from manufacturers in several countries;

a number of HDTV production facilities already used in various parts of the world, certain of the parameter values given in annex to report 801.

there is a need for HDTV studio standard to accommodate future broadcasting systems compatible with existing systems.

Because the views expressed were divergent on a number of issues, many of which were of a fundamental nature, and in view of the apparent advantages that the adoption of a single set of parameters for HDTV would bring, the Plenary Assembly unanimously decided to postpone the taking of a decision on a standard at this time but adopted a Resolution foreseeing an extraordinary meeting of Study Group 11 in 1988 to reach a conclusion on a draft recommendation on HDTV. To accelerate the work of standardizing HDTV, the Plenary Assembly also enlarged the scope of the mandate of Interim Working Party 11/6 - the sub-group within.

Ad Hoc Group supported the SG 11 Chairman's proposal about the adoption of a new global approach which is essential to increase the efficiency of international coordination of studies and standardization of new systems.

The idea of a *Global Approach* was to try to look at the development

of a particular system in the context of the totality of new developments in related areas after looking at all methods of delivering pictures to the consumer, it is important to design as much compatibility and inter - operability into the system as possible. These systems should be developed in close collaboration with leading international organizations, to achieve harmonization of television broadcasting interests with numerous non - broadcast television applications.

These considerations in turn introduce new challenges in terms of spectrum management for television broadcasting; i.e. the determination of power levels, interference and sharing criteria, and the protection ratios for terrestrial and satellite systems. These matters, like the system choices mentioned above, all require extensive coordination among the countries involved and between organizations within countries.

It was decided that this approach will be used in preparing for the Extraordinary meeting of SG 11.

### **3. Period 1987 - 1990: Shaping the Way Towards Global Harmonization**

Just after the XVth Plenary Assembly of CCIR the intensive preparation for the SG 11 extraordinary meeting began. An initial study produced a simplified scheme of a global approach to the HDTV environment, based on a suggestion by the chairman of Study Group 11 and is shown in Fig. 1. The model takes into account the different broadcasting interests, the many possible uses of HDTV and the necessity for harmonization between broadcasting and non - broadcasting applications (Doc 11/164; Doc 11/173; Period 1986 - 1990). In this model, the central element was the HDTV production center serving as the source of programs both for domestic use and for international exchange. Although most programming would be in a high-definition television production format, provision was made for the importing of programming material in other formats both in digital and analog forms, particularly from archival material. One of the stated goals of the HDTV production format was to provide near-35-mm image quality. One application for such a system is the creation of electronic-generated, special-effects image sequences for intercutting with 35-mm film.

From the standpoint of the continued use of existing television transmission networks and cable television systems, maintaining frequency plans currently in force when introducing HDTV, was seen as an important issue. The introduction of narrowband HDTV services in the UHF and VHF bands would be constrained by the nominal bandwidths for the existing standard



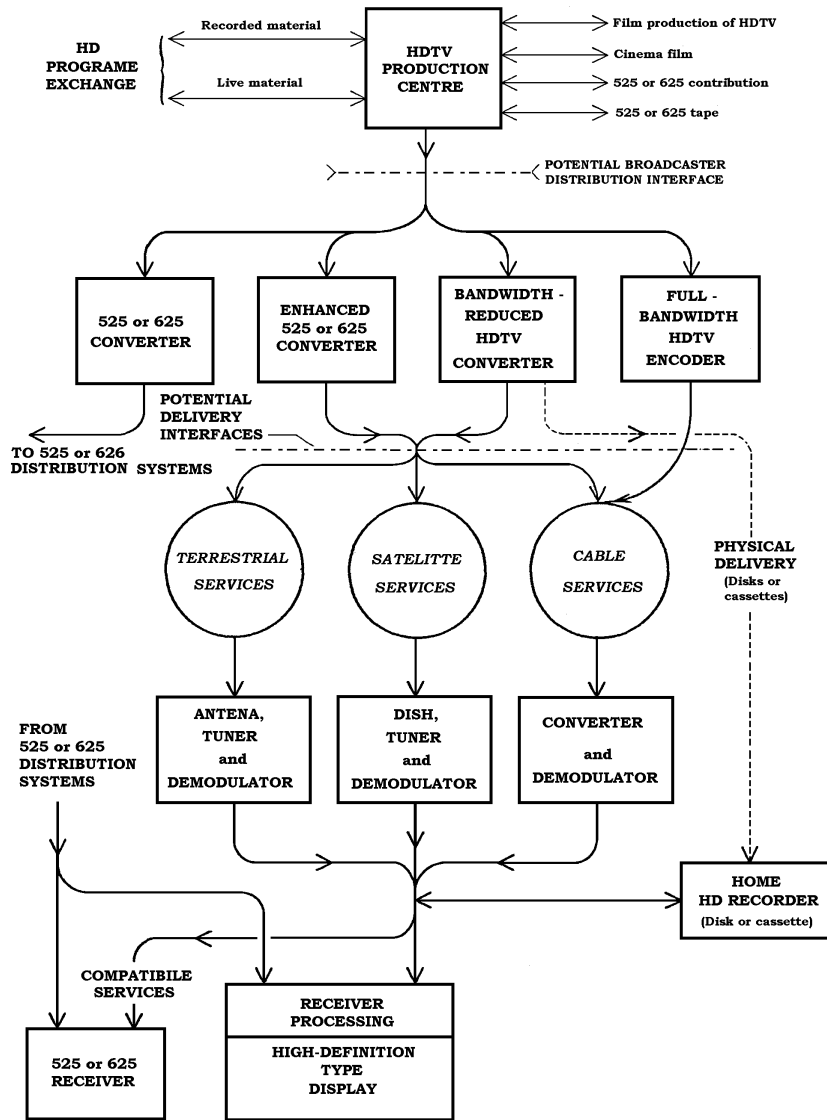


Fig. 1. HDTV delivery—the future environment

television channels used throughout the world, namely 6, 7, and 8 MHz.

A number of European countries presented their draft Recommendation for HDTV for the first time, which is reproduced below:

Documents  
 CCIR Study Groups  
 Period 1986-1990

Document 11/161-E  
 30 October 1987  
 Original: French

*Belgium, France, Germany (Federal Republic of), Italy, Netherlands  
 and United Kingdom*

### DRAFT RECOMMENDATION

#### PARAMETER VALUES FOR A SINGLE WORLD-WIDE HIGH DEFINITION TELEVISION STANDARD FOR PROGRAMME PRODUCTION AND FOR THE INTERNATIONAL EXCHANGE OF HDTV PROGRAMMES

The CCIR,

#### CONSIDERING

- (a) that an HDTV studio standard must provide pictures with approximately twice the horizontal and vertical spatial resolution of, and a larger aspect ratio than studio sources using existing standards;
- (b) that there exists a broad range of applications for HDTV;
- (c) that there has been substantial progress made in High Definition Television technology for production equipment;
- (d) that a multiplicity of standards will cause difficulties among broadcasters in the future;
- (e) that HDTV sources will also be used for current and currently proposed broadcast television systems;
- (f) that a conversion to existing 625/50 and 525/60 standards can be provided with good quality;
- (g) that an HDTV studio standard must be specified in digital form with a simple relationship to Recommendation 601;
- (h) that a 50 Hz field rate has advantages for the transfer to and from the existing film standard, which will continue to be an exchange format;
- (i) that motion portrayal is satisfactory with field rates of 50 Hz or greater;
- (j) that for a given bandwidth and interlace factor a 50 Hz field rate provides greater spatial resolution than higher field rates;
- (k) that a majority of countries currently use emission standards based upon a 50 Hz field rate;
- (l) that HDTV emission, transmission and studio standards are being considered in parallel;
- (m) that all parameters of an HDTV studio standard should be optimized with regard to conversion into the respective HDTV emission standard (either based on 50 or 59.94/60 Hz).

#### RECOMMENDS

*That the following standard parameter values be used for generation of signals for High Definition Television production and for the international exchange of High Definition Television programmes:*

<i>Number of active lines:</i>	<i>1152*</i>
<i>Field rate:</i>	<i>50.00 Hz</i>
<i>Scanning method:</i>	<i>Progressive**</i>
<i>Aspect ratio:</i>	<i>Horizontal 16 to vertical 9</i>
<i>Samples per active line:</i>	<i>1920 for luminance</i>
	<i>960 for colour difference</i>

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*\*This figure is chosen to be exactly twice the number of active lines defined in the interface specification for digital component video signals in 625-line television systems (CCIR Recommendation 656).*

*\*\*This is the target standard. The first implementation may be based on a bandwidth reduced system.*

The Director of the CCIR, on advice from Study Group 11 and the HDTV Coordination Group, confirmed the need for the Extraordinary Meeting which was held in Geneva, 10- 16 May 1989. It made considerable further progress towards the development of a single world-wide HDTV studio standard. At the same time, it forged closer links with other bodies concerned with high-definition television, to ensure the global harmonization of both the broadcasting and non-broadcasting application of HDTV.

The Extraordinary Meeting of Study Group 11 successfully completed all items of its agenda and produced four draft Recommendations on HDTV and a total of 11 new or updated reports. The work of a special ad hoc Group set up during the Extraordinary Meeting to produce the "Conclusions of the Extraordinary Meeting of Study Group 11" (Doc. 11/40, 1989), is particularly noteworthy. This was the first consolidated report that reflects all aspects of the world-wide harmonization taking place in HDTV.

High-definition television advances rapidly and in the short period between the Extraordinary Meeting and the Final Meeting considerable progress was made. For this reason, Study Group 11 decided to convene a special one week meeting of IWP 11/6, with representation from IWP 11/7, in March 1990, to take advantage of the developments prior to the XVIIth CCIR Plenary Assembly. The meeting was asked to prepare appropriate supplementary documentation that the Chairman of Study Group 11 shall consider as an addendum to his report to the Plenary Assembly.

The global approach to high-definition television adopted by Study Group 11 has been a driving force in this rapid progress. By means of Decision 74, the global approach of Study Group 11 towards HDTV was emphasized, including the role of high-definition television in the "Information Society" of the next century. A key component of this global emphasis is the harmonization of standards and operating practices for high-definition

television equipment intended for consumer application. In this regard, the need for coordination of standardization on the international level becomes essential, particularly among organizations concerned with information technology such as the IEC the ISO, and the relevant organs of the ITU.

The Final Meeting of Study Group 11 for the 1986-90 Period continued the pattern of progress in HDTV studies evident at the Extraordinary Meeting and added considerably to its Conclusions (Document 11/410). New draft Recommendation BO/11 has been adopted concerning HDTV telecine. There are now five CCIR draft Recommendations on HDTV matters, showing the progress that the Study Group has made and the value of the global approach taken in HDTV studies during the 1986-1990 Period.

The Study Group has successfully concluded all the tasks assigned to it by the XVIth Plenary Assembly of the CCIR in Resolution 96 and has progressed considerably beyond that point in its studies of HDTV. A good structure has been established also for the future work, recognizing the need for a global approach, taking account of a wide range of applications for HDTV and of the work proceeding in other organizations. The past, the present and the future of HDTV are fully covered in the texts that have been adopted in the Final Meeting and between the Final Meeting and the XVII Plenary Assembly.

#### **4. Challenges of the Global Harmonization: XVII Plenary Assembly of the CCIR**

It is important to note that the difficulties in reaching international agreement on a source standard were caused not so much by the different technical levels and economic capabilities of individual countries as by the question of what HDTV services were envisioned and by the specific national view on an implementation plan.

In international studies, there is often a tendency to focus on the points of disagreement rather than the points of agreement. On the positive note, there was much agreement in the area of an HDTV source standard. The specific parameters agreed upon included a picture aspect ratio (16:9) and a single worldwide agreement on both color rendition and on the equation for luminance. For the first time in the history of television, all countries of the world agreed on the technical definition of a basic tristimulus color system for displays. Also agreed upon, in principal, were the digital HDTV bit rate values for the studio interface signal, important to determining both the interface for HDTV transmission and the use of digital recording. All of these agreements culminated in Recommendation 709 and 710, adopted

by the XVII Plenary Assembly of the CCIR in 1990 in Düsseldorf<sup>23</sup>. The essential elements of Recommendation 709 are reproduced below:

## 2. Picture characteristics

Item	Characteristics Parameter	Value
2.1	Aspect ratio	16:9
2.2	Sample per active line	1920
2.3	Sampling lattice	Orthogonal

### 6.1.1 Form of coding

#### 6.1.2 Correspondence between video signal levels and quantization levels:

- scale,
- luminance signal,
- each colour-difference signal.

Studies are continuing in this area [CCIR, 1986-90g]. There is agreement that at least 8 bits are required for R, G, B, Y, C1 and C2, and that 10 bits will be required for some applications. Therefore, both 8-bit and 10-bit representations are required.

The operational margin of the dynamic range is still subject to further study [CCIR, 1896-90h] even in the case of Recommendation 601 as described in Report 629.

One possible solution is to use the same relationship between video signal levels and quantizing levels as that in Recommendation 601, for 8-bit signals, and for the 10-bit signal, to simply add two bits of lower significance.

### 6.2 Some considerations on bit rates

The source bit rate can be fixed as the result of the choices on relevant parameter values of the studio standard. Transmission of this bit rate in Level 16 of the Synchronous Hierarchy (2488.320 Mbit/s)\* appears to be technically feasibly.

Various bit-rate reduction techniques for HDTV signals are being developed, and the quality obtainable with them is under examination in reference to user requirements which are yet to be established. Many workers are interested in a possibility of achieving contribution quality with a bit rate of 140 Mbit/s. Further comparative study with a unified test method is most desirable before method(s) of bit-rate reduction are recommended.

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<sup>2</sup>CCIR Recommendation 709: *Basic parameter values for the HDTV standard for the Studio and for international programme exchange*, Recommendations and Report of the CCIR, 1990, Volume XI, Part 1, ITU, Geneva, 1990.

<sup>3</sup>CCIR Recommendation 710: *Subjective assessment methods for image quality in high-definition television*, Recommendation and Report of the CCIR, 1990, Volume XI, Part 1, ITU, Geneva, 1990.

*Bit rate reduction techniques may permit use of bit rate for network transmission such as Level 4 (622.080 Mbit/s)\* or Level 1 (155.520 Mbit/s)\* of the Synchronous Hierarchy or possibly lower bit rates.*

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\* See CCITT Recommendation G.707.

Some important parameters relating to picture characteristics and picture scanning characteristics remained to be agreed upon. A number of concepts were proposed that might have formed the basis for a worldwide standard. These included the Common Image Format (CIF), the Common Data Rate (CDR), the Common Image Part (CIP), and the Common Sampling Lattice (CSL) proposals, the latter two providing a combination of the benefits of the CIF and CDR approaches.

The CIF approach suggested use of common values for parameters defining the active picture area in different HDTV system implementations. In this approach, the image space was a bounded, two-dimensional representation of three-dimensional space in which a common set of spatial characteristics and luminance and color transfer functions are shared by all variations of the standard.

The CIF approach implied a worldwide agreement on the following basic parameters:

- Aspect ratio of the image
- Aspect ratio of the picture element (pel)
- Number of active samples in the horizontal direction
- Number of active samples (lines) in the vertical direction
- Sample arrangement (orthogonal)
- Opto-electronic transfer characteristic at the camera
- Colorimetry, reference primaries, and reference white
- Electro-optic transfer characteristic at the display.

The blanking periods, total line period, and the total number of lines would be varied among members of the family to provide compatibility with existing picture rates.

## **5. Breaking down the Barriers: Era of Digital Technology (1990 - 1999)**

The application of digital technology in the various television disciplines began in the early 1970s with the introduction of digital graphics machines

and digital video processing devices.

By mid-1991, publications reporting on work being done in the United States, in the Nordic countries, in the United Kingdom, in France, and in other parts of the world showed that bit-rate reduction schemes on the order of 60:1 could be successfully applied to HDTV source images. The results of this work implied that HDTV image sequences could be transmitted in a relatively narrow narrowband channel in the range of 15 – 25 *Mbits/s*. Using standard, proven modulation technologies, it is therefore possible to transmit an HDTV program within the existing 6–, 7–, and 8 – *MHz* channel band-widths provided for in the VHF and UHF television bands.

Developments in a number of countries and in the MPEG indicated that was possible to overcome the difficulties experienced in the past; this also result in an early agreement of all the outstanding parameter values in Recommendation ITU-R BT.709. That bit-rate reduction method required to be harmonized with those specified, notably by MPEG, for applications outside the studio, including programme contribution, distribution, emission and consumer recording.

In 1992 Task Group 11/1 - High-definition television for studio and international programme exchange (Chairman: Mr. R. P. Green (USA); Vice-Chairmen: Mr. Y. Ninomiya (Japan) and Mr. H. Schachlbauer (Germany)) was formed to continue the work begun in IWP-11/6 in studies of production standards for HDTV as defined with Questions 27/11 and 47/11. Mr. R. P. Green (United States), Chairman of TG 11/1, was appointed Vice-Chairman of ITU-T Study Group 9 (formerly the CMTT) and was unable to chair this Group. After consultation with the Vice-Chairman of TG 11/1, the Chairman of Study Group 11 requested Mr. K.P. Davies (Canada) to act as Chairman TG 11/1 (Doc. 11/223, 1994). The Task Group 11/1 finalized some parameters such as colorimetry and transfer characteristics. It also completed two draft new Recommendations on the use of bit-rate reduction in the HDTV studio and on a target standard for digital video systems, that sets out the necessary commonality for future video systems at all levels of resolution, thus leading to scalability and interchange of television pictures among differing applications. Main results of this Group activity was transferred in WP-11A (Chairman D. Wood (EBU)).

Working Party 11A an the meeting held in Geneva, 14-17 April 1997 made significant progress toward a common HDTV standard in Recommendation ITU-R BT.709, new version ITU-R BT.709-3 applicable to both 50 *Hz* and 60 *Hz* field rates. Outstanding among others was a Common Image Format for future HDTV systems (CIF-HDTV) that was agreed upon.

This 1080 x 1920 format is recommended as the preferred image system for new HDTV implementations. The commonality of this Recommendation will encourage manufactures of studio equipment to produce equipment for a world-wide market. The new format, HD-CIF is expected to be as significant as Recommendation BT.601. The HD-CIF progress was consolidated in New Recommendation ITU-R BT.1360 on image capture format for HDTV for television and other video applications for future implementations.

Several significant milestones were achieved in the June 1999 SG 11 meeting, notably:

- Revisions to ITU-R BT.709-3 now fall into two categories:
  - [a] In Part II of the Recommendation there is only one raster structure, and now, also one total number of lines. This change does not impact the C.I.F. format in any way, or the use of a common sampling frequency for all systems. However, adoption of a constant number of total lines, regardless of frame/field rate, will aid equipment manufacturers to design switchable equipment.
  - [b] In response to industry trends, part II of the recommendation incorporates a number of new frame/field rates. These additions will greatly aid in the international exchange of programme material which originates on film, and is edited electronically.
- The extension of Frame/Field rates. The introduction of digital television services, and the introduction of MPEG compression schemes, has prompted a worldwide review the programme production and post production process. In particular, this is true for the process of editing film material, when it has been transferred from the optical media to the TV raster format.

TV raster formats have in the past been limited to 25/30Hz systems. The 30 Hz system has required that the 24 frame film image be subject to what is known as 3-2 pull down. This process has required complex tracking of the 3-2 sequence, in order not to confuse MPEG encoders, as well as other editing functions.

It would be very convenient for the production industry if the "native" film frame rate [24 Frames] were carried through the entire post production process, through the contribution signal chain, and through MPEG compression schemes, without introducing any 3-2 pull down discontinuities.

In addition, by using the native film frame rate, international programme exchange is simplified. Conversion from the 24 Frame rate



material to 25/30Hz TV formats can be achieved without any loss of quality.

To augment film originated material at 24 frames/sec, there are also electronically captured images at 24 frames/sec. With the availability of both film images and electronic images at 24 Frames/sec, the production and post production world will have achieved a great deal in convenience and quality for production and international programme exchange.

- Electronic Cinema and the new HD-CIF options. In the near term, new applications dealing with electronic projection of images in cinemas, will require that the native film frame rate be preserved from image capture to image display. Having a 24 frame rate option is essential for this application to succeed.
- New draft Recommendations for High Definition Television. Prior to ITU-R SG 11 Meeting in May-June 1999 the ITU-R Recommendation for High Definition television, Rec. 709-3, included the High Definition-Common Image Format, which was encouraged for use in new installations. This is a matrix of 1080 by 1920 picture samples, which can be used at 50 Hz or 60 Hz field rate, and be interlaced or progressively scanned. A draft revision to this Recommendation was submitted by WP 11A (chairman D. Wood - EBU) to Study Group 11 for approval which is a significant improvement in several respects. (11/134 plus corrigendum, 11/125 (Rev.1), Add. 1 to Doc. 11/125, 11/125. The proposed revisions to ITU-R BT.709-3 are addressing critical broadcast industry needs extending the number of applications using this Recommendation:

This Recommendation using C.I.F. along with the extended frame rates will insure that the Recommendation will be accepted by many industry sectors. The total line number per picture or frame is made the same for all field rates, whilst preserving a common sampling frequency, by adjustments to the horizontal interval. This will bring closer the use of field rate agile equipment, and have other advantages.

The essential elements from the 1999 revision to Recommendation BT.709-3 are reproduced below:

## PART II

HDTV SYSTEM WITH SQUARE PIXEL  
COMMON IMAGE FORMAT

## Introduction

The Common Image Format is defined to have common picture parameter values independent of the picture rate. The following picture rates are specified in Part II:

60 Hz, 50 Hz, 30 Hz, 25 Hz, 24 Hz\*

Pictures are defined for progressive (P) capture and interlace (I) capture. Progressive captured pictures can be transported with progressive (P) transport or segmented frame (PsF) transport. Interlace captured pictures can be transported with interlace (I) transport. Refer to Appendix 1 for a description of segmented frame transport.

This results in the following combinations of picture rates and transports:

System	Capture	Transport
60/P	60 Hz progressive	progressive
30/P	30 Hz progressive	progressive
30/PsF	30 Hz progressive	segmented frame
60/I	30 Hz interlace	interlace
50/P	50 Hz progressive	progressive
25/P	25 Hz progressive	progressive
25/PsF	25 Hz progressive	segmented frame
50/I	25 Hz interlace	interlace
24/P	24 Hz progressive	progressive
24/PsF	24 Hz progressive	segmented frame

In cases where a progressive captured image is transported as a segmented frame, or a segmented frame signal is processed in a progressive format, the following rules shall be observed:

- a) Line numbering from the top of the captured frame to the bottom of the captured frame shall be sequential.
- b) Active line 1 and active line 1080 of the progressive captured image shall be mapped onto total line 42 and total line 1121, respectively, of the 1125 total lines.
- c) Odd active lines of the progressive captured image (1, 3, ..., 1079) shall be mapped onto total lines 21 through 560 of the segmented frame interface.
- d) Even active lines of the progressive captured image (2, 4, ..., 1080) shall be mapped onto total lines 584 through 1123 of the segmented frame interface.

With these rules, segmented frame transport has the same line numbering as that of interlace transport.

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\* For the 60, 30, and 24 HZ systems, picture rates having those values divided by 1.001 are also specified. The parameter values for these systems are presented in parentheses.

*To the current Common Image Format family is added picture taking rates which match those used for film. The Recommendation thus provides a specification that can be used for film-style program production, program delivery and exchange. This concept will have a significant impact, not only on its intended audience, the broadcast community, but also on the movie industry as well. It represents a major pre-emptive achievement by the ITU-R, which will be widely welcomed.*

## Conclusions and Acknowledgment

During the current study period I am very pleased, to note that SG 11 has improved a very important Recommendation for HDTV, which has been being developed for many years. Thus the global standard for evolution of TV in the new Millennium was established.

These achievements are undoubtedly connected with a great contribution of professor I. Stojanovic, the Chairman of XVIth Plenary Assembly of CCIR (Dubrovnik 1986), on which the problem of HDTV standardization was for the first time generally discussed by CCIR and a new global approach to this problem was approved.

I wish to express my profound appreciation and recognition to the Chairman of the World Broadcasting Union Technical Committee Dr. J.A. Flaherty for his individual contributions and support in this Recommendation and in support of the work of Study Group 11.

The Study Group also recognizes the continuing collaboration with Study Group 10 in broadcasting matters and with the Telecommunication Standardization Sector, in particular Study Group 9.

The Chairman wishes also to express his gratitude for the constant support provided by the Chairman of Study Group 10, Mr. N. McNaughten, Mr. A.P. Walker, Mr. C. Terzani and Mr. A. Magenta and the former CMTT Mr. M. Angel, Mr. W.G. Simpson and Mr. J. Tejerina, as well as by all the members of the Study Group 11 Coordination Group and Joint Steering Committee of Study Groups 10 and 11.

A special acknowledgement for their personal contribution to this success is to be paid to the Vice-Chairmen of the Study Group and to the Chairmen and Vice-Chairmen of the Working Parties and the Task Groups, as well as to all the contributors and participants in the WP and TG meetings.

Special thanks are finally addressed to the CCIR and ITU-R Secretariat, and in particular to Mr. J.W. Herbstreit, R.C. Kirby, R.W. Jones, Director, Mr. R. Froom, Mr. G. Grotelueschen, Mr. R.L. Nickelson, and last years to Mr. G. Rossi, Head Study Groups Department, Mr. G. Mesias

Counsellor Study Group 11 and Mrs R. Zecha for their valuable and efficient support.

The Study Group 11 has established a strategy and work plan for its future work that will maintain the ITU-R activities at the forefront of broadcasting technology.