RECOMMENDATION ITU-R BR.1376*

# Compression families for use in recording and networked standard definition television production**

(Question ITU-R 238/11)

(1998)

The ITU Radiocommunication Assembly,

*considering*

a) that Recommendation ITU-R BR.1356 "User requirements for application of compression in mainstream standard definition television production and achival" already exists;

b) that maintaining video signals in compressed form as far as possible throughout the production and post-production process offers the potential of increased operating efficiency;

c) that the use of several, incompatible compression families within a production plant will counter-balance the expected gains in productivity and programme throughput;

d) that market forces prevent the adoption of a single compression family[1];

e) that the appropriate selection of a limited number of compatible compression schemes, will be of overriding importance if efficient exploitation of the potential offered by networked operating environments is to be achieved in the future;

f) that the gamut of different quality requirements and economical constraints ranging from acquisition, production, post-production to contribution will require the allocation of different family members for different applications;

g) that the proponents of the compression families listed below have agreed to submit the specification of the compressed data stream and for mapping audio, video and data into different transport mechanisms for standardization,

---

* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2001 in accordance with Resolution ITU-R 44.

** This Recommendation should be brought to the attention of the International Electrotechnical Commission (IEC).

1 A compression family is defined by its ease of intra-family bit-stream transcoding and the availability of an "agile decode" in integrated from.

*recommends*

**1** that for core applications in production and post-production for Standard Definition Television, one of the two compression families which are currently advocated on the market as candidates for future networked television production should be used:

– DV-based 25 Mbit/s with a sampling structure of 4:2:0, DV-based 25 Mbit/s with a sampling structure of 4:1:1 and a DV-based 50 Mbit/s with a sampling structure of 4:2:2, using fixed bit rates and intra-frame coding techniques exclusively[2];

– MPEG-2 4:2:2P@ML using different GOP structures and data rates up to 50 Mbit/s;

**2** that for mainstream television production applications requiring a higher margin of quality overhead for post-production, the member within one compression family based on intra-frame encoding at a data rate close to 50 Mbit/s should be chosen.

Appended to this are the following appendices, which provide background information on the Recommendation:

*Appendix 1:* "Compression issues", which outline the preconditions which have to be met to adopt a compression family for television production operations.

*Appendix 2:* "EBU Statement D 79 – Open standards for interfaces for compressed television signals", which is a policy statement by a large user group to ensure an open platform for the development of hardware conforming to the standard.

*Appendix 3:* "EBU Statement D 80 – Compression in television programme production", which recognizes the need for compression schemes at a higher data rate to meet more demanding post-production requirements.

*Appendix 4:* "EBU Statement D 82 – M-JPEG in future networked television production", which acknowledges that there is a large installed hardware based on M-JPEG. Most equipment employs mutually incompatible M-JPEG versions, however, with little likelihood of reconciliation of the different parameters implemented, thus preventing rather than endorsing interoperability for future networked operations.

---

[2] The DV chip-set has been developed for consumer applications which provides a broad application basewith resultant scaled cost in industrial production. The chip-set can be configured for either processing a 4:1:1 sampling raster ("525-countries") or a 4:2:0 sampling raster ("625-countries"). This chip-set is used within Camcorders for domestic and industrial use, designed by different manufacturers but increasingly used in professional ENG and studio applications. The 4:2:0 sampling raster requires additional vertical pre-filtering of the colour-difference channels to avoid aliasing.

APPENDIX 1

# Compression – Issues[3]

## Introduction

This Appendix is an excerpt of the findings of the EBU/SMPTE Task Force concerning the criteria relevant for the adoption of a compression family for television production and post-production operations.

## Compression

Since the release of the last Special Rapporteur Report, the subgroup on Compression of the EBU-SMPTE Task Force has entertained in-depth discussions on the compression schemes available today and in the foreseeable future and on the balances obtained in terms of:

– ultimate technical programme quality versus data rate;

– editing granularity versus complexity of networked editing control; and

– interoperability of compression schemes using different encoding parameters.

The subgroup is aware that the integration of new digital video data formats based on compression into existing digital production environments is already occurring at a rapid pace, creating a remarkable impact on storage media cost and post-production functionality. Though the widely used Digital Betacam recording format is an obvious example for the successful use of compression in digital television production and post-production operations, the manufacturer advised the Group that Digital Betacam will continue to support digital interfacing at the SDI baseband level only. Interfacing in the native compressed form is not recommended.

Compression based on M-JPEG as the key enabling factor for opening Hard Disk technology for broadcast non-linear editing (NLE) applications is yet another.

The routing of programme data in compressed form through local area as well as national – and international Telco circuits is expected to become the predominant form of distributed programme production in the future.

Although compression can be applied to all data elements relevant to programme production – video, audio and metadata – this Report focuses exclusively on the implications when applying compression to the video signal. It is current thinking that digital audio in production and post-production should remain uncompressed although it cannot be totally excluded that external

---

[3] Excerpt from the Document 10-11R/11, February 1998 “2nd Report of the Rapporteur Group on file formats, interfaces and network protocols to be used in digital television recording for programme production”.

contributions may require handling of audio in compressed form as well. In this case, the considerations described in this Report will also apply. It is further understood, that compression applied to metadata would have to be totally lossless and reversible.

Interfacing between equipment using identical or different compression formats is currently effected through the Serial Digital Interface format in baseband exclusively. On this condition, the existence of different and incompatible compression formats within manufacturers implementations reflects on achievable picture quality and storage efficiency exclusively.

This situation is expected to slowly evolve into a state where programme data composed of compressed video, audio and related metadata will be processed and routed in its native form directly, employing methods and protocols borrowed from the IT community and adapted to meet the quality of service requirements of professional television production.

Although techniques for minimizing quality loss in production and post-production operations by direct manipulation of the compressed bit stream or by using special "helper data" are the subject of research, the subgroup has stated that the majority of broadcast production and post-production operations still cannot be performed by direct manipulation of the compressed data stream, even within a single compression scheme. The consequent cascading of decoding and re-encoding processes within the production chain and the quality losses incurred therefore require the adoption of compression schemes and bit rates which support the quality requirements of the ultimate output product.

Improved operating efficiency by multi-user access to identical programme segments as well as reduced data transfer times for dubbing and transfer to and from different storage – and processing platforms are further benefits of that approach. Though recording formats used in production and for programme exchange will continue to be subject to constant change due to the ever decreasing cycles of storage media development, the significance of guaranteeing future proof replay of digital compressed television signals from a particular recording support will gradually be replaced however by the need for standardized protocols for data transfer across different and changing recording platforms. The compression scheme chosen for that purpose will then no longer be a kernel feature of a particular implementation but will bear the potential of becoming the core element of a total television production chain, including a hierarchy of tape- and disk-based storage devices offered by different manufacturers alliances. Integrating compression and network technology into broadcast operations is therefore expected to increase both operating flexibility and universal access to television archives.

The EBU has acknowledged different quality levels within the confines of professional television production and post-production. Further adaptations may be required to overcome bottlenecks created by particular constraints, e.g. bandwidth, tariffs and media cost.

The subgroup has defined the membership within a "compression family" by its ease of intra-family bit-stream transcoding and the availability of an "agile decoder" in integrated form.

The coexistence of different compression families in their **native form** within both local and remote networked production environments requires the implementation of hardware-based, "**agile decoders**". Software-based agile decoding is currently not considered to be a practical option. It is currently still undefined how an agile decoder will output the audio – and metadata part of the bit stream.

In many instances, such decoders must allow "glitchless switching" and can therefore realistically be implemented within **one compression family** only. The subgroup on Compression concluded, that within the foreseeable future, coexistence and inter-operation of **different compression families** within a networked television plant will pose a number of operational problems and will therefore be the exception and not the rule.

The appropriate selection of a single compression scheme – or a limited number of compression schemes within one compression family, together with the publicly available specifications of the relevant transport streams and interfaces – will be of overriding importance if efficient exploitation of the potential offered by networked operating environments is to be achieved in the future.

For core applications in production and post-production for Standard Definition Television, two different compression families are currently advocated on the market as candidates for future networked television production:

– **DV-based 25 Mbit/s with a sampling structure of 4:2:0, DV-based 25 Mbit/s with a sampling structure of 4:1:1 and a DV-based 50 Mbit/s with a sampling structure of 4:2:2, using fixed bit rates and intra-frame coding techniques exclusively.**

– **MPEG-2 4:2:2P@ML using different GOP structures and data rates up to 50 Mbit/s.**

(For specific applications, this could also include MPEG-2 MP@ML if decodable with a single agile decoder.)

Very recently, **M-JPEG compression** has been submitted to the Task Force as a further contender for use within certain areas of production and post-production, once all requirements have been fulfilled as outlined in the list of requirements below. The Production Management Committee of the EBU has carefully evaluated the impact of a further, incompatible compression family on system complexity of networked production. There was agreement that the EBU will not endorse M-JPEG as yet another compression family.

The positioning of the above compression families within a future networked digital production scenario requires careful analysis and differentiated weighting of the current and future potential influence of various technical constituents on that scenario. This also has to take into account the possible coexistence of Standard Definition Television and HDTV, where the operation at very high data rates within a range of different pixel rasters and frame rates will add yet an extra layer of complexity. **There is agreement in the subgroup that the general rules outlined in this document also apply for HDTV**.

The subgroup has identified the following elements which all have a significant impact on the objectives described above:

– **Format stability**

Availability of chip-sets.

Format commitment by each manufacturer.

Status of standardization.

– **Picture quality ceiling, post-production potential, storage requirements**

As a first step, the EBU has divided the requirements for picture quality and post-production margin of networked broadcast applications into the following categories:

– News and sports applications.

– Mainstream broadcasting applications requiring more post-processing overhead.

– **Interfaces**

A stream interface for use within a television production plant has been standardized recently by SMPTE (305M). The Standard defines a **S**erial **D**ata **T**ransport **I**nterface for the flexible transport of packetized video, audio and metadata over coaxial cable interfaces for different bearers, applications and functionalities have already been standardized or will be standardized in the near future, e.g. fibre-channel, ATM. The DV-based data stream is pending specifications by SMPTE "Data structure of audio, compressed video and subcode data for the 25 Mbit/s and the 50 Mbit/s structure at 525/60 and 625/50 system".

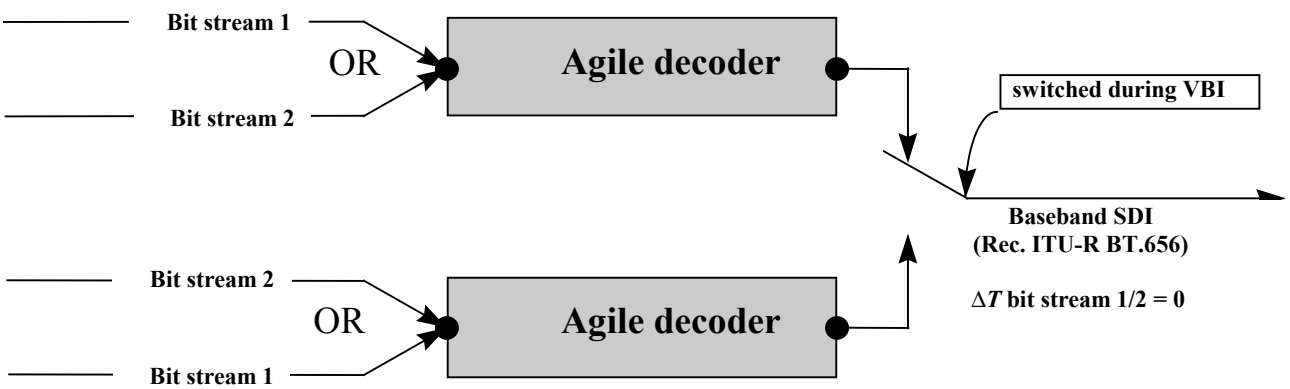
The mapping of the data stream on SDTI is described in a SMPTE draft Standard document "Data stream for the exchange of DV-based audio, data and compressed video over SDTI".

The specification for 422P@ML MPEG-2 follows the MPEG rules. The mapping of 422P@ML MPEG-2 compliant data as a transport stream (TS) or as an elementary stream (PES) is currently under investigation. The actual status of the diverse specifications can be found in the section describing possible production scenarios based on DV and 422P@ML.

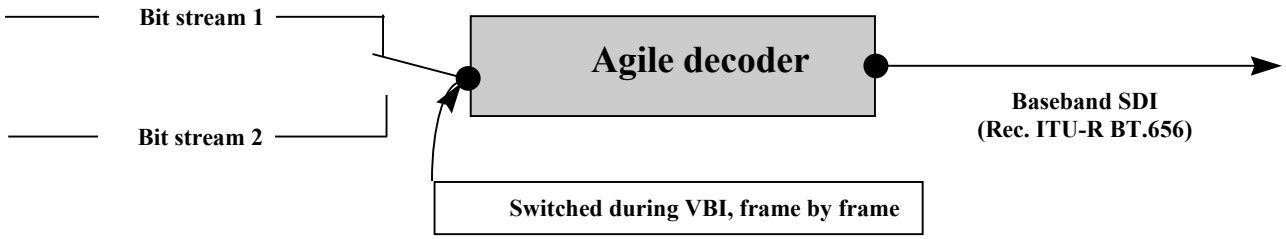
– **Agile decoders**

Agile decoders for intra-family decoding (see Note 1) must be available in integrated form. They are expected to decode streamed real-time packetized video only. Such decoders should comply with the following requirements:

a) Decoding of different bit streams with identical decoding delay at the output.



b) Intra-family switching between different bit streams at the input.




NOTE 1 – As an example, bit stream 1/2 in the above block diagrams could be: DV-based 25 Mbit/s (4:2:0 or 4:1:1) or DV-based 50 Mbit/s within the DV family or MPEG-2 based 422P@ML, 18 Mbit/s, IB or MPEG-2 based 422P@ML, 50 Mbit/s, I within the MPEG family.

c) Intra-family decoding between different bit-stream packets within a single bit stream.

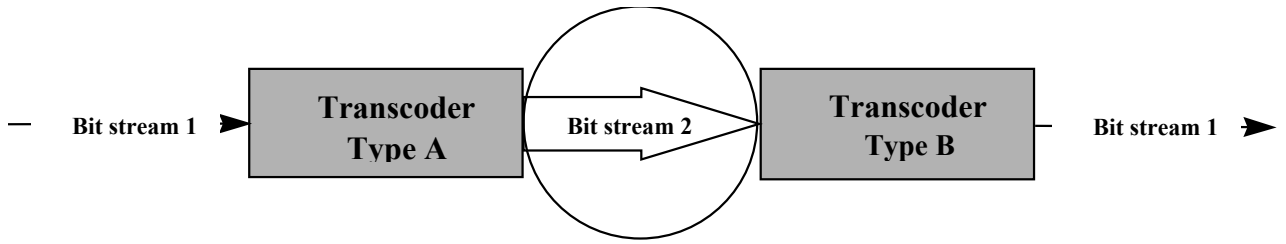

– **Native decoders**

Native decoders, designed to operate on non-standard bit streams, e.g. for optimized stunt-mode performance (e.g. shuttle, slow-motion) or for special functions, are acceptable. The decoder chip-set should be available on a non-discriminatory basis on fair and equitable conditions. Details of possible deviations from the standardized input data stream should be in the public domain.

– **Family relations**

a) Tools available for intra-family transcoding

For reasons of restricted network bandwidth or storage space, a higher data rate family member may have to be converted into a lower data rate member. In the simplest case, this can be performed by simple decoding and re-encoding. Under certain conditions, the quality losses incurred in this process can be mitigated by re-using the original encoding decisions. This can be performed within a special chip or by retaining the relevant information through standardized procedures.



b) Compatible intra-family record/replay

Operational flexibility of networked production will be influenced by the availability of recording devices which can directly record and replay all intra-family bit streams or which allow the replay of different bit streams recorded on cassettes.

– **Editing flexibility and complexity**

Editing restrictions

For compression streams employing temporal prediction, editing granularity of the compressed bit stream on tape without manipulation of pixels within the active picture will be restricted. Remote replay sources will require special control data and internal intelligence to allow frame accurate editing.

– **Examples of commercial format implementations**

Television tape recorders

Disk storage

File servers

– **Format development criteria**

A compression family **must** offer the potential for flexible inter-operation between family members.

It would be conceived as a **benefit** if the family allowed expansion to cope with restrictions imposed by special conditions in the areas of storage and Telco interconnection.

– **Test equipment**

Test equipment should be available on the market which allows conformance testing with the respective standard specifications of all system modules.

## APPENDIX 2

## EBU Technical Statement D 79 – 1996
## Open standards for interfaces for compressed television signals

The proposals to use compressed signals on a number of new television recording formats have raised a number of questions about interfaces.

There are a number of advantages in interconnecting equipment associated with these formats using interfaces which carry the compressed signals.

These advantages include:

– the avoidance of multiple coding and decoding;

– cost-effective storage on disc and tape;

– the possibility of non-real-time transfer, particularly at faster than real-time.

However, to best exploit these advantages, broadcasters should be able to interconnect equipment from a variety of manufacturers.

Therefore, the **EBU requires**:

– that a single interface should be defined to carry compressed television signals;

– that all elements of the interface should be open and fully specified.

# APPENDIX 3

## EBU Technical Statement D 80 – 1996
## Compression in television programme production

At the present time, broadcasters are faced with a choice between incompatible compression algorithms used on different non-linear editing and acquisition devices. Systems based on the new tape recording formats SX and DVCPRO operate on compression algorithms at 18 and 25 Mbit/s respectively and are intended to be used in the acquisition of sports and news material. New tape recording formats for mainstream television applications have already been announced. One is based on an extension of the DVCPRO compression algorithm to the 4:2:2 signal format and will operate at about 50 Mbit/s. Other formats based on the 422P@ML of MPEG-2 may follow.

It is possible to integrate devices using compression systems into existing digital facilities if they are equipped with the standard serial digital component interfaces in accordance with Recommendation ITU-R BT.656. However, the compressed signals must first be decoded into Recommendation ITU-R BT.601 format.

The following consequences also arise:

– any further re-encoding and decoding of the previously compressed signal, such as may be required for further non-linear editing, will further increase the loss of signal quality;

– even for simple assemble editing, programme segments encoded with different compression algorithms would each need to be decoded into BT.601 format. Subsequently, a decision may have to be made on which format is used for the edited programme material for future storage on a server or in the archive;

– the cost and operational benefits of an integrated tape and disk strategy using a single algorithm would be nullified by the time required to transfer the programme material between different media. This is because there is little possibility of faster than real-time transfer between the acquisition, processing and storage devices using signals in BT.601 form.

The provision of a single interface standard to carry compressed signals would alleviate this situation but the interface signal formats based on existing algorithms would not be compatible with each other or with other MPEG-based standards. Unfortunately, the EBU sees little likelihood of achieving harmonization at bit rates in the range 18-25 Mbit/s.

The situation is different for compression algorithms operating at higher bit rates, which may possibly be used in main-stream television studio operations. No significant amount of equipment is installed in this area of activity and hence the possibility still exists for achieving harmonization.

The EBU is encouraged by the continued improvements in performance and cost of disk storage and considers that:

– there are real economic benefits to be achieved through the use of a single compression algorithm and file format for programme exchange;

– intermediate storage and long-term archival of material in a variety of formats is inefficient and creates problems extending into the future;

– disk-based editing produces time and cost benefits over tape-based systems;

– there are technical and system benefits for programme production through an ability to select equipment from different suppliers as appropriate for different applications;

– that compression algorithms operating in an I-frame only format at about 50 Mbit/s have been demonstrated and they are likely to offer a picture quality and a headroom for post-processing which are appropriate for all but the most demanding studio operations.

**The EBU firmly believes that**:

– for high-end programme production, uncompressed signals according to Recommendation ITU-R BT.601 or systems using lossless compression or systems using lossy DCT-based compression with a compression factor not exceeding 2 should be used;

– for mainstream programme production and for programme acquisition using low bit rate compression formats where the operational advantages of compression are obvious, only a single, open compression algorithm should be applied for storage or file transfer applications.

Furthermore, this system should be operating at 50 Mbit/s and use an I-frame only format.

# APPENDIX 4

## European Broadcasting Union

## EBU technical statement D 82 – 1998
## M-JPEG in future networked television production

The joint EBU/SMPTE Task Force on “Harmonised Standards for the Exchange of Programme Material as Bit Streams” is completing its studies. These include a review of digital video compression systems that may be suitable for the exchange of programme material in the form of compressed bit streams in a generalized networked environment for television programme production.

The Task Force has identified two families as contenders for this application:

– DV-based compression;

– 422P@ML MPEG-2 based compression.

Although its initial remit was to try to recommend a single compression family, the Task Force has found that it is not possible to adopt one family over the other. It has therefore decided to recommend the adoption of either of the compression families.

Each family has a number of members at various bit rates. Each member is designed to operate in a different programme production scenario. The Task Force requires each family to have a single "agile" decoder, which will decode all the members of the family. (Transcoding between members of different families requires decompressing the signal to the Recommendation ITU-R BT.601 level.)

The Task Force is satisfied that the specifications of both compression families meet this requirement and that products in each family will be able to meet the requirements for the exchange of digital television programme material in the form of bit streams, already established by the EBU.

Products conforming to the specifications of both compression families are on the market today and more are expected in the future. Eventually, each compression family is expected to cover the complete range of devices needed for television programme production.

At a late stage in its studies, the Task Force was approached with a request that the M-JPEG compression system, currently used by the majority of non-linear editing devices, should also be adopted as a third family.

Having considered this request, **the EBU strongly discourages the adoption of the M-JPEG family in future networked television systems** because:

– Yet another compression family would confuse the market and severely hamper a timely and orderly introduction of the exchange of digital television programme material in the form of compressed bit streams.

– The M-JPEG family would not add any features that at least one of the other two contenders could not supply.

– The M-JPEG system is already used in several variations that are generally not compatible even with each other. A single agile decoder will not decode all variations of M-JPEG and this will not be possible unless there is universal agreement on severe bounds to the coding parameters.

– Even the manufacturers of M-JPEG equipment for programme production do not expect that M-JPEG compression will extend to cover the complete range of devices needed for television programme production.

**The EBU believes that the Task Force should limit their considerations to the two compression families that they have already identified as appropriate, namely the DV family and the 422P@ML MPEG-2 family**.

The EBU commends the Task Force on their activity and energetic pursuit of their aims.