EBU interoperability tests
– DSNG equipment based on MPEG-2

L. Cheveau
Head of Transmission Technologies, EBU

In October 1997, the EBU carried out tests to verify the interoperability of MPEG-2 MP@ML satellite news-gathering equipment from various manufacturers – under operational conditions via an 8.448 Mbit/s satellite channel.

A report on these tests was published by the EBU in July 1998 and this article is based on that report.

1. Introduction

Intelsat, in collaboration with ISOG, carried out a series of tests on DSNG equipment in 1996/7 at their technical laboratories in Washington DC. A complete description of these tests has been published by Intelsat [1] and only an extract of the objectives and results is reproduced in this article.

The last round of these tests was designed to achieve "plug and play" operation with both the NTSC and PAL standards, for several different parameter sets. This was a significant extension of previous tests in the series which did not include PAL, did not address "plug and play", and were only conducted for one parameter set.

In testing "plug and play", the only adjustments allowed to be made to the equipment were those that would be available to the typical user during first-time configuration of the equipment. The aim was to document the interoperability of equipment operating within the MPEG-2 and DVB framework, but not to assess compliance with any standard.

The results for interoperation of the equipment are given in Attachment 2 to the Intelsat report [1]. Each page of this attachment consists of a matrix of connections from one encoder system to multiple decoder systems under different operating parameters, such as the symbol rate, FEC code rate and the video format. The results, in general, are very encouraging and demonstrate which coders and IRDs will "plug and play" at data-rates which might be appropriate for various applications.

The measurements performed through the Intelsat VII simulator showed no degradation of performance for the parameter sets chosen (e.g. 6 Msymbol/s, FEC rate ¾ , PAL). The cases where interoperation was not achieved were due to limitations of the available hardware or software in supporting a particular parameter set.

When the results of these tests were reported at the ISOG meeting in Washington (June 97), there was some discussion about possible further testing. The general feeling was that the Intelsat series of tests had indeed been conclusive and that another round of similar tests

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would bring no further evidence, but would just impose an additional burden on the participating manufacturers and Intelsat.

However, ISOG did identify two possible ways of extending these tests:

- ⇨ by using new technical standards such as MPEG-2 4:2:2P@ML and / or using 8-PSK modulation techniques.
- ⇨ by trying to repeat the tests (made in the laboratory in the presence of manufacturers' engineers) in a real environment with a satellite link, SNG stations and many receiving points.

In response to this "suggestion", the EBU volunteered to make its *Eurovision* network available in order to repeat the Intelsat tests under operational conditions, using a real satellite with links to and from various earthstations and SNG stations.

2. The EBU tests

During the summer of 1997, an invitation to participate in these EBU tests was sent to all EBU members and all the manufacturers who had been involved in the Intelsat tests. It was clearly stated that these new tests were open to anyone willing to participate and they would also be conducted on a voluntary basis.

The tests were carried out over several days in October 1997, using an 8.448 Mbit / s satellite channel. Each day, one SNG earthstation transmitted MPEG-2 MP@ML signals using an encoder / modulator combination from a different manufacturer, as shown in *Table 1*.

Table 1
EBU test programme over several days.

Date	Time: AM/PM	Tx Source	Tx earthstation	Tx equipment	Eutelsat Approval No.
6 Oct	PM	EBU/ GNVE	PTT-CH 1.8m	NDS-DSNG	SUI-001
7 Oct	AM/PM	ZDF/ MANZ	SweDish 0.9m	NDS-DSNG	D-100
8 Oct	AM/PM	ARD/ FFTM	Euroradio 4.2m	Thomson	D-009
9 Oct	AM/PM	BRT/ BRUX	Euroradio 3.7m	Tiernan T-E 3	BEL-BRU-012
10 Oct	AM	BBC/ LNDN	BBC 9m	Wegener DVT 2000	UKI-TVC-002
10 Oct	PM	BBC/ LNDN	BBC 9m	Nextlevel Systems SE-3200	UKI-TVC-002
13 Oct	AM	NBC/ LNDN	Advent Mantis 1.9m	NDS-DSNG	UKI-193
13 Oct	PM	NBC/ LNDN	Advent Mantis 1.9m	Wegener DVT-2000	UKI-193
14 Oct	AM/PM	Tadiran/ ISR Scopus	PTT-ISR 2.4m	T-S E-110	ISR-1
15 Oct	AM	SVT/STOK	SweDish 0.9m	Tiernan T-E 3	SWE-11
16 Oct	AM	NTL/ LNDN	Steerable 5.6m	SA PowerVu	UK-WIN-001
17 Oct	AM/PM	YLE/HLKI	SweDish 0.9m	DMV 3000	FIN-Temp-002

2.1. Transmitting equipment

The following manufacturers made their equipment available for transmission purposes:

- Tiernan;
- NDS (ex-DMV);
- Thomson;
- Wegener;
- Nextlevel;
- Tadiran-Scopus;
- Scientific Atlanta.

In addition, IRDs from various manufacturers were utilized for reception, and MPEG-2 Transport Stream Analyzers from the following manufacturers were used to monitor the signals:

- Adherent Systems Ltd at BBC / LNDN;
- Hewlett-Packard at BRT / BRUX;
- Snell & Wilcox at EBU / GNVE (9 and 10 October only).

2.2. Receiving stations

The following locations on the *Eurovision* network were equipped with at least one IRD in order to receive the signals:

- Germany – Frankfurt (ARD / FFM);
- Belgium – Brussels (BRT / BRUX);
- Finland – Helsinki (YLE / HLKI);
- Sweden – Stockholm (SVT / STOK);
- Switzerland – Geneva (EBU / GNVE);

Abbreviations

DSNG	Digital satellite news gathering	**ISO**	International Organization for Standardization
DVB	Digital Video Broadcasting	**ISOG**	Inter-Union Satellite Operations Group
IEC	International Electrotechnical Commission	**MPEG**	(ISO/IEC) Moving Picture Experts Group
EIRP	Effective isotropic radiated power	**QPSK**	Quadrature (quaternary) phase-shift keying
FEC	Forward error correction	**SDI**	Serial digital interface
IBO	Input back-off	**SNG**	Satellite news gathering
IFLU	Initial full line-up		
IRD	Integrated receiver/decoder		

⇨ UK – London (BBC/LNDN).

Furthermore, the signals were also received in Israel by Tadiran-Scopus in collaboration with the national carrier (PTT/ISR) and also in Ireland by Amstrong.

All these stations sent reports to the EBU in Geneva and these are summarized in the Appendix to this article.

The signals received by the six EBU *Eurovision* stations were also re-injected in analogue format via a *Eurovision* satellite channel when available, and these analogue signals were monitored by EBU/GNVE.

2.3. Technical parameters

The transmission parameters were as follows:

Composite bit-rate	8.448 Mbit/s (including Reed-Solomon)
Modulation rate	5.632 Msymb/s
Modulation	QPSK
FEC	¾
Audio coding	MPEG Layer II, 256 kbit/s

The EUT-P channel [1] was made available between 07.00 - 09.00 and 12.00 - 14.00 GMT from 6 - 10 October and from 13 - 17 October 1997.

Up-link frequency (X polarization)	14 341 MHz
Down-link frequency (Y polarization)	11 041 MHz

The up-link EIRP was set to give 16 dB IBO at the satellite input, (i.e. 67 dBW at the 0.5 dB/°K contour). In the case of the transportable earthstations, an IFLU was carried out with Eutelsat/CSC in Paris at the start of each day's transmission as required.

2.4. Test procedures

Ten 30-minute Betacam test cassettes were prepared at EBU/GNVE and sent to the various originating sources (see *Table 1*). These cassettes consisted of the EBU moving-picture test sequences (nos. 30 to 53) plus five minutes of a "President Clinton – State of the Union" speech, for lip-sync verification purposes.

The test sequences had 1 kHz tone recorded at EBU "Test Level" (i.e. 9 dB below "peak permitted level") on the left audio track, and 500 Hz tone recorded at EBU "Test Level" on the right track.

1. The EBU-leased transponder 25 of the Eutelsat II F-4 M satellite at 7° East.

Each source sent this material at least once. They then sent additional material, usually of sporting events, from local sources.

The input signal to the encoder was PAL in most cases, but an SDI input signal with a true component source was also utilized when available. A 525-line test pattern, from an NTSC source, was transmitted on 13 October from NBC/LNDN. All IRDs automatically decoded the 525-line signal without problems.

To ensure that all the receiving points were aware of the type of video signal being fed to the encoder, the type of encoder/modulator being used and the source location information was inlaid on a test pattern at the start of each transmission.

3. Conclusions

Since the signals were received at various locations, it is inevitable that the attention given to monitoring the video and audio was more assiduous at some locations than at other locations. Therefore, the fact that some receiving sites have noted more incidents of degradation than others does not necessarily mean that the encoder-decoder combinations concerned are less compatible than other combinations.

Interoperability was demonstrated for all tested combinations of encoder/modulator and IRD respectively. Even in cases where one IRD was not correctly receiving the signal at one location, there was always another location where a similar IRD was able to receive the signal satisfactorily.

The most common problem encountered was spectrum inversion, requiring the demodulator to be selected to "Inverted Spectrum" before a signal could be received. However, some IRDs will automatically correct for spectrum inversion.

Another common problem encountered was audio left/right inversion.

Audio levels delivered by the IRDs were up to 12 dB too high and 12 dB too low in some cases.

The video sequences were correctly encoded and decoded for all combinations of encoder/decoder most of the time, although macroblocks were observed in some cases, and a few instances of picture-freezing were also observed. These symptoms suggest that some decoders may have inadequate buffer capacity, where the encoder and decoder buffers do not match.

When one particular encoder was fed from an SDI component source, there were occasions – following scene changes – when some decoders produced visible and audible decoding errors. However, the decoder from the same manufacturer as the encoder had no problem decoding these critical sequences. True component source signals have higher entropy than equivalent composite signals, mainly due to the limited chrominance bandwidth of composite signals. Scene changes represent entropy peaks, so it is not surprising that limitations of encoder-decoder interoperability are noticeable in these circumstances.

The tests demonstrated one of the key advantages of MPEG-2 systems, i.e. the ability of MPEG-2 decoders to adjust automatically to the coding parameters. For example, the actual bit-rate used for video encoding varied between 5.7 Mbit/s and 7.14 Mbit/s, but the decoders adapted to each bit-rate automatically.

On the other hand, differences in the way the composite bit-rate and / or the symbol rate are specified led in some cases to problems in correctly setting up the encoder / modulators and the IRDs.

All the encoder-decoder combinations tested by the EBU have demonstrated correct interoperability. However, as the manufacturers concerned have been making improvemants to encoder and decoder software over a period of time, to achieve this goal, users should make sure that they have up-to-date software versions in order to ensure optimum interoperability.

Bibliography

[1] Intelsat/ISOG: **Digital Video Transmission Equipment Interoperation Tests** Tests Report, March 1997.
http://www.intelsat.int/index.htm

Appendix:
Reports sent in to the EBU from the receiving stations

6 October 1997 – PM

Source: EBU/GNVE
Encoder/Modulator: NDS-DSNG
Tx earthstation: PTT/CH 1.9m (SUI-001)

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR2000 Next Level	Good Good	Good Good	OK OK	
BRT/BRUX	NDS	Good	Good	OK	Audio 2 dB high
SVT/STOK	Tiernan TDR-7	----------	----------	----------	Misunderstanding about compos-ite bit-rate
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	----------	----------	----------	----------	Equipment had not yet arrived at ARD/FFTM
EBU/GNVE	NDS-3000	Good	Good	OK	
Tadiran/ISR	Scopus IRD-250	Good	Good	OK	
Armstrong/IRL	Scopus IRD-250 STS	Good Good	Good Good	OK OK	

7 October 1997 – AM/PM

Source: ZDF/MANZ
Encoder/Modulator: NDS-DSNG
Tx earthstation: SWE-DISH 0.9 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level	Good Good	Good Good	OK OK	
BRT/BRUX	Tiernan TDR-7	Fair	Good	OK	Macroblocks observed during one critical SDI sequence.
SVT/STOK	Tiernan TDR-7	Fair	Good	OK	Some blocking observed following scene cuts. Audio 6 dB high.
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	Good	Good	OK	Equipment ready PM only.
EBU/GNVE	NDS-3000	Good	Good	OK	
Tadiran/ISR	Scopus IRD-250	Fair	Good	OK	Some errors observed during SDI sequence.
Armstrong/IRL	Scopus IRD-250 STS	Fair Fair	Good Good	OK OK	Break up on peak whites. Break up on peak whites.

8 October 1997 – AM/PM

Source: ARD/FFTM
Encoder/Modulator: Thomson DBE2110/DBM 3221 (Software version 5.0)
Tx earthstation: Euroradio 4.2 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Fair	Good	OK	Some macroblocks observed on critical sequences.
SVT/STOK	Tiernan TDR-7	Good	Good	OK	
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	Good	Good	OK	
EBU/GNVE	NDS-3000	Good	Good	OK	Left/Right audio inverted.
Tadiran/ISR	Scopus IRD-250	Fair	Good	OK	Occasional freezing observed on critical sequences.
Armstrong/IRL	Scopus IRD-250 STS	Fair Fair	Good Good	OK OK	Problem with movement. Problem with movement.

9 October 1997 – AM/PM

Source: BRT/BRUX
Encoder/Modulator: Tiernan TE 3
Tx earthstation: Euroradio 3.7 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Good	Good	OK	
SVT/STOK	Tiernan TDR-7	Good	Good	OK	Audio 8 dB high.
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	Good	Good	OK	
EBU/GNVE	NDS-3000	Fair	Good	OK	Spectrum inverted. Blocking during "Diva plus noise".
Tadiran/ISR	Scopus IRD-250	Fair	Good	OK	Blocking during"Diva plus noise".
Armstrong/IRL	Scopus IRD-250 STS	Fair Fair	Good Good	OK OK	Some errors observed. Some errors observed.

10 October 1997 – AM

Source: BBC/LNDN
Encoder/Modulator: Wegener
Tx earthstation: Multipoint Vertex

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Fair	Good	OK	Blocking at top of screen.
SVT/STOK	Tiernan TDR-7	Fair	Good	OK	Blocking at top of screen and following scene changes. Audio 9 dB high.
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	----------	---------	----------	Spectrum inverted – ARD not aware.[1]
EBU/GNVE	NDS-3000	Good	Good	OK	Spectrum inverted.
Tadiran/ISR	Scopus IRD-250	----------	----------	----------	Public Holiday in Israel.
Armstrong/IRL	Scopus IRD-250 STS	Good Good	Good Good	OK OK	

1) The EBU/GNVE NDS-DSNG IRD decoded the signal correctly

10 October 1997 – PM

Source: BBC/LNDN
Encoder/Modulator: Next Level Systems SE-3200
Tx earthstation: Multipoint Vertex

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Good	Good	OK	
SVT/STOK	Tiernan TDR-7	Good	Good	OK	
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	Good	Good	OK	Spectrum inverted.
EBU/GNVE	NDS-3000	Good	Good	OK	Spectrum inverted. Audio -6 dB and L/R inverted.
Tadiran/ISR	Scopus IRD-250	----------	----------	----------	Public Holiday in Israel.
Armstrong/IRL	Scopus IRD-250 STS	Good Good	Good Good	OK OK	

13 October 1997 – AM

Source: NBC/LNDN
Encoder/Modulator: NDS-DSNG
Tx earthstation: Advent Mantis 1.9 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Good	Good	OK	
SVT/STOK	Tiernan TDR-7	Good	Good	OK	Audio 5 dB high
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	Good	Good	OK	
EBU/GNVE	NDS-3000	Good	Good	OK	
Tadiran/ISR	Scopus IRD-250	Good	Good	OK	
Armstrong/IRL	Scopus IRD-250 STS	Good Good	Good Good	OK OK	

13 October 1997 – PM

Source: NBC/LNDN
Encoder/Modulator: Wegener DVT-2000 (Version 2.2.5 firmware)
Tx earthstation: Advent Mantis 1.9 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Good	Good	OK	
SVT/STOK	Tiernan TDR-7	Fair	Fair	OK	Blocking at top of picture and following scene changes. Audio breaks, also noted at same time.
YLE/HLKI	Tandberg TT1200	Fair	Good	OK	Colour flicker and pumping observed.
ARD/FFTM	NDS-DSNG	----------	----------	----------	Reception not working. (IRD configuration problem ?) [1]
EBU/GNVE	NDS-3000	Good	Good	OK	
Tadiran/ISR	Scopus IRD-250	Fair	Fair	OK	Two sequences caused decoder failure.
Armstrong/IRL	Scopus IRD-250 STS	Fair Fair	Good Good	OK OK	Lost picture occasionally. Lost picture occasionally.

1) The EBU/GNVE NDS-DSNG IRD decoded the signal correctly.

14 October 1997 – AM

Source: Bezeq/Israel-1
Encoder/Modulator: Tadiran Scopus E-110 (Software 2.53)/EF Data 2020
TX earthstation: PTT-IR 2.8 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Poor	Good	OK	Intermittent horizontal bar & coloured blocks across top of picture. Many frozen frames and loss of sync.
SVT/STOK	Tiernan TDR-7	Poor	Fair	OK	Blocking at top of picture and following scene changes. Audio breaks also noted at same time.
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	----------	----------	----------	Reception not working. (IRD configuration problem?)*
ZDF/MANZ	Tiernan TDR-7 Philips DVS 3824	Fair Good	Good Good	OK OK	Blocking at top of picture
EBU/GNVE	NDS-3000	Good	Good	OK	
Tadiran/ISR	Scopus IRD-250	Good	Good	OK	
Armstrong/IRL	Scopus IRD-250 STS	Good Good	Good Good	OK OK	

15 October 1997 – AM

Source: SVT/STOK
Encoder/Modulator: Tiernan TE-3
TX earthstation: SWE DISH 0.9 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	----------	----------	----------	----------	No staff available (Belgian holiday)
SVT/STOK	Tiernan TDR-7	----------	----------	----------	No monitoring whilst transmitting.
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	Good	Good	OK	
EBU/GNVE	NDS-3000	Good	Good	OK	L/R audio inverted.[1]
Tadiran/ISR	Scopus IRD-250	----------	----------	----------	Video unusable, unable to decode properly [2].
Armstrong/IRL	Scopus IRD-250 STS	Good Good	Good Good	OK OK	

1) The EBU/GNVE NDS-DSNG IRD decoded the signal correctly.
2) Maybe due to use of 1.4 m dish for reception. (The Armstrong/IRL Tadiran Scopus IRD-250 decoded the signal correctly).

DSNG

16 October 1997 – AM

Source: NTL/LNDN
Encoder/Modulator: SA Power Vu
Tx earthstation: Steerable 5.6 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Good	Good	OK	
SVT/STOK	Tiernan TDR-7	Good	Good	OK	
YLE/HLKI	Tandberg TT1200	Fair	Good	OK	Some colour lag on red areas observed.
ARD/FFTM	NDS-DSNG	Good	Good	OK	
EBU/GNVE	NDS-3000	Good	Good	OK	L/R audio inverted.
Tadiran/ISR	Scopus IRD-250	----------	---------	---------	Holiday in Israel.
Armstrong/IRL	Scopus IRD-250 STS	Good Good	Good Good	OK OK	Lost lock on one occasion. Lost lock on one occasion.

17 October 1997 – AM/PM

Source: YLE/HLKI
Encoder/Modulator: DMV 3000
Tx earthstation: SWE DISH 0.9 m

RX point	IRD	Video	Audio	Lip-Sync	Remarks
BBC/LNDN	Wegener DVR 2000 Next Level SA PowerVu	Good Good Good	Good Good Good	OK OK OK	
BRT/BRUX	Tiernan TDR-7	Good	Good	OK	
SVT/STOK	Tiernan TDR-7	Good	Good	OK	
YLE/HLKI	Tandberg TT1200	Good	Good	OK	
ARD/FFTM	NDS-DSNG	Good	Good	OK	
EBU/GNVE	NDS-3000	Good	Good	OK	One short picture freeze observed.
Tadiran/ISR	Scopus IRD-250	Fair	Good	OK	Some freezing observed.
Armstrong/IRL	Scopus IRD-250 STS	Fair Fair	Fair Fair	OK OK	Occasionally lost lock. Occasionally lost lock.