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THE IMPACT OF DIGITAL TECHNOLOGY ON
THE BROADCASTING BUSINESS

By

G.C. STEPHENS

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THE IMPACT OF DIGITAL TECHNOLOGY ON THE BROADCASTING BUSINESS

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Introduction.

Digital technology has been with us broadcasters for quite a bit longer than we may imagine. It was 1978 when the first commercial digital video processing equipment appeared; a digital timebase corrector designed to correct velocity errors in broadcast videotape recorders. In telecommunications, digital technology has been around even longer, since the late 19th century! Morse Code is essentially a digital signaling system.

But the real digital revolution has only just begun. Until recently, the huge bandwidths occupied by broadcast quality digital video signals rendered them commercially unviable for carriage on any distribution medium designed for domestic use. A standard definition PAL broadcast signal, digitally sampled at 3x colour subcarrier would require a satellite bandwidth of about 85 Mhz for its transmission, assuming minimum overheads for forward error correction. A video signal coded in high quality component form would require about 215 Mhz. A high definition digital signal would require 860 Mhz - almost half the entire bandwidth allocated to satellite television broadcasting and more than twice the entire available terrestrial UHF broadcast spectrum.

The advent of digital compression has changed all of that. Now the high bit rates necessary in a TV production environment can be reduced for transmission to a level that not only matches traditional analogue transmission bandwidths but actually exceeds them. The techniques have been known since before the Second World War but it is only recently that large scale integration has allowed them to be realised cost effectively in hardware.

The impact on the broadcaster will be enormous. Channel capacity (or spectrum efficiency) can be increased by approximately fivefold in terrestrial broadcasting, eightfold in satellite and tenfold or more in cable.
In satellite broadcasting, where spectrum congestion at microwave frequencies is less severe, this has led to an explosion in channel choice. In terrestrial, where the congestion at UHF and competition for spectrum allocation fierce, it is likely to lead to a reduction in spectrum availability for broadcasting use. In cable distribution, the only limitation on spectrum is the capacity of the final drop to the consumer. Current technology using Hybrid Fibre-Coax (HFC) systems theoretically permit channel counts of up to 1000. Fibre to the home will increase this by a factor of 10 and beyond in the foreseeable future.

Where are we now?

The work carried out over the past 7-8 years by the Moving Pictures Experts Group a task force charged with defining standards for picture compression working under the International Standards Organisation has been hugely successful. The MPEG-2 standard was specifically designed to code broadcast quality images at bitrates from 1.5 to 15 Mbps. The “standard” is really a family of standards that allows users to select image quality and coding complexity to best suit their application. Furthermore the data structures ensure that all the options are backwards compatible so that all transmissions of lower complexity can be decoded by receivers of the same or higher complexity.

The standard also ensures that the majority of the processing complexity is contained in the encoder. The decoders required in domestic receivers are relatively simple. Furthermore, providing the MPEG-2 transmission parameters are maintained there is no restriction on how complex the encoding process may become in future, the receiver will still decode the signal. It is thus essentially future proof.

Digital satellite receivers are no longer expensive. A receiver that had an ex-works price of $US 600 18 months ago now comes out of the factory at $US 300 or less. Over the next 18 months we can expect to see a halving of price yet again. Standalone digital terrestrial receivers will have a small price premium of $US 20-30 above satellite receivers initially, because of added complexity in the demodulator but prices will equalise rapidly. When receivers are built into the TV itself (essential for the success of digital terrestrial broadcasting) there is likely to be no price premium whatsoever over the analogue equivalent after 18 months. Indeed governments anxious to recover valuable spectrum may insist upon a price reduction, either by offering taxation or duty relief to digital TV manufacturers or, more likely by imposing additional duty on analogue receivers. The latter seems the most likely, knowing how regulators usually think.

Costs of encoding chains are now coming down fast. $US 85,000 per channel is the current average. This includes all redundancy switching, multiplexing and modulation. Two years ago the price was more like $US 200,000 per channel. The advent of statistical multiplexing means that we can now contemplate channel counts of 15 or 16 per 36 Mhz transponder.
Most Asian countries have now launched Digital Direct to Home systems of 20-30 channels or are about to do so. Many have opted for C-band transmission to avoid rainfade problems; some however are operating in the Ku band. Malaysia was one of the first with its ASTRO 24 channel Direct to User (DTU) service. It has managed to contain the rainfade problem to acceptable levels by using extremely high power uplinks and a leading edge technology satellite system that offers extremely high downlink powers of 57-58 dBW across the entire country. With a 60cm dish and an inexpensive LNB, 150,000 Malaysians can now enjoy satellite TV with an availability of better than 99.8% despite living in one of the world's highest rainfall areas.

Unique features of a digital broadcasting service

Because digital transmissions are essentially packetised data streams, there exists the capacity to allocate some packets for service information and receiver control. The DVB specifies the service information as a series of look up tables that define each service and the individual events within it uniquely. Because of this ability, it is possible to construct "virtual channels" where events from many different real channels can be brought together to create a service tailored to the viewers own specific preferences. The receiver will automatically select the appropriate real channel at the correct time.

Other service information specifies the parameters of the network, allowing the receiver to automatically tune all applicable channel frequencies once it has found the first "base" channel and decoded the SI tables. Other applications of SI allow the receiver to identify audio channels associated with the video and to know what is contained on each channel. Automatic selection of preferred language is thus possible.

Closed caption subtitles can also be sent so that the viewer can decide if he wishes to have the programme subtitled or not and which language subtitles he wishes to access. The implementation on ASTRO is for three different subtitle languages available per programme, but there is no inherent limit in the system.

The final programme related data that is sent is the Electronic Programme Guide. This is a listings service that gives details of programme transmission times and synopses of programme content. The synopses require significant amounts of data capacity and as they need to be repeated on every transport stream in the service bouquet most service providers allow only an abbreviated synopses for programmes on other transport streams. When the viewer selects the programme of interest, the receiver tunes to the appropriate transport stream and a full synopses is then presented.

Initially EPG's were proprietary to receiver manufacturers. However more and more operators are requesting manufacturers to incorporate a generic receiver display application called "Open TV" that allows them to design and run their own EPG and receiver operating menu screens.
Where next? - Pay Per View

The next stage for most satellite broadcasters is to move to Near Video on Demand. With encoder prices dropping, channel counts per transponder rising and little additional traditional TV programming available to fill the capacity, this is perceived by many as the next big revenue earner. Envious eyes are turned to DirecTV in the US which has shown the existence of a market for on-demand broadcast services.

Whether this will materialise in Asia remains to be seen. The original utopian dream of simple revenue sharing with major Hollywood studios and PPV release windows close to theatrical release seems to be fading. The existence of sizable Video rental and sell through markets in Asia, coupled with the threat of piracy leads the studios to offer PPV windows after video release rather than before. Minimum guarantees are also common, especially where subscriber penetration is low.

Another potential problem concerns the flavour of PPV that will be offered. Studies of the PPV market show that buy rates for Impulse Pay Per View (IPPV) are consistently higher than for Order Ahead Pay Per View (OPPV). In IPPV, the subscriber chooses to view the movie or other event merely by selecting the event from the Electronic Programme Guide using the remote control. In OPPV he must make a telephone call in advance to the Subscriber Management Centre. Naturally as human beings are lazy (and sometimes shy) creatures the IPPV method is consistently more popular. Another problem is the possibility of telecommunication congestion as a popular event is about to commence and all the calls come in within 5 minutes of the start.

IPPV is thus the preferred approach for the majority of broadcasters. However this demands a method of determining what value of programming has been impulsively selected. There are three basic methods

- **Pre-paid card**

Here the subscriber pre-purchases a card that permits him to impulsively purchase a preset value of programming at any time. When the card value is exhausted he must repeat the pre-purchase of programme value by taking the card to a place where it can be reprogrammed.

This approach, although easy to implement technically is open to abuse by pirates and is cumbersome. It is also difficult to obtain accurate records of what programming was watched since it relies on the card being returned at some point for refilling. Only then can the viewing data be extracted.

- **Electronic purse**

This is the electronic equivalent of the previous scenario. However, rather than physically returning the card the subscriber receives their refill of programme value via an occasional telephone call to the SMS as the value falls close to zero. The
telephone call can be either manually activated by an on-screen message warning the subscriber that the value is running out or it can be achieved automatically if the satellite receiver contains a modem and is connected to the subscribers telephone line.

The connection to a telephone line is a non-trivial exercise. Although the current generation of ASTRO receivers have a modem connection, it is estimated that less than 50% of all installations have actually been successfully connected due to physical difficulties. We await the activation of the modem with the next release of software in a couple of months time to ascertain whether our fears are groundless or not!

The other limitation of this system is that a successful phone connection and purse refill may not be made in time to stop he purse emptying. This effectively causes a loss of revenue to the broadcaster. Although not a problem in Malaysia, countries that suffer lengthy phone line outages due to adverse weather conditions would do well to consider the implications of this for their business if they chose this PPV approach.

- Post-payment

Here the customer is free to select any PPV event and the events selected are stored in the card. A minimum of once a month (or once a week at the broadcasters discretion) the card will prompt the receiver to call the SMS-usually during the small hours of the morning. The value of the events selected is then downloaded and added to the subscribers next bill.

Although this seems the least secure and potentially the method most open to abuse, this approach has a number of advantages. It does not restrict the ability of a bona fide subscriber to select an event at any time and under any circumstances. A hard credit limit can be added if so desired, but current thinking is that it is better for the card to raise an alarm if unusual buying patterns are observed and to force an early call to the SMS for verification and billing before allowing further purchases. Concerns about non-payment can be alleviated by requiring PPV customers to deposit a bond before activation.

Timeframe

Most digital broadcasters are planning to launch some form of PPV service by the end of 1998 if they have not already done so. Early grandiose schemes of 100 channel systems offering 10 blockbuster movies starting every 10 minutes have given way to 10 channel systems with 3 movies starting every half an hour. Buy rates have also been downscaled from 5 purchases per month to two purchases per month. Confident predictions of PPV subscriber penetrations higher than 70%-80% of total subscriber base have given way to safer predictions of 30%-40%.

Although ASTRO prefers to operate an IPPV service using the post-payment method it now realises that it must simultaneously offer OPPV to those subscribers who cannot achieve a satellite receiver telephone connection, otherwise it risks losing
revenue. It is thus planning a dual OPPV/IPPV approach and will launch both later this year.

Big technical additions to the current conditional access system are now underway, a call collector system is being installed and the Transmission scheduling system must be interfaced to the SMS to allow the latter to learn what PPV events are on offer in future and what events have actually been successfully transmitted. The decision to also go with OPPV means that additional Customer Service Agents must be recruited and the call centre capacity upgraded.

**The next step**

So far, digital broadcasting has focused on the traditional service offerings of video and audio programmes. But digital broadcasting can offer much more than this. The broadcast is a packetised data stream and so any service offering that can be represented as packet data within the allocated bitrate on the system can be provided. All current digital receivers are capable of software download over the air and so there is no inherent restriction on the future service offerings - within the limitations of the receiver hardware. Any new offering merely requires that the application be pre-downloaded to subscribers using the allocated channel capacity. Once this is accomplished the capacity is used for data. The data can be sent selectively to individual subscribers as well as to all subscribers simultaneously, using the conditional access system.

ASTRO is currently planning a number of interactive services using an Electronic Transaction System jointly under development. The first application is likely to be for gaming but other applications such as home banking and home shopping are also under scrutiny. The home banking application will require a separate encryption system to that used for broadcasting as banks insist upon their own proprietary security systems. An enhanced receiver is therefore under development that can accept two smart cards simultaneously, one for broadcast and one dedicated to the banking application.

As most of these data services are planned to be fully interactive the modem connection is required to provide a return path. Although satellite return paths are technically feasible the minimum dish size requirements and increase in receiver cost make it impractical at the moment for domestic subscribers.

The receiver also has limitations in terms of memory capacity. Typical flash memory sizes are 1-2 Mbytes and ROM/Static RAM capacities are similar. Data output ports are RS 232 at 19.2 Kbps. These parameters effectively limit the complexity of the applications that can be loaded to simple text menu pages.

An alternative approach in order to provide more complex applications is to discard the receiver completely and to build the decoder and demodulator on a PC card that can provide a high speed transport stream interface straight into the subscriber's personal computer. More advance applications accessible by this method include download of games and turbo internet access. Such a system is now commercially available.
available in the US where it is known as DirecPC. Other service providers in Asia and Europe also plan to roll out DirecPC-type services next year. ASTRO has no plans for these at the moment, preferring to concentrate on what can be achieved interactively using its Digital Satellite Receiver and about 24 Mbps of satellite capacity.

**Digital Terrestrial**

So far I have concentrated on what is happening in the digital satellite world. Because the microwave spectrum is less congested and more stable than terrestrial VHF/UHF the modulation scheme can be simpler. Satellite digital broadcasts use QPSK modulation, a well tried and tested scheme suitable for channels with low signal strengths such as exists with satellite.

Digital terrestrial broadcasting is however a totally different game. Although signal strengths are much higher, there are problems of time varying parameters in the signal path (fading) and multipath propagation (ghosting). Adjacent channel interference from existing analogue transmissions will also be a reality in most practical applications. Because of this a more robust modulation scheme is required.

The US Federal Communications Commission has opted for a single carrier scheme (8 VSB) with added dynamic channel equalisation to hopefully minimise the effects of fading and ghosting. Trials in the US and Australia have shown the system to be effective in areas where transmitters are widely spaced with no requirements for gap filling relay transmitters. The system is cheap to implement and provides the greatest net channel digital capacity for a given channel bandwidth. It has been developed for a 6 Mhz channel at present but could conceivably be expanded to a 7 or 8 Mhz channel if other countries with these frequency plans were to adopt it. It provides just over 20 Mbps of net bitrate in its 8 Mhz configuration.

The US system cannot cope with strong co-channel interference other than by using a directional antenna so the possibilities for Single Frequency Network transmission or mobile TV in moving vehicles are reduced.

Europe has however gone for a different approach using a complex multicarrier scheme known as Orthogonal Frequency Division Multiplex (OFDM). This itself has two variants, one using 2000 carriers that is likely to be adopted in the UK and another using 8000 carriers that is favoured on mainland Europe. Although initially thought to be mutually incompatible, further development has made the 8000 carrier design backwards compatible with 2000 carrier broadcasts. Forwards compatibility of 2000 carrier receivers into 8000 carrier broadcasts is however not possible for the foreseeable future.

The 2000 (or 8000) carriers are spaced a few kilohertz apart across the 8 Mhz channel. Each carrier carries 1/2000th of the bitrate of the transport stream making the data rate on each individual carrier relatively low -under 10 Kbps even with low order modulation schemes such as PSK. Higher order schemes are however proposed such as 16 QAM or even 64 QAM where symbol rates can be much lower -down to 1K
symbol/sec on average. Because of this it is possible to group symbols at higher rates and leave space for guard bands that protect the signal from co-channel interference - even with an interfering signal of the same strength as the wanted signal in some cases.

The implication of this is that Single Frequency Networks can be contemplated with all transmitters in the network operating on the same frequency even with coverage overlaps and without using directional antennas. The 8000 carrier variant permits true national SFN working with all main and relay transmitters operating at the same frequency. The 2000 carrier version allows relays within the coverage area of the main transmitter to work on the same frequency as the main but main transmitters spaced more than 70 km apart must operate on different frequencies. This is not an issue for most countries where congestion at country borders is not so acute as in mainland Europe.

The system is now due for commercial launch in the UK by the end of 1998. It is planned to share the current UHF spectrum with existing analogue transmissions by locating the new digital transmissions in the unused channels adjacent to the analogue signals. Because of this the digital signals must be broadcast about 30 dB lower than analogue to avoid visible interference into the analogue services. To avoid the analogue signals interfering into the digital services, certain carriers in the bouquet of 2000 are deleted. These carriers correspond to the frequencies in the adjacent analogue service that contain the most energy i.e. the main luminance carrier, line multiples of it and the chrominance subcarrier. This modified transmission is now called Coded Orthogonal Frequency Division Multiplex or COFDM.

Tests have shown the system to be extremely robust under extremely adverse conditions. Perfect pictures have been obtained from a receiver mounted in a car traveling at 160 kph both when traveling directly towards the transmitter and in the opposite direction. Severe ghosting and fading has been shown not to affect the signal and reception inside buildings on small set top antennas is perfectly feasible with similar coverage to existing analogue transmissions.

The European COFDM system is slightly less efficient than the US 8 VSB system and a little more expensive. It is however likely to be more robust in difficult reception conditions and is already fully developed and tested for channel plans other than 8 Mhz. Its main limitation against the US system is that it is not fully forwards compatible to HDTV.

The US system was developed with HDTV in mind and any future HDTV broadcasts can also be received by standard definition (SDTV) digital receivers. (in standard definition of course). The same is true in reverse, SDTV broadcasts can be received and decoded by HDTV receivers (in standard definition and line doubled). The European system however is designed either for SDTV or for HDTV but not for both simultaneously on the same system. Simulcasting is the preferred option. It is likely that the future European proposals for HDTV digital will include the possibility of a HDTV receiver being able to decode SDTV signals so it is backward compatible but compatibility in the reverse direction is not currently possible.
So you pays your money and takes your choice!

The business case - Terrestrial Vs Satellite

While satellite (and cable) can offer more efficiency and/or more choice immediately by a move to digital, the business imperatives for terrestrial digital are less clear. Many countries are planning digital terrestrial networks but in many cases the problems of finding adequate unused spectrum to launch digital alongside the existing analogue services are almost insurmountable. Italy and Germany are two prime examples.

In Asia the spectrum problems are less acute but there is little will to proceed until the regions financial problems ease. Meanwhile, existing satellite systems continue to gain ground.

The advantages to the consumer are less clear cut. Satellite can offer hundreds, even thousands of channels, many in HDTV. Terrestrial can offer 200 SDTV at best - even when analogue is switched off. It is also clear that governments do not favour allocating UHF spectrum to TV broadcasting. The pressures for cellular radio are too intense. It is likely therefore that a maximum of 5 or 6 national networks will be permitted in each country. This translates to perhaps 25 or 30 SDTV services.

So what will prompt the consumer to buy? I believe that terrestrial does have a place. But it is for those things that it is good at. Portable reception, mobile reception, the second set in the kitchen, the third set in the den, the fourth set in the kids room. Wrapping the house in wires in order to receive satellite or cable services is not an attractive option for most people.

However this scenario with terrestrial broadcasts being primarily targeted at portables brings some constraints.

- The digital receiver must be built into the set. No one will want to hump around a second box with a portable receiver.
- Interactive services and PPV will not be possible as no one will want to position the portable permanently adjacent to a phone jack.
- Subscription TV will be possible via a built-in CA system. But which system to standardise on? Built-in CA will certainly need to be a pluggable module with a standardised interface - possibly to the DVB Multicrypt specification (PCMCIA).
- HDTV will just not be viable. It brings no benefits to a universe of small portables and uses too much scarce bandwidth.

How will the transition to digital be managed? It seems clear that the pressure is on from Governments anxious to recover UHF spectrum. But where will the services come from?

The UK proposals for 4 digital multiplexes containing a mixture of the existing 5 national analogue broadcasts simulcast in digital plus 11 additional SDTV services
shared between existing broadcasters and one new entrant seems a plausible model. It is currently unclear whether the 11 new services will be subscription based or free to air—possibly a mixture of both.

My own feeling is that a number of things must happen to attract the consumer to digital terrestrial

• The digital receiver must be built into the TV as soon as possible
• The price of the digital TV must be comparable to analogue
• There must be additional free to air services in the digital bouquet and all exiting analogue services must be simulcast from day 1.
• Widescreen services must be launched early on
• Widescreen TVs must be affordably priced
• Digital coverage reach must be close to current analogue and digital transmitters must be co-sited with analogue as far as possible
• Government must clearly announce a cut-off date for analogue broadcasts.
• Any thoughts of terrestrial HDTV must be abandoned

With these provisos I believe that digital terrestrial will succeed and find a successful market niche alongside cable and satellite. It will be the natural home of free-to-air local broadcasting, the service of choice for those who move home regularly or who cannot receive cable or satellite.

Conclusion

The advent of digital broadcasting is the first major step forward since colour TV. It opens the way to economic Widescreen and High Definition broadcasting. Over the next couple of years we will see the price of digital receivers fall below their analogue equivalents with far greater functionality and flexibility.

The three major distribution methods—Satellite, cable and terrestrial will all have a place. Satellite and cable will be the home of high value, high quality nationally targeted pay per view and subscription based programming. Terrestrial will continue to serve local programming needs, usually free to air and providing a further window of exploitation for product that has passed through theatrical, PPV and subscription windows.

Programme rights holders will prefer to deal with distribution organisations that can offer a one stop shop for all of these windows in any given country. Broadcasters should therefore aim to secure capacity on all three systems so that they can offer the maximum opportunity to exploit their expensive programme rights to the maximum possible audience.

The cozy old days of the monopolistic highly regulated terrestrial broadcaster are over. The message is clear for the new wave of commercial broadcasters, think big but also think broad using as many distribution techniques as you possibly can to reach your audience. In that way you will secure the high quality exclusive content that will make your service a success.
Oh, and make sure you get your digital receiver and your Conditional Access system into the home before anyone else!