Switching to digital

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The EBU's Eurovision network went digital at the end of August, using MPEG-2 4:2:2 P@ML technology. Running in parallel with this major project, the EBU has also been evaluating a new VSAT technology which it helped to develop, to be used for the digitalization of the NCC and TCC sound conference circuits.

This article describes the extensive tests that have been carried out on these two new digital technologies.

1. Introduction

The world of television transmission is currently undergoing a major technological transformation, namely the change from composite analogue transmission to component digital transmission. The EBU's various networks are no exception and, before too long, they will all be totally digital.

There are basically four EBU networks:

- *Eurovision*, which went digital during the last week of August;
- *Euroradio*, created in 1993, which is already fully-digital, using satellite capacity within the transponders leased from Eutelsat for *Eurovision*;
- NCC, which provides news conference facilities;
- TCC, which provides technical co-ordination facilities.

These EBU networks link together the production facilities of member broadcasters in some 50 different countries spread over three continents (Europe, North Africa and Asia / the Middle East). *Eurovision* and *Euroradio* provide contribution-quality links but NCC and TCC – which currently utilize 4-wire terrestrial circuits – can only offer poor telephone-quality speech.

The key to the successful digitalization of these networks has been the use of satellite capacities. This article describes (i) the use of MPEG 4:2:2 P@ML technology in the digitalization of the *Eurovision* network and (ii) the innovative specially-developed VSAT technology which will be used to digitalize the NCC and TCC conference networks in the near future.

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2. Digitalization of the Eurovision network

The digitalization of the *Eurovision* network has been envisaged since 1990 but it is only recently that the economics of the process have become viable. This of course has been a very difficult project to manage since operations have had to continue during the change-over period. (The *Eurovision* network handles around 50 000 transmissions / year involving broadcasters within 50 different countries, each with their own regulations, languages, etc.)

2.1. MPEG-2 4:2:2 P@ML

After several years of testing various potential digital solutions, a decision was taken in 1996 to proceed with the digitalization of the *Eurovision* network using the new MPEG-2 4:2:2 Profile technology [1].

In mid-October 1996, the EBU issued an invitation to manufacturers to submit offers for the equipment required to digitalize the network. Offers were to be received by mid-November 1996. The "Request for Tender" (RFT) was written in such a way that both 34 Mbit / s equipment conforming with ITU-T Recommendation J.81 [2] and MPEG-2 4:2:2 P@ML equipment could be offered.

Previous extensive testing had already been performed on 34 Mbit / s equipment using 8PSK modulation. The results of these tests were reported in a series of articles published in **EBU Technical Review** No. 269 - Autumn 1996 [3][4][5].

However, during 1996 the MPEG-2 family of standards was enlarged to provide a so-called professional profile, referred to as MPEG-2 4:2:2 P@ML. This standard was approved by the ITU in November 1996. At that time, some chips were expected from manufacturers and the EBU decided to perform additional tests before making its final decision about the technology to be used for the *Eurovision* network.

Potential advantages of the MPEG-2 professional solution were:

- The use of a technology already adopted by the broadcasting community world-wide for the distribution of programmes.
- The flexibility of the MPEG system which allows the bit-rate (and the bandwidth) to be optimized according to the application (i.e. around 8 Mbit / s for news applications, around 25 Mbit / s for higher quality contributions by satellite, and up to 50 Mbit / s in the studio). This flexibility would allow one set of new digital equipment to replace two types of existing equipment (8 Mbit / s and analogue).
- The possibility of operating at non-hierarchical levels (i.e. between 8.448 and 34.368 Mbit / s) in order to optimize the satellite transponder capacity (four TV channels at 25 Mbit / s instead of three channels at 34 Mbit / s in one transponder).
- The substantial cost reductions, mainly at the IRD level, that could be achieved through the large volume production of MPEG-related technologies such as DVD and DVB.

Tests on the new 4:2:2 P@ML system, conducted by the Technical Department of the EBU during the first quarter of 1997, were divided into three major sectors: radio-frequency aspects, subjective quality assessments and objective measurements.

2.2. Radio-frequency aspects

The satellite tests were positive, showing that four MPEG-2 4:2:2 P@ML signals – using 20 Mbit/s for the video coding (giving 24.23 Mbit/s total bit-rate including 384 kbit/s Layer II audio and Reed-Solomon error correction) – could be accommodated in one 72 MHz transponder of the type leased by the EBU on Eutelsat II-F4. The modulation was DVB-compliant, using QPSK modulation with FEC = 7/8.

The optimum satellite input back-off (IBO) was found to be 15 dB. The clear-sky uplink margin was 7 to 8 dB and the downlink margin was 12 to 13 dB in the case of standard EBU earth-stations conforming to the EBU specification published in document Tech 3265 [6].

Abbreviations

4:2:2 P@ML (MPEG-2) 4:2:2 Profile at Main Level
8PSK Eight-phase-shift keying
ADPCM Adaptive differential pulse code modulation
BOD Bandwidth on demand
CCIR (ITU) International Radio Consultative Committee
CELP Code-excited linear prediction
CSC Common signalling channel
DAMA Demand assignment multiple access
DVB Digital Video Broadcasting
DVD Digital video (versatile) disc
E_b/N_o Ratio between energy-per-bit and noise density
IEC International Electrotechnical Commission
EIRP Effective isotropic radiated power
ESA European Space Agency
FEC Forward error correction
F_{sc} Sub-carrier frequency
G/T Gain/temperature ratio
GoP Group of pictures
IBO Input back-off
IF Intermediate frequency
IRD Integrated receiver/decoder
ISO International Organization for Standardization
ITS Insertion test signal
ITU International Telecommunication Union
ITU-R International Telecommunication Union, Radiocommunication Sector
MPEG (ISO/IEC) Moving Picture Experts Group
NCC (EBU) news conference circuits
O/P Output
p-p Peak-to-peak
PAL Phase alternation line
PM Phase modulation
QPSK Quadrature (quaternary) phase-shift keying
R-S Reed-Solomon
RFT Request for tender
rms Root-mean-square
S/N Signal-to-noise ratio
SAC Satellite access control
SCH Sub-carrier horizontal
TCP/IP Transmission control protocol / Internet protocol
TCC (EBU) technical co-ordination circuits
VOX Voice-operated switch
VSAT Very small aperture terminal
WAN Wide area network

The bit-rate could be changed to 8 Mbit/s using the same equipment but with a satellite IBO of 18 dB. This bit-rate flexibility is one of the major advantages of the MPEG-2 4:2:2 P@ML / DVB technology.

Carrier	Offset (MHz)	Up frequency (MHz) + pol^n		Down frequency (MHz) + pol^n		Transmit earthstation
E1	-27	14 348.0	Y	11 048.0	X	VNER
E2	-9	14 366.0	Y	11 066.0	X	BRUX
E3	+9	14 384.0	Y	11 084.0	X	FFTM
E4	+27	14 402.0	Y	11 102.0	X	FFTM

Table 1
Frequency plan used for the 4:2:2 P@ML equipment tests.

Tests with 4:2:2 equipment were performed in January 1997. The results obtained during these tests confirmed the feasibility of operating four 24 Mbit/s TV channels in one transponder. The transmitting stations involved were standard *Eurovision* earthstations:

- **VNER** (Vernier, Geneva) operated by the EBU;
- **BRUX** (Brussels) operated by BRTN;
- **FFTM** (Frankfurt) operated by ARD.

The tests were performed with the following channel characteristics:

- Information rate = 24.23 Mbit/s (with R-S error correction);
- QPSK modulation with FEC = 7/8;
- Symbol transmission rate = 13.8457 Msymb/s;
- A nominal EIRP corresponding to a satellite IBO of 15 dB or 68.0 dBW at the G/T = – 0.5 dB/K contour.

The frequency plan adopted for the tests is given in *Table 1*.

The aim of the tests was to determine the value of the EIRPs which give the best global performance of the channels in the transponder. The up-link margin was taken as the criteria for estimating the performance.

Before starting the tests, the EIRPs of the four channels were balanced in order to obtain a down-link EIRP of 38.1 dBW ± 0.3 dB measured by ESA/Eutelsat.

The up-link EIRP was varied from + 4 to – 4 dBW from the nominal values, and the measured margins (in dB) are shown in *Table 2*.

A graphical presentation of the mean values of these results is given in *Fig. 1*.

The mean value of the up-link margins is considered as being representative of the global performance.

	Measured margins (dB) for different carriers			
EIRP	**E1**	**E2**	**E3**	**E4**
+4	8	7	7	7
+3	8	7	8	8
+2	10	8	8	7
+1	10	8	8	8
0	9	7	8	8
-1	9	8	8	7
-2	9	8	7	7
-3	8	6	7	6
-4	7	5	5	5

Table 2
The measured up-link margins at various EIRPs varying from the nominal value.

2.3. Subjective assessments

The subjective quality tests were carried out by YLE (Finland) and SVT (Sweden) who made 1st and 3rd generation subjective evaluation tests, in accordance with ITU-R Recommendation BT.500-6 [7].

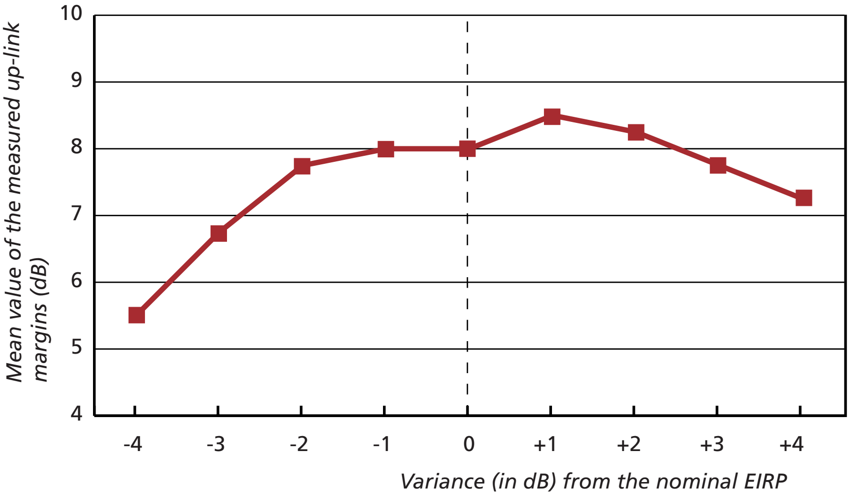

Figure 1
Mean value of the measured up-link margins for different EIRPs.

The subjective evaluation tests produced results very similar to those previously obtained for 34 Mbit/s codecs compliant with ITU-T Recommendation J.81 [2], namely grade 4.5 after one generation of coding and grade 4.0 after three generations when using 270 Mbit/s D1 recordings between generations. A selection of sequences from the well-known EBU/ITU D1 test sequences were used for these tests.

Slow-motion evaluation tests also gave satisfactory results, as assessed by two experienced TV engineers.

The GoP structure used for these tests was:

I B P B P B P B P B P B I

i.e. GoP = 12 (n = 12, m = 2).

The subjective test procedures are described in ITU-R Recommendation BT.500-6 [7]. Several different methods are described and, for this test, the EBU's "double stimulus impairment scale method" was chosen. This method is well known and is suitable for the evaluation of new systems. The procedure as described in ITU-R 500 was followed wherever practical.

For the subjective tests, the following well-known sequences were selected:

- **Tempest** (EBU test library tape);
- **Mobile and Calendar** (EBU test library tape);
- **Renata and butterflies** (EBU test library tape);
- **Basketball** (YLE recording, PAL originated).

The EBU test sequences were supplied in D1 format while the YLE sequence was delivered in composite format. A 1st generation recording of these sequences was produced after passing the test material through the MPEG-2 4:2:2 P@ML encoder-decoder equipment using CCIR 601 digital signals throughout the whole process. This recorded material was then used as the source and passed through the encoder-decoder equipment a second time. The same process was repeated again in order to produce up to nine generations of coding/decoding.

An analysis of the results is given in *Fig. 2*.

2.4. Objective measurements

The BBC carried out laboratory tests, which were also generally satisfactory, apart from the occurrence of a few equipment faults. A separate high-quality PAL coder was used for the PAL – codec – PAL tests.

The codec latency (transmission time) was found to be somewhat greater than the 300 ms limit of the RFT. The video/audio differential delay was also found to be out of tolerance due to the use of a frame-store in the encoder, without automatic audio delay correction. This problem was subsequently remedied by the manufacturer.

The BBC also noticed that, for a certain critical sequence (a moving shot of grass), the 12-frame GoP structure of the signal was evident from a "breathing" of the grass resolution.

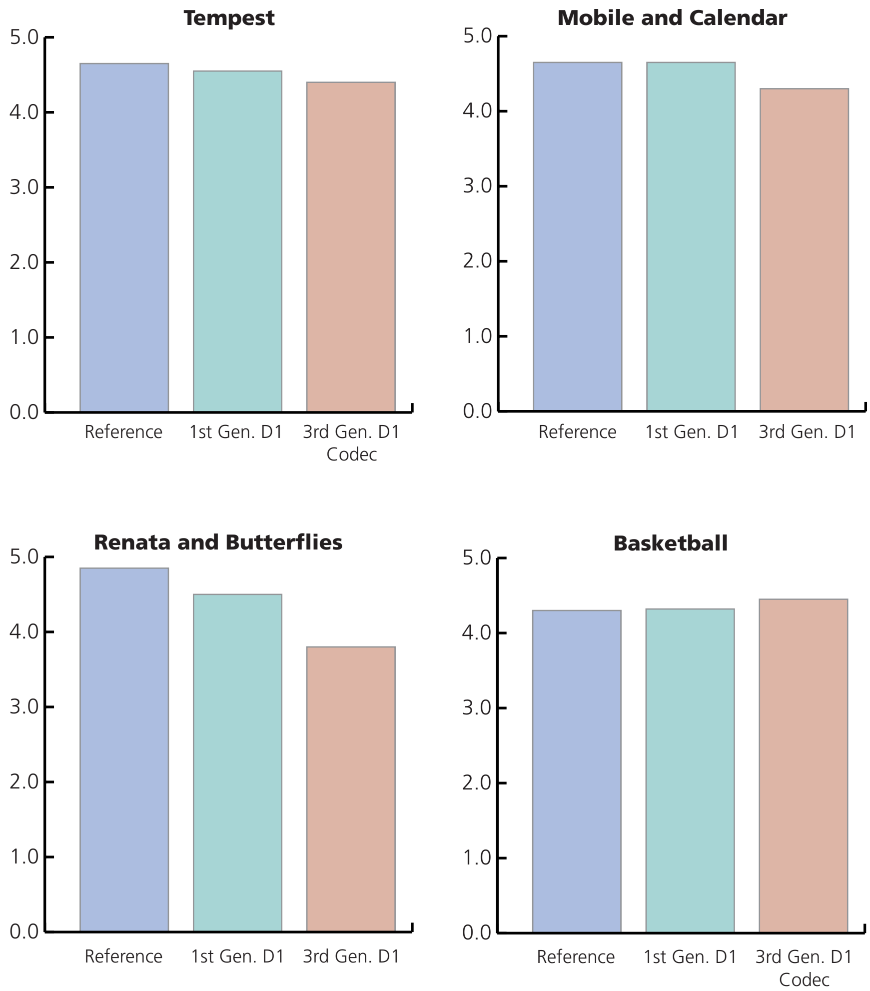

Figure 2
Results of the subjective assessments on four well-known video sequences, for first- and third-generation encoding/decoding.

The GoP structure used for these tests was:

I P P P P P P P P P P P

i.e. GoP = 12 (n = 12, m = 1).

2.4.1. Full-field ITS tests

Measurements were only made with a PAL input/output, using full-field ITSs. The test equipment comprised a Tektronix VM700 analyzer with Tektronix TSG271 PAL TV, and GML video generators. The results of these tests are given in *Table 3*.

The results were generally satisfactory with the following exceptions:

➩ The chrominance/luminance delay inequality of 31 ns is excessive;

⇨ The figures obtained for chrominance noise are rather low.

2.4.2. Tolerance to imperfect inputs

Table 4 shows the codec's tolerance to imperfect input signals.

Parameter	Signal used for Measurement	Result
Bar amplitude	20T/2T pulse and bar	-0.8%
Line time distortion	20T/2T pulse and bar	0.5%
Bar slope (tilt)	20T/2T pulse and bar	0.8%
2T/bar relative amplitude	20T/2T pulse and bar	0.9%
Line time luminance non-linearity	Staircase	2.1%
Differential gain	Mod ramp	1.2%
Differential phase	Mod ramp	0.5%
SCH phase		-1.5°
Chrominance gain		-5.2%
Chrominance Non linearity	Mod 3 step	-0.6%
Chrominance/luminance inter-mod.	Mod 3 step	0.6%
Chrominance/luminance delay inequality	20T with F_{sc}	31 ns
Best amplitude	EBU colour bars	302 mV
S/N unified weighted, Bandwidth 10kHz-5MHz	Sawtooth	-54 dB rms, 0dB = 700 mV p-p
Chrominance AM noise	Red Raster	-51 dB rms
Chrominance PM noise	Red Raster	-44 dB rms
Field time distortion	50 Hz white bar	0.7%
Longtime waveform distortion	Black/white/s interval	OK
Sync amplitude	Black/white/s interval	300 mV
Multiburst amplitude errors	Multiburst	-0.81 dB (-0.26 dB for ref)
Bruch Blanking	EBU colour bars	OK

Table 3
Results of the full-field ITS tests.

2.4.3. BER threshold

It was not possible to insert errors into the MPEG Transport Stream in a controlled way and so the error measurements were carried out by setting particular values of E_b / N_0 by adding noise at the 70 MHz IF stage. Note that E_b is defined as the energy-per-useful-bit and that the useful bit-rate during the tests is taken to be the information rate at the input of the R-S encoder (22.3 Mbit / s).

Recordings were made of the component output signals at values of E_b / N_0 ranging between 4.5 dB and 7.0 dB.

The recordings showed that, at E_b / N_0 values below 5.0 dB, the decoder had effectively failed; the displayed picture was a changing mixture of large horizontal bands from some of the pictures received just before the E_b / N_0 was reduced below the failure point. At values above 5.5 dB, the decoder operated largely error-free, although occasional flashes and freeze-frame effects could be seen at the lower values.

No hysteresis could be detected in the noise performance – the decoder recovered correctly (in about 1 - 2 seconds) when a signal with an E_b / N_0 of 5.5 dB was applied to its input.

2.4.4. Latency and lock-up times

The latency of the codec, measured with a video coding rate of 20 Mbit/s and from a PAL input to a PAL output, was measured as approximately 340 ms.

Parameter	Symptom	Threshold value
Luminance headroom	Luminance clipping	770 mV above black
Luminance margin below black level	Luminance crushing	- 60 mV below black
Chrominance headroom	Chrominance clipping	139% (EBU bars).
Chrominance phase jitter, Vectorscope on internal reference		2° p-p burst, 4° p-p colour
S/N ratio of input signal [1]	Failure of output signal	-13.9 dB rms at codec input -20.0 dB rms at codec output

Table 4
Tolerance to imperfect input signals.

1) Note that for the measurement of tolerance to a noisy input, the VM700 which was measuring the input S/N ratio was also failing. A more stable measurement was possible by measuring the output S/N of the codec and this is also recorded in the table.

It was not possible to measure the latency between the component input and output. However, the measured transmission delay was greater than the EBU's stated requirement that it should not exceed 300 ms.

The video (PAL) arrived 15 ms later than the audio signal. Information received from the manufacturer implied that the video could be expected to arrive over the range of 30 ms late to 10 ms early with respect to the audio signal.

The video/audio delay inequality was well outside the EBU's stated requirement that it should be less than 2 ms.

The PAL output of the decoder stabilized within approximately 360 ms of the connection of a PAL input to the encoder.

The PAL output of the decoder stabilized within approximately 1.5 s of the connection of a normal RF input to the decoder.

2.4.5. Comments

The tolerance to excessive input levels was as expected. The behavior of the codec was good in the presence of noisy inputs.

The performance in the presence of errors was satisfactory with a very rapid failure occurring between E_b/N_0 values of 5.0 and 5.5 dB (using rate 7/8 convolutional coding).

The measured transmission delay and the video/audio delay inequality were outside the EBU's stated requirement.

The lock-up times as measured appear to be satisfactory.

2.5. Current situation

All the tests described above have fully demonstrated that the advantages foreseen by the use of MPEG technology can in fact be implemented in a complex network like the *Eurovision* network of the EBU. MPEG/DVB technology provides a very high quality solution for professional applications while (at least for the receivers) enjoying the cost benefits of a technology that has already been developed for mass production.

A contract for equipping the network was signed and a "Reference System" was successfully tested during summer 1997. More than 50 earthstations have been prepared (and in some cases modified) to be equipped with the new encoders, decoders, modulators etc. The switch-over from analogue to digital was successfully implemented during the night of 24 - 25 August 1998.

2.6. Further studies

Every time a decision is taken in our fast-moving world of technology, new developments occur during the implementation phase.

It is expected that, once the network has been fully digitalized, the introduction of auxiliary data such as MOLE [8] or new modulation techniques (8PSK) will lead to new considerations.

3. VSAT voice-conferencing system

Since the 1960s, the EBU has used voice-conferencing facilities to manage its *Eurovision* network. These facilities are presently achieved by means of two networks of terrestrial 4-wire circuits which are leased permanently: **TCC** (Technical Co-ordination Circuits) and **NCC** (News Conference Circuits). Their quality and reliability is very poor and the costs are very high.

With a view to updating these facilities, an investigation of existing VSAT systems showed that no available system was really suited to the EBU's needs. It was thus necessary to develop a completely new VSAT system which has now been patented.

3.1. The EBU's VSAT concept

The EBU's new VSAT system provides voice-conferencing facilities via satellite, using only three digital voice channels for fifty or more participants. Unlike existing satellite-conferencing systems, it offers real-time unimpeded access to all participants by using DAMA (Demand Assignment Multiple Access) with decentralized access control.

With existing satellite-conferencing systems, the participants need to signal their desire to intervene, then must wait two or three seconds whilst the hub gives them access to a satellite channel. This is too cumbersome for the requirements of the NCC and TCC networks, where instantaneous access is essential. The EBU system requires the digital voice-carrier demodulators to synchronize to any source within 30 ms. Until recently it was not possible to find a digital voice-carrier demodulator with this capability.

Several years ago, NEC found that their BOD (Bandwidth On Demand) VSAT system could be modified to meet the EBU's requirements. Their modified VSAT demodulators could synchronize in less than 30 ms but, at that time, the NEC engineers were not sure about the effects of breaking the "no collision" rule for voice channels.

However, it was possible to demonstrate to NEC that, with the orderly procedure of the EBU News Conference, collisions would be very rare indeed. If they did occur, the offending participant would hear a one second beep of "busy tone", prompting him / her to wait and then try again.

Initially, NEC proposed a system with only two voice channels; one reserved for the hub and one for the VSATs to share. The EBU believed, however, that the VSATs needed an additional channel so that a second VSAT could intervene whilst a first VSAT was speaking. This was accepted by NEC and a special "EBU voice card" was developed to meet the requirement of access control by each individual VSAT, as opposed to the normal system of centralized access control by the hub.

All voice-communication VSAT systems use voice-activated carriers, but most existing systems, apart from the NEC system, initially require up to one second for the demodulators to synchronize to a given source. Thereafter, short bursts of carrier are sent during pauses in the speech signal to keep the demodulators synchronized.

The new EBU / NEC system is able to dispense with this requirement by having demodulators which synchronize within 30 ms. A special 30 ms preamble is inserted by the modulator to allow quick acquisition. Since a single-hop satellite system delays the signal by about 270 ms anyway, this additional 30 ms is not significant.

A Common Signalling Channel (CSC) signal is sent continuously from the hub, via a separate data channel, to provide housekeeping communications with the VSATs. It also provides a frequency reference which helps the demodulators to synchronize quickly despite frequency drift due to the Doppler effect, caused by satellite movement with respect to the Earth.

In addition, the CSC return channel keeps the hub informed about which VSATs are transmitting at any instant so that, if somebody leaves a microphone open, the hub operator can see who the culprit is from his / her selection-panel display. Moreover, the uplink transmitter concerned can then be disabled by remote control from the hub.

Fig. 3 shows the basic configuration of the hub and one VSAT. When a VSAT transmits, it disconnects the corresponding receive signal from its "audio listen mix", to avoid hearing its own signal coming back as an unattenuated echo with a single-hop delay. If however the VSAT does not receive its own signal back from the satellite, it knows that it has collided and thus stops transmitting and sends a "busy signal" beep to its listen mix.

A VSAT will not transmit to a satellite channel which it knows is already occupied. However, due to the single-hop delay, collisions can occur if by chance the VSATs start transmitting within 300 ms of each other. Dealing effectively with this collision scenario was the most difficult part of the system design, but the problem has been solved.

A sophisticated echo-canceller is installed at each VSAT, looking towards the local connection. This ensures that if two VSATs are speaking simultaneously (via the VSAT channel and the VSAT "interrupt" channel respectively), acoustic loudspeaker-to-microphone feedback will not cause echoes to be heard by other participants.

Microphone / loudspeaker terminals which have been designed for conference systems use a 15 dB "autodim" facility to reduce this loudspeaker-to-microphone acoustic feedback. How-

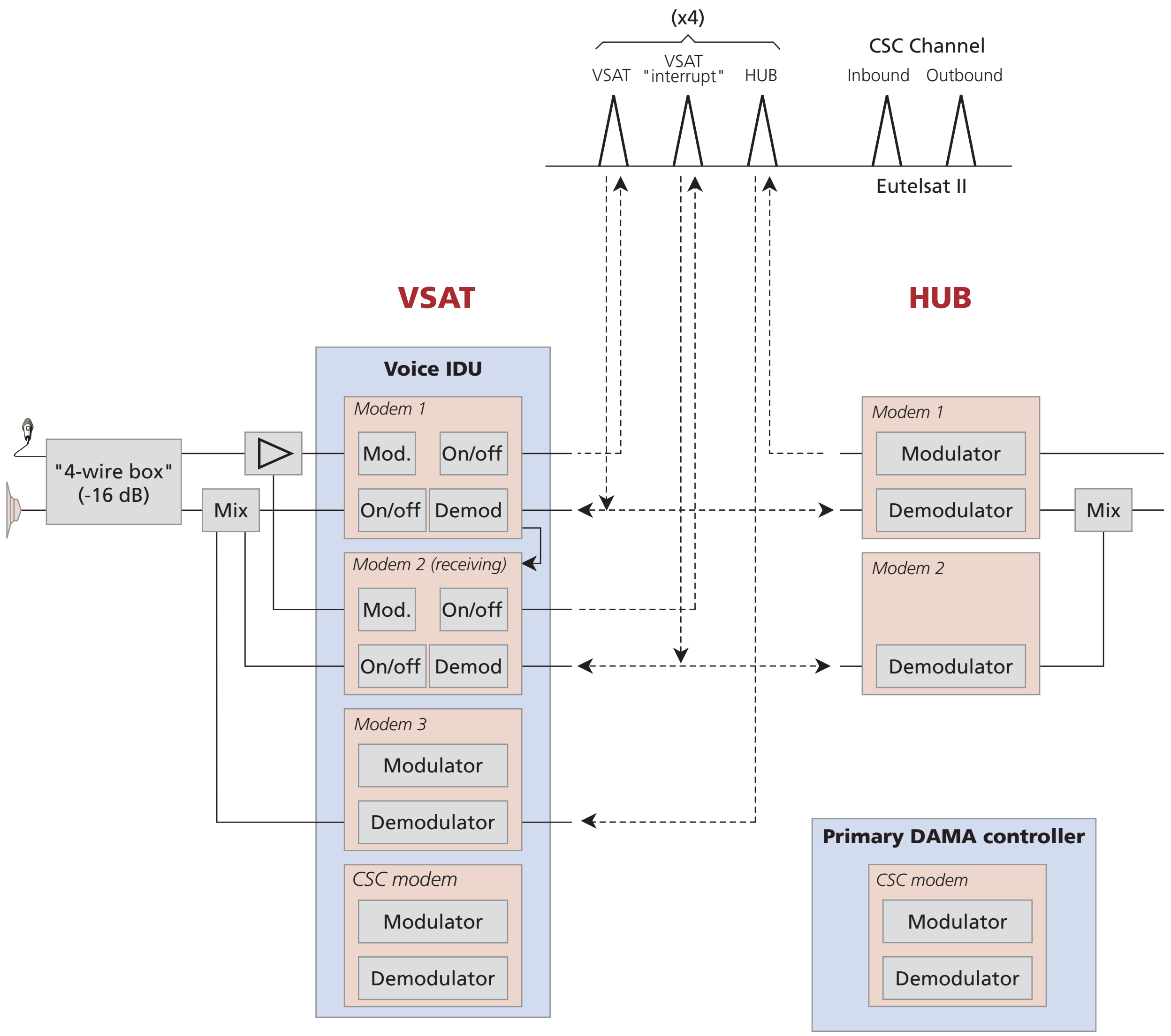

Figure 3
HUB and VSAT modem configuration.

ever, even low-level feedback may be unacceptable in a satellite system because it produces a disturbing echo.

3.2. Sytem facilities

The new system provides voice-conferencing between any number of VSAT locations, using three 32 kbit/s satellite voice channels plus a 64 kbit/s CSC. Both 32 kbit/s ADPCM (ITU-T Recommendation G.726 [9]) and 16 kbit/s CELP (ITU-T Recommendation G.728 [10]) are available for the voice signal coding: the chosen system can be downloaded to the VSATs from the hub. If the 16 kbit/s quality is eventually judged to be satisfactory, the EBU will be able to obtain a 3 dB improvement in the satellite link budget by using 16 kbit/s instead of 32 kbit/s. The hub, plus up to two VSAT terminals, can speak simultaneously and with unimpeded access. This means that the participants do not need to request access to the hub when they wish to speak – they just press their "speak key" and speak. Voice-activated carriers are used for the VSAT uplink signals.

Standard "off the shelf" datacom facilities can be added to the VSAT system for a modest additional cost, thereby creating a WAN. The EBU has recently carried out successful tests with two VSAT datacom terminals, using TCP / IP routers to interface to the EBU Ethernet datacom system.

The foreseen advantages of the EBU / NEC satellite conference system – when compared with the existing terrestrial network conference system – are as follows:

- significantly reduced costs;
- better voice quality;
- higher reliability.

The system is the subject of a joint EBU / NEC patent application.

3.3. EBU pilot project

A four-site pilot project was planned to test the EBU's VSAT concept and NEC subsequently delivered four VSAT terminals to EBU Geneva in November 1996, one of which was programmed to act as the hub. Initial tests on the system were carried out in Geneva using three 1.2 m dishes on the EBU headquarters building. The 64 kbit / s Satellite Access Control (SAC) signal, which is a simplified CSC signal, was transmitted at 50 dBW from the Swiss PTT 7.6 m earthstation located in a suburb of Geneva not far from the EBU headquarters.

The photograph in *Fig. 4* shows the arrangement of the four carriers – the SAC signal and the three voice channels.

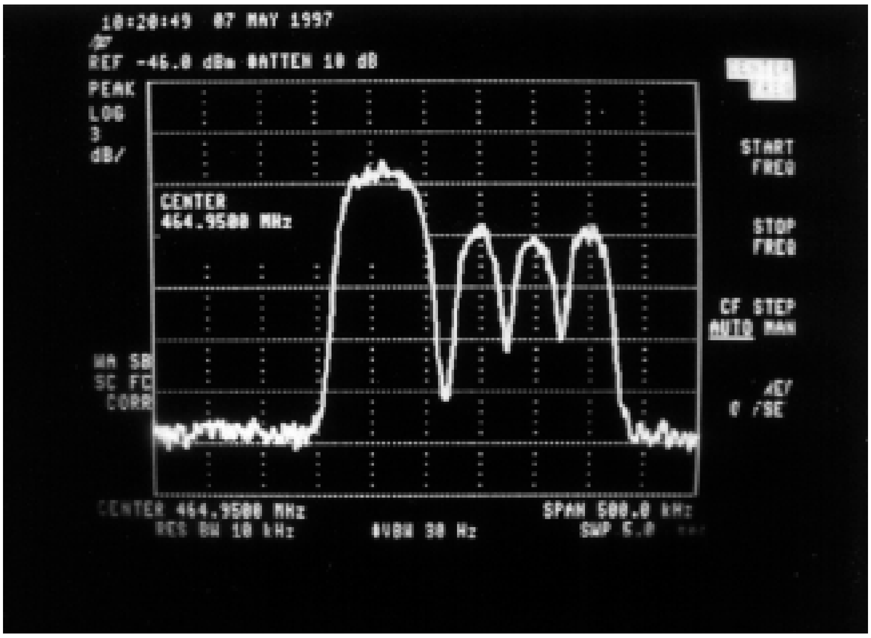

Figure 4
The SAC carrier (64 kbit/s) and the three voice channels (32 kbit/s).

After these initial tests, three VSATs were dispached to BBC London, TDF Paris and SVT Stockholm. The foreseen 1.8 m dishes also arrived at each of the four sites making up the pilot project.

The voice quality was judged to be good and the voice-activated carrier system worked perfectly. As soon as a microphone speak-key was pressed, the appropriate carrier was switched on, regardless of whether anybody was speaking into the microphone or not. The VOX circuit is capable of distinguishing between audio modulation and circuit noise, activating the carrier even on low-level ambient noise, but ignoring random circuit noise.

The "hangover time" of such a system refers to the length of time which the voice-activated carrier stays on after the speech modulation has finished. This is set to 200 ms for normal

VSAT telephony connections, but a longer value may be preferable for the EBU conference system. On the other hand, it is desirable to minimize the changes to the standard BOD system, so the EBU will first try operating the system with the standard value.

The uplink margin was measured using the 1.8 m dishes at Geneva and Paris with the leased Eutelsat II-F4 transponder initially unloaded, then loaded with two analogue TV channels. The resulting clear-sky margins were found to be 11 dB and 7 dB respectively, which are satisfactory values.

A few 2.4 m dishes may be necessary at the edge of the satellite footprint, and further tests will be made to confirm the dish-size requirements before the EBU proceeds with implementation of the full system – whereby 48 VSATs will provide 24-hour news-conferencing facilities between the broadcasters of 48 countries.

Full implementation of the VSAT system is expected to bring about a significant reduction in the cost of providing this news-conferencing service for EBU members, when compared with the current leased 4-wire circuits.

The EBU will go ahead with this project now that the digitalization of the *Eurovision* network has been completed (summer 1998). In the meantime, two VSAT terminals are being used in a pre-operational manner and have already been redeployed in Dublin and Sarajevo.

4. Conclusions

Before entering the next century and millennium, the EBU will have made several important technological changes which will keep it ahead in its domain.

The *Eurovision* network will be the first network of its kind to use the brand new MPEG-2 4:2:2 P@ML. Due to its inherent flexibility, this MPEG-2 technology will support new additional services which, in turn, will provide added value to the services offered by the *Eurovision* network.

The VSAT conference system described here is also at the leading edge of technology. It uses only three voice channels on the satellite and avoids the delay inherent in double-hop solutions while reducing the risk of voice collisions to an acceptable limit.

Louis Cheveau *qualified as a Physics Engineer from the University of Liège, Belgium, in 1967 and obtained a Ph.D. in Physics from the University of Montreal, Canada, in 1974. That year, he joined the EBU Technical Centre in Brussels as head of the computing department and, initially, worked in the field of terrestrial television broadcasting. In 1977, the emphasis of his work changed to satellite broadcasting.*

In 1984, Dr Cheveau was detached for two years to the CBC in Canada. There, he worked in International Relations with a special emphasis on satellite broadcasting and HDTV matters. In 1986, he returned to the EBU Technical Centre, this time to work on Eurovision transmissions. Since 1989, he has been Head of Transmission Technologies within the EBU Technical Department in Geneva.

With these new technologies, the EBU network will shortly be fully digital via satellite – not only for the *Eurovision* and *Euroradio* exchanges (already both digital) but for voice conferencing as well.

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