The technical history of Eurovision

Brian Flowers
EBU Senior Engineer (retired)

The author spent 36 years in the EBU, working mainly on network-related aspects of Eurovision. Here he provides a personal recollection of the many technical developments that took place during his time with the EBU and Eurovision.

Nowadays, we take it for granted that we can see news coverage and live sports events from every part of the world on our television receivers. However, this does not happen by magic! In this article, I shall try to explain how we progressed from the first international television transmission from Calais (France) to London (UK) in August 1950, to the present situation whereby news items and live events are made available instantaneously to television viewers all over the world.

Contribution and distribution

I should explain one basic point from the outset, namely the difference between ***contribution*** and ***distribution*** television transmission.

Relaying television signals around the world using point-to-point links between the broadcasters constitutes "contribution" transmission. The transmission quality must be of a high standard, especially in the case of digital transmission, because the signals may well be subject to further manipulation by the receiving broadcasters before they are transmitted to the public.

Transmission from the broadcaster to the public involves "distribution" transmission facilities, which require less bandwidth than contribution transmission facilities. Hence, the Eurovision Network, which is a contribution network, utilises 24 Mbit/s for sports events, 12 Mbit/s for news items, and 8.5 Mbit/s for Satellite News Gathering (SNG) from mobile uplinks. Conversely, the signals transmitted from the broadcaster to the public utilise only 3 or 4 Mbit/s.

Abbreviations

BISS	(EBU) Basic Interoperable Scrambling System
BISS-E	(EBU) encrypted version of BISS
CET	Central European Time
EVC	(EBU) EuroVision Control centre
EVN	(EBU) EuroVision News exchange
GCE	(UK) General Certificate of Education
NTSC	National Television System Committee (USA)
OIRT	Organisation Internationale de Radiodiffusion et de Télévision
PAL	Phase Alternation Line
PTT	Post, Telephone and Telegraph administration
SECAM	*Séquentiel couleur à mémoire*
TAT	Trans-Atlantic Telephone
TWTA	Travelling-Wave-Tube Amplifier
VSAT	Very Small Aperture Terminal

These bitrates are for standard definition MPEG-2 coded TV signals. For HDTV, these figures increase theoretically by a ratio of 5:1, although the use of a more efficient satellite modulation system (DVB-S2) and a more efficient compression system (MPEG-4) can reduce this ratio to about 3:1.

This article concerns primarily contribution transmission facilities ... or what the Americans call ***"back-haul" circuits***!

Historical transmissions

On 27th August 1950, the BBC made the first experimental international television transmission from Calais in northern France to England. This involved setting up a temporary microwave link across the English Channel from Calais to Dover.

A two-way programme exchange between London and Paris took place from 8th to 14th July 1952, which necessitated standards conversion between the French 819-line television system and the British 405-line system.

On 2nd June 1953, the coronation of Queen Elizabeth II was relayed live from London to France, The Netherlands and Germany.

The coronation of Queen Elizabeth II

This provoked much interest in the possibilities for international television and, on 6th June 1954, the first officially-designated Eurovision transmission (the Narcissus Festival) took place between Montreux (Switzerland) and France, Italy, Germany, The Netherlands, Denmark and the United Kingdom.

Video standards

Most European countries adopted 625 lines for their TV services, although the French 819-line and the British 405-line systems continued to be used until the mid-1960s, necessitating standards conversion for some Eurovision transmissions. Moreover, the USA and Japan adopted 525 lines and 30 frames/second, whereas all European TV utilised 25 frames/second.

This situation arose due to the different mains-supply frequencies in different parts of the world, because for black & white TV the frame frequency was locked to the mains frequency to ensure that any visible hum on the picture remained stationary.

Development of high-frequency amplifiers

Eurovision transmissions were made possible by the invention of the Travelling Wave Tube Amplifier (TWTA) by Rudi Kompfner during World War II, initially working at Birmingham University, then at the Clarendon Laboratory, Oxford University. Rudi Kompfner (1909 – 1977) was a Jewish engineer who emigrated from Vienna to England in 1934.

Rudi's approach to creating a high-power high-frequency amplifier was based on the concept of propagating electrons and an electromagnetic field at the same velocity through a long vacuum tube, by placing a conducting helix between the cathode and the anode.

Rudi consulted an expert on transmission lines at Birmingham University, who told him his idea would not work, but fortunately Rudi persevered despite this pessimistic advice. The resulting

TWTA was able to transmit wide-bandwidth SHF signals and it was subsequently utilised for frequency-modulated SHF links, which facilitated the transmission of television signals using successive 30 km line-of-sight hops.

I have related the development of the TWTA in some detail because very few people realise how much they owe to creative engineers like Dr Rudi Kompfner.

In 1951, Rudi was enticed to Bell Labs, USA, where he was later involved in the development of *Telstar*, the first communications satellite to carry television programmes across the Atlantic in July 1962, also using TWTAs.

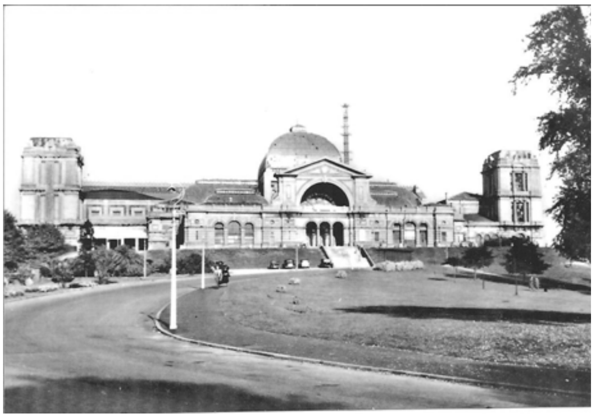
However, before elaborating on TV transmission via satellites, I would like to explain how news items crossed the Atlantic from 1959 to 1962.

Slow-scan transatlantic TV transmission

When I started to work for BBC TV News at Alexandra Palace in January 1960, one of my jobs was to send TV news items from BBC London to NBC New York or vice versa. To do this, BBC Research Department had created a system for sending TV pictures via the transatlantic TAT telephone cable [1].

This was quite an achievement because the bandwidth of a 405-line TV picture was 3.5 MHz, whereas the bandwidth of the specially-prepared pair of telephone lines was 700 times smaller at 5 kHz.

Due to this bandwidth disparity, it would normally take 700 minutes (11 hours and 40 minutes) to send one minute of TV pictures via the TAT cable. Fortunately, the BBC engineers were able to reduce this ratio to 100:1 by means of various tricks.



The BBC's Alexandra Palace in the 1960s

For example, only every second film frame was scanned (taking 8 seconds) then printed twice at the far end. Also, only 202.5 lines were transmitted instead of 405 lines. These measures halved the temporal and vertical resolution. Also, reducing the horizontal resolution by about 2:1 gave a bandwidth ratio of 100:1 instead of 700:1.

Consequently, a one minute news item took 100 minutes to transmit, so I only had to work until about 3 o'clock in the morning to send to NBC New York the pictures of President John Kennedy meeting the Soviet Chairman Nikita Kruschev in Vienna in 1961.

The only alternative for sending urgent news items across the Atlantic Ocean in 1960/1961 was to send the news film on board a USAF Hustler jet that would make the trip in about 3 hours, with helicopters making the broadcaster/airport connections.

The Eurovision News Exchange (EVN)

Another part of my job at BBC TV News in 1960 and 1961 was to send and receive news items in the EBU's experimental Eurovision News Exchanges (EVNs), which took place at 17:00 CET whenever there were urgent news items to be sent to or received from the Continent.

1. For further information on TAT cables, you can read a Wikipedia article here: **http://en.wikipedia.org/wiki/Transatlantic_telephone_cable**

From 1962, the EVN became a daily occurrence and the EBU Technical Centre in Brussels wanted to recruit a multilingual BBC engineer to coordinate the EVNs and televised sports events. I managed to convince the EBU that my GCE O-level knowledge of French and German was adequate and I got the job!

Telstar

One of my first jobs at the EBU was to prepare for the first real-time transatlantic TV transmissions, which took place via *Telstar* on 23rd July 1962. *Telstar* followed an elliptical orbit taking about 2 hours 30 minutes to circle the earth.

Coordinating the first transatlantic TV transmission in 1962
(the author is sitting on the far right)

The earth stations at Andover in Maine (USA), Pleumeu Boudou in Brittany (France) and Goonhilly in Cornwall (UK) had to track *Telstar* as it moved across the sky, and it only remained visible for about 22 minutes per orbit.

On 23rd July 1962, the EBU coordinated the inaugural transatlantic television transmissions from Europe to the USA and from the USA to Europe. Richard Dimbleby (a well-known BBC commentator) presented the Europe-to-USA programme from the Eurovision Control Centre (EVC) in Brussels.

In the interests of historical accuracy, I should add that Radio-Télévision France (RTF) did a transmission from Montreal (Canada) to France about a week before the official EBU inaugural transmissions.

Geostationary communication satellites

In June 1965, *Early Bird* – the first geostationary communications satellite – entered service about 36,000 km above the Atlantic Ocean. People often ask why such geostationary satellites don't fall down. The answer is that they do, but they are moving so fast horizontally that they always fall over the edge of the earth. At the geostationary height, they take 23 hours 56 minutes to complete one orbit, so they remain stationary as seen from the earth.

You may be wondering why the orbital time is 23 hours and 56 minutes and not 24 hours. Well 23 hours 56 minutes is the time it takes the earth to revolve once on its axis. A day lasts 24 hours because the earth has to revolve nearly 361 degrees from one meridian to the next. This is because in addition to rotating on its own axis the earth also circles the sun once every 365.25 days approximately.

By 1967, Intelsat geostationary communication satellites were available above the Atlantic Ocean, the Pacific Ocean and the Indian Ocean.

"Our World" – the first-ever live international TV production

25th June 1967 is a monumental date in the history of television, both for Europe and the world. The Eurovision programme *"Our World"* was the first live international television production, and it was a two-hour broadcast, around the globe, between 9pm and 11pm CET on a warm Sunday evening, forty years ago.

It was an undertaking of incredible complexity, involving control rooms around the world, three geostationary communication satellites (Intelsat I, Intelsat II and ATS-1), over 1.5 million km of cable and ten thousand technicians and programme staff. The programme concept was to link up the world, to demonstrate that we are all part of "our world" – all brothers and sisters. The ground rules for the show included that everything had to be live, and that no politicians or heads of state must be seen.

Four days before the broadcast, five of the participating countries dropped out. The Eastern block countries were protesting at the West's response to the "Six day War" in the Middle East. But the show went on, with an offer to do it again with them – if ever the Eastern block countries could agree to take part.

Preparing for "Our World" – the first live world-wide TV transmission – at the Eurovision Control Centre in the *Palais de Justice*, Brussels, 25th June 1967 *(the author is on the left, Bob Mayo on the right)*

Screeshots of John, Paul, George and Ringo (The Beatles) participating in the "Our World" broadcast on 25th June 1967

The audience was spread across 31 countries and totalled between 400 and 700 million people. The live feeds into the programme showed babies being born, sports and arts events, and samples of "cultures" around the globe. At the time it was a technical marvel, and it was in "black and white" television, soon to be replaced by colour television. The introductory music consisted of the words "Our World", sung in 22 different languages by the Vienna Boys Choir.

Today, "Our World" is probably most famous for the segment starring *The Beatles*. Performing at the height of the Vietnam War, the group wanted to spread a message of peace and love to the world. The band wrote a song especially for the show, which they went on to perform after just one rehearsal. That song was *"All you need is love"*.

Some highlights from the "OurWorld" broadcast, in Windows Media Video (WMV) format, are available **here** *(with thanks to David Wood of the EBU's Technical Department).*

Colour TV

Colour TV was introduced in Europe from 1967 onwards. Unfortunately, the European broadcasters were unable to agree on a single standard, so the Eurovision Network had to transmit both PAL and SECAM signals.

Normally, the standard of the originating service was transmitted and each receiving service was required to transcode from PAL to SECAM or from SECAM to PAL if necessary.

The NTSC system was developed in the USA already in the late 1950s and it was a remarkable achievement, but it was susceptible to colour errors in the presence of differential phase distortion, so European TV engineers referred to it as "Never Twice the Same Colour".

PAL and SECAM were the German and French refinements of NTSC that overcame this lack of colour fidelity. In fact SECAM was said to mean "Supreme Effort Contre l'AMerique"!

SECAM utilised Frequency Modulation (FM) to encode the colour information, which ensured a high degree of colour fidelity. However PAL gave slightly better colour resolution than SECAM, and PAL was easier to manipulate in the broadcaster's studio.

PAL was said to mean, "Prolonged Active Life" and it lived up to this name when most SECAM countries subsequently adopted PAL for production purposes, only transcoding to SECAM for delivery to the public via terrestrial transmitters.

The European Broadcasting Area

By 1970, the Eurovision terrestrial network covered the whole of Western Europe plus North Africa, using SHF links based on TWTAs. Only Iceland, Cyprus, Egypt, Israel and Jordan had to be connected via satellite.

A suggestion to change "Eurovision" to "Euravision", to reflect the participation of the North African countries in the network, was not adopted however.

People are often surprised by the extent of the Eurovision Network. This is derived from the International Telecommunication Union's division of the world into four Broadcasting Areas, which have natural boundaries to facilitate transmitter frequency planning. The ITU is a United Nations agency, responsible for regulating all aspects of international telecommunications.

The European Broadcasting Area extends from the Atlantic Ocean in the west to the Ural Mountains in the east, and from the Arctic Ocean in the north to the Sahara Desert in the south.

Audio transmission

One problem with international TV transmissions in the 1960s was that the audio signal was usually sent via a different route from the video signal and it sometimes got lost!

I vividly remember coordinating a live transmission of UN Secretary General, U-Thant, addressing the United Nations in New York in the mid-1960s, when the audio line from UNTV New York to EBU Brussels was not established.

I had telephone contact with Joe Nichols, head of UNTV, so I asked Joe to send the audio signal via the telephone line, which he did.

Using croc-clips, we connected an audio lead to the phone line in the Eurovision Control Centre in Brussels, not forgetting to include a capacitor to block the 48 volts DC of the phone line and we fed the signal to the whole of Europe via the EBU's Permanent Sound Network.

I held a duster over the mouthpiece of my telephone to prevent ambient noise from our control room mixing with U-Thant's speech. To match the video signal delay via the satellite, we had to delay the audio signal 250 ms by sending it via a tape record/replay machine that was set up for this purpose.

In 1974, these audio circuit problems were solved completely by adopting the BBC's sound-in-sync system on the Eurovision Network. This system transmits audio as a digital signal in the line sync pulses of the analogue TV signal.

Satellite transmission within Europe

In 1984, another major step was taken when the EBU leased two wideband transponders on a Eutelsat satellite to progressively replace most of the Eurovision terrestrial network.

Earth stations, mostly of 9 metres diameter, were installed at or near the European broadcasters' premises over a period of several years.

From 1991, four Eutelsat wideband transponders were leased, which initially carried up to six analogue TV signals between the European broadcasters.

Progressing to digital transmission

By 1989, serious thought was being devoted to replacing the analogue PAL and SECAM signals by digital signals and in November 1992, ETSI (European Telecommunication Standards Institute) issued the specification for a digital compression system intended for contribution transmission.

This system compressed the 270 Mbit/s uncompressed studio signal to about 34 Mbit/s for transmission in Europe, or to about 45 Mbit/s for transmission in North America.

The ETSI 34 Mbit/s system was further developed by Thomson to carry two 17 Mbit/s signals in place of one 34 Mbit/s signal with very little loss of quality, and this system was used on the EBU's leased transatlantic satellite link from 1995 to 1999.

Thomson also produced an 8 Mbit/s system suitable for the transmission of news items and the EBU utilised this system to provide five supplementary channels via the leased Eutelsat transponders, in addition to the six analogue TV channels for sports transmissions. This was known as the "Mini-8" system.

Meanwhile, the MPEG-2 system was being developed for distribution purposes, and the so-called Professional Profile version of MPEG-2 was subsequently developed for contribution purposes. This system required only about two thirds the bandwidth of the ETSI system for a given transmission quality, so when the EBU adopted all-digital satellite transmission in 1998, this was based on the MPEG-2 Professional Profile system.

Merger of the EBU and the OIRT

In 1993, the EBU merged with the OIRT, which was responsible for the coordination of international TV transmissions in East Europe and the former Soviet Union countries.

This merger increased the number of countries whose broadcasters were members of the EBU and Eurovision from about 30 to about 50. (The exact numbers vary somewhat in view of the splitting up of Yugoslavia into several countries).

The EBU Technical Centre moves from Brussels to Geneva

Over the period 1989 to 1993, the EBU Technical Centre staff moved from Brussels to Geneva. This required the creation of a new building in Geneva housing a new Eurovision Control Centre (EVC).

The Eurovision Control Centre in Geneva, 2003

As project engineer for the new EVC, I spent most of my time from 1989 to 1993 working on this project.

During these years, I noticed that if I went to bed with a technical problem for the new Eurovision Control Centre on my mind, I would wake up at about 03:00 with the required solution, which I would scribble on a note-pad then go back to sleep.

Clearly my mind was working on the problem whilst I was asleep, so I asked the Technical Director if he would agree to pay me overtime for sleeping. Unfortunately, he did not agree, but he did give me a promotion when the new Eurovision Control Centre was completed on time and within budget, and everything worked as foreseen. My EBU colleague, Guy Van Gelder, monitored the expenditure and ensured that we stayed within the budget.

Communications

One important aspect of international television transmission that I should explain concerns the communication systems used for technical and programme coordination. You may be familiar with conference telephone calls, whereby several people can talk together in a telephone conference. The EBU uses a highly sophisticated version of this system to provide communication between the EVC and the broadcasters of fifty countries.

The Technical Conference provides voice communication between the EVC and the fifty countries' broadcasters, as though they are all sitting around a table. It is also possible to separate countries for more private conversations.

This communication system enables the coordinator at the EVC to check that all broadcasters foreseen to receive a given transmission – as per the transmission Synopsis prepared in advance by the EBU's Planning Department – are receiving the vision and sound OK. Start and end times are noted to permit correct charges to be made for the use of the Eurovision Network.

The News Conference permits the news services of the fifty countries' broadcasters to discuss which news items they require from each other. The EBU Transmission Centres in New York, Moscow and Singapore also participate in the News Conference, giving access to news items from all over the world.

Most of the participants are connected into the conferences via leased terrestrial circuits, which are mostly 64 kbit/s or 128 kbit/s fibre-optic connections, providing Technical Conference voice circuits and News Conference voice circuits, plus Planning Department Communications in some cases.

In the mid-1990s, there were a few places that were difficult to connect into the EVC conference system via terrestrial circuits. One example was Sarajevo, where it was impossible to lease a terrestrial circuit due to the war in Bosnia.

Another example was Bucharest, where the Romanian PTT charged a very high price for a leased terrestrial circuit. Dublin was yet another example where a good quality voice circuit at a reasonable price was not available at this time.

VSAT communications

Consequently, the Technical Director asked me to find a means of connecting these places using VSAT technology, which would leapfrog over the landline problems. It would have been relatively easy to simply connect these three terminals to the conference facilities in EVC Geneva using go and return digital satellite circuits.

However, this would have created delays of over one second between, say, Dublin posing a question to Sarajevo and receiving a reply, due to the double-hop satellite connection. In addition, connecting each VSAT terminal would require two 32 kbit/s satellite voice channels, which would become 100 satellite voice channels for 50 countries.

I therefore devised a way of providing the conference facilities with only single-hop delays requiring only three 32 kbit/s satellite voice channels, plus a 64 kbit/s Common Signalling Channel. NEC in

Japan agreed to build my proposed system and I was granted a joint patent with two NEC engineers for this system.

RTE Dublin and TVR Bucharest installed their own NEC-VSAT terminals, but the last job I did for the EBU, before retiring at the end of 1997, was to install the NEC-VSAT terminal at the Sarajevo TV Centre. The building had had windows blown out and one staff member had been killed by a shell that had recently hit the loading depot. In addition, there was about two feet of snow on the flat roof where I had to install the 1.8-metre VSAT dish.

Unfortunately, the prototype control system did not restart automatically in the case of a mains interruption, a problem that would have been solved in the final system. In fact the installed system was really just a pilot project, intended to prove that the NEC-VSAT system worked OK before extending it to the whole network. Nevertheless, using the NEC-VSAT pilot system, Sarajevo TV Centre was able to participate in the Technical Conference and/or News Conference.

It subsequently transpired that the required VSAT transmit/receive licences would make the full implementation uneconomic, so only the pilot system was built and installed. Nevertheless, the pilot system was used for several years to provide voice conference communications with Dublin, Bucharest and Sarajevo.

The BISS-E scrambling system

Certain sports events for which rights payments are due must be protected from piracy when using contribution satellite links. Initially, the Eurovision satellite network utilised a proprietary scrambling system for this purpose, but there was a clear need for an internationally-agreed standardized scrambling system.

Consequently, in the late 1990s, the Head of the EBU Transmission Technology Division, Dr Louis Cheveau, coordinated the development of BISS (Basic Interoperable Scrambling System) and BISS-E (Basic Interoperable Scrambling System with Encrypted key) for contribution satellite links. The BISS-E system was finalised in 1999 and was subsequently included in all manufacturers' contribution link encoders and decoders.

Fibre-optic transmission

Nowadays, fibre-optic circuits with their huge bandwidth capacity play an important role in digital TV contribution transmission. For example, the EBU now leases fibre optic transmission facilities from Washington via New York to Geneva, plus several circuits in Europe.

In addition, the Internet can be used for sending TV news reports from anywhere in the world back to the home broadcaster as non-real-time file transfers.

Brian Flowers was born in Edmonton, London, UK in 1938. He studied engineering at Southampton University, RAF Locking Radar School and the BBC's Engineering Training Department, Evesham.

From 1960 to 1962, he worked for BBC Television News at Alexandra Palace, London, before transferring to the Eurovision Division of the EBU Technical Centre in Brussels. From 1973 to 1993, he was Engineer-in-Charge of the Eurovision Control Centre, Brussels, and from 1994 to 1997 he worked as a Senior Engineer in the Transmission Technology Division of the EBU's Technical Studies Department in Geneva, before retiring to Spain in 1998.

Music has always been an important part of Mr Flower's life. He has played the violin since the age of nine and took up the viola later in life. He played in the UK-MTA National Youth Orchestra in 1956 and was subsequently invited to attend the Guildhall School of Music, but he opted for engineering.

I have now gone full circle, because sending a 3-minute TV news report across the world via the Internet in 30 minutes is very similar to using the transatlantic slow-scan TV transmission system that I described at the start of this article.

Concluding thoughts

I was born in North London in 1938, so my first memories as a small boy are of bombs, V1s and V2s falling on London during World War II. In fact, the Flowers family came close to being annihilated one night in March 1945 when a V2 hit the Dunlop tyre factory just across the road from our house in Edmonton, North London. The house was badly damaged but we all survived OK.

Since then, my generation can claim to have created a united, peaceful Europe. International television has played a crucial role in bringing together the countries of Europe and I like to think that my 36 years work for the EBU has made a small contribution to this end.

Brian Flowers
March 2007