MPEG-2 4:2:2 – interoperability tests via satellite

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This article describes the interoperability tests, via satellite, which the EBU recently carried out on commercially-available MPEG-2 Professional 4:2:2 Profile@Main Level encoders and decoders.

The Eurovision Network became fully digital in September 1998, using MPEG-2 Professional 4:2:2 Profile@Main Level codecs. Two bit-rates were chosen – nominally 24 Mbit/s and 12 Mbit/s. The high bit-rate (HBR) is preferable for sports events, whilst the low bit-rate (LBR) is adequate for news events.

These bit-rates are much higher than the MPEG-2 MP@ML bit-rates used for secondary distribution, because the Eurovision Network is basically a contribution network. However, the possibility of providing an economical Eurovision Network service at about 6 Mbit/s is presently being investigated.

The adoption of MPEG-2 Professional Profile for satellite contribution purposes – and utilizing the first generation of equipment available from just one manufacturer – was a pioneering decision by the EBU in 1998. Today, about a dozen manufacturers offer MPEG-2 Professional Profile equipment, so clearly there was a need to check the interoperability of this equipment.

Earlier this year, back-to-back laboratory tests on these codecs were organized by Intelsat in conjunction with the ISOG group, and then a series of tests via satellite was organized by the EBU in May 2000. This report gives details of the test procedure and results of these EBU satellite tests.

The objective of the tests was to check the interoperability of MPEG-2 Professional 4:2:2 Profile@Main Level encoders and decoders – from various manufacturers – in an operational environment, using a Eurovision HBR satellite channel.

Encoders and decoders were provided by:

⇨ Thomson, Tandberg, Barco, Alacatel, Wegener, Tadiran Scopus, Tiernan and Sony.

Encoders only were provided by:

⇨ Scientific Atalanta and Philips.

An IRD only was provided by:

⇨ Newtec.

The Newtec IRD was installed at VRT-BRUX but, unfortunately, VRT was unable to continuously monitor the IRD due to a high workload,. Thus, the Newtech IRD results are not included in this report.

The modulators were normally part of the earthstation Tx (transmit) chain and the demodulators were part of the Rx (receive) chain, although complete encoder-modulator combinations and/or IRDs were used for transmission and/or reception in some cases.

The Satellite link

For these tests – which took place between 22 and 26 May 2000 – channel **R0** of the EBU-leased transponder B4, on Eutelsat W3 at 7° East, was reserved daily from 0700 to 1000 UTC.

The **R0** channel transmission parameters were as follows:

Bit-rate (Ru 204)	24.23 Mbit/s
Bit-rate (Ru 188)	22.3296 Mbit/s
FEC	7/8
Modulation	QPSK
Symbol rate	13.8457 Msymb/s
Allocated bandwidth	18 MHz
Up-link frequency	14 402 MHz – polarity X
Down-link frequency	11 102 MHz – polarity Y
EIRP	68 dBW at 0 dB/°K contour

Encoder settings

The specified video bit-rate was 20 Mbit/s. Two dual-mono audio pairs (MPEG-2 layer II at 384 kbit/s) were also specified.

Furthermore, EBU network PIDs were requested. However, since MPEG-2 decoders have automatic retrieval of PSI, non-observance of this request did not cause any problems.

No scrambling was utilized.

Normal delay coding was tried first, but if several decoders had problems with this signal, low-delay coding was selected.

Source material

A master D5 tape was prepared by the EBU in Geneva, from which Betacam copies were made, converting directly from 270 Mbit/s to analogue component signals at the input to the Betacam VTRs.

The sequences were as follows:

Timing (minutes)	Video content	Audio content
0 - 10	Opening caption	Ident on ch. 1/2/3/4
10 - 35	EBU/ITU test sequences	400 Hz tone [a] on ch. 1 during sequences
35 - 55	BBC 24 hour news	Programme audio on ch. 1/2
55 - 60	EBU colour bars	1 kHz tone [b] on ch. 1/2/3/4 (intermittent on ch. 1/3)

a. Tone level 21 dB below DFS (Digital Full Scale).

b. Tone level 18 dB below DFS.

Sources were requested to send an identified caption, giving the source and encoder type (plus delay mode when appropriate), prior to the start of transmission.

Transmission schedule

The original planned transmission schedule had to be modified to some extent due to a problem of some artefacts on the original Betacam tapes, which were noticed only a few days before the start of the tests. These artefacts occurred principally on the "Kiel harbour" and the "Table tennis" sequences.

New Betacam copies, without artefacts, were made and distributed only two or three days before the start of the tests, so the final transmission schedule had to be adapted according to the availability of the new test tapes at the various sources.

BBC-LNDN and VRT-BRUX were obliged to use the first tape copy (flawed), due to non-availability of the second copy. The receive points were requested to disregard the resulting artefacts.

The actual transmission schedule was as follows:

Date	Timing-UTC	Source	Encoder	Remarks
22 May	**0750-0850**	EBU-GNVE	Tandberg (E 5410)	
	0850-0955	EBU-GNVE	Tandberg (E 5610)	
23 May	**0815-0915**	DR-KOBN	Barco (Saturn-MkII)	Normal delay
	0920-1000	DR-KOBN	Barco (Saturn-MkII)	Low delay
24 May	**0715-0808**	SRG-ZRCH	Alcatel (1761VC)	Spectrum inverted
	0810-0820	BBC-LNDN	Wegener (Envoy)	Spectrum inverted
	0820-0845	BBC-LNDN	Wegener (Envoy)	Spectrum correct
	0910-1010	BBC-LNDN	Scientific Atlanta (D 9150)	
25 May	**0700-0800**	Satlink-JRSM	Tadiran Scopus (E 1100)	
	0820-0917	BBC-LNDN	Tiernan (TE 600)	
	0927-0940	BBC-LNDN	Sony (BDX-E1000)	
	0945-1045	BBC-LNDN	Sony (BDX-E1000)	
26 May	**0700-0800**	TVR-BUCO	Tandberg (System 3000)	
	0820-0917	France Telecom	Thomson (DBE 4110)	Low delay
	0927-0940	France Telecom	Thomson (DBE 4110)	Normal delay
	0945-1045	VRT-BRUX	Philips (DVS 3165)	

Results

The outputs of the decoders/IRDs were monitored by EBU members in most cases, except for Tadiran Scopus and Thomson who, for logistical reasons, monitored their own received quality.

The Tiernan and Tandberg received quality was monitored by these two manufacturers at their UK premises, in addition to being monitoring by the EBU member concerned (BBC-LNDN).

In addition, several EBU members (NRK-OSLO, BT-SOFO, TDA-ALGR, ERT-CAIR) monitored the tests with their EBU-network Tandberg (NDS) 3000 decoders and/or Tandberg Alteia decoders.

A simplified summary of the results is given in matrix form in *Appendix A*.

Conclusions

⇨ In several cases it was necessary to select the encoder to "low delay" mode in order to obtain stable video from certain decoders, especially the earlier models. However, in some cases the "low delay" mode then produced noticeably lower resolution on critical sequences. This problem may be due to buffer size mismatch between encoders and decoders, which requires further investigation.

⇨ In two cases, the source sent an inverted spectrum. In the first case, (where the Wegner Envoy encoder was transmitting via a Wegener modulator from BBC-LNDN), this problem was subsequently corrected, but in the other case, (where the Alcatel 1761VC encoder was transmitting via a Radyne DVB 3030 modulator from SRG-ZRCH), it was not corrected.

In the latter case, three of the receive points did not demodulate the inverted spectrum signal, indicated as "not measured" in the *Appendix A* matrix.

⇨ Some problems arose because the "test procedure" specified 22.33 Mbit/s for the Ru 188 bit-rate.

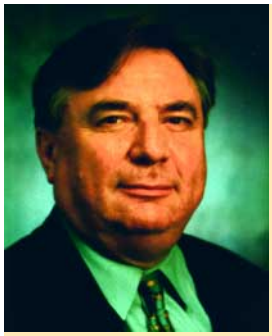
In fact, the EBU-HBR figures are based on the choice of 24.23 Mbit/s for the Ru 204 bit-rate, since this is the parameter to be set on the EBU's Tandberg 3000 encoders.

This gives an Ru 188 bit-rate of 22.3296 Mbit/s and a symbol rate of 13.8457 Msymb/s.

Most encoders require the Ru 188 bit-rate to be selected, not the Ru 204 bit-rate.

If the Ru 188 bit-rate is set to 22.33 Mbit/s, this gives a symbol rate of 13.846 Msymb/s.

The resulting symbol rate error of 300 symb/s may have caused some demodulators to refuse to lock to the received signal. Since the consequent absence of received video and audio is not really an encoder-decoder interoperability problem, these results are shown as "not measured" in the *Appendix A* matrix.



Brian Flowers studied Engineering at the University of Southampton, UK. In 1960, after serving two years in the Royal Air Force (RAF), he joined BBC Television News. Then, in 1962, he was detached to the Eurovision Control Centre (EVC) in Brussels.

Mr Flowers worked at all levels of responsibility in the EVC – technician, supervisor, engineer-in-charge, and as the project leader for the new EVC in Geneva.

Prior to his retirement in 1997, Brian Flowers was a Senior Engineer in the Transmission Technology division of the EBU Technical Department, Geneva.

Abbreviations

DFS	Digital full scale	**PID**	(MPEG) Packet Identification Number
DVB	Digital Video Broadcasting	**PSI**	(DVB) Programme Service Information
HBR	High bit-rate	**QPSK**	Quadrature (quaternary) phase-shift keying
IRD	Integrated receiver/decoder	**UTC**	Universal Time Co-ordinated
LBR	Low bit-rate		
MPEG	Moving Picture Experts Group		

⇨ Audio levels varied considerably, mainly due to analogue audio level problems between the Betacam player and the encoder at each source. Since these level problems occurred upstream of the encoders, they have not been taken into account in the *Appendix A* matrix.

One or two sources were not able to encode the ch. 3/4 signals.

⇨ Video and audio PIDs did not conform to the EBU-network values in many cases but this did not cause any problems.

⇨ The simplified results matrix (see *Appendix A*) permits the following analysis of the performance of 180 encoder-decoder combinations:

- No significant video or audio problems: 74 %
- Minor video and/or audio problems: 11 %
- Unusable video and/or audio: 7 %
- Not measured: 8 %

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Appendix A: Interoperability of the tested encoders and decoders.

	Decoder											
Encoder	**Alcatel 1761V**	**Barco Stellar**	**NDS 3000**	**Sony BDX**	**Tadiran Scopus**	**Tandberg Alteia**	**Tandberg PSR942**	**Tandberg PSR942B**	**Thomson 4432**	**Tiernan TDR6**	**Tiernan TDR60**	**Wegener 4422**
Alcatel 1761VC	OK	OK	NM (3)	OK	OK	NM (3)	NM (5)	NM (5)	OK	NM (3)	OK	OK
Barco Saturn Mk II (low delay)	OK	OK	OK	OK	VP	OK	OK	OK	OK	NV	OK	NM (1)
Barco Saturn Mk II (normal)	NM (2)	OK	NV	OK	OK	NV	NV	OK	OK	NV	OK	NM (1)
Philips DVS3165 (low delay)	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Philips DVS3165 (normal)	OK	OK	NV	OK	OK	VP	OK	VP	OK	OK	OK	OK
Scientific Atlanta D9150	OK	OK	VP	OK	OK	NV	NV	OK	OK	NV	OK	OK
Sony BDX-E1000	OK	OK	OK	OK	OK	OK	OK	AP	OK	OK	OK	OK
Tadiran Scopus E1100	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Tandberg (NDS) 3000	OK	VP	OK	OK	OK	VP	OK	OK	OK	OK	VP	OK
Tandberg E5410	OK	VP	OK	OK	VP	OK	OK	OK	VP	OK	VP	NM (1)
Tandberg E5610	OK	VP	OK	OK	VP	OK	OK	OK	OK	OK	OK	NM (1)
Thomson DBE4110 (low delay)	VP	OK	OK	OK	OK	OK	NV	VP	OK	OK	OK	OK
Thomson DBE4110 (normal)	VP	OK	OK	OK	OK	NV	NV	VP	OK	OK	OK	OK
Tiernan TE600	OK	OK	OK	OK	OK	VP AP	OK	AP	OK	OK	OK	OK
Wegener Envoy	NM (4)	OK	NM (4)	NM (4)	OK	NM (4)	NV	OK	OK	OK	OK	OK

OK= video and audio OK
VP = minor video problem
AP = minor audio problem
NV = No video
NA = No audio

NM(1) = not measured due to late arrival of equipment
NM(2) = not measured because personnel were preoccupied
NM(3) = not measured due to inverted spectrum
NM(4) = not measured due to symbol rate high (+300 symb/s)
NM(5) = not measured due to dish misalignment