RECOMMENDATION ITU-R BT.1662

General reference chain and management of post-processing headroom for programme essence in large screen digital imagery[1] applications

(Question ITU-R 15/6)

(2003)

The ITU Radiocommunication Assembly,

considering

a) that the ITU is studying a new broadcasting service called large screen digital imagery (LSDI);

b) that several LSDI applications will likely be identified that comply with the definition in *considering* a);

c) that it would be useful to specify a general reference chain for typical LSDI applications, to provide a single framework in which they can be studied with uniform methodology,

recommends

1 that the general reference chain described in Annex 1 should be used as a framework to study post-processing headroom management for typical LSDI applications that are based on the use of a fully digital signal chain for programme essence;

2 that the general implementation guidelines detailed in Annex 1 for the various blocks in the reference chain should be used in the design of the signal path and of post-processing headroom management for programme essence for those LSDI applications. They recommend that:

– the programme chain should be digital from acquisition to presentation where acquisition can be by means of:

  – digital camera producing a signal to the desired specification, or

  – film, which is then scanned via a telecine to a digital format of the desired LSDI specification;

– a single native format depending upon the quality level should be used for programme essence throughout the chain, if possible;

– if that is not possible due to complex post-processing requirements, then a minimum number of native formats should be used along the chain, and their parameter values should stand in a simple relationship to each other.

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[1] Large screen digital imagery (LSDI) is a family of digital imagery systems applicable to programmes such as dramas, plays, sporting events, concerts, cultural events, etc., from capture to large screen presentation in high resolution quality in appropriately equipped cinema theatres, halls and other venues.

Annex 1

Reference chain and guidelines on the management of post-processing headroom for programme essence in LSDI applications

1 The reference chain

The general reference chain specified here is considered to be a useful tool in the design and analysis of the signal path and the management of post-processing headroom of programme essence for typical LSDI applications, namely for those applications that meet the definition for LSDI as outlined in Question ITU-R 15/6.

The general reference chain is made up of the following blocks, shown in Fig. 1. Each block in the chain is supposed to be digital.

– *Acquisition* – where images and sounds are transformed into their digital representation. The input to this block consists of light and sound stimuli, its outputs are digital, audio and video essence signals.

– *Post-production* – where the digital audio and video essence signals are processed to produce a finished master of the programme that suits the creative intent of the producer. The inputs to this block consist of the acquired audio, video and electronically generated digital signals, its output is the finished master of the programme.

– *Distribution* – where programme signals are encoded, multiplexed and modulated in view of their delivery to end users. The inputs of this block consist of the programme essence digital signals coming from the finished master, its outputs are the demodulated, demultiplexed and decoded digital signals fed to the presentation block.

– *Presentation* – where programme essence digital signals are transformed into light and sound stimuli to be presented to the audience. The inputs to this block are the programme essence signals received from the distribution block, its outputs are the image and sound stimuli presented to the audience.

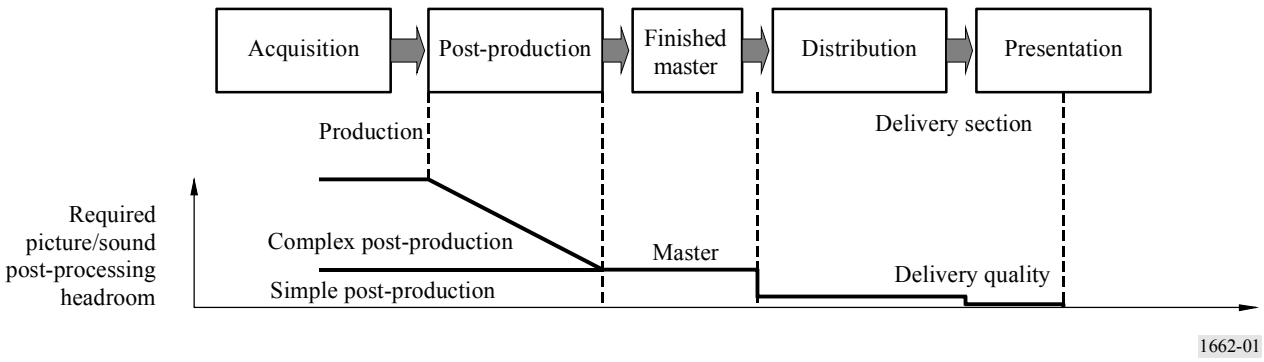
The two blocks of acquisition and post-production make up the production section of the chain which ends with the finished master.

The two blocks of distribution and presentation make up the delivery section of the chain which begins from the finished master.

The finished master is thus the hinge between the production section and the delivery section.

FIGURE 1

Reference chain for typical LSDI applications and cognitive evolution of picture/sound post-processing headroom along the chain



2 Some general rules on picture/sound quality and the propagation of impairments

The general rules detailed below apply to picture/sound quality in a programme essence digital signal chain like the reference chain and to the propagation of impairments through it.

Rule 1 – As picture/sound signals proceed along the chain, picture/sound quality may decrease but it will never increase. In other words, all picture/sound quality lost along the chain is lost forever.

Rule 2 – Any transformation of picture/sound representations from their analogue to their digital form and back introduces some degree of impairment. This is so because every time an analogue picture/sound representation is transformed into the corresponding digital representation, this involves signal sampling and the accompanied filtering.

Rule 3 – Any transformation of picture/sound representations from one native format to a different one introduces some degree of impairment. This is so because every time the native format is changed this involves some kind of sample interpolation with the accompanied filtering.

Rule 4 – Any transformation of picture/sound representation from one source coding method to another one at a lower bit rate introduces some degree of impairment. This is so because every time the source coding bit rate is decreased this involves discarding some additional high-order source-coding components that contributed to picture/sound quality.

These fundamental rules allow setting general guidelines that help avoid unnecessary picture/sound impairments as programme essence signals progress along the chain. Those guidelines are given below for the various blocks of the reference chain. For better clarity the blocks are listed in reverse order, i.e. from the presentation block to the acquisition block.

3 Analysis of the digital reference chain

3.1 The presentation block

The picture and sound quality required for programme presentation of LSDI applications is dictated by the presentation objectives applicable for those applications.

That quality is denoted as “delivery quality” in the picture/sound quality diagram of Fig. 1.

The picture/sound quality at the input of the presentation block will thus need to be adequate to provide that performance but not necessarily higher than that.

The presentation block will degrade the received signal by some small amount.

3.2 The distribution block

It is assumed that the delivery section in the digital reference chain does not need any picture/sound quality headroom to compensate for losses due to post-production downstream from the finished master since all post-production should have been completed at the finished master.

This being the case, and if the distribution channel uses subjectively transparent source coding and adequate protection against channel errors, as it should, then the delivery block will introduce no quality losses and the picture/sound quality required at the input of the distribution block in the chain will not need to be any higher than the one at its output, namely at the input of the presentation block. This means that the picture/sound quality along the whole of the delivery section needs to be no higher than the delivery quality (see Fig. 1).

This is only true if there are no picture/sound quality losses due to complex signal transcoding at the interface between the distribution block and the presentation block. This condition is met when the distribution and the presentation blocks use the same native signal format (e.g. digital sampling and quantising structure) and the same source-coding method, or when they use two different native signal formats and/or two different source-coding methods, which are both related to each other in a direct and simple way, so that they can be transparently transcoded from one to the other.

3.3 The finished master

The production section in the reference chain culminates with the finished master which materialises the creative intent of the programme producer. The finished master is thus the hinge between the production section and the distribution section. No further postproduction should normally be required downstream from the finished master. Nevertheless, it is good practice to leave some picture/sound quality headroom in the finished master, to allow performing some further simple post-production interventions, should they occasionally be needed.

In that way, the finished master will, even in that case, be able to supply the delivery section with the picture/sound quality that it requires, which is the one that should be delivered to the audience during programme presentation. The quality headroom still present on the finished master will be discarded at the interface between it and the delivery section (see Fig. 1). This generally is done by reducing the programme bit rate present on the finished master, to the lower one needed for programme delivery, e.g. by decompressing the essence signals which are present on the finished master in lossless or quasi-lossless compressed form as appropriate, and recompressing them in the lossy compressed form appropriate to programme delivery which uses a lower bit rate, but still provides a subjectively quasi-lossless performance to the human visual system at the target viewing distance.

This operation is most transparently performed when the finished master and the delivery section both use the same native signal format and the same source-coding method, or two different native signal formats and/or two different source-coding methods which are both related to each other in a direct way.

3.4 Finished masters for multiple applications

It should be noted that, if the finished master has been produced to be used for multiple LSDI applications that have different picture/sound quality requirements, it must be able to supply the delivery section with a picture/sound quality that meets the requirements of the most quality-demanding application that the finished master needs to serve. Lower-quality applications will be served with signals that have been down-converted to the appropriate native signal formats. Depending on operational convenience, it may be desirable to produce down-converted sub-masters of the finished master.

3.5 The post-production block

The post-production block is where the audio and video signals generated in the acquisition block are processed to produce a finished master of the programme that suits the creative intent of the producer. The required post-production processes may be:

– simple ones, such as cut or cross-fades, wipes or captioning or simple audio mixing; or

– complex ones such as major colour grading or mattes on video or major filtering and mixing on audio.

Depending on its nature, complex video/audio post-processing may perceptibly reduce the audio/video quality of the programme. If it is likely to do that, then it is necessary to provide the required video/audio quality headroom at the input of the post-processing block. The amount of quality headroom provided must be sufficient to ensure that the audio/video quality on the finished master at the end of the post-processing block is the one required at the output of the production section.

The parameters on which quality headroom may need to be provided depend on the specific post-processing operation. Some video examples are given below.

– When high-quality chroma-key is planned, a native format with full-resolution primary RGB signals may provide the needed colour resolution headroom.

– When massive colour or level correction is planned, a native format with a finer quantisation granularity than the one required on the finished master may provide the needed level-discrimination headroom.

– When massive picture reframing is planned, a native format with a finer sampling lattice than the one required on the finished master may provide the needed spatial headroom.

– When a large amount of slow motion is planned, a native format with a picture frequency higher than the one required on the finished master may provide the needed temporal headroom.

3.6 The acquisition block

The acquisition block should normally use the same audio and video native format that is planned to be used for the finished master. However, when quality headroom is required to compensate for expected quality losses due to planned post-processing operations, the required amount of headroom on the required parameters should be provided in the acquisition block. There is no way to introduce the post-processing headroom that may be required for postproduction, if it is not already present at the output of acquisition.

When the need emerges to provide post-processing headroom at the output of the acquisition block, this can be done by using different native signal formats that have a finer quantising or a finer sampling (temporal or spatial) than the one intended for the finished master.

In order to be able to fully benefit from the use of such finer sampling or quantizing, however, the finer formats should be related in a direct way to the format intended for the finished master, so that, when post-processing is completed, the post-processed programme segments can be resampled or requantized to conform to the finished master format without introducing further undue impairments.

4 Guidelines on transformations of programme essence signals

The analysis above points to the fundamental rules below, to be observed in the design of the programme chain.

4.1 Transformations from analogue to digital representation along the chain

When the chain is fully digital, the only analogue representations along the chain should be in the acquisition block, where the light and sound stimuli will necessarily be in analogue form when they reach the relevant sensors, and in the presentation block where the picture and audio digital signal will generate analogue stimuli during programme presentation to the audience.

These considerations suggest a preference for the use of a fully digital signal chain for programme essence from acquisition to presentation.

In no place along the chain, except at its very beginning and at its very end, should image and sound need to be represented in analogue form, except of course at picture and sound monitors used to monitor the programme along the chain. Steps should be taken so that any transformation from a digital to an analogue representation along the programme signal path would be unnecessary.

4.2 Changes of the native signal format along the chain

The analysis of the reference chain has shown that measures can be taken so that there would be no reason to change the native digital format of video and audio signals along the delivery section of the reference chain.

By contrast, changes in the native signal format can occasionally be expected in the production section of the reference chain, in those cases when massive essence post-processing is required. In this case, proper measures in production planning and organisation can be taken to limit the number of those changes, and the technical measures delineated above can help to minimize the related signal impairments.

4.3 Changes of source coding along the chain

Source coding is extensively used in digital television to reduce the bit rate required to carry programme essence without introducing objectionable picture/sound impairments. For a given source-coding family, the lower the bit rate, the lower the residual picture/sound quality headroom that can be spent to compensate for impairments introduced along the chain.

Figure 1 includes a cognitive representation of the evolution of the picture/sound quality level along the chain. Each level in that evolution corresponds to a specific picture/sound quality headroom, which in its turn corresponds to a specific maximum bit rate, needed to carry programme essence.

Figure 1 shows that the quality headroom in the delivery section of the chain is quite modest and it practically does not change along the chain. It is intended to be sufficient to compensate for the small impairments occasionally introduced by the delivery channel, and it uses the minimum bit rate required to achieve that objective, since transmission bit rate is an expensive commodity.

The quality headroom of the finished master is somewhat higher than the one needed in the delivery section of the chain, since it is necessary to have some quality headroom in the finished master, in order to cater for those cases when creative reasons make it necessary to reprocess the finished programme essence to some extent.

Figure 1 also shows that the degree of picture/sound quality headroom that must be provided in the acquisition block of the chain depends on the amount of postproduction planned for each programme sequence. The quality headroom needed in acquisition may change from sequence to sequence, and it must be sufficient to cater for the picture/sound impairments introduced by the specific postproduction processes required by each specific programme sequence.

In any case, in order to minimise picture/sound impairments due to changes in source coding along the chain, it is desirable that the various source-coding systems used along it should all belong in the same compression family (e.g. the MPEG-2 family), although they may need to use different bit rates.

5 Conclusions

The principal objective of ITU activity on LSDI is to guarantee that LSDI programmes may be delivered, displayed and exchanged with optimal and predictable quality.

To achieve this objective, a single native signal format and a single source-coding method for the picture and sound signals on the finished master for each LSDI application should be specified. It is also desirable to specify a single multiplexing, channel coding and modulation system for each mode of delivery (terrestrial, satellite, television cable, optical fibre, etc.) of each LSDI application.

Concerning LSDI programme production, guidelines on preferred methods, systems and formats should be provided in order for LSDI programmes to be produced with maximum picture/sound quality and minimum complication. However, it will in the end be up to each programme maker to decide case by case which production methods he needs to use for each individual sequence of his LSDI programmes.

Since programme essence bit rate is a valuable commodity, the technical objective in LSDI programme production and distribution should be to provide the picture/sound quality required for programme presentation to the audience, using the minimum possible quality headroom in programme production, that is needed to attain the desired creative impact.

The key to attain this goal is a thorough understanding of methods and constraints in the acquisition, postproduction, distribution and presentation of LSDI programmes, and a careful, detailed advance planning of every phase of programme production, to optimize the choice and scheduling of technical solutions to be used in the production of each individual programme sequence.