SMPTE ENGINEERING GUIDELINE

MPEG-2 Operating Range Applications

Contents

1 Scope and application

1.1 Scope

The aim of this document is to provide practical guidelines to users of MPEG-2 in studio and in other professional applications.

This guideline provides a system overview, detailing the elements to be considered when choosing an MPEG-2 operating range.

This guideline describes how the structure and parameters defined in SMPTE RP 213 may be configured to meet a selected operating point. This is achieved by giving specific, but representative, implementation examples planned or in use around the world.

Examples are included from both intraframe and temporal predictive coded MPEG-2 for both 4:2:2 profile at main level and high level.

1.2 Application

The picture quality obtained when decoding an MPEG encoded signal is largely dependent upon the combination of bit rate and GoP structure. The results of tests made by the SMPTE and EBU are shown in figure 1 and are as reported in the EBU/SMPTE task force report (for full details of the test procedures please refer to the report).

Figure 1 illustrates that for a given sequence of images, the same image quality can be obtained by various combinations of bit rate and GoP structure.

The curves shown in figure 1 should be taken as an indication of first-generation performance within the wide span of MPEG-2 encoding options only. Taking signal differences as a measure of picture quality only allows coarse evaluation of actual quality performance. The variance of encoding parameters allowed in MPEG-2 encoding structures to achieve the desired flexibility will require subjective testing of each individual encoder design to determine the actual quality performance at a given data rate and GoP structure. The arrows indicate possible members of the MPEG-2 4:2:2@ML compression family envisaged for mainstream broadcasting, news and sports, and for contribution, as implemented in current industrial designs.

Since this figure was produced, for example, temporal predictive coding efficiency has improved allowing lower data rates than those given in figure 1.

A specific operating point for mainstream production has been defined at 50 Mb/s and this is described in SMPTE 356M.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this guideline. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this guideline are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

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Approved August 30, 2001

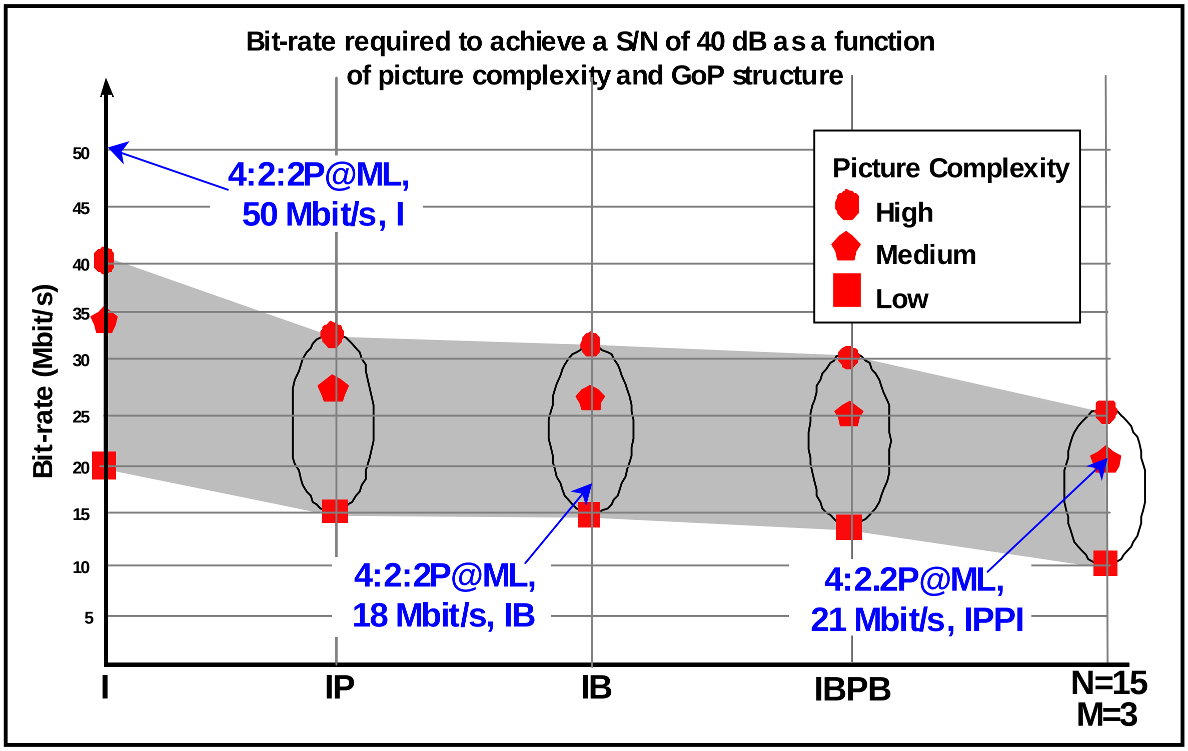

Figure 1 – Basic characteristics of compression for news and sports — MPEG-2 4:2:2P@ML

SMPTE 312M-2001, Television — Splice Points for MPEG-2 Transport Streams

SMPTE 327M-2000, Television — MPEG-2 Video Recoding Data Set

SMPTE 356M-2001, Television — Type D-10 Stream Specifications — MPEG-2 4:2:2P @ ML for 525/60 and 625/50

SMPTE RP 202-2000, Video Alignment for MPEG-2 Coding

SMPTE RP 213-2001, MPEG-2 Operating Ranges

3 Introduction to operating points

SMPTE RP 213 defines the MPEG-2 operating ranges. These ranges constrain characteristics of the MPEG-2 4:2:2 profile to ensure bitstream interchange in the professional environment.

The operating ranges are subsets of ISO/MPEG profiles and levels. SMPTE RP 213 defines two operating ranges for standard-definition television and three operating ranges for high-definition television. It also defines a hierarchical relationship among the ranges.

This guideline analyzes the production system data flow, describes the operating range applicable for each main production stage, and gives examples of operating points. For each stage in the production system data flow, the guideline discusses considerations that influence selection of an operating range and within it an operating point or points. Specific considerations include quality of video and audio, efficiency, technology, and existing equipment and services.

This guideline elucidates choice of operating points to enable bitstream interchange within professional applications. It enhances the user's ability to specify equipment and set application-specific parameters. The clauses that follow will inform and help guide the users to an optimum choice for their applications.

Clause 4 describes the production system data flow and defines its stages.

Clause 5 gives, for each stage, example data rates and operating ranges. This is done separately for SDTV and HDTV. Further considerations for each stage follow.

Clause 6 lists applications that use the production system described in clauses 4 and 5 and identifies issues that need to be considered when implementing a system.

3.1 Nomenclature

The following definitions will be used in the clauses that follow:

3.1.1 acquisition data rate: The (net or total) data rates used in field acquisition recording.

3.1.2 contribution data rate: The (net or total) data rates used to back-haul signals to a network center or station operating facility.

3.1.3 distribution data rate: The (net or total) data rates used to pass network signals to regional or local stations.

3.1.4 editing data rate: The (net or total) data rates used for a reasonable number of post-production generations, not including the most demanding high-end post-production applications.

3.1.5 emission data rates: The (net ot total) data rates used in digital television broadcasting, either by terrestrial or satellite paths.

3.1.6 headroom: The additional data rate necessary to permit a naive transcode or naive compressed family conversion while retaining an acceptable picture quality.

3.1.7 intelligent compression family conversion: The conversion between the MPEG and non-MPEG (DV, JPEG, etc.) families of compression using nonessence data (such as bit-rate allocation and quantization) in the recompression to minimize quality loss.

3.1.8 intelligent transcoding: The conversion between two MPEG-2 formats using MPEG-2 recoding data set in the recompression to maximize quality. The formats may differ in GoP structure, bit rate, frame rate, or frame size.

3.1.9 naive compression family conversion: The conversion between the MPEG and non-MPEG families (DV, JPEG, etc.) of compression using only uncompressed video and audio in the recompression.

3.1.10 naive transcoding: The conversion between two MPEG-2 formats using only uncompressed video and audio in the recompression. The formats may differ in GoP structure, bit rate, frame rate, or frame size.

3.1.11 net data rate: The data rate of the video elementary stream.

3.1.12 on-air operations data rates: The (net or total) data rates used for local storage prior to master control in an on-air playout facility, and may be subsequently recoded for analog transmission or lower bit-rate digital transmission.

3.1.13 total data rate: The net data rate plus audio, data, and any system overhead.

3.1.14 transcoding: The process of converting one MPEG-2 format to another.

4 Professional production system data flow

Figure 2 illustrates the various strategies available to broadcasters when designing a compressed video production flow process. In this example, the split between long GoP and I-frame-only systems at 30 Mb/s reflects the point of approximately equal performance for long GoP systems at 30 Mb/s and I-frame-only systems at 50 Mb/s.

Acquisition: The program may be captured in I-frame only or using long GoP MPEG-2 to provide higher storage capacities (principally camcorders).

Contribution: Where there is a need to electronically transmit the captured information over a network (satellite/telco/wireless camera), the long GoP MPEG-2 format is more likely to be used as this provides for higher transmission efficiency.

Source storage: Ideally the signal should be stored in its received format, that is I-frame-only for I-frame-only systems and long GoP for long GoP systems to maintain the highest possible quality. It is also possible to transcode the incoming feed to permit a standard

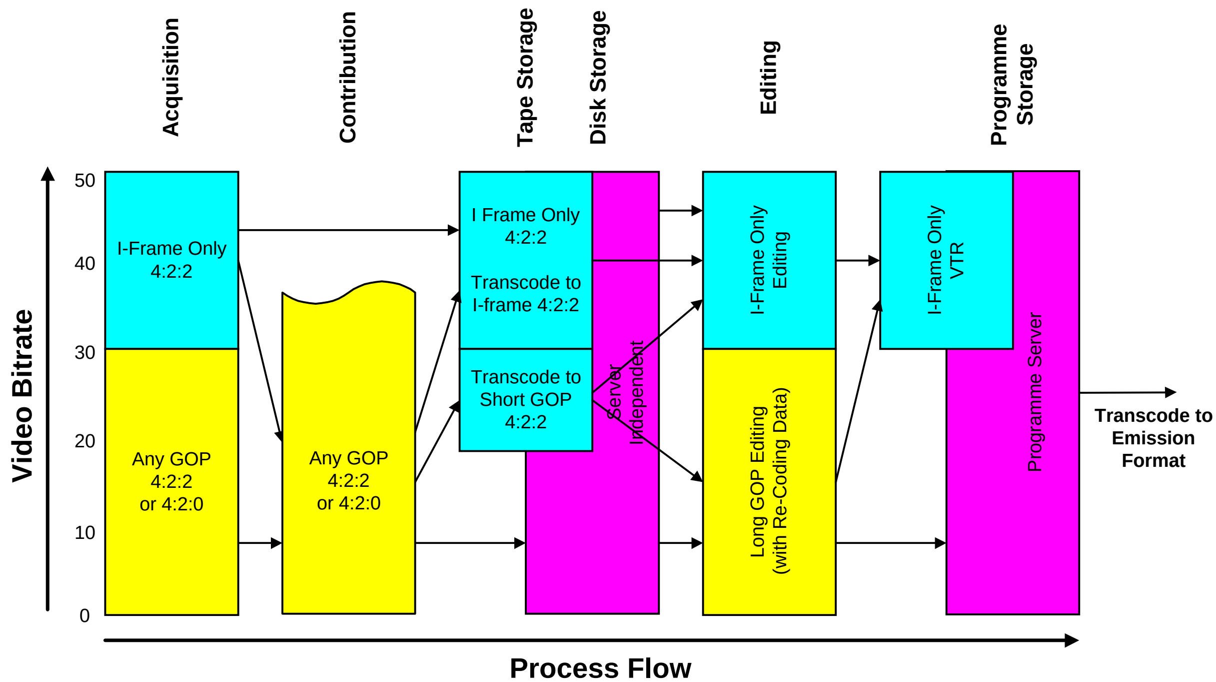

Figure 2 – Compressed video process flow — Current practice — SD example

native storage format. However, care must be taken to ensure that the quality is not degraded.

Editing: Cuts only editing is simple to perform in the MPEG-2 domain in the case of I-frame-only VTRs or servers. Where more complex editing is required, the signal has to be processed at video baseband. This can be achieved using either I-frame or long GoP MPEG-2 provided that the system has sufficient headroom. Where this headroom does not exist, it is necessary to use the MPEG-2 recoding parameters as defined in SMPTE 327M if MPEG-2 concatenation artifacts are to be avoided.

Program storage: Program storage should also be made in the editing format or in the transmission format so that the number of transcoding stages is reduced to a minimum.

The key options available to the program maker can therefore be summarized as:

– An I-frame-only or long GoP system with a sufficiently high data rate to allow multiple naive decoding/recoding processes while maintaining the overall quality.

– A long GoP system using lower data rates but passing forward recoding information as described in SMPTE 327M to minimize MPEG-2 concatenation artifacts.

4.1 System issues

To maintain quality throughout the production chain, the following issues should be taken into consideration:

1) The same GoP structure should ideally be maintained throughout the production chain in order to minimize the number of transcoding stages required.

2) The alignment of the MPEG-2 video should conform to that defined in SMPTE RP 202.

3) For long GoP inputs or systems, recoding data should be used to minimize concatenation artifacts by feeding forward previous encoding decisions as defined in SMPTE 327M.

In practical systems and for economic reasons, it may be necessary to transcode between one form of

MPEG-2 and another, for example, to pass through a Telco or satellite contribution circuit.

4.2 Transcoding issues

Multiple stages of compression encoding and decoding will introduce artifacts in the program content. Some conversions between different bit rates or compression structures will also introduce artifacts. Where practical, compressed program material should be transported and stored in the original compression format to minimize the number of cascaded encoding and decoding stages in the production chain. However, for many applications, it is necessary to mix sources derived from different MPEG compression parameters to create a final program. In these instances some form of transcoding will be required.

A method for reducing the number of transcoding stages is to define a set of encoding parameters to be applied as consistently as possible within an applications area. To ensure the consistent operation of encoders between different manufacturers, it is necessary, as a minimum, for the coded picture area to be the same for a given MPEG-2 level so that the MPEG-2 macroblocks within the picture are correctly aligned as defined in SMPTE RP 202.

Transcoding techniques now exist to optimally convert compressed video bitstreams from one bit rate to another either via digital video baseband or through an I-frame-only stream. These techniques are defined in the MPEG-2 recoding data set, SMPTE 327M. Using recoding information enables the next encoder to follow the same decisions as the previous encoder, thereby minimizing or eliminating concatenation artifacts.

4.3 Analog legacy issues

SMPTE RP 202 also makes reference to the 512-line and 608-line formats, which were introduced into the MPEG-2 4:2:2 profile to accommodate processing of vertical interval data through the compressed video path. This was done with analog television systems in mind, in advance of substantial digital television broadcasting deployment. Particularly in confined data rate environments, mixing data and video paths (composite analog inputs to encoders) has resulted in suboptimal processing of both signals. With increased emphasis on digital broadcast emission, there is new motivation to pass only video through the MPEG-2 compression process and pass data via a separate data path. In this case, only the 480-line and 576-line formats would be used for standard-definition television. Consequently, phasing out the 512- and 608-line MPEG-2 formats, which are based only on legacy analog requirements, is recommended.

Digital high-definition systems do not have the burden of analog heritage of standard-definition systems. HDTV does not therefore have a legacy of analog and digital vertical intervals being carried with compressed video. It is imperative that HDTV systems maintain their clear distinction between video data and ancillary data.

4.4 Standards conversion issues

There is frequently a requirement during international electronic program exchange to have both an MPEG-2 long-GoP link coupled with a frame rate standards conversion process.

MPEG-2 relies on smooth motion rendition for the accuracy of its predictive modes. Where this motion is modified, as in the case of standards conversion, temporal disturbances will be introduced. These disturbances are minimized by the use of motion compensated rather than linear standards converters.

Ideally, the contribution link would be MPEG-2 compressed at the source frame rate and standards converted at the receiving end, thereby allowing the contribution link to work at its maximum efficiency. This assumes that the contribution link has a sufficient overhead for the subsequent processing and MPEG-2 recoding for emission.

Although the above situation is preferred, it is acknowledged that in the case of point-to-multipoint contributions, the alternative solution of standards conversion before the MPEG-2 contribution link may be chosen for economic reasons.

4.5 Historical process-related metadata

As source content is moved through the transmission chain, it is likely to undergo a series of conversions such as coding to MPEG-2 for a contribution link, standards conversion, conversion from MPEG-2 4:2:2 to 4:2:0 or vice versa. Each new modification is typically performed without reference to what has happened previously.

To retain the maximum signal quality at the end of the chain, it is advisable to retain the knowledge of what has been done to the content during its progress through the chain. Although this information may be of limited use at present, future process control systems should allow the interrogation of this information in order to optimize the next content modification from editing to color balancing.

5 MPEG-2 application examples

Table 1 provides examples of actual bit rates and GoP structures being used in current real-time streaming applications. Table 1 shows HDTV application examples. Table 2 shows SDTV application examples. Application examples are derived from representative implementation examples planned or in use around the world.

All the examples in tables 1 and 2 are for streaming formats. Where file transfer is the preferred method of moving information, the data rates remain unchanged; however, the real time constraints are removed. Thus signals may be transferred over lower bandwidth communication channels than listed in table 2, but at rates slower than real time or alternatively over higher bandwidth channels at faster than real time.

6 Key issues by application area

6.1 Acquisition

Ideally the acquisition format would be chosen to match the predominant format of the following processes. However, for practical reasons, this is frequently not the case. Where transcoding is likely, the choice of acquisition or process formats should take into account the availability of intelligent transcoding.

The first compression system will determine the maximum quality attainable in the chain. This issue becomes critical where the contribution link is of a very low bit rate.

The use of an unfortunate combination of systems/equipment may create a situation where the low bit-rate contribution link performance, while providing acceptable quality when received, becomes degraded to an unacceptable point by subsequent studio processes.

The following areas, which apply to both SD and HDTV services, should be considered:

6.1.1 Video sampling structures

To ensure optimal system performance, all sources should ideally have the same luminance and chrominance sampling structures. In both MPEG and non-MPEG systems, there exists the possibility of different sample structures being mixed. Where such mixing is required, it is important to retain the history of the signal so that any subsequent processing can take these filtering processes into account.

6.1.2 Frame rates

Although mixing frame rates can introduce well-known temporal artifacts, MPEG-2 offers a substantial coding efficiency improvement when dealing with 24- or 25-Hz progressive frame-rate source material. The successful use of such techniques is not only dependent on the type or genre of the source material, but also on the choice of the correct equipment and the operational settings downstream of the acquisition process.

6.1.3 Non-MPEG systems

This is not an ideal starting point for an MPEG-2 based core system, but there inevitably will be a need to accommodate such systems. High bit rate acquisition minimizes any problems, but lower bit rate, non-MPEG acquisition will benefit from intelligent family transcoding to minimize artifacts which could otherwise become unacceptable in later reuse or with special picture processing such as chroma key.

It should be noted that non-MPEG systems frequently use an alternative sampling structure. Where this is the case, care must be taken to ensure that sufficient headroom is provided to allow for a naive family transcoding.

6.1.4 Latency

Where a program requires a real-time link between two or more sites, the time delay for live contributions and/or two-way exchanges is critical as this may damage the continuity of the program or even make a two-way interchange impossible.

MPEG-2 provides the flexibility to implement low-latency coders in both I-frame and long-GoP formats. There is, however, no standard specification for such usage. The temporal predictive modes of MPEG-2

Table 1 – MPEG-2 application examples: HDTV

	Acquisition (camcorder)	Contribution and distribution	Editing	On-air operations	Emission
IR 4 (I-only)	300 Mbit/s net (note 1)	(Note 6)	300 Mbit/s net (note 1)	300 Mbit/s net (note 1)	
IR 3A (any GoP)		40 Mbit/s net (note 2) 45 Mbit/s total (note 2) 52 Mbit/s net (note 7) 68 Mbit/s (note 3) (Note 6)		40 to 80 Mbit/s net (notes 2 / 4)	19.4 Mbit/s total (note 5)
IR 3B (any GoP)	Non-MPEG solutions exist at these bit rates	(Note 6)			

NOTES
1 300 Mbit/s I-only is specified in EBU/SMPTE Task Force report.
2 40 Mbit/s net, 45 Mbit/s total is capacity of DS3 – commonly used by U.S. broadcasters for this application. In Japan, 39 Mbit/s net is used.
3 68 Mbit/s is approximate capacity of Ku-band satellite.
4 Data rates up to 80 Mbit/s are being used in on-air playout servers.
5 19.4 Mbit/s is the total payload rate (US ATSC HDTV standard).
6 Possible when 622 Mbit/s ATM becomes widely available.
7 52 Mbit/s net, 59.684 Mbit/s TS+RS rate – ARIB standard for contribution satellite (ARIB STD-B26) and/or microwave link (ARIB STD-B11).

Table 2 – MPEG-2 application examples: SDTV

	Acquisition (camcorder)	Contribution and distribution	Editing	On-air operations	Emission
IR 2 (I-only)	25-30 Mbit/s (note 1) 50 Mbit/s (note 2)	30 Mbit/s net 40 Mbit/s net (notes 3 / 4) 50 Mbit/s net (note 2)	50 Mbit/s net (note 2)	20-50 Mbit/s net	
IR 1 (any GoP)		2 Mbit/s net (note 5) 7.5 Mbit/s net (note 6) 10.5 Mbit/s net (note 9) 20.5 Mbit/s net (note 7)	Contribution rate to 30 Mbit/s net	Emission rate – 20 Mbit/s net (note 8)	3-8 Mbit/s

NOTES
1 25 Mbit/s – 30 Mbit/s I-only is being used in Japan.
2 50 Mbit/s I-only – EBU Technical Statement D84/D85-1999.
3 30 Mbit/s net (34 Mbit/s total) on E3 links.
4 40 Mbit/s net (45 Mbit/s total) on DS3 links.
5 Data rates as low as 2 Mbit/s net (3 Mbit/s total) are used in limited bandwidth applications.
6 7.5 Mbit/s net is specified for ENG by the Inter-Union Satellite Operations Group (ISOG) and is currently using MP@ML (also in standardization in ITU).
7 EBU 4:2:2 – 22.3 Mbit/s rate used by Eurovision Network.
8 8 to 20 Mbit/s is commonly used for on-air playout servers in NTSC or PAL transmission. Coding for on-air playout servers may be at emission rate in the case of digital transmission.
9 EBU 4:2:2 – 12 Mbit/s rate used by Eurovision Network.

require a higher latency for their operation than I-frame-only systems, but in practice this has to be weighed against the higher bit rate requirement for the same quality.

6.1.5 Consumer formats in news

Frequently the only source of material available is from a consumer camcorder. Although these machines produce acceptable first- or even second-generation quality, they were not designed for the broadcast environment and cannot therefore be treated as professional sources.

The consumer camcorders in the market today do not have a sampling structure conforming to broadcast standards and were not designed with sufficient overhead for decoding and recoding to an MPEG-2 emission format. Nonetheless, by careful manipulation of the images, intelligent family transcoding and the avoidance of multiple decode/recode cycles, acceptable news transmission quality can be obtained.

6.2 Contribution

In studio-to-studio applications, the highest possible quality is required within cost constraints. Often the available transport media determines what kind of bit rate can be achieved, but for a given bandwidth, the quality will always be optimized.

Long GoP always gives the best quality at a given bit rate — be it at 4 Mbit/s or 50 Mbit/s video rate. As reported in the EBU/SMPTE Task Force Report, the quality of 50 Mbit/s I-frame-only is comparable with 25 Mbit/s long GoP (see figure 1).

The following are different examples, very much driven by the transport medium.

6.2.1 Satellite

The EBU, for example, uses transport stream rates of about 24 Mbit/s (video rate ~ 20.5 Mbit/s) for their satellite based contribution network. This gives a good tradeoff between cost and quality as satellite space is costly.

For news gathering, an alternative set of parameters has been defined, known as DSNG (digital satellite news gathering). The most popular set of parameters used in DSNG is the ISOG mode (Inter-Union Satellite Operators Group).

This mode specifies the following parameters:

– TS rate: 8,448 Mbit/s excluding Reed-Soloman coding
– Video bit rate: 7.5 Mbit/s
– Audio data rate: 256 kbit/s (stereo)

ISOG frequently conducts tests between equipment from various manufacturers and has achieved acceptable results. Some DSNG operators use slightly lower and higher bit rates, but MP@ML, long GoP, and QPSK (quadrature phase shift keying) are prevalent, as they fit in a 9-MHz satellite slot.

In the future, higher-order modulation schemes like 8PSK and 16QAM will enable higher bit rates and the use of 4:2:2P@ML.

6.2.2 PDH/SDH

For some time, broadcasters have used 140 Mbit/s links for uncompressed video transmissions and many of these links are still in use today, as it achieves a very high-quality level. However, increasing use is being made of dedicated 34- or 45-Mbit/s connections; consequently, the broadcaster/telco is able to obtain an effective video bit rate of 32- or 43-Mbit/s, respectively.

For example, a large contribution network in the Pacific region uses a video rate of between 25-35 Mbit/s long GoP together with linear audio (~2 Mbit/s) and some data channels which completely fill the DS-3 link. Several other E3 and DS-3 networks are in operation world wide using these high video bit rates (>30 Mbit/s) with long GoPs.

6.2.3 ATM

Physical connections to ATM networks suitable for compressed contribution/primary distribution applications are commonly available at the following rates:

– OC-3 / STM-1: 155.52 Mbit/s
– E-3: 34.368 Mbit/s
– DS-3: 44.736 Mbit/s

These bit rates represent ceiling values. ATM offers the flexibility to allocate any lower data rate, and to support multiple channels and data types (refer to the Pro-MPEG Code of Practice #2, May 2000, WAN Operating Points).

To match MPEG-2 to the ATM payload area, 188-byte packets are used. Consequently the transport stream with FEC which requires 204-byte packets is not used and error monitoring at the transport stream level is not possible. The adaptation layer, normally AAL1, must therefore provide this FEC function for MPEG-2 streams transported over ATM.

6.3 Editing

Editing alters the time order of video and audio samples. Editing may also alter the content of the video and audio samples. In order to perform these two tasks, it is useful to exchange video and audio elements in a format that is either not multiplexed, or one which can be easily demultiplexed.

General considerations:

– Format needs to be easily demultiplexed;
– Random access needs to be achieved;
– Quality of the compressed media must be preserved.

Two operating ranges are required for SDTV and two for HDTV. One of these ensures operating by simplicity, the other by flexibility.

Considerations for simple interchange:

– Constrained bytes per GoP;

– I-only;

– Select single bit rate with sufficient headroom for multiple generations; 50 Mbit/s is sufficient for SDTV;

– Repeat sequence headers on every frame;

– If nondefault quantization tables are used, repeat quantization tables on every frame;

– Carry a valid vbv_delay in each picture header.

Considerations for flexible interchange:

Compressed video and audio elements should be recompressed as few times as possible. This minimizes quality loss due to multiple generations of compression. Efficient use of bandwidth dictates that flexible GoPs be allowed:

– Leave compressed elements in their original form;

– Support multiple formats, flexible GoP, bit rates;

– Preserve timing information that exists in the compressed stream (either implied, or vbv_delay, or PCR/PTS/DTS);

– Use of recoding data to ensure the minimum picture degradation throughout the process;

– Disallow intra_slice_update for MPEG-2 coding.

6.4 On-air operations

There are currently two methods in common use:

– the use of play-to-air servers often using a high data rate, followed by real time MPEG-2 encoder;

– the alternative is to encode onto the server at the play-to-air bit rate and to stream out directly.

Today, the first solution is primarily used for broadcast stations that have a major interest in live program material such as sports or news, whereas the second solution is preferred where the majority of the content is preauthored before transmission.

6.5 Emission

To permit the insertion of local programing and advertising, two different techniques are currently in use:

– A hierarchical system which has sufficient headroom to permit the naive decode and recode of the video and audio signal before the final emission.

– A play-to-air system using the same bit rate as the emission bit rate.

– To enable the downstream insertion of local content or advertisements, the distribution stream requires authoring to add SMPTE/SCTE splice points to allow for these insertions. In addition, care must be taken to ensure that the SI/PSIP and data essence information is suitably modified to take into account the emission point.

– A more flexible solution may be achieved by decoding the MPEG-2 signal to baseband, mixing with other baseband sources and recoding. To avoid MPEG-2 codec concatenation losses, it is desirable that the parameters defined in the MPEG-2 recoding data set are passed from the decoder to the encoder.

Both systems can also provide the necessary flexibility to allow for logo or bug insertion by an affiliate.

6.6 Archiving

The choice of archive strategies is highly dependent on the user's business needs. As such there is no single recommendation that can be made for the selection or format to be used for a facility's archive. Applications that may determine specific requirements include:

– Long-term storage of material in a master quality format;

– Temporary storage of material used in production (work in process);

– Short- or long-term storage of finished program material;

– As-aired recordings of material transmitted to air (for legal confirmation).

Additional requirements may also need to be considered:

– The need for browse copies that provide a visual index to the content;

– The need for access by users that may be located off-site;

– The choice of a single format or a multiformat archive;

– The need to access a segment of material from within a stored program file;

– Access time (search and fetch time);

– Speed of delivery (how fast the material can be delivered from the archive format);

– File transfer versus streaming delivery.

In many facilities, users will be faced with a variety of different audio and video coding formats. In addition, facilities today generate a wide variety of valuable information that is associated with the audio and video material. This may include scripts, EDLs, captioning files, and other data essence. Archive systems should ideally be format independent and allow storage and access to all these data types.

Where selecting a format for archiving, users may choose to archive material in either its native coding format (D-5, HDCAM, DTF, DV, MPEG, etc.), or they may select a single format, such as MPEG, for all stored material. For MPEG-2-based facilities, the latter approach allows access from a wide variety of equipment without the need to transcode to the house format at the time of access.

The MPEG toolbox offers the flexibility to work at a variety of data rates and GoP structures, which can be selected appropriate for the quality supported by the source format. For example, if archiving material that originated on U-matic, the user may select to use main profile @ main level, while material that originated on a higher-quality format such as D-1 might be archived using the higher-quality 4:2:2 profile.

Similar considerations exist for selection of compressed or uncompressed audio formats.

6.6.1 Video formats

Transcoding techniques provide a means of moving between different GoP structures and data rates. When transcoding, it is important to select a data rate that minimizes loss of quality in the copy.

Experimental results showing equivalent picture quality for different data rates and GoP structures are shown in figure 1. These tests were reported as part of the work of the EBU/SMPTE task force. It should be noted that the current state of the art provides considerably better pictures at the data rates than those shown in the figure. Users should carefully consider where and when transcoding takes place in their facility based on their specific application.

In a production environment (where the material will subsequently be used in the editing process), if frequent reuse is anticipated, users may choose to transcode all source material to a single operating point such as 50 Mb/s I-frame only as the material is ingested. Where high-speed transfer of material over networks or other compressed interfaces is used, users should consider the speed of any required format conversion and/or transcoding processes as these may limit the speed of transfer.

6.6.2 Audio formats

New audio compression formats allow for efficient transport of multichannel audio within and between facilities (for example, AAC or Dolby-E). In a production environment, audio and video will typically be handled separately. Audio processing is normally performed in the uncompressed environment. Just like video, audio decompression is a real-time process and should be accomplished at the same time as and in synchronism with any video transcoding that occurs.

6.6.3 MPEG transport streams

If material arrives as a transport stream, specific applications will dictate whether the material should be stored in its native transport steam format or decomposed to elementary streams. For facilities that process incoming material before retransmission, the transport stream must be decomposed to separate audio and video elementary streams before post-production processing takes place. For processing within the facility, material is best stored in an elementary stream format. Examples of such processing may include the production of promos in an edit suite, or mixing, keying, and audio voice-overs that may be added in master control.

In the event that metadata and/or data essence are carried in the TS, users are advised to determine the value of such data and to select equipment that preserves the data for reuse or reinsertion in the facility's emission stream.

Annex A (informative)
Related documents

The relationships among related documents are shown in figure A.1.

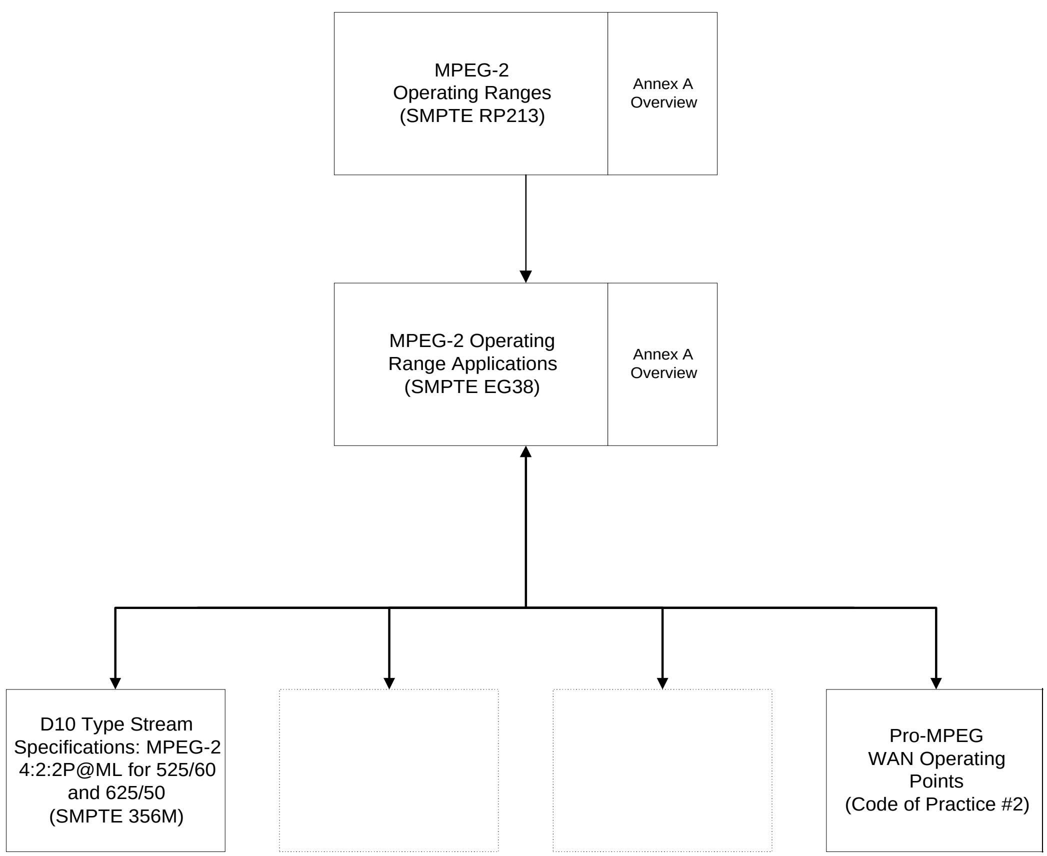

Figure A.1 – Related documents relationships

Annex B (informative)
Bibliography

SCTE DVS 253-1999, Digital Program Insertion Cueing Message for Cable

ARIB STD-B11, Portable Microwave Digital Transmission System for Television Program Contribution

ARIB STD-B26, HDTV Digital SNG Transmission Systems

EBU D84-1999, Use of 50 Mbit/s MPEG Compression in Television Programme Production

EBU D85-1999, Constraints on MPEG 4:2:2P@ML Compression to Ensure Interoperability in Television Production

EBU D89-2000, Quality and Interoperability in a 625/50 Digital Television Production Environment Using MPEG Compression

EBU/SMPTE Task Force for Harmonized Standards for the Exchange of Program Material as Bitstreams, Final Report: Analysis and Results, July 1998, SMPTE J. 107(9):603-815; 1998 September

Pro-MPEG Code of Practice #2, May 2000, WAN Operating Points