

EBU – TECH 3312



Digital Terrestrial HDTV Broadcasting in Europe

The data rate capacity needed (and available) for HDTV

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Digital Terrestrial HDTV Broadcasting in Europe

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1. Introduction

The digital capacity needed to deliver HDTV depends on a number of factors. They include the following:

- The type of compression used (such as MPEG-2, MPEG-4-AVC, or the proposed SMPTE standard VC1).
- The degree to which picture impairments are acceptable.
- Whether the compression has to be done as the programme unfolds -'on the fly'- or not. There may or may not be time for several passes through the encoder for quality optimisation scene-by-scene. At least some broadcast material will always demand 'real-time' encoding because the material is live.
- Whether the HDTV signal is part of a 'statistical multiplex'.

All broadcasters that have to date announced plans to broadcast HDTV will use MPEG-4 AVC compression. Several European HDTV services now use MPEG-2, but MPEG-4-AVC is likely to be used for all new HDTV services starting in the next five years.

The performance of MPEG-4-AVC codecs, initially developed in software, indicates that relatively uncritical content can be delivered with adequately low compression artefacts at about 8-10 Mbit/s. Critical content appears to require up to 16 Mbit/s. The relative spread of bit rates needed for MPEG-4-AVC codecs to cope with different types of content appears to be larger¹ than for MPEG-2.

MPEG-4-AVC hardware codecs that fully utilise all the AVC compression tools are not yet (January 2006) available. Early versions of MPEG-4-AVC hardware codecs have not met the performance of the software codecs, and are closer to mature MPEG-2 codecs in performance. Encoders may be expected to improve over the next two years, based on similar experience with the maturity of MPEG-2 codecs in their early years.

MPEG-4 AVC transmission (as with other advanced coding systems) will particularly benefit from statistical multiplexing. In a large statistical multiplex, with mature encoders, future services may be able to operate with an average bit rate of about 8-10 Mbit/s. In a standalone service, up to 16 Mbit/s will be needed, depending on the development of encoders in the future. In a small

¹ As a generality, this bit rate spread appears to increase in relative width, as compression systems grow in complexity and improve in average performance.

statistical multiplex, the bit rate needed will lie between the two. Capacity for 5.1 audio (about 0.5 Mbit/s with the DD system) and appropriate capacity for interactive multimedia (MHP, OpenTV, MHEG) need to be added to the video bit rate when calculating the bit rate needed for an HDTV service.

2. The context of non-terrestrial options for HDTV broadcasting

High definition services will be introduced by digital satellite in Europe in the next 12 months. Satellites have ample data capacities for HDTV channels. Introducing HDTV in the terrestrial bands is less straightforward mainly because terrestrial spectrum is a more scarce resource.

The digital satellite transponder is essentially a container that can carry digital signals of any form, and there is considerable airwave capacity available in DTH bands. Circumstances favour satellite broadcasting even more: new technology, DVB-S2, applied to digital satellite broadcasting systems means that the capacity of each satellite transponder can be increased by about 30% without needing an increase in transponder power or in receiving dish size. The DVB-S2 digital multiplex will be typically about 52 Mbit/s. If this is used as a single statistical multiplex of HDTV services with diverse types of content, with mature encoders, the multiplex should be able to carry up to 4-5 HDTV MPEG-4-AVC services with acceptable levels of impairment.

Broadband networks offer a container that is not particularly large relative to digital satellite, terrestrial, and cable capacities. However, the television service the viewer sees is switched at a distant point, so, provided each individual channel does not need more than the broadband channel can carry into the home the range of (HDTV) channels offered can be very large. However, most European Broadband networks today do not have the capacity to deliver a single channel of HDTV with low levels of impairment.

It may be possible to deliver HDTV on the Internet by downloading, and eventually by a peer-to-peer networking, but work remains to be done to establish the practicality of doing so.

3. The terrestrial option for HDTV broadcasting

Frequency planning for the digital television environment is based on using the same channel widths as are used for analogue television broadcasting. Changing the bandwidth would have made the future complete transition from analogue to digital services complex and difficult, or even impossible. This means that any digital terrestrial television (DTT) service, including HDTV terrestrial services, will have to be based on conventional radio frequency channels, and the consequent size of digital multiplexes.

Most countries that have already begun DTT broadcasting using DVB-T have done so using channels available, but not usable, for analogue broadcasting. This is not the case in Germany where current analogue broadcast channels are switched off, area by area, before and after digital television is introduced.

The DVB-T digital terrestrial television system (DTT) is essentially a 'container' with a capacity of between 12 Mbit/s and 24 Mbit/s, depending on the error protection level and modulation scheme used, for a 7/8 MHz (Band III) or 8 MHz (Bands IV and V) channel.

In principle, the container can be used to deliver any picture quality, including HDTV, which can fit into the available channel capacity and is receivable with adequate bit error rate.

Reducing the 'net' bit rate in the DTT multiplex to 12 Mbit/s and including extensive error correction allows, or makes easier, reception on televisions with indoor aerials. But the extent to which an indoor or outdoor aerial is required for reception depends not only on the level of error correction and modulation system but also on the way the transmitter network is configured.

In some network configurations, using 24 Mbit/s for the 'net' bit rate means that, in the outer parts of the coverage area, good reception would largely only be possible with rooftop aerials, whereas less elaborate aerials would be adequate closer to the transmitter. However, in other network configurations, such as those used in Germany the aerial requirements are more uniform across the coverage area.

European nations, Africa and the Middle East, are currently preparing a new spectrum usage plan for digital broadcasting in Bands III, IV and V (the 'RRC-06' conference). Though the allocation arrangements are complex, and not yet final, this is likely to result in about 6-8 multiplexes depending on transmission and reception conditions being available for digital terrestrial broadcasting in each European country. These could be used to provide, after analogue switch off, for example, services with near universal digital television coverage - equivalent to today's analogue television - for all multiplexes, but the precise arrangements will be decided by individual national administrations.

After analogue switch-off, for those who have already started DTT, more spectrum capacity may be available in some countries for additional multiplexes or other services. This will partly depend on decisions that have not yet been taken by individual national administrations about the extent and quality of the desired coverage. The analogue switch-off date will vary from country to country, as will the way that any additional spectrum capacity is used.

Transition will vary from country to country, but two limits have to be taken into account. The EU proposes that a deadline of the beginning of 2012 be set for completing analogue switch-off in all EU Member States. Furthermore, RRC-06 will agree on date after which analogue TV will no longer be protected. The European proposal for that date is 2015. However countries outside Europe indicate 2025.

Plans have been announced (October 2005) for HDTV terrestrial technical trials in the UK (BBC) and in France (TF1) in 2006, and for digital terrestrial broadcasting in Norway (NRK) in 2007 with the potential for an HDTV component.

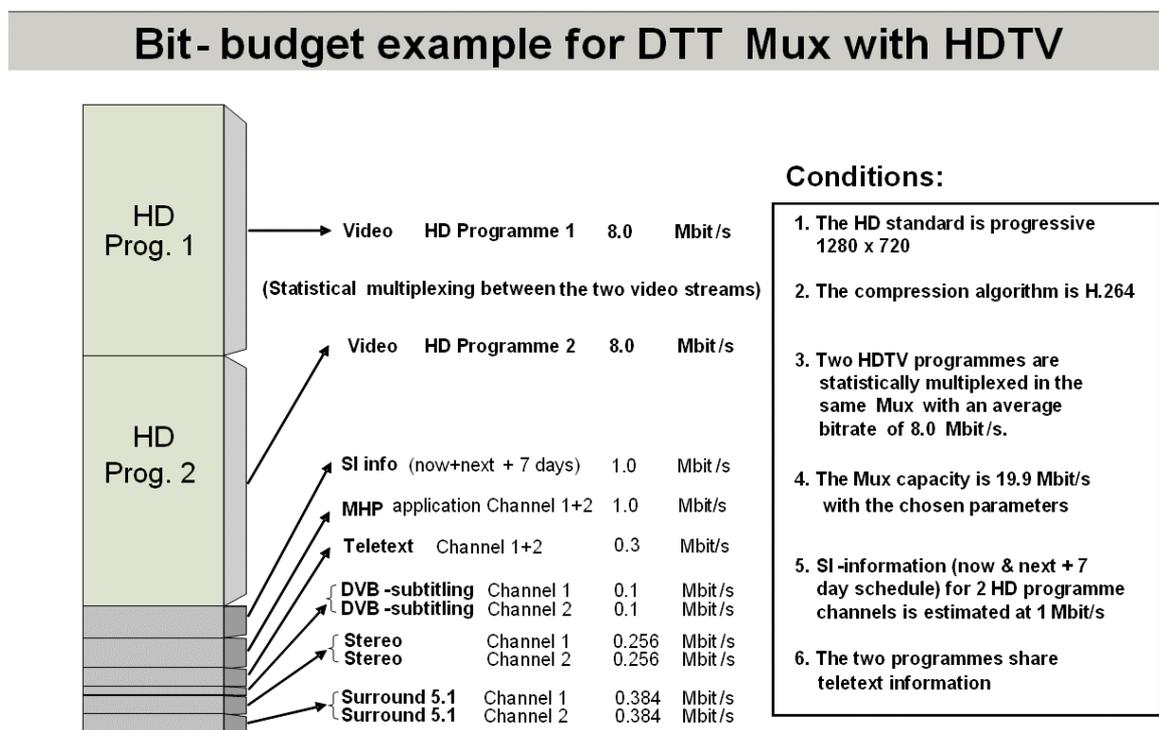


Fig. 1: Example of a multiplex bit budget, based on assumed performance of mature MPEG-4-AVC encoders.

An example of a multiplex bit budget, for a time when mature performance MPEG-4 AVC codecs are available, is given in Fig. 1. This is an example and not a proposal; however, it gives the general idea of a possible, future terrestrial HDTV multiplex structure. The broadcast HDTV format is taken to be 720p/50 to take advantage of the coding gain of progressive scanning, and the example assumes adequate performance will be obtained at average bit rates of 8 Mbit/s in the coming years.

4. Conclusions on the use of DTT for HDTV

Delivering two HDTV channels in a digital terrestrial broadcast multiplex may eventually be viable using the full capacity of a 24 Mbit/s statistical multiplex, but the performance of hardware AVC encoders needs to improve before this is possible. Furthermore, this would depend on a specific transmitter network arrangement being used; and, in such a case, good reception in the outer regions of the coverage area would need a well-installed rooftop aerial. If these conditions are not met only one HDTV programme channel per DTT multiplex could be used.

Another option could be to include one HDTV channel and one or more SDTV channels in the multiplex. In principle these could operate together as a combined statistical multiplex.

Whatever bit rate is used for the high definition signal, there will always be less risk of compression artefacts if 720p/50 is used rather than 1080i/50, and thus there will be advantages in using 720p/50 for terrestrial HDTV broadcasting.

The choice of bit rate for broadcasting HDTV needs to take into account a number of factors, and there will be a trade-off of advantages and disadvantages. One of the dimensions of this trade off is as follows. Any HDTV DTT broadcast will need to stand picture quality comparison (in the home) with downloaded and packaged HDTV media, which will have the capability to use relatively high bit rates. Matching these may mean using only one HDTV programme channel per DTT multiplex. On the other hand, the economic savings associated with having two HDTV programmes per multiplex, and the benefit of more viewer-choice of programmes, have to be weighed against the quality benefit. The EBU hopes to evaluate HDTV encoder performance to provide more information to help make such decisions well informed.

If an HDTV DTT service is not likely to start for more than five years, it is possible that a compression system which is more efficient than MPEG-4 AVC or VC1 will by then be available, though this system too will be subject to a maturity stage. This is not certain, but as a general rule it seems best to make the choice of compression technology only just before the major launch of the service.

For broadcasters that do have terrestrial capacity, HDTV broadcasting may be an attractive option because it will make the service more future-proof against an environment when there are many other HDTV sources against which the viewer will compare. A major factor shaping audience perception will be the 'context' of other sources of television pictures.

Creating a small number of 'high value' channels in HDTV may be more attractive for smaller countries than creating a larger number of standard definition channels. It could help ensure that viewers are retained for local channels, in the face of non-local channels available in HDTV.

5. Further Reading

- ETSI TS 101 154: "Digital Video Broadcasting (DVB); Implementation guidelines for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream; MPEG-2 Implementation guidelines"
- EBU Technical Recommendation R112 - 2004 "EBU Statement on HDTV Standards"

6. Appendix: Suggested functional requirements for PVRs/PDRs

Broadcasts will support strategies that might be implemented in PVRs by providing a description of the set of components that belong to an event through the following means:

- As default, the programme map table lists all components relevant for recording at the time of recording.
- The EIT (schedule as well as now/next) may contain a valid list of all components that belong to the service at the time of recording. This information will be available at the time of programming the PVR.
- Advanced description schemes such as TV-Anytime may provide additional information on service components

The PVR shall make use of information in the order as listed, if the related functionality is implemented in the specific device.

TV-Anytime supports the following functionality. Basic features that should be supported are:

- On-the-fly (i.e. 'record now') recording for time-shift viewing (private copy)
- Timed channel recording (analogue VCR-like programming)
- Ability to select the appropriate language audio, alternative audio tracks or audio description
- Ability to record essential related streams - subtitles, accessibility streams such as signing for the deaf, associated interactive applications
- Trick modes such as pause, fast-forward, etc.
- Storage and content management mechanisms
- Ability to support parental guidance systems

Furthermore, broadcasters will transmit programme schedules in the form of SI tables and/or TV-Anytime (ETSI TS 102 822 series). HDTV receiver should be compliant with the reception of signals as defined in ETSI TS 102 323 for the transport and delivery of DVB SI and TV-Anytime Phase 1 data. Work is already underway with the validation of test streams for TV-Anytime PVRs (standard definition). The extension of this work to encompass HDTV streams should occur in 2006.

In this context, the following additional features should be supported:

- EPG with current event, next event and minimum of 7 days forward-looking schedule
- EPG updating (including partial) mechanisms
- EPG-based programming and recording for time shift-viewing
- Ability to schedule recordings via trailers
- Group recording / recording of related programmes (e.g. all episodes of a series)
- Storage and content management mechanisms using in-band or off-band metadata, including user profiles for e.g. personalized recording.

Advanced TV-Anytime features should allow in the longer term to deliver advanced services such as the delivery of content packages (Audio, video, data, applications, web-pages etc.), target advertising and other segment- based services. HDTV recorders should follow this evolution.