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EDITORIAL

Program broadcasting and distribution constitute the technical background of the electronic media. The importance of the same increases more and more due to the world-wide growth of the media. The following two facts characterize the statement above: 100 million radio sets have been sold per annum throughout the world (with slightly decreasing tendency), while the number of TV sets sold is about 150 million (with growing tendency). The new possibilities for value-added services increase the importance of the program broadcasting network further on. Data broadcasting networks have appeared on the scene. World has been shrivelled by introduction of satellite technologies, everybody and everything can be found in the neighbourhood by means of the news and data communications.

1995 is the year of anniversaries for the broadcasting. 1895 is the birthday of the radio, hence it is 100 years old now. In 1920, 75 years ago has been established in Pittsburgh the first radio station serving exclusively for radio broadcasting. Our most important anniversary reminds us of the 70 years of Hungarian radio broadcasting, which started on its way in 1925. Nevertheless, this should not make us forget another event which happened 50 years ago: Hungarian Radio, the transmitter network of which was completely demolished in World War II, restarted in the still ruinous country.

Hungarian program and data broadcasting followed the international forefront very closely for a long time. Setting up of the big transmitter of Lakihegy was a prominent event on this way. In addition to its technical modernity, it was one of the three transmitter stations of highest power in Europe. Most recently the first satellite TV program of the region has been relized by our country.

Thus, the salute of the Journal on Communications before the broadcasting on the 70th anniversary of its start is reasonable. The present issue consists of two parts. In the first part a survey is presented by well-known Hungarian authors on the domestic history of broadcasting, on the experimental DAB just starting on its way, on the present position and prospects of satellite broadcasting, on the selective radio paging, on the value-added services of the radio broadcasting network, on the GSM system as a special and fast growing branch of the radio communications and finally on the domestic data broadcasting experiments. The restricted volume impeded presenting futher interesting topics, as well as entering excessively into details. Nevertheless we hope that the papers provide valuable and up-to-date knowledge to the reader.

The supplement of the issue makes the reader acquainted with the activity of Antenna Hungária Co., which is the unique domestic broadcasting and radio communications company for public service programs and dominant in supplying other programs as well. Each part of the activity is introduced by the experts of the Company providing a full review on the present position of the broadcasting technology.

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László Zombory is Professor of the Technical University of Budapest, Head of the Department of Microwave Telecommunications. He graduated in telecommunications engineering in 1965. He received the Dr. Univ. degree in 1972 and has been the Candidate of Tech. Sciences in 1974. He received the Dr. of Sciences degree in 1989. He was Dean of the Faculty of Electrical Engineering and Informatics of the Technical University of Budapest between 1988 and 1994. He has been Chairman of Board of Directors of Antenna Hungária Company since 1993. He is member of presidency of Scientific Society for Telecommunications. His field of activity is the technical applications of electromagnetic fields: wave propagation, EMC, microstrip lines and antennas, field-substance interaction, computer methods of modelling.

SATELLITE BROADCASTING

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For new TV programmes with nation-wide or regional international coverage the satellite transmission is generally cheaper than its terrestrial alternatives. Instead of the Direct Satellite Broadcasting System the distribution type of transmission is penetrating with technical characteristics suitable for home reception by small size dishes. With digital coding and information compression technology the transmission capacities are considerably increased.

The first satellite, the Soviet "Sputnik" went up to orbit around the Earth in 1957. Two years later pictures were transmitted to Earth by another artificial space object. The first transatlantic TV transmission was made via TELSTAR in 1962. The era of commercial satellite communication has begun.

The satellite transmission of television programs at that time was used only for point-to-point transport of television signals taken at highlighted events like Olympic games, political summits, etc. The long-distance transmission of television signal was usually carried out on terrestrial radio-relay links, but for transatlantic television links this new satellite technology was available only.

The prospect of real radio sound or television broadcasting direct to receivers of the population became a very attractive theoretical possibility, but technologically unrealistic at that time. The development of the satellite technology made possible to plan a "direct broadcast satellite service" during the 1970's. The ITU World Administrative Radio Conference allocated a frequency band (In Region 1: 11.7 – 12.5 GHz) for this kind of radio service (BSS; Broadcasting Satellite Service) and a special planning conference in 1977 drew a direct broadcasting satellite orbital position and frequency plan for the European countries.

The basic idea of the 1977 DBS plan consisted of having one orbital position and five channels for individual countries. The radiation patterns of the onboard antennas were to be designed to cover the country, but the footprint of the radiation on the surface of the Earth must not extend too much over the territory of that country.

One of the five television channels of a country might have been used for multi-channel radio sound broadcasting instead of television. According to the plan the picture would have been transmitted as an analogue signal, while the sound broadcasting was considered as a digital one.

The introduction of satellite technology into broadcasting service carried the idea of connecting the change of transmission medium with the improvement of television technology by utilization of new television standards suitable for high definition.

Soon after the approval of the DBS plan in 1977 a new television standard was proposed known as MAC system which was a hybrid analogue video and digital audio transmission scheme. With the MAC system, the colour picture signal is transmitted in pieces of separate luminance signal, chrominance signal and digital audio and control (synchronization) signal. The analogue luminance and chrominance signals are time compressed to ensure time period allowance for each component and for the digital audio-synchronization data package.

The MAC system is resistant to the intermodulation effects and helps to utilize the full power capacity of the satellite transponder. The MAC process has the capacity of the transmission of high definition television also (HD-MAC, D2-MAC).

The MAC systems, and real DBS systems, however, have not been generally introduced yet. Among the reasons there are the following two facts:

- The development of satellite power technology, receiver technology made easily possible to transmit and receive analogue TV signals transmitted via point-to-point or point-to-multipoint telecommunication satellite channels for cheap, small size earth-stations suitable even for home application.
- The approval of a common HD-TV world standard has failed. This fact together with the market attitude of not really demanding the early introduction of the high definition TV service, partly because of the continuous improvement of the conventional one, broke down the evolution.
- The promising successes of digital television using compressing technics with the suggestion that direct-to-home satellite service could be solved soon economically by this way.

In the 1980' s the TV coverage by telecommunications satellite became a widely available service all over the world, using analogue FM modulation and sometimes FDMA access to the satellite transponder.

In the moderate continental climatic zones the popular frequency band used up-link is 14.0 – 14.5 GHz and the satellite transponder output is in the 10.7 – 11.7 GHz band (Ku Band). In the tropical environment and where there is not available coverage in this band, the down link band is the C band (3.4 – 4.2 GHz). In Europe the Ku Band is used for TV coverage. The usual effective isotropic radiated power of the up-link transmitter is in the range of 72 – 77 dBW, the bandwidth of the satellite transponder is either 72 MHz or 36 MHz (in some cases 54 MHz or 27 MHz, respectively). The deviation of the carrier by the composite television signal is 25 MHz_{p-p} in the 36 MHz system and 16 MHz_{p-p} in the 27 MHz bandwidth transponder. The double bandwidth transponders (72 or 54 MHz) are generally used for two TV channels in FDMA mode. In this kind of operation the carrier power of each TV channel on the satellite transponder must be set some 4.6 dB lower than the saturation power of the transponder power amplifier due to the multicarrier back-of requirement of the non-linearity of the amplifier.

To deliver usable signal to the small size home receiver dish relatively high effective radiated power of the order of 42–60 dBWi is required. With a maximum of 1.8 m dish 40–42 dBWi radiated power level can be taken as the edge of the coverage, while 60 dBWi radiated power could be used for good quality reception with around 0,5 m antennas.

Depending on the geographical area to be served by the television program the satellite coverage can be very economical compared with the conventional terrestrial transmitter network. This time the annual rate of a TV channel on satellites is in the range of $ 3 million – $ 10 million depending on the effective power radiated, the area of the footprint with usable level, the orbital position of the satellite carrying the transponder, the program offering of the same satellite/orbital position, the availability of the channel (protected, non-protected, preemtible for restoration of other services, system background of the satellite operator capable of substituting the satellite in case of emergency, etc.). This price of leasing of TV channel is much lower than the operational cost and maintenance of a terrestrial network even in a small country like Hungary. For new national TV programs considering the lack of usable frequency set for terrestrial solutions the satellite alternative may be the only possibility.

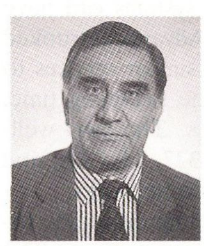
The burden of this kind of program coverage is on the viewer. In spite of the fact, that the price of an individual satellite receiver is only half of the average price of a good quality colour set, it is not realistic to expect that the majority of the population will acquire a satellite receiver. For that reason the satellite TV is strongly bound to the cable TV system. The satellite TV was the engine of the proliferation of cable TV in the end of the 1980's at least in Central and Eastern Europe, and probably the existence of a good coverage of cable TV will pave the way for the rush increase of satellite TV coverage by the presently most common analogue system or already in the near future by the systems using compressed digital transmission format.

Recently the INTELSAT, the biggest satellite service provider of the world made a demonstrative digital TV transmission, in which more than 50 TV channels were delivered on only one standard 72 MHz transponder with a quality suitable for supplying cable headends.

Even for Hungary we have an offer for commercial lease of a 36 MHz transponder for transmission of four digital TV channels for distribution of cable programs in 8 Mb/s stream.

It is an expectation that the commercially available digital TV receiver-demodulator-decoder will go to market at the end of 1995. It will be a set top unit using the conventional TV set to display the program. The key issue is the construction of the specific large scale integrated chips consisting the necessary circuitry.

The acceptance of the MPEG-II standard for coding digital TV will certainly accelerate the process that will transform broadcasting to digital. It can be foreseen that the real direct broadcasting via satellite will be based on the digital compressing technology. Meanwhile the satellite TV broadcasting carried on by telecommunication channels in the FSS (Fixed Satellite Service) radio service will continue to be a very popular solution either as distribution medium to cable systems or even as DTH (direct-to-home) applications. In some cases this kind of service tends to occupy the frequency band allocated for BSS (Broadcasting Satellite Service) because the FSS band can not provide enough channels to the program offer of co-located satellites.



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INTRODUCTION TO THE GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

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This paper gives a comprehensive overview of the GSM network architecture. The functionality of the various network elements is analyzed. The peculiarities of the radio path and signalling are described. Services, charging and future developments are presented.

1. MOBILE RADIO SYSTEMS

Mobile telecommunications are a rapidly evolving technology. In the beginning of mobile telephony expensive vehicle mounted sets were available and mobile radio services were luxury products for few. Now, in the 1990's this technology reached a mass-market and tends to be so common for many as wired telephony.

Numerous mobile telecommunications systems have been developed after World War II to provide services for different markets. These mobile radio systems can be classified into the following categories:

1. Public Land Mobile Networks (PLMNs). The architecture of PLMNs is based on the principle of cellular coverage. The service area consists of cells which are formed in such a manner that the properties of the wave propagation over the earth are taken into account. These systems provide advanced telecommunications services as well as access to the PSTN. Eventually they can be regarded as wireless extensions to the fixed telephone network. Such systems are the AMPS, TACS, NMT, GSM, DCS etc. The DECT and the cordless telephone systems are also reckoned in this category although they provide access to global systems such as the PSTN or PLMNs.

2. Dispatcher Land Mobile Networks are mainly private networks providing services for business users. Communications are performed between base stations and mobiles, or group of mobiles. Both speech and data services are possible, although the former is usually limited to simplex transmission. Private dispatcher systems are often separated, typically they satisfy the telecommunications requirements of a company. Dispatcher systems can have access to the PSTN or to PLMNs. Advanced trunked cellular dispatcher systems provide very similar services to those in a PBX. The difference is in the switching time, the tariffs and the optimum service types. The most well-known DLMNs are the MDTS, MPT 1327, TETRA, and the various private and public mobile data networks.

3. Pager systems provide one-way communications towards the paged person through selective paging. The transmitted information is typically some kind of data. Depending on how sophisticated the system is, pagers provide a simple sound alert, light signal, numeric or alphanumeric information displayed on a small display. Intelligent value added services, like storing and forwarding or repeating messages, are also possible. Messages can get to the receiver through an operator or they can directly be entered from the PSTN. Paging networks can be operated independently or as a supplementary service to another existing service. Independent paging services are provided by e.g. the POCSAG or the Pan-European ERMES systems. Paging functions can also be realized with the help of UHF FM broadcasting systems, radio data networks, DECT, GSM or DCS systems.

4. Satellite telecommunications systems can provide all those telecommunications services that can be provided by terrestrial networks: telephony, extension to the PSTN, data transmission, radio and television broadcasting, positioning, etc. They are classified as LEO, MEO or GEO systems according to the orbit of the satellites applied. GEO satellites are used for telephony, data transmission, radio and television broadcasting, business purposes, VSAT and GPS systems. Such satellites are applied in EUTELSAT, INTELSAT and INMARSAT. In the future, several LEO and MEO systems are planned to be introduced, too. Among these there are smaller systems that periodically scan the surface of the Earth and use a store-and-forward technique to transmit information (ORBCOMM, VITA). Other systems, such as ARIES, IRIDIUM, GLOBALSTAR, INMARSAT Project 21 and ODYSSEY plan to provide a continuous cellular coverage and real-time transmission with high number of satellites.

Mobile radio systems underwent a rapid evolution recently. This process is likely to lead to a new generation of mobile systems by 2000. The Universal Mobile Telecommunications System (UMTS) will provide services as far as possible identical to fixed networks in a wide range of environments. It will support a great variety of mobile terminals and will provide world-wide inter-operability.

2. CELLULAR SYSTEMS

Early mobile radio systems based on a single transceiver station located at a favourable geographical location. Mobile terminals communicated via the central transceiver station, and the service area of the system was limited to the coverage area of the base site. However, with decreasing weight mobile terminals have a limited transmission range. The power density of radio waves decreases rapidly at high frequencies. Moreover, ground reflections and obstacles introduce a lot of additional attenuation in the radio path, thus limiting the service area. Another problem is spectrum scarcity; the available frequency range for mobile services is limited.

Cellular systems are based on a large number of reception and transmission devices (base stations). This architecture allows high traffic density in a wide area in spite of both above mentioned problems. Using a number of base stations allows low-power mobile stations to access the system anywhere. Spectrum scarcity is circumvented by the reuse of radio resources. Frequencies used in a given cell are reused a few cells away, at a sufficiently high distance, where the interference falls below an acceptable level. In order to maintain the communication at cell boundaries cellular systems allow handovers between cells.

Cellular systems are characterized by their spectral efficiency. The spectral efficiency is determined by the frequency reuse factor and the modulation and diversity techniques used in the system. It can be improved by using appropriate system architecture, controlling the transmitted power, using frequency hopping and discontinuous transmission. All these means aim at decreasing the interference and, thus, reducing the minimum distance of frequency reuse.

3. THE GSM SYSTEM – NETWORK ARCHITECTURE

The architecture of a GSM network is shown in Fig. 1. The network is composed of four subsystems: the Mobile Station (MS), the Base Station Subsystem (BSS), the Network and Switching Subsystem (NSS) and the Operation Subsystem (OSS). Functional units within the system are separated by interfaces. Such interfaces are the Air interface (MS-BSS), the Abis interface (BTS-BSC) and the A interface (BSC-MSC).

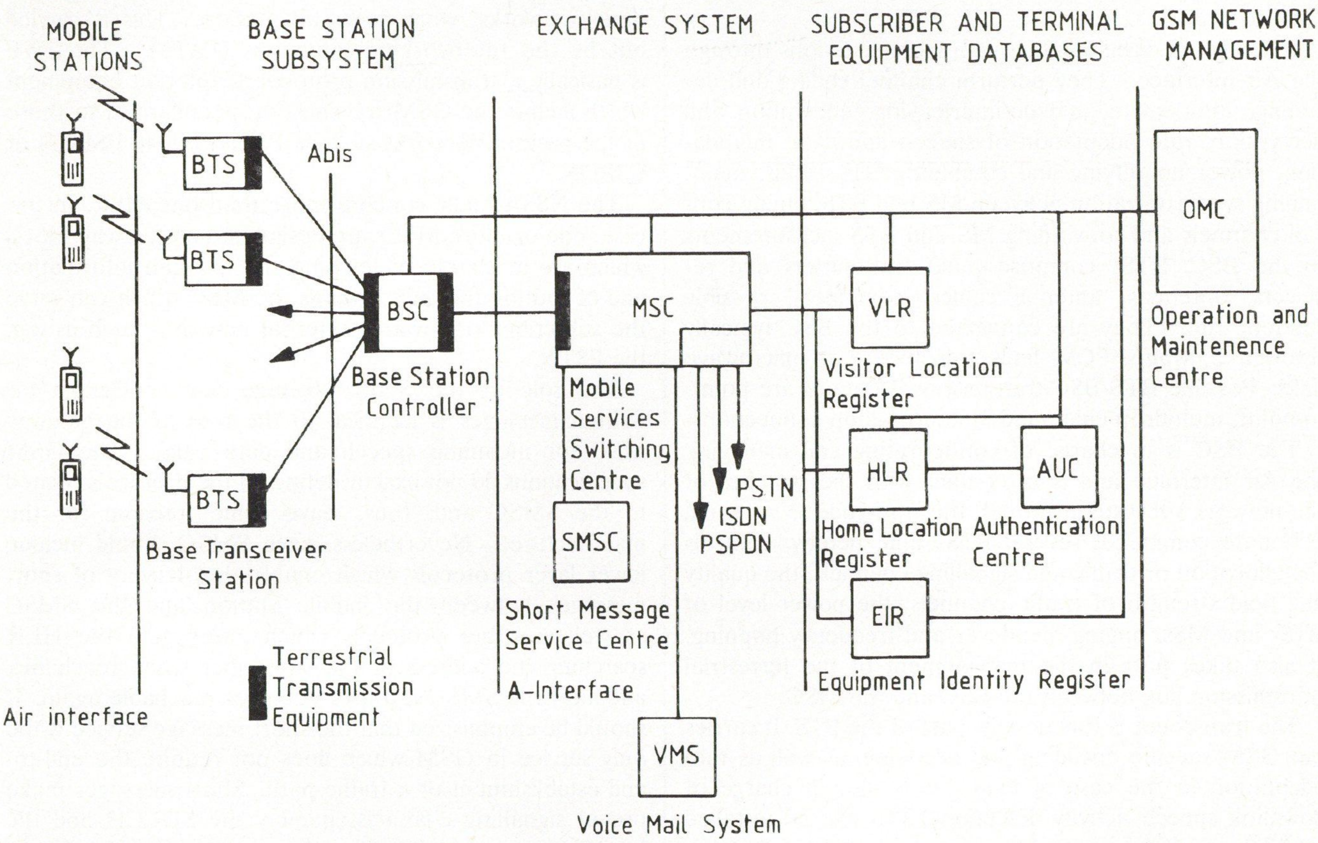

Fig. 1. GSM network architecture

4. MOBILE STATION

Mobile Stations represent the only equipment that ordinary users ever see from the whole system. Being a mobile termination, MSs carry out, among others, all functions related to transmission on the radio interface. A mobile station is also a terminal equipment executing functions specific to the service: e.g. fax machine. MSs can possibly act as terminal adaptors realising a gateway function between the terminal and the mobile termination. In other words, beside radio and processing functions to access the network, mobile stations offer either an interface to the human user (such as microphone, loudspeaker, display and keyboard) or an interface to some other terminal equipment (such as interface towards a PC or a fax machine).

A MS has two main working states. In idle mode, it listens to the broadcast channels (see later) but it has no channel of its own. In dedicated mode, a bi-directional channel is assigned to it for its communications needs.

The term mobile station generally includes a smart card, the so called SIM card, on top of the mobile equipment. The Subscriber Identity Module is a kind of key to the mobile station: once it is removed, the mobile can only be used for emergency calls. It contains subscriber specific information on the local provision of services to the user. It serves as a telephone directory, stores short messages and the list of preferred networks, and later — when real-time advice of charge becomes reality — memorises charging information as well.

The SIM is involved in all security functions such as the authentication of subscribers, radio path ciphering and subscriber identity protection. The SIM plays an important role in roaming, too. SIM roaming offers inter-operability to users between systems with different radio interface. Subscribers do not need to carry their mobile stations; they should only take their SIM card with them and they can use different mobile equipment to access different networks. Last but not least, it should be remarked that the SIM card can be protected by a subscriber chosen password.

5. BASE STATION SUBSYSTEM

The base station subsystem includes all the transmission facilities, which are specific to cellular radio aspects. Three major functional units are included: the Base Transceiver Station (BTS), the Base Station Controller (BSC), and the Transcoders (TCs).

BTSs are in direct contact with mobile stations through the Air interface. They perform channel coding and decoding, interleaving and de-interleaving, encryption and decryption, rate adaptation of speech and data, modulation, power amplifying and combining RF signals, maintaining synchronization between MS and BTS, timing control channels and forwarding MS and BTS measurements to the BSC. BTSs comprise radio transmitters and receivers, antennas, antenna cables, combiners, possibly splitters, etc. They are connected to the BSC typically through 2 Mbit/s PCM lines transferred on microwave links. Possible BTS-BSC transmission solutions are point-to-point, multidrop chain and multidrop loop connections.

The BSC is in charge of configurating and managing the Air interface and is in contact with the switches of the network subsystem through the transcoders. As such, it remote commands several BTSs and, hereby, controls the allocation of traffic and signalling channels, the quality and field strength of traffic channels, the power level of BTSs and MSs, paging, handover and frequency hopping. It also takes part in the management of the terrestrial transmission link between the BSC and the MSC.

The transcoder is functionally part of the BTS. It carries out GSM-specific encoding and decoding, as well as rate adaptation in the case of data. It is also in charge of downlink speech activity detection. TCs can be installed in BTSs or in a remote location such as the BSC or even the MSC. By moving the transcoders to the BSC or to the MSC, operators can save cost of the terrestrial transmission link, as TCs have a gateway function between 16 and 64 kbit/s transmission; the transmission capacity between the BTS and the TC can be reduced to 16 kbit/s.

6. NETWORK AND SWITCHING SUBSYSTEM

The main role of the network and switching subsystem is to manage communications between GSM users and other telecommunications network users. It has two functional parts: the exchange system and the subscriber and terminal equipment databases. The exchange system comprises the Mobile Services Switching Centre (MSC) and potentially other service centres, such as e.g. the Short Message Service Centre (SMSC). The subscriber and terminal equipment databases contain the Visitor Location Register (VLR), Home Location Register (HLR), Authentication Centre (AuC) and the Equipment Identity Register. Another functional unit of the NSS is the Voice Mail System (VMS) which does not actually fit in either of the above functional parts and is not defined by GSM specifications.

The MSC performs the basic switching and routing functions within the NSS. Its main function is to coordinate the setting-up of calls to and from GSM users within its service area. The difference between the MSC and an ordinary telephone exchange is that the MSC has additional functions to take into account the allocation of radio resources and to cope with the mobility of subscribers. These functions include location registration, paging, the handover procedure and transferring encryption parameters and dual tone multifrequency signalling.

The MSC is also a gateway for communicating with other networks, what needs adaptation. This is carried out by the Interworking Functions (IWFs). The IWF is basically a transmission protocol adaptation equipment which adapts the GSM transmission peculiarities to those of the partner networks such as PSTN, ISDN, PSPDN or CSPDN.

The NSS usually contains more than one MSC. In this case, one or more MSCs are designated as gateway MSCs which are in charge of fetching the location information and of routing the calls towards the MSC which can serve the subscriber or towards external networks such as e.g. the PSTN.

The role of the Short Message Service Centre for written messages is identical to the role of the gateway MSC for incoming speech and data calls. The GSM specifications do not exactly define all the protocols related to the SMSC and, thus, leave some freedom for the manufacturer. Nevertheless, each SMSC should include lower layer protocols which enable the delivery of short messages between the mobile station and the SMSC as well as other protocols which interrogate the HLR searching the address of the subscriber when reachable, and alert the SMSC if a user becomes reachable again. It should be emphasized that the short message service is the only service in GSM which does not require the end-to-end establishment of a traffic path. Short messages make use of signalling channels (namely the SDCCH and the SACCH channels), therefore, they can be transmitted even when the mobile is engaged in full circuit communications.

The HLR is a database which contains subscriber-specific information relevant to the provision of telecommunications services and the current location. The HLR identifies whether a given teleservice or bearer service can be provided for a subscriber. Information on supplementary services is not necessarily stored in the HLR.

Two numbers belong to each subscriber in the home location register: the Mobile Station International ISDN number (MSISDN) and the International Mobile Station Identity (IMSI). The MSISDN is the directory number which is dialled in order to contact a mobile. It defines the service of a subscriber and not the subscriber's telephone equipment. This means that subscribers have different MSISDNs for different services. The IMSI is the unique identification number of a SIM card, used within the GSM network. It is allocated and cross referenced with MSISDN at initial subscription and stored in the HLR, AuC and SIM.

The HLR enables to forward calls towards the MSC/VLR within the service area of which the moving subscriber is situated by storing some location information, including at least the address of the visited MSC/VLR and the identification of the local MS, and by requesting the visited MSC/VLR to provide a Mobile Station Roaming Number (MSRN).

Beside HLR, another database function is realized in GSM: the Visitor Location Register (VLR). VLRs are connected to one or several MSCs, each controlling a number of cells and being in charge of temporarily storing subscription data for the subscribers currently situated in the service area of the corresponding MSC(s), as well as of holding data on their location at a more precise level than the HLR.

In GSM cells are grouped to compose location areas. Each time a mobile crosses the boundary of two location areas or it is switched on in a different location area than the one where it was last successfully registered, it attempts to register the subscriber by performing a location updating procedure. The result of the last location update attempt is stored in the SIM. During location updating, information on the subscriber is fetched from the HLR to the VLR. By doing so, VLR takes part in the authentication and handover procedure, supports encryption and handles supplementary services and short messages.

The management of security data for the authentication of subscribers is carried out in the Authentication Centre (AuC). In order to protect the network against unauthorized use, the authentication of the GSM subscriber identity can be applied at each registration, each call set-up attempt and before performing activation, deactivation, registration, or erasure of supplementary services. The principle of authentication is to compare the subscriber authentication key (the so called Ki number) on the network side with the Ki in the SIM without ever sending it. The AuC is the network element which stores the Ki number on the network side. It contains encryption parameters and a random generator as well. The AuC is actually a functional subdivision of the HLR but it can be a separate network element, too.

The GSM specifications identify a network element specific to MS management, called Equipment Identity Register. It is a database which contains information about mobile terminals. Here MSs are referred to by their unique International Mobile Equipment Identity (IMEI) number. Three different lists are used for IMEIs in the EIR. The white list includes the range of IMEIs allocated to type approved mobile equipment, the grey list is for terminals that need to be observed for some reason and finally the black list includes the IMEIs of mobile stations which need to be barred, either because they have been stolen or because of severe malfunctions.

The Voice Mail System enables to store voice messages. Incoming calls can be forwarded into the subscriber's voice mail box when he is busy, is out of the coverage, is switched off, does not answer or activates unconditional call forwarding into his voice mail box. Some VMSs can also provide an intelligent alert system. Repeated delivery calls can inform the subscriber of a new message in his voice mail box. The timing of such calls follows a timing matrix of which the rows correspond to the possible reasons why the call was forwarded into the voice mail box. When the GSM system contains an SMSC, delivery calls can be combined with short messages: a short message is delivered to the customer subsequent to receiving a message in his voice mail box and delivery calls are only activated if the short message was unsuccessfully delivered.

From architectural point of view the VMS is divided into message storage units (winchesters) and call, message and alarm management units.

7. OPERATION SUBSYSTEM

The Operation Subsystem enables the operator to monitor and control the GSM network. According to Telecommunications Management principles, on the one hand the OSS is linked to major network elements such as the MSC, BSC, HLR and others (BTSs are accessed through BSCs), on the other hand it provides a man-machine interface for the operation personnel. The network element which is in contact with BSS and NSS machines is called Operation and Maintenance Centre (OMC). An OMC typically consists of a database for network data and a couple of workstations which are in charge of managing the OMC database and are in connection with other network elements. A GSM network can include several OMCs; in such a case OMCs are linked together.

The OSS enables the operator to continuously check the quality of the service provided for users through measuring parameters like traffic, congestion, handovers, dropped calls, interference, etc. This feature helps to find the bottlenecks and problematic areas in the system. It also provides means to modify the network once a reaction to a given problem is decided. OMC plays an important role in the daily maintenance, too. It collects and displays alarms from all network elements and, thus, allows the operator to detect, locate and correct faults and breakdowns in the system.

8. FROM SPEECH TO MODULATED SIGNAL

In GSM speech undergoes multiple signal processions in the transmission path in order to overcome problems on the Air interface. Fig. 2 shows the sequence of operations performed in the MS and the BTS to convert speech into radio waves and back to speech.

First the analogue speech signal is segmented and then the segments of 20 ms are transformed into a digital information stream at a rate of 13 kbit/s (1 segment is coded into 260 bits). Due to the limited bandwidth available in the radio path, a special speech coding algorithm is used called LCP-LTP-RPE coding. This algorithm applies three filters in succession: a pre-emphasis, a Linear Prediction Coding and a reverse Long Term Prediction filter. The LPC and LTP filters are chosen in such a way as to minimize the energy of their input signal; their parameters are transmitted in the speech frame.

It is important to know that GSM speech coding is optimized for speech, therefore, it is not appropriate for coding e.g. music.

Channel coding introduces redundancy into the data flow to allow detection or even correction of signal errors during transmission. It is a two-step procedure: first block coding adds a parity or check sum to allow us to detect errors then convolutional coding generates two bits from each incoming bit to enable to correct any errors detected within a block by the block coding. The principle of the latter coder is that the output not only relies on the state of a single bit but also on the preceding bits.

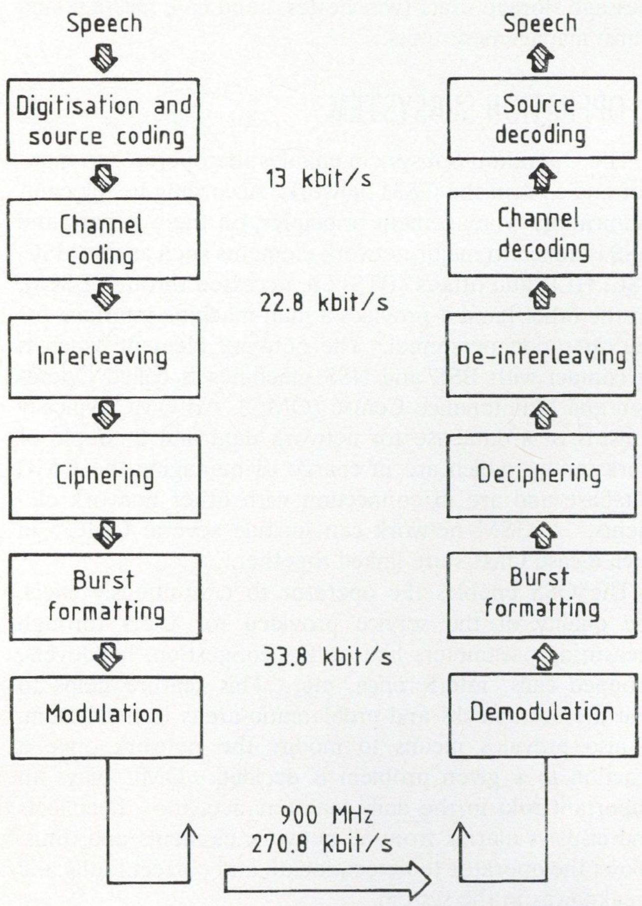

Fig. 2. Operations needed to transform speech into radio waves and back to speech

The channel coding is able to detect and correct errors if there is not more than 12.5 % loss of information during the transmission and if the loss is spread out within a burst (bursts are discussed in the next section). However, the Air interface is changing all the time (e.g. due to flat fading and selective fading) and it is inevitable that sometimes even a higher percentage of information will be lost. It is generally assumed that the Air interface remains constant for the period of one burst (about 577 μs); the probability of disturbances lasting more than one burst period is relatively low. Therefore, if we manage to mix up our bits of information in such a way that the loss of a whole burst results in not more than 12.5 % loss of information, we can substantially reduce the possibility of error during transmission. In order to achieve this, bits are moved around within a burst during the first level of interleaving followed by a second level which mixes halves of the successive bursts. In this way, the loss of information through transmission is minimized at the price of introducing a time delay of 40 ms in the transmission path.

Ciphering modifies the bit flow through performing an exclusive or operation between the information bits of a normal burst and a pseudo-random bit sequence derived from the TDMA frame number and the so called ciphering key (Kc) established previously through signalling means. This operation aims at protecting user data on the Air interface. The algorithm used to generate the pseudo random sequence (A5) was developed for military applications; it is distributed under severe conditions by GSM MoU.

Burst formatting helps the synchronization and equalization of the received signal by adding some binary information to the ciphered bit flow.

Finally, modulation transforms the binary signal into phase shift of a high frequency radio wave. The modulation method applied in GSM is called Gaussian Minimum Shift Keying. In GMSK the outgoing phase shift is smoothed in order to reduce the necessary bandwidth. However, this reduction of the frequency spectrum has a counter-effect as well, the intersymbol interference: each data bit influences the signal during a period exceeding the bit duration.

The modulated signal is then radiated as radio waves. On the receiver side reverse operations should be performed in order to convert it back to speech.

9. RADIO PATH

A specific 900 MHz band, called primary band, is allocated for GSM on the frequency axis. The primary band for phase 1 GSM services includes two subbands of 25 MHz each, 890 – 915 MHz for the uplink (MS to BTS) and 935 – 960 MHz for the downlink (BTS to MS). Within these bands, 124 different frequency slots of 200 kHz were defined, starting 200 kHz away from the band borders.

The GSM Air interface uses combined FDMA and TDMA technique. The transmission quantum is called burst. A burst is a series of modulated bits, it has a finite duration (about 577 μs) and occupies a finite frequency range of 270 kHz. The time and frequency window, in which a burst fits, is called a slot. Bursts are not identical; with regard to their amplitude profile, normal, access, synchronization, frequency correction and dummy burst are distinguished.

The description of the time axis, which is one of the most difficult issues in GSM, refers to TDMA frames that is a succession of 8 slots. TDMA timeslots are called physical channels. Onto the physical channels several logical channels are mapped. Logical channels are organized in such a way that signalling occupies minimum space whilst the required service is still maintained. This enables to use the remaining channels for traffic.

The organization of logical channels depends on the application and the direction of the information flow (uplink, downlink or both directions). Logical channels belong to one of the following four categories:

1. Traffic Channels (TCHs) are intended to carry speech or data with limited data transfer rate. In phase 1, only full rate TCHs are in use which carry speech coded at 13 kbit/s. In phase 2, half rate traffic channels carrying speech coded at 6.5 kbit/s will also be introduced. The transfer rate of the information bits is lower than the data transmission rate in the traffic channels; it is 9.6 kbit/s for full rate coding and 4.8 kbit/s for half rate TCHs.

2. Broadcast Channels carry downlink information. Such channels are the Frequency Correction Channel (FCCH), the Synchronization Channel (SCH) and the Broadcast Control Channel (BCCH). The FCCH and the SCH transmit information needed for the mobile to stay synchronized with a cell. The BCCH contains general information about the BTS. When a mobile station is switched on and not engaged in communications with the BTS (idle mode), it listens to the BCCH channel.

3. Common Control Channels (CCCHs) are used to access the BTS or MS, and as such they are associated with a particular MS. The Paging Channel (PCH) is a downlink channel used to page the mobile if there is an incoming call for it. The Random Access Channel (RACH) is used by the MS to initiate a call set-up, to respond to paging and to request an SDCCH channel. When an SDCCH channel is assigned to a mobile, it is indicated on the Access Grant Channel (AGC).

4. Dedicated Channels include three logical channels. One of them is the bi-directional Stand Alone Dedicated Control Channel (SDCCH) which is used during call set-up (e.g. authentication, TCH assignment) and location up-dating. The second is the Slow Associated Control Channel (SACCH) which is associated with each SDCCH and every TCH. It is used to transmit measurement samples, to control the power and to maintain the correct timing alignment of mobiles. Finally, the Fast Associated Control Channel (FACCH) is used to exchange information in a much quicker manner than would be possible by using the SACCH (e.g. when a handover is performed). It is used in "steal" mode: it replaces 20 ms of speech.

Logical channels are usually organized in such a way that signalling channels take up one timeslot out of the 8 slots of a TDMA frame. The remaining 7 timeslots carry traffic channels. An optimum organization of logical channels in a cell with one transmitter (TRX) is, therefore, the following:

TS0: FCCH, SCH, BCCH, CCCH
TSl to TS 7: 1 TCH/F each.

Frames transmitted on the Air interface are organized in multiframes, superframes and hyperframes. The frame structure is shown in Fig. 3. TCHs, FACCHs and SACCHs use 26 TDMA frame multiframes, the rest of the logical channels are organized in 51 TDMA frame multiframes.

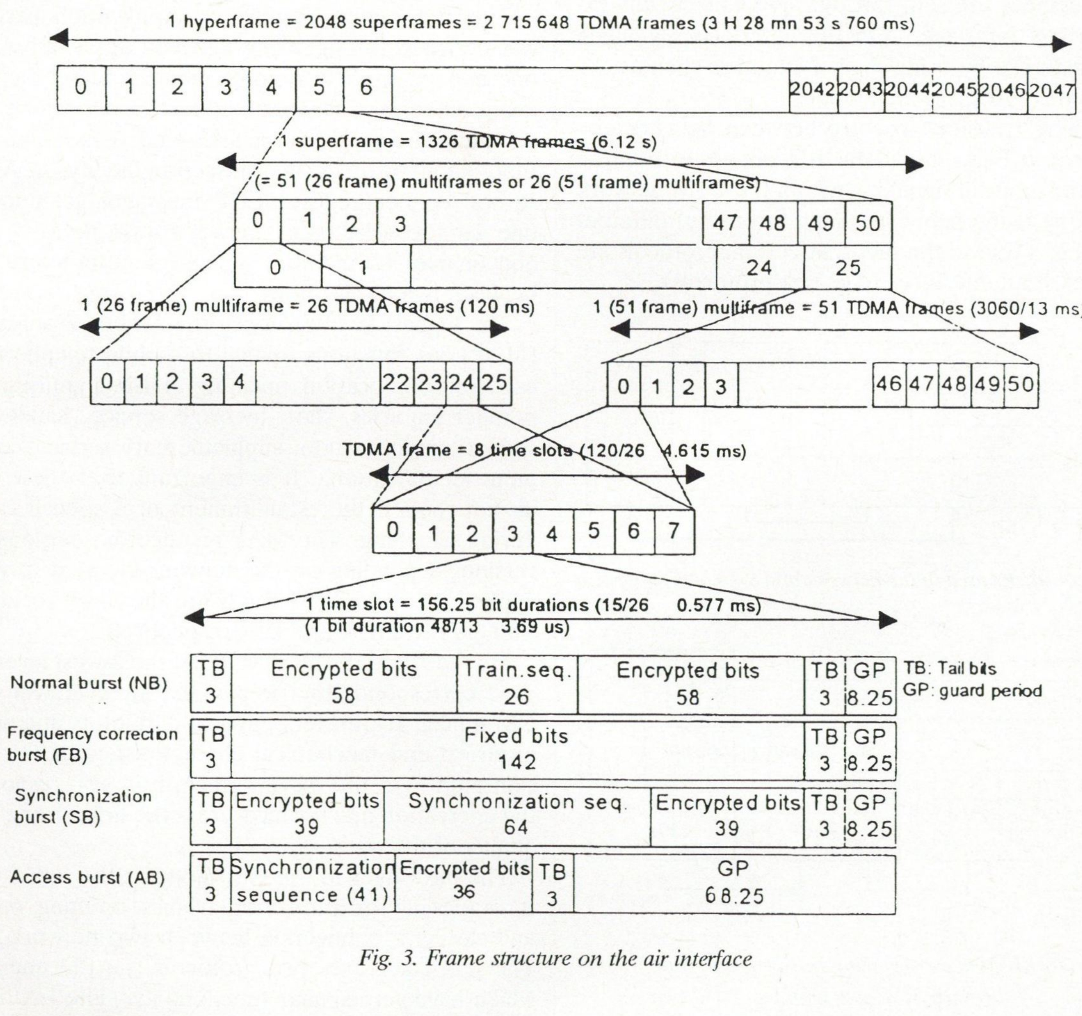

Fig. 3. Frame structure on the air interface

10. SIGNALLING

Signalling is a transfer of data that enables speech or data connections between users. It is needed for establishing, maintaining and releasing calls as well as for performing specific functions such as subscriber administration, location updates, handovers, transferring short messages, controlling charging, services and network elements. It is actually the glue which sticks together the different machines of the GSM system.

GSM networks widely use the CCITT Common Channel Signalling System Nr. 7 which is also used in PSTN and ISDN networks. However, depending on national regulations, the PSTN can make use of channel associated signalling. In such a case, the internal SS7 signalling of the GSM network should be converted into channel associated signalling in or after the GMSC. In the description hereafter, we assume that SS7 signalling is implemented in the PSTN.

In SS7 one PCM timeslot is assigned to handle the signalling of several other timeslots of the same PCM line or might as well of different PCM lines used for speech. Messages transferred through signalling contain information about the circuit to be signalled, the origin, the destination and the length of the message. The message structure also enables error detection and correction. Furthermore, in order to make signalling connections more reliable, it is possible to route signalling differently from signalled calls. Signalling messages are sent through 64 kbit/s circuits except for the Air interface. On this interface, signalling data are transferred by using logical channels such as the SACCH and the FACCH (steal mode).

The signalling transfer structure between network elements is shown in Figs. 4a and 4b. It is apparent from the figures that the internal signalling within the GSM network is performed by using many (perhaps too many) different protocols. This is due to the fact that certain protocols are not the same on all interfaces (e.g. link protocols).

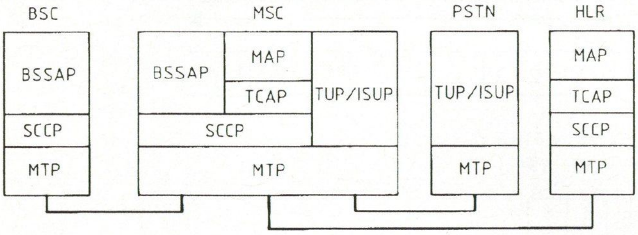

Fig. 4a. Protocol stacks used in the network and switching subsystem

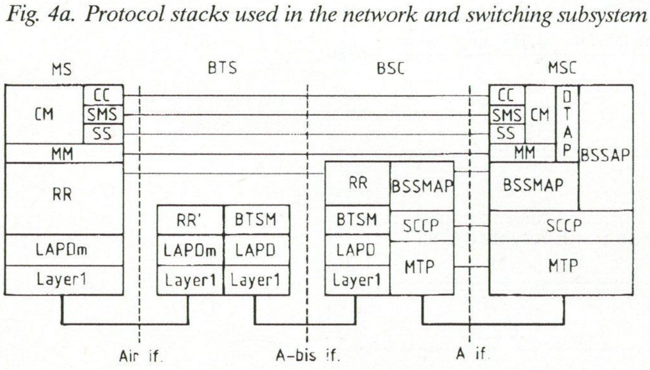

Fig. 4b. The protocols used for signalling between MSC and MS and between MSC and BSC

The same protocols should exist in each layer of two network elements if they wish to communicate with each other. This is called the principle of the peer-to-peer communications.

In the NSS, the lowest level protocol is the Message Transfer Part (MTP). It is responsible for transferring messages through the signalling link, routing the signalling information to the proper PCM line, controlling and testing the signalling network. It provides a physical interface to higher level protocols. The MTP can be divided into three levels; level 2 matches with the OSI layer 2.

The Telephone User Part (TUP) (or ISDN User Part – ISUP) defines the necessary telephone signalling functions used in SS7 for international telephone call control. It only uses the services of the MTP and of the SCCP in some cases. TUP signalling data are included in MTP messages.

The main task of the Signalling Connection Control Part (SCCP) is to provide different classes of services for upper layers. From these service classes only two are used in GSM. Connection-oriented services provide means to establish a virtual connection between two network elements. In connectionless mode SCCP enables to transfer signalling messages through the network without exactly knowing the network structure. In this case no speech connection is set up (e.g. location update when roaming) and routing is performed by adding and analysing a so called global title.

The Transaction Capabilities Application Part (TCAP) was designed for signalling between applications. On the one hand it provides a component handling facility which enables to operate the data units, through which two users communicate (e.g. commands and responses). On the other hand, through the transaction facility, TCAP handles several connectionless SCCP messages (components) as one context (dialogue) between two network elements and enables to maintain several simultaneous dialogues between two applications.

The highest level protocol, the Mobile Application Part (MAP) has functions related to mobile telephony such as call control, location updating, HLR inquiries, roaming number inquiries, short message service, handovers, subscriber administration, supplementary services and equipment identification. It is important that these functions do not require the establishment of a speech connection during signalling. The MAP protocol has various different versions depending on the network element to which it is applied. MAP-M, V, H and E are the MAP versions of the MSC, VLR, HLR and EIR respectively.

On the Air and Abis interfaces, the lowest layer protocol used corresponds to the physical layer (Level 1) of the OSI model. It transfers physical data units and defines the electrical and mechanical characteristics of the transmission path. On the Air interface, it is also responsible for the encryption and for measuring the field strength and the quality of the radio channel.

The next layer in the OSI model is the link layer which is responsible for transferring frames, opening, maintaining and closing a connection between two network elements. The link layer uses two protocols (LAPD and LAPDm) which have very similar functionality. The LAPDm (Link

Access Protocol on the Dm channel) has actually been developed from the LAPD protocol used in fixed networks.

The Base Station Application Part (BSSAP) carries out functions including call control, location updating, handover management, paging, etc. The network layer of BSSAP is divided into three hierarchical sublayers: Radio Resources Management (RR), Mobility Management (MM) and Connection Management (CM). The RR protocol is responsible for establishing, maintaining and releasing physical connections for control channels and for routing messages to the appropriate channel. The MM layer is in charge of user identification and subscriber equipment registration, as well as of some security measures related to the radio path. The CM protocol is further split into a Supplementary Services layer (SS), a Short Message Service layer (SMS) and a Call Control layer (CC) which is used to set up, maintain and release calls.

The application layer of BSSAP is divided into two parts. The Direct Transfer Applications Part (DTAP) carries CM and MM sublayer messages between the MSC and the MS. The Base Station Subsystem Management Application Part (BSSMAP) is responsible for the signalling between the MSC and the BSC.

Finally, for OMC connections, either the OMAP protocol (hierarchically above TCAP) and the SS7 signalling network or other networks such as e.g. the X.25 packet switched network, can be used.

11. SERVICES AND CHARGING

GSM provides a great variety of telecommunications services for the user. These services are divided in two categories: bearer services and teleservices. Bearer services provide the capability to transfer data between data interfaces. They include transparent and non transparent data transmission capabilities in different modes with different speed. In the case of teleservices, the communications between users take place by means of terminals. Such services are the speech transmission, short message service, MHS access, videotext access, teletext transmission and facsimile transmission.

In addition to bearer and teleservices, there are supplementary services which modify or supplement basic telecommunications services. They are offered together with a basic service and are applicable to a number of telecommunications services. Supplementary services include call forwarding, call hold, call waiting, call barring, calling and connected number identification presentation/restriction, advice of charge, closed user group, multiparty service, call transfer, etc.

In GSM subscribers not only have access to the services provided by their home operator's network but they can enjoy a service area which theoretically extends to 67 countries in the world. This feature is called roaming. If administrative issues, like charging and subscription management, are solved between different network operators, a single piece of equipment enables the subscriber to access different networks.

A regular telephone bill for a GSM subscriber contains an operator defined fixed (monthly) fee and a varying per call or per minute fee. The use of different networks such as the PSTN or other PLMNs also has an impact on the total cost. In normal cases charging starts when the called subscriber answers. However, it is theoretically possible (although not usual yet) to charge about some signalling connections, too.

Charging is based on collecting toll tickets on each transaction. Toll tickets are individual records created by MSC/VLRs and by GMSCs. Such a charging record contains information necessary to calculate the call charges. It includes the numbers of the calling and called subscribers, starting and ending time of the transaction, time and type of the day, transaction type, bearer capability used, teleservice used, etc.

The general principle in GSM is that the calling subscriber is charged. However, the total cost of the call depends on the location of both the calling and the called subscribers. Therefore, in certain cases charging is divided between the calling and the called parties:

1. When the called subscriber is roaming outside of his home PLMN, the calling party is unaware of his actual location and, therefore, can not be charged for using international networks. In such a case, the cost of the international leg is covered by the called subscriber.

2. The same principle is used when the called party activates call forwarding: the called subscriber is charged for the cost of the call forwarding from his home GMSC.

3. Probably the most subscriber annoying principle of GSM charging is applied when both the calling and the called parties are roaming outside of their home PLMNs. In this case, both of them pay for the international leg even if they happen to use the same network as calls are routed back and forth between the two countries. Today great efforts are made to solve this problem by working out the specifications of optimum routing.

12. FUTURE DEVELOPMENTS IN GSM

GSM is an evolving standard. The GSM specifications were designed to be implemented in three phases. In the current GSM networks the phase 1 GSM specifications are implemented with some phase 2 features in certain cases. In the meantime there is an ongoing standardization work within the scope of the European Telecommunications Standards Institute (ETSI) which aims at developing the new phase 2 specifications for GSM. GSM phase 2 and phase 2+ will introduce a lot of functional enhancements compared to phase 1 and will make use of the experiences gained in phase 1 networks. The enhancements include the following extensions of phase 1 features:

- implementation of half-rate coding,
- extension of the frequency-band by adding 50 additional channels,
- support of multiple ciphering and alternative ciphering algorithms,
- improvements in SMS (e.g. cell broadcast SMSs),
- enhancement of some SIM-related functions,
- new functions in the area of bearer services,
- new supplementary services such as:
  - closed user groups,
  - conference calls,
  - advice of charge,
  - call hold,
  - call waiting,

- calling number identification presentation/restriction,
- connected number identification presentation/restriction,

• merging the GSM and the DCS 1800 specifications.

The above mentioned new services and the numerous minor and major improvements will be introduced in such a way that the upward compatibility is maintained.

The introduction of phase 2 and phase 2+ afterwards is, however, not the end of the standardization. Nowadays, we are witnesses to an ever accelerating technical evolution. The time between successive technical generations is ever shorter. Future more sophisticated components will enable to construct more complex systems what should be reflected in the specifications. In the future, the evolution of the GSM specifications will probably lead to a smooth transition to the UMTS.

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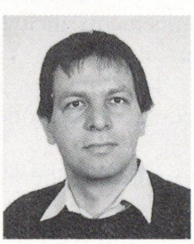
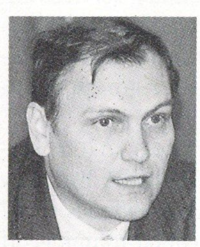


Tibor Rakó received his M.Sc. degree in electrical engineering from the Technical University of Budapest in 1990. From 1990 to 1994 he pursued postgraduate studies at the Technical University of Budapest and the Ecole Nationale Supérieure des Télécommunications de Bretagne in Brest, France. During this time he was a scholarship holder of the Hungarian Academy of Sciences. He researched numerical techniques for analysing microstrip antennas and calculating the scattered electrical field from various objects. In 1994 he joined the Pannon GSM Telecommunications Co. At Pannon GSM he provides assistance on special tasks related to radio and transmission systems. He developed a measurement report system using the OMC database, studied indoor wave propagation, the integration of repeaters in the GSM network, microcellular systems and the application of new propagation prediction methods in urban environment. He participated in the standardization work of ETSI Sub Technical Committee SMG4.



Győző Drozdy holds the Bachelor of Sciences, the Master of Sciences degrees in electrical engineering and the Ph.D. from the Technical University of Budapest. He is presently the director of External Affairs Department at Pannon GSM. He joined the company in 1993. Prior to his present position he had other responsible positions, e.g. Deputy Technical Director. Before that he lived in Finland from 1986, leading a GSM simulator project at the Technical Research Centre of Finland for Telecom Finland so he was involved in developing Telecom Finland's GSM network. He also wrote about 40 scientific publications.

SELECTIVE RADIO-PAGING AND ITS VALUE-ADDED SERVICES

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Wide area selective radio-paging systems basically transmit tone, numeric and short alphanumeric messages towards portable receivers. The messages may be conveyed into the system via telephone calls through the dispatching centre, direct access is usually provided for DTMF dialled as well as for computer-edited messages. New value-added services appear like the distribution of information, combination of alarm or positioning (GPS) systems, etc. with the traditional paging. OPERATOR hungaria Ltd provides all those and more, prepares new services based on it's FM paging system functioning since 1989 and covering 75 % of Hungary.

The first "beep-only" paging systems were aimed to direct the attention of the pager-user, moving around at an unknown spot within the covered large area, to the fact that a given person asks him to call back a pre-defined phone number.

Using numeric paging the message was able to indicate the number to be called or to convey a more complex message using a pre-arranged coding system between the caller and the paged person.

The highest level of paging permits the transmission of free though short alphanumeric texts. The message is thus not limited to ask for call-back but it has its own information value. This fact permits the creation of a certain number of value added services.

Basic services are usually provided by applying telephone lines, either through DTMF coding or using manual message entry to the system. The more advanced services contain added values, either paging-specific or exceeding these limits.

The paging-specific value-added services increase quality, convenience of the message collection or advance its transmission.

Development possibilities of the input function characteristics are largely dependent on the features provided by the connected networks. (E.g. French paging services may use the well-running and popular MINITEL equipment.) The fast development of the Hungarian PSTN called for the more efficient and comfortable usage of the DTMF input. At present this provides for synthesized human voice response and offers several options concerning the content and the transmission mode of the messages. As a consequence its usage is increasing despite the wide popularity of the short conversation with the well-known voice of the unknown but certainly nice girls sitting in the OPERATOR centre. Other new offerings are the reception through modems and transfer of messages sent from the PC of the caller as well as the voice mailbox combined with pager alert.

The transmission of the messages usually follows immediately their registration to the system, that means they may be received within 1/2-2 minutes. Of course this may be unnecessary or even inconvenient (e.g. during the night hours). It is not excluded either that the pager user keeps running at places disturbed or shadowed from radio reception (METRO) during most of his/hers working hours. The ability of the system permitting the transfer of the message at a given time may help. Optimally it is possible to send a message "immediately and once more at... ", but timing systems may accept specific transmission schedules as well. They may serve as daily alarm clocks or replace a manager agenda, as messages to be sent to the user's own pager may be registered one year in advance!

Despite the limits of DTMF devices' capabilities providing by definition only the transfer of numbers standard, pre-selected text messages may be initiated towards alphanumeric pagers. The receiver displays the clear text thus circumventing the problem of the user missing his/her decoder table when receiving a coded numeric message walking around in the nature.

Transmitted messages contain different accompanying information indicating the time of transmission or the daily serial number, permitting to check for eventually missed messages. In such a case the dispatching centre may be called back and the message not received earlier will be retransmitted.

Other value added services are only indirectly linked to the paging. They use its infrastructure but are independent of the basic services. Typical examples are the information provided for the message-initiating callers and more-or-less independent services dispatched jointly with paging.

Paging as it is provides unidirectional information flow. The originator of the message may never be sure if his/her message arrived. (Just imagine the addressed pager being lost or stolen!) Traditionally the owner asked in such a situation that his pager shall be excluded from the service thus preventing confidential information to be sent to strangers. In this case the operator informed the caller that the message may not be transmitted, but no detail about the reason could be given. The simplest secretary service permits now to tell the callers, whom and how they should address their message or even diverting the message to the right place if it is asked for.

The alphanumeric pagers are naturally not only able to receive and display messages but all textual information. Meteorological, traffic, stock exchange or other data may be transmitted to them either at pre-arranged hours of the day or triggered through a DTMF call at any time.

Keeping the content of the messages up-to-date is the task of the dispatching centre or of contractual partners.

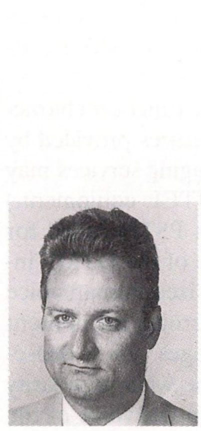
In particular cases the use of non-conventional pagers is necessary. Nowadays PC add-on boards, PCMCIA cards permit to deposit the message at a given memory address offered for further treatment by the computer-resident program. This may change contents of a database, trigger some program runs or even "read" the message by a voice-synthesizing program for blind. A concrete example is given by the usage for simultaneous updating of police data banks about stolen cars, installed at border cross-point. The stolen car itself may contain a special pager triggering the alarm system of the car transmitting radio identification signals when the thief — having neutralized the primary alarm — is unaware of providing guidance for the police. This is only one step away of the satellite-based localization and guidance systems (i.e. GPS) presenting an optimal combination with the paging, permitting avoidance of traffic jams, etc.

Finally there are value added services integrating paging with other, self-contained services. These are reasonable if the infrastructure of both services is overlapping to an extent offering economic advantages or if the combination with paging represents an added value for the other side, as well.

Speaking about cars an evident example is present in the usage of RDS system most frequently built in car radios. Information like station identification, alternative frequencies, central time and even the transparent data channel may be inserted to the broadcast transmission through the same modulators that are used for paging.

Another possibility is the combination of alarm systems with paging. Aged, disabled or just lonesome persons often need a tool to call for help without needing to go to their phone, look up for numbers and dial them. OPERATOR sos enables it, using automatic diallers (equipped with panic button that permits distant triggering through radio signal) calling the already installed round-the-clock dispatching centre. The alert messages then are transmitted to pager numbers, registered in advance. But additional information is also available, indicating if the caller has allergy or indeed a giant dog preventing easy help action.

All described services are realized, most of them here and now by OPERATOR *hungaria*, as well. They represent only typical examples of the possibilities and are in continuous development. It is important to see that their presence and capabilities demonstrate and warrant the ability of paging to compete with other mobile radio-communication technologies, not by beating but by complementing them.



László Binder graduated at the Budapest Technical University in 1966. Member of the EMG 830 computer development team between 1964 and 1968. Later sales service manager, then international co-operation manager dealing with the French-Hungarian know-how transfer and computer development co-operation between 1968 and 1983. Employed successively by EMG, SZKI and from 1979 till 1983 as commercial secretary of the Hungarian Embassy in Paris. Active also from 1970 till 1987 in the software export to France, Germany, Austria, Canada, and US as foreign trade manager of SZKI. Commercial Counsellor of the Hungarian Embassy in Algiers between 1987 and 1991. Engaged in 1992 as marketing, commercial and economical director of OPERATOR *hungaria* Ltd, co-general manager since September 1992.

ANTENNA HUNGÁRIA

Products – Services

Business – Research – Education

THE PRIVATIZATION OF ANTENNA HUNGÁRIA

ANTENNA HUNGÁRIA

Antenna Hungária has been incorporated on July 1992 as the legal successor of the Hungarian Broadcasting Company, which itself resulted from a division of the former Hungarian Postal Company.

Antenna Hungária is presently the only terrestrial broadcasting company operating in Hungary, and the second largest telecommunications operator, behind MATÁV, through activitics of trunk telephone communications and an increasing diversification in added value services.

In 1994, the turn over of the company has been 6.13 Billion HUF. The State Holding Company presently owns 83 % of Antenna Hungária's equity, the remaining shares being held by municipalities, by the company itself and by individuals following an operation of exchange against recompensation vouchers which took placein May, 1994.

WHY TO PRIVATIZE?

While the main business of Antenna Hungária is presently the supply of transmissioln and distribution services to public radio and television companies, its constant policy in the recent years has been to take advantage of its exceptional transmitter network and of the high qualification of its manpower to engage diversification into different fields. These new activities, which will allow Antenna Hungária to reduce its dependence from the Hungarian TV and the Hungarian Radio as clients, are all competitive and capital intensive.

- Antenna Hungária then needs to accomplish a "cultural reovlution" in order to face this challenge.
- Antenna Hungária also needs new equity that the Hungarian State, its sharcholder, is today unable to provide.

The future equilibrium of the Hungarian telecommunication market, with one or two powerful and professional competitors in each aspect of the market, greatly depends on the success of Antenna Hungária strategy and ambition.

The privatization of Antenna Hungária must then be clearly targeted at diversified and successful telecommunication groups.

HOW TO PRIVATIZE?

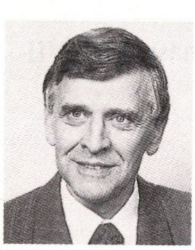
Antenna Hungária today needs money in order to finance its development and to modernize its present broadcasting equipments. The tariffs obtained from the Hungarian TV and Hungarian Radio are not important enough to provide this finance. The privatizatioln is then an opportunity to raise new money through a capital increase.

In addition, professional investors do prefer to invest through capital increase, as they will indirectly manage the actual use of their funds, rather than through sale of existing shares, which does not bring any Forint to the company. A capital increase must then be preferred to any other form of privatization, as it is consistent with the policy of the company and of the Hungarian government to have a second powerful and diversified telecommunication group operating in Hungary.

The government resolution N° 1110/1994 (XII.2), announcing the time schedule of the privatization of Antenna Hungária, has drawn a great deal of attention within European, American and Japanese telecommunication groups. All these companies have ambitions for the Hungarian market, and all have something to bring to, and to learn from Antenna Hungária.

Our role for the next months is then to organize the dialogue and the negotiation with them, in oder to select the most attractive investor(s) who, bringing managerial know how, a vision of the future, and a financial capacity, will confirm and amplify the success of Antenna Hungária as a large and professional high technology Hungarian company.

LÁSZLÓ HAJDÚ
Antenna Hungária Co.



László Hajdú graduated in electrical engineering in 1969 and received a special engineering degree in 1975 both at the Technical University of Budapest. He continued studies at the University of Economics, Budapest with state examination in 1981. He received doctor's degree both from the Technical University and the University of Economics of Budapest. From 1969 to 1977 he was involved in the development of integrated circuit technology. From 1977 to 1988 he worked on the organization of industrial projects, coordination of research programs and preparation of international cooperations. From 1988 he was employed by the Ministry of Commerce dealing with market regulation of electronic devices and telecommunications equipment. From 1990 he was department head at the Ministry of Transport, Communications and Water Management and authorized executive of the Research Institute for Telecommunications. From 1991 he was manager at the InvesTel Hungarian Telecommunications Investment Co. and from 1994 Senior Engineer at the Hungarian Telecommunications Company. From March 1995 he is Chief Executive Officer of Antenna Hungária Co.

ON THE WAY TO THE EUROPEAN DIGITAL TELEVISION STANDARD

GY. SOGRIK

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The DVB (Digital Video Broadcasting) project offers good chances to establish a set of European digital television which commonly defines the principles of satellite, cable and terrestrial broadcasting to the highest possible extent and incorporates also the opportunity of the high definition television. In the following, the main parameters of the digital television system are summarized together with its relation to MPEG-2. The results achieved so far as well as the current status of standardization are also reviewed.

1. INTRODUCTION

The European organizations working on the development of digital television systems unified their forces officially in 1993 and launched the DVB project. This step was of urgent necessity also because the earlier ideas to propagate the essentially analogue, component coded D2-MAC and HD-MAC systems remained unsuccessful. It became clear that the demands for the future television services cannot be satisfied by analogue systems. Another incentive for the joint effort was that in 1993 the Grand Alliance was created in the US among developers of the earlier competing HDTV systems and a digital system was proposed essential parameters of which (line and vertical frequency) are incompatible to the European standards.

The number of organizations participating in the DVB project has already exceeded 130. Groupings earlier working separately (e.g. dTTb, HDTVT, HD-DIVINE), jointly achieved significant results in a short time [1]. They designed a hierarchical system capable of broadcasting both traditional and high definition television programmes. In this system, the baseband coding, multiplexing and forward error correction will be the same for all three transmission media (satellite, terrestrial broadcasting and cable). There is a chance that the system developed will be adopted also by non-European countries.

At the current stage in DVB, the elaboration of the terrestrial channel coding and modulation procedures are under way. There is also a perspective to implement an interface allowing connection to the telecommunication network.

2. THE BASIC PRINCIPLES OF THE DVB SYSTEM

For the satellite and cable systems, the objective of the developers were the small size parabolic antenna at the receiving side, receivers for an affordable price and compatibility with the existing satellite transponders. Although the specification of the terrestrial system is not completed yet, it can be stated that the basic principles of the general technical solution are valid for all of the three media [2]:

- The systems shall deliver image and voice information according to the MPEG-2 coding system;
- the systems shall use multiplexed data streams according to MPEG-2;
- the systems shall apply a common Reed-Solomon (RS) forward error correction (FEC); and
- the modulation and channel coding procedures as well as any further necessary error correction methods shall be selected based on the signal transmission conditions of the particular medium.

Comparing these conditions, one can essentially conclude that in case of the satellite broadcasting the necessary bandwidth is available but the radiation power is limited; in case of the cable transmission the power is sufficient but the bandwidth is limited, similarly to the terrestrial television broadcasting. Therefore, different solutions are optimal for modulation and error correction methods.

The general structure of the digital television transmission system is shown in Fig. 1. The contents of the boxes is dealt with in the following sections.

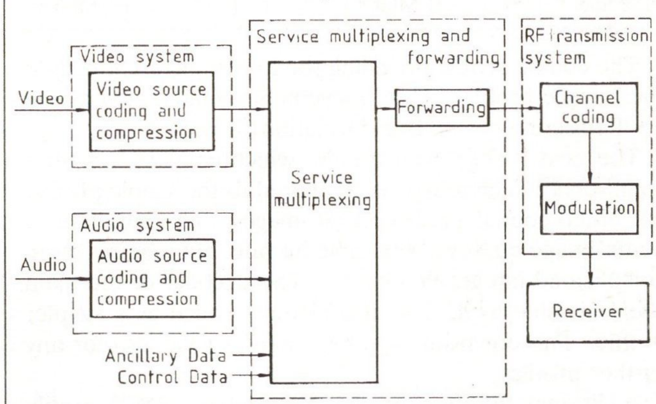

Fig. 1. Digital television transmission system

3. IMAGE AND VOICE CODING SYSTEM

The DVB adopted the voice coding system used for DAB (Digital Audio Broadcasting), specified by MPEG.

The MPEG-2 image coding system finalized in 1994 includes a family of standards according to Table 1 [3]. (B-image means the image produced by bi-directional prediction.)

It can be seen that there are five profiles built up on one another. Any subsequent profile offers additional features compared to the previous one, but implies also a more complicated and more costly implementation.

The input signal of all the systems is a video signal containing YUV (brightness and color difference) components. In case of the 4:2:0 profiles, alternating line by line, only one of the colour difference signals is present (similarly to the SECAM system).

Table 1. Coding systems according to MPEG-2 (combinations marked X are not allowed)

Profile / Level	*Simple* no B-image; 4:2:0; non-hierarchical	*Main* B-image; 4:2:0; non-hierarchical	*SNR scalability* B-image; 4:2:0; SNR-hierarchy	*Spatial scalability* B-; image; 4:2:0; spatial and SNR-hierarchy	*High* B-image; 4:2:0 or 4:2:2; spatial and SNR-hierarchy
Low 352 pixels; 288 line	X	4 Mbit/s	4 Mbit/s	X	X
Main 720 pixels; 576 line	15 Mbit/s	15 Mbit/s	15 Mbit/s	X	4 Mbit/s
High-1440 1440 pixels; 1152 line	X	60 Mbit/s	X	60 Mbit/s	80 Mbit/s
High 1920 pixels; 1152 line	X	80 Mbit/s	X	X	100 Mbit/s

The coding profile providing the lowest picture quality is the "simple profile". Here movement compensated hybrid DCT (discrete cosine transformation) is used.

The next is the "main profile" which employs a further compression technology as compared to the simple profile, the bi-directional prediction (B-image). This results in a better image quality at the same bit rate, but requires more complicated integrated circuits. The decoder of the main profile is able to decode also pictures coded by a simpler profile. This downwards compatibility is valid also for any further profiles.

Additional function of the "hierarchical SNR" profile to the main profile is that it divides the data flow into two parts, a so-called base-layer signal and the so-called top-up signal. Forwarding of the base-layer signal with a decreased SNR (signal-to-noise ratio) occupies only a part of the utilized bit rate. If the top-up signal is added to the base-layer signal, the signal-to-noise ratio improves. When combined, these two signals provide an image quality equal to the main profile, but require more sophisticated hardware because of the scalable (hierarchical) SNR. The transmission of the base-layer signal shall be implemented in a way that is less sensitive to noises and disturbances in order to be able to receive this signal even if the whole package of signals cannot be detected. The scalable structure is advantageous also in case if the necessary bit rate is not available and only the base-layer signal can be transmitted.

In the profile of "spatial scalability" the data flow is divided also in resolution into a "base-layer signal" and a "top-up signal". This division necessitates not only more complex circuitry, but requires 10 to 20 per cent more bit rate to get the same image quality. The purpose of the scalability is to cover a larger area with a base-layer signal of smaller resolution which is less sensitive to noise. This way, if the reception conditions become worse, at least an image of lower resolution can be obtained.

The additional function of the "high profile" as compared to the previous one is that it allows simultaneous, line-by-line coding of the colour difference signals. This provides a better image quality but can only be used if the increased bit rate is not a problem.

There are four "levels" associated with the five profiles corresponding to input image formats. The "low level" provides 1/4 of the resolution as per ITU-R 601. The "main level" corresponds to the format of Recommendation 601. The "High-1440" is a resolution four times larger than the previous one and is an HDTV format where the number of samples per line is 1440. In case of the "high level", the number of samples in each line is as many as 1920.

The decoders shall have downwards compatibility for the levels, too. However, a lower level decoder is also capable of decoding the base-layer signal from a bit flow with spatial or SNR scalability.

From among the 20 possible level/profile combinations shown in Fig. 1, MPEG-2 considers only 11 as useful and necessary. Various bit rates could be associated with the allowed combinations. In MPEG-2, the bit rate can be changed so as to ensure image transmission without coding errors for any combination.

MPEG-2 allows both interleaved and progressive scanning as well as both 50 and 60 Hz vertical frequency.

It is probable that the first generation of DVB receivers will be produced by manufacturers for the main level/main profile combination, because this service seems to become implemented within the shortest time via satellite in the 11/12 GHz band or through cable. Further combinations and/or bit rates are to be agreed upon by organizations and companies interested in broadcasting and production of receiver units.

The quality of the images with main level/main profile combination has been investigated most intensively and mainly by simulation with various bit rates. The main results are as follows:

- 9 Mbit/s was found to be enough to reach the studio quality specified in Recommendation 601;
- for PAL, it is sufficient to use 5 Mbit/s;
- the 50 Hz scanning provides better image quality as compared to the 60 Hz scanning at the same bit rate;
- the coding of movie pictures is simpler than of those produced by electronic cameras and requires not more than 4 Mbit/s for transmission.

4. THE MULTIPLEX SYSTEM

The multiplex system i.e. the signal flow of MPEG-2 TS (transport stream) consist of packages of equal length with 187 byte useful data. In addition, service information can also be transmitted and reserve bytes are also available for further development [3].

The MPEG-2 TS is capable to indicate the presence of access control, but the scrambling system to be applied is not defined in it.

5. THE SATELLITE MODULATION SYSTEM

The satellite modulation system had to be designed so as to match the bandwidth (27 to 72 MHz) and the power (49 to 61 dBW) of the existing transponders.

In the DVB, it was decided to apply a single carrier system [4], because in the multiple carrier systems a back-off should be used in the transponder to reduce the intermodulation which would necessitate more expensive receivers. This disadvantage was deemed to be more significant than the advantage of the multi-carrier systems that into the different subranges of the same channel uplink signals from different places can be inserted. Thus, the specified satellite system is essentially a digital time division multiplex system.

The image and sound information and the ancillary data — that is, the useful information — are packed into TS packages of equal length before transmitting. 8 such packages form a transmission frame.

The next step of processing the useful data is to randomise the bit-stream. Afterwards, the Reed-Solomon (RS) error correction part is added to the signal (outer code). This is a very efficient error correction method increasing the bit rate only by 12 %. The same outer code is used also for the other transmission media.

Thereafter, a further error correction layer is added by convolution coding which is preceded by a convolutional bit interleaving. This second error correction layer i.e. the internal code can vary according to the features of the transponder and the demands of the programme provider.

In the last step, the QPSK modulation of the carrier is performed.

As the number of the layers and the extent of the second error correction layer can vary, the receiver should be able to recognize the applied combination from the signal. A practical combination might be e.g. for a 36 MHz (1 dB) transponder to use the 3/4 convolutional code whereby the useful data rate would be 39 Mbit/s.

6. THE CABLE MODULATION SYSTEM

The modulation system elaborated for the DVB cable networks is based on the quadrature amplitude modulation [5]. The basic version is 64 QAM, but lower order procedures, like 16 QAM or 32 QAM are also applicable. Naturally, the high data transmission capacity and the ruggedness of the system are contradictory requirements. As cut-off factor, 15 % was determined.

The condition of using higher order procedures (128 QAM or 256 QAM) is that the cable network can be able to cope with the decreased eye height. Reflection depression may also be needed.

As regards to capacity, in a cable channel of 8 MHz bandwidth 38.5 Mbit/s useful data transmission rate can be implemented by using 64 QAM.

7. THE TERRESTRIAL TELEVISION SYSTEM

For the 8 MHz European channels, the practical limitation to the useful programme signal is 24 Mbit/s which can even be reduced by an extensive error correction. (In the US, the 6 MHz channels ensure approx. 18 Mbit/s for the useful bitstream.)

In elaborating the terrestrial version of DVB, there were to basic concepts [6]: the "graceful degradation" and the "scalability". By the "graceful degradation" the abrupt transition characteristics of the digital systems can be avoided at the boundaries of the covered and uncovered areas. The scalability has the advantage that the broadcasting organization can target several groups of subscribers simultaneously, if the same programme can be received by conventional and enhanced resolution. To receive the more rugged "base-layer signal", a simple rod antenna might be sufficient while to receive the whole bitstream and an HDTV quality, high gain directional antennas are required. In addition, the digital system can be started with conventional resolution at the beginning and can be extended to a high definition service in a compatible way at a later stage.

In MPEG-2 the European concept of scalability is reflected (Table 1), thus the baseband coding ensures the implementation of a three-step, graceful degradation: the highest layer is the whole HDTV; the middle layer is the HDTV with a smaller SNR while the lowest layer is the 625-line TV signal. The HDTV data flow is divided into three parts: to a 625-line base-layer signal and two top-up signals which carry altogether the full HDTV. These signal streams can occupy 6, 6 and 12 Mbit/s, respectively.

The modulation system should be designed in a way that for the base layer a higher ruggedness is ensured than for the other two layers. For example, if the basic layer is transmitted with 8 QAM, the second and third layers can be transmitted with constellations around 8 QAM, i.e. 16 QAM or 32 QAM. This method is called MR-QAM (multi-resolution QAM).

The scalability has also a disadvantage: to achieve the same quality HDTV image, a greater SNR is required in the hierarchical system than in one transmitting only HDTV quality. The terrestrial version of DVB, similarly to the satellite and cable versions, has to transport MPEG-2 combinations and therefore it allows the broadcasting companies to select either scalable or non-scalable systems according to their interests. In addition, multi-programme systems inserted into one transmission frame can also be implemented.

A group of developers of DVB supports OFDM (orthogonal frequency division multiplexing) based modulation for the terrestrial system. In this method, the information content of the signal is distributed among a large number of carriers. OFDM has already been successfully applied in the DAB system. Its greatest strength is to remain operational also in harsh, multi-path conditions. This feature of OFDM may be used to create a single-frequency network (SFN), as in the areas with multiple coverage the receiver handles the signal of the weaker source as a reflection. (Of course, the distance between two neighbouring transmitters cannot be too large, because a big difference in propagation times results in a long "protection interval", reducing the transmission capacity.)

From the aspect of the frequency planning, there are three possibilities to put into operation the terrestrial digital television system: in a channel prohibited for use by now (e.g. in a neighbouring channel where the traditional analogue transmission has not been permitted so far because of the mutual interferencies); in a free channel; in SFN system. A problem might arise from the fact that the three possibilities can be implemented by different optimum system technologies.

Some organizations propose a single-frequency system instead of OFDM in order to allow the terrestrial digital broadcasting to start immediately with the same specification as used for the DVB cable system.

Another complication with the introduction of the digital services is that in a long transitional period the digital broadcasting can only be operated if the PAL/SECAM broadcasting is maintained. Meeting this requirement would be eased if the flexibility of DVB would be ensured not only by the possibilities of MPEG-2 but also by the variability of OFDM carriers (e.g. in between 2000 and 5000), because it would simplify the solution of problems in connection with the spectrum usage and the coverage areas.

8. THE RESULTS OF THE DVB PROJECT

Experimental transmissions with satellite and cable DVB are under preparation. The first terrestrial, scalable QAM and COFDM trial systems are being built and demonstrations are scheduled for mid-1995.

For the success of DVB, programmes and receivers are also needed. According to plans, by the end of 1995 satellite and cable receivers will also be available.

In Fig. 2 the functional units of a future digital receiver are demonstrated [2]. For the functions of MPEG-2 video decoder, MPEG audio decoder, TS multiplexer, RS FEC decoder and QPSK demodulator, the integrated circuits have already been developed. In the near future several of these units will be integrated into one IC.

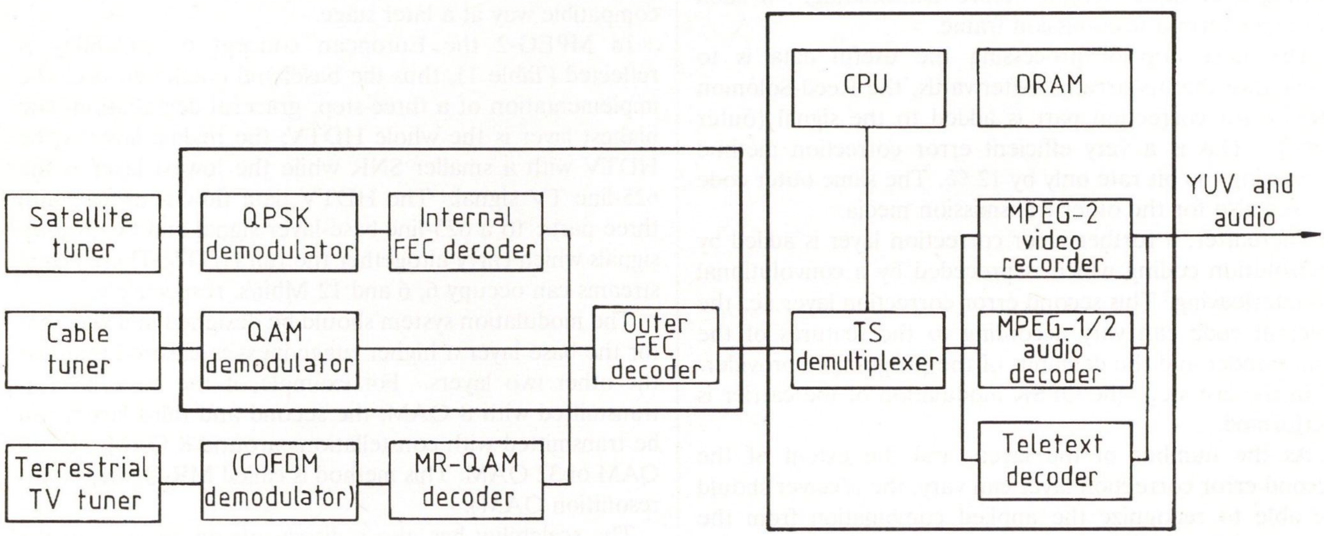

Fig. 2. The elements of a digital receiver (the units independent of the transmission media are bold framed)

The digital broadcasting requires the development of video and audio decoders and multiplexers for the MPEG-2 standard. However, MPEG-2 specifies only the protocol of decoding. The implementation of the encoder is left for the manufacturer with the condition that the signal can be decoded with the standard procedure. This allows a continuous development of coding technology while the receiving side is maintained operational. The prototypes of MPEG-2 encoders have already been produced.

Some specifications prepared within the framework of the DVB project will probably become a European Telecommunication Standard (ETS). From the specifications of the satellite and cable transmission of DVB signals prepared by the end of 1993 and at the beginning of 1994, two draft ETS's were composed. The standard describing the service informations is ready too and the common scrambling system is also elaborated [1].

MPEG-2 is a set of standards comprising three parts which can be used within the DVB if the services to be actually implemented are defined. In the DVB the guidelines for the multi-programme services have already been prepared. In the multi-programme system several programmes with LDTV (low definition TV), SDTV (standard definition TV) or EDTV (enhanced definition TV) quality can be broadcast in the same channel (the number of programmes is naturally limited by the transmission capacity of the channel).

9. CONCLUSIONS

The technological background to replace the existing analogue television systems by more advanced digital ones has been created. The lesson from the recent development projects in the television technology is that new systems should offer fundamentally new services in order to be acceptable and attractive for the industry, the broadcasters and the subscribers.

The wide support of the DVB and the quick achievements offer a good chance to turn it into a common European digital television system the flexibility of which allows the transmission of different programme qualities ranging from LDTV to HDTV. All these justify that also the Hungarian professional organizations should follow the developments and prepare for the accommodation of the digital technology and the changes affecting the whole transmission system.

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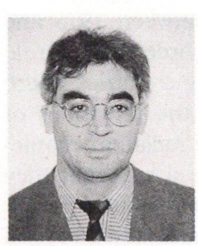

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THE STATUS OF THE TERRESTRIAL TELEVISION BROADCASTING IN HUNGARY

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In this paper a brief history is given about the deployment of the Hungarian TV transmitter networks and about the technological development of the transmitters used. The problems of further extension of the networks as the planning aspects of starting local television broadcasting services are also dealt with. Coverage, quality and reliability characteristics of the existing networks are presented. We also outline our ideas about the further developments.

1. THE DEPLOYMENT OF TV TRANSMITTER NETWORKS

The regular television broadcasting started in Hungary in May 1956 from a temporary location with a 10/4 kW transmitter produced by BHG and with a two-level butterfly antenna mounted onto a 50 m high mast, on the OIRT 1 channel. The Budapest TV transmitter station received a 30/10 kW RFT transmitter in 1958 which already allowed to achieve a significant coverage [1].

In the subsequent years TV transmitter stations were constructed in Pécs, Sopron, Mickolc, Kékes, Szentes. The first stage of deploying the backbone network for the TV1 programme was completed in 1974 with the starting of the Nagykanizsa transmitter.

The second Hungarian national TV programme started in 1969 in Budapest with an EMV-made 4W transmitter on channel 24. In the 70s, further high power transmitters of the TV2 programme were put into operation step by step which, with one exception, are transmitting in the UHF band from the same sites as the transmitters of the TV1 programme. Owing to the UHF propagation properties, the coverage of TV2 is slightly smaller than that of the TV1 network operated mainly by VHF band transmitters.

After the first stage of the establishment of the backbone transmitter networks was completed, it became clear that in order to reach a full area and population coverage, further transmitters should be installed. This was permitted by the the Stockholm agreement too. As a result, the Vasvár, Csengőd, Ózd, Fehérrgyarmat and Aggtelek TV transmitter stations were constructed between 1975 and 1993. (The transmitters near the state border have a role in covering the areas of the neighbouring countries where Hungarian nationalities are living. As the provisions of the international agreements restrict the radiation characteristics of the terrestrial transmitters in a way that they would radiate only inside the country, it is evident that a Hungarian TV programme can only be transmitted beyond 20 to 30 km from the border by satellite.)

Parallel with the construction of the backbone network, the creation of the transposer network was started as early as in 1963, to provide programmes for smaller uncovered areas, settlements or districts. Three relay stations were built in 1963/64 of which the Ózd and Salgótarján stations were manned, but the Szekszárd station has been remote controlled from the very beginning. In these relay stations the equipment of Thomson-LGT and CSF was installed.

The Hungarian EMV company started to develop its 1, 5 and 20W transposeres in 1968, thus providing the basis for the further serial production.

Between 1963 and 1975 only 8 relay stations were constructed, but 33 were built from 1975 to 1980. From 1979 BHG was producing its solid-state 20-40-80 W transposer family for band III which had also an automatic reception monitoring and reflection protection. Antenna systems for the band III transposers were manufactured by HTV.

The deployment of the transposer network of TV2 was planned to start only after the completion of the backbone network, but this work had to be commenced earlier because of the demand of the public. However, BHG was not yet prepared for that and no western import was possible to contemplate. Having recognized the situation, the Videotechnika Company of Salgótarján undertook developing and supplying first a 5 and a 10W and later an 80 W transposer for the UHF band. At the same company a 5-20-40 W transposer family was also developed to relay the TV2 programme. The transposers of BHG and Videotechnika are for indoor use and special containers have to be used to install them outdoor. For the relay stations BHG has supplied from the beginning right until now the antenna systems for bands IV and V.

2. THE EVOLUTION OF THE APPLIED TV TRANSMITTERS

As it was mentioned, for the TV1 programme a 10 kW BHG transmitter with triode output stage was used first. This was followed by a 30 kW transmitter of RFT, with also a triode output stage. The French 20/4 kW tube transmitter made by CSF was installed in Szentes in 1959 and remained operational right until 1992 [2].

4 kW transmitters with complementer triode output stage were installed in Kékes in 1960 and later in 1970. These transmitters were modulated in the output stage and were built by EMV which supplied with its legal successor, BHG the band I–III TV transmitters until the beginning of the 80's for the Hungarian Post, operating the transmitter network that time. After 1976 they produced more advanced equipment modulated in the intermediate frequency stage.

The first transmitter of the TV2 backbone network, a channel 24, 4 kW transmitter in Budapest was also made by EMV. This was operated in common image and sound amplification (multiplex) mode.

From the 70's, transmitters made by NEC and having separate image and sound channels were put into operation because their characteristics are overriding those of the multiplex transmitters in many respects. One of their advantages is that if any of the image or sound output stages becomes faulty, the transmitters can be switched over into the common image and sound amplification mode (the output power is halved, of course). The reliability of these transmitters was also increased by reserve (standby) exciter stages. The operational experiences were favourable, the transmitters needed to switch over into multiplex mode only in a very few cases.

Beside their advantages (reliability and stability), klystron transmitters have also drawbacks: the lifetime of the klystron is limited to a maximum of 15000 to 25000 hours and it has a relatively low efficiency (50 %). The manufacturers wanted to reduce these disadvantages by designing fully semiconductor transmitters. In the 80's it was a serious problem to produce the necessary high frequency and high power transistors for this purpose. At the start, bipolar power transistors were applied, but now in the most advanced output modules MOSFETs are being used. These have better linearity, higher gain, better efficiency, higher supply voltage and less dependence on temperature. With a MOSFET output stage 150W output power can be attained along with an efficiency of cca 50 %. Therefore, the same output power can be achieved with less components as compared to the bipolar solution, so the reliability of the transmitter can be improved.

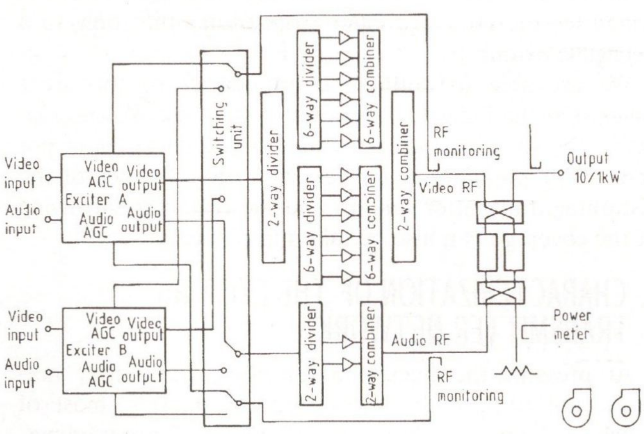

Fig. 1. Block diagram of a 10 kW semiconductor TV transmitter for the UHF band

As an example, in Fig. 1 the block diagram of a UHF semiconductor transmitter with 10 kW video power and 1 kW audio power is shown. The transmitter has also a reserve exciter and an automatic changeover function. In the image channel, 2 power amplifier units with 6 kW power each are located, so the transmitter has also some reserve power. The 6 kW power is produced by six MOSFET transistor units 1000 W each and thus the input signal is distributed into 6 signal paths. The signals from the 1000 W modules are combined by a 6-way combiner producing the 6 kW output power. At the output of each 1000 W module 12 MOSFETs and 6 circulators are used.

Comparing the solid-state, klystron and the tube transmitters, the following can be stated:

- From among the klystron transmitters those having different image and sound channels can be converted to a multiplex mode of operation if any of the channels fail. This reserve operation mode causes, however, at least 3 dB power fall. In case of malfunction of the multiplex (generally tetrode-based) transmitters the service can be maintained only if there is a complete back-up transmitter available.
- Due to their redundant structure, the semiconductor based transmitters have an intrinsic reserve. The outage of an amplifier module does not cause a signifiant reduction in the output power. Therefore, the semiconductor transmitters do not necessitate the application of back-up transmitters.

In case of the 10 kW transmitter shown in Fig. 1, the breakdown of one of the twelve 1000 W modules results in a power loss of 0.76 dB. The probabiliy of defects occuring in several modules at the same time is very low. Such small decrease of the power can be compensated by the automatic gain control (AGC).

There may not be a considerable difference in the image and sound transmission parameters of tetrode, klystron and semiconductor transmitters, because all they have to meet the Hungarian and the international regulations. Therefore, when choosing a new transmitter model, the most important aspects are the reliability (MTBF), the efficiency, the maintenance time and the price. Comparing these parameters for the various types, the following results were obtained [2]:

- the reliability of the semiconductor transmitters is 3 to 6 times higher than that of the klystron and tetrode transmitters (MTBF $\approx$ 40000 hrs);
- there is no significant difference regarding the efficiency;
- the maintenance time of the semiconductor transmitters is 1/6 of that of the klystron or tetrode transmitters (2 man-days/year); and
- the capital investment cost of the semiconductor transmitters exceeds that of the tube-types by 10 to 15 %.

A further advantage of the semiconductor transmitters is that they require only air cooling, there is no heat-up time and no mechanical tuning is required. As a result, the opinion was evolved that despite their higher investment cost, only semiconductor based transmitters are worth to be taken into consideration for the reconstruction and extension of the TV transmitter networks.

In 1995 the transmitter network will be further upgraded because — first in Europe — so-called "digital quality" transmitters will be put into operation. The most recent VHF and UHF band NEC transmitters have digitalized video stages. Thereby the temperature dependence has been substantially decreased and the stability of the parameters has been improved. In order to maintain the quality of the signal, in these transmitters a digital correction is used operated by a push-button to adjust the differential amplitude, the differential phase, the non-linearity of the luminance signal and the group delay (see Fig. 2). This corrector has its own signal generator which can be used as a signal source for other purposes as well. The correction requires a high quality TV demodulator by which the automatic system performs the adjusment of the transmitter on the basis of 100 measurement cycles and for three output power levels within 20 seconds. Thanks to this automatic corrector, the parameters of the transmitter can be adjusted to the factory values each day if needed.

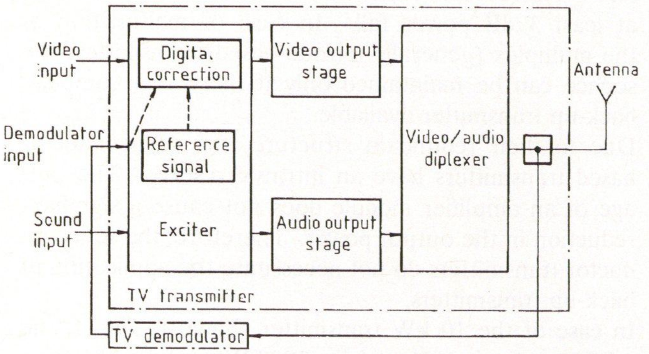

Fig. 2. Block diagram of the digital correction

As the power of the transponders (1 to 500 W) is considerably less than that of the backbone transmitters, fully semiconductor transposers could be manufactured earlier. Fig. 3 demonstrates the typical configuration of the equipment used in the transposer network.

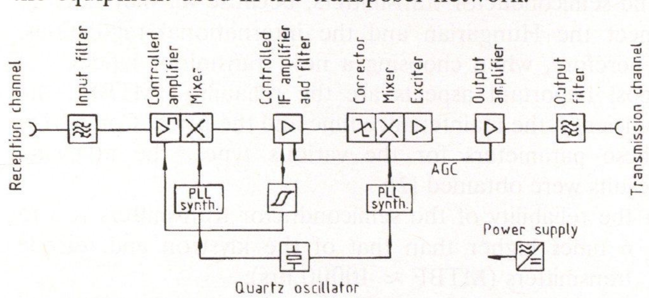

Fig. 3. The typical configuration of a TV transposer

3. THE PROBLEMS OF THE NETWORK PLANNING

3.1. Past experience

The extension of the terrestrial television transmitter networks has not been completed yet. There are still possibilities to put into operation both high power (over 5 kW) and low power, mainly UHF transmitters. The band I and II transmitters are planned to be replaced by UHF band transmitters because of the interference problems and the interests of other radio services.

In the course of the development of the transposer network there was no general development policy. One of the reasons was that in the past no accurate information on the coverage was available. Another reason was that the local demands often backed by financial arguments could not be left out of consideration. As the acquisition of the coverage measurement data was performed later than the optimization of the territorial coverage, the network emerged is far from being ideal.

As providing the necessary coverage is the responsibility of the network operator, an optimum solution has to be found which takes into account the costs involved too. Thus, with regard to the reception and distribution possibilities of the satellite programmes, as an alternative to the transposers, the implementation of cable networks may also be worth considering. In addition to inland programmes, the headends can also transmit foreign programmes (both terrestrial and satellite) as opposed to the transposers which are only able to relay domestic programmes and in case of complicated geographical conditions and shadows the full coverage can not be guaranteed.

In the last years, the selection of the appropriate sites for the transmitting stations became a rather serious problem. This is valid for both new backbone and transposer stations. The revaluation of land, the changes in the behaviour of the owners and the increased assertion of the environmental protection aspects all are making the acquisition of new plant sites more and more difficult.

The experience of several decades gained in the operation of the national networks, the well trained professionals and the service support can be effectively used in the installation of local transmitting stations for smaller regions, cities, districts and in determining their coverage areas.

3.2. New methods

In the course of network planning the ITU-R recommendations are used as a basis for calculating the signal propagation and the coverage. In the recent years, for the calculations we have been using a digital topographical model running on PCs. We also have a 220 Mbyte digital map with a resolution of 50×50 m, containing elevation and coverage data. By using this advanced method we achieved that the calculated and the measured data obtained for the coverage differ from each other only to a negligible extent.

We are able to define the boundaries of the areas covered by the individual transmitter stations. We can also define the shadowed areas as well as the coverage in per cent of the population. If necessary, the influence of the disturbing transmitter stations and the resulting narrowing of the coverage can also be taken into account.

4. CHARACTERIZATION OF THE EXISTING TRANSMITTER NETWORK

At present, the backbone television transmitter networks are comprising 17 transmitting stations, most of which are being used both for TV1 and TV2 programmes. The exclusions are Aggtelek, Fehérgyarmat, Csengőd and Ózd where transmitters only for the TV1 programme could be installed, because non-broadcast services are still operating on the frequencies allocated to TV2.

It is a problem that some transmitters still operate in the channels of OIRT bands I and II where the reception is often unsatisfactory due to long distance propagation and reflection reasons. Such channels are 0.1 in Budapest and Nagykanizsa, 0.2 in Pécs and 0.4 in Tokaj. From among them the reallocation of TV1 to UHF channels has been solved or is under way. Nagykanizsa, because of the engagement of channel 60, channel 0.1 should be used for several years.

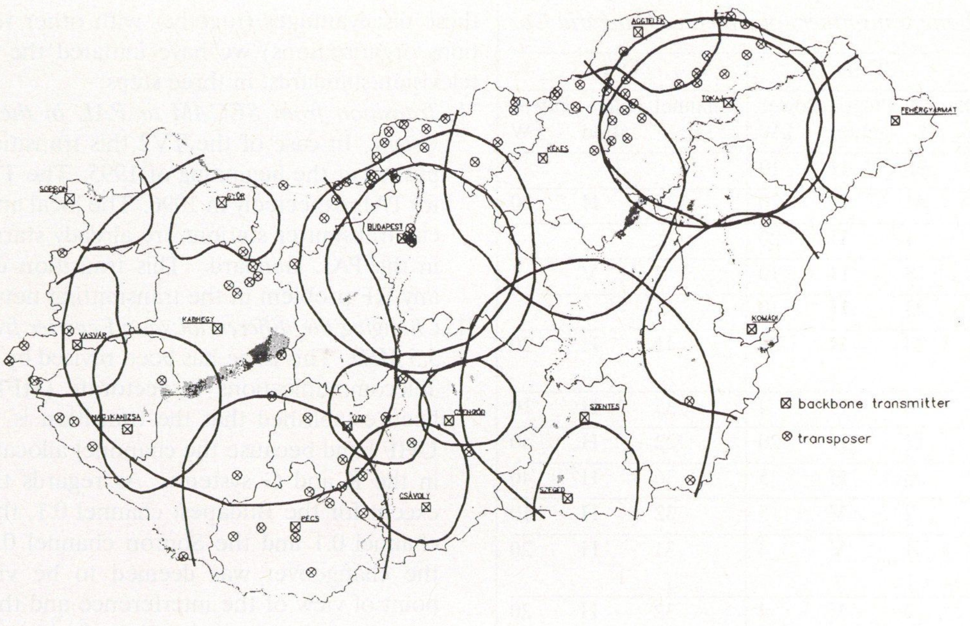

Fig. 4. The TV1 transmitter network

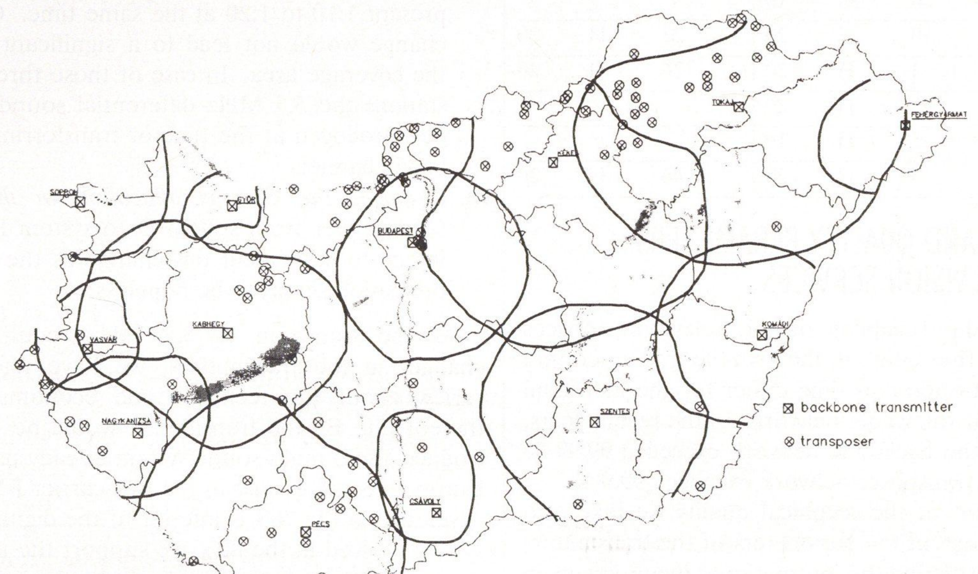

Fig. 5. The TV2 transmitter network

The backbone transmitter stations together with the associated coverage curves are shown in Figs. 4 and 5. It can be seen that between the reception regions of the transmitters there are uncovered areas too. Due to the terrain and the buildings in residential areas, the coverage may not be satisfactory even at some places inside the covered regions. We intend to overcome this problem by a continuous development of our transposer network. Presently, we have 91 TV1 and 75 TV2 transposers, territorial distribution of which is also shown in the figures. In Table 1 we have listed the locations, the channel numbers, and the power of the TV1 and TV2 backbone transmitters.

For the more efficient utilization of manpower as well as for the higher operational reliability and safety, for the transmitter network a nation-wide supervision system has been designed, the construction of which is now under way. The system consists of a computer network monitoring the most important operational parameters of the stations and preparing their statistics. The automatic start and shut-off of the stations can be programmed. The system displays any failures of the transmitters and turns them off in emergency situation. The transposers are not being monitored continuously, but they are checked regularly by a local supervisor.

Table 1. The backbone transmitters of Antenna Hungária Co.

No.	Location	TV1			TV2		
		Channel	Polarization	Power kW	Channel	Polarization	Power kW
1	Aggtelek	28	H	10			
2	Budapest	41	H	20	24	H	20
2	Budapest	1	H	20			
3	Csávoly	28	H	10	7	V	1
4	Csengőd	25	H	10			
5	Fehér-gyarmat	24	H	20	41	H	20
6	Győr	8	H	4	35	H	10
7	Kabhegy	12	H	20	22	H	40
8	Kékes	8	H	5	36	H	40
9	Komádi	7	V	5	32	H	10
10	Nagyka-nizsa	1	V	4	31	H	20
11	Pécs	2	V	4	32	H	20
12	Sopron	9	V	1	32	H	10
13	Szeged	26	H	10			
14	Szentes	10	V	20	23	H	20
15	Tokaj	4	H	20	26	H	20
15	Tokaj	43	H	20			
16	Ózd	35	H	10			
17	Vasvár	33	H	20	46	H	20

5. RELIABILITY AND QUALITY PARAMETERS OF THE TELEVISION SERVICES

The rate of the reliability of the television services is expressed by the ratio of the trouble-free operation time and the full operation time either for the individual transmitters or for the whole network. In the recent years, the reliability of the backbone network exceeded 99.99 % while that of the transposer network exceeded 99.9 %.

In the definition of the technical quality we take into account to what extent the parameters of the transmitters fulfill the Hungarian and the international requirements in a given period. In the last years the quality factor exceeded 99 % as a national average.

6. ACCOMMODATION TO THE EUROPEAN BROADCASTING STANDARDS

By the end of 1994, the terrestrial transmission of the public television programmes (TV1 and TV2) was performed in the in D/K standard with SECAM colour coding according to the definitions of ITU-R.

In our country, in the 50's and the 60's television standards being different from those used in most of the Western-European countries were chosen which has caused numerous disadvantages in the studio, the transmission and the reception technology. (The procurement of the equipment is more difficult and more expensive, the frequency planning and the calculation of the interferences is more complicated, multi-standard receiver sets are to be purchased, the operation of the value added services — like teletext, VPS — is restricted.) In order to diminish these disadvantages (together with other telecommunications organizations) we have initiated the change of the television standards, in three steps:

I. *Transition from SECAM to PAL in the colour coding system.* In case of the TV2 this transition was accomplished at the beginning of 1995. The TV1 will change for PAL expectedly in 1996. The local and the commercial transmitter stations are already starting to operate in the PAL standard. This transition does not cause any RF problem in the transmitting network.

II. *Changing the differential sound carrier from 6.5 MHz to 5.5 MHz.* This issue has been revised by the Hungarian Telecommunications Inspectorate (HFF) [3]. It has been established that the transition is possible in the UHF band because the channnel allocation is identical in the K and G systems. As regards the VHF band, except for the Budapest channel 0.1, the Nagykanizsa channel 0.1 and the Sopron channel 0.9 transmitters, the changeover was deemed to be viable from the point of view of the interference and the international co-ordination, supposing that the power ratio of the image and sound carriers would be reduced from the present 1:10 to 1:20 at the same time. Generally, this change would not lead to a significant narrowing of the coverage area. In case of those three problematic stations the 5.5 MHz differential sound carrier could be introduced at the time of transferring to the UHF band channel.

III. *Changing the channel allocation in the VHF band* (changeover from system D to system B). We do not intend to implement this change as the frequency co-ordination seems to be hopeless.

As the transition to 5.5 MHz requires substantial changes in the transmitters, we have made a detailed review about the technical and economical conditions thereof [5]. By the transition it would be possible to introduce also a multi-sound system already used in Western Europe. As the quality of the two-carrier FM system (A2) developed in the 70's is inferior to the digital NICAM 728 system evolved in the 80's, we support the introduction of the latter. We have studied the technological conditions of the introduction of both systems [6] and in 1994 we carried out experimental transmissions in Budapest on channel 58.

7. CONCLUSIONS

The national terrestrial television transmitter networks which have been continously extending during the last decades are at the European average in terms of area and population coverage. By applying ever more advanced transmission equipment, establishing the supervision system the quality and reliability parameters of the conventional television services are becoming more and more favourable. The experience gained with the backbone network can well be used in the emerging local broadcasting. The aim of our efforts to change the existing standards is the harmonization of our system with the Western European television standards, as it might lead to the improvement of the conventional services and the new additional services could be introduced in a compatible way.

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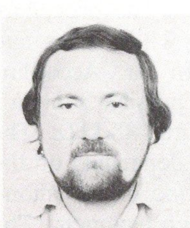
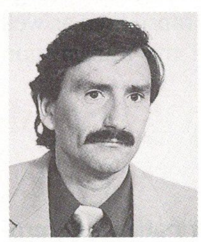
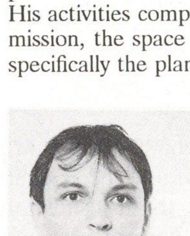


Zoltán Buzogány graduated from the College of Traffic and Telecommunications in Győr in 1973 where he studied wireless telecommunications. From that year, employed by the Radio and Television Technical Directorate of the Hungarian Post, he took part at the deployment of the TV transponder network first as a service engineer, later as the technical executive of the opeartions department. From 1982 the operational problems of the TV transmitters are also belong to him. At present, as the leader of the TV group, he is engaged in the technical questions of the operation of the terrestrial networks and antenna systems.

György Sogrik Photograph and biography on page VI.



Csaba Szili graduated from the College of Traffic and Telecommunications in Győr in 1975. He studied wireless technology. Between 1975 and 1983 he worked at the frequency management department of Radio and Television Technical Directorate of the Hungarian Post first as a technical executive, later as a system designer. In 1983–1990 he acted as a project manager mainly in telecommunications developments. Since 1990 he is employed by Antenna Hungária Co. At present he serves as the deputy head of the designing department. His activities comprise the radio and television programme transmission, the space communication and the mobile radio systems, specifically the planning works.



Gábor Szűcs graduated from the Technical University of Budapest, the Faculty of Electrical Engineering where he studied telecommunications. Later he worked at Mechanikai Laboratórium as a development engineer. From 1989 he was the head of the television transponder service at the legal predecessor of Antenna Hungária Co. For the time being he is engaged in the television affairs at the service department. His main subjects are the quality of the TV transmitters and transposers, the introduction of new television services (e.g. multi-sound system).

THE PRESENT AND FUTURE OF THE PROGRAMME DISTRIBUTION

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The paper discusses the present and future of the programme distribution. It gives an overview about the main characteristics of the radio and television signals used for programme distribution, describes and compares the various transmission methods with special regard to the digital formats. Finally the paper introduces the existing network of Antenna Hungária Co. and its development trends.

1. INTRODUCTION

The term of programme distribution and programme exchange is as old as the broadcasting itself. The required territorial coverage can only be obtained by using sufficient number of transmitting antennas distributed over a defined region. Therefore the modulating signal should be transmitted to several places. This is what we call programme distribution. Another important task is the programme exchange between the studios and the transmission of signals to the studios during outside broadcasts. So the demands can be classified as follows:

- programme transmission within the country;
- programme transmission from a local studio to a local transmitter;
- programme exchange between studios within the country;
- international programme exchange.

For installing and extending a network which satisfies the above demands, we should have a thorough knowledge of the characteristics of the signal to be transmitted as well as those of the transmission media and the transmission methods.

2. CHARACTERISTICS OF THE RADIO AND TELEVISION SIGNALS

With respect to the programme distribution and programme exchange, the most important parameter of the radio or television signals is the bandwidth. It is dependent also on the transmission format which can be analogue or digital.

2.1. Analogue format

In case of analogue radio transmission, two types are distinguished: the Q quality (CCITT J.21) and the B quality (CCITT J.23) sound. In the first case the transmission of the $0 \ldots 15$ kHz range while in the second case the transmission of the $0 \ldots 7.5$ kHz range is aimed at.

The composite TV signal consists of the video signal and the accompanying sounds. The bandwidth of the video signal is 5 (systems B/G) or 6 (systems D/K) MHz. Originally the accompanying sound was a Q quality audio. At the beginning of the 80-ies the multi-sound broadcasting appeared in Europe too. The analogue two-carrier FM (A2) standard was introduced earlier, but in the last years also the digital NICAM system is expanding.

2.2. Digital format

The digital "revolution" has affected also the radio and television technology. As the sound and even more the picture have a rather high information content, the real-time transmission of the digitized signals requires a very high data rate. Therefore, many efforts have been and are being taken for elaborating source coding and compression procedures to reduce the bandwidth of the digitized signal without a significant loss in the signal quality.

The digitalization and the source coding methods of the sound signal can be divided into two groups: near real time algorithms and those causing considerable delay in signal transmission. From the first group the NICAM (Near Instantaneously Companded Audio Multiplex) system, while from the second group the MUSICAM (Masking Pattern Universal Subband Integrated Coding And Multiplexing) system — which is an ISO/MPEG audio standard — are worthy of closer attention.

The primary aim of the creation of the NICAM system was to provide a possibility to transmit two new audio channels with one stereo or two independent sound information in compatibility with the existing analogue TV video and audio transmitting systems. This requires a near real-time transmission, because a delay of more than cca. 20 ms between the picture and the sound is noticeable and annoying for the viewer. The NICAM system facilitates the transmission of the 40 Hz – 15 kHz range with 728 kb/s data rate.

If the time delay is not very critical (e.g. in case of the radio signals), the application of the MUSICAM system can be more advantageous, because it requires a lower data rate while providing better quality. The procedure is based on a frequency domain coding which takes into account the characteristics of the human ear. According to the ISO/MPEG audio standard, the possible sampling frequencies are: 16, 22.05, 24, 32, 44.1 and 48 kHz. The data rates are between 56 and 384 kb/s, depending on the transmitted information which can be one or two mono or one or two independent or joint stereo channels. The delay time of the encoding/decoding procedure is in the order of 10-100 ms.

There was a great progress in the digitalization and compression of moving pictures in the last years, motivated mainly by the growing demands (e.g. multimedia). The real time transmission of the component coded 4:2:2 video signal according to CCIR 601 would necessitate a data rate of 216 Mb/s. This would require a bandwidth which is both technically and economically too large. The video signal, however, contains a lot of redundancy and shows high degree of intraframe and interframe correlation. Based on these features, a number of methods and techniques have been developed and standardized that compress the visual information into a digital signal with essentially lower bit rate. One set of these standards which seems to become most widely accepted was proposed by MPEG (Motion Picture Experts Group).

The MPEG system was developed from the compression method used in video conferencing, an application of multimedia. The MPEG1 already has an ISO number (ISO 11172) and also the standardization of MPEG2 should be finalized in the near future. Basically it applies two techniques: DCT (Discrete Cosine Transformation) and motion estimation. One of the major advantages of MPEG is the asymmetric algorithm which means that the compression procedure is much more complicated, includes more operations than the decompression. It is an economic solution, because the number of the applied expensive compression units is much lower than that of the cheaper decompressors.

Finally we try to give an indication concerning the acceptable bit rates in the present situation. The opinion of the largest Hungarian programme provider (MTV) is that the digital transmission of the TV signals requires 140 Mb/s for contribution purposes and 34 Mb/s for distribution purposes. However, according to some (mainly American) papers, in case of the MPEG coding 4.6 Mb/s is enough even for live sport programmes containing a lot of motion which are very sensitive to the compression; the transmission of the contribution quality signals needs not more than 8 Mb/s [1][2].

3. TRANSMISSION METHODS AND SYSTEMS

3.1. Analogue systems

The last 100 years witnessed the fast evolution of the analogue transmission systems. Although they occupied all areas of the telecommunication and the broadcasting, they have two essential disadvantages: they are expensive and noisy.

3.2. Digital systems

The great advantage of the digital networks is that they are signal independent. The operation of the system is not affected by the origin of the data stream (sound, picture, data). Further advantages are the higher protection against external interferences and the intermodulation as well as the safe operation even at low signal-to-noise ratios.

Two main groups of digital transmission systems exists:

- non-synchronous systems (PDH: Plesiochron Digital Hierarchy) and
- synchronous systems (SDH: Synchronous Digital Hierarchy).

PDH

For the time being PDH, the digital hierarchy based on the multiplexing of digital signals being in plesiochron clock connection is the most frequently used transmission system. PDH equipment are widely used in copper wire and fiber optic cable as well as in microwave radio networks. The recommendations for the PDH equipment and networks were prepared and finalized by the CCITT and the CCIR in the past years.

The hierarchical bit rates are the following:

2.048 Mb/s
8.448 Mb/s
34.368 Mb/s
139.269 Mb/s.

The bit rate differencies caused by the plesiochron clock connection are compensated by the so-called bit stuffing method. This facilitates the co-functioning of systems using independent (not synchronized) clocks.

Beside their advantages, the PDH systems have some deficiencies too:

- The PDH frame structure allows few possibilities for exchanging maintenance and management information.
- Bit rates above 140 Mb/s are not standardized, their co-operation is not viable.
- The PDH systems are best suited for point-to-point transmissions. The extraction of the branching streams is complicated. The PDH does not support the ring structure which provides high reliability.

The elimination of all these drawbacks stimulated the development of a new hierarchy (SDH) based on different principles.

negyedsor*SDH*

The extremely high data rates enabled by the fiber optics could not be exploited by the systems operated on the PDH concept, therefore from the mid eighties an intensive research and development was initiated to establish new transmission systems better suited to the new technology. The basis for the creation of the system now referred to as SDH was the SONET system developed in the USA. In 1989-92 the CCITT practically prepared the recommendations for the SDH equipment and networks. Now they are working on the unification of the network management system. The telecommunications service providers having appropriate technological and economical background already install primarily SDH systems.

Herebelow we are listing some advantageous SDH features:

- The SDH add-drop multiplexers allow simple branching of 2-34-140 MHz streams without the complete demultiplexing necessary in the PDH systems.
- The SDH frame (STM-1) is capable of transmitting together with the payload the necessary additional information important for the system operation and the network control within the overhead. It makes possible the computer-controlled configuration of the SDH networks and their fast reaction to eliminate the failures occurred in the network and to satisfy the varying demands of the users.
- In the STM-1 frame the tributaries do not engage fixed time slots, their actual positions are indicated by point-

ers. Therefore, at this level no strict synchronization is needed. At the higher multiplex levels (STM-4, STM-16) the connection is isochron, so that a very simple multiplexing can be accomplished by byte interleaving. Due to this fact, the modern technology has already made available the 2.4 Gb/s multiplexers.

- The networks established with SDH equipment have topologies based on new principles. The SDH supports the so called self-healing network structures (rings, meshes).

According to the SDH multiplexing principle, the following tributaries and rates have been defined:

STM-1 level 155.520 Mb/s
STM-4 level 622.080 Mb/s
STM-16 level 2488.320 Mb/s.

The structure of the STM-1 frame can be seen on Fig. 1. Having a periodicity of 125 μs, the time frame consists of 2430 bytes, $261 \times 9 = 2349$ bytes of which are the payload and $9 \times 9 = 81$ bytes are the overhead.

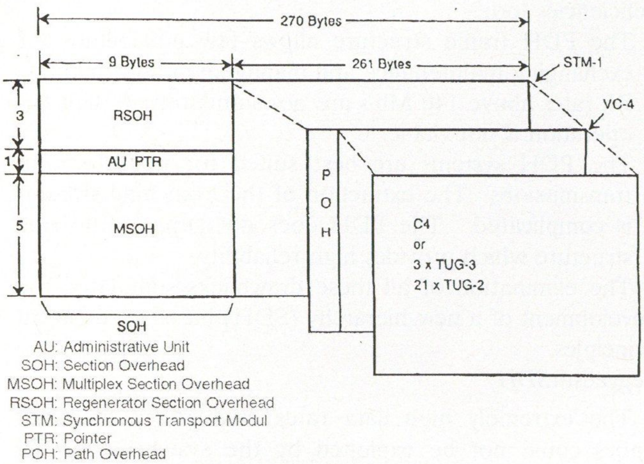

Fig. 1. The structure of STM-1 frame

In consequence of the multiplexing principle, the following number of PDH channels can be inserted into an STM-1 frame:

1×140 Mb/s or
3×34 Mb/s or
63×2 Mb/s or
2×34 and 21×2 Mb/s or
1×34 and 42×2 Mb/s.

The higher order multiplexers are simple byte interleaving multiplexers combining four STM-1 or four STM-4 streams.

The manufacturers have developed the full selection of the optical systems for STM-1, STM-4 and STM-16 levels and for 1310 and 1550 nm wavelengths.

For the microwave SDH systems, now only STM-1 level equipment is available. Using the CCIR frequency assignment, the 64 and 128 QAM modulation schemes are employed.

Because of the problems of the technical implementation, up to our knowledge the STM-4 level 622 Mb/s microwave transmission equipment has not been developed yet, but reports on the experimental operation of 2×155 and 4×155 Mb/s systems with polarization separation have already been published.

3.3. The comparison of the microwave, the fiber optic and the satellite technology

When the distribution system of Antenna Hungária was created, the microwave radio was the only available transmission medium. Fortunately enough, since that time the fiber optic and the satellite technology have turned up too. When deploying a new distribution system, also these new possibilities must be taken into consideration in order to establish a national data transmission network which is optimal in every respect.

Theoretically any of the microwave radio, the fiber optics and the satellite technology can fulfil all the tasks of such a network alone. The question is: what are their costs? Due to their specific properties, these technologies provide an optimum performance/cost ratio only for certain applications. Table 1 shows the level of suitability for some general cases [3], [5].

Table 1. Level of suitability

Service type	Microwave	Fiber optics	Satellite
High capacity point-to-multipoint (TV distribution)	medium	high	medium
High capacity point-to-point (TV programme exchange, data transmission)	medium	high	low
Low capacity point-to-multipoint (radio distribution)	low	low	high
Low capacity point-to-point (radio programme exchange)	medium	low	medium

4. THE EXISTING MICROWAVE NETWORK

Antenna Hungária Co. is operating radio and TV transmitters distributed in the country. The modulating signals must be transmitted to the stations in good quality and with high reliability. Additionally we are providing links for the programme exchange between the studios within the country and internationally and also for the outside broadcasts. In the future we have to appear on the national or eventually on the international data transmission market.

Our existing, mostly analogue microwave network demonstrated on Fig. 2 is not capable of fulfilling all the tasks mentioned above. The deployment of the system took quite a long time, therefore the microwave links comprising the network are of different ages. The oldest operational link is a 4 GHz microwave system manufactured by Siemens-Auso which was installed on the Budapest (OMK)-Gerecse-Győr-Sopron-Anninger (Austria) line in 1970. This equipment is 25 years old now and that means both obsolescence and physical depreciation.

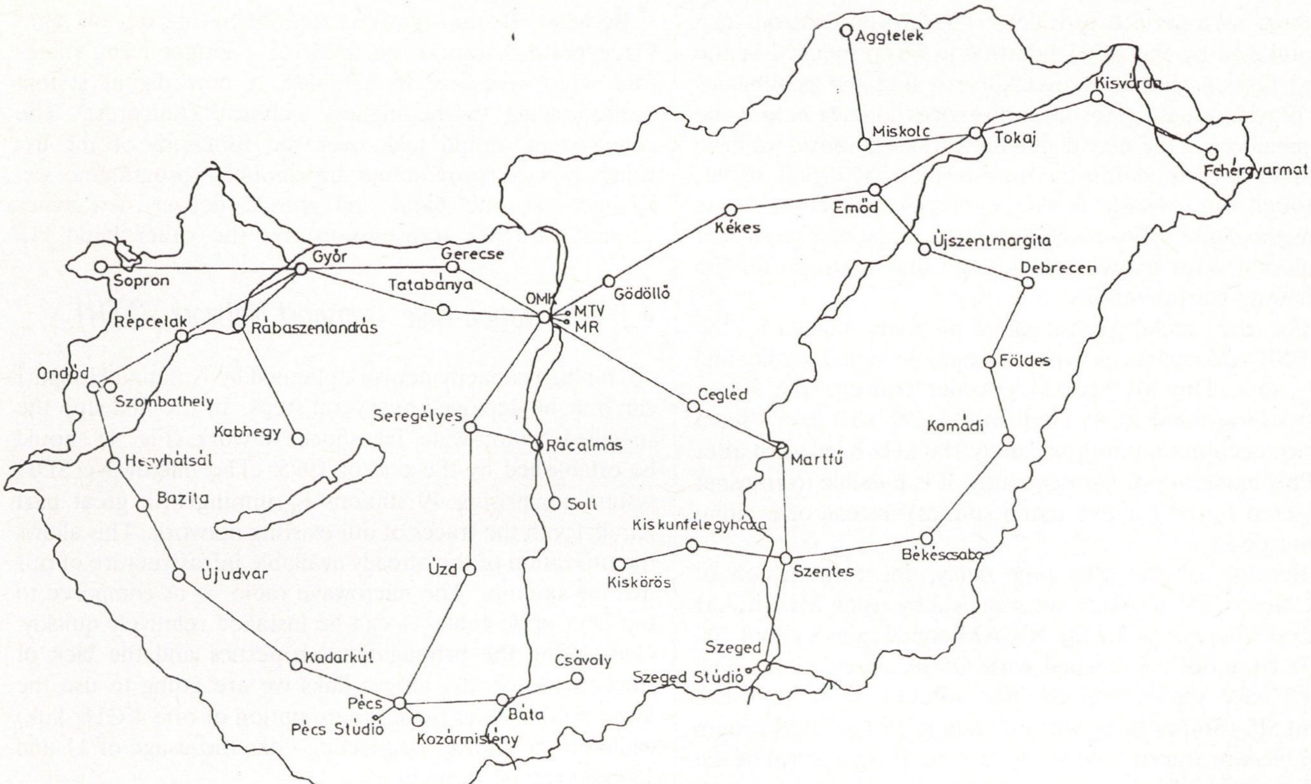

Fig. 2. The microwave network of Antenna Hungária Co.

The network has a star type structure with the OMK (National Microwave Centre, located on the Széchenyi hill in Budapest) in its centre. The modulating signals are transmitted via the so called microwave studio access link from the radio and television studios to the OMK. In case of the radio programmes also a wired line is used as back-up. In the OMK the programme signals are distributed in the main directions by a swithing matrix.

The analogue system is using mainly the 4 and the 6 GHz band, but in case of the branches the usage of the 8 and 11 GHz band is typical. Each link supports several channels which can be duplex (bi-directional) or simplex (unidirectional) ones. Basically the programme distribution requires unidirectional transmission, so the return path of a duplex channel can be used for programme exchange or for transmission of outside broadcasts.

Fig. 3 is illustrating the baseband spectrum of the signal to be transmitted in the television channel. Above the video signal there are 4 audio carriers to transmit the accompanying sound channels and the 3 radio programmes. For the distribution of the stereo programmes two audio carriers are needed: one for the left and one for the right channel. The Q quality audio signals are transmitted with FM modulation, the max. deviation is 100 kHz, so each audio channel requires 200 kHz bandwidth. On the Figure also the so-called pilot carrier can be seen, by means of which the distortion caused by interferences and fadings occuring in the transmission can be measured to allow the automatic control to switch over to the back-up channel if necessary. This complex baseband signal is transmitted by FM modulation (FDM/FM system).

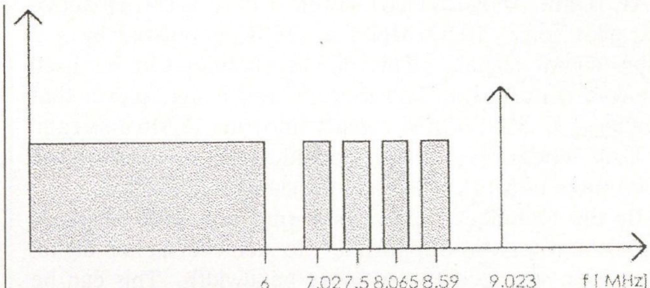

Fig. 3.

Until now only the analogue part of the existing system has been discussed. As mentioned above, there are some digital branches with PDH type links as well. Such are the Tokaj-Kisvárda-Penyige, the Tokaj-Miskolc-Aggtelek and the Szentes-Kiskunfélegyháza-Kiskőrös lines where 140 Mb/s data transfer is possible on each channel. The encoders provide for the transmission of one video and 2x4 audio signals per channel.

Although a great part of the equipment is several decades old, the analogue network can still work satisfactorily for 4-5 years. Because of the expected abrupt growing of the demands (e.g. after the enactment of the law on the media), at least until or may be also after the deployment of the new digital system, the still operational analogue links should be maintained and even some developments on them can be economically profitable.

It is a general trend in the world and also in Hungary that the interest for the data transmission facilities is increasing. Of course, the growing demand creates a larger market on which also Antenna Hungária should be present as a service provider. The arosen demands can be fulfilled by the SDH network to be introduced in the next section, but it is necessary to find the possibilities of providing data transmission services already before the completion of the new digital network. Therefore we have to find a method for the transmission of digital signals through our existing analogue microwave network. As now the digital transmission of the modulating signals is of importance for us, we have chosen this approach for the following considerations.

For the digital transmission of radio channels, the MUSICAM coding provides acceptable signal quality and bit rate. The MUSICAM encoder converts the stereo sound presented to its input into a 192 kb/s data stream which occupies an approximately 180 kHz bandwidth after QPSK modulation. Consequently, it is possible to transmit a stereo sound (or two mono sounds) instead of a mono one (see Fig. 3).

Because of the long time delay, the transmission of the stereo TV sound is not practical by using MUSICAM encoder/decoder. For the NICAM-coded signals about 700 kHz bandwidth is needed with QPSK modulation. The trials have shown that the best solution is the so-called dual SIS (Sound In Synchron) coding. In the DSIS system the bits are transmitted in the line blanking interval of the video signal by using 4-level PAM modulation.

The spectrum of the complex analogue baseband signal (Fig. 3) shows that there is a relatively wide free region above the pilot carrier. This is utilized by the so-called DAV (Data Above Video) system where a carrier above the pilot (e.g. 10.87 MHz) is QPSK-modulated by a 2 Mb/s digital signal. This digital channel can be used for data transmission and there is also a multiplexer that combines 6 MUSICAM signals into one 2 Mb/s stream. A DAV modem (modulator-demodulator) installed on the microwave network is already providing a digital link.

By the techniques mentioned until now only relatively low data rates are supported. To achieve higher digital capacities, we need to use more bandwidth. This can be accomplished by utilizing the releasable TV or telephone channels. Theoretically it is possible to realize 8 or 16 Mb/s data transfer on the analogue channels without carrying out significant changes on the network, because in case of 4-level PAM modulation the spectrum of the digitized video signal fits into the 6 MHz bandwidth, so it can be transmitted within the frequency range of the analogue video without disturbing the audio carriers. If the transmission channel is linear enough, the resulting bit error rate can be maintained low. With respect to the programme distribution, the significance of this procedure is that if the programme providers accept the 8 Mb/s digital video compressed according to the MPEG than we can transmit two TV programmes in one microwave channel.

Because of the reasons mentioned above the analogue network cannot be used for a longer term, therefore it is necessary to establish a new digital system corresponding to the highest technical standards. The new system should take over the functions of the existing system (programme distribution, programme exchange) on one hand and should deliver new types of services (data transmission) on the other hand [4].

4.1. The Nation-wide Transport Network (OTH)

The high capacity network planned by Antenna Hungária can only be deployed in several steps. In the first step the so-called Nation-wide Transport Network (Fig. 4) should be established by the end of 1995. The microwave SDH system comprising 49 stations is running in a great part parallel with the traces of our existing network. This allows the utilization of the already available infrastructure of our existing stations. The microwave radio — as compared to the fiber optic cable — can be installed relatively quickly. Considering the propagation properties and the lack of frequencies, on the longer links we are going to use the lower 6 GHz band (with the exception of one 4 GHz link) while on the shorter connecting links the usage of 11 and 18 GHz can be thought of.

Incorporating the backbone network, the OTH provides access to the major correction points. The access network covering the whole country will be established according to the demands.

Consisting of five 155 Mb/s duplex rings, the whole system is making use of all the advantages of the SDH structure. The branching links — including the Rábaszentandrás-Seregélyes link — are also employing SDH equipment. This is to enable the management centre (OC) located in Budapest to supervise and control the whole system. In the rings the USHR (Unidirectional Self-Healing Ring), the 1+1 protection structure is applied in the branches.

The add-drop multiplexers (ADMs) at the nodes allow the extraction of the 2 and 34 Mb/s streams from the 155 Mb/s stream. At the stations shown on Fig. 4, 21×2, 42×2 or 1×34 Mb/s tributaries will be available, but the flexibility of the network and the modular structure of the ADM enable us to extend the accessibility at the particular points according to the demand.

The cross-connect equipment located in the OMK provides a gateway between the rings at the package level.

It is important to note that the so-called Budapest Ring fiber optic network will operate in close connection with (and in our plans as part of) the OTH. In the programme transmission, the main function of the Budapest Ring is to transport the signals of the radio and TV studios in the capital to the OMK.

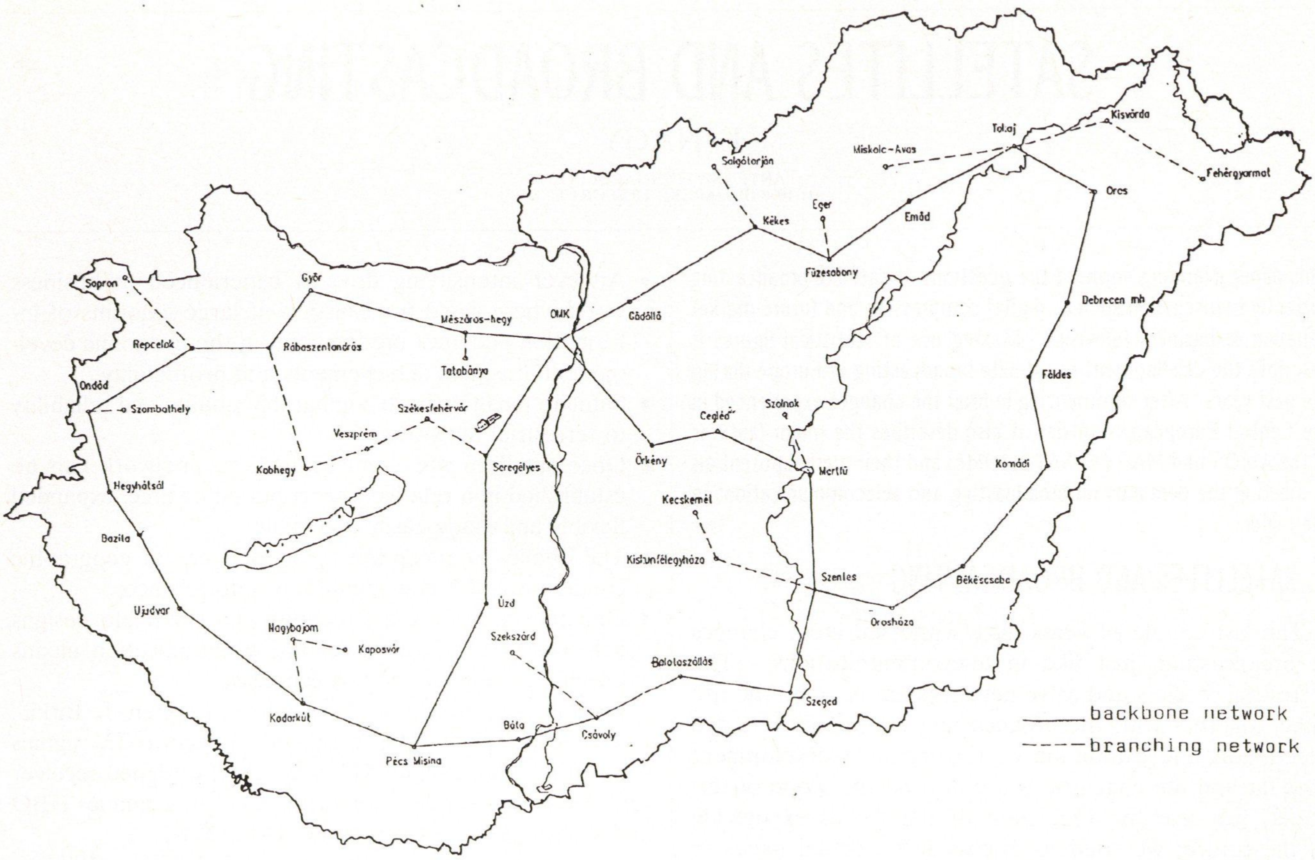

Fig. 4. Nation-wide transport network

5. SUMMARY

The telecommunication of the world and within it the programme distribution and the programme exchange is developing in the direction of the digital solutions. Following this trend, with its developments also Antenna Hungária has turned to the application of the latest telecommunications technologies. However, the firm is also interested in the best possible utilization of the existing assets and the infrastructure for the high level satisfaction of the demands. We are on the right way and expect that despite the ever increasing competition we can keep our leading position in the programme transmission.

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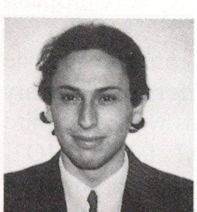
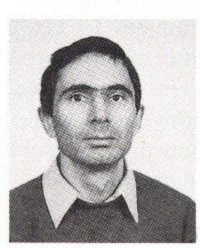


Zoltán Szepesi graduated from the Technical University of Budapest, the Faculty of Electrical Engineering in 1994. Specializing in telecommunications, he studied microwave technology. After his studies he began to work at the Long-term Development Division of Antenna Hungária Co. where he is engaged in the development of microwave and fiber optic networks.



József Turschl graduated from the Telecommunications University of Moscow, the Faculty of Radiocommunications and Broadcasting in 1978. During his career he has always been engaged in the technical problems of radiocommunication. In 1993 he was granted an engineer-specialist diploma in microwave PCM and space communications. For the time being he is working for Antenna Hungária Co. at the Long-term Development Division as the leader of the microwave group.

SATELLITES AND BROADCASTING

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This paper examines some of the questions of satellite broadcasting currently in discussion such as digital compression and future market situation of business television. Making use of statistical figures it describes the development of satellite broadcasting in Europe during the past years. After summarizing in brief the changes experienced in the Central European countries, it also describes the major features of the AMOS and MAGYARSAT satellites and their market potentials in meeting the demands on broadcasting and telecommunications in the region.

1. SATELLITES AND BROADCASTING

The last couple of years have witnessed great changes in broadcasting, just like in telecommunications. The terrestrial wireless and cable networks has been on the rise alike, together with the broadcasting via satellites. Since description and evaluation of the trend in development thus far and the conclusions are beyond the scope of this paper, just like the prediction of the trends expectable in the future, we tried to discuss some actual issues in relation to satellites and broadcasting.

1.1. Brief review of the past

The first step in satellite broadcasting was the launching of the satellite TELSTAR in 1962; this was capable of transmitting TV picture signals as well. However, large diameter antennas capable of tracking the elliptic orbit of the satellite were needed to receive the signals, apart from the fact that reception was restricted in time.

EARLY BIRD, launched and brought to orbit in 1965 was already a geostationary satellite capable of simultaneously transmitting 240 telephone channels or a single TV program. This was the advent of geostationary satellites, followed by ever sophisticated satellites. The focus was extended from classic telephony to TV and radio programmes as well as data transmission. The last decade witnessed the appearance of nationally owned and operated satellites, supplementing the international satellite operating organizations. Figures showed that more than 80 nationally owned satellites were launched until 1992. This rapid development was spurred by social, economic and technologic aspects, such as:

- Users of telecommunications and broadcasting facilities want not only communicate with each other but also have a wide variety of TV programmes to keep pace with world-wide events and enjoy international programmes directly from an armchair. This is reflected in the rapid spreading of mobile telephony and satellite broadcasting. The facilities offered by networks and service operators in turn further intensify demands.
- An ever intensifying drive is experienced in business world where rapid transmission of large amounts of information becomes predominant in the economic development, business achievements and profitability.
- Satellite facilities have comparable quality and reliability to terrestrial networks.
- Once satellites are commisioned, the network can be established in a relatively short period of time, expanded flexibly and made easily accessible.
- The quality of reception is independent of geographic conditions and highly immune to interferences.
- Due to state-of-the-art technology of satellite designs achieved in the past, terrestrial communication means are more compact and less expensive.

Another era began in 1975 when Stephen J. Birkill, a technician of the BBC managed to receive TV signals beamed off the satellite ATS-6 by a self-designed receiver set. The same year the American cable programmes HBO and WTBS move to the satellite SATCOM-1.

A paper published in the magazine CATJ in 1978 by Robert Cooper describes the potentials of home reception of satellite TV programs. What followed in the ensuing years was an unprecedented spreading of ever sophisticated and inexpensive satellite receivers.

In 1986 HBO and CNN launched their services in America for home satellite receivers and cable networks.

In Europe the first commercial broadcasting for cable networks began in 1982 via the satellite OTS-2.

ESA launched and brought to orbit the satellite EUTELSAT-1 in 1983, heralding a new era of satellite TV broadcasting in Europe. In order to meet the increasing demand on capacity additional satellites were launched. At that time, however, a major obstacle before spreading home reception was in addition to legal restrains that large diameter antennas and expensive receivers were needed for reception.

The satellite ASTRA-A was launched in 1988 by a Luxemburg based business group, the first of a family receivable in Western-European countries by a 60 to 80 cm diameter dish. The success was boosted when several European programme suppliers including Sky TV moved to ASTRA. Through the launching of additional members of the family in 1991 and 1993 respectively, ASTRA has succeeded to gain dominating position in the European satellite TV broadcasting.

Throughout Europe, the EUTELSAT satellites provide not only broadcasting services, but also offer the necessary capacity for telecommunication services as well. The third generation members of the EUTELSAT family (HOT-BIRD) cover all Europe, providing transmitting power of 49 dBW EIRP throughout most part of the continent.

1.2. Digital compression

From the components making up the overall costs of satellite broadcasting services is the rental fee of the transponders that prevails. Accordingly any reduction in the transmission bandwidth could result in considerable cost-savings. An important consequence thus would be that programme suppliers of less capital could make use of the satellite capacity, as well. This is the reason why digitally compressed moving picture transmission has come into the limelight.

Let's see where standardization in this field has come by now and what conditions on the equipment's market prevail? The MPEG-1 standard has been developed for errorfree recording of pictures in CD disks or magnetic disks at 1.2 Mb/s transmission rates. MPEG-2 has been optimized in view of the requirements on picture transmission up to 40 Mb/s rates to satisfy TV broadcasting requirements. The great rival in compression technology is Digicipher 2 developed by General Instruments (GI). This system employs a double-compression technique (MPEG-2 and DCII) both on the coder and decoder side. The coder is so designed as to allow the selection of MPEG-2 or DCII coding, whereas decoding is automatic. Digicipher 2, however, does not provide bidirectional predictive picture coding as MPEG-2 does, which makes greater compression possible. To allow the Reader to get an idea of the conditions of competition, here are the statements of some companies interested in system selection:

- *LSI Logic, Motorola* is about to put in manufacture dual mode decoder chips based on MPEG-2 and Digicipher 2.
- *IBM* announced the launching of its MPEG chip, a component capable of decoding MPEG-1 and MPEG-2 signals. In the 4 to 15 Mb/s range it meets the specifications of CCIR 601.
- *Scientific Atlanta* is in favour of MPEG-2.
- *Hewlett-Packard (HP) Pacific Telesis* employs the MPEG-2 standard in implementing its own interactive video system. HP supplies to CBS a digital video server intended to replace the former VCR recorder system. CBS has chosen the MPEG coding system.
- *EUTELSAT* announced the launching of Simulcast satellite service. In the pilot scheme Digicipher and NTL 2000 equipments were used.
- *Deutsche Bundespost Telecom* concluded a contract several millions of dollars worth with TV/COM International to get its products supplied. This system utilizes MPEG-2 coding. TV/COM is represented in Europe by FUBA.
- *ABS-CBN* a broadcasting firm in the Philippines launched a 6 channel digital video service via satellite. It has stood up for the DigiCipher system.
- *NEWSFORCE, UPLINX firms providing SNG services* use Thomson's 8 Mb/s, MPEG-2 encoders/decoders in the SNG transmissions.

Interestingly, it is predicted in the United States that digital home receiver sets will exceed in number the analogous sets by 1997.

A trend is emerging where the MPEG-2 system seems to gain ground all over the world. However, the current situation deserves mentioning of the following facts:

- experts think that further details are to be specified in the standard to make it applicable to open networks as well,
- systems manufactured according to the MPEG standard at different manufacturers are not being fully compatible, consequently a requirement is that products of the same manufacturer should be used at both ends of a transmission path.

The standard is expected to be precised by the end of 1995. Receiver sets of the leading firms are already available on the market, albeit at high prices, and their usage in closed networks may continue to be rising.

1.3. Business television

On hearing the term business television (BTV) one might associate it with video conferences offered as part of the VSAT services, providing point to point or point to multipoint picture, voice and data transmissions. Here, a highly compressed picture transmission is used to obtain a reduction in bandwidth.

From the point of view of quality, required bandwidth and number of users of the service business TV is in fact closer to programme broadcasting. By definition the BTV is a point to multipoint transmission of TV pictures, live or recorded, with a quality identical with programme broadcastings for groups of audiences at given locations that are able to communicate with the participants of the programme on screen via telephone lines. Both the picture and the sound are scrambled in the transmission. In addition to picture and (multilingual) sound transmission, data transmission is also possible.

In the United States this service has been present for over 10 years and by now it normally ensures bidirectional and digital transmission between the network centre and the different sites. In Europe, this service is predicted to gain ground a couple of years from now. Currently, there are 23 established BTV networks, 15 of which is operated by MAXAT, a British firm founded in 1991.

Here are some of the applications for BTV:

- school educational systems at different levels,
- company management, information and training systems,
- networks of bookmaker agencies with live broadcasting of races,
- auctionary networks, such as e.g. the sale of used cars a successful business branch in Japan,
- sales demonstrations and other informatory networks.

Digital compression is expected to lead to considerable saving in BTV as well, regarding both satellite resources and service charges. All this may contribute to accelerated spreading of the applications.

1.4. Satellite Broadcasting in Europe

Statistical figures show that in Europe an ever increasing ratio of the capacity of satellites are dedicated to programme broadcasting as well as other related services (such as SNG, programme transmission, modulation distribution). The demands in terms of absolute number are also on the rise.

Below is a list summarizing the number of programmes transmitted via transponders leased on the ASTRA, EUTELSAT and DFS satellites either full- or part-time as per countries (according to figures based on 1994 data):

Country	#1	#2	Country	#1	#2
England	26	14	Yugoslavia	1	–
Germany	18	4	Hungary	1	–
USA	9	8	Morocco	1	–
Sweden	2	–	Croatia	1	1
Belgium	1	–	Egypt	2	1
Luxemburg	1	–	Vatican	1	1
The Netherland	4	3	Albania	1	1
Spain	6	2	Tunesia	1	–
Italy	3	–	Algeria	1	–
Mexico	1	–	Ciprus	1	–
Turkey	3	1	Arab Emirates	1	–
Poland	4	–	Portugal	1	–
Czech Republic	2	–	International	23	10
Greece	2	–	Total:	118	46

#1 number of TV programmes in the interest of the country,
#2 number of programmes per #1 transmitted in part time (via shared transponders).

In view of the fact that 33 TV channels were leased on the EUTALSAT satellites at the end of 1992 and that the capacity available on the two ASTRA satellites in operation at that time amounted to 32 maximum it can be said that the number of programmes has doubled during the past two years.

It is worth to examine also that how many percentage of the capacity of satellites has been allocated to programme broadcasting. This is summarized in Table 1.

Add to this the capacities of the EUTELSAT satellites allocated to telecommunications the net result is that the factor of utilization of both the ASTRA and EUTELSAT satellites is approx. 75 %. Since a certain number of reserves are also necessary, an oversupply of transponders in these systems is currently not the case.

Digital compression may theoretically increase the capacity 3 to 4-times of broadcasting satellites. Practicable implementations however depend on several factors. A cable TV network is able to change to this new technology rapidly and economically. Large-scale usage in home reception is however expected with the advent of cheap decoders (digital home receivers) only. The desire to serve both spheres of users is reflected in the introducing of the EUTELSAT SIMULCAST system. For the time being, however, this solution does not result in the saving of capacity of satellites. And since a boom in the demands and more sophisticated broadcasting systems are expected, it is hard to predict whether or not there would be an oversupply in transponders in the future.

Table 1. Broadcasting capacity of satellites

	ASTRA-A,B,C,D	EUT II-F1,2,3,4,6	EUT I-F4,5
Number of TV programmes	58	60	4
Number of physical channels used for TV programmes	48	47	4
Number of EBU and other TV programme transmission channels	–	18	14
Number of physical channels used for the transmission of EBU and other TV programmes	–	16	12
Overall capacity of the satellites (TV channels)	64	108	40
Utilization	48/64=75 %	63/108=58 %	16/40=40 %

1.5. Situation of broadcasting in Central Europe

Eastern European countries are characterized — albeit to different degrees — as having outdated infrastructure and limited basic transmission and broadcasting services both quantitatively and qualitatively. The situation is further aggravated by the lack of sufficient funding available for expansion and development.

On the other hand, however, the restructuring of the economy, privatization, joint ventures and credits granted as development sources bear the potential of closing the gap. In addition this potential may also carry in itself the possibility of overstepping interim phases of development, adopting an up-to-date solution. In respect to broadcasting, this would mean the creation of the resources for satellite broadcasting.

In the countries of the region, parallel to the circumstances cited above, the number of companies producing commercial programmes has been rising steadily. The terrestrial networks, on the other hand, are however not able, or to a restricted degree only, to transmit and broadcast their programmes. For them, satellites would constitute a rapid and efficient solution.

Television broadcasting through cable network has been gaining ground because this offers the quickest way for the viewers to get higher quality and wider program selection at acceptable costs.

As far as the public service programmes are concerned, broadcasting via satellites could also help in improving national territorial coverage and providing programmes in native language for communities living beyond the border.

The Reader may have heard already of the MAGYARSAT project, a satellite program to be implemented in a joint venture of Antenna Hungária Co. and Israel Aircraft Industries Ltd. (IAI). As planned, two low-capacity satellites, AMOS and MAGYARSAT would be brought to orbit at identical position in the near future.

This solution would have the benefit offered by one of the two satellites being steadily at standby of raising the overall reliability of the services. In what follows the major features of both satellites are summarized in Table 2, enhancing in particular those with interest for the potential users.

Table 2. Major features of the satellites

	AMOS	MAGYARSAT
General contractor	IAI	
Manufacturer of:		
• Communication unit	ALCATEL	
• Antenna system	DORNIER/MBB	
• Mechanical structure	IAI	
• Thermal control system	IAI	
• Telemetry and command system	IAI	
• Power supply system	DORNIER	
• Propulsion system	MBB	
• Firm in charge of launching	ARIANESPACE	
Location of ground control station	Israel	Hungary
Number of antenna beams	2	2
Area coverage (for both satellites)	Middle East and Central Europe	
Number of active transponders	7	8
Number of transponders in reserve	2	2
Transponder bandwidth (MHz)	72	72/36
Number of cross-connectable transponders between beams	2	min. 2
EIRP at boundaries of the coverage area (dBW)	52	52
Uplink frequency band (GHz)	14–14.5	13.75–14.5
Downlink frekquency band (GHz)	10.95–11.7	10.95-11.7 and 12.50–12.75
Planned lifetime (year)	11	11

The service areas covered by the satellites are depicted in Fig. 1. The concentric circles show the areas of AMOS, the innermost one corresponding to EIRP=55 dBW and the division equalling ΔEIRP = -2 dBW. At this beam, 4 pcs. of 72 MHz transponders will be available from January 1996, in the following frequency ranges:

Uplink 14.17–14.50 GHz, Vert. polarization;
Downlink 11.12–11.45 GHz, Hor. polarization.

In the lower channels of the frequency range two transponders would be cross-connectable between the Middle Eastern and Central European beams, allowing European uplink and Middle Eastern downlink or vice-verse. The Central European area of AMOS is shown by the dash-and-dot contour covers Slovakia, Hungary, Slovenia, Croatia, Bosnia-Hercegovina and Serbia fully and Poland, Czech Republic, Austria, Romania and Lituania partially (the majority of their territories). It should be noted that the service area actually covered by the beam can be extended up to the contour of EIRP = 47 dBW, even for home reception if the two channel signals are transmitting at asymmetrically distributed power, e.g. one broadcasting and one SNG service in pair.

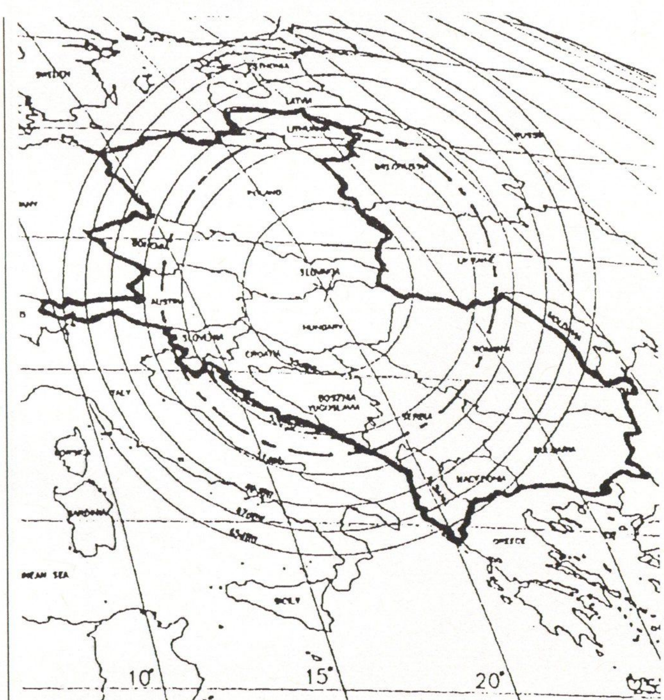

Fig. 1. Coverage map of the European beam

The service area in Central Europe to be covered by MAGYARSAT is so defined on the map that the area solidly encircled should fall to within the contour of EIRP=52 dBW. It is seen that this area can be covered properly by slightly forming and rotating the antenna beam to get an elliptic beam. This means that the boundaries of the service area would be shifted eastwards, covering a portion of Belorussia and Ukraine, which could even bring along added business benefits.

Once put into operation, the countries of the region could gain access to satellite capacity at acceptable prices. In addition, these satellites could contribute to their achieving significant progress in meeting the demands on national programme broadcasting or to rapid spreading of new services.

Studying the conditions in the developed Western countries or those catching up reveals that terrestrial and satellite infrastructures supplement each other even if the capacity of any one of them alone would suffice to meet current demands.

As far as the consumer's side is concerned, the demands on their part should nowadays be met in a short period of time and at high quality by making optimal use of either one or the other infrastructure.

2. CONCLUSIONS

The market of satellite broadcasting in Europe has considerably widened during the past couple of years. The number of programmes has doubled in the past two years. The capacity for this increased demand on transponders was served by new satellites commisioned (ASTRA und EUTELSAT).

In the countries of Central Europe similar market intensification is expected during the years to come. The number of programme makers as well as programmes is on the rise not only in our country but also in the neighbouring countries as well. So does the number of viewers connected to cable TV networks. A significant boom in demand on such services as programme exchange and transmission, SNG, modulation distribution and business TV besides the traditional satellite broadcasting is also expected. Digital compression introduced places a constrain on the rate of increase of the capacity requirements in the domain of broadcasting. Yet it can be stated that the rising demands in the region do create market potentials for the satellites AMOS and MAGYARSAT which could and should be utilized with appropriate timing, optimal coverage and competitive price structure.

László Nagy graduated from the Technical University of Budapest, Electric Engineering Faculty in 1971. Between 1974 and 1991 he was with the Research Institute for Telecommunications, designing, developing and measuring microwave devices and receiver systems. In 1986 he concluded a post-graduate training at the Budapest Technical University, graduating in Radiofrequency Telecommunications and obtaining a Ph.D. degree. Since 1991 he has been with Antenna Hungária Co. at the Long-term Strategy Development Department. He acted actively in preparing and introducing the domestic satellite broadcasting. Currently he works on the AMOS–MAGYARSAT project.

THE PRESENT AND FUTURE OF MIDDLE-WAVE AND SHORT-WAVE BROADCASTING IN HUNGARY

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This paper gives a detailed survey of the present state of the middle and short-wave transmitter network and discusses the development proposals for improving the emission and introducing the SSB broadcasting. Finally, an international outlook on the development trends of the short-wave broadcasting is presented.

1. MIDDLE-WAVE BROADCASTING

1.1. Preliminaries and the character of middle-wave broadcasting

In Hungary, the radio broadcasting in its formal quality started on December 1st, 1925, by using a Telefunken-made middle-wave transmitter of 2 kW capacity, operated at the old transmitter station of Csepel.

After an experimental period, the home middle-wave broadcasting showed a very significant development during the past seventy years.

Development is proven by the system of transmitter stations with increasing transmitter powers to improve coverage.

Development can also be expressed by the increase in the number of subscribers. In the first year, 15 thousand listeners were officially registered, while the number of subscribers already exceeded 2.6 million by the mid of eighties.

The significant changes in respect of the transmission power were justified — primarily during the last two decades — by the interference phenomena that were typical during night due to the wave propagation features.

Considering that the frequency band available for middle-wave radio broadcasting is given and more and more transmitter stations were put into service, the conditions of reception were significantly deteriorated, especially during night.

In the case of middle-wave broadcasting, the propagation during day-time and night shall be considered separately. During day-time, there is exclusively surface propagation, which is influenced only by the geological effects of the earth and the soil characteristics. After sunset, the reflection caused by the ionosphere will be intensified, thus, the absorption caused by the ionosphere occurs only to a small extent. Thus in the case of middle-wave broadcasting, the coverage can be ensured to an area of 1300 to 1500 km radius by using the so-called ionosphere propagation during night.

1.2. The present situation

The parameters of the home middle-wave broadcasting with respect to frequency and transmission power were specified by the Regional Administrative LF/MF Broadcasting Conference held in Geneva in the year 1975.

The program of Radio Kossuth is broadcasted by two transmitters: the 2000 kW transmitter of Solt and the 15 kW transmitter of Miskolc at frequencies of 540 kHz and 1116 kHz, respectively. In the latter case, the program is periodically interrupted and replaced by programs of regional interest.

The program of Radio Petőfi is broadcasted full time by the main transmitters of Marcali, Lakihegy and Szolnok as well as the low-power transmitters of Szombathely, Nyíregyháza, Pécs, Lakihegy, Mosonmagyaróvár and Győr, with their regional programs inserted periodically.

The coverage areas of our present middle-wave network during night and day-time are represented by the Figs. 1, 2, 3 and 4.

The coverage areas of Radio Juventus and Radio Calypso are shown in the Figs. 5 and 6.

The middle-wave transmitter network consisting of 18 transmitter equipment operated by us broadcasts the programs with a total power of 3580 kW at 8 different frequencies.

The antenna systems of our middle-wave transmitter network consist of one-pole, grounded, free-standing or stayed radiators of omnidirectional pattern. Exceptionally the 25 kW transmitter of Szombathely is provided with an antenna of directional pattern. The antenna system of Szombathely with its two towers provided with appropriate feeding assures the coverage of Western Hungary, by using cardioid-shape radiation pattern. It is also possible to invert the direction of radiation (to Burgenland, Austria), which could be utilized e.g. for broadcasting of commercial programs.

Analysis of the network

The Kossuth program can be well received in the whole area of Hungary during day-time, while the reception is subject to interferences in the western and northern part of the country during the evening hours. Beyond the borders, the coverage of farther regions inhabited by Hungarian people is unfavourable (fading zone during night).

In case of the Petőfi program, the coverage is very unfavourable at national level, especially during night (the coverage is estimated to be 80 % during day-time and about 54 % during night).

It is another difficulty with the Petőfi network, that the frequencies allotted by the Regional Administrative Conference in 1975 are unfavourable as the high-power and medium-power transmitters use the same frequencies, causing significant interference especially during the evening hours (transmitter pairs of Lakihegy-Pécs; Marcali-Nyíregyháza: Szolnok-Szombathely).

A study aimed at eliminating the interference is in progress.

In respect of our home middle-wave transmitter network, the problems which occurred in the recent past are listed below:

- Dominant part of our middle-wave transmitter stations consists of old and outdated equipment. Due to the low efficiency, their operation is unreasonable. Remote supervision have not been solved yet.
- Manufacturing of transmitting tubes was terminated in Hungary; the purchase of appropriate transmitting tubes is often difficult.
- Existing transmitters shall be operated in order to fulfil the listeners' needs; therefore, modifications on the circuits have to be performed to accommodate other types of tubes that are available; however, the basic problem (that is, an up-to-date network) remains still unsolved.
- The 135 kW Transmitter Station of Szolnok is the oldest main one of Petőfi Network, without any equivalent standby equipment.
- The transmitters used in the stations of Szombathely, Nyíregyháza and Miskolc are the oldest and the most outdated ones of lower capacity; their replacement is indispensable.

1.3. Proposals on the improvement of our middle-wave broadcasting

In order to maintain the middle-wave broadcasting of the program of Radio Kossuth and primarily that of Radio Petőfi at its current level, or even, to improve it to a certain extent, as well as to increase the coverage of the middle-wave Calypso program, the following aspects shall be considered and implemented progressively in the next future:

- The most important task is of the reconstruction of the transmitter station of Szolnok, with the restriction that the transmitter power of the existing transmitter station shall be limited to 150 kW, due to the high-frequency interference problems (short-distance to the town). The reconstruction shall be started as soon as possible, by installing and operating an up-to-date solid-state MW transmitter. In the coverage, the present situation will remain nearly unchanged.
- The reconstruction of the middle-wave transmitter stations of Szombathely, Nyíregyháza and Miskolc shall be implemented as soon as possible, by installing new and unified up-to-date solid-state transmitter equipment of 20 kW capacity, suitable to be remotely controlled.
- The frequency changes to 864 kHz at the 20 kW transmitter of Lakihegy and to 990 kHz at the 25 kW transmitter of Nyíregyháza shall be implemented, in order to eliminate the mutual interference and to increase the area of coverage to a significant extent.
- Considering the increase and continuity of the program transmitted by the Radio Juventus, the old and outdated 15 kW transmitter equipment of Siófok should be replaced by an up-to-date equipment, possibly by the end of 1997. (Broadcasting a so-called Balaton-oriented program would also be possible).
- The frequencies and transmission powers of our middle-wave transmission network are fixed; thus, this network is unsuitable to ensure the full coverage of the Carpathian Hollow.

A general way of broadcasting home programs to cover the Carpathian Hollow might be to use a long-wave transmitter of appropriate capacity to broadcast some of our main programs (e.g. Petőfi program).

At present, no frequency in the long-wave band is allotted to Hungary; therefore, we propose that the Hungarian Administration shall take measures at the world conference WARC expected to be held in 1998, in order that frequencies in the long-wave band will be allotted to Hungary.

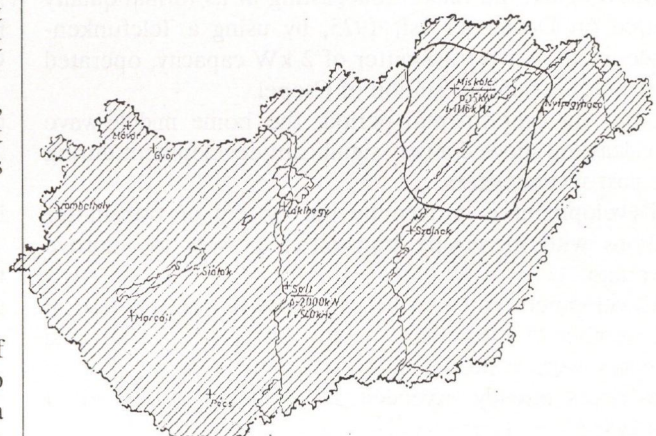

Fig. 1. Day-time MW coverage area of Kossuth from 1991 to 2000

Fig. 2. Night-time MW coverage area of Kossuth from 1991 to 2000

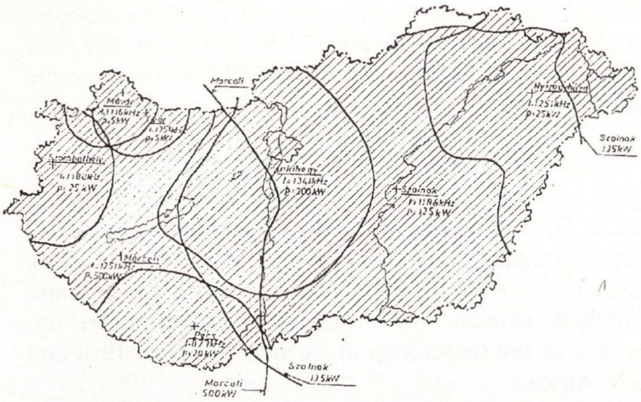

Fig. 3. Day-time MW coverage area of Petőfi from 1991 to 2000

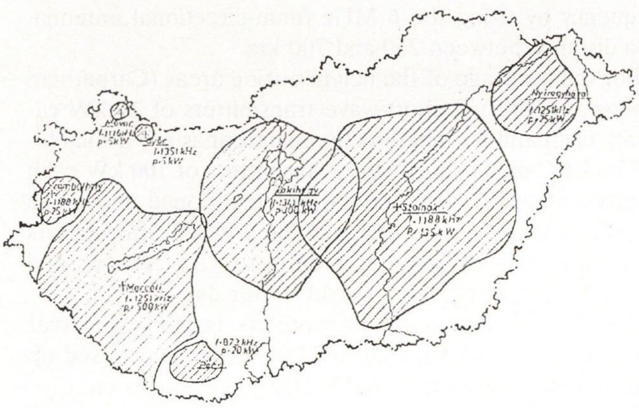

Fig. 4. Night-time MW coverage area of Petőfi from 1991 to 2000

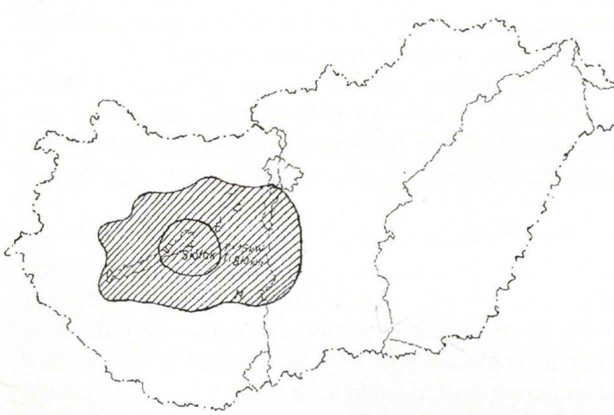

Fig. 5. Night- and day-time MW coverage area of Juventus — 1994

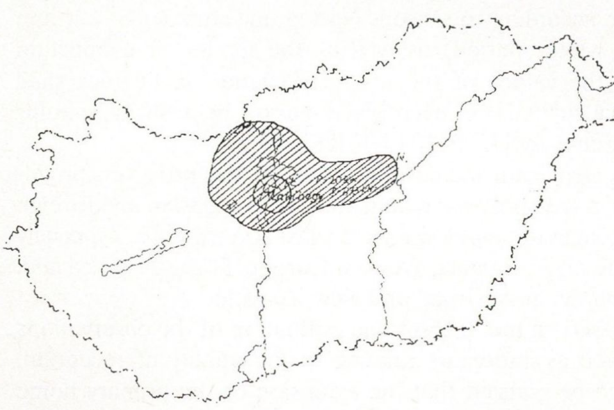

Fig. 6. Night- and day-time MW coverage area of Calypso — 1994

2. SHORT-WAVE BROADCASTING TO FOREIGN COUNTRIES

2.1. *Preliminaries; characteristics of the short-wave radiation*

To some extent, the short-wave broadcasting plays a distinguished part within broadcasting, as the short-waves do not follow the surface during their propagation. Therefore, by using antennas of appropriate design, the spatial waves are suitable to bridge long distances and to cover far areas.

The basic objectives of broadcasting directed to foreign countries are to popularize the special features of a given country in respect of music, culture, technique, tourism and sport in a direct way and making them known to the listeners of the target area.

Having realized the importance of the short-wave broadcasting in Hungary, the Radio Transmitter Station Székesfehérvár started the short-wave broadcasting to North America and Western Europe in 1933 and, later, to South America from 1937 onwards.

The short-waves propagate by means of the ionosphere. In the knowledge of the reflection features of ionosphere layers depending on the season, hour of the day and the degree of latitude as well as the number of solar spots, the operating frequency most suitable to cover the desired target area can be determined for various periods of a day.

The proper frequency selection, that is, the use of an optimum frequency is indispensable, in order to achieve the highest field strength at the target area, with a given transmission power.

The use of an improper frequency may prevent the reception at the target area, even with a high-power transmitter and high-gain antennas used.

In the short-wave radio communication, it is very important to predict the operating frequencies to be used in specified directions and at specified times within a season and a solar activity period.

Therefore, the optimum frequency for each target area and period shall be calculated (frequency plan).

2.2. *The present situation*

Antenna Hungária Co. uses three short-wave transmitter stations located at Jászberény, Diósd, Székesfehérvár to broadcast programs (in Hungarian and in foreign languages) to specified target areas, by using various directional and omni-directional antennas.

The target areas are as follows:

- Europe, Near East, North Africa;
- North America, Canada;
- South America.

In the short-wave broadcasting, seven bands and 9 languages are used at present.

Analysis of the existing SW transmitter stations

Transmitter station of Jászberény

Two Hungarian made short-wave transmitters of 250 kW capacity are installed here, provided with automatic tuning and operating in the frequency range of 3.9 to 26.1 MHz. The audio-frequency and high-frequency circuits of the transmitters are accommodated in a concentrated so-called monoblock unit. The tubes used in the driver and power stages of the transmitter are provided with an evaporating type cooling system, while the other active elements are solid-state devices. The transmitters include 10 fixed-frequency crystal oscillators and 1 continuous decade oscillator each. The frequency changes can be preprogrammed and each tuning element will be adjusted automatically. The high-frequency output of the transmitter is asymmetric, with a symmetrizing system of automatic tuning connected (300 ohm symmetric output). For measuring and testing purposes, an artificial antenna built with soda solution is available. Both transmitters are capable of radiating in DCC mode and in the so-called trapezoid modulation mode. In the DCC mode, the carrier level will be decreased by 2 to 3 dB during modulation-free periods; thus enabling significant energy saving.

The transmitter station is provided with 28 planar antennas of various direction and 2 short-distance radiators. The station is provided with an antenna-system consisting of planar antennas suitable for long-distance (over 4000 km) and medium-distance (over 500 km) radiation, in a star configuration. The rows of planar antennas form an angle of about 120° oriented according to the main directions of radiation. The selection of antennas will be accomplished by remote control from the operator room, with the possibility of pre-selection. The 2/7 symmetric antenna-combiner of 300 ohm ensures the possibility of connecting the transmitters either to the main feed-lines of antenna branches or to artificial antennas by means of remote control, while the main feed-line switches ensure the selection of each individual antenna.

Transmitter station of Diósd

The station is provided with 2 modern SW transmitters, BBC-made, put into service in 1983 as a replacement for the old and outdated 100 kW transmitters.

The transmitters of low space requirement are well serviceable; they are provided with automatic tuning and operate in the frequency range of 3.9 to 26.1 MHz. The 300 ohm symmetric output is ensured by a symmetrizing system connected between the 75 ohm asymmetric feed-lines of the transmitters.

The station is provided with eight outdated directional — so-called resonant — planar antennas that were not allowed to be operated from March, 1994, due to their high field intensity near the motorway M0.

Furthermore, the station is provided with 5 wide-band omni-directional antennas (covering 2 to 3 bands). These up-to-date antennas were put into service in 1990, and ensure the coverage of the target areas in Europe, Near East and Nort Africa, in the frequency bands of 4-5-6-7-9-11-13-15 MHz. The omni-directional antenna of 4 MHz was also prohibited to be operated at its current location from March, 1994 on.

The station is also equipped with an up-to-date remotely controlled log.per antenna system, suitable to be rotated and tilted, that can be used towards any target area located at a distance between 300 km and 10 000 km in a wide band (from 6 to 30 MHz), depending on its angle of tilting (+30° to −40°).

Both the directional planar antennas and the wide-band omni-directional antennas are fed by means of 300 ohm symmetric aerial feed lines, with a BBC made remotely controlled antenna combiner.

Transmitter station of Székesfehérvár

Two modern short-wave transmitters of 100 kW each, made by BBC as well as four double-band omni-directional antennas (bands 4 to 5 MHz, 6 to 7 MHz, 9 to 11 MHz and 11 to 13 MHz) together with a new log.per antenna of 100 kW, suitable to be rotated and tilted, ensure the coverage of the target area in Europe, the Near East and North Africa.

One of the 100 kW transmitters of Székesfehérvár is used to broadcast the Kossuth program at 6025 kHz frequency by using the 6 MHz omni-directional antenna, to a distance between 250 and 700 km.

For the coverage of the neighbouring areas (Carpathian Hollow, Croatia), 2 short-wave transmitters of 20 kW capacity each and 4 omni-directional antennas are available.

The BBC-made short-wave transmitters of 100 kW each installed at the transmitter stations mentioned above are of relatively up-to-date design. The 250 kW transmitters installed in Jászberény have been in use for 20 years and do not fulfil the requirements set in our days.

The 20 kW short-wave transmitters in Székesfehérvár have been in service for 20 to 24 years; they are used up and outdated (tubes are used in the power stages etc.).

The dominant part of the broadcasting antenna systems used at the three transmitter stations is of relatively up-to-date design, except the planar antenna system of Diósd which consists of outdated resonant antennas.

A further problem with the planar antennas of Diósd directed towards South America is that, due to the unfavourable geographic configuration (inclined and slashed terrain), the antenna pattern suffers a significant distortion.

The basic problem of the Transmitter Station Diósd consist in that the planned reconstruction of the planar antennas could not be implemented, due to the motorway M0 built in the immediate vicinity of the station. It is in order to replace them at least in part, that the new log.per antenna system suitable to be rotated and tilted was implemented in Székesfehérvár.

The optimum frequency for each target area and target zone according to seasons (spring and summer or autumn and winter period) as well as the modes of connection and the values of the proper elevation in degrees shall be calculated for each given period by using computer programs (MUF-FOT-LUF-REP 89).

A significant increase in needs for the programs broadcast in the short-wave band in both Hungarian and foreign languages appeared during the last several years, especially in the USA, Canada, Western Europe, South America and, primarily, in Australia and New Zealand.

Based on the analysis and evaluation of the observations as well as interviews relating to the quality of reception, it can be realized that the extension of the primary home programs is highly required.

2.3. Proposals on the improvement of our short-wave broadcasting

Considering the needs of the Hungarian Radio for target areas and the needs of simultaneous broadcasting at several frequencies as well as the wave propagation aspects, and observing the proposals and recommendations made by the WARC '92 in respect of the improvement of our short-wave broadcasting, it is reasonable to take the measures listed below in the near future:

- In order to ensure the coverage of Australia, New Zealand and the areas in the Far East, it would be reasonable to establish a wide-band high-gain special purpose antenna system at the Transmitter Station of Jászberény, thus solving the problem of radiating in the 13 MHz band and, with a planar antenna system suitable to be rotated.
- In order to ensure the coverage of the neighbouring areas more efficiently, it would be reasonable to put at least one new omni-directional antenna into service at the station of Jászberény or Diósd.
- It would be absolutely justifiable to put a new and up-to-date transmitter of at least 100 kW capacity into service at the station of Jászberény, in order to replace some existing low-power (20 kW) transmitters (to ensure simultaneous broadcasting to several target area at various optimum frequencies).
- The broadcasting in the 4 MHz band directed towards Central Europe shall be intensified during the next 8 to 10 years (WARC '92). The relocation of the 4 MHz omni-directional antenna system of Diósd is absolutely necessary.
- Based on the resolution made by WARC '92, and in order to achieve a higher radiation efficiency, the use of frequencies in the extended bands according to the solar activity periods shall be ensured.
- Based on the resolution made by WARC '92, our short-wave transmitters shall be prepared for SSB broadcasting.

2.4. Development trend at the international level

During the past decade, the short-wave broadcasting was developed and expanded all over the world. Development measured in daily frequency hours is represented by the figures below

1955	12 000
1960	15 000
1970	20 000
1980	27 000

To improve the efficiency of short-wave broadcasting, the service suppliers ensure the proper coverage of their target areas by increasing the transmission power and by using several frequencies simultaneously for the same target area, and, in addition, by using high-gain antenna systems, while utilizing the available frequencies in a flexible manner.

New and more efficient procedures (transmitter systems) are used in the short-wave broadcasting (SSB technology). SSB technology enables the frequency spectrum to be better utilized.

At the international level, the high-capacity integrated short-wave transmitting station — the so-called ALLISS system — of modular design (suitable to be expanded) was already developed, in order to replace the "traditional" short-wave transmitting station. The new equipment is of high efficiency and flexibility, that represents an outstanding solution.

The essence of the system is, that the transmitter (or transmitters) and the wide-band planar antenna systems suitable to be rotated are accommodated in a basic module.

The high-gain antenna system consists of a rotatable broad-band planar antenna system provided with two radiating planes, one of which operating in the bands between 6 and 11 MHz while the other in the bands between 11 and 26 MHz. Between the two sets of planes, a passive reflector net is installed.

The antennas can be used in various configuration of radiation; in fact, several types of planar antennas can be configured (by means of remote control). Thus, by changing the vertical characteristic, an optimum coverage of areas located at medium and long distances can be ensured.

The system can be used everywhere, and ensures high-efficiency radiation. In addition, it can be installed within relatively short time.

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THE PRESENT AND FUTURE OF VHF-FM BROADCASTING

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VHF-FM broadcasting in Hungary looks back to a history of 40 years. The frequencies alloted in the OIRT band do not allow the appropriate coverage of the country with the three public service radio programmes. The use of the CCIR band frequencies for the purpose of commercial and local radios has been started. The facilities of Antenna Hungária Co. broadcasting the nation-wide and the regional programmes only include a few up-to-date transmitters, but the reconditioning of the old equipment has been carried out for years. In addition to the programme, the transmitters also offer data transmission services. The problems of quality, mobile reception and frequency portfolio corresponding to the current requirements will be resolved by digital audio broadcasting.

1. HISTORY

The expansion of radio broadcasting to the VHF (30 to 300 MHz) frequency range was initiated in the forties on the basis of the requirements for a better quality. This was because contrary to the amplitude modulation exercised on middle wave, high-deviation FM modulation offered an opportunity for a much more undisturbed reception with a lower transmitter output, but this could only be achieved in a higher frequency range because of the large bandwidth requirement.

In Hungary, VHF-FM broadcasting started in 1954, with experimental broadcasting.

European frequency distribution allocated the 87.5 to 100 MHz range for VHF-FM broadcasting. However, the radio organization of the former "socialist" countries, that is OIRT, assigned the 66 to 73 MHz range for this purpose. The allocated frequencies were sufficient for setting up three and a half nation-wide networks. The network plan drawn up by the Research Institute of the Hungarian Post Office dedicated nation-wide networks to broadcasting the programmes of Radios Kossuth and Petőfi in order to improve the penetration of programmes broadcast on the middle wave, and the third network was reserved for a new public-service programme, called Radio Bartók today. All the three public-service programmes were transmitted by the Hungarian Radio from the beginning. The utilization of the one-half network opportunity for nation-wide purposes was hindered by frequency clashing reasons. Therefore, these frequencies remained usable for the broadcasting of regional programmes.

Building up the main transmitter network of the three programmes (with full stand-by capacity) was started in 1965 with BRG transmitters. Supplying stations with modulating signal was mostly resolved by means of the nation-wide long haul microwave network.

Changing from mono broadcasting to stereo happened after some years of experiments in 1970 for Radio Bartók and in 1983 for Radio Petőfi. The limitation of frequencies allotted in the so-called 70 MHz band has become obvious very soon.

The utilization of the 100 MHz (called the CCIR band) frequencies started in 1986 with the launching of the Hungarian Radio's commercial programme, Radio Danubius in Budapest. In 1993, the commercial private radio Juventus which has only broadcast thus far from Siófok on middle wave has started its operations from Kabhegy and Budapest also in the 100 MHz band.

The establishing of a nation-wide network in the 100 MHz band has not yet been started. Because of the huge proliferation of Western norm receivers there is a strong pressure from the general public to enable the reception of public service programmes in the CCIR band. Minister of Transport, Communication and Water Management appointed the General Inspectorate of Communication to prepare the study for initiating the change-over.

Adaptation to the Western European situation could make it logical to withdraw broadcast gradually from the 70 MHz band. Since, however, in the 100 MHz band we cannot even implement a nation-wide coverage with three programmes, we have to still think in terms of two bands. This situation will change presumably only with the introduction of digital audio broadcasting.

The economic and political changes of recent years have imposed a huge demand on new programme services. Since Act 72 of 1992 on telecommunication liberalized local broadcasting, the frequency assignement could be started in the 70 and 100 MHz bands. Due to the limited and narrow nature of the frequency portfolio considered to be part of the national wealth, distribution is carried out on the basis of competitive bidding. For studio licenses, preparing the radiation plan and obtaining the radiation licence (frequency assignement resolution) generally takes 4 to 6 months and only then may the transmitters be ordered. Therefore it is understandable that local broadcasting has only been launched at a relatively small number of places.

However, progress has commenced and it is only a question of time for the overwhelming part of the population to be able to listen to programmes dealing with local concerns, in addition to the nation-wide public service programmes.

The launching of new nation-wide and regional programmes on the basis of concession bidding will only be possible once the so long awaited media act is passed.

2. TECHNICAL REQUIREMENTS OF VHF-FM BROADCASTING

As already mentioned, VHF-FM broadcasting is based on a large deviation, wide-band FM modulation. The base-band frequency range to be transmitted undistorted is 30 (40) to ±15000 Hz, the deviation in the CCIR band is ±75 kHz and in the OIRT band it is ±50 kHz. The high frequency transmission band around to the carrier is approx. ±100 kHz.

Technical specifications relating to the transmitters can be divided into two main groups. The task of one group is specifying the basic system engineering parameters. These are included in international regulations (CCIR recommendation, IEC recommendation). In the framework of standardization carried out for the purposes of the united Europe, exactly such a draft standard was ultimately formulated at the end of 1994 (prETS 300 384, Radio Broadcasting Systems; Very High Frequency — VHF — frequency modulated, sound broadcasting transmitters). This includes the regulations involving the radio frequency spectrum, for transmitters the modulation of which corresponds to the CCIR 450-1 (1982) recommendation.

The other set of technical specifications intend to keep on the appropriate level those transmission and connection parameters of the transmitter that guarantee the high quality of broadcasting. These parameters apply to the input and output levels, impedances, the linear and non-linear distortions of the transmitted signal, the noise and other characteristics. The regulations also include the requirements on the radiated spectrum, by taking the international recommendations into consideration.

In Hungary, concerning VHF-FM transmitters, the postal organizations worked out specifications prior to 1990. They were decisive for Hungarian transmitter development. These documents served as a basis for the standard issued by the Ministry of Transport, Communication and Water Management in 1992 under the title "MSZ-17-302-5: Technical requirements and test methods of VHF-FM broadcasting transmitter equipment". The standard only applies to transmitters of not less than 100 W output, indicating that for the purposes of small penetration local radio transmitters, lower priced devices could also be acquired. However, even the standard of these lower priced equipment is guaranteed by the obligation to submit them to a type test by the General Inspectorate of Communication.

Simultaneously with the standard applying to transmitters, Hungarian Standard MSZ-17-302-2 covering VHF-FM transposers has entered into force.

Links between the studio and the transmitter stations have a decisive impact on the quality of broadcasting, too. Concerning the frequency dependence, noise, distortion and cross-talk of the modulation lines, CCIR and CCITT recommendations must be complied with because the lines are also connected to the international network. For example concerning 15 kHz sections of defined length (the so-called music circuits), recommendation CCITT J.21 applies to the analogue transmission. In Hungary, the modulation lines are typically microwave based relatively outdated connections, which are owned — with some exceptions — by Antenna Hungária VHF. Sufficient funds have not been available for proper maintenance and so the technical conditions are not satisfactory today. Since their capacity is not enough anyway for the expansion of the network, their role will be taken over gradually by Antenna Hungária's envisaged high capacity optical fibre based data transmission network, which will also result in the required quality improvement.

3. COVERAGE WITH PUBLIC SERVICE PROGRAMMES

Coverage is determined by taking into consideration receivers of standard sensitivity. A place is considered to be covered if the reception field strength ensures a signal to noise ratio higher than the specified limit after demodulation, for the radio which has an appropriately adjusted antenna. Since the circumstances of reception are significantly influenced by unpredictable factors (e.g. the shielding effect of buildings, reflections), coverage may only be defined statistically. In the case of VHF-FM transmission/broadcasting, an area is considered as covered, if the field strength is not less than 48 dBμV/m (in the case of a mono programme) and 54 dB μV/m (in the case of a stereo program) in 50 % of the place and time, when measured at a height of 10 m from the ground. This shows that to cover the same area by a stereo programme, four times as high transmitter output is required than for the mono programme. It is also shown that this definition does not take into consideration car radios and portable devices. The reception zone of each transmitter station — disregarding eventual restrictions along the country's border — is roughly of circular shape. The radius of the circle depends on the transmitter output and the transmitter antenna gain (with the latter including the so-called height gain as well), and all in all it is a function of the so-called effective radiated output. This is specified for each transmitter site by the Stockholm Agreement and the Geneva Plan of 1984. The relationship of the area covered by the circles to the total area of the country is called location coverage, and the ratio of population within the covered area related to the total population of the country area is the coverage of the population. The coverage is of a nation-wide extent, if both the location and the population coverage is higher than 50 %. In the 70 MHz band, three nation-wide networks could be established, partly in stereo configuration. The coverage figures for these are shown in Table. 1.

Table 1. VHF-FM coverage in the 70 MHz band

	Location	Population
Radio Kossuth (mono)	69 %	78 %
Radio Petőfi (mono)	86 %	90 %
Radio Petőfi (stereo)	54 %	61 %
Radio Bartók (mono)	93 %	95 %
Radio Bartók (stereo)	67 %	76 %

Fig. 1 shows the coverage boundaries of VHF-FM mono programmes, and the same is shown for stereo in Fig. 2.

In the 100 MHz band, no public service transmission is carried out as yet. A nation-wide stereo coverage could be developed with two and "a half" programmes, with the coverage indices shown in Table 2.

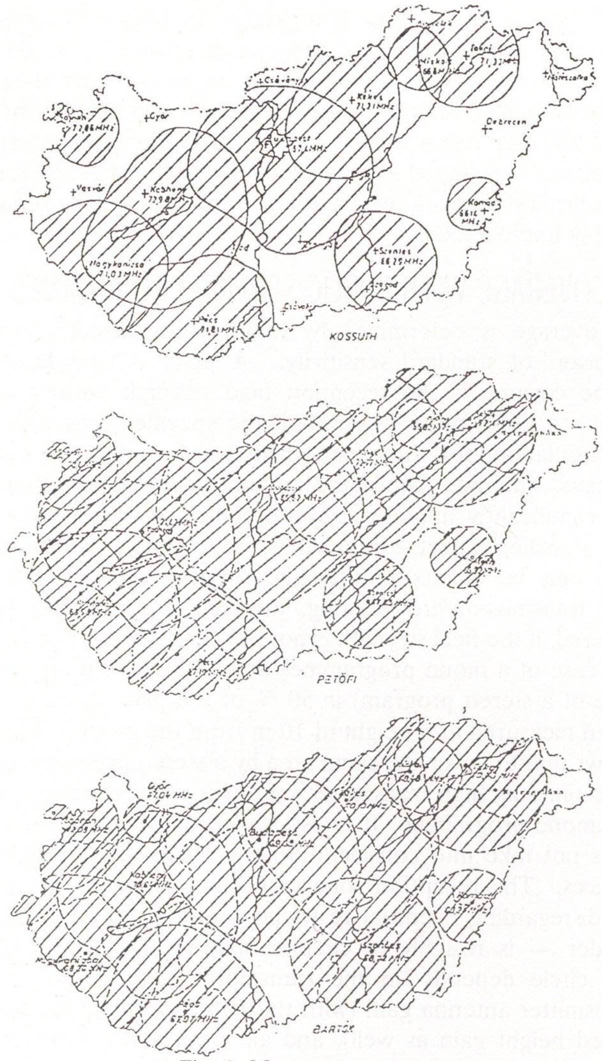

Fig. 1. Mono coverage zones

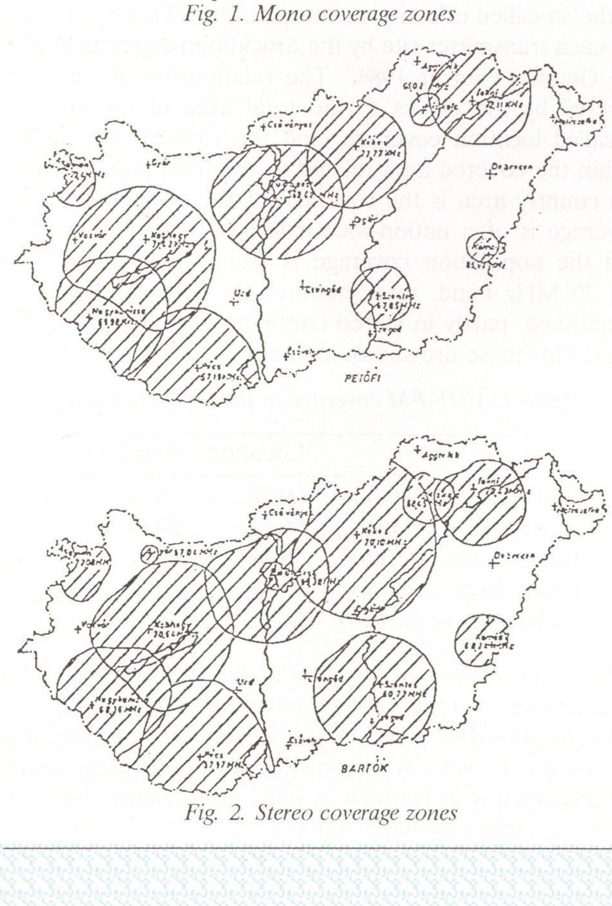

Fig. 2. Stereo coverage zones

Table 2. Stereo coverage indices of networks in the 100 MHz band

	Location	Population
Programme 1	72 %	81 %
Programme 2	67 %	93 %
Programme 3	49 %	68 %

(The figures of the data come from the August 1993 study of the Frequency Management Institute).

It is shown that the coverage of either Radio Kossuth or Radio Petőfi would significantly improve by transfer to the 100 MHz band.

The establishing of 100 MHz networks is hindered by the lack of Media Act and by that of the financial resources.

Coverage may also be improved by transposers. These are low output, relatively low priced equipment, with a coverage zone of some kilometre radius. Their frequency assignment is not subject to international limitation, and they do not need the establishing of a modulation line. They are really cost efficient if they are located at the points where TV transposers stations are. However, on most TV transposer's service areas the VHF-FM coverage is satisfactory. Consequently, a large improvement may not be expected of the VHF transposers.

4. FACILITIES

The main transmitters of the three public service programmes are located at the following sites: Budapest, Kabhegy, Komádi, Kékes, Miskolc, Nagykanizsa, Pécs, Sopron, Szentes, Tokaj. In addition Radio Bartók is broadcasting from Győr. The transmitter output is 10 or 3 kW, matching the effective radiated power permitted for each site (ERP = transmitter power x antenna gain).

The oldest transmitters of the current VHF transmitter facilities were developed under the name UZA... by the former Hungarian transmitter manufacturer, Elektromechanikai Vállalat (Electromechanical Enterprise). The end stage included a 4 CX10000/B tetrode. Using UZA transmitters, as of 1969 in ten years the main VHF transmitter network was built up (except for the transmitter station in Kékes), with three programmes at almost all stations, and with stand-by transmitters in many places.

In the second half of the seventies, Elektromechanikai Vállalat merged into BHG Telecommunications Works, and it developed its new VHF transmitter range of 3-5-10 kW power. This development aimed at the use of semi-conductors to the extent allowed by the technology of that time. These third generation BAB... transmitters of 3 and 10 kW power completed in the period between 1980 and 1985 the network which was operated partly without stand-by facilities. With the CCIR band version of BAB transmitters — developed in the meantime — the broadcasting of the Radio Danubius programme started between 1986 and 1988 in Budapest, Kabhegy and Sopron.

In the second half of the eighties, BHG introduced a throughout transistorized transmitter range of 250-500-1000 W power. Such transmitters were used by the Danubius network in Szeged and Debrecen (where the transmitters are also the independent transmitters of regional studios) and furthermore such transmitter has been used since 1990 by Radio Bridge.

For its solid-state transmitter range, BHG developed the (n+1) protection switching, enabling thereby the conversion of transmitter stations at a relatively low cost, and the release of already operating transmitters for the purposes of new programmes. In this direction, the first step was taken by the transmitter station in Szentes, in 1993.

The Danubius network also started to use in 1989 a pair of Rohde-Schwarz transmitters replacing the BHG transmitter in Sopron (output power 100 kW, final stage, built up with one tetrode). The BHG transmitter was transferred to a different place as a stand-by unit.

Antenna Hungária Co. did not have sufficient resources for replacing the transmitters installed in the seventies, which have become obsolete in the meantime. Therefore, a gradual revamping of high technical significance was launched in 1992. In the course of the upgrading, BHG replaced the tube-based driving stage of UZA... transmitters by transistor stages, the end stage was re-conditioned, and the pre-stages and automatic system were replaced by more up-to-date unit. The operational reliability of old transmitters has been increased dramatically and the quality characteristics also improved.

By 1993, BHG designed its 3 kW transistor-based power amplifier and the transmitter circuitry based thereon. This enables replacing the tube-based end-stages of the old 3 kW transmitters, which process has been started already.

The most up-to-date equipment of the transmitter network are represented by two solid-state 10 kW Rohde-Schwarz transmitters put into operation in 1994. The power amplifiers of those transmitters already include MOSFETs, and the protection switching is based on microprocessors. These two transmitters are used in Budapest for Danubius and Juventus programmes.

It is to be noted that Antenna Hungária started to work out the concept of a nation-wide radio and TV remote monitoring system in 1992. By today, the implementation of the system has also been started. In the course of this work the earlier VHF transmitters are supplemented with interfaces enabling link-up to a computer system.

The antennas of the main transmitter network have been exclusively of BHG make until the recent years. These were multi-level omni (or nearly omni) directional antennas consisting of dipoles fitted with reflector panels, using horizontal polarization. With some exceptions, they were designed for the 70 or 100 MHz band. The exceptions are the so-called broadband antenna systems, which cover both bands. Since the technical characteristics of such an antenna are somehow weaker (the radiation characteristics are not so uniform), application is justified primarily by the lack of space.

In 1992, the bidding for supplying VHF antennas for the re-vamping of the system of antennas on Széchenyi hill was won by Kathrein. The new antenna operates impeccably, so in our antenna network the age of multicoloured approaches based on a competitive situation has started.

The discussion above shows that the facilities used in VHF-FM transmission/broadcasting are mostly old, but well maintained and they are being upgraded at a rate permitted by financial opportunities.

5. SUPPLEMENTARY SERVICES IN THE VHF-FM RADIO NETWORK

With a small investment, stereo transmitters can be made suitable for including supplementary information signals in the multiplex channel, outside the 53 kHz band utilized by the two audio signals. The CCIR recommendation No.450 assigns the range from 53 to 75 kHz for supplementary information transfer in the pilot signal stereo transmission. West Germany started to make use of this opportunity in the early seventies for identifying the transmitter zone and for traffic information purposes (ARI system). One decade later, a similar initiative was made in Hungary on the Radio Petőfi network. This was later replaced by the pager service, still in operation nationwide.

In Germany, with the transmitter network being increasingly dense, the tuning of receivers becoming more and more difficult led to the development of RDS (Radio Data System). The process was approved in 1986 by EBU. The digital information supplied by the 57 kHz subcarrier enable zone identification, traffic information lock-in, recognition of the type of programme, automatic volume adjustment depending on the type of programme, radio paging and several other services. One part of the services improves the comfort of receiving programmes. Unfortunately, we can utilize RDS only in the 100 MHz band, because there are no OIRT band RDS receivers on the market. Therefore, the RDS service has only started in the Danubius network (in 1992) with a low level of utilization.

(For more information on supplementary services see [1]).

6. PROBLEMS AND IMPROVEMENT OPPORTUNITIES OF VHF-FM BROADCASTING

As already mentioned, VHF-FM broadcasting is not really suitable for mobile radios. The physical reason for this is that radio waves reflected by mountains and buildings could seriously influence the strength of received signal in the VHF band, especially in the case of omnidirectional antennas. A well known consequence is frequent fading, clicking and crackling experienced in the car. In a city environment, a car radio is impossible to enjoy.

As a result of the increasing use of the VHF spectrum, the reception conditions which were very good earlier, deteriorated, and the reception is more and more noisy. There are signal processors in use to improve the signal to noise ratio, and they considerably increase the average modulation of transmitters by dynamic compression. In Hungary, in the VHF-FM band, only local radios apply dynamic compressors. Hungarian Radio has not implemented the use of these compressors because of their fidelity deteriorating effect.

Against the radio reception of no longer satisfactory quality, a serious competition is represented by the appearance of digital sound sources. The radio may only compete with that quality through digital technology.

Beyond quality concerns, FM broadcasting struggles with quantitative limitations. The frequencies available in the VHF band and being very favourable from a wave propagation aspect are close to being depleted. There is a high demand for a transmission procedure which makes use of the frequency range with a better efficiency.

7. DIGITAL BROADCASTING

The problems outlined above and advanced semi--conductor technology led to the development of a revolutionary new process, DAB (Digital Audio Broadcasting). The ETSI standardization process of the scheme elaborated with European contribution in the framework of the Eureka 147 project has come to an end, so the appearance of DAB receivers in the shops is to be expected shortly (at least at the places where regular DAB transmission is available). The technical foundation of DAB is represented by two great novelties:

- The MUSICAM source coding procedure, which — by making use of psychoacoustical possibilities — reduces the data speed of digitalized audio signal excessively, without a detectable change in sound quality. For the transmission of the coded stereo signal, a data rate of 192 kbit/sec is sufficient, approx. one-seventh of the data speed of the CD signal. This enables the transmission of the digital signal in a radio channel of such a bandwidth that can be considered for terrestrial broadcasting.
- The COFDM wideband transmission process, by which distortions resulting from multi-path wave propagation can be eliminated.

(For papers published in the Hungarian language about the technical details of the DAB procedure see references [4] and [5]).

Advantages of DAB are:

- Impeccable reception even on mobile and portable devices, using an omnidirectional whip antenna.
- CD quality.
- The possibility to build single frequency networks, resulting in a huge frequency saving.
- Low transmitter power.

For DAB, a frequency band is to be allocated. For covering several countries, a satellite transmission (S-DAB) could be involved, for which the range 1452 to 1492 MHz already appointed in the "L" band can be used. To cover a country or a smaller area, terrestrial (T-DAB) broadcasting is suitable. For the purposes of a nation-wide single frequency network, the VHF band is the most suitable, while for regional transmissions, even the UHF band is satisfactory. (The suitability of T-DAB broadcasting in the L band is still disputed). Currently the biggest concern about introducing DAB is that there is no freely available part of the VHF band in Europe. (Each country would need a frequency range of some MHz). The views are getting firmer that the final frequency band of T-DAB should be allocated in TV channels 11 and 12. Concluding an agreement is made difficult by some high power 12th channel TV transmitters in Eastern Europe. Hungary would have to replace of the Kabhegy transmitter. All over Europe (and also in Hungary) intensive work is carried out to prepare the DAB frequency planning meeting due to take place in July 1995.

In Hungary, an experimental DAB broadcast is planned at the end of 1995.

The objective of experimental transmissions in the years to come will be to obtain fundamental planning information for the final networks and to arouse public interest toward DAB.

Concerning VHF-FM broadcasting, the view has been held for a long period that it will gradually be replaced by DAB. The picture currently is more varied. It can be seen that there is a large requirement for local and regional radios, and they cannot make use of the high frequency utilization of DAB. Therefore it is predictable that DAB will be applied in addition to VHF-FM broadcasting, and so the latter will perhaps regain a high quality that can be achieved by analogue technology.

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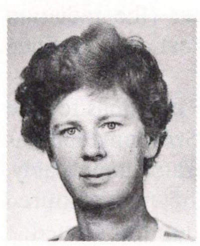

Cecilia Somodi graduated from the Communication Faculty of the Technical University of Budapest and then was engaged in the development of VHF-FM and TV transmitters between 1964 and 1993 at Electromechanikai Vállalat and later on at the legal successor BHG Communication Enterprise. Since 1993, she is responsible for the VHF portfolio at the Long Term Development Department of Antenna Hungária Co. One of her main tasks is to prepare Hungarian DAB broadcasting on the transmitter side.

RADIO SERVICE ON MOTORWAYS

The demand on motorway radio service has been rising steadily. To satisfy this demand, a solution is to be adopted that meets frequency management requirements and ensures compatibility with conventional receiver sets. Synchronous FM is just the suitable solution. This is proved by examples in Italy and France, where such service is available already on a number of motorways. Antenna Hungária Co. has been engaged for some time in the effort to introduce this service in Hungary too.

1. INTRODUCTION

Nowadays we listen to the radio in our car while driving along on motorways more and more. According to a survey made in France, approx. 90 % of all cars are equipped with radio receiver and 80 % of the motorists are listening to the radio while driving. It is therefore understandable that the demand on programmes that, in addition to offering entertainment, also provide actual traffic information meeting the expectations of motorists in this respect (conditions of road and visibility, volume of traffic, traffic obstacles, accidents etc.) has been growing steadily. Broadcasting programmes with such informations crammed may contribute to considerably raising traffic safety. These points should be taken into consideration by the programme makers as well. It poses however a serious difficulty for them that their programmes are listened to by a portion of the motorists only, while the majority of the listeners are not interested in the traffic information at all. The best solution therefore would be if a separate programme intended specifically for motorists could be broadcast. This seems, however, not viable because of the scarcity of frequencies available. Frequently a major source of nuisance for motorists posing problems is that motorists have to retune their sets steadily to the frequency of the transmitter whose reception area they are driving in. With view to solve these problems several systems have been developed in which turning on as well as retuning of the receiver on detecting broadcasting of traffic news occur automatically.

An example of such systems is ARI (Autofahrer Rundfunk Information) developed in Germany. RDS (Radio Data System) is also capable of meeting the demands on part of motorists (automatic retuning, identification of traffic information etc.) in addition to other services offered. In these systems the traffic information is embedded in the VHF-FM stereo multiplex signal and transmitted as additional data without disturbing the original programme. A severe drawback delaying large-scale usage however is that a special, state-of-the-art receiver capable of decoding the information provided is needed, and traditional receivers are unusable for the purpose of reception. Broadcasting on long waves would be suitable and a single transmitter could cover the entire motorway network of the country, however, the problem would emerge: receivers capable of receiving long-wave transmitters are extremely few in number.

2. A POSSIBLE SOLUTION: SYNCHRONOUS FM

A single-frequency (izofrequency) FM network seems to promise the most suitable solution. In such a network each of the transmitters broadcast programmes at one and the same frequency. Using a single frequency could help to meet all needs cited above. It would be, a major benefit that frequencies could be spared. However, in order for such a network to function properly, severe constraints should be imposed on the carrier-frequency of the transmitters. A frequency accuracy as high as approx. 10^{-8} should be kept. Neglecting this requirement could lead to interferences on receiving several transmitters at the same time. With this interference severely deteriorated signal would emerge, in particular with stereo signals. To avoid any perceptible deterioration in sound quality, in addition to the synchronization of the carrier frequency provisions should also be taken to prevent the amplitude and phase differences of the signals. Obtaining high frequency stability and conveying programmes to the transmitters on the one hand and maintaining the required conditions cited above on the other hand would require serious efforts. Accordingly, a solution is to be sought after that results in receptions of acceptable quality without the conditions having to be satisfied, that albeit not entirely removes the interference area but reduces its extension as much as possible und thus counteracts its adverse effect.

In a "quasi-synchronous" VHF-FM network where the carrier frequencies of the transmitters are identical only nominally, the disturbances due to interference (the mush) can be reduced considerably by commissioning several lower-power transmitters. Such lower-power transmitters are to be erected as close to motorways as possible so that the covered areas do not overlap at all or only to a small extent (Fig. 1).

This requirement can be achieved by employing highly directional antennas (having approx. 20 dB front-to-back ratios), making absolute use of the conditions of terrains (valleys, road curves, etc.) and adjusting each transmitter power acccurately. Ideally, this results in approx. 10 km transmitter spacing and 100 to 200 W transmitter power. Through the use of this technique the extension of the interference area (designated CE in Fig. 2) can be reduced to some hundred meters. In the AC and EG section a single transmitter can be received, therefore these areas of the network are considered to be like conventional VHF-FM systems.

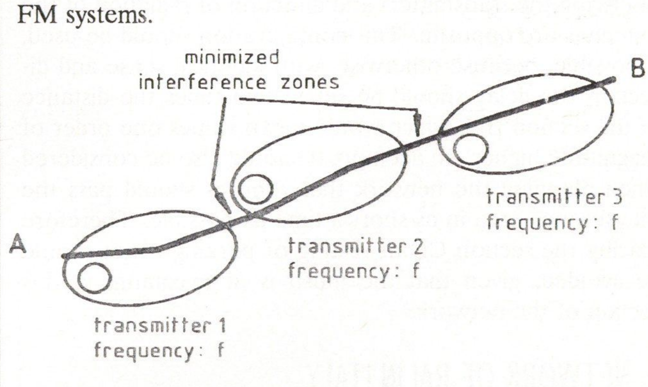

Fig. 1. Placement of the transmitters along the motorway

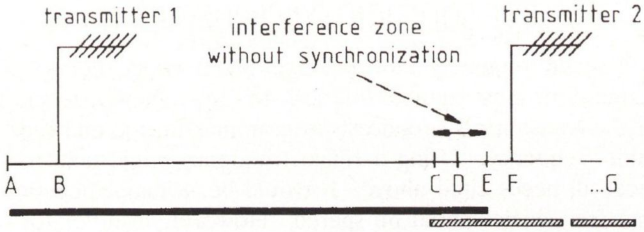

Fig. 2. Interference zone between two transmitters
ABE: covered by the first transmitter
AB: several hundreds of meter; BE: approx. ten km
CFG: covered by the second transmitter;
CF: several hundreds of meter; FG: approx. ten km

The mush may be at maximum where two signals transmitted by different transmitters are equal in amplitude. Accordingly, the signal of one of the transmitters should be delayed such that the signals arrive at the above mentioned point in the same instant. This point is designated D in Fig. 3. The transmitted signal No. 1 (useful signal) arrives at point D via points ABRD, whereas transmitted signal No. 2 (interference signal) via points ABDFD. R designates the delay element. As is seen in the Figure, the interference signal travels a distance two times the distance of the section DF. The delay element should therefore be set such that the time delay will equal the time needed for the signal to travel this distance.

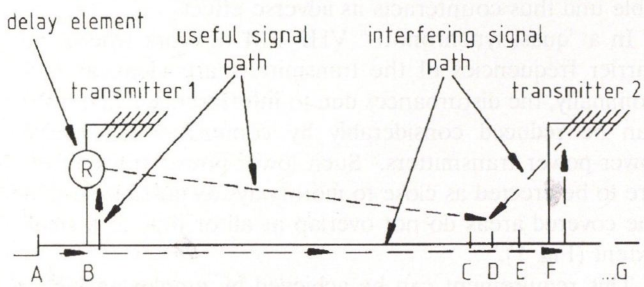

Fig. 3. Using delay element at the transmitter

In a configuration like above the section DF measures several hundred meters. Assuming 700 to 800 m approx. 5 μs delay is needed. With the use of several transmitters, this same delay should be set between each transmitter pairs. When the transmitters are erected along an imaginary line in parallel to the motorway, the delays are added. This means that the longest delay should be set at the end of the network toward the studio. In Figure 3, the sense of driving the transmitters and direction of radiation of the antennas are opposite. This configuration should be used, if possible, because otherwise, with identical sense and direction the delay should be set to two times the distance of the section BD, which would mean values one order of magnitude higher. In addition, it should also be considered when planning the network that vehicles should pass the interference area in as short a time as possible. Therefore placing the section CD at resting or parking zones should be avoided, given that the mush is at maximum in this section of the network.

3. NETWORK OF RAI IN ITALY

In Italy, the first synchronous FM network was established in 1987 between Firenze and Bologna by RAI (Radiotelevisione Italiana) in a joint cooperation with Societa Autostrade S.p.A. The mono programmes were radiated by 20 to 250 W transmitters. The transmitters alongside the motorway were driven through optocables buried earlier for other purposes. The 103.3 MHz frequency modulated signals were applied to a laser transmitter driving the optocable. At the transmitters one portion of the optical power was decoupled and converted to RF signals, which served as input to the transmitters. Where the level of the optical signals was too low, the entirety of the signal was converted to RF signal and, following amplification, decoupled towards the transmitter, using the remaining portion of the signal to drive another laser transmitter. The pilot stretch, which was approx. 120 km long, run through longer or shorter tunnels. In the shorter (150 to 200 m long) tunnels reception was acceptable at such transmitter power, however, in the longer tunnels, radiating cables were employed to ensure uninterrupted reception. The extension of the interference area could be reduced to 250 to 1000 m. In another phase of the pilot operation it was demonstrated that conventional VHF-FM transmitters could also be used in the system by making maximum use of the topographic conditions. So RAI decided to introduce this service alongside all Italian motorways. In 1991 approx. 650 km long motorways were already covered with as many as 52 transmitters, of which 44 were erected close to the motorways and were driven through optocables. The other were conventional VHF-FM transmitters, of which some were already in operation prior to introducing the synchronous FM service. Using the CCIR five-grade scale, a subjective evaluation of grade 4 was found to stand for the quality of reception.

4. NETWORK OF TDF IN FRANCE

In France TDF /TéléDiffusion de France) was asked in 1988 by Radio France to prepare a feasibility study on the possibility of establishing a synchronous FM network, to be introduced at the time of the Winter Olympic Games 1992 in Albertville. The working group of TDF concluded its activity by 1989. They had come up with a solution different from that employed by RAI, since no optical cable was available alongside the motorway leading to the site of The Olympic Games. TDF opted for digital signal distribution. Following an A/D conversion carried out in the studio the programmes along with the additional information were conveyed to the stations through a 22 GHz microwave link. Here, the signals were applied to a so called digital modulator after the necessary delaying. The digital modulator, a circuitry capable of producing IF signals using directly the digitalized sound signals, was developed by the Research Institute of TDF. From this point onwards, signal processing was the same as used in the conventional VHF-FM technique. Digital signal distribution makes transmission of additional sound and data also possible. In addition, the transmitters or groups of transmitters can also be addressed selectively, which enables arbitrarily selected transmitters or groups of transmitters to be interrupted and forced to radiate important messages and actual informations. The studio was established at a major traffic node where picture signals from video cameras located at different locations alongside the motorways were also concentrated. In this way, motorists could be informed of the traffic situations, obstacles, accidents most rapidly. The first (20 km long) pilot stretch was introduced to motorists in 1990. The difference in quality between synchronized and non-synchronized single-frequency networks was demonstrated in that the delay elements inside the transmitter were cycled on/off from a vehicle while travelling alongside the motorway. The disturbances occuring without synchronization disappeared immediately on activating the delays, even with stereo signals. An additional stretch was commissioned in that same 1990, and the stretch of the motorway leading to the scene of the Olympic Games was put into use in 1991. Ever since the network has been developing uninterruptedly.

A French society running motorways examined the so called Ballempfang method. Here, each one of the transmitters radiates the signals received from the previous transmitter at the same frequency. In this case, only two antennas (one transmitting and one receiving) and one amplifier are needed. The experiences and results of this examination are not available for the time being. Certain is, however, that separation of the transmitting and receiving antennas of the station is a very severe problem. For, it must be avoided that the receiving antenna of the station receives the own station signal to prevent overdriving and instability.

5. ESTABLISHMENT OF THE DOMESTIC SYNCHRONOUS FM NETWORK

The project of establishing the domestic synchronous FM network was begun three years ago when the need for introducing radio service on motorways surfaced. The task was assigned to the defunct Frequency Management Institute (today General Inspectorate of Telecommunications) and the Hungarian Radiocommunications (Antenna Hungária Co.). As starting base existing foreign networks were taken. Antenna Hungária Co. started negotiations with TDF on the domestic introduction of this service. Final decision on the matter, however, has not been taken yet. Currently, a pilot network incorporating 3 to 5 stations is being considered. This pilot stretch would be established between Budapest and Tatabánya and the authorization for use of the frequency 107.4 MHz is already available. Once sufficient and positive experiences and skills are gained, establishing such stretch alongside the motorway Budapest- Hegyeshalom would follow, with as many as approx. 20 stations planned. The ultimate goal would be a system covering all major highways of the country, which could of course be dealt with only following the completion of constructing all domestic motorways. The greatest problem seems to be the modulation link between the studio and the stations given that optocables are also not available here. A viable solution could prove to be via digital microwave and satellite links. However, modulation distribution through satellite is economically viable only with extended networks given the high rental fees of the transponders, since its value is independent of the networks extension.

6. THE FUTURE

Although sound quality obtainable with synchronous FM broadcasting is far from perfect, yet its nationwide usage throughout the European countries is expected. In addition to the excellent frequency utilization, its major benefit is that it is compatible with conventional receiver sets. For this reason it may prove "viable" besides systems developed for similar reasons until the digital radio broadcasting (DAB) gaining sufficient ground.

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SUBSIDIARIES AND AFFILIATED COMPANIES OF ANTENNA HUNGÁRIA

INTRODUCTION

Activities of Antenna Hungária Co. cover the operation of two national television and three national UHF radio broadcasting networks. Technical support for satellite broadcast program of Duna Television is also provided by Antenna Hungária. The company operates a country-wide microwave network including servicing. It has over 150 branches all over the country belonging to six operating directorates. Infrastructure at branches consists of buildings, towers, energy and roads, in most of them.

Geographical location of branches have been suited as demanded by broadcasting and microwave networks, but settlements, in all, servicing more than one network are able to meet almost all kinds of broadcast and wireless telecommunications needs.

TO MAKE USE OF OPPORTUNITIES

The common past with telecommunications, broadcasting and related program distribution has created an infrastructure at the company which provides opportunities for expanding basic activities.

These new ventures are based upon present services, though in many cases operating basis of subsidiaries is value added services.

Accumulating professional experience of decades has not been in vain. Antenna Hungária not only keeps up with global technical progress, but contributes to the advancement of broadcast and wireless telecommunications with many of its own achievements. These development activities are essentially different from that of the equipment development processes. They have a dual goal:

- to establish tomorrow's business, the future of the company by keeping track of industry trends,
- to provide high level technical background for marketing, business and investment activities.

Values of experience and development appear in ventures, thus increasing supply and company assets.

INVESTMENT AREAS

The company and its predecessors have established subsidiaries and purchased shares in other existing enterprises since 1990.

- Operátor Ltd was established in 1990.
- AM Mikró Ltd, Macronet Ltd and Eurotel Ltd were set up in 1991.
- In 1992 TeleDataCast Ltd, P.T.N. Ltd, Hunsat Syndicate were established.
- In 1993 Hungária Rádiótelefon Ltd, Magyarsat Ltd, were established, ownership interests in HungaroDigiTel Ltd, and Pannon GSM Co. Ltd were purchased.
- Antenna – BHG Ltd was established in 1994.

Establishment of companies and purchase of shared ownership aims at the following goals:

- Basic aim is to have dividends in middle and long term investments.
- Other goals are to involve external capital for development of main profile
- A goal of high importance is to create opportunities for selling infrastructure, technology, expertise and human resources.
- Companies were created to introduce services requiring special technology impossible to be provided within Antenna Hungária's frame of activities (Magyarsat).
- Establishment of companies in many cases aims to be present on the market. To reach market shares is an important factor in establishing future services.

SUBSIDIARY AND AFFILIATED COMPANIES

Having given a general view of Antenna Hungária's investments we would like to introduce the most important subsidiaries and affiliated companies.

Significant data of these ventures can be found in the table

Operátor hungária Ltd

This is the first established venture to provide paging as value added service on UHF-FM transmission networks. An early start of the company resulted in reaching favourable market position. Developing services have furnished further good business results.

The service permissions for two networks issued in 1994 for single frequency paging challenge operating companies, but results achieved so far support further successful operations in the competitive environment.

P.T.N. Ltd

The company name is the abbreviation of Professional Telecommunication Networks Ltd.

Its main goal is to design, build and operate a national digital optical telecommunication network, which utilizes the existing favourable conditions of network realization.

The company will use most up-to-date technologies in building this high capacity backbone network for data transmission.

HungaroDigiTel Ltd

The company provides VSAT data transmission services for financial institutions, banks, etc. It operates in a very competitive market since five companies offer similar services in Hungary. In such an environment success cannot be guaranteed solely by modern technology. Good marketing and management activities are essential in this competitive business area.

TeleDataCast Ltd

TeleDataCast is the other venture to provide value added services to its partners. Adding value in this case means a secondary use of the broadcasting network of Hungarian TV1 program for data transmission. Two blanked lines of the TV frame are used for this data transmission — rather data broadcast — service. (Blanked lines are used also for teletext and program identification services as well.)

This special, low capacity data transmitting channel forwards information only from the transmitter station towards the TV receivers. Its advantage is that the TV transmission network covers the whole country, and at the receiver end data input to computers can be realized with simple and economic equipment.

Hungária Rádiótelefon Ltd

A wide choice, of high quality mobile telephone services are offered through operating systems and networks under construction. Accordingly tariffs and equipment prices are also high.

There is a huge demand among Hungarian mobile phone users for lower Ievel (less choice) and more economic services. Those needs could be met by trunk or dispatch radio telephone networks (Public Access Mobile Radio). Hungária Rádiótelefon Ltd was established to offer this service. Having realized an experimental network the company had to face problems in service approval. At present preliminary works are being done.

Magyarsat Ltd

Magyarsat Ltd is the first organized form of Antenna Hungária's initiatives of strategic importance. The aim of this venture is to launch and operate a regional satellite providing 16 channel capacity for TV program distribution for the countries in Central Europe.

Importance of this satellite of medium capacity would be — besides being the first satellite in the region of Central Europe — to provide high level program broadcast and telecommunications services in Hungary applying most up-to-date technologies.

The business opportunity is likely to be profitable for the participants.

Hunsat Syndicate

Hunsat Syndicate was established to represent the Hungarian Government at international space communications organizations and events.

Pannon GSM Co. Ltd

Antenna Hungária is participating in the mobile telephone services in Hungary as a member of Pannon GSM Co. Ltd Its ownership is not very significant, however its role is more important than its share.

The infrastructure of Antenna Hungária (towers, buildings, energy, etc.) was in great extent built into the system of Pannon GSM. Moreover Antenna Hungária provides services to Pannon GSM Co. Ltd through its servicing network.

The agreement between the companies is based on mutual interests and enables them for long time cooperation.

Antenna Hungária Co. Ltd takes part in capital raising needed for the development of the company in accordance with its investment conditions and wishes to keep its shares in this company.

Antenna-BHG Co. Ltd

A significant rate of Antenna Hungária's equipment was manufactured and installed by BHG Communications Co. and its legal predecessor.

The two companies has established a joint venture for technical support and for manufacturing telecommunication and broadcast equipment besides the above.

Table 1. Data on Antenna Hungária Co. joint ventures

Company name	Capital in mio HUF	Antenna Hungária share %
Operator hungaria Ltd	80	51
P.T.N. Ltd	51	0.2
HungaroDigitel Ltd	451	25.92
TeleDataCast Ltd	50	34.93
Hungaria Radiotelephon Ltd	60	51
Magyarsat Ltd	50	50
Hunsat Syndicate	18	50
Pannon GSM Co.	10450	2.25
Antenna – BHG Ltd	170	52

CONCLUSION

The transition of the Hungarian economy has opened up new vistas for establishing ventures. Besides or in contrast with huge companies with traditional and old services small companies with new technologies and new services are able to enter the broadcast and telecommunications markets. The dynamics, flexibility, market sensibility and other important features of small companies starting in the "development phase" provides for a more favourable framework to introduce new technologies and new services than big companies operating in a later phase.

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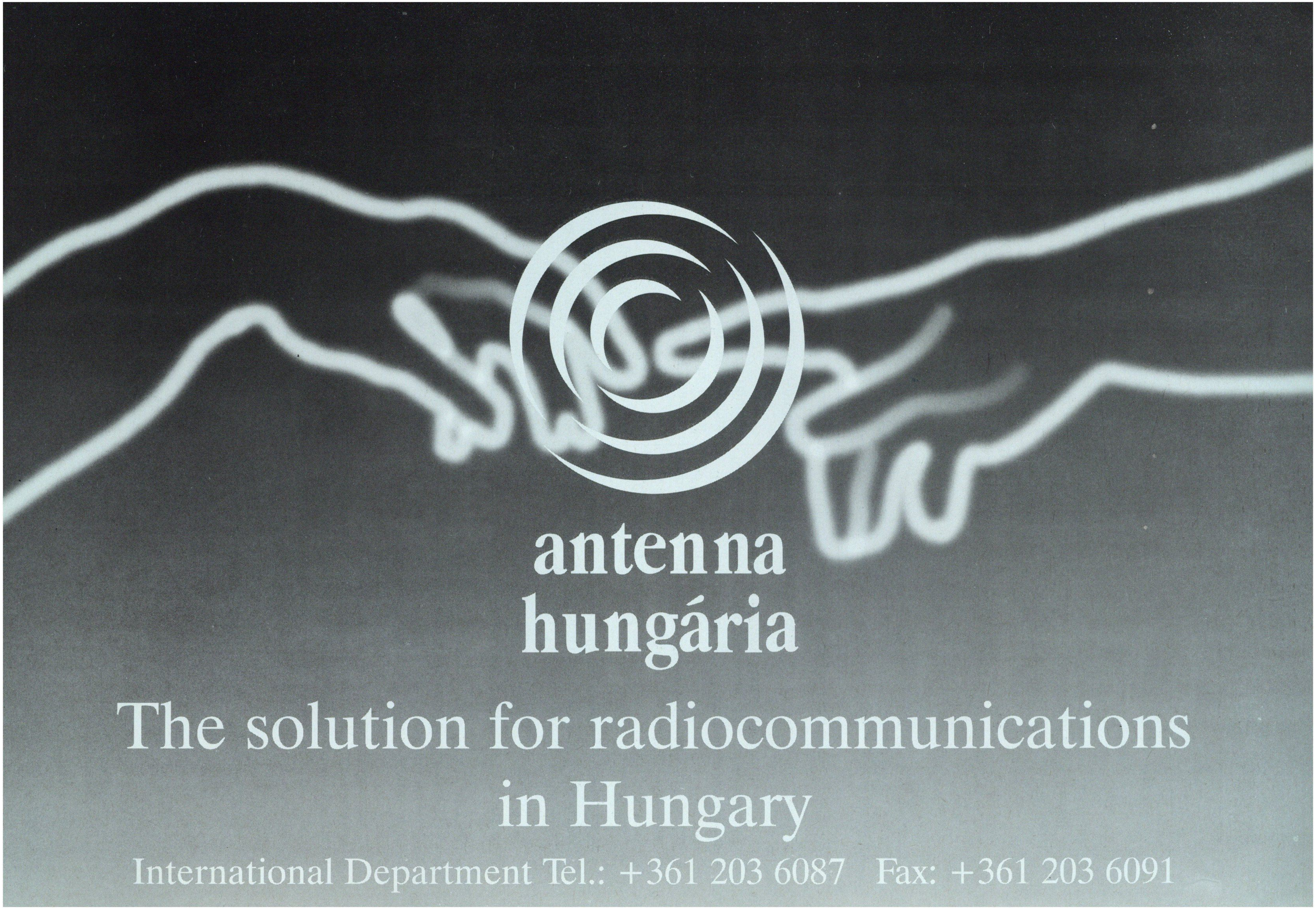
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PAST, PRESENT AND FUTURE OF BROADCASTING IN HUNGARY

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The radio is one of the earliest and most outstanding technical systems developed by mankind. Hungarian broadcasting was among the first to join the world-conquering movement of the radio. In cooperation with leading experts of the world, the experts of Hungarian radio technology are working on the introduction of the radio and television of the future, that is the DAB and the HDTV. The information available up till now concerning the new era is not yet sufficient to see clearly the trends of the future, but it can be stated that in the past 100 years radio broadcasting of the world has gone beyond all expectations.

1. INTRODUCTION

The radio is one of the earliest and most outstanding technical systems developed by mankind. This invention, hallmarked by the names of Hertz, Marconi, Slaby and Popov, and radiocommunications created 100 years ago to meet the need of people to maintain contact with each other, is possibly still the most widespread means of public communications.

Hungarian broadcasting was among the first to join the world-conquering movement of the radio. Hungarian radio also had a special feature — not observable anywhere else — in that the ingenious invention of Tivadar Puskás, the Telefonhírmondó (a kind of telephone newscast), was put into operation even before radio broadcasts started via radio waves.

In spite of economic and political hardships and the damage caused by wars, Hungarian broadcasting has undergone dynamic development starting with the Telefonhírmondó to satellite broadcasts of the present.

In cooperation with leading experts of the world, the experts of Hungarian radio technology are working on the introduction of the radio and television of the future, that is the DAB and the HDTV.

The unprecedented pace of development in radio techniques can be well represented by the fact that work has already been started on the innovation of multimedia broadcasting, while the novel fields of radio and television broadcasting, the DAB and the HDTV, have not yet been introduced.

Like a magic word *radio* is able to incorporate more and more systems and activities of the same concept, while it is also the source of the development of various new professional fields.

In the early stages of Hungarian radio broadcasting — from the development of the spark telegraph transmitter to radio broadcast networks — radio was able to maintain its own character. However, with the development of technology the transmission of voice-signals on radio-waves started including the transmission of video signals, and *Hungarian television broadcasting* developed as a new branch of the RADIO.

Naturally, the radio had taken part in man's first space travel and space communications is also developing at an unprecedented pace — including satellite radio and television broadcasting, and opening the way for *Hungarian satellite broadcasting* too.

2. THE GOLDEN AGE OF RADIO BROADCASTING

The Telefonhírmondó service, launched on February 15, 1893 as the forerunner of Hungarian broadcasting, started operating with a mere 60 subscribers. The number of subscribers, however, grew to 7000 by the turn of the century and the entire network reached 1200 km.

The first real radio station of Hungarian broadcasting was the Csepeli Szikratávíró Állomás (Spark Telegraph Station in Csepel), where construction began in 1914, served for more than twenty years. Hungarian radio broadcasting was started on December 1, 1925.

Later, the Csepel station was substituted by two new stations, the Lakihegyi Radio-broadcasting Station and the Székesfehérvári Telegraph Centre. This was the first step in the establishment of the national radio transmitter station network, which later included the establishment of countryside relay stations.

The transmitters of the radio transmitter network were low power ones, but as early as November 1933 a 120 kW transmitter was put into operation on Lakihegy. This is when the "cigar antenna" of Lakihegy, the symbol of Hungarian broadcasting, was erected as a novelty in the whole of Europe.

In the 1930s Hungarian radio broadcasting was among the leaders in European radio broadcasting with its BLAW-KNOX-system antenna and 120 kW transmitter at Lakihegy. Back then there were only three stations in Europe which could compete with the modernity of the Lakihegy station.

Parallel to the development of European radio broadcasting the need for international standards also grew. In April 1925 the broadcasting companies established the International Radio Union, and afterwards the International Radio-communications Consultative Committee (CCIR, Comité Consultatif International des Radiocommunication) was founded.

The first stage of Hungarian broadcasting ended with the destruction caused by the second world war — when in September 1944 the Miskolc Radio Station was exploded to be followed by further destruction. The establishments of the Lakihegy radio station were exploded at the end of November and early December 1944. After the second world war, the reconstruction of the Hungarian broadcasting network was started on May 1, 1945 by putting into operation a 500 W transmitter built from an old transmitter. Afterwards, broadcasting power was gradually increased at the Lakihegy station and the countryside radio stations were also rebuilt.

Modernization was soon to follow on the transmitter network rebuilt from the ruins; transmitters of increasing power and higher standard were used.

In addition to the traditional medium wave, radio broadcasting also expanded to the FM and SW bands.

Stereo transmission became widespread in FM broadcasting. Quadrophonic experiments were performed with success and similar results were achieved in upgrading services such as paging and other RDS services in the field of radio communications.

A significant milestone of the development of the Hungarian radio broadcasting network was the putting into operation of a 2x1000 kW transmitter station at Solt in February 1977.

At present Hungarian broadcasting meets European standards both in power and in quality.

3. HUNGARIAN TELEVISION BROADCASTING

The preparations for television broadcasting — as the new branch of Hungarian broadcasting — were commenced in the early 1950s. As a result of this preparatory work experimental broadcasts were made twice weekly from the Széchenyi Hill from January 29, 1954.

The first major milestone of Hungarian television broadcasting was the 30 kW transmitter station of the Széchenyi Hill put into operation on January 22, 1958.

Following the operation of the Széchenyi Hill TV station the establishment of the national microwave network, and later the countryside television stations was started at a rapid rate. Parallel to the establishment of the national transmitter network, the assurance of the technical conditions of colour television broadcasting was gradually introduced besides the black&white transmission.

After the TV1 program was already available, the preparations were started for an experimental TV2 program. A high number of relay transmitter networks were built for reaching areas not accessible by the television backbone transmitters.

4. HUNGARIAN SATELLITE BROADCASTING

The construction of the Hungarian terrestrial station for space-communications has to be mentioned as the precedent of Hungarian satellite broadcasting.

The space-communications terrestrial station, suitable for receiving and transmitting video, audio and multiplex signals, was opened on January 20, 1978 at Taljándörögd. This station served primarily telecommunications goals, but it also provided high volumes of technical knowledge for the preparation of satellite broadcasting.

The first Hungarian satellite broadcast experiment took place at 16 o'clock on March 16, 1992 by using the terrestrial up-link station located at Széchenyi Hill and the satellite of Eutelsat. This experiment meant the start of another golden age of Hungarian broadcasting. As early as the second day of the program, the Hungarian minorities living beyond Hungary's borders in Europe gave many positive remarks about its reception, and also ensured us of their support in continuing the experimental broadcast.

The first Hungarian satellite broadcasting experiment was followed by an experimental period of even greater importance, when broadcasts were made on the programs of TELECOM '92 held in Budapest. Regular Hungarian satellite broadcast was started early 1993 by the transmission of the program of DUNA TELEVÍZIÓ.

In addition to satellite broadcast from the Eutelsat satellite, the preparations of the establishment of the first Hungarian telecommunications satellite system was commenced in 1992 with the preparation of the MAGYARSAT program.

According to our plans, the first Central European regional satellite will be capable of broadcasting Hungarian TV and radio program, as well as further television, audio and data transfer.

5. THE FUTURE

In the present the development of radio and television broadcasting has reached a stage bringing major changes.

The construction of the majority of terrestrial transmission systems has been completed in Europe. The new means of program distribution and transmission like fiber optics cable-television networks, and the AM-micro networks are rapidly developing parallel to satellite broadcasting. Digital sound (DAB) and digital video (HDTV) system experiments were also commenced. The application of effective compilation techniques was started.

The joint utilization of digital audio, video, and data signals has started in multimedia. The number of available radio and television programs can be given in hundreds, and they include programs intended for the world or even for a single settlement.

The information available up till now concerning the new era is not yet sufficient to see clearly the trends of the future, but it can be stated that in the past 100 years radio broadcasting of the world has gone beyond all expectations.

Károly G. Tóth got the diplom with first class honours for telecommunication Engineering of the Technical University of Budapest. In 1976 he postgraduated with distinction in economics. In 1979 he obtained doctors's degree in Radio and TV Transmitter Engineering. From 1971 to 1987 he was the deputy development director of Radio and TV Direction of the Hungarian Post. From 1987 to 1990 he worked as the head of the Broadcasting Department of the Hungarian Post. From 1990 he was the technical general manager of the Hungarian Broadcasting Company. He took an important role in elaborating a general strategy for the company. As from February 1993 he is the strategic director of the company Antenna Hungária Co. He has been the secretary of the Radio and TV Broadcasting Section of HTE for more than 10 years. On behalf of HTE's Executive Committee the first strategy of the Scientific Society was elaborated under his direction in 1994.

EXPERIMENTAL DATACASTING BY LEO SATELLITES

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This article introduces an experimental data broadcasting system using low earth orbit satellites to spread information all around the world. The first part summarizes the general features of LEO satellites as the essential elements of modern long-haul communication. In the following we describe a particular application: distribution of scientific data by radioamateur store-and-forward "flying mailboxes" and the ground station built at the Technical University of Budapest.

1. INTRODUCTION

Nowadays the LEO satellite based telecom services are expected to have a very fast growing. The series of flying cellular base stations, the 66 satellite Iridium, the 48 satellite Globalstar, the 12 bird Odyssey or the proposed Teledisc 840 satellite networks will give us new, global voice/data communication possibility.

To help the education of the future telecom engineers a real ground station has been developed at the Radio Club of the Technical University of Budapest. One of the LEO satellites made by university students for radioamateurs has been chosen for experiments.

The data source was in Canada linked by Internet e-mail system to the control computer of the ground station in Budapest. The content of the data files is describing the activity of the Sun. By the reception of the data one can load a computer to get short-wave propagation prediction.

The results of the experiment, carried out during a 6 month period, are excellent. It was a good, practical work for the students and teachers also, proving that the LEO satellite based datacasting is a cheap, reliable method to help overcoming the problems of the classical solar data distribution using shortwave transmissions which are often blocked by poor propagation.

2. THE LEO SATELLITES

The Low Earth Orbit satellites have a nearly round-shaped or slightly elliptical orbit with a height in the range of 400 to 2000 km. Their properties are quite different from the geostationary satellites, which are dominant in satellite telecommunications nowadays. These features may be advantageous or not, depending on the application of such satellites. In any case we must adapt our systems to the special requirements.

We calculate the actual position and velocity using the Keplerian model of orbital mechanics. Computer programs simulate the real motion, display it on graphic screen and make visibility schedules. We can calculate in advance when the satellite "rises" and "goes down" and which time periods are convenient for communication.

Because of the low altitude of the orbit, the satellite can "see" a small area of the Earth, about a circle of 8000 km diameter from 1500 km height (Fig. 1). This circle is called "footprint". The satellite takes 12–14 revolutions per day around the Earth, the time window when the satellite is visible from a given earth station is short, about 5–25 minutes. If the inclination (the angle of the equatorial and the orbital planes) is high (usually 60–90 degrees), the footprint scans the entire surface of the Earth twice a day meanwhile a terrestrial observer can see the satellite about 6–10 times. The visibility schedule displays these periods (Fig. 2).

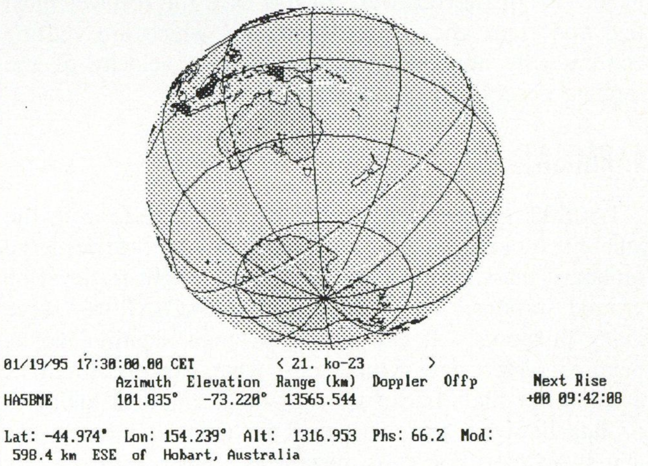


Fig. 1. Satellite footprint

A special case of the orbits is the sun-synchronous one. Such orbits pass over the same part of the Earth at roughly the same time each day, making communication convenient and can provide nearly continuous sunlight for solar cells. Because of these desirable features orbits are often chosen to be sun-synchronous.

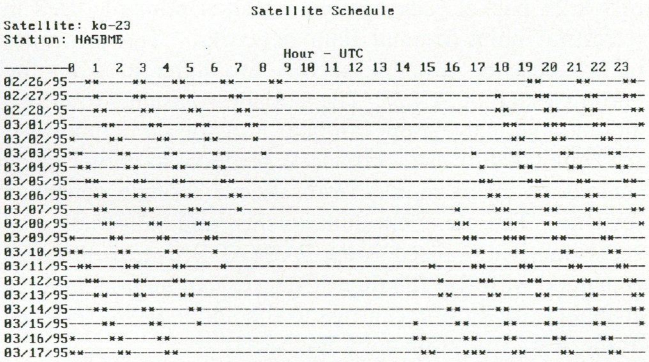


Fig. 2. Satellite visibility schedule

The upper atmosphere affects the motion of the satellites, thus to decrease this effect the solar cells should be placed on the surface, not on large "wings", so the available electrical power is small. The satellites often get in the shadow of the Earth, and then batteries provide the required power. The braking caused by the atmosphere and the aging of the extensively used batteries determine the lifetime that is usually five-seven years.

3. RADIO COMMUNICATION WITH LEO SATELLITES

The distance between the ground station and the satellite is small (400 – 4000 km), the radio frequency path loss is smaller than at a geostationary orbit, thus we do not need high gain antennas or high transmitter power. The visual angle of the horizon from the satellite is about 130 degrees, so wide-beam antennas should be used on board. We should use circularly polarized antennas at least on the ground station to prevent the fading caused by the varying of the polarization direction of the received waves.

Doppler shift is a typical phenomenon of the fast moving satellites. The offset of the received carrier frequency from the nominal value may be greater than the bandwidth of the receiver. In this case the receiver must find and track the actual frequency, which are shifting continuously depending on the relative velocity of the satellite observed from the station.

4. PACSATs

PACSAT (packet radio satellite) is generic term in the amateur radio service for a LEO satellite that carries large on-board mass memory for data storage and retrieval by ground stations. As a file server, a PACSAT can serve many purposes. It can store text mail, digitized voice, pictures, video or anything else what can be stored as a computer file. It can transfer more hundred kilobytes of data between any two points on the Earth every day, and store more than 10 megabytes. They usually carry other related experiments, for example earth imaging systems, synthesized speech transmission and cosmic ray measurements.

Similar systems are in service for professional purposes, forwarding mails and medical data for hospitals in the developing countries, where there is no suitable communication infrastructure.

The data transfer protocol is based on the link layer of AX.25 packet radio system, which is primarily used in terrestrial point-to-point data networks. The principles of broadcasting and file servers are different from the current usage of AX.25. The satellite transmits from high altitude and many users can hear it at the same time. It is recommended to use a broadcast protocol to permit many stations to make simultaneous use of a single download session. The excellent link quality and non-traditional access method realized by the PACSAT Broadcast Protocol combined with the full-duplex nature can approach 90 % channel utilization in contrast to the about 30 % efficiency of the AX.25 used on early PACSATs.

The files stored on board are identified by a number. Each file has an attached record in a directory, which contains the callsigns of the sender and the recipient, the identification number, size, type and subject of the message. The satellite periodically broadcasts the directory, so the ground stations can keep an update copy of the contents of the mass memory. The operators can browse the directory and mark the messages they want to download. When the satellite rises, the station automatically asks it to begin broadcasting the file. The on-board computer cuts the file into 200 bytes long packets, attaches the file number and offset from the beginning of the file then transmits them. After reception, each packet is checked for errors with CRC16 method. The software at the ground stations keeps a record about the received and the missing packets. After successfully reassembling the file, it asks for the next file, in case of failure it requests the retransmission of the missing packets. While one station is active in downloading a file, many other stations (even those eavesdroppers who are able to receive only) collect the same file. To prevent the users having high transmitter power pushing others out of the channel, the on-board computer put the download requests in a queue. Upon receiving a request it answers "OK" or "NO" and periodically transmits the state of the queue. If a station receives the "OK" or sees its callsign in the queue, it stops transmitting, and begins waiting for the requested file. While the strong station is in the queue, weaker ones have a chance to communicate. The number of the packets sent for one request is limited, but download can continue during the next orbital period.

Uploading a file is similar to a traditional point-to-point contact. Because of the full-duplex nature of the satellite the low number of uploads do not degrade the efficiency of the broadcasting process.

5. DATACASTING SYSTEM AT THE TECHNICAL UNIVERSITY OF BUDAPEST

A small group of students have built a ground station for a satellite based datacasting system in an educational project. The system communicates with the PACSATs built at the University of Surrey in Great Britain (UO-22) and the Korean Advanced Institute of Technology (KO-23, KO-25) by students. These are relatively small satellites, with a total mass of 47 kg. They have sun-synchronous orbits with heights in the 800 – 1300 km range. Their uplink frequencies are in the 145 MHz band, the downlink ones in the 435 MHz band. Their transmitter power is very low, 2 to 5 W. The nominal data rate is 9600 BPS in both directions. The system uses FSK modulation, and a special modem, which decreases the occupied bandwidth of the radio frequency signals by a bit scrambling method developed for satellite communication links.

The goal of our ground station is to provide daily data for making shortwave propagation predictions. The system works automatically, without manual intervention. It receives a solar and geophysical activity data package each day from the Solar Terrestrial Dispatch in Canada by Internet e-mail. After preprocessing, it uploads the data to the KO-23 satellite. Radioamateurs can download this bulletin and update the database of their ionosphere modelling software.

The upload takes only a few minutes, and after finishing it the station enters download mode, collecting all the bulletins and the letters addressed to us. After each satellite pass the station checks the Internet mailbox for incoming data packages and sends its log file to the operators.

The ground station consists of two parts, the satellite tracking and the communication managing subsystems (Fig. 3).

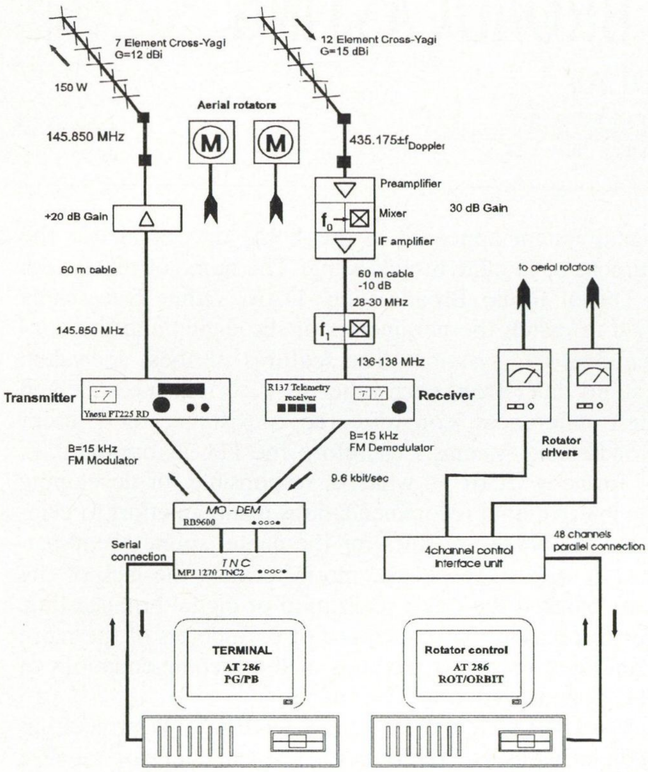


Fig. 3. Satellite ground station at the Technical University

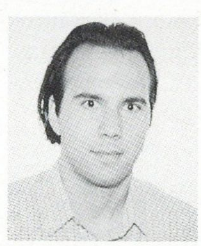
The transmitted power of the satellite is small, so we must use higher gain receiving antenna to achieve good signal-to-noise ratio. The sharp beam pattern attenuates the high-level background noise produced by the urban and industrial environment. The gain of the transmitting antenna helps to successfully compete with the high power stations in Western Europe. Because of the narrow beamwidth the antennas must point at the satellite. The tracking computer calculates the actual position and controls the aerial rotator units through the control interface unit. The orbit calculation model is accurate enough to keep the errors below a few degrees, which is negligible at the beamwidth of about 15–30 degrees. The upper atmosphere and the corpuscular radiation of the Sun perturb the orbital motion of the satellite, which effects cannot be predicted. Therefore updating the orbital elements is recommended at least once a month. We usually download fresh data provided by NASA from the satellites.

We use a radio receiver (Tesla R137), designed for satellite telemetry links, which could be made suitable for us by rather small modification. Because of the high bandwidth (higher than a voice signal) of the baseband data signals, we had to modify the FM modulator circuits of the amateur transmitter (Yaesu FT225RD). The terminal node controller (TNC) is a small microcomputer that can realize all the AX.25 levels, but in this configuration it is employed as the controller of the physical and data link layers only. The higher levels of the Open System Interconnection reference model are managed by the PBP ground station software running on the communication computer. Another software handles the incoming mail messages containing the solar and geophysical data packages, controls the activity of the upload and download programs, keeps contact with the system operators by e-mail, and processes their telecommands.

Many hardware blocks and software were built and written by students as educational exercise, which helped them to get practical experiences from engineering. The station is now complete, but there are many possibilities of enhancements. Our short-term plans include tracking and communicating with further satellites, broadcasting of propagation data by synthesized voice and making propagation predictions by simulating the ionosphere on high performance computers. This station is part of a long term program that opens a new approach in the research of the ionosphere by using spaceborne measuring equipment and data collection and distribution by LEO satellites. The experimental datacasting service started in June 1994, already met with warm response from the scientific society. Foreign universities, organizations and radioamateurs assist our work.

András Gschwindt received his degree as telecommunication engineer from the Technical University of Budapest in 1965. From 1965 he is working at the Microwave Telecommunication Department as teacher. His education activity is in the field of radio systems. He is the head of the Space Research Group and the Radio Club of the Technical University.

Péter Bakki is student at the Technical University of Budapest. His research activity is connected with the LEO satellites, their construction and operation. He is deeply involved in the on-board and the ground station control software work. He made also the automated satellite antenna tracking system for the KO-23 datacast experiment.



Sándor Blaskó got his degree as telecommunication engineer in 1993. He stayed at the Microwave Department of the Technical University. He is doing his study and research work for his Ph D. He is expert in the field of radio system integration including software and hardware areas. Member of the team working on the construction of a top-side sounding experiment planned to be installed on three different satellites.

PROBLEMS OF THE INTRODUCTION OF DIGITAL SOUND BROADCASTING

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The digital audio broadcasting (DAB) as a new area of broadcasting has numerous advantages over conventional FM systems, e.g. very good spectrum usage, excellent transmission quality etc. The introduction of DAB, however, has brought a number of problems to be solved before the start of the service. The most important problems are the lack of operating frequency, the initial cost of the DAB transmission networks, the relative large cost of DAB receivers. The most important problems pointing out the way of their solution are discussed in the paper.

1. INTRODUCTION

The digital sound broadcasting was demonstrated in Europe first in Geneve in 1988. Long theoretical and practical research work preceded this successful introduction. Thereafter other test transmitters were going into operation in Germany, England etc. The main features of the digital sound broadcasting system can be characterized as follows:

- excellent spectrum usage, two-three times more programs can be transmitted in the same frequency band as compared to the FM broadcasting,
- lower field strength level is sufficient for excellent reception as compared to the FM transmission,
- high grade of protection against multipath, Doppler effect and interference,
- rugged multiplexing capability of various programs,
- signal-to-noise ratio of 90 dB.

An other interesting feature of the new system is that the minimum bandwidth of the transmission — the so called block — is 1.5 MHz. In this block there is possible, however, to transmit 6 high quality sound programs, furthermore significant data broadcasting capability is available too. In case of moderate sound quality requirements the number of programs may be raised.

The tests verified the expectations concerning the digitalized sound broadcasting. However, before the introduction, we have to solve a number of different problems. The author is tending to look over some of the important questions appeared after the technical demonstrations.

2. THE STANDARDIZATION OF THE PARAMETERS OF DIGITAL SOUND BROADCASTING

The characteristics of the new transmission have been elaborated in the frame of a project work named EUREKA 147 and it has been labelled as Digital Audio Broadcasting, DAB. However, in the same time a similar digital system appeared in the USA, first of all for the purpose of satellite broadcasting. The name of this system is Digital Radio Broadcasting, DAR. Other researchers tried to match the parameters of the digital and the conventional FM systems. The features of those individual systems differ from each other to a certain measure and these differences jeopardize the coexistence of different broadcasting systems. Therefore the ITU-R organization — formerly CCIR — which is responsible for developing the international recommendations made an effort to elaborate the necessary rules for the digital sound broadcasting. It was urgent all the more because the lack of the rules blocked the quick realization of digital broadcasting. For this reason the acceptance of parameters of the more elaborated system as the basis of the recommendations of ITU-R appeared to be reasonable.

The DAB system due to the EUREKA 147 project has been introduced as the official European standard labelled as ETS 300401. The European Broadcasting Union has stood up for the system DAB. Thereafter the system DAB named as Digital System A was accordingly recommended by ITU-R for acceptance with the note that if other broadcasting organizations want to introduce a different system which satisfies the requirements of ITU, they can do it. This mitigating expectation is reasonable all the more because the development of the technique of the digital sound transmission did not come to an end and one may expect further new results.

It can be stated that the system DAB in respect of standardization of its technical parameters is in a more advantageous position compared to other digital systems.

3. SELECTION OF THE TRANSMISSION BANDS

Multiple test transmissions of DAB were performed in the band VHF-II- and in the TV channel 12.

The selection of the proper frequency band for the DAB transmission was a difficult task. Estimations showed that for the terrestrial DAB in the beginning at least 8.5 MHz, but after 15–20 years about 25 MHz bandwidth will be necessary. However, choosing frequencies from the VHF-II/IV bands between 27–960 MHz is impossible because recently these bands are saturated.

For the introduction of the DAB it seemed to be advantageous that in the beginning the DAB must share bands with other services where the bands are not utilized completely or one can achieve free bands by a small rearranging of the frequencies.

The situation in certain bands are the following.

a) Due to an earlier concept it was projected that the start of the DAB transmission may be in the upper edge of the VHF-II band occupying a single 1.5 MHz DAB block. After this the DAB will spread gradually into the band, overtaking more and more programs from the FM transmitters creating the possibility of the rearranging of the band. However, this plan could not be realized because of overcrowding of the VHF-II band. Ultimately in this band no free frequency could be found necessary for starting with DAB. Beside this the relative low frequency of the VHF-II band is disadvantageous for the RF circuits of the DAB receivers.

b) Both in the presence and in the future the usage of the TV channel 12 (223–230 MHz) seems to be hopeful. In Western Europe this band is only moderately used for TV purposes. Therefore the broadcasting services could utilize this band for the DAB tests and probably this band will remain later usable for the regular DAB service.

The usage of a TV channel having 7 MHz bandwidth offers another advantage. In such bandwidth one can insert four 1.5 MHz DAB blocks providing the transmission for 24 high quality stereophonic programs. Unfortunately the start of the Hungarian DAB transmission is not possible in the TV channel 12 because of the TV station of Kabhegy. The release of the band will be feasible only later.

c) Where the TV channel 12 is occupied by TV transmitters the broadcasting services are trying to introduce the DAB transmission in the 230–240 MHz band. Although this band is used by military communication services but with some reconciliations there is possible to use a part of this band for DAB purpose. In many European countries the use of this band will solve the problems of the DAB start. Later on the ITU is tending to allocate this band for DAB.

d) In the TV channel 11, between 216–223 MHz there is a similar possibility to introduce the DAB transmission. Namely there can be taken into consideration that in TV broadcasting a process of digitalization is proceeding similar to the case of the sound. The digitalized TV programs will probable get place in other frequency bands. Together with this the usage of the TV channel 11 perhaps will decrease so that a full unloading of the channel will be possible. After this DAB services will occupy the channel.

e) Recently the bandwidth of the VHF-II band is 20 MHz. After a wide spreading of the DAB, the transmission of the conventional VHF-II programs will be radiated by DAB transmitters. Then the VHF-II services need less and less frequencies in the band. For the FM programs a bandwidth of approximately 10 MHz will be enough and 10 MHz band will be free for other services.

f) The frequency band between 1452–1492 will be used by satellite DAB services shared with terrestrial DAB programs. Recently in this band a number of test systems are operating but probably in the near future regular terrestrial services will be opened. However, until now there is no experience enough about the usage of the band. The allocation of the frequencies of the band has not been performed by ITU up till now.

Summarize everything reported above one may declare that the 25 MHz frequency band demanded for DAB will be available in the UHF region between 216-240 MHz and perhaps in the VHF-II band. The usage of the L band means a further possibility. It seems to be realistic from side of ITU that in 2005 the final decisions related to distribution or rearranging of the bands mentioned above will be made. Until this the service may begin or can continue their transmission in the bands mentioned above.

4. THE COMMERCIAL USAGE OF THE DAB

The high level scientific and technical elaboration of the DAB system together with the solving of the frequency problems not yet mean the commercial utilization. Searching for the market brings new financial problems occuring in every country. The problems we have to take into account are as follows:

a) The broadening of the recent transmitting networks or opening new programs in the future are possible only in the frame of the DAB system. Attractive features of DAB such as high transmission quality, insensibility to transmission errors makes favourable the passing from the recent FM transmission over the DAB system. Therefore we can count with the spreading of the DAB services.

However the development of the DAB networks needs a considerably amount of cost. This cost can be paid only by the suppliers. The investments will be recovered only. in case when the service makes money. However, the income will not be paid by the subscribers because the fee — where it exists — can not be raised after the introduction of the DAB. Therefore it is necessary to find another methods for financial usage of the DAB.

A solution of this problem may be the introduction of DAB services paid by the users. Such services are e.g. selective personal calling, data broadcasting for fix and mobile receivers, advertisements, radiating high quality music programs for recording purposes etc. There is an other possibility to reduce the costs where the introduction of DAB creates employment and this yields a certain type of tax reduction.

b) An other condition of the spreading of DAB is the presence of low cost receivers. Recently there is no cheap receiver on the market. E.g. the price of the experimental DAB receiver type DAB 452 from Philips costs about half a million Ft.

The importance of the development of cheap receivers is recognized by manufacturers on the electronic market. It is known that a number of firms promise low cost DAB receivers developed with common research work. For example in England a manufacturer association initiated the delivery of a low-cost one-chip full DAB receiver in 1996. BBC promised that DAB network in England will permit in 1998 a 60 % covering ratio. Similarly the big car manufacturers indicated that the cars of medium and upper category will be provided with DAB receivers.

The introduction of the DAB service raises similar problems in Hungary. The domestic DAB tests will start in 1995. In the frame of the test transmission new services promising also financial success will be expectedly introduced.

Taking into account that similar problems have been faced before the introduction of stereo broadcasting or the colour TV transmission and later on the problems of the start practically disappeared, we hope that similar situation will occur in the case of the introduction of the DAB service.

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Mihály Szokolay graduated at the Technical University of Budapest, in 1952. He started his teaching work at the same University as an assistant professor. Recently he is an associate professor of electrical engineering. His teaching area is the radio systems first of all the technique of the terrestrial and satellite broadcasting. His research areas were formerly the source coding, later he turned to error correcting codes. He took part in the development of the Hungarian FM paging network. Since 1988 his main activity is the development of DAB service in Hungary. He is the chairman of the Hungarian DAB Circle.

TELECOMMUNICATION SERVICES OF HUNGARY IN 1995*

1. PRESENT STATE AND STRATEGIC GOALS

In developed countries the main driving forces of telecommunications development are business globalization and pervasive technological evolution. In Central & Eastern European (CEE) countries these forces are also valid, in addition to the infrastructural needs of economic renewal and growth and the integration with Europe as well as customer dissatisfaction and pent-up demand. Teledensity and compound annual growth rate (CAGR) figures are shown for CEE countries in Fig. 1.

The recognition of the significance of the telecommunications and the beginning of an intensive development period can be generally stated. As regards Hungary, the CAGR of the number of main lines was 5,6 % in the eighties, and 14.8 % since 1991. By the end of 1994 we reached the average CEE teledensity figure, 16.8 main line per 100 inhabitants.

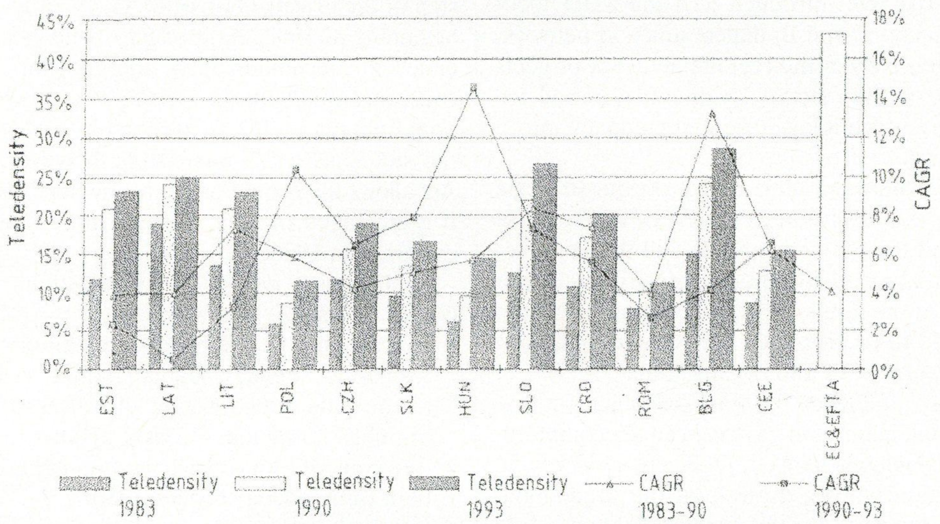

Fig. 1. Teledensity and its compound annual growth rate (CAGR)

Here are some benchmarking figures of Hungarian telephone services at the end of 1990, 1993 and 1994:

	1990	1993	1994
Number of connected main lines (in thousands):	996	1498	1732
Number of registered requests (in thousands):	657	730	713
Teledensity (number of main lines per 100 inhabitants):	9.6	14.5	16.8
– in Budapest	22.8	28.6	33.2
– in the Provinces	6.4	11.1	12.8
Distribution of lines (%)			
– residential	70.8	75.8	78.1
– business	26.6	22.2	20.0
– payphone	2.6	2.0	1.9
Local automatization (%):	93.5	96.5	98.3
Long-distance automatization (%):	92.2	95.8	97.8
Digitalization (%):	5.3	26.5	39.8
Manpower efficiency (main lines per employee)	46	79	90
Mobile telephone density (mobile subscribers per 100 inhabitants)	0.02	0.4	1.4

The key-objective of Hungary is to reach a telecommunication level equivalent to the economic and political importance of Hungary in Europe by not later than the year 2000. Owing to the back-logs accumulated for several decades in the area of telecommunication development, the implementation of this objective requires a longer time and a deliberate strategy. Fig. 2 illustrates the four phases of the development strategy where the following goals to be implemented become in the forefront as follows:

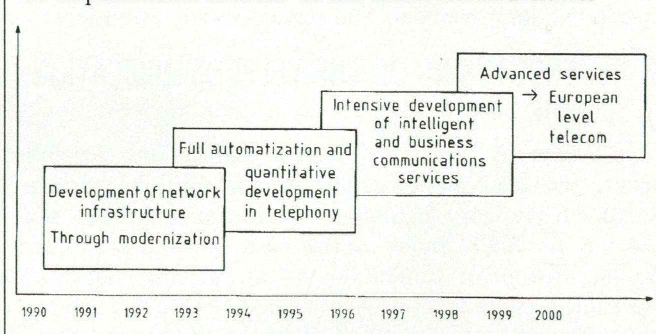

Fig. 2. Main objectives and development strategies

* Paper extracted from the lecture delivered at Seminar "Week of MATÁV in BTC", Sofia, 8 June 1995.

In the first phase between 1990 and 1993 although we increased the pace of the growth, the main strategic goal was to establish a modern nation-wide network infrastructure that provides for the foundation of the subsequent quantitative development. The nation-wide overlay digital backbone network, implemented during three years interconnects the 54 district centres (45 primary and 9 secondary nodes) of the upper two-levels of the newly defined network structure, mainly by single mode optical fibre links, partly by digital microwave systems. In the capital, Budapest, digital interexchange junction network has been established too, based on optical and digital microwave facilities. Since 1991, only digital switches are installed.

In the second phase between 1994 and 1997, the highest priority will be given to an intensive quantitative telephone development and the automation of the telephone network (completing by 1996), besides the introduction of most important new services for business customers (See Sections 3–6). We introduce also the SDH technology into the backbone and Budapest junction network, and participate intensively in the regional network projects (TEL, METRAN, INMS, etc.). During this period we should transform the technology-oriented company into a market-oriented one.

In the third phase between 1997 and 2000 the strategic focus is moving to the extension of variety of the business communication and information services and the improvement and differentiation of the quality of services with a relative reduction of the tariffs. This needs a marke' ·lriven company to be able to to introduce new services and have customer-oriented processes and organization.

In the fourth phase, following the year 2000 main emphasis is put on the implementation of advanced telecommunications services including advanced intelligent services and personal telecommunications, as well as the broad-band ISDN multimedia services. By the year of 2000 we could have a European level telecommunications, involving the provision of full (or quasi full) variety of telecommunications services for the business sector and a teledensity value in harmony with our economic wealth.

The subsequent development phases are overlapped in practice, and the objectives of each phase are of non-exclusive nature. Naturally, our attention is to be focused on different strategic objectives in each phase and yet, a proper harmony must be achieved among the development projects aimed at quantitative expansion, qualitative improvements and service variety extensions.

2. RESTRUCTURING OF THE TELECOMMUNICATION SECTOR

In order to accelerate telecommunications development, the telecommunications sector must be restructured. In Hungary legislation of telecommunications services is gradually fitted to the basic principles adopted by the European Community in the Green Paper. A new Telecommunications Act has been drafted, which end the monopoly of Hungarian Telecommunications Company Ltd. (HTC, in Hungarian: Magyar Távközlési Rt, MATÁV), deregulate the telecommunications market and give the framework for the new telecommunication sector structure. The privatization of MATÁV has also been decided, driven by the need for additional financing for the implementation of an intensive development program and for transforming MATÁV into an efficient, market-driven, customer-oriented company.

The telecommunication services together with postal services were regulated and provided by a single organization, the Hungarian PTT (in Hungarian: Magyar Posta). As first step, the operational and regulatory functions were separated in 1989, when the Ministry of Transport, Communication and Water Management took over the regulatory functions. In 1990, the postal services, telecommunications and broadcasting were separated from each other. The three companies were independent, but they remained in state ownership. MATÁV was transformed into a joint-stock company at the end of 1991. Hungary's new Telecommunication Act passed by Parliament in November 1992, came into force in July 1993. The first step of the privatization of MATÁV officially started at the beginning of 1992. As a result of the privatization process ended in December 1993, the MagyarCom Consortium, consisting of Deutsche Telekom and Ameritech International obtained 30.2 % ownership of MATÁV. Presently, the state has a 2/3 ownership; however, the Concession Act allows the reduction of this ownership to 25 %+1 vote. It is envisaged that the shares will be floated on the stock exchange in 1996.

In Hungary *the Telecommunication* Act creates two classes of services provision:

- concessions, i.e. limited competition (public switched telephone services, public mobile telephone services, nation-wide public paging, distribution and broadcasting of public radio and TV programs);
- free competition (terminal equipment, data communication, value-added services, etc.).

International and long-distance services are likely to remain with the country's dominant operator, MATÁV, at least up to the year 2002. As regards local telephony, the country had been divided into 54 geographic areas (so-called primary areas, having a dedicated area-code). Taking into account the opinion of the local municipalities and the bids of the competing service providers, the primary areas have been allocated among them at the beginning of the year 1994. MATÁV has 36 primary areas, including the area of Budapest. The selected additional 9 service providers (with at least 50 % of foreign ownership each) have a 25 year concession for local telephony in the 18 primary areas, up to 2002 exclusively. By April 1, 1995 MATÁV transferred the assets on 13 primary areas to the new service providers.

3. SERVICE DEVELOPMENT, POTENTIAL MARKET

The telecommunication revenue is about 2 % of GDP in Hungary, which is in harmony with the international figures. Distributions of the telecommunication revenue in 1994 among various services and various customer groups are shown on Figs. 3 and 4. It can be seen, that only a 6 % of the revenue comes from business communications services compared to the value of 20...25 % in the advanced countries. It is also shown, that a half of the revenue is provided by cca. 2000 medium, large and key business customers, requiring a wider variety and sophisticated applications of telecommunication services.

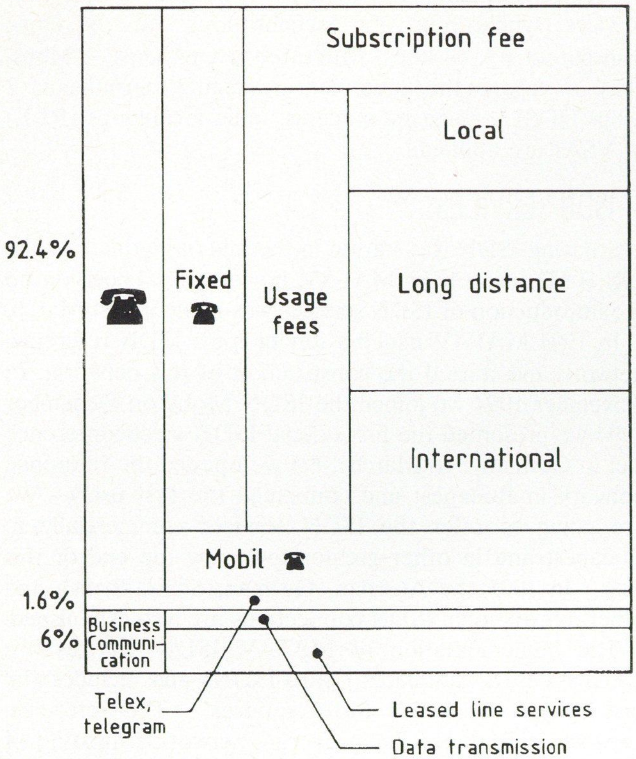

Fig. 3. Revenue split by service groups

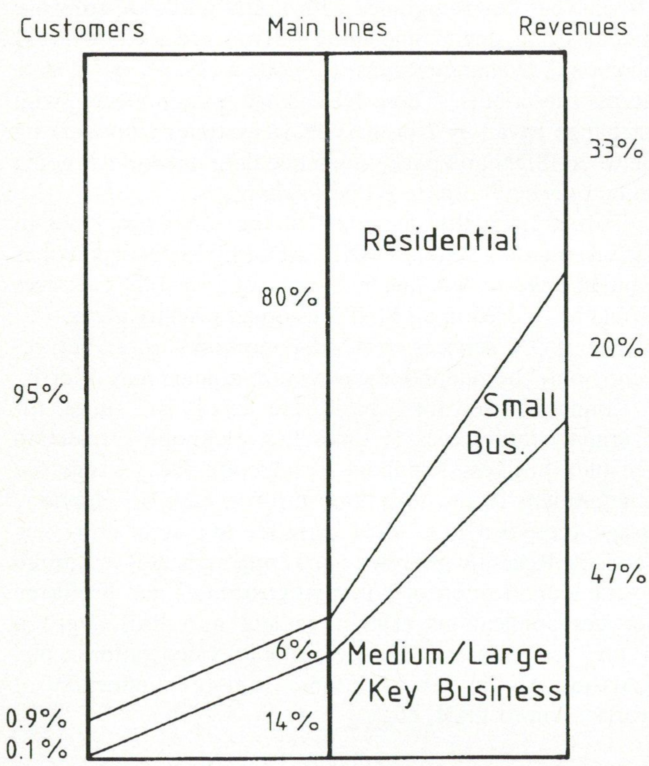

Fig. 4. Revenue split by customer groups

In order to satisfy the business customers' demand and utilize the network capacity numerous novel services are under introduction. Simultaneously, the organizational structure of the company is transformed into a market oriented one, where business segmentation is made according to major customer groups (residential and small business customers; medium, large and key business customers; domestic and international partner service providers), which require very different marketing, sales and service provision strategies.

Reviewing *the technical capabilities* of the Hungarian networks from the point of view of the introduction of new services we conclude:

- the introduction of digital technology created the technical grounds for implementation of services on a local basis in individual exchanges;
- the main constraints on the introduction of novel services are:
  - unavailability of signalling system CCS No.7,
  - the existing electromechanical and manual exchanges;
- preconditions for intensive progress are:
  - electronization of the crossbar (AR) exchanges,
  - replacement of the rotary and manual exchanges,
  - introduction of signalling system CCS No.7.

Automatization and electronization of crossbar exchanges will be ended in 1995, the introduction of CCS No.7. began in 1994.

Considering the overall Hungarian market, the solvent demand for main lines is forecasted in 2002 depending on the development of GDP as follows:

- 3,4 million in optimistic scenario (best),
- 2,6 million in pessimistic scenario (worst).

The Ministry for Transport, Communication and Water Management, the regulator of the Hungarian telecommunications fixed a price-cap tariff regulation for the next years and defined development criteria to the bidding procedure for local telephone concessions. The most important requirement is, that the concession-holder must implement more than 15.5 per cent annual growth rate, and from January 1997 90 per cent of the customer demands must be performed within six months, 98 per cent within twelve months for each primary areas.

Besides the intensive fix telephone service development a country-wide coverage with *analogue NMT cellular mobile telephone system* (Westel 450 Ltd.) is available for more than 60 thousands subscribers. The *digital cellular mobile telephone service (GSM)* was launched in April 1994 by two service providers (Westel 900 GSM; Pannon GSM), and a country-wide coverage will be implemented by the end of 1995. The rapidly increasing number of GSM subscribers exceeded 100 thousands.

Recently MATÁV provides the following non-concession telecommunication services: *telex, telegram, circuit-switched data, packet data (X.25), leased lines, audiotext, fax, tv-signal transmission, VSAT-based services, etc.* In the following sections we overview the development and introduction of three new services, which are going to launch in 1995.

4. INTELLIGENT NETWORK SERVICES

The intelligent network (IN) services provide significant additional revenues at the advanced telecommunication companies.

Although the technical conditions of Hungarian network are not appropriate to introduce IN services in a desired way (eg. CCS No.7), we are planning to introduce three IN services in 1995. As a result of the current technical development project, a temporary technical environment is created, which will make feasible the following IN services:

- *Domestic freephone service (green number, 06 80 XXXXXX):* the charges for all calls coming to this number will be taken by the subscriber called.
- *Long-distance calls at local tariff service (blue number, 06 40 XXXXXX):* the part of the charge of the national long-distance call in excess related to the charge of the local call is taken over by the called party from the calling party.
- *Premium rate tariff service (06 90 XXXXXX):* when the calling party calls up a value-added service (eg. audiotext, information services) in the course of a national call, then he/she pays a charge higher than the normal charge for the used information from which the value-added service provider will get a share.

While the business customers will actually purchase these IN services from MATÁV, the end-users will mainly be the residential customers. Additional IN services are under preparation (eg. universal number service) and various supplementary features are also offered (eg. time-dependent filtering / routing).

The field trials have been just started. Fully charged services will be open this autumn. We ensure the technical conditions that the IN numbers be accessed from the whole country, from settlements that can be accessed through domestic long-distance call (Remark: they cannot be accessed through international calls, but the international freephone services, have already been introduced.).

5. MANAGED LEASED LINE SERVICES

The purposes of the establishment of the managed leased line network (MLLN) are:

- to satisfy the leased line demands from 2.4 kbps up to 2 Mbps of the business customers within a short time;
- to provide enhanced quality-of-service and end-to-end management;
- to provide wide opportunities to introduce value-added services (frame relay, interconnection of LAN's, ATM, etc.);
- to use efficiently digital backbone network's capacity.

The MLLN is a nation-wide overlay network based on the digital backbone network and Budapest junction network, with Digital Cross Connects DXC 1/0 in the nodes for rearrangement at the level 64 kbps. Alternate paths are automatically formed. Flexible multiplexers are provided at the nodes and the major customers. The network terminations (NT) are also managed. The selected software-based Newbridge technology (supplier: Siemens) makes possible central network management (configuration-, failure-, alarm-, performance-, security-, bandwidth-, etc. management).

In 1995 we install the MLL equipment at almost all the district centres and offer a variety of digital leased lines services (synchronous and asynchronous 2.4...64 kbps; transparent n x 64 kbps, structured n x 64 kbps, 2 Mbps, etc.). As regards the subscriber lines digital transmission (2 Mbps HDSL), managed modems, radio local loops (RLL) or VSAT are applied.

6. ISDN SERVICES

Studying ISDN was started in the mid of eigthieth at the PKI R&D Institute of MATÁV, however final decision on the introduction of ISDN services was made in last March.

In 1994 MATÁV issued a tender for a ISDN reference network and started the construction of this network. In November 1994 we joined the ISDN MoU, on December 1994 we presented the first official ISDN videoconference call to Germany. In March 1995 we opened the reference network in Budapest and connected the first users. We are going to offer the ISDN services commercially in Budapest and in other greater towns by the end of this year. In 1995 the Austrian, German, Swiss, British and other international ISDN connections are also established.

The implementation of MATÁV ISDN services are based on ETSI standards (Euro-ISDN) and includes the first set of the ISDN MoU services. The reference network in Budapest is an overlay network consisting of an ISDN exchange and 11 remote units, providing 100 primary and 600 basic rate accesses. An EWSD exchange (István) has been upgraded with ISDN hardware-software modules and digital line units (DLU) are located in 11 additional exchange areas to collect ISDN basic rate access subscribers. These DLU-s are interconnected with exchange István by 2 primary PCM systems. Interworking between ISDN and packet switched data networks is going to be provided both on B and D channels.

During 1995, the upgrading of the other two types of digital switching systems (AXE, ADS) by ISDN capabilities would be also tested, and by the end of 1996 ISDN services would be offered in all MATÁV-served primary areas.

The ISDN services are non-concession ones, but recently only the telephone-concession holders may offer it.

Connection fee for a basic rate access is 2 times, for a primary rate access 11 times the telephone connection fee of a business telephone connection fee. Usage fee is equivalent to the telephone tariff in case of telephone usage, there is a 20...40 % extra fee in case of non-voice services. Recently intensive marketing activity is organized to the identification of potential customers and preferred services applications (Direct dialling into PABX, group 4 fax, file transfer, videotelephony, videoconferencing, LAN-to-LAN inter-connections, remote connection of workstation to LAN, etc.).

GYULA SALLAI
MATÁV Hungarian Telecommunications Co.

BOOK REVIEW

MODERN QUADRATURE AMPLITUDE MODULATION
by William Webb and Lajos Hanzo

The QAM, as one of the best methods of digital transmission has a long history of about thirty years. During that time it has been the exclusive solution in some applications and in many others it has been or has become a real alternative. The secret of its long term success is probably due to its ability to adapt itself to the varying requirements and the possibilities offered by the technological development. The comprehensive book (557 pages) of Webb and Hanzo introduces many-sided that method, with a great success.

Apart from the first four chapters that discuss the history of QAM, summarize backgrounds, channel models, the main functions of QAM modems and the possibilities of QAM signal generation, the remaining 14 chapters of the book contain three further, independent and independently readable parts.

The second part reviews the conventional applications of the QAM, those systems, where the linear distortion and the additive Gaussian noise are the dominant disturbances of the channel. The determination of the error probability is explained in Chapter 5. After it the clock and carrier recovery methods are presented, followed by the thorough introduction of the equalization techniques. Chapter 8 deals with the basic ideas and gives two examples of the trellis coding. At last, a review is given on modems applied for data transmission on telephone channels (CCITT Recommendations V.26...V.33). That part of the book (120 pages) can serve as a good reference-book for graduate courses on conventional QAM applications.

The third part (100 pages) discusses the particular questions of channels characterized by Rayleigh fading. Because under such circumstances the error probability of the simple square QAM is not acceptable, some pilot techniques are introduced (Chapter 10). The star QAM, a solution relatively insensitive to multiplicative distortions is analyzed in the next chapter, then some timing recovery systems specialized for mobile radio are detailed.

Six chapters (about 150 pages) constitute the fourth part. Containing very up to date techniques these are recommended also by the authors to the highly qualified readers. Indeed, novel topics are included here. Some of the main titles are: variable rate QAM, orthogonal multiplex systems, spectral efficiency of QAM. The remarkable last chapter on special speech transmission systems deserves particular attention, its bibliography proves the activity of the authors: 21 publications out of the total 35 are their own works. These six chapters could be interesting for postgraduate students and researchers, too.

The book has a logical structure and it is well arranged. All of its chapters contain a concise summary and a bibliography. The index with near 500 entries is also very useful for the readers. This book is the co-publication of IEEE Press (New York) and Pentech Press (London), 1994.

OSVÁTH LÁSZLÓ

The JOURNAL ON COMMUNICATIONS will publish a double sized special issue in in January-February 1996 on

ATM NETWORKS

ATM, the standardized carrier of B-ISDN, plays central role in future telecommunications. The rapidly increasing number of new research results, as well as competing products and services clearly show the outstanding importance of the subject. This double sized Special Issue is intended to provide both a wide-scale overview of ATM related research, including original technical papers and invited tutorials, and also the introduction/description of new ATM related products and services.

The special issue is supported by
- IFIP Working Group 6.3 "Performance of Communication Systems"
- COST 242 "Methods for Performance Evaluation and Design of Broadband Multiservice Networks"
- IEEE Communication Society Hungarian Chapter

Guest editor of the issue Tamás Henk, Technical University of Budapest, Hungary.

Interested authors are requested to send a one sentence description of the topic by June 1 to

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INTERNATIONAL SEMINAR ON MOBILE COMMUNICATIONS

and

WORKSHOP ON NMT SYSTEMS

November 6-8, 1995
BUDAPEST, HUNGARY

Organized by the
Scientific Society for Telecommunications

and

Journal on Communications

The seminar will give a comprehensive review of the problems of mobile communications especially on the problems of analogue and digital radiotelephone systems. Starting with basic system concepts the design, installation and operational aspects of the mobile communication systems will be presented. Special attention will be given to future system developments. Speakers are invited from well-known Western companies and Hungarian operators with outstanding results on the domestic market.

Participation at the seminar is especially recommended to specialists of the Central and Eastern European countries working on the establishment of mobile communications systems.

Seminar topics will be the followings:

- System development
- System concepts
- Network planning
- Services and tariffs
- Future systems
- Radio applications
- Mobile terminals
- Data transmission
- Base stations

Parallel to the oral presentation a poster session will be organized for the introduction of specific results within the scope of the meeting. Design tools and equipment will be presented at an exhibition organized concurrently with the seminar. Any person or organization is welcome to present contributions in the poster session and to introduce products at the exhibition.

Following the seminar a one day WORKSHOP will be devoted to the problems of NMT systems with the headlines Marketing and Manufacturing of new Services.

Language of the seminar will be English with simultaneous translation. Seminar and workshop talks and descriptions of the exhibited material will be published in the JOURNAL ON COMMUNICATIONS.

Registered participants will receive copies of the Journal at the registration.

Important deadlines:

• Submission of 150 words abstract for the poster session:	July 31
• Notification of acceptance:	Aug 15
• Final manuscript (21000 characters including 1200 characters for each figure)	Sept 4
• Request for exhibition space	Oct 1
• Registration for the seminar and workshop	Oct 15

Fees:

• Seminar and workshop	200 USD
• Exhibition (6 sqm area, one table, two chairs)	500 USD

Further information

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