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— new economics and approaches for digital broadcasting

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Based on a recent presentation given in Tokyo to the ITE on their 50th anniversary, this article describes the market and other forces that will affect the successful roll-out of digital broadcasting systems (DAB and DVB-T) in Europe and elsewhere.

In particular, it addresses the digital-to-software revolution which has now overtaken the analogue-to-digital revolution of the past two decades.

The late twentieth century was a unique time for broadcast engineers in Europe. Broadcasters and equipment manufacturers were able to invest heavily in research & development, and to encourage excellence. Our own engineers in the EBU developed the PAL, MAC and DAB broadcasting systems, and many of the concepts for the MPEG coding system. The grand march of broadcast technology, scaling ever-higher walls, seemed to be inevitable and natural.

Today, the situation is different. Gradually, and irreversibly, our world has changed. Over the last few years, the world has been on an economic roller-coaster ride – indeed, right now, we seem to be at the bottom of one of the economic curves. Economics aside, the broadcasting landscape and the media world have changed dramatically in Europe, and with it has changed the way we have to work.

Previously, the cornerstones of the media environment were (i) the availability of modest broadcast spectrum and (ii) the small number of national broadcasters. All that has gone. Today, we have no shortage of means of delivering media content to the viewer, and no shortage of broadcasters. Equipment is better and more reliable – but the world is now much more complex.

The role and scope of the engineer in public service broadcasting has, of necessity, evolved over the years – particularly in the last five to ten years. Fundamentally, in a world where everything is technically possible, there is an inevitable problem in knowing what to make, or which new system or service to pursue.

Technological advancement, alone, is no longer enough. The work we do, the projects we undertake and the emphasis we place on our work, all have to be guided by more that just the **technology** "pillar". There are two other main dimensions which need to be considered. The first of these is the **economic** dimension – will it, or can it, be a commercial or market success, with or without the helping hand of governments? The second is the **sociological** dimension – what impact, if any, will it have on society? Will it create a better world, or not?

Part of the new vista for broadcast engineers needs to be an understanding of the mechanisms that influence worldly events, such as the future of the media. This means that we must turn our attention to knowledge areas that may well be new to us. One example is "**chaos theory**".

Predicting the future of digital media

One thing we need to do – if we are to do our jobs well – is to try to predict the future. As engineers, we know that the future is not arbitrary – every effect has a cause. But equally, as engineers, we know that the future is in fact a "system" which has **non-linearity** (new technology growth rates are in the form of S-shaped curves, etc.), **positive feedback** (peer pressure to buy new technologies, etc.) and **a large number of variables**. The future of new technology is the world's most complicated feedback amplifier. In mathematical terms, the future is a "chaotic" system.

There are many chaotic systems in the natural and man-made worlds. They include the weather, the stock exchange and many more. To understand the future we need to take into account the key characteristics of chaotic systems.

The first is sometimes called the "**signature of chaos**". Events that can pass un-noticed at the time, can have a dramatically large effect later on. In short, small events – which are too small to notice – can trigger much larger ones. In the case of media technology, a small event might be an idea from a small start-up company, or the work of an individual in a large company. This means that predicting the future precisely, is not possible – it could depend on small events which are either passing by un-noticed now, or have not yet happened.

The second characteristic is the existence of what are sometimes called "**attractors**". In any chaotic system, solutions tend to group themselves together, and the overall picture has the appearance of some degree of order. Solutions or eventualities do not occur all over the place; they group themselves around trends and tendencies. For example, we cannot know exactly what the weather will be on any particular day of the year (at least in Europe!), but we can recognize the seasons, which give us general tendencies. Thus, for the chaotic system of media evolution, we need to identify the media seasons and, indeed, this should be possible.

In summary, we can say that to predict the future of digital media we need to do two things: (i) look for attractors – trends and tendencies – which should begin to be apparent now and (ii) recognize that we cannot predict exactly what will happen in the future, because the machine which is generating the future is too complex and non-linear.

What are the main attractors of the media digital age? There are probably at least three.

- One is the tendency towards **personalisation**. Activities are becoming more individualised; services are more and more tailored to the individual. "Micro-marketing" is being developed.
- A second is the tendency to use **software** rather than purpose-designed/built hardware solutions. Systems are being implemented via software on standard platforms, rather than being hard-wired for a specific purpose.
- A third is **globalisation**. Organizations are becoming less constrained by national boundaries and are providing services, although tailored to local needs, across ever wider geographical boundaries.

Personalisation

If we look at the first attractor mentioned above – personalisation – we are led to conclude that the ultimate media delivery system will be a fully "on-demand" system. Referring to *Fig. 1*, the earlier stages of television and radio broadcasting can be depicted as having either a limited number of broadcasting channels (**Stage A**) or having the form of a multi-channel broadcasting environment (**Stage B**). But these are just transitory developments. In the end, the public will want "on-demand" (**Stage C**) services.

We cannot predict the timescales for the transitions between these three Stages, but we can see that – eventually – everyone in every part of the world will pass to Stage C.

For the first fifty years, broadcasting in Europe was largely in Stage A. Now, in several countries, it is in Stage B. Gradually, we will migrate to Stage C – the "on demand" or broadband delivery world, where anything is available anywhere.

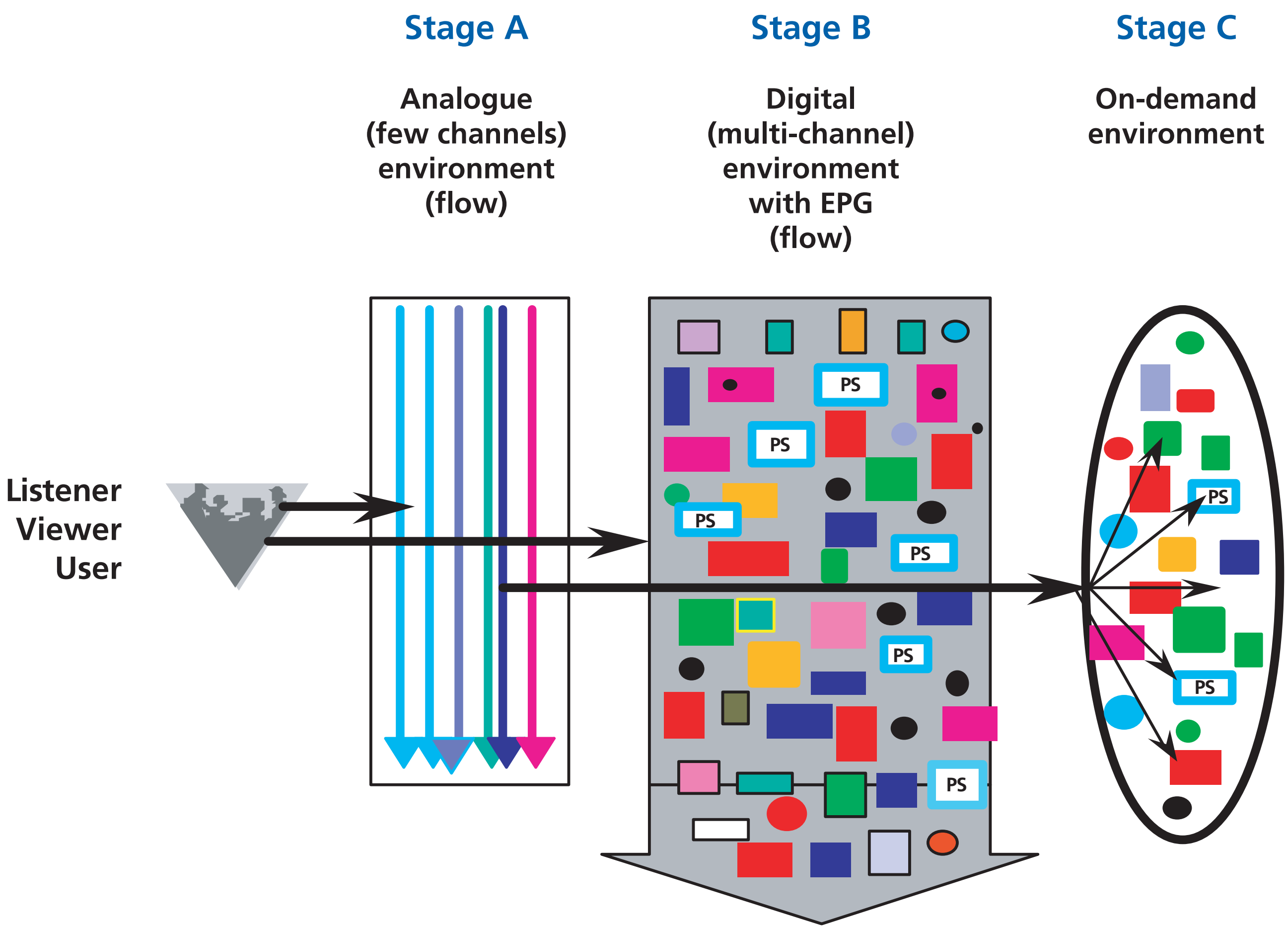


Figure 1
The shift in patterns of media consumption over time.

We can argue that PVRs, and the generalised **TV Anytime** concept, are actually a way of making a pseudo-Stage C environment from a Stage B environment. We create an on-demand environment artificially in the viewer's receiver, by topping up – via the broadcast path – a storage medium inside the receiver. In a sense, the **server** (in the computer sense) moves forward in the network, until it is at the same location as the **client**, and is topped up by the broadcast path.

This pseudo-Stage C environment may go a long way towards meeting the immediate on-demand needs of viewers, and could be a much more economical method of creating an on-demand environment in the short term. On the other hand, PVRs may actually delay the arrival of true on-demand systems. True on-demand systems will not be implemented until the cost of delivering signals by broadband networks becomes really inexpensive, or until there are overwhelmingly superior programmes on offer via true on-demand systems (Stage C).

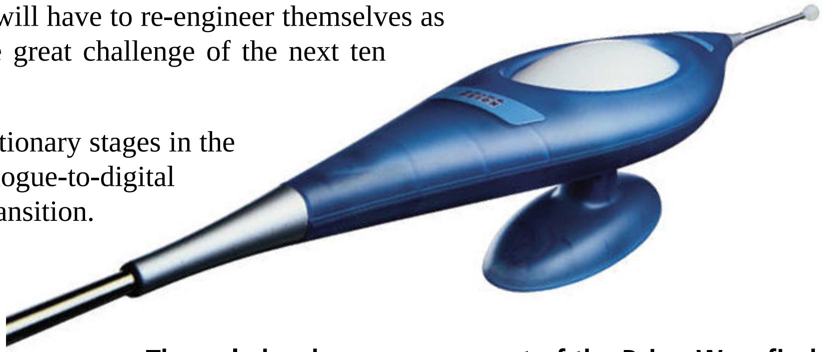
The software attractor

The second attractor is "software". Software solutions are becoming more attractive and ubiquitous. More and more equipment today is based on "platforms" (PCs, laptops, PDAs, mobile phones, etc.) which include standard processors. "Systems" can be loaded onto these platforms in the form of a software application. The focus of standards work is thus now changing from system hardware implementation to the operating system, or application-programming interface (API) or middleware.

The "software" attractor is not just a fact of life in programme delivery. There is every reason to believe, and evidence to suggest, that software will also gradually take over from hardware in television programme production, as it has already done in radio. The age of television programme-production centres, based on software, is not very far away.

This poses major problems for many organizations in Europe, whose traditional base has been hardware systems. Somehow, they will have to re-engineer themselves as software companies, and this will be the great challenge of the next ten years.

In fact, we can see two consecutive evolutionary stages in the development of the media chain: the analogue-to-digital transition, and the digital-to-software transition. Both are inevitable.



The only hardware component of the Psion Wavefinder.

To illustrate the digital-to-software trend now occurring in the media world, we shall take a brief look at the Psion Wavefinder (http://www.wavefinder.com/frHome.asp?page=home.asp). (There will most certainly be other products of this type on the market already, or coming to the market shortly.)

Launched in Europe some months ago, the Psion Wavefinder is a DAB receiver intended for use with a laptop or PC. In fact, it is an extremely simple receiver. The only hardware it uses is the RF demodulator, which is housed in a small plastic module that clips onto a wall, or onto a PC or laptop. The COFDM decoding which is used for DAB, and the MPEG audio decoding, are both done in software – so the real part of this receiver is contained on a CD-ROM that comes with the radio. The user can also use the Psion website to update the software continually, or to add new applications as they become available.

One of the great things about software applications like this, is that they can be personalised very easily. *Fig. 2* shows the result of someone with no artistic talent (e.g. the author) trying to create the interface used for the radio, which appears on his laptop screen. It may be a poor design, but at least it's my own!

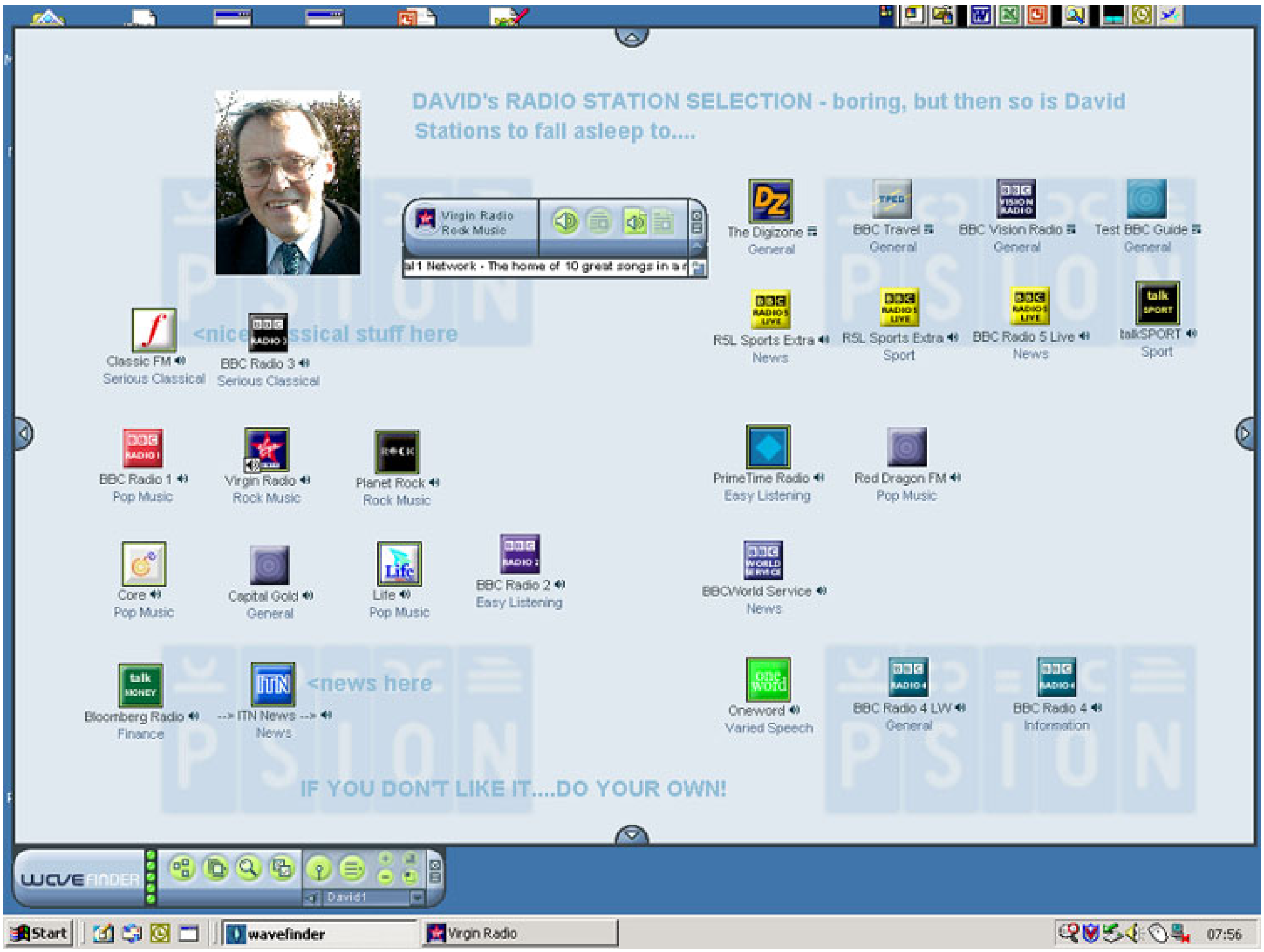


Figure 2
Sample screenshot from a currently-available software DAB receiver.

The DAB system – like all digital broadcasting systems – can be used to broadcast multimedia and, because a PC is used with the Wavefinder, multimedia coding can be done with standard browser tools. At the moment, HTML and Macromedia are used, which are usually available on modern PCs.

The software also allows readily-available standards conversion. For example, the software can currently convert – in real-time – from MP2 (which is broadcast via DAB), to MP3 music files which can be loaded onto personalised solid-state audio recorders. This is a major attraction for young people, in particular.

Of course, by no means all media receivers will be located in laptops, palm tops or PCs but, wherever they are, there will be a trend to take advantage of digital signal processing and software in their implementation.

Globalisation

The third attractor is "globalisation". Companies and organizations that operate in a market economy need to grow, even if they just want to stand still. Profits must be re-invested. This means that it is almost inevitable that successful media companies will become worldwide companies, or seek to become them.

However, there are other forces at work. We know from experience that as an industry develops, there is a definite tendency towards "oligopoly". That is to say, while there may be competitors in an industry, over a period of time there is a tendency towards just a few large companies remaining in business: the smaller competitors are usually absorbed in a cyclical way by the larger companies.

The basic mechanisms for commercial success

To predict whether any new technology is likely to be commercially successful, we can go back to a simple recipe. The perceived value of a product or service has to be greater than its cost. A service has to be at, or beyond, a market equilibrium point where demand equals supply. Indeed, it is working out where this point is located that is the basis of any viable business plan. The supply and demand curves must cross. If they don't cross, the product or service will not be successful.

So what influences the customer's perception of "value" in a media delivery system? Mostly it is the content. Are the programmes attractive and not available elsewhere, or not available elsewhere at this price? Technical quality is important too, but only if the content is attractive. Finally, we should not forget that part of the reason why someone buys a particular item is because they like the shape and style of the box it is sold in. Product design can be critically important, and sometimes may even outweigh a better technology. Of course, we need better technology too. What we really need is everything at once: the *content*, the *technical quality* and the *product design*.

Abbreviations

API Application Programming Interface
CA Conditional Access
COFDM Coded Orthogonal Frequency Division Multiplex
DAB Digital Audio Broadcasting
DTT Digital Terrestrial Television
DVB Digital Video Broadcasting
DVB-RCT DVB - Return Channel via Terrestrial
DVB-T DVB - Terrestrial
HTML HyperText Markup Language
IDTV Integrated Decoder TeleVision
MAC Multiplexed Analogue Component
MFN Multi-Frequency Network
MHEG Multi- and Hyper-media coding Experts Group
MHP (DVB) Multimedia Home Platform
MPEG Moving Picture Experts Group
PAL Phase Alternation Line
PDA Personal Digital Assistant
PVR Personal Video Recorder
SFN Single-Frequency Network
STB Set-Top Box

The overall keys to success

If there is a way to evaluate potential new technologies, it is first of all to ask which systems or services will be in sympathy with one or more of the attractors discussed above? Secondly, which systems or services can be produced that are likely to operate at, or above, market equilibrium? If we have these two elements right, then it is time to develop the system. If we don't, we are probably wasting our time in doing so.

The DVB journey

The DVB Project has been a voyage of discovery – through the changing needs of broadcast media delivery.

In the early years (1991), there was recognition that digital television broadcasting needs a standardized **modulation system** and **video/audio compression**. This was accomplished successively for satellite broadcasting, cable broadcasting and, finally, for terrestrial broadcasting.

By 1993, there was recognition of the need for **conditional-access** arrangements. These comprised a scrambling algorithm, and a hardware interface to the key encryption system (in those days, DVB members thought that key encryption would always need to be a company-proprietary part of the broadcasting system).

In 1996 came recognition that more was needed, and so began the most difficult standardization work that the project has accomplished: the multimedia software interface or Application Programming Interface – a task that took about four years.

The DVB Project believed that, to be future-proof, the system should be designed from the beginning to allow both conventional multimedia content (declarative multimedia) and content which would execute itself in the receiver (procedural content). This led to the development of the Java-based MHP (Multimedia Home Platform) system, with the optional use of HTML. This allows for simple low-cost delivery of multimedia now, but also makes the system future-proof for the provision of more advanced multimedia, which will inevitably be needed in the years ahead.

The system is arranged in layers so that it can be implemented as:

- **Enhanced television** (broadcast interactive multimedia applications which run without the need for a return path);
- **Interactive television** (applications which also need a return channel), or;
- **Internet television** (applications which need the synergy of the broadcast path and an Internet channel).

Our task today is to encourage the migration of all DVB digital broadcasting systems to the MHP API. This will be no easy job because, during the intervening period when MHP was being developed, a number of other APIs were of necessity brought into service.

This year (2001) will see recognition that, even with all the elements so far standardized, the total system is not yet complete. We need specifications for metadata, and the API needs to be arranged to function in the PVR environment. Hopefully, the metadata will draw heavily on the work of the worldwide TV Anytime project, and thus constitute a worldwide standard.

What lies beyond the development of broadcast metadata? The author's guess is that it will be the gradual transformation of all the DVB systems to software-based solutions. It would certainly help to create open markets for receivers if, for example, the conditional-access system – and any copy-protection system that was needed – could be run as a downloaded software application in the receiver.

DVB
Digital Video Broadcasting

The growth of digital satellite television and digital cable systems has been relatively smooth in Europe. However, the most complex and difficult environment is that of digital terrestrial television (DTT). The DVB digital terrestrial system (DVB-T) is technically the most sophisticated and, indeed, the legislative and spectrum environment is also the most complicated. There are ongoing developments in this area. *Appendix A* is intended to be a snapshot of current DTT developments in Europe and Australia.

The earliest DVB-T launch was in the UK in late 1998 and, today, about one million DVB-T receivers are in use there. A number of other European countries have begun their services (Spain, Sweden). Denmark, Norway and Finland will begin soon. France, Ireland, and the Netherlands should begin next year (2002).

The population coverage at launch varies from 50% to 90%. For each European state, there is usually space for about five or six digital multiplexes to co-exist with the analogue broadcasts, by using adjacent channels which are unusable in the analogue environment. Spain is an exception, with the potential for eleven digital multiplexes.

The question of when analogue services should be switched off, and what will be done with the spectrum when it is, is much discussed. The author's suspicion is that it will prove difficult to give back spectrum (for possible sale, by governments, for services other than broadcasting) and, at the same time, achieve universal terrestrial coverage.

Universal coverage is a fundamental part of the public service broadcasting remit, but the question remains: *Is it reasonable to achieve it by terrestrial broadcasting alone, or by a combination of terrestrial, satellite and cable delivery – with no terrestrial coverage in areas where satellite is much more cost-effective?*

The services to be offered via DVB-T include conventional programming, text services, audio descriptors, the Internet and e-mail, as shown in *Appendix A*.

Almost all the DVB-T services will use a 16:9 aspect ratio, for at least part of the programme offer.

Combinations of single-frequency networks (SFNs) and multiple-frequency networks (MFNs) will be used, depending on the local needs and environment.

One interesting point to note is that in Germany and the Netherlands, where there is already substantial cable penetration and indeed a substantial free-to-air programme choice, efforts are being focused on developing services for portable receivers, as this is something which neither cable nor satellite can provide.

Both **integrated receivers** and **set-top boxes** will receive the DVB-T services. It is also interesting to note that, in the UK, the cost of the set-top box is essentially hidden in the cost of the subscription packages. About half the channels available in the UK from DTT are pay-TV services, and half are free to air.

The roll-out of digital terrestrial television in Europe is well underway but it would not be true to say that there are no barriers to success. It is now becoming clear that the most successful digital broadcasting services – satellite or terrestrial – are those with a substantial pay-TV offer. This provides not only something new in content for the viewer, it also provides the means to subsidize the cost of the set-top unit, to the point where the viewer sees it as too good an offer to miss.

There are real questions about how free-to-air broadcasting can survive in future, in the face of the spending power and subsidising capacity of pay-TV. This will be one of the great challenges over the next few years.

Conclusions

The past decade has seen major changes in the approach to media technology in Europe. Digital technology has had a liberating effect on the means available to deliver media to the listener and viewer. A new media landscape has been created.

This new media environment includes the "digital-to-software" revolution, which is just as problematical and challenging as the analogue-to-digital revolution of the last decades. For all its advantages, software never works without enormous care and attention, and those who work in broadcasting will need to acquire major software skills in the years ahead.

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Over the years, Mr Wood has chaired ITU Working Parties in New Systems and Quality Evaluation, and currently chairs the European Community's IST E3 concertation group.

Within the EBU, David Wood is currently Secretary of the Digital Strategy group and the On-line Services group.

If there is one most critical dimension to identify in media development, it is the "conditions for success". We can do this, but only to a limited extent. Because we are dealing with complex chaotic systems, we need to be able to anticipate the unexpected. One thing is certain – if we can identify the conditions for success, they will not be an "**either/or**" set of conditions; rather, they will be an "**and/also**" set.

Acknowledgements

This article is based on the work of the EBU, the DVB Project and DigiTAG.

Continued ...

Appendix A –Service models for DTT services in Europe and Australia, in 2001.

	Australia	Belgium	Denmark	Finland	France	Germany	Ireland	Italy	Nether-lands	Norway	Spain	Sweden	UK
DTT launch date	01/01/01	?	2001	08/27/01	Q4 2002	As of 2001 in selected areas	Q3 2002	2003	Q1 2002	09/01/01	05/05/00	04/01/99	11/15/98
Coverage at launch (percentage of population)	60-70	<50	60-70	<50	60-70	<50	>90	<50	<50	60-70	60-70	<50	60-70
Analogue switch-off policy	2005-10	?	?	2005-10	?	2005-10	2010-15	2005-10	Before 2005	?	01/01/12	?	?
DTT services													
Linear TV: audio + video	1	1	1	1		1	1	1	1	1	1	1	1
Subtitles	1	1		1		1	1	1	1	1	1	1	1
Teletext	1	1	1			1	1	1	1	1	1	1	
Audio description									1	1			
Signing							1		1	1			
Digital text	1	1		1			1		1	1			1
Entertainment (e.g. games, voting)			1	1			1	1	1	1		1	1
Information & Education	1	1		1			1	1	1	1		1	1
Internet access (walled garden)				1					1	1	1	1	
Internet access (full)									1	1			1
E-mail							1		1	1	1	1	1
Transactional (e.g. Home shopping, banking)	1			1			1		1	1		1	1
Free-to-view commercial broadcaster(s)	1	1	1	1	1	1	1	1	1		1	1	1
Free-to-view public service broadcaster(s)	1	1	1	1	1	1	1	1	1	1	1	1	1
Subscription broadcaster(s)			1	1	1	1	1	1	1	1	1	1	1
Pay-per-view broadcaster(s)			1	1			1	1	1	1	1		1
Widescreen proposals	Yes	Yes	Yes	Yes	?	?	No	Yes	?	Yes	Yes	Yes	Yes

Appendix A – Service models for DTT services in Europe and Australia, in 2001.

	Australia	Belgium	Denmark	Finland	France	Germany	Ireland	Italy	Nether-lands	Norway	Spain	Sweden	UK
Multiplex occupancy	5	<4	<4	<4	6	6	>6	<4	5	<4	5	4	6
System variant proposed	2k + 8k	8k	8k	8k	8k	8k	8k	8k	8k	8k	8k	8k	2k
SFN or MFN planning	Both	SFN	Both	Both	Both	SFN	Both	Both	Both	Both	SFN	Both	MFN
Selected API for DTT system	Migration to DVB-MHP planned	DVB-MHP	Migration to DVB-MHP planned	DVB-MHP	?	DVB-MHP	DVB-MHP	DVB-MHP, Media-Highway MHEG-5	DVB-MHP, Media-High-way MHEG-5	DVB-MHP	OpenTV	OpenTV Migration to DVB-MHP planned	MHEG-5
CA system for DTT system	DVB Simulcrypt compliant	None	None	?	?	?	None	Media-Guard (SECA)	MediaGuard (SECA)	Conax	Nagra-vision	Viaccess	Media-Guard (SECA)
Number of transmitters													
Set-top boxes / IDTVs	Both	Both	Both	Both	Both	Both	STB	STB	Both	STB	STB	STB	Both
Return channel	None	None	Yes	Yes	None	Yes	DVB-RCT	Yes	Yes	None	Yes	Yes	Yes
Number of DVB-T receivers sold or rented			~50	100				1,000				~35,000	$1x10^6$

Sources: EBU Strategic Information Service – EBU / CEPT / the Web.