Eurovision voice conferencing using VSAT technology

B.G. Flowers (EBU)

If Eurovision can be likened to a Tower of Babel, then it is probably during the news and technical coordination conferences that this comparison is most justified. For forty years, these conferences have sought to offer users the maximum of freedom to express their views and state their requirements, as if they were all siting round a table together, although in reality they are dispersed throughout the Eurovision network, linked via an ingenious 4-wire telephone-quality conference system.

With the advent of satellites and their exploitation for television transmission, and with the growing needs of the conference participants as the network extends into Eastern Europe, the search has begun for a new technical basis for the Eurovision conference facilities, also using satellite technology. The article explains some of the factors to be considered in the choice of a system.

1. Introduction

The Eurovision Control Centre at EBU Headquarters in Geneva (EVC-G) is often referred to as a switching centre, but this description is misleading. The primary rôle of the EVC is transmission coordination, both as regards technical facilities and programme content. Most of the circuit switching is done at network control centres in the various countries covered by the Eurovision network.

The key to the successful accomplishment of this coordination rôle is a very sophisticated communications system, based on "*N-1*" conferencing.

The basic principle of an "*N-1*" conference system is that a number (*N*) of four-wire communication circuits are interconnected in such a way that each remote terminal receives a mix of the modulation from all other terminals, but excluding modulation from the terminal in question.

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Features of a conference system adapted to the requirements of Eurovision are:

- instantaneous access for all participants;
- availability of conference groups;
- total flexibility.

The EBU technical conference and the news conference connect the television services of about 50 different countries in such a way that they can talk to each other as though they were all sitting round a conference table. Moreover, if a few participants wish to have a separate discussion, they can be transferred, as if by magic, to another "conference room" for the duration of their private session.

The technology used has evolved over a period of about 35 years, with significant contributions from EBU engineers such as Eric Griffiths, Bill Potter and Henk Van Immerzeel to name just a few. Eric Griffiths established the first international conference systems in 1960, and he introduced the facility of transferring participants to an individual duplex connection when appropriate. In 1978, Bill Potter created the single divisible conference matrix, by mixing the various "*N-1*" combinations at the matrix cross-points. This permits the creation, by software control, of any number of conference groups using a single *N*-input/*N*-output conference matrix. Henk Van Immerzeel helped to make this idea into a working system, and he added the refinement of the "monitor/mix" facility. (This provides a monitoring mix of all selected incoming lines, so the operator hears people calling, regardless of which conference group they are selected to.)

In the Geneva EVC, built in 1993, the author introduced a further refinement, called the "conference monitor", which is simply a monitoring mix of all inputs which are selected to a given conference group. This simple idea turned out to be an essential element in the conception of one particular satellite conference system, as explained later in this article.

The main incentive for creating a satellite conference system is that leasing the existing telephone-quality terrestrial 4-wire circuits from the PTT Administrations costs several million Swiss francs per annum. A VSAT system would leap-frog over these terrestrial circuits with costs only for the space segment and the terminals at the hub and the broadcasters' premises. Voice quality and system reliability should also improve significantly with the proposed VSAT system.

2. "Off-the-shelf" VSAT conference systems

These systems are single-hop DAMA (Demand Assignment Multiple Access) with the hub controlling access to the satellite channels. They consist of a duplex connection between the hub and one VSAT, with a mix of this duplex connection fed to all other VSATs via a third satellite channel. The hub can change the duplex connection from one VSAT to another VSAT on demand, an operation which takes about two seconds.

Such systems are far too cumbersome for EBU requirements, where all conference participants must have immediate unimpeded access to the conference. Moreover it must be possible for participants to intervene during an ongoing duplex conversation without delay.

Another problem with such systems is that they require signalling from telephone terminals, whereas in the EBU we use only microphone/loudspeaker 4-wire terminals without signalling. There are about 300 such terminals in use for the EBU news conference, so changing them would be a major and expensive undertaking.

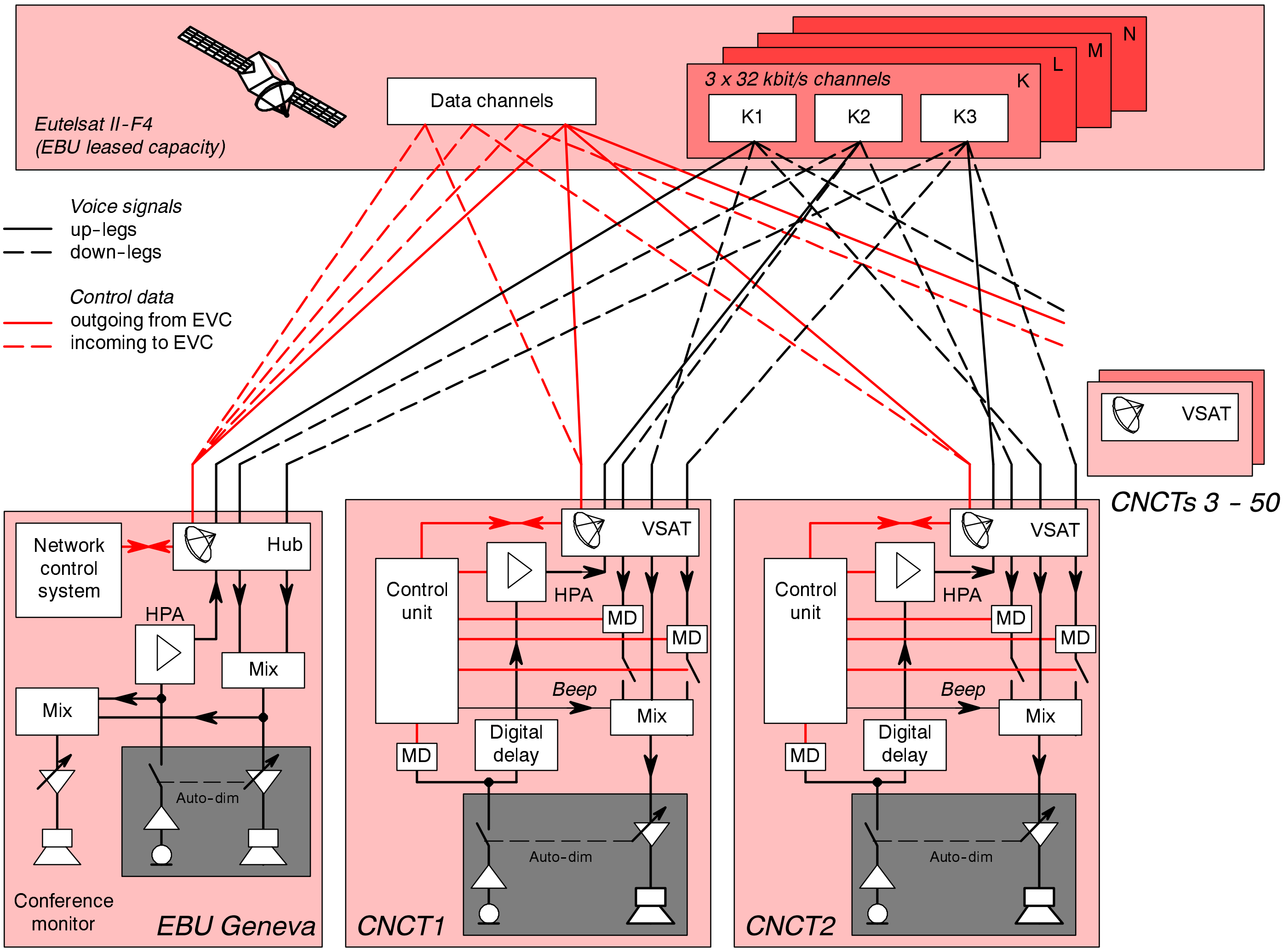
3. VSAT conference systems adapted to Eurovision requirements

The choice of a VSAT conference system for the Eurovision network has been the fruit of detailed reflection on the respective advantages and disadvantages of many potential solutions.

3.1. The "Elegant" VSAT conference system[1]

This system, illustrated in *Fig. 1*, was a first attempt to improve the flexibility and operating speed of existing DAMA systems, and it involves decentralising the control system to the VSATs. However this approach requires considerable development work and the end result would still have the inherent limitations of DAMA systems, whereby participants are refused access in some cases. The system can nevertheless be improved by allocating three satellite channels per conference group instead of two (one for the hub and two for the slaves). This requires an additional

1. The system described in *Section 3.1.* of this article is being patented by the European Broadcasting Union.



Codecs, modems, combiners etc. not shown
MD: modulation detector

Figure 1
The "Elegant" VSAT conference solution.

modem at each VSAT and the two modems must communicate with each other via an intelligent control system which coordinates channel utilisation independently at each VSAT.

Each VSAT upleg must be identified, probably in the overhead data of the 32-kbit/s signal, which therefore becomes about 33 kbit/s. Thus, when a VSAT receives its own signal back from the satellite, it automatically disconnects it from the "listen" mix to avoid any participant hearing delayed feedback of his or her own voice.

Another possible improvement to the "Elegant" system can be achieved by conferencing (i.e. interconnecting, via an "N-1" conference unit) the conference groups at the hub. This ensures unimpeded access for selected VSATs via the hub (e.g. the rota news editor and the sports editor), albeit via a double-hop connection, to the other VSATs. The implementation of several conference groups, as selected by the hub, can be achieved by changing the VSAT transmit/receive frequencies to match the satellite channels foreseen for each group.

If it can be made to work satisfactorily, the "Elegant" solution has the following advantages:

- All communications within a given conference group are single-hop.
- The satellite bandwidth requirement is only 0.5 MHz.
- There is no inherent restriction on the number of VSATs, because there is no requirement for a hub conference-matrix with a fixed number of 4-wire channels.

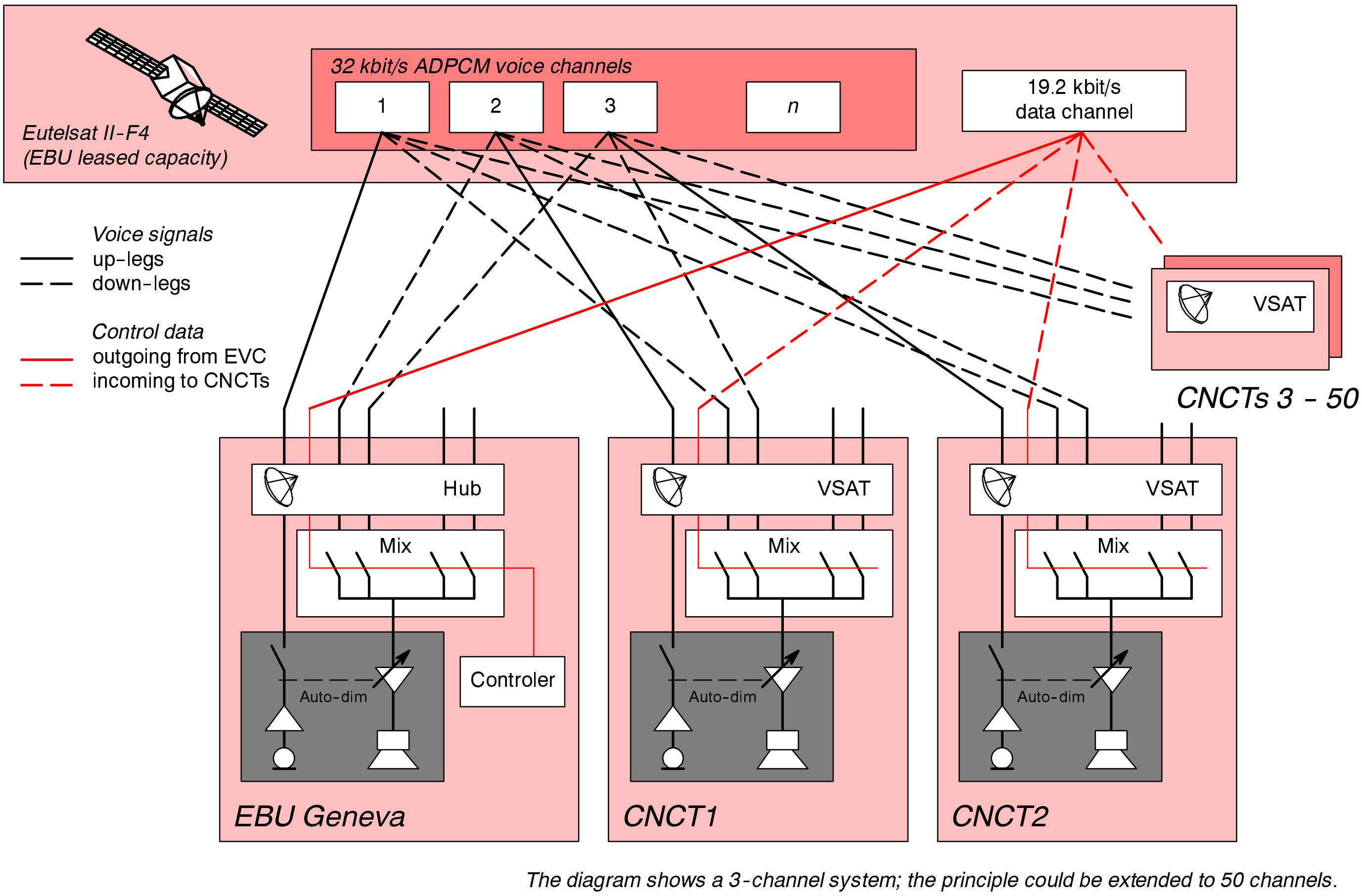


Figure 2
The "Sledgehammer" conference solution.

3.2. The "Sledgehammer" conference system

The "Sledgehammer" conference system, so named for its over-scaled use of hardware in comparison to the true size of the task in hand, is illustrated in *Fig.* 2.

This is a PAMA (PreAssigned Multiple Access) single-hop system, which requires *N-1* receive-units/demodulators at each VSAT, where *N* = number of VSATs. This solution is clearly too expensive for a 56-channel system. The number of receive-units/demodulators could be reduced cosiderably by using agile receivers but it would remain an expensive solution. Moreover the provision of four conference groups would require a very complex control system.

3.3. The "Alohah" system.

This TDMA system was invented at the University of Hawaii to facilitate satellite communications between the Hawaiian islands. The basic idea is that if a given transmitter finds that the channel it tries to utilise is occupied, it changes frequency to a different channel. The same principle is used for local area networks such as Ethernet. This approach may well be suitable for hub/VSAT data communications. However it is not well suited to voice-conference systems due to access delays.

3.4. The "Horseless Carriage" VSAT conference system.

In this solution the existing EBU conference architecture is maintained and the terrestrial 4-wire circuits are simply replaced by satellite duplex connections. This is analogous to replacing the horse by an engine, without redesigning the carriage, for the first horseless carriages. Connections between VSATs are via the hub and hence double-hop, but all EBU conference requirements presented in the introduction are met, namely instantaneous access, availability of conference groups and total flexibility.

Tests with simulated double-hop delay have shown that the delay does not cause any serious problems, provided there are no echos. The use of the normal "auto-dim" facility on microphone/loudspeaker 4-wire terminals, plus the use of echo-cancellation on the local "tails", which is a normal facility in VSAT systems, take care of this potential problem.

Compressed digital coding systems are not suitable for double-hop applications, because a VSAT-hub-VSAT connection requires two codecs in tandem. End-to-end quality is poor and the significant codec delay is unacceptable, when added to a double-hop satellite delay. Hence the EBU requirement is to use 32kbit/s ADPCM, in accordance with CCITT Recommendation G.712.

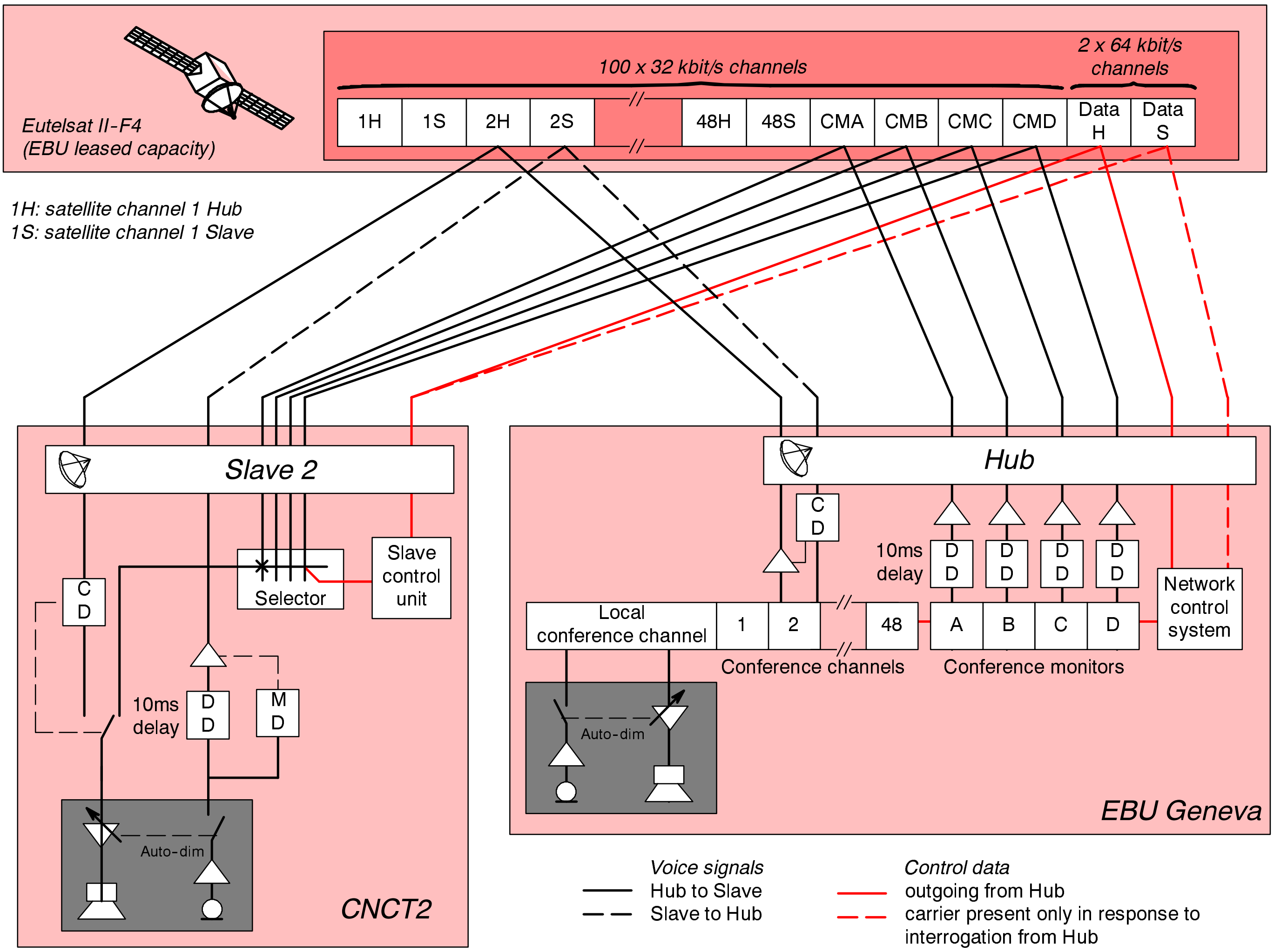
The disadvantage of the "Horseless Carriage" system is that a separate "*N-1*" signal must be sent from the hub to each slave-station, since each "*N-1*" mix is specific for a given VSAT. Therefore *N* satellite channels (48 in our case) are continuously modulated, which is unacceptable in terms of satellite power restrictions in a crowded transponder.

Multiplexing the 48 "*N-1*" signals into a 2-Mbit/s multiplex would solve this problem, but then a demultiplexer would be required at each slave-station, which is an expensive solution. It must be concluded, therefore, that the standard "Horseless Carriage" is not suitable for a 48-channel voice conference. However the system is suitable for smaller conference systems and the Arab States Broadcasting Union (ASBU) has implemented the "Horseless Carriage" with twenty VSATs connected to the hub in Algiers.

3.5. *The "Elegant Horseless Carriage" VSAT conference system*

This improved "Horseless Carriage" (see *Fig. 3*) was made possible by the realisation that all VSATs can quite well listen to a common signal from the hub, called "conference monitor *X*", except when a given VSAT is actually talking into the conference. Only then does the VSAT require its specific "*N-1*" signal from the hub. "Confer-

Figure 3
The "Elegant Horseless Carriage" conference solution.



CD: carrier detector MD: modulator detector DD: digital delay ence monitor *X*" is a mix of all conference inputs which are selected to conference group *X*, where *X* is *A*, *B*, *C*, or *D*. Since normally only one or two VSATs talk simultaneously in a given conference group, this approach greatly reduces the number of satellite channels which are simultaneously modulated. Voice-activated carriers are used for VSAT-to-hub signals and the carriers of the corresponding hub-to-slave "*N-1*" signals are activated when the VSAT-to-hub carriers are detected incoming to the hub. One of the problems with voice-activated carriers is that the first word of an intervention may be clipped. This is avoided by activating the carrier with the undelayed signal; the digital signal is then subject to some delay in the A/D coder, so it does not reach the modulator until a few milliseconds after the carrier has been activated.

Another problem with voice-activated carriers is that receivers/demodulators may take one or two seconds to lock-up to the incoming signal, especially when a satellite circuit is involved. This arises because a geostationary satellite is not really stationary at all with respect to the Earth, but moves over a 24-hour cycle, thereby tracking a figure of eight as seen from the Earth. The variable Doppler shifts caused by this movement adversely affect the lock-up time of receivers/demodulators.

This problem is overcome in VSAT systems by updating the receiver/demodulators about the exact downleg frequency to be received if a carrier appears. This updating takes place every few seconds using a periodic data signal. This facility is variously known as "keep alive" or "heartbeat", depending on the manufacturer, and it enables the receiver/demodulators to lock-up to incoming carriers almost instantaneously.

The requirement for four conference groups is implemented by distributing "conference monitor *A*, *B*, *C*, and *D*" continuously from the hub and informing each VSAT to which of these four groups they have been selected. They then automatically monitor the correct conference group. To reduce costs, each VSAT will use only two receiver/demodulators; one will be tuned to the (*N-1*) signal and the other will be tuned automatically to "conference monitor *A*, *B*, *C* or *D*" as appropriate.

There is a subtle relative timing requirement which must be respected concerning the "conference monitor *X*" signals and the "*N-1*" signals. In principle, these signals should be synchronous to ensure that words are not lost or repeated when switching between these signals at the VSAT. However in practice the "conference monitor *X*" signals must be delayed by a few milliseconds with respect to the "*N-1*" signals. This enables the VSATs to switch their "*N-1*" signal to the listen side of the 4-wire connection before the VSAT-to-hub modulation arrives back from the hub in the "conference monitor *X*" signal. If this requirement were not respected, the VSAT participant would hear an annoying burst of his own speech coming back half-a-second after starting to speak.

The "conference monitor *A*, *B*, *C*, *D*" signals block four satellite channels and each activated VSAT/hub duplex connection blocks two satellite channels. Even if, by chance, there is an overlapping conversation between two VSATs in progress simultaneously in all four conference groups, the total number of satellite channels occupied is only 20. The normal traffic situation would activate only 6 or 8 satellite channels.

The required satellite bandwidth is about 3.6 MHz for a 48-channel/4-group conference system using QPSK modulation and having forward error correction (FEC) with code-rate 3/4. This bandwidth can easily be accommodated within the leased EBU satellite transponders of Eutelsat II/F4.

Nevertheless, there is one remaining problem with the "Elegant Horseless Carriage", namely that the horse has a bit in its mouth, so when you eliminate the horse you lose one bit ...

Brian Flowers *studied engineering at the University of Southampton. In 1960, after serving for two years in the Royal Air Force, he joined BBC Television News, and in 1962 he was detached to the Eurovision Control Centre in Brussels. He has worked at all levels of responsibility at the EVC – technician, supervisor, engineer-in-charge and project engineer for the new EVC in Geneva.*

Mr. Flowers now works in the Transmission Technology sector of the EBU Technical Department.

4. Data communications

Future data communications requirements can be added to the VSAT system using standard off-the-shelf units, once the requirements have been defined. As a preliminary proposal, the author has suggested having a 64 kbit/s "broadcast" signal from the hub, incorporating global addressing or individual slave-station addresses, plus duplex 19.2-kbit/s slave-to-hub connections available "on demand", with a maximum of eight simultaneous duplex connections.

These data channels could be used for various functions within the foreseen "Eurovision Network Management System (ENMS)"[2]. Examples include:

- distribution of transmission planning synposes to EBU Member services (thereby economising on public telex service costs);
- access for EBU Members to the Eurovision Transmission Planning Procedures (TPP) computer[3];
- distribution of conditional-access authorizations to CNCTs, for use in conjunction with the scrambling facilities of digital video and/or audio codecs;
- distribution of network user information, in an electronic form of the present-day Eurovision Code of Practice.

5. Conclusions

The EBU is presently evaluating offers from four manufacturers to provide a VSAT system for the news conference and for the data communications facilities. Both the "Elegant" system (*Section 3.1.*) and the "Elegant Horseless Carriage" (*Section 3.5.*) have been proposed.

Implementation of the chosen system will reduce the cost of the news conference and message distribution by about 50%, whilst ensuring better voice quality and improved reliability.

At the time of going to press, the "Elegant" system is the clear favourite, due to its economical satellite bandwidth requirement, its single-hop delay, and its unrestricted number of VSAT terminals. In fact, the advantages of this solution are such that further work on the "Horseless Carriage" and the "Elegant Horseless Carriage" can now be regarded as flogging a dead horse.

2. See *page 35* of this issue of **EBU Technical Review**.

3. See *page 26* of this issue of **EBU Technical Review**.