Television in the digital era

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The Royal Television Society recently opened one of its Centres in the Republic of Ireland and the inaugural lecture was given by Dr. George T. Waters (Technical Director, EBU).

This article summarizes Dr. Waters' lecture which was delivered at the University College, Dublin, on 15 May 1996.

1. Introduction

It is just over 100 years since Guglielmo Marconi and Aleksander Popov claimed success in propagating electromagnetic waves over a distance. Both claimed to be the first but we will never know which of these gentlemen was actually the first.

Since 1895, enormous developments have taken place and I have been privileged, in one way or another, to have participated in most of the more recent developments.

When I joined Radio Eireann as an Assistant Engineer, there were just three radio transmitters in Ireland, all of them on medium-wave – one high-power transmitter in Athlone and low-power transmitters in Dublin and Cork. Proud as we were of our radio programme schedule, it did have large gaps of silence during the day and it ended before midnight.

But, of course, there have been many important and significant developments in the meantime; FM radio, television, colour television, the huge expansion in the number of radio and television services, etc. And there are more to come.

I can truly say that my 40 years in broadcasting have been very self-fulfilling and exciting. I have, literally, never had a dull moment.

For some unknown reason, I seem occasionally to have been cast in the role of a prophet; most of the time I have got things wrong but now and again – with some marvellous foresight of wisdom – I have "hit the jackpot". Sometime in the early 1970s, I remember giving a lecture to the Institution of Electrical Engineers (*Fig. 1*). I think it was during my Chairman's Address that I spoke about broadcasting from satellites. Not an original projection I might add, but merely a reiteration of the idea put forward by Arthur C. Clarke in 1945.

Late in 1978, I talked about the flat-panel display – the television set of the future that would hang on the wall like a painting. Aided by my colleague, Ted Crowly, we even faked the large-area wide screen.

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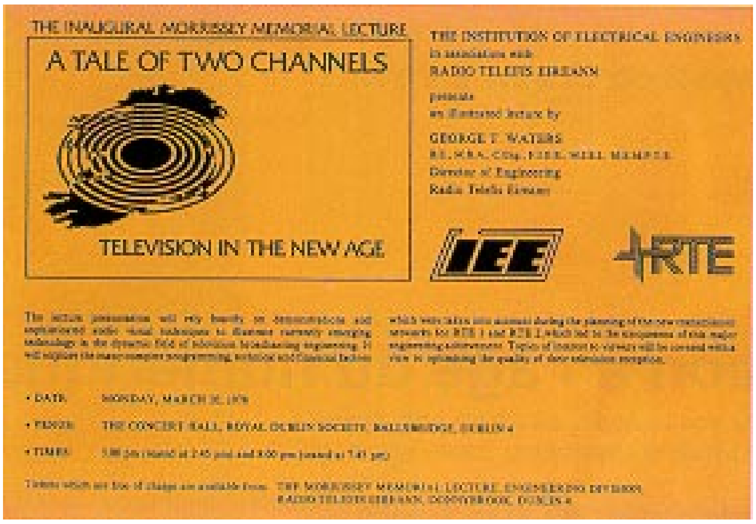

Figure 1
Poster advertising the inaugural Morrisey Memorial Lecture in Dublin, in 1978.

Now – some 18 years later – I am pleased to say that such screens will shortly be released on the consumer market. Flat panels made with plasma technology will be incorporated in domestic television receivers before the end of this year. The Japanese broadcaster NHK and the Japanese industry have set themselves the ambitious target of mass-producing large screens, measuring up to 50 inches (1.28 m) across the diagonal, by 1998 – in time for the Winter Olympic Games which in that year will be staged in Japan.

In case you might imagine that I was the only one to make projections into the future, I draw your attention to a reproduction from a 19th century magazine in which the artist has depicted the advent of the “Multimedia Era” in the year 2000 (see *Fig. 2*). The equipment, of course, has become much more sophisticated since then but the substance hasn’t changed. This was very perceptive for someone living more than a hundred years ago; a perfect forecast for it’s time.

The positive nature of this illustration can be contrasted with the apprehension which accompanied the introduction of electric light. Around about the same time, circa 1880, the notice shown in *Fig. 3* appeared in public places in Dublin. Electric light had just been introduced and this notice illustrates the public reaction to new technology. Things have changed a little bit since then but, even today, I am reminded of the concern at the effects of electro-magnetic radiation and, sometimes, the public reaction to new developments.

Well, enough of the past and nostalgia. Let’s look to the future. Today I am better equipped to interpret the pending developments than, perhaps, I may have been in the 1970s. Undoubtedly, there is more certainty about the future.

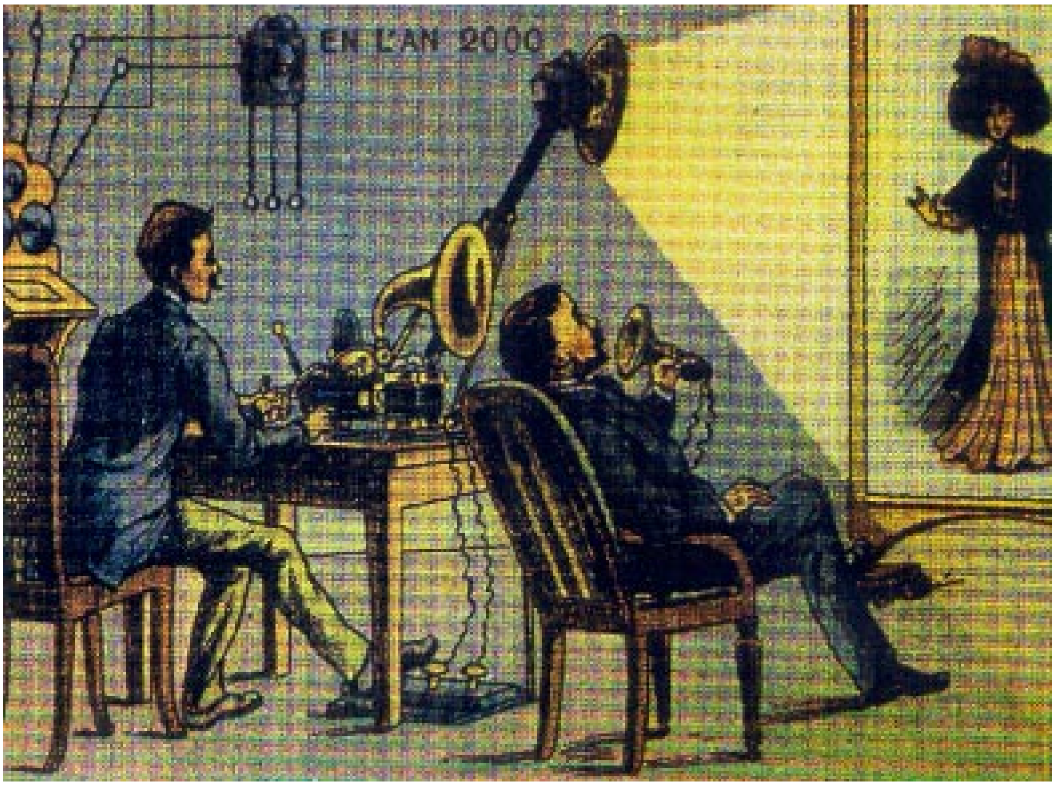

Figure 2
Reproduction of a 19th century cartoon depicting the “Multimedia Era” of the year 2000.

2. Digital technology

Nowadays, we hear a lot about the necessity to have our industry "market driven". This is a worthy aspiration but there is no doubt that the broadcasting industry is now and always has been "technology led". The technology that is leading us into the 21st century is, of course, digital technology. Inherited from the computer industry, digital technology is set to change fundamentally our whole approach to media and broadcasting.

We will be moving from a position of relative scarcity to one of plenty. This will be made possible by a combination of new technologies but, probably, the most important element will be the enormous increase in the processing capacity of the silicon chip.

The processing power of the chip and the amount of storage capacity has doubled every eighteen months during the past decade, a trend that seems likely to continue for the next twenty years. The increasing capabilities of such chips now make it possible to carry out complex signal-processing tasks that would have been inconceivable a few years ago. Silicon is cheap and, hence, once the basic manufacturing technology is mastered, the economies of scale come into operation and prices fall very rapidly with quantity production.

3. Fibre-optic networks

Fibre-optic networks will play a significant role in future developments. Following the well-established laws of light, bundles of glass fibres – each one with a diameter less than that of a human hair – are being used to carry a wide range of information ranging from simple text through to the most complex high-definition pictures. Fibre-optic networks continue to be built throughout the world and the information conveyed across such networks is, of course, in digital form.

The great advantages of fibre-optic networks are their almost unlimited capacity and their two-way capability. However, they have a number of major disadvantages as well: they do not support portability and they are expensive and time consuming to install.

In any event, it is globally believed that such networks shall one day bind the Earth into a maze of cable, connecting large centres of information to every household.

4. Information Superhighway

The so-called "Information Superhighway" is being hailed throughout the world as the panacea for all the ills of this century. From the broadcasters' point of view, it will present still another medium for the dissemination of programmes to the public.

The Superhighway is seen as an interconnected global system of fibre-optic cable, reaching like a tentacle into every home. It will be capable of distributing hundreds or even thousands of television, radio and data channels. The mind boggles at the thought – and yet that is what we have in store for ourselves.

Today there is much hype about the Internet and, of course, it has become a useful tool for the exchange of information, for business use and for entertainment. Even today, it is capable of carrying real-time radio programmes, although of doubtful quality.

The Internet can be considered as the precursor to the Information Superhighway, which will become a reality in due course – although perhaps not in the timescale predicted by the politicians.

One could say that the wheel has turned full circle because the earliest diffusion recorded seems to have been the diffusion of speech and music over the public telephone network in Budapest, Hungary, in 1893. Although this was not broadcasting as we have come to know it, it was nevertheless a very important development. In fact Alexander Graham Bell, who patented the telephone in 1876, envisaged it being used as an instrument to broadcast music and speech. Such networks will again be used in the Multimedia Era.

It seems – if the optimists are right – that, in the early part of the 21st century, our globe will be

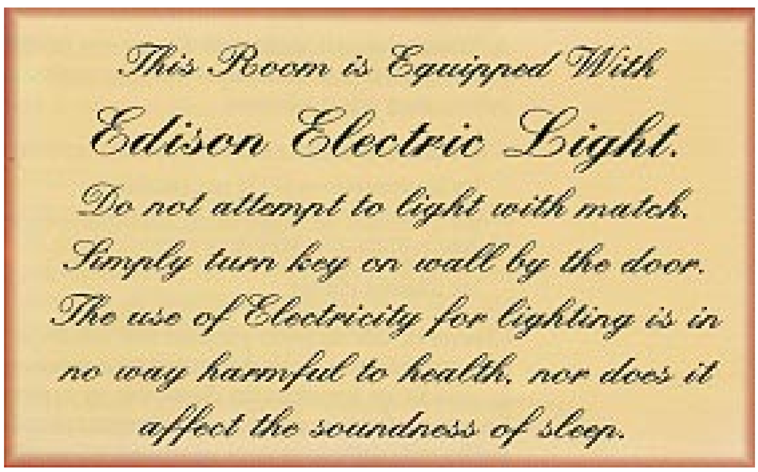

Figure 3
A public notice seen in Dublin when Edison's electric light bulb first entered service.

entwined in a net of fibre-optic cable and will be illuminated by a plethora of satellite beams, delivering a multitude of services to each and every home. Certainly in the more advanced parts of the world, there is no lack of enthusiasm for this scenario on the part of our politicians.

In the United States, the National Information Infrastructure (NII), strongly encouraged by Government and championed by no less than Vice-President Gore, is seen as the ultimate in information technology. The NII is described as thousands of interconnected, interoperable telecommunications networks, computer systems, television receivers, fax machines, telephones and other "information appliances". It will be serviced by computer software, television programmes, information services of all kinds, and digital libraries or information databases.

In the words of an American colleague: *"The NII will enable all Americans to get the information they need, when they need it, where they need it and at an affordable price"*.

The Japanese Report entitled "Reforms toward the Intellectually Creative Society of the 21st Century" is a comprehensive document which proposes an extensive system of fibre-optic cable throughout Japan. It envisages a broadband interactive network, reaching 20 % of Japanese homes by the year 2000 with a rapid growth to 60 % by 2005 and an impressive 100 % penetration by 2010.

In Europe, the EU report of the Bangemann Group, entitled "Europe and the Global Information Society", is also available. Among other issues, this report focuses on the regulatory aspects and the continuing liberalization of Europe's telecommunications sector, with a view to encouraging further development and the promotion of the European Integrated Services Digital Network (ISDN).

It is interesting that all three projects – the American, Japanese and European – do not foresee any central financing; they leave the initiative here to the private sector. With a price tag of about 1,000 ECU per household, formidable investment will be necessary.

In the future, then, broadcasters will have a number of media through which they can reach the home. These are principally:

- traditional terrestrial-based transmitter networks;
- satellite DTH transmissions;
- multipoint microwave distribution systems (MMDS);
- cable networks.

Each of these media has its own advantages and disadvantages but the one fact that is abundantly clear is that there will be a quantum leap in the transmission capacity that will be available. The constraints of the frequency spectrum, which for so long have hampered the broadcasters, will no longer be the limiting factor.

5. Bit-rate reduction

This situation will be further improved by the way that digital signals can be manipulated. One of the most important tools that can be applied to digital signals is *bit-rate reduction* whereby the amount of data transmitted over a network to reproduce a sound or television signal is considerably reduced by digital compression techniques, thus reducing the bandwidth required to carry these signals.

In other words, within a given channel – for example a 27-MHz satellite transponder which, in the analogue world of today, supports only one television programme – as many as eight compressed digital programmes of the same (PAL) quality can be accommodated. Many more programmes of lower quality could be carried, the number depending only on the picture quality level that can be accepted.

Original studio signals which accord with ITU-R Recommendation BT.601 [1] require a bit-rate of 200 Mbit/s for faithful reproduction. A rate of 8 Mbit/s gives what is described as "perfect" domestic quality – a quality standard that is higher than PAL analogue television. Even a rate of 5 Mbit/s is regarded as not being any worse than PAL. These are values that should be kept in mind when the various compression rates are considered. Movies for instance, because they have only 24 different pictures per second, look better at low bit-rates than electronically-originated television pictures.

Compression is fundamental to the economical use of bandwidth, allowing a multiplication of services to be accommodated within the confines of well-established channel capacities. It applies equally well to all the means of signal delivery: cable, satellite and terrestrial.

5.1. Eurovision 34 Mbit/s project

One of the earliest projects to involve digital compression was the Eurovision 34 Mbit/s project.

Picture material transmitted daily over the Eurovision Network is a basic ingredient in television schedules throughout Europe. The Network in fact extends to North America and Asia.

A decision to digitalize the Network was made on the basis of two requirements: quality and economy. A compressed digital signal takes up less space in a satellite transponder than a traditional analogue signal and, hence, the capacity of the Eurovision Satellite Network could be increased considerably by adopting this digital technology. In order to preserve a quality standard that would allow further picture processing at the broadcasters' premises, it was decided to adopt a 34-Mbit/s compression system. This, it is considered, gives enough headroom for multiple encoding and decoding, and for the application of picture-processing techniques such as chroma-keying.

ETSI has standardized the 34 Mbit/s codec that may now be used on the Network. The first test programmes have been completed (see the article starting on *page 24* [2]) and the Network should be fully digitalized by the beginning of 1998.

6. Methods of digital delivery

For many years to come, television delivery to the home will still primarily depend on the classical well-proven techniques of broadcasting from terrestrial transmitters and satellites.

There are currently many different analogue television transmission systems in use throughout the world: NTSC, PAL, SECAM and variants of all three. The wide timespan that was required to introduce colour television in different countries, and the need to remain compatible with existing monochrome systems, meant that no single colour standard was acceptable to all. This has led to major problems for broadcasters, equipment manufacturers and viewers. It means that electronic pictures recorded in the USA cannot be used directly in Europe but must go through a standards-conversion process. A television receiver bought in the UK cannot be used twenty miles (32 km) away in France.

Broadcasters have had to spend large sums of money on standards-conversion equipment, and on providing different versions of the same programmes for the different markets. Viewers living near the borders of adjacent countries have had to invest in more expensive multi-standard receivers.

It was hoped that the introduction of digital technology would provide the opportunity to solve this problem. Alas, that is not to be. However, at least some elements of commonality have been achieved.

6.1. Digital television in the USA

In the United States, Advanced Television (ATV) has been the subject of great debate. The Federal Communications Commission (FCC) set up an Advisory Committee on Advanced Television Systems (ACATS) in 1987. The mandate given to this Committee was to recommend a standard for an Advanced Television System which would eventually replace the NTSC standard. The new system would be required to be accommodated within the standard 6-MHz terrestrial channel now used for NTSC. In this respect, the Americans are at a disadvantage with respect to Europe where 7-MHz and 8-MHz channels are the norm.

The stated objective of the FCC was to assign to each existing broadcaster one additional channel in which a simulcast of the existing NTSC programme would be transmitted in high definition. It was intended that the so-called "taboo" channels[1] would be used for these new transmissions.

The FCC has stated that, after a period of time yet to be decided, it will withdraw the existing channels and offer them for alternative use.

The ACATS committee – in which I was priveledged to participate – sat for eight years before finally coming up with a recommendation on 28 November 1995. The system chosen was, of course, an all-digital system put forward by the "Grand Alliance", which is a grouping of interested parties who had originally submitted unsuccessful individual proposals. The "Grand Alliance" eventually brought together the best features of each original proposal.

In early May 1996, the FCC issued a Ruling which accepted the adoption of the "Grand Alliance" system. It is now a US Standard.

The FCC's Ruling states: "*The proposed standard ... is dynamic, flexible and of high quality. The technology provides a number of formats that will allow broadcasters to select the one most appropriate for their programme material, from very high resolution providing the best possible picture*

1. "Taboo" channels are those which cannot be used for analogue television because of the potential interference which could be caused to other transmitters on the same and the adjacent channels.

quality to multiple programmes of lower resolution which could result in increased choice for viewers."

No strict operational rules have yet been set by the FCC but it is likely that broadcasters will be required to:

- simulcast programmes in ATV and NTSC
- observe a strict schedule which will include six months to announce the intention of making an application, 2 $^{1}/_{2}$ years to file a licence application and 3 years to commence broadcasting.

It looks, then, as if the American public will have to wait another three to six years before they can enjoy the pleasures of HDTV. At the NAB annual convention in Las Vegas during April 1996, Westinghouse and CBS demonstrated the first over-the-air transmission in HDTV. The picture quality was outstanding, any deficiencies being in the original recorded high-definition material.

Of course, satellite services have already commenced in the United States with four major operators providing hundreds of programme services. The first services were DirecTV and USSB, introduced in 1994. Their target viewing figures have been far exceeded and they have firmly established DTH subscription services. They have been joined more recently by the Echostar and Alphastar services.

6.2. Digital Audio Broadcasting

The European system for Digital Audio Broadcasting (Eureka-147) is now fully developed and standardized, and is attracting attention in other parts of the world. With the exception of the USA, it could well become a universal standard worldwide. Regular DAB services have now commenced in some countries – notably the UK and Sweden – and there are many pilot and experimental services in other countries.

DAB offers many advantages over conventional AM and FM transmissions. It provides a technical quality equivalent to the Compact Disc and it is less demanding on spectrum space. It provides a very robust signal suitable for both fixed and mobile reception.

The DAB system uses a modulation technique known as Coded Orthogonal Frequency Division Multiplexing (COFDM) in which a large number of carriers are used, each modulated by a small portion of the signal being broadcast. With this technique, irregularities in the signal path tend to enhance the signal rather than distort it. It is therefore very suitable for mobile reception – a motorist's dream come true.

The technique of COFDM is also applicable to television and is incorporated in the terrestrial standard of the Digital Video Broadcasting (DVB) Project.

6.3. The DVB Project

The DVB Project in Europe was formally set up during the autumn of 1993. DVB has been a milestone in the evolution of standardization; it has brought together, in one forum, representatives from all sectors of the broadcasting industry. The Project now has 200 Members drawn from more than 25 countries and comprises broadcasters, programme production houses, transmission compa-

IBC

Dr. George T. Waters receives the IBC John Tucker Award

Dr. George T. Waters, Director of the EBU Technical Department, has been awarded the IBC John Tucker Award for 1996. The unique sculpture in glass – designed by John Tribe to portray the marriage between technology and artistic creativity – was presented to Dr. Waters during September at the 1996 International Broadcasting Convention in Amsterdam.

The Award Scroll bears the inscription: *"The IBC John Tucker Award was presented to Dr. George T. Waters in recognition of his outstanding contribution to broadcasting over the last 25 years and for his leadership over the past 10 years as Director of the EBU Technical Department, where he has played a creative and decisive role in the many milestones in broadcasting technology."*

Dr. Waters (left) receiving the IBC Award from Mr. John Tucker at IBC '96 during September.

nies, satellite operators, consumer electronics manufacturers, regulatory bodies and government representatives.

This collaborative project – for which the EBU provides the project management – has undoubtedly been the most successful ever; in less than 2 $^{1}/_{2}$ years, it has virtually completed the preparation of all the major specifications required.

From the outset is was agreed that the Project would cover all forms of delivery: satellite, cable, terrestrial, MMDS and telecom networks. The technical approach taken by DVB envisages each channel as a sort of "container" which has a specific capacity, depending on the bandwidth of the channel. Terrestrial channels with bandwidths of 7 or 8 MHz can accommodate about 20 Mbit/s of information. Satellite channels of 27 MHz bandwidth have a capacity of about 40 Mbit/s. The "containers" may then be subdivided into a discrete number of subchannels with bit-rates corresponding to the quality standards required.

It is now generally accepted that a data rate of around 4 – 5 Mbit/s is acceptable – even for demanding programme material – and that 2 Mbit/s is sufficient for news, movies and services such as home shopping. Utilizing the MPEG-2 compression system – which has now been adopted worldwide – allows satellite receivers to be manufactured at a relatively low cost.

The main advantages of satellites are that they give instant coverage and have a large capacity compared with terrestrial transmitters. Their main disadvantages are that they do not directly support interactivity, they are not suitable for small-area coverage and they do not lend themselves to portable reception.

6.3.1. The satellite specification

Satellite operators were anxious to commence multichannel services at the earliest possible time, so the DVB Project started work on this specification first. The main demand at the time seemed to be for video-on-demand (VOD) or near video-on-demand services.

The satellite standard was completed some while ago and various media consortia have already launched or have plans to launch digital "bouquets" of programmes in Europe, via the Astra and Eutelsat "Hotbird" satellites.

Unlike terrestrial broadcasting, satellite services are unregulated and can adopt any transmission standard they wish. Nevertheless, several of the digital satellite services already announced conform to the DVB Satellite Standard.

6.3.2. The terrestrial specification

The DVB Project has now completed the specification for the terrestrial transmission standard.

Terrestrial transmission also has advantages and disadvantages. By far the most important advantage is its ability to provide reception on portable receivers not connected to a cable system or to fixed antennas. This is extremely important today when many households have second and even third receivers. In the USA, the estimated number of portable receivers which operate with a set-top antenna amounts to 60 % of the total. The estimated figure in the UK is 40 % and those percentages will grow with time.

The introduction of digital terrestrial television in Europe, unlike the USA, is going to be extremely difficult because of the vast number of television transmitters operating in the VHF and UHF bands. In the centre of Europe, the congestion is most acute whilst in the peripheral countries – such as Scandinavia, the UK, Portugal and Ireland – the problem is not so bad.

The UK, for instance, has established that sufficient channels can be found to allow for six independent multiplexes in the UHF band. Four of these multiplexes will provide coverage to 90 % of the UK population and the remaining two will reach 70 %.

The UK plan involves the separation of the broadcasting process into three stages:

– the licensing of service (programme) providers;
– the licensing of multiplex providers who will be responsible for compiling the various services into a digital multiplex for transmission;
– the licensing of transmission companies to deliver the already-multiplexed programmes to the public.

Thus, we see a new type of operator entering the broadcasting chain – the *multiplex operator.*

Other European countries are now considering similar arrangements. As often occurs, the regulatory environment is lagging behind the technical environment but, of course, it is equally important for the successful implementation of new systems.

It has been decided that one multiplex in the UK will be assigned to the BBC and will carry BBC1, BBC2 and a number of new services including a 24-hour news channel. It is interesting to note that at least some of the additional channels will be paid for by subscription. A second multiplex will carry a combination of the existing commercial programme channels in the UK and some new ones.

In the case of Ireland, even with four national programmes (the two existing ones and the two to be introduced shortly), adequate spectrum capacity exists to allow for the transition to digital technology. The present transmitter infrastructure, if equipped with digital transmitters of much lower power than the existing analogue transmitters, could adequately cover the whole island.

An important consideration in frequency planning for digital services will be the ability to use Single Frequency Networks (SFNs) which will allow one frequency assignment to cover the whole country. This will allow the maximum utilization of the spectrum.

SFNs are possible because of the use of the multi-carrier COFDM modulation technique that I mentioned in relation to DAB. This technique is also employed in the DVB Terrestrial Specification. The COFDM techniques were applied experimentally to television over five years ago and a very extensive range of experience has been built up in France, the UK and Scandinavia. Although single-carrier systems such as the one proposed in the United States have been considered, COFDM is really the only option in the densely-packed spectrum environment of Europe, which also has the requirement to maintain all existing analogue services during the transition to digital systems.

7. Economics of digital delivery

Leaving aside the technology for the moment, what are the economics of all this progress?

Satellite and cable services are now well-established services for which the viewer pays either a monthly rental or watches programmes on the basis of pay-per-view (PPV).

The terrestrial channels, in the main, are "free-to-air"; they are financed by licence fees and/or advertising. It has become abundantly clear in recent years that governments are no longer ready to allow increases in licence fees, in order to fund new technologies. Furthermore, the elasticity of advertising revenue continues to be tested. Therefore, new methods must be found to fund the new developments.

Some broadcasters will undoubtedly resort to providing one or more subscription channels, in addition to their free-to-air channels, as a means of generating additional revenues. This now seems to be the declared intention of the BBC.

It has recently been proposed in the UK that an accelerated programme for the introduction of digital receivers be undertaken. This would involve some form of subsidisation. At first sight this proposal seems to be impractical but, on further analysis, may not be so farfetched.

We have said many times in the past that the broadcasters' greatest asset is the frequency spectrum; that statement is even more true today. Competition for access to the spectrum has never been so acute.

Digitalization would allow part of the spectrum now in use for our present television services to be released for additional services or for other uses such as mobile telephony. This would then become a marketable asset worth many millions of ECUs per year. A rough calculation of the situation in the UK reveals that a pay-back time of two to four years might not be unreasonable.

Statistics show that new consumer technologies take an average of 10 years to attain 50 % penetration. This has been true of television, colour television, the VCR and more recently the CD. There is no reason to believe that it will be any different for digital television, unless some form of accelerated implementation approach is adopted.

Apart from freeing up the spectrum, such an approach would have other advantages such as providing quicker access to more programme services, better technical quality, reduced operating costs for broadcasters and a stimulant for the consumer electronics industry.

This concept is certainly worth a study at EU level. The economics of the concept seem sound but its sheer magnitude might, of course, be a deterrent.

Digital technology will present broadcasters with more competition but with many more opportunities. If it is to appeal to the public it will have to offer more than the present services. Near-VOD seems to be the service that the satellite operators in particular are most enthusiastic about. It means that the same movie is shown on a number of channels with staggered starts, perhaps at 15- or 10-minute intervals. Full VOD, where there is no waiting time, is the ultimate goal but will take some more time to achieve.

Abbreviations

ACATS	Advisory Committee on Advanced Television Systems (USA)
ATS	Advanced television system
ATV	Advanced television
CA	Conditional access
COFDM	Coded orthogonal frequency division multiplexing
DAB	Digital Audio Broadcasting
DTH	Direct-to-home
DVB	Digital Video Broadcasting
DVD	Digital versatile disc
ECU	European currency unit
EPG	Electronic Programme Guide
ETSI	European Telecommunication Standards Institute
EU	European Union
FCC	Federal Communications Commission (USA)
HDTV	High-definition television
ISDN	Integrated Services Digital Network
MMDS	Multipoint microwave distribution system
MPEG	Moving Picture Experts Group
MUSE	Multiple sub-Nyquist sampling encoding
NAB	National Association of Broadcasters (USA)
NII	National Information Infrastructure (USA)
PPV	Pay-per-view
SFN	Single frequency network
SMS	Subscriber Management System
VOD	Video on demand

The results obtained by DirecTV in the USA are very heartening. DirecTV is a 175-channel system and costs the viewer a subscription which is four or five times higher than that for cable. Yet the service has proved very popular, with the subscriptions outstripping all expectations.

Interactivity is a feature which will be important. Electronic games, audience participation in programmes, computer software and telephony services are all potential attractions. And then, ultimately, not too far down the road, we have the prospect of High Definition Television (HDTV).

8. HDTV

HDTV production is now firmly established and HDTV cameras, for instance, are today available at prices just 10% higher than that of conventional cameras. The question of standards conversion has been solved. The Olympic Games will be covered in both the Japanese 1125-line/60 Hz standard and the European 1250-line/50 Hz standard with an exchange of signals between the two. Indeed, this type of exchange was already a feature of the Winter Olympic Games in Lillehammer, Norway, in 1994.

However, an HDTV standard for transmission still remains to be agreed. In the USA, impressive demonstrations took place during the NAB Convention in Las Vegas in April 1996, so the technology is there. Further pronouncements from the FCC regarding channel allocations are eagerly awaited.

Japan continues to push ahead with its satellite HDTV service using the analogue MUSE system. Last month, transmission hours were extended further (to 13 hours per day).

In Europe, the DVB specifications support HDTV transmissions.

All the ingredients are there – apart from an acceptable home HDTV receiver. For a full appreciation of HDTV, a large screen is necessary. Cathode-ray tube technology does not lend itself to displays larger than 80 cm or so. Above that size, the receivers become too bulky and heavy for the average home.

But help is around the corner; the flat-panel display mentioned earlier is likely to be available in quantity and at a reasonable price in a few year's time. This will undoubtedly stimulate a new awareness in HDTV.

Another new development – the Digital Versatile Disc (DVD) which will be released later this year – will provide a new level in home quality. The DVD, with a playing time of about 3 $^1/_2$ hours, will provide a quality level that is higher than that of PAL or indeed PALplus.

I believe that the flat-panel display and the DVD system will create a demand for broadcast HDTV, just as the CD created a demand for higher quality radio and, hence, encouraged the development of the DAB system.

There are many more aspects to Digital Television which I have omitted but perhaps there is one further important topic that is worth mentioning: *conditional access*.

9. Conditional access

The question of conditional access (CA) has proved to be the most controversial within the DVB Project. This is because it is so commercially sensitive.

CA systems ensure that broadcasting services are accessible only to those who are entitled to receive them. Such a system usually consists of three main parts:

– signal scrambling;

– encryption of the "electronic" keys needed by the viewer;

– a Subscriber Management System (SMS) which ensures that entitled viewers are enabled to watch the programmes.

The importance of CA is not only confined to subscription channels but might also be required for free-to-air services where intellectual copyright agreements relate only to specific-area coverage.

A number of proprietary CA systems are already in use for analogue services; these have made a common approach within the DVB Project impossible.

A European directive on digital television makes mention of a Common Interface in receivers; this would encourage the manufacture of a standard receiver, irrespective of the CA system used. This directive, however, does not make the Common Interface mandatory for receivers.

The DVB Project has agreed on a Common Scrambling Algorithm which will now be used in all European systems and may be licensed by any manufacturer.

The Subscriber Management System is the business entity which issues smart cards, sends out bills and, of course, receives payments from subscribers. An important resource of the SMS is the subscriber database which contains sensitive business information. Consequently, operators with existing systems are not prepared to change to new systems and, indeed, are anxious to expand their systems into other channels.

The result, today, is that the large media conglomerates are vying for position. Each week brings news of new alliances. The landscape is like shifting sands. It is inevitable that Europe will end up with three or four different CA systems, necessitating in most cases more than one set-top decoder.

10. Implications of the digital era

The implications of the digital era are, indeed, far-reaching and will affect all involved in the broadcasting chain – from the programme originator to the viewer at home.

We are really entering a new culture, the *digital culture*. Already, technical personnel have had to undergo a fundamental change in thinking and reasoning. The concepts of analogue technology must be put to one side whilst the new technology must be seen in terms of streams of data passing through various processes. An understanding of the effects of these processes on the bit-stream is essential.

Programme-makers and schedulers will have to learn how to cater for audiences which may have as many as 500 or even 1,000 channels from which to choose. Network names such as RTE1 or Channel 4 will no longer be important; the audiences of the future will choose their programmes according to subject matter. They will probably programme their own schedules, selecting from the myriad sources available to them.

The viewer will be assisted by the Electronic Programme Guide (EPG), a device built into the system which will provide programme information on all sources, catalogued according to programme type, presenter, programme rating etc. A remote control will allow easy manipulation of the EPG so that viewers can navigate through the programmes and instantly select the programme of choice.

The future is not far away now and it is *digital*.

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