This document was prepared on behalf of the Conference of Television Operations Managers (FSBL-K) by the “Technical Production Guidelines for Television” (TPRF) work group. It represents the status of their work in April 2015, as approved by the FSBL-K.

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*Technical guidelines and standards referred to in these guidelines are available from the reference sources listed under item 46.*

Access to the guidelines and work-group findings of

http://www.irt.de/richtlinien
changelog for TPRF-HDTV 2014

Note on Versions

The Technical Guidelines – HDTV are periodically revised by the TPRF Working Group and aligned with the current technical standards. Relevant amendments, modifications, and revisions are noted in each new edition. The specifications in each edition remain in force up to the publication of the next edition. Interim versions of the TPRF-HDTV Guidelines contain amendments and revisions for purposes of information and clarification as well as minor modifications, and they are identified by a new status date.

Revisions executed in the April 2015 interim version

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Technical Guidelines – HDTV
for the Production of HDTV Programs for ARD, ZDF, and ORF

April 2015

These guidelines cover all high-definition (HD) program material delivered or supplied to, exchanged with or broadcast by ARD, ZDF, or ORF.

In principle, any such program material has to be available in a format suitable for broadcast.

For the production of such program material, compliance with the agreements detailed in this document is mandatory, both for in-house processing and the commissioning of outside contractors.

By and large, the key technical details of the specifications listed in these guidelines follow the recommendations of the European Broadcasting Union (EBU) and the guidelines of ARD, ZDF, and ORF, including the standards that are referenced in the text.

The definition of the technical parameters listed in these guidelines is based on the HDTV scanning rasters specified for Europe in EBU Tech 3299. Corresponding specifications for these scanning rasters can be found in SMPTE 274M and 296M, and for the HD serial digital interface (HD-SDI) in SMPTE 292M.

Procedures and formats for shooting, post-production, and supply shall be defined in individual agreements with contractees.

It is explicitly stated that the use of non-permissible video compression formats during the production of HD programs will not be tolerated. Such actions must not be covered up, either, e.g. by supplying the program on an HDCAM-SR cassette!

Exceptions from these specifications are only permissible upon written mutual agreement.
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1 Basic Quality Requirements

The audience’s viewing and listening habits demand the best possible video and audio quality. In order to achieve this, the technical provisions for audio and video recording as well as acoustics and lighting conditions have to be of suitable quality and used to their best effect.

Considering the conceptual ideas and expectations on the part of the executive producers as well as the variety of new options, technical implementation needs to observe a number of basic requirements. The desired result can only be achieved, if potential technical challenges during actual production are addressed in the earliest pre-production phases.

As early as the production stage, it should be taken into consideration whether the employment of certain artistic devices, the use of low-quality equipment, or the inappropriate application of certain technologies might lead to effects down the distribution chain that would be perceived as technical flaws, for example:

- video noise may lead to a loss of resolution down the line;
- numerous dark portions of the frame may create blocking artifacts down the line;
- a downmix from multi-channel to stereo sound may compromise the intelligibility of speech on the user device.

Each stage of the production chain – including acquisition, production, and contribution – needs to meet the quality target set for the program. Even in a tapeless production chain, copying and cascading effects have to be avoided wherever possible.

1.1 Barrier-free Access

People with handicaps should also be able to benefit from the technical innovations introduced in public-television programming. ARD, ZDF, and ORF are pioneers in barrier-free access to media, e.g. through closed-captioning and signing.

All program suppliers, both in-house and outside, are therefore urged to consider the needs of the deaf and hard-of-hearing as well as the blind and visually impaired when producing titles, subtitles, captions, and graphics (item 26), off-camera narration and sound mixes (item 0).

2 Transition from QPPM to Loudness-Based Audio Leveling

2.1 Implementation Guidelines for Loudness Normalization

The transition of audio leveling from QPPM (Quasi-Peak Program Meter) to Loudness (Loudness Meter) has been completed, which means that all new productions will have to be loudness-leveled.

ARD, ZDF, and ORF are broadcasting their programs loudness-normalized (cf. items 0 and 20.3), i.e. in accordance with EBU R128. Consequently, any program audio-leveled in any other way will be subjected to an automated process, in order to align it with other, loudness-normalized programs.

For the exchange of programs and production contributions as well as for delivery to the playout centers, it is stipulated that existing material shall be supplied in its current state, i.e. that loudness normalization shall be applied at the place of use.  

Note: File-based tools for automated loudness normalization are being discussed by the 5.1 work group.

2.2 Operational Implementation

For reaching an optimized loudness balance, the transition will require the integration of suitable loudness meters into operational processes. In order to facilitate working with the encoded Dolby
E and Dolby Digital (AC-3) audio formats, a manageable number of Dolby metadata presets has been developed for various genres (cf. item 20.4.3).

For the supply and exchange of programs, it is mandatory that information (labeling, metadata) about loudness-based leveling or – in the case of non-normalized stock or legacy material – QPPM is clearly indicated.

2.3 **Subjective Perception of Loudness Level Differences**

Loudness leveling is performed in accordance with EBU R128. Following an EBU-wide concerted effort, all those in charge should realize that LOUDER is not better!

For clarification purposes, the following table lists the subjective assessment of loudness level differences.

<table>
<thead>
<tr>
<th>Subjective Perception of Loudness Levels</th>
<th>±LU/dB</th>
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<tr>
<td>significantly too loud</td>
<td>10</td>
</tr>
<tr>
<td>slightly too loud</td>
<td>6</td>
</tr>
<tr>
<td>louder, but acceptable</td>
<td>3</td>
</tr>
<tr>
<td>comfortable volume (comfort zone)</td>
<td>3 &lt; LU &gt; 6</td>
</tr>
<tr>
<td>slightly softer, but acceptable</td>
<td>–6</td>
</tr>
<tr>
<td>turn volume down</td>
<td>–10</td>
</tr>
<tr>
<td>annoyingly soft</td>
<td>–20</td>
</tr>
</tbody>
</table>


2.4 **The Term “Lautheit”**

A national preface for the German translation of EBU R128 states:

In the German speaking domain and in the metrological evaluation of sound, the term *Lautheit* [*Loudness*] is used for a value already. Usually it describes the value calculated by using a method developed by [Eberhard] Zwicker and measured in a unit called *sone*. This unit indicates a proportional representation of the subjective perception of sound intensity by the human ear, i.e. a sound perceived as twice as loud as another should have twice the value in *sone*. The DIN 45631/A1 standard defines the “Calculation of the Loudness of Time-Variant Sound.” To avoid confusion, the English term *loudness*, as used in EBU R128 and measured in *loudness units* (LU), should therefore not be translated as *Lautheit* but rather (and more precisely) as *Lautstärke* [*English: volume*]. However, in German broadcast jargon, the term *Lautheit*, as a colloquial translation of English *loudness*, has already been established and is used in the same sense as *loudness* in EBU 128.

3 **Speech Intelligibility**

Even after the transition of audio leveling from QPPM to loudness-based leveling, programs must not contain any unintentional alterations of the acoustic ambiance and must have a balanced mix throughout. In particular, a version deemed suitable for broadcast must always favor speech intelligibility in its audio mix.

Detailed information about the improvement of speech intelligibility can be found in the ARD Guidelines “Sprachverständlichkeit im Fernsehen” (“Speech Intelligibility in Television”).
4 Profiles for MXF Files

Uniform MXF profiles are currently being developed, in which all relevant file parameters are specified unambiguously. These MXF profiles will be specified as mandatory in the TPRF-HDTV for the exchange between broadcasters, for the delivery to ZSAW, and for the supply of external productions.

The introduction of MXF profiles is intended to improve the operational interoperability significantly and to establish a solid foundation for an automated quality check.

The MXF profiles will be specified and published in separate documents (cf. item 13).

5 Medienbegleitkarte

For a controlled handling of metadata relevant to production, a so called Medienbegleitkarte for file-based productions has been developed that will replace the VTR record card.

In the present TPRF-HDTV 2014, a chapter on the Medienbegleitkarte (item 0) was added, defining the Medienbegleitkarte and describing its introduction and use for the supply of both in-house and outside productions.

For the applications listed in this chapter, it is intended to make the use of the Medienbegleitkarte mandatory by the time VFT 2.0 becomes operational (presumably mid 2016), at the latest.

After the mandatory XML template for the exchange of the Medienbegleitkarte has become available (early 2014), it should be employed as soon as possible.

6 Production Pre-Planning

In order to achieve an optimum quality in video and audio, technical provisions for audio and video recording, acoustics and lighting have to be discussed ahead of the actual shoot between director, producers, and crew, or their respective representatives. In view of the technical implementation of conceptual ideas and expectations on the part of the executive producers as well as the variety of new options, the technical side should, in general, offer production counseling. This is the only way to eliminate potential problems and conflicts in technical implementation ahead of the actual production.

The specifications contained in these Technical Production Guidelines are supplemented by recommendations for special applications.

6.1 Production Counseling

In “Premium / High Quality” and “Mainstream” production, the specifications contained in these Guidelines may serve as the basis for counseling.

In any case, special requirements necessary to fulfill specific requests and demands in terms of design or content – in particular, the effects of certain cameras and types of equipment intended to be used – need to be explained in detail.

It is advantageous to discuss special requirements that will occur at any given point in the workflow at the earliest possible stage, in order to estimate extra work and expenditures.

As a means of supporting and conducting production counseling, the broadcaster in charge may summarize all issues relevant to the upcoming production in a check list, an example of which is given under item 40.
6.2 Example for the Specification of HD Formats by a Broadcaster

In addition to the check list mentioned above, it may be helpful for a broadcaster communicating with outside producers to summarize their own requirements and specifications. This may serve as a quick but helpful overview.

For reference purposes, an example is shown under item 41, which is based on a WDR document entitled „Allgemeine Festlegung der HD-Produktionsformate des WDR“ (“General Specification of HD Production Formats for WDR”).

7 HD Image Format

EBU Tech Doc 3299 specifies the four image formats and digital sampling systems (scanning rasters) relevant to European broadcasters. In order to avoid quality loss during conversion, a single format should be applied throughout the production process. For in-house productions, the rasters currently permitted are 1080i/25, 1080p/25, and 720p/50.

The 1080p/25 scanning raster should be considered a special case that requires a separate arrangement when supplied, in order to prevent additional costs and/or technical quality issues.

**Note:** For artistic and esthetic purposes, drama productions prefer the 1080p/25 format. Filmed productions are also usually scanned in 1080p/25. For international p-raster co-productions, 1080p/23.98 should be given preference over 1080p/29.97.

**Note:** Programs produced in 1080p/25 are frequently transported (transmitted, stored) as 1080i/25! This variant of the system is designated as 1080psf/25 (psf = progressive segmented frame) (cf. item 33) and has to be signaled for subsequent processing and taken into account.

7.1 Identification

The production image format of a program has to be identified and described in all details on the media operations sheet or in metadata. Attention has to be paid, e.g. in playout via HD-SDI, that the correct image and scanning formats are selected and identified, in particular with regard to the distinction between “progressive” (p) and “segmented” (psf) scans (cf. item 33).

8 HD Programs

In general, a program commissioned in high definition has to be produced in HD throughout, i.e. from shooting through editing all the way to its delivery.

In special cases, an HD program may contain up to 25% of standard-definition (SD) material (as defined in item 8.20).

Exceptions to this rule are only permissible when required by the content of the program, e.g. when using stock footage in a documentary. In such cases, the acceptable percentage of SD material (as defined in item 8.2) requires an explicit prior agreement.

SD percentages have to be listed in accompanying documents, indicating their original format, if known. If the original format is unknown, this fact has to be indicated as well.

An HD master has to be supplied as a master without commercial breaks.

HD production has to ensure that the master contains the least possible number of generations (reencodings), whereby any format or frame-rate conversion has to avoided at all (cf. item 10).

**Note:** The delivery of more than one program on a single linear recording medium (tape) requires bilateral agreement.
8.1 Conversion from SD to HD

In order to achieve the highest possible quality from converted SD sources, a converter* has to be used that can ensure a high-quality image.

For SD material that is available in a 4:3 aspect ratio, the executive producers will decide whether the existing 4:3 framing should be maintained (“pillarboxing”), or whether the 4:3 frame should be panned and scanned (usually shot by shot), in order to adapt it to the 16:9 aspect ratio of the HDTV frame.

SD material supplied in a widescreen format (e.g. 1.85:1, 2.35:1) has to be centered along the vertical axis (letterboxed). Zooming or pan & scan are only permissible if the artistic intention of the original material is preserved.

Note: In cases where 4:3 file footage is intended for HD transmission in a program exchange, a pillarbox version must be generated prior to converting to HD, in order to preserve image geometry.


8.2 Standard Definition (SD)

In the context of HD programming, the following formats are considered SD:

- a) all SD video formats,
- b) low-cost formats as well as HD consumer formats from all manufacturers (conditions for special applications are described under item 9.3),
- c) cameras with image sensors of less than half an inch (½”)
- d) intra-frame-based recording formats with less than 100 Mbit/s (I-frame: coding of only a single full frame),
- e) inter-frame-based recording formats with less than 50 Mbit/s (group of pictures [GOP]: coding of several full frames),
- f) Super 16-mm (S16mm) film, if quality falls below the specifications listed under item 11,
- g) 35-mm film or super 16-mm film transferred to an SD format,
- h) NLE codecs with compression formats NOT recommended for Mainstream production,
- i) live contributions via links using codecs with an insufficient data rate (for details, cf. item 22).

8.3 Compression vs. Data Reduction

Both colloquially and in technical literature, within the broadcast industry, the terms compression and data reduction are used interchangeably. However, especially in communication with IT colleagues, it should be remembered that compression, in its original meaning, designates a lossless compression and decompression, while in broadcasting, nearly all compression formats (actually data reduction formats) include a lossy compression and decompression.

The principal purpose of data reduction processes is the reduction of the required data rate. It should be noted in this context that in practical application, the data rate has often been reduced already in the signal components received, before the actual data reduction (video compression) is applied. This data-rate reduction may be achieved by reducing the following parameters:

- resolution (e.g. additional subsampling from 1920 × 1080 to 1440 × 1080 pixels),
- sampling rate (e.g. from 4:2:2 to 3:1:1 or 4:2:0),
- quantization (e.g. from 10 to 8 bits).

The application of any of these options will affect the image quality of the original signal, which might substantially reduce the quality buffer for subsequent processing stages.

For this reason, all video compression procedures applied to HD programs have to be listed in detail in the accompanying documentation.
9 HD Production Platforms

Three different qualities have to be differentiated in the production of program material, for which the respective specifications detailed in these Guidelines have to be observed.

9.1 Mainstream

The Mainstream platform, which includes program exchange, forms the foundation of day-to-day operations, e.g. magazine programs and newscasts. Programs and contributions for the Mainstream often require several processing stages. For this reason, the equipment and systems used in this domain have to perform well in multi-generation processing, in order to ensure acceptable video and audio quality in the final stage.

For economic reasons, only very efficient formats are used which nonetheless warranty that all specifications are met in full. For these applications in particular, EBU work groups are testing multi-generation video compression tools with the goal of publishing their recommendations.

9.1.1 Technical Specifications

For the Mainstream platform, a subsampling rate of 4:2:2 is specified. Further subsampling of the luminance and chrominance components is not permissible. Suitable recording formats for Mainstream productions are:

- XDCAM-HD422 with MPEG-2, 4:2:2, long GOP, 50 Mbit/s,
- P2 with AVC-I 100, 4:2:2, I-frame, 112 Mbit/s (SMPTE RP 2027).

**Note:** Experience in HD production as well as EBU tests have demonstrated a substantial deterioration of image quality with each additional generation for compression formats with additional subsampling (3:1.x:1.x, 3:1.x:0, 4:2:0, etc.), especially in the form of noise.

Implementations with additional subsampling – e.g. 3:1:1, 4:2:0 – are inadequate as the foundation of a comprehensive HD production platform.

In order to avoid multiple generations, it may be advisable to adjust the shooting format from the outset to one of the two accepted Mainstream target formats, and to maintain this format all the way to the delivery.

9.2 Premium / High Quality

Special “high quality” workflows for drama and repertory productions as well as major live events are produced outside the Mainstream platform in a more demanding, high-quality environment. In this domain, with its clearly defined workflows, a limited number of generations is practicable. In addition, only moderate video compression, if any, will be applied. Examples for this platform are:

- drama or repertory productions, such as Tatort (anthology crime drama series), New Year's Concerts, etc.,
- major entertainment shows in prime time, major sporting events such as the Olympic Games, World Cups and world championships, European championships, international matches, and co-produced events over an entire evening.

The supply format for premium productions has to be discussed in advance. However, due to operational requirements, an additional mainstream format copy – e.g. in XDCAM HD422 or AVC I 100 – has to be supplied in all cases.

9.3 Special Applications, including Video Journalism

Workflows with special conceptual demands, as well as news (ENG), including video journalism (VJ), may be acquired and partially processed (e.g. edited, but not color-graded) in low-cost formats (cf. item 0).

- In this instance, cameras and other equipment are frequently employed that were selected based on the demands of design or content.
- HD low-cost and consumer formats are merely acquisition formats and used only for special applications, e.g. video journalism, reporting from areas of conflict, etc. (cf. item 0).
10 HD Acquisition

In order to achieve the required HD quality, the quality of the camera has to meet workflow specifications, i.e. apart from an HD-capable optical system, the HD resolution available on the image sensor, including subsequent steps in the proposed workflow, has to meet the requirements specified for the applicable production platform.

For the use of various camera types and sensor sizes, the following specifications have to be observed.

10.1 Cameras for Mainstream Production

For Mainstream productions, HD camera sensors need to have a minimum size of $\frac{3}{4}$" and should have a native resolution of 1920 pixels × 1080 pixels. In this context, system cameras (studio and OB) are always Mainstream cameras.

The cameras have to be operated in their native mode at all times. Any in-camera conversion, such as cross-, up- or down-conversion, has to be avoided. If necessary, such conversions have to be performed at a later stage using external converters that guarantee a high image quality.

As lenses, only broadcast HD ENG zoom lenses (or better) must be used. These lenses have to comply with the specifications detailed in the Technical Guidelines: Parameters for the Classification of HD Lenses for ARD, ZDF, ORF, and SRG, which lists HDTV thresholds and explains terminology and interrelationships.

10.2 Single-Sensor Cameras

Single-sensor cameras have become available in all categories, from high- to low-end products. Depending on the demands of concept and content, single-sensor cameras are thus used over the entire range as well, from premium to low-budget productions.

It has to be noted that sensor size alone is not necessarily an indicator of the actual performance of a single-sensor camera! The quality of the output is frequently affected and diminished by the camera’s internal signal processing.

If single-sensor cameras are to be used for certain particular properties they possess, it is necessary to ensure in advance whether the subsequent production process can be covered by existing workflows. In any case, special requirements (data format, file format, compression, sampling rate, raster, audio, time code, metadata) will entail extra costs.

Adequate planning in pre-production, including technical production counseling (cf. item 4), is strongly recommended.

10.3 Cameras for Single-Camera Workflows

In workflows with special conceptual requirements as well as in newscasts, incl. VJ productions, cameras with sensors of $\frac{1}{2}$" or less may be used. In these cases, the workflows are usually single-camera workflows. However, in these areas, too, HD-capable lenses have to be used.

- The cameras, at least in single-camera use, have to meet basic specifications, e.g. HDV cameras, etc.
- The use of these cameras has to be limited, e.g. to areas of conflict, where considerations of inconspicuousness, sensitivity, size, weight, and replacement costs outweigh video and audio quality.
- In no case the internal converters or transcoders built into these cameras should be used! Any conversions, e.g. to SD, should under no circumstances be performed inside the camcorder but instead by external converters that guarantee a high video quality, before or after processing the material to the target format.
- In these formats, any chaining or cascading should be avoided in professional acquisition, as it leads to an increase in noise and a loss of resolution.
- If, however, this material requires intensive post-production work, it should be transferred to a professional platform, e.g. HD Mainstream with 4:2:2 sampling.
• Systems working with sensors smaller than 1/3" no longer meet the requirements with regard to video parameters and optical imaging performance that would make them suitable for subsequent integration into the Mainstream process.

10.4 Frame Rates in Acquisition

If, for pressing reasons, the acquisition of programs with frame rates other than 25 or 50 is the only option, e.g. in 60-Hz countries, it is recommended that the 24p (or 23.98) mode be used. The material can then be played back at 25 f/s, and the pitch, which is altered as a result of the 4% speed-up, can be compensated using audio pitch control. In order to avoid motion artifacts, frame-rate conversion is not acceptable.

Note: If the frame rate is changed during the shoot, it is imperative that a new/separate recording medium (Professional Disc, solid-state memory, etc.) be used.

10.5 Film Scanning

Material supplied which was scanned from film material has to correspond, by and large, to the original work. However, the aspect ratio of the television image (16:9) will not always match that of the film frame, especially when widescreen feature films are scanned that were originally produced for theatrical release. The decision on how to position the television frame should always be made on the basis of an artistic assessment, i.e. the director’s original intention should be preserved to the widest extent possible. In critical cases, the broadcaster responsible for the broadcast should be consulted in the decisionmaking process.

11 Super 16-mm Film

In today's state of the art, the broadcasting of material originated on Super 16-mm (S16mm) film will frequently lead to quality problems in the HD process chain. For example, excessive grain will create distracting artifacts in subsequent encoding at a high compression rate, significantly diminishing image quality for the viewing audience. If S16mm film is used for image acquisition in new productions, the full quality potential inherent in today's film stock has to be used for subsequent HD processing, taking into account the entire production chain from shooting to post-production. The audience’s viewing habits demand that the image be as noise-free as possible. The following aspects require special attention:

• Only state-of-the-art film emulsions must be used.

• Modern emulsion technology offers a wide dynamic range (currently 16 f-stops). However, proper exposure of the film stock is an essential condition for HD scanning. Excessive granularity caused by underexposure, causing noise in the darker areas of the image, has to be avoided. A minimum density of 0.25 ±0.1 D and a maximum density smaller than 2.75 D have to be observed.

• For a further reduction of grain, programs shot on S16mm film should, in general, be degrained. Such degraining is essential in cases where highly sensitive film emulsions were used. In view of the potential loss of sharpness, degraining has to be used with restraint. In order to keep the degree of degraining as low as possible, film emulsions have to be used whose speed complies with production requirements (without push processing!).

• For HD image acquisition on S16mm film, as with a digital camera, only lenses with high resolution, excellent MTF factor, and minimal chromatic aberration must be employed. Image acquisition on S16mm film thus requires HD-optimized lenses.

• The entire available area of the negative frame has to be scanned, in order to make full use of the 16-mm negative’s target.
This will also ensure that the framing determined by the cinematographer within the 100% frame is preserved. The focusing screen in the camera's viewfinder always marks 100% of the film frame, with an additional safety cut-off displayed. A modified S16mm viewfinder mask is currently being tested, with a reduced safety margin, which would "enlarge" the actual "safe area" by about 10 percent.

For HD processing, the post-production of an S16mm program has to be performed in HD! Scanning or post-production in SD will not yield acceptable results in the conversion to HD. The Premium segment in particular (drama productions) demands excellent image quality for HD broadcasting. SD scanning or SD post-production would render the S16mm product unusable for HD broadcasting.

12 MXF File Format
For the exchange of broadcast material between broadcasters and for delivery to the Central Playout Center (ZSAW), file transfer has become the standard format, and it is also used more and more frequently for the supply of material, both in-house and from outside sources. For all these cases, the MXF file format is mandatory.

12.1 Structure
For MXF files, the following conditions have been specified:

a) The MXF file format has to conform to operational pattern (OP) 1A.

b) Sequential individual objects are transferred in separate files (as for SDTV).

c) The essences (video, audio, and data) have to be exchanged in a temporal multiplex (compound) to ensure that the exchanged MXF files are streamable.

d) The partition status of the header position has to be "closed" and "complete," ensuring that header metadata are available in their entirety at the start of the file.

e) In the initial phase, metadata currently used for SDTV (electronic VTR record card) are adopted, which may be expanded as necessary.

**Note:** Due to the wide variety of HD formats, it is essential that the encoders used write all technical metadata – completely and according to the MXF standard – into the corresponding files, in order to enable, for example, automated decisions on transcoding, if necessary.

12.2 Mapping
The corresponding standards for mapping the permissible compression formats into the MXF file format have to be observed:

- SMPTE 381M: Mapping MPEG Streams into the MXF Generic Container (including Long-GOP)
- RP2008: Mapping AVC Streams MXF Generic Container (H.264)
- SMPTE 2019-4: Mapping VC-3 Coding Units into the MXF Generic Container (DNxHD)
- **N.B.:** There is no SMPTE mapping standard for ProRes into MXF.

12.3 Compression Formats
The corresponding standards for mapping have to be observed for embedding the compression formats into the MXF file (cf. **item 14.2**).

For the supply of material, for the exchange between broadcasters, and for the delivery to ZSAW-ARD, the following two HD compression formats are permitted:
- MPEG-2, 4:2:2, long GOP, 50 Mbit/s (XDCAM-HD422 implementation); for XDCAM HD422, the embedding (mapping) of the essence has to conform to SMPTE RDD-9;
- AVC-I 100, 4:2:2, I-Frame, 112 Mbit/s (SMPTE RP 2027).

In addition, the following additional HD compression formats may be used by arrangement for the supply of material:
- DNxHD, 4:2:2, I-Frame, 175/185 Mbit/s with 10 or 8 bit, as well as 115/120 Mbit/s with 8 bit (SMPTE 2019-1 VC-3 picture compression);
- ProRes, 4:2:2, I-Frame, ~184 Mbit/s (ProRes HQ) with 10 bit and ~122 Mbit/s (ProRes) with 10 bit (Final Cut Pro implementation)

12.4 Audio Track Allocation
For the supply, exchange, and delivery of MXF files, audio track allocations as specified under item 20.5 are permissible.

12.5 Time Code
For the supply, exchange, and delivery, a time code according to EBU R122 has to be embedded into the MXF file, i.e. restrictions regarding the use of the three time-code options have to be observed. For a more detailed explanation, please refer to item 42.

- The start of the time code is set at the beginning of the file.
- The start time code of the program does not necessarily have to start on 10:00:00:00. It may vary, as the case may be, e.g. time codes may differ in a subtitle (STL) file and the corresponding MXF file; consequently, the TC would have to be adjusted, in this case, in the STL file.
- If a corresponding subtitle file is exchanged together with an MXF file, subtitles and video have to be in sync, even though the subtitle file would not necessarily have to match the video’s time code. For an exchange, the offset of the time codes between subtitle file and MXF file should be specified.

12.6 Technical Leaders
There is a general consensus not to use legacy workarounds from the linear tape era during the transition to file-based production. Files do not require leaders of any kind!
As the number of files increases, such legacy issues would create significant extra effort and expenses – e.g. for additional trimming – and thus have a negative impact on overall efficiency.
When taped programs are transferred to files, the material is, in most cases, not trimmed to the frame for economic reasons. As a result, many such files end up containing leaders of some sort. For this reason, files generated from legacy material may, for a transition period yet to be specified, contain leaders.

**Note:** Additional specifications for media are listed under item 17.

12.6.1 Definition
No leader whatsoever may be contained in new productions supplied, delivered, or exchanged via file, meaning that the file will start on the first full frame of the program and end on the last full frame.

Consequently, no Dolby E leader may be included, either.
Material supplied, delivered, or exchanged on tape, Professional Disc (PFD), P2 card must contain leaders, as in the past.
13 MXF Profiles

In order to improve interoperability, establish a foundation for automated quality checks, and support both users and manufacturers, uniform MXF are currently being developed, specifying relevant file parameters.

The following profiles for HDTV are already in development:

a) MXF profile for XDCAM HD422

b) MXF profile for AVC-Intra 100

The specifications for both profiles are currently available in public beta 1.0 versions. Subsequent to discussions with users and manufacturers, they will be submitted to the “Prod” working group (FSBL) and, upon approval, included in the TPRF-HDTV.

**Note:** Two MXF profiles are also being developed for SDTV: for D-10 (IMX) and DV-based (DVCPRO50).

Until these profiles become part of the present Guidelines, the current status can be requested from the contact person at IRT listed on page 2.

13.1 MXF Profiles for XDCAM HD422

Due to the wide variety of application cases in the supply and delivery as well as the exchange between broadcasters and also for the generation and processing of MXF files,

- option 1 ("Multiple Body Partition") in SMPTE RDD 9-2013 ("MXF Interoperability Specification of Sony MPEG Long GOP Products") is specified as fundamental standard for the XDCAM HD422 MXF profile.

A public beta 1.0 version of the XDCAM HD422 MXF profile has been distributed for final comment to relevant users and manufacturers.

13.2 MXF Profiles for AVC-Intra 100

A public beta 1.0 version of the AVC-Intra 100 MXF profile has been distributed for final comment to relevant users and manufacturers.

13.3 General Specifications

Up to the definitive specification of the MXF profiles and corresponding implementation guidelines, the general specifications for MXF files (cf. item 12) will apply. In addition, the operational specifications for MXF in the various chapters should be observed.

14 HD Supply Format

For the supply of HD programs, the following media, file, compression, and scanning formats are accepted.

For file-based supplies, the specifications detailed under item 12 need to be observed as well.

14.1 Media

Mainstream

- Professional Disc (PFD)
- P2 memory card
- mobile data storage devices (e.g. hard discs) with NTFS formatting

Premium / High Quality

- HDCAM-SR cassette
14.2 File Format

For the supply on tapeless storage media or via the VFT, the MXF file format is mandatory. In general, MXF files have to conform to the specifications listed under item 12 in terms of structure, audio track allocation, time code, and technical leaders.

14.3 Compression Formats

Two compression formats – XDCAM HD422 and AVC-I 100 – are permissible. In addition, the DNxHD and ProRes compression formats may be used by arrangement. For details, please refer to item 12.3.

For material supplied on HDCAM-SR cassette, the following compression format is used:

- Type D-16 encoding protocol, IEC 62141 (HDCAM-SR implementation, MPEG-4)

14.4 Scanning Formats

- For HD programs supplied to ARD and ORF, the 1080i/25 image format is mandatory. For drama productions, the 1080psf/25 format is also acceptable.
- For HD programs supplied to ZDF, the image format may be either 720p/50 or 1080i/25. For drama productions, the 1080psf/25 format is also acceptable.

Note: For the exchange of program material, please cf. also item 15.4.

15 Exchange between Broadcasters

15.1 VFT – ARD Video File Transfer System

HDTV program material is usually exchanged via file transfer. For any such transfer, each broadcaster has to provide an MXF file compliant with the specifications under item 12.

The broadcaster supplying the material has to ensure that the specifications are met.

Note: The exchange of non-compliant formats requires mutual agreement.

15.2 File Format

For an exchange via VFT, the MXF file format is mandatory. In general, MXF files have to conform to the specifications listed under item 12 in terms of structure, audio track allocation, time code, and technical leaders.

15.3 Compression Formats

Two compression formats – XDCAM HD422 and AVC-I 100 – are permissible. For details, please refer to item 12.3.

15.4 Image Formats (Scanning Rasters)

- The image format for the exchange (storage medium, line, file) of Mainstream programs is 1080i/25.
- ZDF will provide the format used for production, i.e. if the source material is in 720p/50, this scanning raster will also be accepted.
- For the exchange (storage medium, line, file) of drama productions and for the transfer from film to HD, the 1080psf/25 image format is also admissible.

Note: Should an image format conversion become necessary, a converter* has to be used that guarantees maximum video quality.

15.5 Exceptions for the Exchange of HDTV Program Material

In exceptional cases, where an exchange via file transfer is not feasible for operational reasons, an exchange via physical storage media is permissible by mutual agreement. In such cases, only the following media and compression formats should be used:

Mainstream
- Professional Disc with XDCAM HD422 (50 Mbit/s)
- P2 cards with AVC-I 100
- mobile storage media (e.g. HDD) with a file system compatible with either Windows or MAC OS.

Premium / High-Quality
- HDCAM-SR cassette

**Note:** The HDCAM-SR format is only permissible for the supply of Premium productions. However, by bilateral agreement, it may also be used to forward Premium productions in high quality. In any case, a workprint in an accepted Mainstream format has to be supplied for organizations who did not invest into HDCAM-SR equipment.

15.6 Exchange of Subtitles

Since 1 January 2013, subtitles have to be delivered separate from video. For details, cf. item 21.

16 Delivery to Playout Centers

16.1 ARD

For the delivery of HD program material to the playout centers, the following formats are currently accepted:

Media and Compression Formats
- Professional Disc with XDCAM-HD 422 (50 Mbit/s)
- P2 cards with AVC-I 100

For specifications of media and compression formats, cf. items 12.3 and 17.

File Format and Compression Formats
- MXF with XDCAM-HD 422 (50 Mbit/s)
- MXF with AVC-I 100

For specifications of file format and compression methods, cf. item 12.

In general, MXF files have to conform to the specifications listed under item 12 in terms of structure, audio track allocation, time code, and technical leaders.

Image Format (Scanning Raster)
- Delivery to Playout Center (ZSAW) via media, line, and file in 1080i/25.
- For delivery on PFD, the 1080p/25 image format may also be used.

16.1.1 Audio Track Allocation

Item 20.5 specifies six options for audio track allocation, whereby options 1 through 3 are four-track and options 4 through 6 eight-track options.

For the future, the goal is an increasing use of option 4 (8-channel standard) for delivery to the Playout Center, as the Playout Center also uses this option for in-house operations. The following specifications define the audio track allocation for the various delivery options:

Delivery via Storage Medium
- In case the material is supplied on tape, PFD, or P2 card, all options (1–6) may be used.

**Delivery via File Transfer**
- For file transfer, material can be supplied with 8 audio tracks. However, the handling of metadata may cause problems, as the DAVID ingester does not permit identification (labeling) of the three 8-track options.
- For a transition period – until VFT-2.0 becomes operational –, only options 1 and 4 may be used with regard to metadata for transferring files to the Playout Center (in accordance with the current ZSAW Guidelines for Material Delivery).
- VFT-2.0 is expected to become available mid 2015. The requirement of being able to identify a larger number of audio channels in the metadata will be conveyed to the work group in charge of functional specifications.

**Live Delivery**
- In the case of live delivery, a large percentage of programs is supplied in options 1 through 3. For option 3 (with Dolby E), a rerouting at the Playout Center may be required.
- Option 4 may also be used for delivering multi-channel audio.
- Option 5 is still available for the delivery of discrete multi-channel audio.

16.1.2 Delivery of Subtitles
Since 1 January 2013, subtitles have to be delivered separate from video. For details, cf. item 21.

16.1.3 Loudness-Normalized Delivery
New productions have to be delivered loudness-normalized.
It has been agreed that legacy material, in general, shall be supplied in its current state, i.e. that its loudness will be normalized at the point of use.
Cf. item 2.

16.1.4 Lead Time for VFT Delivery
Video files must be transferred no later than 6 hours – plus duration of the program – before the start of the broadcast!

16.2 ZDF
Currently, most programs are delivered in HDCAM-SR. HDCAM and DVCPRO-HD are regarded as interim solutions for the delivery of HD programs and should gradually be replaced by tapeless formats.

16.3 ORF
Programs may currently be supplied in either HDCAM, HDCAM-SR, or XDCAM-HD422.

17 Additional Specifications for Media
Based on initial experience in operations, a number of specifications are listed below with regard to the exchange via physical storage media.

**Note:** Mobile storage devices are reserved for temporary use only and are not suitable for long-term storage or archiving purposes! For reasons of IT security, all ZDF production departments have to abide by the „Richtlinie zur Verwendung mobiler Datenträger zur Fernsehproduktion im ZDF“ ("Guidelines for the Use of Mobile Storage Media in ZDF Television Production") when handling mobile storage media, regardless of their origin, e.g. outside producers, other broadcasters, etc.
17.1 Professional Disc with XDCAM-HD 422 (50 Mbit/s)

As specified under item 12.6, MXF files have to be generated in file-based production without any leaders, meaning that the file will start on the first full frame of the program and end on the last full frame.

For material supplied on Professional Disc (XDCAM and XDCAM-HD), leaders are still required for operational reasons. It is therefore stipulated that the following three files be created for playout of XDCAM on Professional Disc:

- File 1: content “10 sec. black/technical leader (10 sec. start),” representing the leader;
- File 2: content “program 1”;
- File 3: content “10 sec. black,” representing the trailer.

For the supply of more than one program file on a single Professional Disc (XDCAM and XDCAM-HD), a separation file is required for operational reasons. For the playout of such Professional Discs, the following sequence of files is therefore stipulated:

- File 1: content “10 sec. black/technical leader (10 sec. start),” representing the leader;
- File 2: content “program 1”;
- File 3: content “10 sec. black,” representing the separation;
- File 4: content “program 2”;
- File 5: content “10 sec. black,” representing the trailer or, in the case of additional program files, the separation;
- File n: for additional program files.

**Note:** Video contributions, e.g. on Professional Disc, require a “black leader” for automated processes. File contributions do not require any leaders, in order to avoid unnecessary extra trimming. The three-file option allows for both. In order to ensure a smooth process, the time code has to be consistent across all files on the Professional Disc.

17.2 P2 Cards with AVC-100

Supply to ZDF:

- Admissible data formats/encodings are: AVC-Intra 100 with the 720p/50, 1080p/25, and 1080i/25 image formats.

18 Additional Standards for the Exchange between Broadcasters

An integration of the VFT into the FESAD, program and production item exchange is currently in preparation. The following issues have been specified:

a) The existing physical exchange system – VFT – will be used for all exchange scenarios.

b) The existing FESAD ordering system will be used for all exchange scenarios.

c) Two additional data fields are defined for the exchange of programs and items: Field-1 „BezugZurProduktion“ (hierarchically superior to) Field-2 „ProduktionBemerkung“.

d) The two new data fields will be implemented in the FESAD exchange module as well as in the VFT system.

The definition of two additional data fields allows the transmission of an internal production ID and/or a textual remark on the use/application for operational implementation. These two data fields ensure that, in the ordering process, each orderer can add an ID that will allow him to match the delivered file to the order after delivery. The ID or the free text entered in these fields have to make sense only to the orderer.

This ensures that delivered files can be identified by the recipient and matched to the ordering process, e.g. production item exchange or FESAD program exchange.
Note: Subsequent to the operational implementation of the integration, detailed information on the operational use will be included in subsequent editions of these Guidelines.

19 Medienbegleitkarte

For the supply of program material both in-house (internal) and from outside sources (external), a uniform Medienbegleitkarte has been developed, which may be interpreted as an electronic version of – and eventually a replacement for – the familiar VTR record card. It was agreed that the Medienbegleitkarte should be handled separately from the MXF file, in order to avoid, for example, problems with transcoders, MXF fixers, or files in automated processing, and to make it conveniently available within an office network – for executive producers, for instance – without the large essence file.

The basis of the Medienbegleitkarte is an XML schema (BMF subschema), which is mandatory when transmitting metadata in VFT 2.0. It has been adapted to the requirements of various applications.

In general, the Medienbegleitkarte must be usable in a variety of visualization formats, e.g. on a printed page, as a PDF (for a sample, cf. item 44 in the appendices), or electronically integrated into a graphic user interface. In addition to the shared information, individual broadcasters may need different metadata for their own specific requirements, such as in-house IDs. For this reason, it is important that a uniform data model exists which forms the basis of the Medienbegleitkarte and from which the various display options may be generated, e.g. hard copy or graphic user interface (GUI).

19.1 Application Scenarios for the Medienbegleitkarte

A number of application scenarios for the Medienbegleitkarte has been defined. In all of these cases, the Medienbegleitkarte should be used for entire programs as well as for individual production items.

The subsections below will detail the following application scenarios:

- external supply,
- acceptance check,
- media-based transfer, e.g. on Professional Disc,
- ingest, and
- delivery of co-productions.

19.1.1 External Supply

This covers both the supply from outside producers and productions purchased from outside sources. The Medienbegleitkarte has to detail all relevant information on the material, including media and content.

19.1.2 Acceptance Check

The acceptance check usually includes the technical assessment of audio and video, based on a given set of criteria. It should be possible to assess audio and video independently of each other. Information describing the results of the assessment in the acceptance check should be included in the Medienbegleitkarte. In addition, an overall grading is required, i.e. suitable/not suitable for broadcast, etc.

19.1.3 Media-based Transfer, e.g. on Professional Disc

A program or segment is stored on a medium (e.g. Professional Disc) and passed on to a recipient. The Medienbegleitkarte has to detail all relevant information on the material, including media and content.
19.1.4 Ingest
Material supplied in a suitable form is ingest and allocated into an internal system (usually a production CMS). The Medienbegleitkarte has to detail all relevant information.

19.1.5 Delivery of Co-Productions
Material is supplied by another broadcaster via VFT as part of a co-production. Information contained in the Medienbegleitkarte has to be supplied along with the material via VFT.

19.2 Information for the Medienbegleitkarte
The information covered by the Medienbegleitkarte has been coordinated with the broadcasters. For the sake of readability and further simplification, the information has been structured, i.e. grouped into meaningful units, e.g. description of a program or description of a production.
In addition to the required (mandatory) information listed below, the use of additional information from the Medienbegleitkarte for a specific use or purpose has to be arranged between broadcasters (e.g. for a co-production) or specified by the broadcaster (e.g. for the supply of a commissioned production).

19.3 Required Information for External Supply and Co-Productions
The information detailed below is essential for co-productions and material supplied by outside sources and therefore has to be recorded on the Medienbegleitkarte

19.3.1 Program – Required Information

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program</strong></td>
<td></td>
</tr>
<tr>
<td>Series Title</td>
<td>If the program forms part of a series, the main title currently used has to be indicated.</td>
</tr>
<tr>
<td>Program ID</td>
<td>Unique ID number for the program, e.g. BID in BRID format</td>
</tr>
<tr>
<td>Program Main Title</td>
<td>Main title of the program, as currently used</td>
</tr>
<tr>
<td>Episode Title</td>
<td>If the program is an episode of a series, the series title and the program main title will be identical (e.g. Tatort), and the episode title will be the program title (e.g. „Kaltes Herz“)</td>
</tr>
<tr>
<td>Executive Producer in Charge</td>
<td>Name of the executive producer or department in charge; may differ from the original executive producer, e.g. for reruns.</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td></td>
</tr>
<tr>
<td>Material RT</td>
<td>Total running time of the production material in minutes and seconds</td>
</tr>
<tr>
<td>TC Start</td>
<td>Start of program without leaders, pre-roll, etc. (format: XX:XX:XX:XX)</td>
</tr>
<tr>
<td>TC End</td>
<td>End of program without trailers, post-roll, etc. (format: XX:XX:XX:XX)</td>
</tr>
<tr>
<td>Manufacturer Name Encoding Process</td>
<td>Name of the manufacturer of the encoding standard used, plus additional encoding parameters, e.g. XDCAM HD422 50 Mbit/s, AVC-I 100, DVCPRO50, IMX 50 Mbit/s, JPG2000</td>
</tr>
<tr>
<td>Scanning Raster</td>
<td>Scanning raster of the video signal, e.g. 576i/25, 720p/50, 1080i/25</td>
</tr>
<tr>
<td>Audio Encoding</td>
<td>Audio signal encoding, e.g. PCM, Dolby E, Dolby ProLogic, AAC</td>
</tr>
<tr>
<td>Subtitles (if applicable)</td>
<td></td>
</tr>
<tr>
<td>Subtitle Type</td>
<td>Type of subtitling, e.g. closed captioning (for the hearing-impaired), translation of foreign-language dialog</td>
</tr>
</tbody>
</table>
### 19.3.2 Segment – Required Information

<table>
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<tr>
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<th>Description</th>
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</tr>
<tr>
<td><strong>Segment ID</strong></td>
<td>Unique ID number for the segment, e.g. BID in BRID format</td>
</tr>
<tr>
<td><strong>Segment Main Title</strong></td>
<td>Main title of the segment, as currently used</td>
</tr>
<tr>
<td><strong>Executive Producer in Charge</strong></td>
<td>Name of the executive producer or department in charge; may differ from the original executive producer, e.g. for reruns.</td>
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<td>End of segment without trailers, post-roll, etc. (format: XX:XX:XX:XX)</td>
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<tr>
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<td>Audio signal encoding, e.g. PCM, Dolby E, Dolby ProLogic, AAC</td>
</tr>
<tr>
<td><strong>Subtitles (if applicable)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Subtitle Type</strong></td>
<td>Type of subtitling, e.g. closed captioning (for the hearing-impaired), translation of foreign-language dialog</td>
</tr>
<tr>
<td><strong>Subtitle Start TC</strong></td>
<td>Start time code of stored subtitle data coinciding with the start TC of the video signal to be played out</td>
</tr>
<tr>
<td><strong>Subtitles End TC</strong></td>
<td>End time code of stored subtitle data coinciding with the end TC of the video signal to be played out</td>
</tr>
<tr>
<td><strong>Subtitles First Pos.</strong></td>
<td>Position of the first visible subtitle</td>
</tr>
<tr>
<td><strong>Publication (if available)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Air Date</strong></td>
<td>Date when the segment is supposed to be aired</td>
</tr>
</tbody>
</table>
20 Audio

Recordings have to meet the quality standards of professional studio technology. Sound recordings have to correspond with image content in a reasonable way. They must not contain unintentional alterations of the acoustic ambiance and must be balanced in their mix throughout the program. To be suitable for broadcast, the mix always has to favor the intelligibility of speech.

For HDTV programming, stereophonic sound is a minimum requirement, while multi-channel sound (Dolby E or 5.1 discrete) are desirable expansions of audio quality as they complement the high-resolution image. Preferably, multi-channel audio should be supplied alongside 2.0 stereophonic sound.

20.1 Formats

20.1.1 Mono

In television studios, monophonic audio systems with a single audio channel are increasingly being replaced by the multi-channel systems in use today, including the widely used stereophonic system. These multi-channel audio systems are designated by the umbrella term multi-channel stereo systems.

20.1.2 Stereo

In producing stereophonic programs, compatibility with monophonic systems is essential. This has to be verified via an adding stage, not via an 90-degree filter.

The following statements can be made about the degree of correlation between two channels:

<table>
<thead>
<tr>
<th>Signal Type</th>
<th>degree of correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>mono</td>
<td>1</td>
</tr>
<tr>
<td>stereo (optimal)</td>
<td>0.3 … 0.7</td>
</tr>
<tr>
<td>left and right decorrelated</td>
<td>0</td>
</tr>
<tr>
<td>stereo (mainly negative correlation)</td>
<td>–0.3 … –0.7</td>
</tr>
<tr>
<td>mono (out of phase)</td>
<td>–1</td>
</tr>
</tbody>
</table>

*Note:* The degree of correlation in a stereo signal may temporarily take a negative value. However, should the degree of correlation stay in the negative range over an extended period of time, it must be assumed that the channel is out of phase.

20.1.3 Dual-Channel Audio

Dual-channel audio designates a technology with two independent audio channels. In television production, the two available audio channels are used for carrying the original and the dubbed version of a film, respectively (Dual-Channel Audio stereo).
Note: Since it has become customary to produce alternative language versions, audio descriptions, commentaries, etc. in stereo as well, attention has to be paid to the correct channel assignment when working with legacy (archival) two-channel footage.

20.1.4 Multi-Channel – Dolby Surround

Dolby Surround and Dolby Surround Pro Logic systems constitute special cases among multi-channel systems, as the four channels are not transmitted discretely but matrix-encoded.

The Dolby Surround system is basically a 3.1 system with three front channels and a (band-limited) surround channel, which is reproduced via the two surround speakers, LS and RS, in accordance with the reference configuration (Recommendation ITU-R BS.775-2).

For storage and transmission purposes, the four channels are matrix-encoded into two stereo-compatible channels and decoded for reproduction by means of a Dolby Pro Logic decoder. This encoding and decoding process has to be taken into account in the production of Dolby Surround recordings. This means that the mix, in principle, has to be based on the reference configuration, but only after encoding and decoding the four-channel signal by means of the Dolby Surround processor.

During production, surround audio signals have to be checked for adequate stereo and mono compatibility.

As the matrix-encoded stereo signals of Dolby Surround recordings are indistinguishable from conventional stereophonic recordings, the program has to be clearly identified as “Dolby Surround” on the VTR record card and on the tape label. Tracks have to be identified as Lt (left total) and Rt (right total).

20.1.5 Multi-Channel – Discrete

For systems with more than two channels, an international consensus was reached a few years ago about a configuration which represents a compromise between the demand for optimum spatial expansion of the playback on the one hand and compatibility with conventional two-channel stereophonic systems on the other. This standard configuration (cf. item 35), according to ITU-R BS.775-2, is a multi-channel stereophonic system designated as 5.0 or 5.1, referring to an audio system with 5 discrete broadband channels, three of which are being directed to the front speakers and two to the surround speakers.

The extension, “.1”, in “5.1” represents an additional – optional – sixth (LFE, or low-frequency effects) channel with a limited bandwidth, which may be used to carry low-frequency effects (cf. item 20.3.2.1).

3.0 is a subcategory of 5.1 and has to be treated as if it was 5.1 with the LFE and surround channels silent. The same applies to other subcategories, from 1.0 through 5.1.

For broadcast purposes, an additional mono-compatible stereophonic version is required in any case (cf. EBU Technical Recommendation R96).

In order to ensure downward compatibility within the hierarchy of multi-channel audio systems, provisions have been made for simple matrixing conditions to add missing channels or signal components to the remaining channels. ITU-R BS.775-2 should be used for reference. According to this recommendation, the formula for the downmix from 5.0 to conventional (2.0) stereo is as follows (with a factor of 0.7 corresponding to a level change of −3 dB):

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>R</th>
<th>C</th>
<th>LS</th>
<th>RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>L'</td>
<td>1.0</td>
<td>0.0</td>
<td>0.7</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>R'</td>
<td>0.0</td>
<td>1.0</td>
<td>0.7</td>
<td>0.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>

As multi-channel signals are not necessarily readily identifiable, any multi-channel production has to be identified clearly on the VTR record card or Medienbegleitkarte and on the label as such, e.g. “5.1 discrete,” or “3.0 discrete.”

It is desirable that multi-channel productions be announced in the trailer and identified for the viewer in teletext listings.
20.2 Leveling – Loudness Range

The measurement of both analog and digital audio signals has to comply with ITU-R BS.1770 and EBU Technical Recommendation R128, “Loudness normalisation and permitted maximum level of audio signals.” An audio signal is thus defined by the following parameters:

1. Program Loudness,
2. Loudness Range,
3. the “exact” Maximum True Peak Level.

20.2.1 Program Loudness

Measurement has to be performed by means of a loudness meter compliant with EBU Tech Doc 3341. These meters usually include a built-in “EBU mode” that ensures compliance with these guidelines for all parameters.

Loudness is expressed in loudness units (LU), a relative measurement. 1 LU is the equivalent of 1 dB. Absolute values are indicated in LUFS, i.e. loudness units referenced to digital full scale.

An “EBU mode” loudness meter offers three different time scales for the representation of loudness:

1. momentary loudness (abbreviated as “M”), sliding time window of 400 ms;
2. short-term loudness (abbreviated as “S”), sliding time window of 3 s;
3. integrated loudness (abbreviated as “I”), time window from “start” to “stop.”

Momentary loudness and short-term loudness are required for momentary measurement and mixing, in order to reach the Target Level for program loudness (see below).

Program loudness describes the long-term integrated loudness over the duration of a program, without emphasis on specific elements, such as speech, music, sound effects, etc. A program is a thematically self-contained audio-visual item, produced as a unit, including commercials, trailers, promos, interstitials, etc.

The program loudness parameter is expressed in a single figure with one decimal in LUFS.

The target level for program loudness has been set at –23.0 LUFS. Any deviation from this target level should not exceed ±1.0 LU.

**Note:** A certain tolerance may be necessary, e.g. for programming in which a precise normalization at the target level is practically not feasible (e.g. live programming).

For the computation of program loudness, blocks of audio (time window 400 ms) below –70 LUFS are excluded (absolute gating), as are blocks that are more than 10 LU below the absolute-gated integrated loudness level (relative gating). This accounts for the fact that – after loudness has been normalized - very soft sequences of above-average length would result in an unnaturally high overall loudness of a program.

If corresponding metadata are available, they always have to indicate program loudness correctly, even if a program was not leveled to –23 LUFS.

For all programs normalized to a target level of –23 LUFS, the corresponding parameter in the metadata has to indicate “–23.”

The loudness algorithm is defined in ITU-R BS.1770. All channels (except the LFE channel) are K-weighted.
K-weighting curve according to ITU-R BS.1770

In the case of 5.1 signals, the three front channels are weighted with a coefficient of 0 dB and the two surround channels with +1.5 dB. The weighted channels are summed up and integrated over time.

Channel processing, based on ITU-R BS.1770

20.2.2 Maximum Permitted True Peak Level

For checking the peak level, measuring of the true peak level (TPL) is recommended. The TPL describes the peak level of a continuous (analog) signal, determined by oversampling. In general, its value is thus higher than that measured with a conventional peak program meter or a sample peak meter. The maximum permitted true peak level in production (MTPL) is \(-1\) dBTP (decibel True Peak, relative to digital full scale, measured with a true-peak meter).
The true peak level is measured with a meter compliant with both ITU-R BS.1770 and EBU Tech Doc 3341.

20.2.3 Loudness Range (LRA)
The loudness range (LRA), previously designated as “dynamic range” – meaning the range between sequences with very soft (“ppp”) and very loud (“fff”) sounds – is relevant in the consideration of particular listening situations. In a downtown apartment, for example, with clearly audible traffic noise, an “excessively high” LRA would cause “ppp” sequences to be drowned out by background noise. It is possible to specify loudness range based on EBU Tech Doc 3342. Typical LRA values, expressed in loudness units (LU), are:

- LRA < 5 LU – small
- LRA ~ 10 LU – medium
- LRA > 15 LU – large

The computation of loudness range is based on the statistical distribution of measured loudness levels, according to EBU Tech Doc 3342, with an integration time of 3 seconds (“short-term loudness”) and an overlap between consecutive analysis windows of no less than 2 seconds. As in the measurement of integrated loudness, values below −70 LUFS are excluded (absolute gating), as are values lower than −20 LU relative to the absolute-gated integrated loudness level. LRA is defined as the difference between the estimates of the 95th and 10th percentiles of the statistical distribution of measured loudness (maximum value = 95%, minimum value = 10%), disregarding extreme levels below 10% and above 95%. This will prevent the fade-out of a music track or a single unusually loud effect sound, such as a “gunshot” in a movie, to affect LRA measurement.

Loudness range is measured on the basis of “short-term loudness,” as defined in EBU Tech Doc 3342.

Additional specifications have been published in the following EBU documents:

- EBU Technical Document 3341 “Loudness Metering: ‘EBU Mode’ metering to supplement loudness normalisation in accordance with EBU R 128,”
- EBU Technical Document 3342 “Loudness Range: A measure to supplement loudness normalisation in accordance with EBU R 128,”
- EBU Technical Document 3343 “Practical guidelines for Production and Implementation in accordance with EBU R 128,”
- EBU Technical Document 3344 “Practical guidelines for distribution systems in accordance with EBU R 128.”

20.3 Multi-Channel Audio
Multi-channel audio is optional and should preferably be employed in genres where the use of center and surround channels makes sense, e.g. in sports, entertainment shows, feature movies, musical productions, and documentaries.

- In the future, the exchange of multi-channel productions should be conducted with discrete PCM signals, if a sufficient number of audio channels is available.
- Alternatively, the exchange may be conducted in the Dolby E format, e.g. if the number of available audio channels is insufficient, if the necessary metadata cannot be found in the existing metadata presets, or if the program in question is Dolby-E-encoded legacy material.

20.3.1 Dolby E
Dolby E is an encoded audio format for professional use, which is able to carry up to 8 data-reduced audio channels, along with corresponding metadata and time codes via an existing stereo-PCM infrastructure and coupled to video.

*Caution: Beware of unintentional listening!* The Dolby E signal is a full-scale (0 dBFS) encoded data stream, not a linear audio signal. No changes whatsoever (such as level changes or sample-rate conversions) must be performed.
Dolby E was developed especially for the transportation of multi-channel audio within and between broadcast organizations. For this reason, Dolby E is, at all levels before the actual broadcast, a suitable process for exchanging and distributing multi-channel audio, particularly in connection with video. Dolby E may contain up to eight discrete audio channels (up to 8 individual audio programs), including individual metadata for each audio program. The up to 8 audio channels can be distributed in an existing infrastructure for digital stereo via an AES3 channel, or recorded on two channels of a digital video recorder. All 8 audio channels, including the metadata, are encoded with the common data rate of 1.92 Mbit/s (corresponding to a 20-bit word size and a 48-kHz sampling rate). The audio channels may have a bandwidth of 20 kHz and a dynamic range of up to 110 dB. If the transmission or recording channel is limited to a word size of 16 bits, six audio channels can be transported or recorded in the Dolby E format.

In contrast to Dolby Digital (AC-3), Dolby E is able to pass through numerous concatenations (up to 10 generations), i.e. multiple encoding and decoding cycles, without displaying discernible artifacts. Moreover, the integration of the SMPTE time code as well as the Dolby E framework structure ensure perfect synchronicity of audio and video throughout the entire post-production and distribution stages.

Dolby E is a professional system, which was developed exclusively for use in post-production and conventional broadcast infrastructures. Audio never reaches the consumer in the Dolby E format, since no such decoders are found in consumer electronics. Prior to broadcast, the multi-channel signal has to be converted either into the Dolby Digital format (currently the preferred option, as it is supported by all consumer devices which permit the reception of multi-channel sound via DVB) or into the DTS format.

20.3.1.1 Dolby E Word Size

In a hybrid SDTV/HDTV production environment, it has to be taken into account that an encoded Dolby E signal with a 20-bit word size may cause problems in day-to-day broadcast operations, e.g. due to the fact that IMX (in 8-channel mode) and DVCPRO50 offer only 16 bits for audio recording.

For supply and exchange (line and file transfer), Dolby E signals therefore have to be encoded with a word size of 16 bits (corresponding to 6 audio channels or less). A 20-bit word size is only permissible by bilateral agreement.

20.3.1.2 Dolby E Frame Positioning

The correct positioning of the Dolby E frame relative to the video frame permits clean splicing or switching of the Dolby E data stream every 40 ms without corrupting the data. This is achieved by the so-called “guard band,” which is inserted into the bit stream at the beginning and end of each Dolby E frame. When the Dolby E frame is positioned correctly, relative to the video frame, the guard band overlaps the specified switching point in the vertical blanking interval (VBI) of the video signal.

According to SMPTE R168, “Definition of Vertical Interval Switching Point for Synchronous Video Switching,” a blank line has to be taken into account following switching line before Dolby E metadata can be embedded. Ancillary data may thus be embedded in line 8 or higher in the 576i/25 raster and in line 9 or higher in the 720p/50 and 1080i/25 rasters.

For a trouble-free workflow, however, the table shown under item 36 has to be adhered to, which shows the specifications recommended by Dolby Laboratories, including further restrictions applying to the 1080i/25 and 720p/50 formats.

20.3.2 Dolby Digital

The Dolby Digital format is supported by all multi-channel receivers and all DVB set-top boxes (STBs) with a digital-audio interface that are available to consumers today, supporting data rates between 56 and 640 kbit/s. Caution: For reasons of complexity, older multi-channel receivers do not support 640 kbit/s data rates. In the DVD standard, a maximum data rate of 448 kbit/s has been specified. At a data rate of 192 kbit/s for a 2.0 signal, Dolby Digital is also Dolby-Surround compatible.

For a 5.1 signal, the target data rate lies between 384 and 448 kbit/s.

- The main channels (1 through 5) support a frequency range between 3 Hz and 20 kHz. In this case, the upper limit can be defined by the user.
- The optional LFE channel has a bandwidth from 3 Hz to 120 Hz.
- Resolution of audio samples: 16-, 20, or 24-bit resolution are supported.
- The data rate can be determined by the user.

**Note:** Dolby Digital is not suitable for the distribution of multi-channel audio in professional broadcast post-production:

- Multiple encoding and decoding cycles should be avoided, since Dolby Digital was optimized for low bit rates and does not support high bit rates.
- The length of Dolby Digital frames is different from that of video frames. Dolby Digital is thus not suitable for video editing.

### 20.3.2.1 Multi-Channel, LFE Signal

The low frequency effects (LFE) signal typically has a bandwidth of less than 120 Hz and is used optionally for low frequency effects. It is thus not a “subwoofer signal.” However, the subwoofer signal may be identical to the LFE signal, e.g. in theatrical motion-picture productions. For home cinema systems, 99 percent of which include satellite subwoofers and thus bass management, the subwoofer signal consists of the LFE signal plus the low frequencies of the five main channels.

According to SMPTE, the LFE channel should be reserved for parts of the program with extremely low frequencies and very high levels, whose lack during reproduction does not impair the artistic integrity of the program.

In production practice, the standardized use of a “+10 dB in-band-gain” creates an artificial headroom for lowest-frequency effects in places where the “normal” headroom is insufficient.

On the consumer side, decoders disregard the LFE signal in their downmix (see block diagram of an AC-3 decoder above), while raising the output level of the LFE signal by 10 dB.

![Bass management of an AC-3 consumer decoder (LFE crossover)](image_url)

In order to maintain compatibility in a broadcast production environment, the “+10 dB in-band-gain” has to be guaranteed on the listening side at all stages of production, post-production, and testing (cf. ITU-R BS.775 and SMPTE 320).

As a consequence, the level of the LFE channel has to be raised by 10 dB for loudspeaker calibration during the production process.

**Note:** However, if the check is conducted with a consumer decoder, the level must not be raised externally, since the +10 dB gain will be performed by the decoder (cf. the block diagram of an AC-3 decoder above).
20.3.3 DTS

Digital Theater Sound (DTS), originally developed for theatrical use and later also employed in DVD video, has been adopted as an additional audio system option in the DVB standard. This means that, in theory, DTS has the same status in digital video broadcasting as Dolby Digital. DTS permits a 5.1 and even a 6.1 multi-channel signal (the latter including a center-surround audio channel) to be transmitted in a single data stream with a sampling rate of 44.1, 48, or 96 kHz. The new DTS ES 96/24 format is downward compatible to the conventional DTS format. DTS is a scalable format and thus cannot be used only for the actual broadcast but also for production, post-production, and distribution. The source format may be available in 44.1 kHz and 20 bits, but also in sampling rates of 48, 88.2, 96, or even 192 kHz and word sizes of up to 24 bits. Bit rates range from 64 kbit/s for a mono channel up to a maximum of 4.5 Mbit/s for a 6.1 multi-channel signal, compared to a maximum bit rate of 640 kbit/s for Dolby Digital. In January 2004, the first DVB-STBs were marketed that can receive a DTS signal and loop it through to a hooked-up multi-channel receiver. All multi-channel receivers sold today support the DTS format, but with older multi-channel receivers, a built-in DTS decoder cannot be taken for granted.

Note: ARD, ZDF, and ORF do not use DTS. No other European broadcaster, except Sveriges Radio, currently uses the DTS system, either.

20.4 Metadata

Cascaded transmission paths with Dolby E and Dolby Digital permit a continuous transportation of metadata. These data contain various information on the audio tracks (copyright, content, properties, format, encoding, etc.). Metadata are adapted to the specific conditions of a production and determined by the sound engineer prior to encoding. They enable the decoder to be configured for optimized playback, depending on the individual listening conditions and personal preferences of the listener.

Key parameters for sound reproduction on the listener’s side are:

- dialog normalization ("dialnorm")
- dynamic range control, and
- downmix coefficients.

Apart from these “consumer parameters,” there are additional so-called “professional parameters” contained in the Dolby E bit stream, but not in the Dolby Digital bit stream.

20.4.1 Dialog Normalization

The dialog normalization ("dialnorm") parameter helps broadcasters adjust playback for the audience to a balanced level for different program types (music, announcement, action movie, talk show, etc.) or playback sources (STB, DVD player, etc.). The dialnorm value is the integrated average dialog level of a program, based on which the Dolby decoder normalizes playback to the same level as all other programs and sources on the receiver side, as long as they have the correct dialnorm values. The effect is a loudness balance controlled by the broadcaster, which, however, does not affect level control. After the transition to loudness-based audio leveling and normalization, the dialnorm value will be –23 in most cases, i.e. static.

20.4.2 Dynamic Range Control

Dynamic range control (or compression) (DRC) metadata in the decoder serve the purpose of optionally compressing all audio channels into the dynamic range preferred by the listener ("midnight mode"). Using preset DRC profiles that affect the dynamic range to varying degrees (such as “Film Standard,” “Music Light,” etc.), it is possible to influence the compression range on the receiving end already during production or before distribution.

20.4.3 Dolby Metadata Presets

A Dolby signal always contains metadata. If they are not set during production (e.g. because no Dolby encoding takes place at that stage), they have to be added at the final transmission point. For this purpose, a manageable number of Dolby metadata presets have been defined for a manageable variety of genres (cf. item 38). In addition, these presets serve as guidelines for setting metadata in production. In general, their use is recommended, based on the genre at hand.
Overview of Dolby metadata presets:
- Preset 1: loud, stereo (Dolby 2.0)
- Preset 2: loud, Dolby 5.1 (multi-channel)
- Preset 3: standard, stereo (Dolby 2.0)
- Preset 4: standard, Dolby 5.1 (multi-channel)
- Preset 5: dynamic, stereo (Dolby 2.0)
- Preset 6: dynamic, Dolby 5.1 (multi-channel)
- Preset 7: classic, stereo (Dolby 2.0)
- Preset 8: classic, Dolby 5.1 (multi-channel)
- Preset 9: sports, stereo (Dolby 2.0)
- Preset 10: sports, Dolby 5.1 (multi-channel)

20.5 Audio Track Allocation

20.5.1 Admissible Options

The audio track allocation described in the table under item 20.5.2 applies to program exchange and supply as well as to the delivery of programs to the Playout Center (ZSAW), regardless of the mode, i.e. on a physical medium, via line, or as files.

The following issues have to be observed:
- Audio track assignment is identical for SD and HD formats to be supplied.
- The table below lists options 1 through 6:
  - option 1 (programs with 4 audio tracks) is identical to the first four tracks of option 4 (programs with 8 audio tracks);
  - option 3 (programs with 4 audio tracks) is identical to the first four tracks of option 6 (programs with 8 audio tracks);
  - option 2 is only used for programs with 4 audio tracks;
  - option 5 is only used for programs with 8 audio tracks.
- For an unambiguous differentiation and identification, the 6 available options have been assigned the following distinct labels:

<table>
<thead>
<tr>
<th>Option</th>
<th>Application</th>
<th>Audio</th>
<th>Audio Tracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4-channel, M&amp;E (music and effects)</td>
<td>1 thru 4</td>
<td>for 4 audio tracks</td>
</tr>
<tr>
<td>2</td>
<td>4-channel, SAP (second audio program)</td>
<td>1 thru 4</td>
<td>for 4 audio tracks</td>
</tr>
<tr>
<td>3</td>
<td>4-channel, Dolby E</td>
<td>1 thru 4</td>
<td>for 4 audio tracks</td>
</tr>
<tr>
<td>4</td>
<td>8-channel, standard</td>
<td>1 thru 8</td>
<td>for 8 audio tracks</td>
</tr>
<tr>
<td>5</td>
<td>8-channel, discrete</td>
<td>1 thru 8</td>
<td>for 8 audio tracks</td>
</tr>
<tr>
<td>6</td>
<td>8-channel, SAP (second audio program)</td>
<td>1 thru 8</td>
<td>for 8 audio tracks</td>
</tr>
</tbody>
</table>

- All audio signals listed in the table are broadcast versions, except for the M&E signal.
- Option 2 may be used for programs with only stereo audio, but with a second audio program (language version), since an additional Dolby E version is only available for 5.1 multi-channel audio (a Dolby E encoding in multi-channel 2.0 is only designed for broadcast in most cases).
- Option 6 for 8-channel audio with a second audio program (SAP) in Dolby E is only admissible in cases where a second audio program including a Dolby E version exists. An SAP may consist of an audio description, a second language version, a commentary, or the original version. For programs supplied to ORF, this option is also permitted for programs with an SAP that is not available in Dolby E.
For all 6 options, the use of additional audio tracks that may be available on the delivery medium requires bilateral agreement.

**Note:** Supply and exchange of material with 16 audio tracks (for allocation, cf. item 34, appendix 4) is possible upon mutual agreement between contractor and broadcaster, or between broadcasters.
### 20.5.2 Audio Track Allocation for Program Exchange, Program Supply, and Program Delivery

<table>
<thead>
<tr>
<th>Option</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6&lt;sup&gt;(8)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>4-channel, M&amp;E</td>
<td>4-channel, SAP</td>
<td>4-channel, Dolby E</td>
<td>8-channel, standard</td>
<td>8-channel, discrete</td>
<td>8-channel, SAP</td>
</tr>
<tr>
<td>Audio 1</td>
<td>stereo broadcast audio&lt;sup&gt;(1)&lt;/sup&gt; (left)</td>
<td>stereo broadcast audio&lt;sup&gt;(1, 7)&lt;/sup&gt; (left)</td>
<td>stereo broadcast audio&lt;sup&gt;(1)&lt;/sup&gt; (left)</td>
<td>stereo broadcast audio&lt;sup&gt;(1)&lt;/sup&gt; (left)</td>
<td>stereo broadcast audio&lt;sup&gt;(1, 5)&lt;/sup&gt; (left)</td>
<td>stereo broadcast audio&lt;sup&gt;(1, 4)&lt;/sup&gt; (left)</td>
</tr>
<tr>
<td>Audio 2</td>
<td>stereo broadcast audio&lt;sup&gt;(1)&lt;/sup&gt; (right)</td>
<td>stereo broadcast audio&lt;sup&gt;(1, 7)&lt;/sup&gt; (right)</td>
<td>stereo broadcast audio&lt;sup&gt;(1)&lt;/sup&gt; (right)</td>
<td>stereo broadcast audio&lt;sup&gt;(1)&lt;/sup&gt; (right)</td>
<td>stereo broadcast audio&lt;sup&gt;(1, 5)&lt;/sup&gt; (right)</td>
<td>stereo broadcast audio&lt;sup&gt;(1)&lt;/sup&gt; (right)</td>
</tr>
<tr>
<td>Audio 3</td>
<td>music and effects (left)</td>
<td>SAP&lt;sup&gt;(2, 7)&lt;/sup&gt; (left)</td>
<td>Dolby E&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>music and effects (left)</td>
<td>multi-channel audio/L</td>
<td>Dolby E&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Audio 4</td>
<td>music and effects (right)</td>
<td>SAP&lt;sup&gt;(2, 7)&lt;/sup&gt; (right)</td>
<td>Dolby E&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>music and effects (right)</td>
<td>multi-channel audio/R</td>
<td>Dolby E&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Audio 5</td>
<td></td>
<td></td>
<td></td>
<td>SAP&lt;sup&gt;(2)&lt;/sup&gt; (left)</td>
<td>multi-channel audio/C</td>
<td>SAP&lt;sup&gt;(2)&lt;/sup&gt; (left)</td>
</tr>
<tr>
<td>Audio 6</td>
<td></td>
<td></td>
<td></td>
<td>SAP&lt;sup&gt;(2)&lt;/sup&gt; (right)</td>
<td>multi-channel audio/LFE</td>
<td>SAP&lt;sup&gt;(2)&lt;/sup&gt; (right)</td>
</tr>
<tr>
<td>Audio 7</td>
<td></td>
<td></td>
<td></td>
<td>Dolby E&lt;sup&gt;(3, 4)&lt;/sup&gt;</td>
<td>multi-channel audio/LS</td>
<td>SAP&lt;sup&gt;(2)&lt;/sup&gt; Dolby E&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Audio 8</td>
<td></td>
<td></td>
<td></td>
<td>Dolby E&lt;sup&gt;(3, 4)&lt;/sup&gt;</td>
<td>multi-channel audio/RS</td>
<td>SAP&lt;sup&gt;(2)&lt;/sup&gt; Dolby E&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

For footnotes, cf. following page.
Footnotes:

(1) In some program listings (magazines, announcements, etc.), Dolby Surround programs are specially designated as “surround broadcasts.” If required, the stereo broadcast audio may be recorded with a Dolby-Surround encoding. Such productions have to be clearly identified as “Dolby Surround” programs, e.g. on the VTR record card, on the tape label, in the Medienbegleitkarte, in the metadata, etc. The assigned tracks have to be labeled as Lt (left total) and Rt (right total).

(2) The SAP (second audio program) may consist of: foreign language, audio description, commentary, original version, etc. For the audio-descriptive version, visual content description is added to the German-language broadcast version.

(3) Caution: Productions will Dolby E have to be clearly identified and labeled as “Dolby E,” e.g. on the VTR record card, on the tape label, in the Medienbegleitkarte, in the metadata, etc.

If a Dolby E signal has to be encoded from a multi-channel audio source which also uses tracks 7 and 8, e.g. for M&E or STEREO, the Dolby E signal has to be recorded with a resolution of 20 bits. This exception requires a specific agreement.

(4) In option 4 (8-CH ST), audio 7 and 8, a Dolby E signal must only be present in the case of a multi-channel production. In all other cases, audio 7 and 8 must contain a PCM signal (e.g. audio silence) (NO Dolby E frame).

(5) For television broadcast purposes, it is necessary to include a compatible stereophonic version on tracks 1 and 2 with the recording of discrete multi-channel audio.

(6) Caution: Productions with discrete 5.1 audio have to be labeled unambiguously as “5.1 discrete,” e.g. on the VTR record card, on the tape label, in the Medienbegleitkarte, in the metadata, etc.

In contrast to television production, in the case of an exchange of pure audio (e.g. no video formats), the following track allocation is used for the supply and exchange of audio programs, in accordance with EBU R91:

1 = L, 2 = R, 3 = C, 4 = LFE, 5 = LS, 6 = RS, 7 = stereo broadcast audio (left), 8 = stereo broadcast audio (right).

(7) Audio track allocation options used in the past, which may be found, for example, in stock footage or other legacy material (Audio 1 = German-language broadcast version, mono; Audio 2 = original version or audio description, mono) have to be processed in such a way that the German-language version is available on tracks 1 and 2 for exchange and delivery, the audio description on tracks 3 and 4.

Note: In this regard, it has been agreed that for playout via the ARD-POC (Play-Out Center) or ARD-CC (Compression Center), audio tracks 1 and 2 (Audio PID1) shall henceforth be signaled as “stereo” without variation, while tracks 3 and 4 (Audio PID2) follow PDC (program delivery control). This permits the supplying broadcaster to control signaling on Audio PID2.

(8) Caution: Option 6 is used, for example, for acquired programs with two language version. It has to be noted that it is NOT possible at this time to broadcast two multi-channel versions simultaneously, NOR is it possible to transfer two Dolby E versions simultaneously via SNG.
20.6 Audio Description

Audio description designates a brief commentary between dialog on purely visual content that enables visually impaired viewers to follow a scene.

20.7 Synchronization of Audio Signals

EBU Technical Recommendation R83 contains standards for the synchronization of digital audio signals in television production. All digital audio signals have to be phase-locked to the frame rate of the video signal and coupled to each other without any sample offset.

PCM audio signals are synchronized and phase-locked via time code by the process defined in AES3.

Non-PCM audio signals, according to SMPTE 337, “Format for Non-PCM Audio and Data in an AES3 Serial Digital Audio Interface,” are synchronized and phase-locked via time stamps according to SMPTE 338, “Format for Non-PCM Audio Data in AES3 – Data Types,” and SMPTE 339, “Format for Non-PCM Audio Data in AES3 – Generic Data Types.”

20.8 Audio/Video Offset

In television production in general, audio/video offset (asynchronicity) should be avoided. If, however, unavoidable errors (e.g. in live programs with digital effects or use of digital wireless remote camera systems) occur, it is, in most cases not possible to compensate for all errors.

**Note:** In cases where wireless cameras are used side-by-side with delay-free wirebound cameras, sound should be delayed in such a way that the audio/video offset to the wireless camera is less than that to the wirebound camera, as audio lagging video will be perceived as less annoying than audio leading video.

It should also be noted that in these cases, too, the tolerances specified in EBU Technical Recommendation R37 should not be exceeded at the end of the entire production chain (the output intended for emission):

- audio must not lead video by more than 40 ms,
- audio must not lag video by more than 60 ms.

In general, it should be noted that seemingly minor offsets between video and audio will add up throughout the production chain. For this reason, everybody involved is responsible for achieving the smallest possible audio/video offset during his or her part of the chain. A single device or production change must never use the full tolerance granted for the entire process. Therefore, there is a strict demand to pay close attention to the A/V offset during shooting, editing, and transmission.

In accordance with EBU Technical Recommendation R37, it is therefore recommended that any differences in the relative timing of the sound and vision components of a television signal be minimized whenever and wherever possible. At any given point, the delay should not exceed the following limits:

- audio must not lead video by more than 5 ms,
- audio must not lag video by more than 15 ms.

If a significant audio/video offset occurs in a production, it has to be minimized immediately, preferably by the use of automated correction techniques.

20.8.1 Encoded Audio Signals

For encoded audio signals, e.g. Dolby E, no additional offset is permitted in comparison to discrete audio signals, e.g. stereo; they have to be provided in synchronicity (±0 full frame) with the corresponding video and stereo audio, e.g. on medium, in file, exchange line, etc.

This means that the delay of 40 ms caused by a subsequent Dolby-E decoding is not “pre-compensated.” This ensures that for all programs supplied, the discrete audio signals as well as the Dolby E signal have no delay relative to the video signal.
20.9 Separate Audio Supply Format
The methods to be used for ADR (dubbing and looping) of programs have to be arranged with the client. This also applies to the production of a separate synchronized audio recording, e.g. for multi-channel productions.
For broadcast, the entire broadcast audio has to be recorded on the broadcast tape or the tapeless system.

20.10 Track Assignment for Audio Exchange Formats
For pure audio exchange formats – without video program content –, the 5.0 or 5.1 system with the following track assignment is prescribed for the supply and exchange of programs with multi-channel audio signals, in accordance with EBU Technical Recommendation R91:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Audio Signal</th>
<th>5.0</th>
<th>5.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>left (multi-channel)</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>R</td>
<td>right (multi-channel)</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>C</td>
<td>center</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>LFE</td>
<td>low frequency effects</td>
<td></td>
<td>✗</td>
</tr>
<tr>
<td>LS</td>
<td>left – surround</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>RS</td>
<td>right – surround</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>MS</td>
<td>mono – surround*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>left (stereo)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>right (stereo)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*) in case of a single-channel surround signal (in lieu of LS and RS signals)

20.11 Handling Exotic Audio Formats
In general, the quality of audio signals has to meet the standards of state-of-the-art professional studio technology. Audio signals have to be supplied and exchanged on professional audio storage media as specified in these Guidelines.

Note: Nevertheless, for the handling of unconventional program demands, it may be useful to set up a central ingest facility with suitable playback equipment that is able to handle non-professional audio formats and storage media, such as Blu-ray discs, etc. This would constitute an efficient solution for achieving a technically satisfactory decoding and ingest.

21 Subtitles for HDTV Productions
Subtitles or captions have to be produced and supplied separated from the audio and video content of a program. This applies both to file exchange and live contribution. The following issues have to be observed:

- The format to be used for file exchanges is STL.
• SD may still be supplied via VFT, and in these cases, any subtitles contained in the material would have to be supplied separately as an STL file.
• In the case of live contributions in HD via Hybnet, (teletext) captions have to be supplied separately via Newfor protocol. Proprietary protocols may be used upon prior arrangement, since the caption systems communicate via point-to-point connections.
• Within a program, subtitles – e.g. for sequences that require translation of foreign dialog – will be hard-coded to the corresponding video, as in the past. These sequences should not have additional captioning for the hearing-impaired. Any overlapping (superimposition) of subtitles and captions must be avoided.

21.1 Subtitle Delivery to the ARD Playout Center (ZSAW)
Programs are delivered via line only in HD. Subtitles (captions) have to be delivered in a separate stl file.
In addition to the specifications laid out above (item 21), the following issues have to be observed:
• As long as there is no integrated solution for the exchange of subtitle files, subtitles have to be sent by e-mail to the Playout Center (ZSAW) at this address: ARDSZ-Untertitel@ard-stern.de. The subject header of the e-mail message must contain the „SZ-Abspielnummer“ (transmission ID) and, to be on the safe side, also the title of the program.
• DVB captions have to be pre-rendered via IP in FAB’s proprietary format and sent to the FT-DVB interface at the broadcast center. Individual solutions may be arranged with the ZSAW.

21.2 Subtitles for Internet Broadcast
An XML format based on EBU-TT has been specified for the exchange and supply of subtitles and captions for Internet broadcast use. The format has been described in the IRT project report, „XML-Format für die Distribution von Untertiteln in den ARD Mediatheken“ ("XML Format for the Distribution of Subtitles in the ARD Media Libraries").
For the time being, the online departments of the respective broadcasters will be responsible for supplying subtitle files to the joint media libraries, „ARD Mediathek“ and „Das Erste Mediathek.“ Subtitles may only be supplied in the XML format mentioned above. Arrangements on the supply of subtitles have been made in the "Web Technology" work group.

22 Live Contribution
The live contribution of HDTV material should be handled, whenever possible, in a transparent form (1.5 Gbit/s, HD-SDI). Avoiding codecs not only preserves the original video quality but also avoids the problems of latency. In any case, only 4:2:2 profiles should be used in live contribution!
In general, the specifications in these Guidelines also apply to live contribution. For profile recommendations, the operational applications listed in the tables below apply.
Note: Special attention has to be paid to the fact that in the domain of live contribution, several production stages are cascaded. Quality losses at each stage affect the overall quality on the receiving end for the consumer. The final quality will never be higher than that of the stage with the lowest quality!
Thus, if live contribution continually falls below the required thresholds (i.e. if they are not achievable, available, or affordable), the quality demanded for this particular application cannot be achieved!
Based on experience with H.264 codecs, it turns out that four SNG profiles are more than sufficient for day-to-day operations. The following paragraphs will list these four application scenarios in the field of satellite news-gathering (SNG) as examples, along with their specific requirements.
22.1 Latency

The latency for live contributions should be kept to a minimum, even with the H.264/AVC encoding process. Up to now, almost all SNG transmissions, including interviews in MPEG-2 SDTV, have had an encoder delay of 470 ms, in addition to the satellite propagation delay (280 ms)! In view of this situation, the demand for a latency of less than 400 ms may be ambitious but desirable! The priority demand on the operational units involved is the secure handling of all necessary processes, even if it requires the use of codecs from different manufactures. For this reason, latency-reduction demands, which tend to favor a single-manufacturer solution (for encoder and decoder), should be seen in a critical light, as for example the ultra-low-delay (ULD) mode. Moreover, the ULD mode is not necessarily practical for sportscasts and newscasts (except for interviews).

In general, the latency actually available depends on codec type (e.g. MPEG-2 or H.264), GOP structure (e.g. number of B-frames), and the combination of encoder/decoder manufacturers. Current implementations show that a mere H.264 encoder/decoder latency of 800 ms is realistic.

22.2 Satellite News-Gathering (SNG)

In the area of SNG, the bottleneck with regard to the achievable HDTV quality is determined by both available capacities and affordable bandwidths. Usually, transponders with bandwidths between 6 and 36 MHz are available, i.e. a maximum of 56 Mbit/s is available for HDTV video in the DVB-S2 modulation format with 8-PSK.

22.2.1 SNG Profiles

With a few exceptions, codecs with MPEG-2 compression were the only ones offered for SNG applications at the time when HDTV was launched. The basis for transmission were the three MPEG-2 HD profiles specified by EBU Eurovision: 60HD, 42HD, and 32HD.

By now, all relevant manufacturers are offering codecs with the more efficient video compression format, H.264/AVC. These codecs were also introduced for EBU’s Eurovision Satellite Network. Corresponding H.264 HD profiles were presented (as of October 2011). Eurovision’s profiles can be looked up in “Eurovision Network in 2012 – MPEG4. Information Letter for ACE Meeting Glion 6+7/10/2011.” The H.264 profiles specified for the EBU’s Eurovision Satellite Network also form the foundation for domestic SNG applications. However, some parameters have to be adapted to slightly differing condition, e.g. the use of mainly 4-meter dishes for Eurovision and 1.5-meter dishes domestically. Only strict adherence to these specifications is able to warrant sufficient reliability for the actual transmission paths.

The roll-off factor is thus set at 25% for all profiles in domestic use (EBU profiles 11HD and 22HD are set at 20%). However, depending on the case at hand (cf. item 22.2.2), Dolby E is optional on the national level, e.g. for profile HD 8-18 PAA (18 MHz transponder). This will more than compensate for the video data-rate loss caused by the increase of the roll-off factor.

The “domestic” H.264 profiles are listed in the table "SNG Profiles for H.264 Recommended by ARD, ZDF, ORF, and SRG" under item 45, both for 8 PSK and the more efficient 16 APSK modulation. The only difference lies in the modulation parameters, while audio and video parameters are identical in both modulation processes. There is no obligation to accept 16 APSK modulation, which means that its use has to be agreed upon bilaterally.

**Note:** The term PAA (phase-aligned audio) may be copyrighted, but (also due to the distribution of the Eurovision codecs), it has become common practice to use this term for “phase-locked discrete audio” (PDA).

22.2.2 SNG Scenarios

As a guideline, four relevant scenarios – SNG 1 thru SNG 4 – have been identified for HDTV (cf. table below, “Relevant scenarios for SNG”). The corresponding SNG profiles in H.264 can now be matched to these scenarios.

**Note:** The HD Low Profile (SNG 4) is NOT suitable for content requiring high motion resolution! It should only be used for low-demand video content, i.e. when content is technically simple, e.g.
a press conference, or not essential to the program, e.g. for one of several remote contributions. As a rule of thumb, the HD Low Profile should be considered unsuitable in the following cases:

- scenes with numerous camera positions
- sportscasts
- broadcast line

Since a satellite broadcast channel is not a constant and since the quality of transmission may vary with a variety of parameters, additional considerations are relevant in practical application.

- Since transmission margins vary constantly, depending on a variety of parameters, recommendations can only be given that apply to the majority of transmissions. The actual results will depend on the following parameters:
  - the satellite system used,
  - solar flux and the resulting variations in solar panel output,
  - the overall load on the transmission transponder,
  - the type (TWTA or SSPA) and characteristic level control of the output amplifier,
  - the current weather conditions at the uplink and downlink end of the transmission.

- An optimized calibration of the transmission parameters is only possible, if information about the signal margin at the receiving location is available to the sender. For a high-quality transmission, the highest possible payload rate should be aimed at. This data rate can only be transmitted, though, if the receiving system can achieve the necessary margin for the satellite system used and for the current weather conditions.

<table>
<thead>
<tr>
<th>No.</th>
<th>Scenario</th>
<th>Short Form(1)</th>
<th>Video Quality</th>
<th>Latency</th>
<th>Audio Tracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNG 1</td>
<td>HD Double-Hop (live broadcast line, high-quality transmission)</td>
<td>HD 8-24 PAA</td>
<td>very good [422]</td>
<td>low approx. 1 s</td>
<td>8 phase-locked</td>
</tr>
<tr>
<td>SNG 2</td>
<td>HD Mega-Low Delay (high-quality transmission with low latency)</td>
<td>HD 8-18 PAA</td>
<td>good [422]</td>
<td>low approx. 600 ms</td>
<td>8 phase-locked</td>
</tr>
<tr>
<td>SNG 3</td>
<td>HD Standard</td>
<td>HD 8-12 PAA</td>
<td>good [422]</td>
<td>low approx. 1 s</td>
<td>8 phase-locked</td>
</tr>
<tr>
<td>SNG 4</td>
<td>HD Low Profile(2)</td>
<td>HD 8-9 PAA</td>
<td>low [422]</td>
<td>low approx. 1 s</td>
<td>8 phase-locked</td>
</tr>
</tbody>
</table>

Relevant scenarios for SNG

(1) **Note:** The short form for the profiles is generated as follows: [SD/HD] [modulation type]- [bandwidth satellite/MHz] [suffix, if applicable, e.g. PAA].

(2) **Note:** For the use of the HD Low Profile, the restrictions listed under item 22.2.2 must be observed.

The following chapters list, apart from an application example, the specifications for video quality, latency, and audio channels for each of the four scenarios.

**Note:** In practical usage, additional specifications apply, e.g. bit depth, GOP structure, and profile/level of the encoding formats (cf. item 45, appendix 15).

**22.2.2.1 SNG 1 – HD Double-Hop (Live Broadcast Line, High-Quality Transmission)**

**Example:** An ARD co-op broadcast, e.g. winter sports: If two compressed paths (double-hop) are necessary, quality loss due a concatenation of two contribution codec profiles has to be taken into account. The second hop may be avoided, e.g. for international matches, if the broadcast director located at the stadium is
linked by fiber-optic cable. The latency delay has to be appropriate for switches between different venues.

**Video:**
Maximum video quality: If no further processing follows, the effect of the SNG codec on video quality must not (or barely) be noticeable for the viewer. Due to cascading, a quality buffer has to be available for the second hop.

**Latency:**
Low-delay mode; the actual latencies for the entire path are in the area of one second.

**Audio:**
Eight mono channels (phase-locked for discrete multi-channel audio), i.e. $4 \times 384$ kbit/s, MPEG-1, Layer 2, or replacement of a stereo pair by $1 \times 2.304$ Mbit/s (7/8) transparent AES channel for Dolby E (20 bit).

### 22.2.2.2 SNG 2 – HD Mega-Low Delay (High-Quality Remote Interview)

**Example:**
A live connection with a remote interviewee during a magazine program requires minimal latency. Video quality has to be adequate for a magazine program.

**Video:**
Good video quality: If no further processing follows, the effect of the SNG codec on video quality may be just noticeable for the viewer, even in complex images with a lot of movement, i.e. for images rich in detail, a slightly lower resolution and possibly slightly more noise may be acceptable, but no additional artifacts (such as pixel structures) must be visible.

**Latency:**
Mega-low delay mode; the actual latencies for the entire path are in the area of less than one second.

**Audio:**
Eight mono channels (phase-locked for discrete multi-channel audio), i.e. $4 \times 384$ kbit/s, MPEG-1, Layer 2.

**Note:** If required, a stereo pair by $1 \times 2.304$ Mbit/s (7/8) transparent AES channel for Dolby E (20 bit) may be used. However, this will reduce the available video data rate, depending on the manufacturer, by up to 3 Mbit/s.

### 22.2.2.3 SNG 3 – HD Standard (Standard Remote Interview)

**Example:**
This profile is the first choice for standard SNG applications with a single hop. No further hop (cascading) is required. Video quality and latency have to match the target program.

**Video:**
Good video quality: If no further processing follows, the effect of the SNG codec on video quality may be just noticeable for the viewer, i.e. for images rich in detail, a slightly lower resolution and slightly more noise may be acceptable, but no additional artifacts (such as pixel structures) must be visible.

**Latency:**
Low-delay mode; the actual latencies for the entire path are in the area of one second.

**Audio:**
Eight mono channels (phase-locked for discrete multi-channel audio), i.e. $4 \times 384$ kbit/s, MPEG-1, Layer 2.

### 22.2.2.4 SNG 4 – HD Low Profile

**Example:**
This profile is NOT suitable for content requiring high motion resolution! It is only sufficient for video content with low demands on the encoder. It may be used when content is technically simple, e.g. a press conference, or not essential to the program, e.g. for one of several remote contributions (cf. item 22.2.2).

**Video:**
Sufficient video quality, if no further processing follows. For unsuitable content requiring high motion resolution, a higher-quality profile has to be used, in order to avoid a deterioration of video quality.

**Latency:**
Low-delay mode; the actual latencies for the entire path are in the area of one second.
Audio: Eight mono channels (phase-locked for discrete multi-channel audio), i.e. 4 × 384 kbit/s, MPEG-1, Layer 2.

22.3 Landlines
Audio, video, and Ethernet/IP connections are being established in the networks currently available (e.g. cross-connected carrier-class multi-service edge routers) by means of special mechanisms and a special control software. For the integration of live telecast contributions, more and more connections are being offered using H.264 and J2K codecs.

22.3.1 H.264-encoded Connections
In general, hardware configurations in this case are similar to those in SNG vehicles, and thus the data rates used for landlines may use them as a guideline. However, the underlying parameters (bandwidth of carrier link, latency requirements) are different for landlines.

Recommendations for the implementation of BNS profiles are currently under discussion in the FELA expert group. For HD, the solution will have two phases. Based on the profiles currently available, the following profiles are recommended:

- **transfer**: HD-422-20-A2
- **remote interview**: HD-422-29-A2-LD
- **return audio and video for remote interview**: HD-422-14-A1-LD

22.3.2 J2K-encoded Lines
Currently, a variety of transmission profiles with J2K codecs is offered for landlines booked to carry HD signals, apart from a transparent connection (1.5 Gbit/s).

Based on operational experience, the following reference values are recommended:

- If further cascading with other codecs is necessary, connections with no less than 200 Mbit/s are required for very good video quality.
- For simple connections without any further cascading, connections with 175 Mbit/s will suffice for very good video quality.
- For good video quality, a profile with 150 Mbit/s seems to be sufficient, i.e. for images rich in detail, a slightly lower resolution and possible slightly more noise may be acceptable, but no additional artifacts (such as pixel structures) must be visible.

23 Outside Broadcasts (OB)

23.1 Broadcast Technology
Outside broadcasts (OB) use cable-linked transmission facilities (e.g. fiber-optic cable), satellite uplinks (SNG), or mobile microwave radio relay systems owned by public broadcasters as well as commercially operating producers and service providers.

23.2 Organization of Broadcast Facilities
Both for in-house productions and programs produced outside, the broadcasters’ offices in charge of transmission are the primary contacts for all contribution-related issues. They will support producers in finding available options for transmission:

- via broadcaster-owned network lines,
- via broadcast service providers’ lines,
- via satellite, or
- by other means, e.g. UMTS, Internet.
The line-management offices (Leitungsbüros) will communicate the options to the producers and arrange booking procedures as specified by the service provider. The offices are aware of the current service portfolios offered by various providers and of any general agreements that might exist between the broadcaster and the service provider. They will also coordinate available capacities (e.g., permanently available transponders on various satellites) with the ARD-TV Leitungbüro, the ZDF-Leitungswesen, or the WDR Leitungbüro.

The producers will be responsible for procuring and organizing the technical facilities and equipment needed at the uplink location, such as booking an SNG vehicle and a fiber-optic link.

23.3 Outside Broadcasts Using SNG Facilities

Ordering an SNG transmission requires the booking of a space segment and of SNG uplink and downlink capacities.

“Booking a transponder” for SNG purposes requires the following information:

- start/end date and time (on an international level in UTC);
- originating location for assessing footprint and availability of the satellite to be booked;
- receiving location for assessment of the downlink situation, possibly simultaneous activities at the receiving facility;
- content of the transmission with program title, information on: SD or HD, live or transfer, audio track allocation;
- information on SNG, operator, Earth Station Code and corresponding telephone number (available for the satellite operator throughout the transmission); name of operator with telephone number, if possible;
- desired bandwidth with profile specification and type of modulation: DVB-S, DVB-S2, MPEG4-2, H.264;
- name of person ordering, with telephone number for any queries;
- production number or cost center for billing.

23.4 OB Facilities Using Proprietary Mobile Microwave Systems

Proprietary (broadcaster-owned) microwave transmission systems in the 21-GHz band and mobile or portable systems in the 12-GHz and 2.3-GHz band (“window-ledge units”) can be used for outside broadcasts.

It is possible to feed their signals into the system at proprietary feed points.

24 HD-SDI (HD Serial Digital Interface)

Detailed information on and explanations of relevant HD interfaces can be found at [http://www.irt.de/richtlinien](http://www.irt.de/richtlinien) in the section called „Handbuch der Fernsehsystemtechnik“ (“Handbook of Television System Engineering”). The relevant document is entitled „Fernsehsystemtechnik Kapitel 5, Messtechnik für Multiformat-Systeme” (“Television System Engineering, Chapter 5, Measurement Techniques for Multi-Format Systems”).

The following paragraphs summarize part of the information with regard to the HD-SDI.

24.1 Transmission Capacities of Various HD-SDIs

The following table lists the physical interface specifications for the four HD systems recommended in EBU Tech Doc 3299 (cf. item 7) and the corresponding SMPTE standards. As an additional information, the video net data rates and the total data rates for the various HD systems have been listed.
## Interfaces required for the EBU HD systems

<table>
<thead>
<tr>
<th>EBU HD Systems</th>
<th>SMPTE</th>
<th>292M</th>
<th>372M 292 M</th>
<th>424M</th>
<th>435M</th>
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<td>Total Data Rate</td>
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<td></td>
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<td>✗</td>
<td>✗</td>
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<td></td>
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<tr>
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<td>✗</td>
<td>✗</td>
<td>✗</td>
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<td>1.4850</td>
<td>✗</td>
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<tr>
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<td>✗</td>
<td>✗</td>
</tr>
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</tr>
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<td>4.4550</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
</tbody>
</table>

### 24.2 1.5-Gbit/s Interface

The HD-SDI with a 1.485 Gbit/s data transmission rate is specified in SMPTE 292M and ITU-R BT.1120.

Among others, this interface is used by the four digital HDTV formats recommended by EBU. The serial digital transmission of the signals (video, audio, and data) with bit rates of 1.485 Gbit/s is performed via 75-Ω coaxial cable or fiber-optic cable.

### 24.3 Dual-Link

If data rates higher than 1.485 Gbit/s are required, as in EBU HDTV system 3, two transmission paths are used in a so-called “dual link.”

A dual link consists of two identical 1.485-Gbit/s channels (link A and B), which are being assigned depending to the application at hand. The assignment of links A and B for EBU HDTV systems 1 through 4 is specified, complete with diagrams, in the *Handbuch der Fernsehsystemtechnik* ("Handbook of Television System Engineering").

### 24.4 3-Gbit/s Interface

The 3-Gbit/s interface with a data transmission rate of 2.97 Gbit/s is specified in SMPTE 424M and SMPTE 425M, whereby SMPTE 424M lists primarily the physical specs and SMPTE 425M specifies the mapping structure.

HD-SDI signals are routed in the 3-Gbit/s interface via different paths, e.g. 2 × HD-SDI and 1 × dual link. For this reason, the structure of the 3-Gbit/s signal's multiplex data varies, depending on the signal processing performed by the serializer. While the 3-Gbit/s signal maintains the same physical properties throughout, incompatibilities occur on the logical level. In practice, this means that 3-Gbit/s-capable equipment without signal processing (such as distributors and routers, etc.) will support all 3-Gbit/s signal types. Equipment, however, that does perform signal processing (such as mixers, NLE systems, etc.) has to be compatible to the level and mapping chosen.

SMPTE 425M currently defines two different “levels” and distinguishes between two different mapping formats within Level B:

- Level A: direct image format mapping
- Level B-DL: SMPTE 372 dual-link mapping
- Level B-DS: 2× SMPTE 292 (HD-SDI) dual-stream mapping
Note: A detailed explanation of the different mapping structure in the various levels is given in the „Handbuch der Fernsehsystemtechnik“ ("Handbook of Television System Engineering"), chapter 5, „Messtechnik für Multiformat-Systeme“ ("Measurement Techniques for Multi-Format Systems") (http://www.irt.de/richtlinien).

25 Color Space

The standardized color spaces for SDTV and HDTV are nearly identical in their primary valences and their white levels. The main difference is caused by the different specification* of the Y matrix:

- **SDTV**: \[ E'_Y = 0.299 E'_R + 0.587 E'_G + 0.114 E'_B \] (ITU-R BT.470)
- **HDTV**: \[ E'_Y = 0.212 E'_R + 0.715 E'_G + 0.072 E'_B \] (ITU-R BT.709)

For this reason, in any up- or down-conversion, attention has to be paid to the correct adjustment / selection of the target matrix (SDTV matrix or HDTV matrix).

*) Note: While in the “old” HDTV systems (e.g. 1250/50), thanks to the Europeans’ active participation, the same matrix as in SDTV was specified, the matrix in the “new” HDTV systems was specified differently by the rest of the world, due to the lack of European activity (HDTV was not a business model at the time).

N.B.: The integration of non-broadcast-specific sources with “alien” color spaces requires a color-space conversion!

In producing television programs with digital component signals (Y, C_R, C_B), care has to be taken that the reproduction of the broadcast material (tape or file) will permit an encoding into MPEG-2 and/or H.264 compliant with the respective standard.

25.1 Video Level and Gamut (Illegal Signals)

Digital signals are assessed on the basis of the ITU-R BT.709-5 Part 2 recommendation. Video levels of the material supplied have to fall within the specified range, in order to allow the program to be used without any further calibration. Any signal outside the specified range will be considered a gamut error.

Note: Gamut designates the total amount of colors that a device or medium (e.g. a monitor, printer, scanner, film) is able to reproduce, display, or record.

25.1.1 Measurement of Signal Levels

Digital video levels are usually measured by means of a device that displays the signal curve, i.e. a traditional waveform monitor. This device displays the results either in millivolts (mV), emulating an analog signal, or as a percentage of the permissible levels. The limits of the signal levels are defined in reference to a nominal black and white level. The black level for the R, G, and B signals is zero (0% or 0 mV), and the white level for all three signals is 100% or 700 mV. All three video-signal components – R, G, and B – may vary between 0% and 100% (or 0 mV and 700 mV). This is equivalent to the digital sample levels 16 and 235 (8-bit systems) or 64 and 940 (10-bit systems).

25.1.2 Tolerance for Out-of-Gamut Signals

In practice, it is difficult to avoid that signals occasionally slightly overshoot the specified limits. It is therefore customary to allow for a small tolerance, which is defined as follows in EBU R103:

- all of the R, G, or B signals should lie between −5% and 105% (−35 mV and 735 mV);
- the luminance signal (Y) should lie between −1% and 103% (−7 mV and 721 mV).

Minor over- or undershoot might be filtered out prior to measurement. This will result in errors being registered only when out-of-gamut signals occur over more than 1% of the image area, since many monitoring devices are set up according to this specification.
**Note:** Both tolerance ranges must be observed at all times. It is not acceptable to comply with or verify only one of the limits, as the two parameters are not mutually dependent. For example, an RGB signal combination with signal portions reaching 105% may very well result in a luminance signal with portions exceeding 103%.

Values above 109% and below –6.84% for luminance (Y) are defined as Time Reference Signal (TRS). They are absolutely prohibited in video signals and have to be clipped in the serializer. The same applies to values above 106% and below –6.68% for chrominance signals (CR and CB).

Values between 100% and the maximum value of 109% and 106%, respectively, or below 0% are headrooms and footrooms reserved for over- or undershoot. The “mean” white or black level, respectively, should not be located in these ranges.

### Quantisation level for Y

<table>
<thead>
<tr>
<th>decimal 10 Bit</th>
<th>%</th>
<th>video content</th>
<th>decimal 8 Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1023</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1020</td>
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<td></td>
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<td>1019</td>
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<td>headroom</td>
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<td>960</td>
<td>103%</td>
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<td>940</td>
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<td>headroom</td>
<td>15</td>
</tr>
<tr>
<td>55</td>
<td>-1%</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>-6.84%</td>
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### Quantisation level for C

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<tr>
<td>1020</td>
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<td>128</td>
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<td>15</td>
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<td>19</td>
<td>-5%</td>
<td>headroom</td>
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</tr>
<tr>
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<td>-6.84%</td>
<td></td>
<td>1</td>
</tr>
<tr>
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</tr>
<tr>
<td>0</td>
<td></td>
<td>not allowed in active video</td>
<td>0</td>
</tr>
</tbody>
</table>
25.2 Operational Implementation

The headroom provided for in the ITU specifications is intended for unavoidable short gamut overshoot errors, e.g. during the transient state of filters, unexpected peaks caused by camera pans, etc. This headroom must not be used (i.e. exhausted) for artistic purposes! For this reason, analyzers are useless which only register threshold exceedances regardless of the temporal extent of the error (e.g. from the duration of a sampling value!)

It is important that for any program material intended for exchange or broadcast, the nominal video level exceeds the signal levels specified in ITU-R 601 for SD and in ITU-R BT.709 for HD only for a very short period!*

*) A reasonable specification of the permissible duration [number of sample values] and/or frequency [sample values per second, minute, or hour], i.e. an integration constant, is currently under discussion.

25.3 Permissible and Valid Signal Levels

At this point, it should also be mentioned that not all signal level combinations admissible on the analog and digital component level are necessarily “legal” signal levels. Experience has shown that these “illegal” signal states occur with production equipment that performs internal signal manipulations or creates signals on the Y, C_R, C_B level, e.g. computers, paint systems, digital effects hardware, component mixers, and character generators. The “super black levels” used in analog technology as keying signals are also not suitable for the digital domain.

A reliable signal legality check can be performed by an oscilloscopic RGB representation. The validity of signals may be monitored by means of a suitable meter or a monitor that indicates a violation of the RGB color space (cf. item 32) in relation to its duration.

Note: Experience has shown that so-called color gamut “legalizers” should be used with caution, as they may create artifacts in the image that are more visible than the original color gamut errors (cf. EBU R103, “Tolerances on ‘illegal’ colours in television”!)

26 Image Center and Safe Areas

In view of the increasing number of consumer-side flat screens with the option of 1:1 pixel mapping (true pixel), it is vital to work with extreme diligence on the production side, which means that active contents has to flawlessly fill the entire image area that is transmitted (cf. item 31), from edge to edge.

Note: In 1:1 pixel mapping, the borders on all four edges of the frame are no longer areas hidden from view by the consumer’ display, as the entire active picture area is displayed without any overscan.

The relevant specifications for image center and safe areas have been specified in EBU R95, “Safe areas for 16:9 television production.” These specifications are based on the relevant SMPTE standards:

- SMPTE 296, 1280 x 720 Progressive Image Sample Structure – Analog and Digital Representation and Analog Interface, item 6, “Raster Structure.”

26.1 Image Center

In general, the relation between the synchronization signal and center of the active picture (image center) should not be altered (e.g. by any processing equipment involved) at any stage of the production process. If a deliberate shift is demanded for creative reasons, the entire blank area
thus created on the edge opposite to the direction of the shift has to be filled completely with active content.

In order to ensure that the entire image area is filled with active content on consumer sets with 1:1 pixel mapping, which are commonly used today, the specifications for the image center listed under item 31 have to be observed:

**System 1 (720p/50):**
- vertical*: between lines 385 and 386;
- horizontal**: between pixels 639 and 640.
  *) The total number of lines is 750 (active lines from 26 through 745 = 720 lines)
  **) The complete digital line consists of 1650 pixels (active pixels from 0 through 1279 = 1280 pixels)

**System 2 (1080i/25) and System 3 transported as System 2 (1080psf/25):**
- vertical*: between lines 291 (F1) and 853 (F2);
- horizontal**: between pixels 959 and 960.
  *) The total number of lines is 1125 (active lines in F1 from 21 through 560; in F2 from 584 through 1123 = 1080 lines)
  **) The complete digital line consists of 2200 pixels (active pixels from 0 through 1919 = 1920 pixels)

**System 3 (1080p/25) and System 4 (1080p/50):**
- vertical*: between lines 581 and 1083 = 1004 lines;
- horizontal**: between pixels 67 and 1852 = 1786 pixels.
  *) The total number of lines is 1125 (active lines from 42 through 1121 = 1080 lines)
  **) The complete digital line consists of 2200 pixels (active pixels from 0 through 1919 = 1920 pixels)

26.2 Action-Safe Area

In order to ensure that the action-safe area of the image is displayed on all consumer displays in use today, the specifications listed listed under item 31 have to be observed. In accordance with EBU R95, safe areas of 3.5% (relative to the 16:9 full frame raster edge) have been taken into account for HD, resulting in the following line and pixel limits:

**System 1 (720p/50):**
- vertical*: between lines 51 and 720 = 670 lines;
- horizontal in the digital line**: between pixels 45 and 1234 = 1190 pixels.
  *) The total number of lines is 750 (active lines from 26 through 745 = 720 lines)
  **) The complete digital line consists of 1650 pixels (active pixels from 0 through 1279 = 1280 pixels)

**System 2 (1080i/25) and System 3 transported as System 2 (1080psf/25):**
- vertical in field 1*: between lines 40 and 541 = 502 lines;
- vertical in field 2*: between lines 603 and 1104 = 502 lines;
- horizontal in the digital line **: between pixels 67 and 1852 = 1786 pixels.
  *) The total number of lines is 1125 (active lines in F1 from 21 through 560; in F2 from 584 through 1123 = 1080 lines)
  **) The complete digital line consists of 2200 pixels (active pixels from 0 through 1919 = 1920 pixels)

**System 3 (1080p/25) and System 4 (1080p/50):**
- vertical*: between lines 80 and 1083 = 1004 lines;
- horizontal in the digital line **: between pixels 67 and 1852 = 1786 pixels.
  *) The total number of lines is 1125 (active lines from 42 through 1121 = 1080 lines)
  **) The complete digital line consists of 2200 pixels (active pixels from 0 through 1919 = 1920 pixels)

26.3 Titles and Graphics

In order to ensure the legibility of titles and graphics on all consumer displays, these elements should be produced with due diligence. This requires designers to use only large, readable fonts, which also increase the program's accessibility – a term that not only covers barrier-free broadcasting for viewers with disabilities but also means providing the best possible viewing experience for the widest audience.
Due to the simulcast of HD and SD, graphics generated in HD have to be downward-compatible to the SD domain, where characters at least 21 or 22 lines high in the 576i/25 SD scanning raster have been established. In HD terms, this translates into a character height of 26/27 lines in the 720p/50 HD raster and 40/41 lines in the 1080i/25 HD raster.

In order to ensure the legibility of crawls and scrolls on flat screens, in addition to the minimum character size, certain maximum crawl speeds must be observed. A special legibility test has been developed to determine these thresholds (cf. EBU Tech Doc 3325, 1.2 “Test pattern,” test sequence no. 6), which permits the vertical and horizontal scrolling of text in various sizes and at various speeds across the monitor. This allows a subjective assessment by running the test on various monitors.

**Note:** In EBU Tech Doc 3325, “Methods for the Measurement of the performance of Studio Monitors,” various test patterns are described, which may be downloaded as zip files in uyvy 10-bit and .v210 format via the EBU website under “EBU Tech Doc 3325s ‘Studio monitors – test patterns.’”

**Note:** In general, crawls and scrolls should be produced in the same raster format as the program content. Converted graphics and titles may already display very noticeable effects in the master, such as strong vertical or horizontal judder. Moreover, converted graphics will cause additional quality issues in any subsequent format conversions that may be necessary.

Titles and graphics for HD should be placed within the title (or graphics)-safe area (cf. item 31). In accordance with EBU R95, vertical safe areas of 5% and horizontal safe areas of 10% (relative to the 16:9 full frame raster edge) have been taken into account, resulting in the following line and pixel limits:

**System 1 (720p/50):**
- vertical*: between lines 62 and 709 = 648 lines;
- horizontal in the digital line**: between pixels 128 and 1151 = 1024 pixels.

  *) The total number of lines is 750 (active lines from 26 through 745 = 720 lines)

  **) The complete digital line consists of 1650 pixels (active pixels from 0 through 1279 = 1280 pixels)

**System 2 (1080i/25) and System 3 transported as System 2 (1080psf/25):**
- vertical in field 1*: between lines 48 and 533 = 486 lines;
- vertical in field 2*: between lines 611 and 1096 = 486 lines;
- horizontal in the digital line**: between pixels 192 and 1536 pixels.

  *) The total number of lines is 1125 (active lines in F1 from 21 through 560; in F2 from 584 through 1123 = 1080 lines)

  **) The complete digital line consists of 2200 pixels (active pixels from 0 through 1919 = 1920 pixels)

**System 3 (1080p/25) and System 4 (1080p/50):**
- vertical*: between lines 96 and 1067 = 972 lines;
- horizontal in the digital line**: between pixels 192 and 1727 = 1536 pixels.

  *) The total number of lines is 1125 (active lines from 42 through 1121 = 1080 lines)

  **) The complete digital line consists of 2200 pixels (active pixels from 0 through 1919 = 1920 pixels)
27 Time Code

First of all, it has to be noted that LTC and VITC are no longer recorded “internally” by the equipment in the traditional way, yet both terms are still in use, even though LTC and VITC are generated from different internal time code versions.

27.1 Linear Time Code (LTC)

Time codes have to comply with the specifications of SMPTE ST 12-1:2008.

27.2 Vertical Interval Time Code (VITC)

Most current and new recording formats no longer support the traditional form of VITC (digitized analog signal) but implement the time code as an ancillary data packet in the VBI (Ancillary Time Code = ATC) in accordance with SMPTE ST 12-1:2008.

Note: The SMPTE time code standard, 12M, was developed in 1975 (!) for analog recording systems and thus referred only to interlaced broadcast formats with up to 30 (full) frames per second. It proved, however, flexible enough to be adopted for digital broadcast systems, both SDTV and HDTV. However, for frame rates of more than 30 f/s, which are achieved by most progressive systems, the counting capacity of the time address is exhausted, and frames can only be referenced in pairs, resulting in an editing accuracy of 2 frames for traditional linear time-code application.

This situation required a revision for progressive video systems with more than 30 f/s, as documented by a “de facto implementation” that is already widely used, employing a field flag in VITC and ATC to distinguish and identify the first and second frame of a frame pair. The preferred implementation sets the field flag to 0 for the first and to 1 for the second frame.

The status quo is described in two documents:

SMPTE ST 12-1:2008, “Time and Control Code,” describing the time-code format (replacing previous documents SMPTE 12M, RP164 and RP159), and


Note: In the future, it should be noted that equipment and applications based solely on VITC in its traditional form can no longer be used.

27.3 Time Code in MXF

For the supply, exchange, and delivery via VTF, it has been agreed that the time code has to be embedded into the MXF file, in accordance with EBU R122, meaning that restrictions on the use of the three time-code options have to be observed. A more detailed explanation can be found under item 42. For operational specifications, please also refer to item 12.5.

28 Technical Video and Audio Acceptance Tests

Video and audio acceptance tests should be conducted in control rooms compliant with the DIN 15996 standard (“Image and Sound Production in Film and Video Studios and Radio Stations: Principles and Provisions for a Work Station”).

For a correct assessment, it is essential to establish the correct relative timing of the audio and video signals of the program to be tested. For this propose, it may be necessary to delay, for example,

- all corresponding audio signals when displaying the image on flat screens (due to the internal delay in image reproduction), or
- the corresponding video signal when testing of Dolby-E-encoded audio signals (due to the audio delay caused by decoding).
In a file-based production environment, automated testing procedures are used with increasing frequency, since they are capable of checking numerous technical parameters simultaneously, but they are not yet able to replace a subjective (human) assessment of audio and video quality.

**Note:** A special work group is currently in the process of developing guidelines for measurement and analyses in file-based production systems.

The results of the technical audio and video acceptance test are documented in an Acceptance Test Record (VTR record card / metadata / Medienbegleitkarte). A sample is shown under item 43.

### 28.1 Technical Video Acceptance Tests

HD productions should be tested for acceptance on a Class-1 monitor with a screen diameter greater than 20 inches. In addition, the use of a display with a diameter of 42 inches or more is strongly recommended for focus assessment and the detection of motion artifacts.

Since all flat screens have to scale the raster and de-interlace the television signal (as they display the image only progressively), the acceptance-tester has to pay particular attention to the display of graphic elements, such as scrolling or crawling titles, which has to be as flawless as possible.

Screen size is of fundamental importance for the assessment and acceptance of a program’s HD quality! During the transition period, as long as no reference monitor with a screen diagonal of approximately 50 inches is available, the use of two monitors is recommended for acceptance-testing image quality:

a) an available reference monitor with a screen diagonal of no less than 23 inches, and

b) a high-quality flat screen from an established manufacturer, with good properties and a screen diagonal between 42 inches and 50 inches, preferably plasma (for economic reasons, a consumer display may be used as a substitute).

**Note:** In order to make an identical reference available to all partners involved in the production, both in-house and outside, ARD, ZDF, ORF, and SRG are aiming at establishing a uniform display type as a common reference.

In any case, an optimum viewing distance of **3 times the height of the screen** has to be maintained for a proper assessment of HD video quality.

**Note:** The specifications for Class-1 monitors are documented in EBU Tech Doc 3320. The measurement methods relevant to monitor adjustment are specified in EBU Tech Doc 3325.

#### 28.1.1 Gamma Characteristics

The luminance gamma characteristic (electro-optical transfer function) of the screen should be equivalent to that of a reference CRT with the rendering intent (dim-surround) expected of a TV system.

The EBU, in **EBU Tech 3320**, recommends that a nominal value of **2.35** be used.

### 28.2 Technical Audio Acceptance Tests

The listening conditions for the assessment of sound program material, both monophonic and two-channel stereophonic, are described in EBU Tech Doc 3276, and for multi-channel material in EBU Tech Doc 3376, Supplement 1.

In general, all audio tracks intended for broadcast have to be listened to from beginning to end and approved, in order to ensure that they are completely free of any technical deficiencies.

**Note:** If sound is only spot-checked, this fact has to be noted in the acceptance test record. In this case, the audio acceptance test cannot be considered complete and comprehensive.

For a qualified sound assessment, the audio reproduction (mono, stereo, or multi-channel) has to be performed using high-quality professional loudspeakers with linear frequency response, if possible (cf. EBU Tech Doc 3276). Multi-channel sound requires a suitable 5.1 set-up for listening and monitoring (cf. EBU Tech Doc 3376, Supplement 1).

The mere audio reproduction via built-in TV-set speakers or other consumer loudspeakers or speaker systems is not sufficient. It has to be emphasized that they do not cover the full range and variety of the audience’s listening conditions.
28.2.1 Acceptance Tests of Programs with Discrete Audio Signals

For a qualified sound assessment, the audio reproduction (mono, stereo, or multi-channel) has to be performed using high-quality professional loudspeakers with linear frequency response, if possible (cf. EBU Tech Doc 3276). Multi-channel sound requires a suitable 5.1 set-up for listening and monitoring (cf. EBU Tech Doc 3376, Supplement 1).

The mere audio reproduction via built-in TV-set speakers or other consumer loudspeakers or speaker systems is not sufficient. It has to be emphasized that they do not cover the full range and variety of the audience’s listening conditions.

28.2.2 Acceptance Tests of Programs with Encoded Audio Signals

Multi-channel programs supplied in an encoded format as a Dolby-E data stream, e.g. on tracks 3 and 4 of a videotape cassette, have to be decoded for acceptance-testing (cf. item 37.1). Since Dolby metadata are not read out and interpreted in Dolby-E decoding, it is recommended that the audio signal either be routed through a Dolby Digital encoder and decoder (cf. item 37.2), or that the Dolby Digital path be simulated by means of a suitable audio tool, e.g. Dolby DP 570, in order to read out the metadata (cf. item 37.3).

**Note:** If the acceptance test of a Dolby-E-encoded 5.1 signal is performed without the option to simulate the effects of the metadata, the following limitations have to be taken into account:

- In this case, the full dynamic range is always played back, while the home viewer has the option to limit the dynamic range!
- Due to the lack of metadata interpretation, the loudness of the signal relative to other programs cannot be assessed.
- No automatic downmix of the 5.1 signal to mono, stereo, or Dolby Surround can be listened to.

For decoded linear audio signals, the listening arrangement described above has to be used in conjunction with a loudness meter capable of measuring multi-channel sound.

29 Lightning, Set Decoration, Costume, and Make-up

29.1 Lighting

With the development of new light sources with a higher light yield, these have now also become available options for lighting TV productions. Their benefits include reduced power consumption and heat emission, but on the other hand, they yield an inhomogeneous light spectrum in combination with television cameras.

LEDs emit light which, compared to traditional light sources, does not cover a continuous spectrum of light but rather a line spectrum. As a consequence, the colors of objects recorded by a camera are recorded differently than with traditional lighting. This requires a certain amount of extra work in color matching. A mixed use of conventional lights and LED lights in particular will cause problems. The suitability of a light source can be determined by means of a process published by EBU (EBU Tech 3355). The BBC has tested several light sources using this process and published their results in a document entitled “Low Energy Lighting Guide for TV Productions” in October 2014.

Various techniques are used for dimming LEDs. The most common one is currently pulse-width modulation. This technique may cause interferences between the camera (shutter speed/exposure time) and the modulation frequency of the pulse-width control unit, which appear as interference patterns. To avoid these interferences, it has to be ensured in advance that the camera technology to be used will be in sync with the lighting technology.

Phosphor-converted LEDs in particular have a relatively high spectral component in the blue range that may be hazardous to the eye (blue-light hazard). For further information on this subject, please consult DIN EN 62471(VDE 0837 471) and guideline 2006/25/EG.
None of the manufacturers of LED lights for studio or field use has yet classified them according to EN 62471, and thus a key factor for the required risk assessment is missing. As a precautionary measure, however, LED floor lights should not be used for productions involving children. For reasons of occupational safety and health, the use of LED lights, luminaires, and effect devices should always be assessed and decided individually for each device and scenario at hand.

29.2 Requirements for Set Decoration, Costume, and Make-up in HD productions

Due to the higher resolution of the HD format, significantly more detail in set decoration and make-up is displayed on screen. In contrast to SDTV, where skin imperfections, for example, could be compensated by contour correction in post-production, such devices would be counterproductive in HDTV. In general, HDTV offers a more natural detail rendition, displaying textures in a more natural way and hair with far more detail! Reds are represented well, while strong shades still tend to contract and bleed. However, during the transition from SD to HD, the actual benefits will be limited, because delicate textures and titles have to be discernible in both formats for the time being.

29.2.1 Set Decoration

Art direction and set decoration for HD require more precise workmanship, due to the enhanced demands of the format:

- Wear and tear as well as imperfections on the sets are more noticeable. Damage caused by multiple construction and dismantling cycles of a set has to be repaired.
- Delicate textures, small lettering, and small graphics become discernible. For this reason, greater care has to be taken in the finish, in order to avoid, for example, a fake brick wall to be identified as a fake.

29.2.2 Costume

As mentioned above, textures and patterns in cloth and costumes are rendered in much greater detail on HD screens. For this reason, in HD productions, the costumes of extras should be prepared in the same quality with the same precision and attention to detail as those of the main characters.

29.2.3 Make-up

The specifications for make-up should be coordinated with the art director. Experience has shown that the implementation of methods employed in SD production is severely limited. The following procedures are recommended:

- Make-up as for motion pictures: the guideline for HD make-up should be make-up for 35-mm film.
- The rule of thumb in HD should be: less is more. The high resolution of HD requires the exclusive use of extremely fine particles in make-up and powders.
- In HD, reddishness easily tends to take a neon hue or to frazzle on screen. It should also be noted that areas without make-up, e.g. ears, are much more noticeable in HD. It is thus important for make-ups artist to check the results of their work on an HD screen.
- HD shows hairdos in great detail, down to a single hair. It is thus essential that wigs and hairpieces fit perfectly. Hairdos and netlines, make-up applications and their transition to skin, etc. require extreme precision to be convincing in HD. For special make-up effects, such as blood, skin glue, etc., the same guidelines apply as for 35-mm film. This does not mean, however, that all conventional products and techniques have to be abandoned.
- Due to the increased demands, make-up artists are required to work with greater precision.
30 Archiving Format for HDTV

The goal is to preserve all productions in the best possible quality and in the best, most efficient and most economic form possible that allows easy retrieval and re-use.

30.1 Mainstream

In the area of HDTV Mainstream productions, the archiving of program material as files in a mass storage system, such as a datatape library, seems practical, as the XDCAM HD422 and AVC-I 100 compression formats are already used with tapeless systems in HDTV Mainstream production. VTR formats are no longer available. It has to be noted that a minimum of eight audio channels are required.

Note: For XDCAM HD422, programs may be played out to optical disc for archiving. For AVC-I 100, a playout to P2 memory cards for archiving is not economical.

30.2 Premium / High Quality

For high-budget Premium productions, from the point of view of quality preservation, the HDCAM-SR format is currently recommended for high-quality archiving. In addition, it may make sense to store a copy in an HD Mainstream format, which is required for operational reasons, in a mass storage system, e.g. an MXF file with XDCAM HD422, or a P2 AVC-I 100.

In general, solutions have to found to integrate the Premium domain economically into a future computer-based tapeless production and archiving system. This may require a suitable compression format type to be identified that would preferably allow storage, transportation, and archiving in the MXF format, which has already been established for the Mainstream domain.

30.3 Audio Track Allocation in Archives

It would make sense to use the mandatory audio-track assignment specified under item 20.5 for the archiving of program material as well.

Any audio-track allocation that diverges from this standard has to be re-arranged for program exchange and playout delivery!
31 APPENDIX 1 – Frame Raster Edge and Safe Areas

31.1 Scanning Raster 720p/50

31.2 Scanning Rasters 1080i/25 and 1080psf/25 (1080p/25 transported as 1080i/25)
31.3 Scanning Rasters 1080p/25 and 1080p/50

![Diagram of scanning rasters for 1080p/25 and 1080p/50]
32 APPENDIX 2 – RGB Color Space

Matrixing according to the formula:

\[ E'_{CR} = 0.71 (E'_R - E'_Y) \]
\[ E'_{CB} = 0.56 (E'_B - E'_Y) \]

will turn the \( E'E'\alpha E'\beta \) color space (cube) displayed in the image above into a parallelepiped (a body defined by three pairs of parallelograms) position within the \( E'YE'\text{cr}E'\text{cb} \) color space as shown in the figure below.

“RGB” color space within an \( E'YE'\text{cr}E'\text{cb} \) color space
**33 APPENDIX 3 – 1080psf/25 Variant**

Programs produced in the 1080p/25 scanning format are frequently transported (transmitted, stored) as 1080i/25! This option, designated as “1080psf/25,” has to be flagged and taken into account for subsequent processing!

**Attention:** If 1080psf/25 material is treated as 1080i/25 material (i.e. if psf was not flagged) and subsequently played out as 1080p/25 material, vertical resolution may be cut in half under certain circumstances!
### 34 APPENDIX 4 – Specification for a 16-Channel Audio Track Allocation

**ATTENTION!** This audio track allocation is for in-house use with 16 channels. For the supply and exchange of programs, this option is currently only admissible by mutual agreement.

<table>
<thead>
<tr>
<th>Option</th>
<th>7 (IN-HOUSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>16-channel, standard</td>
</tr>
<tr>
<td>Audio 1</td>
<td>stereo broadcast audio(^{(1)}) L</td>
</tr>
<tr>
<td>Audio 2</td>
<td>stereo broadcast audio(^{(1)}) R</td>
</tr>
<tr>
<td>Audio 3</td>
<td>music and effects (M&amp;E) L</td>
</tr>
<tr>
<td>Audio 4</td>
<td>music and effects (M&amp;E) R</td>
</tr>
<tr>
<td>Audio 5</td>
<td>second audio (SAP)(^{(2)}) L</td>
</tr>
<tr>
<td>Audio 6</td>
<td>second audio (SAP)(^{(2)}) (right)</td>
</tr>
<tr>
<td>Audio 7</td>
<td>broadcast audio Dolby E(^{(3, 4)})</td>
</tr>
<tr>
<td>Audio 8</td>
<td>broadcast audio Dolby E(^{(3, 4)})</td>
</tr>
<tr>
<td>Audio 9</td>
<td>multi-channel broadcast audio L</td>
</tr>
<tr>
<td>Audio 10</td>
<td>multi-channel broadcast audio R</td>
</tr>
<tr>
<td>Audio 11</td>
<td>multi-channel broadcast audio C</td>
</tr>
<tr>
<td>Audio 12</td>
<td>multi-channel broadcast audio LFE</td>
</tr>
<tr>
<td>Audio 13</td>
<td>multi-channel broadcast audio LS</td>
</tr>
<tr>
<td>Audio 14</td>
<td>multi-channel broadcast audio RS</td>
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<td>Audio 15</td>
<td>blank</td>
</tr>
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<td>Audio 16</td>
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</table>

For footnotes, cf. *item 20.5.2.*
35 APPENDIX 5 – Multi-Channel Stereo Systems

35.1 Reference Loudspeaker Arrangement According to ITU-R BS.775

Reference Speaker Arrangement
with speakers L/C/R and LS/LR (from ITU-R BS.775-1)
Screen 1: reference distance = 3H (2β₁ = 33°)
Screen 2: reference distance = 2H (2β₂ = 48°)
H = height of screen
B = loudspeaker base width

<table>
<thead>
<tr>
<th>Loudspeaker</th>
<th>Horizontal angle</th>
<th>Height</th>
<th>Inclination</th>
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<tr>
<td>C</td>
<td>0°</td>
<td>1.2 m*</td>
<td>0°**</td>
</tr>
<tr>
<td>L, R</td>
<td>30°</td>
<td>1.2 m</td>
<td>0°</td>
</tr>
<tr>
<td>LS, LR</td>
<td>± (100…120)°</td>
<td>≥ 1.2 m</td>
<td>≤15°</td>
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</table>

*) depending on screen shape and size
36 APPENDIX 6 – Dolby E Frame Positioning

The Dolby E frame positions shown in the table below are recommended by Dolby Laboratories.

<table>
<thead>
<tr>
<th></th>
<th>576i/25</th>
<th>1080i/25</th>
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<td>17</td>
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<td>Position/µs(1)</td>
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<td>22</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>position ±80 µs</td>
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<td></td>
<td></td>
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<tr>
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<td>28</td>
</tr>
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<td>Position/µs(1)</td>
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<td>730</td>
<td>730</td>
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<td>48 kHz AES sample(3)</td>
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<td>Ideal Dolby E line</td>
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<td>position +80 µs</td>
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</tr>
<tr>
<td>TV line</td>
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<td>23</td>
<td>31</td>
</tr>
<tr>
<td>Position/µs(1)</td>
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<td>810</td>
<td>810</td>
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<td>48 kHz AES sample(3)</td>
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(1) in relation to SMPTE RP168 reference point and approximate values
(2) relative to the first (odd) frame
(3) where the start of 48 kHz AES sample number 1 is approximately aligned to the SMPTE RP168 reference point
37 APPENDIX 7 – Acceptance of Dolby-E-Encoded Audio Signals

37.1 Encoded Audio Signals without Metadata Readout

37.2 Encoded Audio Signals with Metadata Readout – Dolby En-/Decoders

37.3 Encoded Audio Signals with Metadata Readout – Audio Tools
### 38 APPENDIX 8 – Dolby Metadata Presets

#### 38.1 Preset: Loud

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Stereo</th>
<th>5.1 Mode</th>
<th>Notes</th>
<th>Program Type</th>
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</tr>
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<td>Bit stream Mode</td>
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<td>RF Mode Pro</td>
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<td>RF Ovmd Protect</td>
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</tr>
<tr>
<td>Center Dwntx Lvl</td>
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<td>–3 dB</td>
<td></td>
<td>Verstehen Sie Spaß?</td>
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<td>–6 dB</td>
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<td>Wetten dass..?</td>
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<td></td>
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<td>Mix Level</td>
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<td>N/A</td>
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<td>Room Type</td>
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<td>yes</td>
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<td></td>
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<tr>
<td>Orig. Bit stream</td>
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<td>Lo/Ro</td>
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<td>–3 dB</td>
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<td>LFE Lowpass Filter</td>
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<td>Snd 3 dB Atten</td>
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<td>Snd Phase Shift</td>
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Extended bit stream information in *italics*
### 38.2 Preset: Standard

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<thead>
<tr>
<th>Parameter</th>
<th>Stereo</th>
<th>5.1 Mode</th>
<th>Notes</th>
<th>Program Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRG Config</td>
<td>3 × 2</td>
<td>5.1</td>
<td>16-bit word size</td>
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<td>PRG Descrpt Text</td>
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<td></td>
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</tr>
<tr>
<td>Dialog Level</td>
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<td>Channel Mode</td>
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<tr>
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<td>Prfd Stereo Dwnm Lv</td>
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<td>Snd Phase Shift</td>
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<td>disabled</td>
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<td></td>
</tr>
</tbody>
</table>

**Notes:**
- "Standard" medium dynamic range
- Program Type:
  - Band and Orchestra
  - weather, news, TV series, documentary, entertainment, news, magazine, children's movie, crime drama, morning TV, live reports on current events
  - commercials, trailers, interstitials, station ID
  - jazz concerts, crossover concerts

*extended bit stream information in italics*
### 38.3 Preset: Dynamic

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<thead>
<tr>
<th>Parameter</th>
<th>“Dynamic”</th>
<th>wide dynamic range</th>
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<td>Snd Phase Shift</td>
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<td>disabled</td>
<td></td>
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</tr>
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</table>

Extended bit stream information in *italics*

- church service, theater, theatrical motion picture
- high-quality crime drama
- concert programs with a high percentage of spoken dialog

Motion pictures, such as *Blade Runner*, *The Bridge of Remagen* (theatrical mix)

Example: *ZDF Klassik* with G. Alsmann
### 38.4 Preset: Classic

<table>
<thead>
<tr>
<th>1st Special:</th>
<th>“Classic”</th>
<th>very wide dynamic range, “soft”</th>
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</tr>
<tr>
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</table>

- few spoken words, little compression, radio broadcast material, typically: 3sat
- opera, classic concert, chamber music

extended bit stream information in italics
### 38.5 Preset: Sports

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td>Snd Phase Shift</td>
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<td></td>
<td></td>
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</tbody>
</table>

Note: Not sports magazines

Live broadcast of major event: Olympic Games, soccer World Cup, track and field world championships, handball, etc.

Extended bit stream information in *italics*
39 APPENDIX 9 – Peak Normalization – Dynamic Range

For guidance when using non-normalized material (e.g. stock footage or foreign productions), the following audio signal leveling guidelines still apply, as specified in the Technical Guidelines for SDTV (December 2006 edition). The following is an excerpt from chapter 6.2:

EBU Technical recommendation R68 specifies coding level as well as a uniform reference level for digital audio systems. The value for this alignment level has to be 18 dB below the clipping level, regardless of the number of bits available (16, 18, 20, …).

This will result in a 9 dB headroom.

A system calibrated to +6 dB full scale will show the following relationship between digital and analog signals (cf. also HFBL-K Recommendation 15IRT):

Relation of analog and digital alignment levels, based on Recommendation ITU-R BS.646

Only digital audio signals with a sampling rate of 48 kHz shall be used.
APPENDIX 10 – Production Counseling Check List

The proposed check list is meant to provide technical service providers with a basis for production counseling.

It has to be accepted, in general, that EVERYBODY is looking for the ultimate NEW look, particularly in dramatic productions! For this reason, the creative side will appreciate (and want to use) each and every feature that new cameras have to offer.

In this context, it is necessary to discuss to which degree the cameras and equipment intended for the production at hand are actually capable of fulfilling expectations. In addition, the expenses expected to be incurred by special workflows and solutions should be addressed as early as possible.

It has to be noted that special demands will incur special (extra) costs.

40.1 Basics

- Can all scenes be shot at the intended location (genre) with the intended look?
- Do certain situations require quick switches in field size that cannot be achieved with prime lenses?
- Do certain locations require the use of very small, compact cameras, while maintaining the overall look of the production?
- Is the mix of camera types and recording formats supported by the crew, who can secure these materials in a responsible manner?
- What are the requirements for raw data back-up and protection, with regard to insurance issues and potential extra costs due to the recording and storage formats chosen?
- The target has to be: achieving maximum technical quality in digital recording, while guaranteeing sufficient production security.
- Is it possible to achieve the desired image characteristics with suitable technical options?
- Counseling on and possibly testing of the DP’s visual concept with regard to its feasibility in production and post-production
- Planning of the actual workflow, taking into consideration that complex workflows will incur extra costs!

40.2 Camera Type

- Is all relevant information available about camera type, storage medium, and the formats to be supplied at the output as well as their specific capabilities and limitations? How far does built-in signal processing affect quality (e.g.: although the Canon EOS has a large image sensor, its built-in signal processing is relatively low in quality, which practically rules out any long shots that are rich in detail!)?
- Are any alterations in the shooting parameters which might be necessary for optimizing the desired image characteristics feasible within the scope of look management, e.g. matching in multi-camera production?
- Do the available options for focus control and lighting as well as the audio settings meet the requirements?
- Does the camera have an HD-SDI or HDMI output that allows “good” camera quality to be recorded on a suitable external recording device, such as AJA, Blackmagic, nanoFlash (8-bit limit!)?
- Consideration of operational aspects, e.g. the time required for any conversion of the recorded material that might be necessary (in multiples of real time)
- Which sampling formats are supported? Does recording require built-in signal converters? How will standard format conversions (30/25 f/s) be handled?
- Special aspects of single-sensor cameras for high-end, low-end, and DSLR competing products (Panasonic AG-AF 101 and Sony NEX-FS100, PMW-F3)
• Is additional time-code equipment necessary, e.g. for the wireless transmission of the TC to the camera?
• Can the external recorder be triggered from the camera, e.g. via TC trigger?

40.3 Production Ramifications
• Does the intended camera type fit into the workflows of the proposed production, and does it fit its production and post-production techniques, which might be different?
• Will an additional specialist be required for the camera department, who might take over new, additional tasks and offer advice to the team?
• Is a preliminary technical quality check of the recording (digital gate check) possible or necessary on location? Who will be in charge?
• Assessment of data security for various storage media used in recording
• Coordination of data mapping and data management (spot-checks, possibly back-up) with post-production
• Equipment selection and assembly with the camera assistant
• Is there a lo-res preview concept, which takes into account the camera’s options (metadata) and the demands of the executive producers?

40.4 Post-Production Ramifications
• Demonstration of technical options and workflows in post-production, e.g. ingest, color-grading, etc.
• Specification of material logistics, e.g. handover of footage for post-production, data back-up, transfer, etc.
• In which format will the technical acceptance check of the material be conducted?
• Can the technical/visual check of the material with the necessary equipment be guaranteed?

40.5 Delivery – Broadcaster Requirements
• Selection of the data supply format for productions using digital motion-picture cameras, e.g. Red, Arri Alexa, Arriflex D-2, etc.
• Scope of supply, data format, file format, compression format, scanning raster (e.g. 1080i/25), and data storage medium (e.g. Professional Disc)
• Which are the absolute minimum requirements, and does the supply format have to match the in-house platform(s) in each and every case?
• Are there any differences regarding the supply of Mainstream vs. Premium productions?
• Can a camcorder system only be used with different crews (standard crew or special crew)?
• How will the use of DSLR cameras be handled? Some external producers already use them for 30-minute reports, i.e. they have already entered the Mainstream segment.
APPENDIX 11 – Example: Broadcaster HD Format Specs

GENERAL HD PRODUCTION FORMAT SPECS

In the production of HD programs, there is a general distinction between Premium and Mainstream productions.

The term Premium is applied to special high-quality workflows for drama and repertory productions, such as the Tatort series or the New Year’s Concert. The allocation of a production to either of the two formats will be specified in the contract.

MANDATORY HD PRODUCTION FORMATS FOR IN-HOUSE PRODUCTIONS

For HD productions, the following parameters are specified:

1. HD Mainstream Production
   - Sampling: 4:2:2
   - Raster: 1920 × 1080
   - Resolution: i/25 (50 fields per second)

2. HD Premium Production:
   - Sampling: 4:4:4 (minimum 4:2:2)
   - Raster: 1920 × 1080
   - Resolution: p/25 (25 frames per second), or i/25 (50 fields per second)

Camera examples for HD Premium productions:
Sony F35, F23, and HDW-9000, Red One, Arri D21, film cameras with subsequent digital HD scanning of 16-mm and 35-mm film and storage on HDCAM-SR.

The following formats no longer meet current minimum quality requirements and thus are no longer accepted as HD production formats:

- HDCAM (3.1.1, 1440 × 1080, 8 bit, Intra)
- XDCAM 35 Mbit/s (4:2:0, 1920 × 1080, 8 bit, Long GOP)
- XDCAM 18 or 25 Mbit/s (4:2:0, 1440 × 1080, 8 bit, Long GOP)
- HDV

For supply, no less than 75% of the finished program have to consist of native formats according to the specifications above.

MANDATORY HD SUPPLY MATERIAL FOR SUPPLY TO [XYZ]

“Supply material” designates the medium which has to be supplied to the broadcaster according to the contractual agreement.

1. HD Mainstream Production (1080i/25):
   - XDCAM HD optical disc (4:2:2, 1920 × 1080, 8 bit, 50 Mbit/s, Long GOP)

2. HD Premium Production (1080p/25 or 1080i/25):
   - HDCAM-SR tape (4:2:2, 1920 × 1080, 10 bit)

Formats other than those specified above are only admissible on prior arrangement with the production manager in charge of programming. In certain, justified cases, a Mainstream production may thus be shot in p/25. The material for such a HD Mainstream program would have to be supplied on an XDCAM HD 4:2:2 Optical Disc, but in a 1080p/25 (or 1080psf/25) format.
42 APPENDIX 12 – Time Code in MXF

In accordance with EBU R122, the time code should be embedded in the MXF file format, i.e. the restrictions on the use of the three time code options have to be observed.

The main content of this Recommendation can be summarized as follows:

For frame-wrapped essence containers (mostly OP1a):
Applications should not use time code that is embedded in essence of edited material. Updating time code embedded in the compressed stream (e.g. after post-production/editing) is only feasible though an alteration or even regeneration of the encoded bit stream, which requires significant effort and is thus not recommended. The number of fundamentally different TC locations is thus reduced to three.

For clip-wrapped essence containers (mostly OP Atom):
Due to the clip-based key-length-value (KLV) structure, no system item exists that can be placed ahead of each video frame. As a substitute, it is recommended to use time code embedded in the essence. R122 specifies the source-time-code carriage mechanism to be used, depending on essence stream format.

42.1 MXF Encoder
The definition of the term source time code is essential. According to R122, an MXF encoder application should offer users the option to select, e.g. LTC, VITC, ATC, preset, control time code, etc.

The Recommendation specifies that, after selecting the source, the source time code has to be encoded – with frame-accuracy (including any discontinuities) – in the corresponding source package. Time-code discontinuities are represented with additional “time-code components” metadata sets.

The time code should transferred, frame-accurate, to the system item (with frame-wrapped essence containers) or to the essence itself (with clip-wrapped essence containers). For operational patterns (OPs) with exactly one material package (such as OP1a and OP Atom), the starting value of the source time code should additionally be represented in the material package. By definition, material packages are not capable of supporting time-code discontinuities, which means that material package and source package time codes will diverge after the first discontinuity (which may or may not exist).

42.2 MXF Decoder
The counterpart of the source time code (see above) is the output time code, which is output by an MXF decoder, such as a playout server. Recommendation R122 specifies that this time code should be read from the MXF file from the material package (with OP1a, et al.) or from the source package (with OP Atom). For more complex applications, a select option is recommended to allow the user to choose between, for example, a preset time code or a source time code (including time-code jumps).

42.3 Partial Restore
For partial restore applications, EBU R122 recommends that the time codes of the material package, the source package, and the essence container of the new file correspond to the material package / source package / corresponding material of the original file.

The EBU document also includes OP-specific recommendations on the conversion of MXF OP1a files into OP-Atom files (and vice versa), as well as a documentation template for vendors.
Technisches Abnahmeprotokoll

Nr. 2

Serien-/Sendetitel:
Unter-/Originaltitel:
Eigen-Produktion:
Fremd-Produktion:
Programm:
Sendelänge:
Folgenummer:
Sendedatum:

Medien / Dateien
Sendematerial/Medium: XDCAM-HD
Sendefassung ARTE: Erstlieferung
Erstes Bild:
Leiters Bild:

Video
Seitenverhältnis: 16:9 Vollformat
Abtastformat: 1080/25
Abtastung psf: □
VITC/ATC vorhanden: □
LTC durchgeh./aufst.: □
VITC = LTC: □
Abnahme in Stichproben: □
Abnahme in voller Länge: □

Audio
Tonart
Kanal 1 Sendeton Stere0
Kanal 2 Sendeton Stere0
Kanal 3 IT Fassung Stere0
Kanal 4 IT Fassung Stere0
Kanal 5
Kanal 6
Kanal 7
Kanal 8

Untertitel
Art:
Sprache:

Bemerkungen

Sprachfassung (ARTE):

<table>
<thead>
<tr>
<th>Datum</th>
<th>Name</th>
<th>Unterschrift</th>
</tr>
</thead>
</table>

Seite 1 von 2

Gedruckt am um
## Technisches Abnahmeprotokoll

### Nr. 2

<table>
<thead>
<tr>
<th>Serien-/Sendetitel:</th>
<th>Fremd-Produktion:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unter-/Originaltitel:</td>
<td></td>
</tr>
<tr>
<td>Eigen-Produktion:</td>
<td></td>
</tr>
</tbody>
</table>

### Medium / Datei Nr. 1

<table>
<thead>
<tr>
<th>Unique-Key POC:</th>
<th>Technischer Vorspann</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC-Anfang:</td>
<td>Bild: Farb balken sek</td>
</tr>
<tr>
<td>TC-Ende:</td>
<td>Schwarz sek</td>
</tr>
</tbody>
</table>

### Beurteilung Video

<table>
<thead>
<tr>
<th>Qualitätsbeurteilung Bild</th>
<th>Technischer Befund Video</th>
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</thead>
<tbody>
<tr>
<td>Weiβwert</td>
<td></td>
</tr>
<tr>
<td>Schwarzabhebung</td>
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</tr>
<tr>
<td>Schärfe</td>
<td></td>
</tr>
<tr>
<td>Farbstiche/-</td>
<td></td>
</tr>
<tr>
<td>Farbsättigung</td>
<td></td>
</tr>
<tr>
<td>Farbraum</td>
<td></td>
</tr>
<tr>
<td>Digitale Fehler</td>
<td></td>
</tr>
<tr>
<td>sonstige</td>
<td></td>
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</table>

### Beurteilung Audio

<table>
<thead>
<tr>
<th>Qualitätsbeurteilung Ton</th>
<th>Abnahmeart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aussteuerung</td>
<td>Volle Länge Stichprobe</td>
</tr>
<tr>
<td>Synchronität</td>
<td>Kanal 1</td>
</tr>
<tr>
<td>Sprachverständlichkeit</td>
<td>Kanal 2</td>
</tr>
<tr>
<td>Klangbild</td>
<td>Kanal 3</td>
</tr>
<tr>
<td>Dynamik</td>
<td>Kanal 4</td>
</tr>
<tr>
<td>Verzerrungen</td>
<td>Kanal 5</td>
</tr>
<tr>
<td>Stereobalance / Surround-Balance</td>
<td>Kanal 6</td>
</tr>
<tr>
<td>Korrelation</td>
<td>Kanal 7</td>
</tr>
<tr>
<td>sonstige</td>
<td>Kanal 8</td>
</tr>
</tbody>
</table>

### Lautheit

<table>
<thead>
<tr>
<th>Programmalaufnahme (LUFSS)</th>
<th>Maximaler True Peak (DBTP)</th>
<th>Lautheitbereich (LU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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</tbody>
</table>

### Beurteilung Untertitel

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<th>Dateinamen</th>
<th>Technischer Befund Untertitel</th>
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<tbody>
<tr>
<td>i.O.</td>
<td>Mängel</td>
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<tr>
<td></td>
<td>Techn. abzulehnen</td>
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</tbody>
</table>

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Gedruckt am um

78
44 APPENDIX 14 – Sample of a Medienbegleitkarte

**MEDIEN - BEGLEITKARTE**

<table>
<thead>
<tr>
<th>Serien-Reihentitel (SRTI), Untertitel</th>
<th>Archiv-Nr.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sende-/Haupttitel (SHTI)</td>
<td></td>
</tr>
<tr>
<td>Untertitel (UNTI)</td>
<td></td>
</tr>
<tr>
<td>Arbeitsstitel (ARTI), Sonstiges Titel (SOTI)</td>
<td></td>
</tr>
<tr>
<td>Produzent / Lizenzgeber / Co-Partner</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medium</th>
<th>von</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sendelänge:</th>
<th>Min.</th>
<th>Sek.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**VIDEO**

- 576/25 (SD)
- 720p/50 (HD)
- 1080i/25 (HD)
- 1080pF25 (HD)
- IMX
- Digital Beta
- HD-CAM
- HD-CAM SR
- XD-CAM
- VT-Untertitel

**AUDIOD**

<table>
<thead>
<tr>
<th>Spurbelegung</th>
<th>Aussteuerung</th>
<th>Dolby Metadaten Preset</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPRF-Variante</td>
<td></td>
<td>Programmlautheit (LUF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>max. True Peak (dBTP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lautheitsbereich (L)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aussteuerung gewollt leise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aussteuerung unbekannt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technischer Vorspann: Farbbalken: 100/75</th>
<th>Minute(n) 100/100</th>
<th>Minute(n) Ton: 1kHz / -18dBFS</th>
<th>Minute(n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Überlappung</td>
<td>nein</td>
<td>ja</td>
<td>Real-Time</td>
</tr>
<tr>
<td>Hinweise für den Sendebetrieb:</td>
<td>TC:</td>
<td>Std</td>
<td>Min</td>
</tr>
<tr>
<td>Medium 1 Anfang</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium 1 Ende</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bemerkungen</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Beurteilung | Vollprüfung | Stichproben | Zur Sendung geeignet: |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bild Ton</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Technisch in Ordnung | 01.10.2013 | Datum | Unterschrift Technik |
Technische Mängel | | | Datum | Unterschrift Programm |
APPENDIX 15 – SNG Profiles for H.264 Recommended by ARD, ZDF, ORF, SRG

In the two tables below, the “domestic” H.264 profiles are listed, both for 8 PSK and the more efficient 16 APSK modulation. The only difference lies in the modulation parameters, while audio and video parameters are identical in both modulation processes. There is no obligation to accept 16 APSK modulation, which means that its use has to be agreed upon bilaterally.

<table>
<thead>
<tr>
<th>8PSK</th>
<th>PID</th>
<th>HD 8-24</th>
<th>HD 8-18</th>
<th>HD 8-12</th>
<th>HD 8-9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>H.264</td>
<td>H.264</td>
<td>H.264</td>
<td>H.264</td>
</tr>
<tr>
<td>profile name</td>
<td></td>
<td>HD 8-24</td>
<td>HD 8-18</td>
<td>HD 8-12</td>
<td>HD 8-9</td>
</tr>
<tr>
<td>PMT</td>
<td>32</td>
<td>Service ID: 1</td>
<td>Service ID: 1</td>
<td>Service ID: 1</td>
<td>Service ID: 1</td>
</tr>
<tr>
<td>PCR (embedded)</td>
<td>308</td>
<td>embedded</td>
<td>embedded</td>
<td>embedded</td>
<td>embedded</td>
</tr>
<tr>
<td>video Mbit/s</td>
<td>308</td>
<td>39,183</td>
<td>28,940</td>
<td>18,697</td>
<td>13,575</td>
</tr>
<tr>
<td>audio 1 Mbit/s</td>
<td>256</td>
<td>PAA</td>
<td>0,384</td>
<td>PAA</td>
<td>0,384</td>
</tr>
<tr>
<td>audio 2 Mbit/s</td>
<td>257</td>
<td>PAA</td>
<td>0,384</td>
<td>PAA</td>
<td>0,384</td>
</tr>
<tr>
<td>audio 3 Mbit/s</td>
<td>258</td>
<td>PAA</td>
<td>0,384</td>
<td>PAA</td>
<td>0,384</td>
</tr>
<tr>
<td>audio 4 (or Dolby E) Mbit/s</td>
<td>259</td>
<td>PAA 1</td>
<td>0,384</td>
<td>PAA</td>
<td>0,384</td>
</tr>
<tr>
<td>Latency ms</td>
<td>2</td>
<td>&lt; 500 ms</td>
<td>&lt; 300 ms</td>
<td>&lt; 500 ms</td>
<td>&lt; 500 ms</td>
</tr>
<tr>
<td>GOP constellation</td>
<td>IBBP</td>
<td>IP</td>
<td>IBBP</td>
<td>IBBP</td>
<td></td>
</tr>
<tr>
<td>info bit rate (net) Mbit/s</td>
<td>41,808</td>
<td>31,356</td>
<td>20,904</td>
<td>15,678</td>
<td></td>
</tr>
<tr>
<td>overall bit rate Mbit/s</td>
<td>43,200</td>
<td>32,400</td>
<td>21,600</td>
<td>16,200</td>
<td></td>
</tr>
<tr>
<td>FEC</td>
<td>3/4</td>
<td>3/4</td>
<td>3/4</td>
<td>3/4</td>
<td></td>
</tr>
<tr>
<td>modulation</td>
<td>8PSK</td>
<td>8PSK</td>
<td>8PSK</td>
<td>8PSK</td>
<td></td>
</tr>
<tr>
<td>symbol rate Msymb/s</td>
<td>19,2</td>
<td>14,4</td>
<td>9,6</td>
<td>7,2</td>
<td></td>
</tr>
<tr>
<td>allocated bandwidth MHz</td>
<td>24</td>
<td>18</td>
<td>12</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>double-hop</td>
<td>HD</td>
<td>mega-low delay</td>
<td>HD</td>
<td>standard</td>
<td>HD</td>
</tr>
<tr>
<td>16APSK</td>
<td>PID</td>
<td>HD 16-18</td>
<td>HD 16-12</td>
<td>HD 16-9</td>
<td>HD 16-6</td>
</tr>
<tr>
<td>--------</td>
<td>-----</td>
<td>----------</td>
<td>----------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H.264</td>
<td>H.264</td>
<td>H.264</td>
<td>H.264</td>
</tr>
<tr>
<td>profile name</td>
<td></td>
<td>HD 16-18</td>
<td>HD 16-12</td>
<td>HD 16-9</td>
<td>HD 16-6</td>
</tr>
<tr>
<td>PMT</td>
<td>32</td>
<td>Service ID: 1</td>
<td>Service ID: 1</td>
<td>Service ID: 1</td>
<td>Service ID: 1</td>
</tr>
<tr>
<td>PCR (embedded)</td>
<td>308</td>
<td>embedded</td>
<td>embedded</td>
<td>embedded</td>
<td>embedded</td>
</tr>
<tr>
<td>video Mbit/s</td>
<td>308</td>
<td>39084</td>
<td>25459</td>
<td>18647</td>
<td>11835</td>
</tr>
<tr>
<td>audio 1 Mbit/s</td>
<td>256</td>
<td>PAA</td>
<td>0,384</td>
<td>PAA</td>
<td>0,384</td>
</tr>
<tr>
<td>audio 2 Mbit/s</td>
<td>257</td>
<td>PAA</td>
<td>0,384</td>
<td>PAA</td>
<td>0,384</td>
</tr>
<tr>
<td>audio 3 Mbit/s</td>
<td>258</td>
<td>PAA</td>
<td>0,384</td>
<td>PAA</td>
<td>0,384</td>
</tr>
<tr>
<td>audio 4 (or Dolby E) Mbit/s</td>
<td>259</td>
<td>PAA&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0,384</td>
<td>PAA</td>
<td>0,384</td>
</tr>
<tr>
<td>latency ms</td>
<td></td>
<td>&lt; 500 ms</td>
<td>&lt; 300 ms</td>
<td>&lt; 500 ms</td>
<td>&lt; 500 ms</td>
</tr>
<tr>
<td>GOP constellation</td>
<td></td>
<td>IBBP</td>
<td>IP</td>
<td>IBBP</td>
<td>IBBP</td>
</tr>
<tr>
<td>info bit rate (net) Mbit/s</td>
<td>41707</td>
<td>27805</td>
<td>20854</td>
<td>13902</td>
<td></td>
</tr>
<tr>
<td>overall bit rate Mbit/s</td>
<td></td>
<td>43200</td>
<td>28800</td>
<td>21600</td>
<td>14400</td>
</tr>
<tr>
<td>FEC</td>
<td></td>
<td>3/4</td>
<td>3/4</td>
<td>3/4</td>
<td>3/4</td>
</tr>
<tr>
<td>modulation</td>
<td></td>
<td>16APSK</td>
<td>16APSK</td>
<td>16APSK</td>
<td>16APSK</td>
</tr>
<tr>
<td>symbol rate Msymb/s</td>
<td></td>
<td>14,4</td>
<td>9,6</td>
<td>7,2</td>
<td>4,8</td>
</tr>
<tr>
<td>allocated bandwidth MHz</td>
<td></td>
<td>18</td>
<td>12</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

(1) **Note:** As an alternative to 0.384 Mbit/s, Dolby E is only recommended in profile HD 8-24 PAA. The use of Dolby E will reduce the available video data rate, depending on the manufacturer, by up to 3 Mbit/s.

(2) Latency (with Ericsson Voyager-II): Low Delay & IBBP ≤ 500 ms (470 ms) / Mega Low Delay and IP ≤ 300 ms (291 ms)

Applicable to all DVB-S2 profiles:

- Roll-off factor: 25%
- GOP length: 24
- video sampling: 4:2:2
- Frame (64800 bit) = normal
- Pilot: on
- Phase-Aligned Audio: on
- PMT Repetition Time: 100ms
46 APPENDIX 16 – Resources

Technical guidelines: Institut für Rundfunktechnik GmbH (IRT)
Floriansmühlstraße 60
80939 München (Munich)
Germany
e-mail: gerlinger@irt.de
Web site: http://www.irt.de/richtlinien
phone: +49 89 32399-391
fax: +49 89 32399-200

EBU documents: European Broadcasting Union (EBU)
Ancienne Route 17A
1218 Grand-Saconnex GE
Switzerland
e-mail: miles@ebu.ch
Web site: http://tech.ebu.ch/publications
phone: +41 22 71727-43
fax: +41 22 71727-10

SMPTE publications: Society of Motion Picture and Television Engineers (SMPTE)
595 West Hartsdale Avenue
White Plains NY 10607
U.S.A.
general e-mail: smpte@smpte.org
Web site: https://www.smpte.org/standards
phone: +1 914 761-1100
fax: +1 914 761-3115

ITU documents: International Telecommunication Union (ITU)
Publication Sales
Place des Nations
1211 Genève 20 (Geneva)
Switzerland
e-mail: sales@itu.int
Web site: http://www.itu.int/publications
phone: +41 22 730-6141
fax: +41 22 730 5194

DIN/ISO standards: Beuth Verlag GmbH
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10787 Berlin
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e-mail: info@beuth.de
Web site: http://www2.beuth.de
phone: +49 30 2601-2260
fax: +49 30 2601-1260

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Postfach 120143
10591 Berlin
Germany
e-mail: vertrieb@vde-verlag.de
Web site: http://www.vde-verlag.de
phone: +49 30 34-8001220
fax: +49 30 34-17093
Notice

Access to the guidelines and work-group findings of

http://www.irt.de/richtlinien
this page is intentionally left blank