White Paper

The Development of Digital Television And The Challenges It Now Presents

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Introduction

Switch on a light, make a phone call, turn on the TV……today these are small actions that are part of everyday life. Most people however, will rarely give a second thought to the collective global effort made by individuals, industry and governments in delivering these resources to our fingertips.

Over the past century the technological revolution has had a fundamental influence on the development of nations. Today television is commonplace throughout the World; however, because of the nature of its development there are an ever increasing number of methods and technologies used for broadcasting. In the short term, if ever, it is unlikely that there will be global harmonisation for the same reasons there has not been one so far. This is in stark contrast to the computing industry which can boast many examples of global standards in order to make equipment compatible.

This paper focuses on the development of digital television and the influences that have shaped it. The aim is to aid understanding of how the various broadcast technologies have evolved to the multiple digital television standards that we see today and the role of the various stakeholders in their genesis. Further, we take a look at today's challenges and the possible future directions for broadcast technology.

The Standards Process

Technology is changing the world we live in and the way we live our daily lives. There is a constant evolution of new products on the market offering an ever greater range of services. Global industry standards are established to enable consumer electronics manufacturers to develop products that work in different countries and that are compatible with other manufacturers' products. There are different standards for different applications using specific frequencies of the RF spectrum. They are set by broadcast and communications industries working collaboratively with governments and committees made up of respected people from across the industry. It can take years to determine a standard and this is particularly tricky when the technology is constantly evolving since no one wants to set a standard that will hold back the progress of future technological development.

Standards define the architecture, communications model, management structure, security mechanisms and physical access to a specific frequency spectrum for a particular type of communication in a given environment. Once a standard is agreed this is adopted industry-wide and adhered to throughout the design of applications operating in a specified environment. Network services are also part of the standard so that applications can be seamless without regard to specific manufacturers.

Having more than one standard for broadcast presents challenges for consumer product designers. For electronic products to operate, they need to be fitted with components to meet a country's particular regulated standards for broadcast. It is costly to design a product for each country when the ideal would be to have a product that can be distributed worldwide. Advancing technologies can create a situation where outmoded ones are made obsolete. This is costly for product manufacturers if they have stocks containing the older technologies.

The semiconductor industry is presented with a delicious challenge to create a programmable chip for consumer electronics manufacturers that can support the range of global broadcast standards.

The Spectrum

The ability to receive television is possible because we can transmit video signals over large distances as electro magnetic waves, through air, cable or optical fibre. These waves are separated at different frequencies within the electro magnetic spectrum so that they each can be received in isolation more easily. The free-air spectrum is thus a finite resource and a valuable commodity; most countries consider the spectrum as property of the state to be used as a national resource, much like water and land.

Prior to the digital switchover that has been implemented in recent years, analogue television used spectrum based on a 50 year old planning model when there were very few alternative uses of these frequencies. The latest digital broadcasting is about six times more efficient than analogue, allowing more channels to be carried across fewer airwaves and enabling a large amount of spectrum to be released for new services like mobile phones, GPS and future applications.

What Does Television Mean To Society Today?

Before looking at why many organisations are involved in the standard setting process let's consider the impact of television on society.

***Security* –** For every country safety is a primary concern. Governments recognised early on the value of broadcast during a time of war. Television is employed to support war and peace time surveillance operations as well as ensure rapid and comprehensive delivery of communications to a nation. In times of war no country wants to be dependent upon another for its broadcasting. It is for this reason that during the First World War the US military lobbied hard for America to establish its own wireless industry so that it was not dependent upon the British owned Marconi. In Japan television is deployed as an early warning system for cyclones, tsunami and even once for a volcano eruption.

***Economy* –** The television industry is a massive employer. It includes consumer electronics manufacturers, research and development, television/film production and retailers to name but a few.

***Political* –** The two previous references about security and the economy make television a focus for politics. Politicians also recognise the power of the medium as a means to build public support for their political party.

The Players in the Standards Setting Process

There are many bodies with a vested interest in broadcast standards.

Governments – play a key role in appointing semi- independent bodies to govern the system of broadcasting.

Broadcasters – There are public and private broadcasters. The public broadcasters are funded through national licensing schemes and the private ones are funded through advertising. Strong broadcasting industry bases developed in different countries – for example American NBC, Japanese NHK and the UK's BBC - creating a sense of national pride as their engineering R&D sustains healthy competition between them all as they push back the barriers improving picture quality and accessibility.

Electronics industry – As a massive employment sector, this includes the areas of research and development, manufacturing and retailing of consumer electronics. R&D engineers from electronics companies, public broadcasting institutions and universities work, often collaboratively within their country, to develop new technologies to improve broadcasting methods.

IT industry – A relative new comer to the broadcast standards debate joining in the 1980s on the back of developing internet technologies and a growing appreciation of how it could be applied to broadcast television.

Film Industry – Film makers have traditionally had a big influence on the development of television in a bid to overcome constraints that it poses. The picture size and quality of cinema films generally have to be reformatted for TV meaning the viewer will not always get the full view originally shot by the camera. For this reason filmmakers have always been pushing to create television with the quality seen in cinemas and from 1970's onward there has been a strong push from the film industry to develop High Definition television.

Institutions – These are the committees involved in the process for standard debate that represent the views of its members

Consumers – Although not involved in the standards debate, consumer desires and behaviour have a direct impact upon the setting of standards.

A Closer Look at the Development of Digital Television

As with most technological developments, to understand today's television broadcast landscape we must look at the past. The early days of television were pioneered by a number of individuals around the globe; especially separate efforts in America and the UK. In the UK, John Logie Baird developed his semi-mechanical electronic model in 1924. This was trialled by the BBC alongside a fully electronic model developed by Marconi-EMI. The latter became the preferred system due to the fact that it was backed by the larger commercial operation which was able to indulge resources in the development of television. This was the start of the television phenomenon in Europe. In America, television technology was being developed by Vladimir Zworykin and Philo Farnsworth who were leading competing research teams (RCA and Philco respectively). It was Zworykin's technology that was progressed as the preferred option after family tragedy struck Farnsworth.

Although the global television industry itself was halted by the outbreak of the Second World War, the underlying electronics and communications technology moved forward at speed. Such that after 1945 television spread rapidly into homes thanks to the vision of individuals and financial support from a number of institutions, in particular the radio and movie-making industries. In terms of developing broadcasting standards there have been three major milestones. The 1920s saw debate about monochrome and in the 1950s colour standards began to be introduced. The three main emergent colour analogue broadcast standards were NTSC, PAL and SECAM, each being incompatible with the other.

The NTSC standard (National Television Standard Committee) was introduced by the United States in 1954 and is used by many countries on the American continent as well as many Asian countries including Japan.

SECAM (Sequential Electronique Couleur Avec Memoire) was developed by the French in 1956 and introduced for consumer use in 1967. It is mainly used in France now although has had spells of adoption in other regions of Europe.

PAL (Phase Alternating Lines) was introduced by a German company in 1967 and was implemented by almost all 50 Hz (50 cycles) countries in the world including many Western European counties and Australia due to its quality and simplicity.

As the analogue television technology of the 50s matured new digital technologies were postulated as replacements.

Focus On The Early Digital Developers In The 1980s and 1990s: Japan, US and Europe.

Japan - The growth of the Japanese economic bubble

In the 1970s, Japan began a strategic approach to build its prominence within the global television marketplace by implementing intelligent technology and marketing strategies coupled with predatory pricing. Much of this success lay in their ability to replace the unwieldy, expensive and less reliable electron valves used within electronics products with the more capable solid state transistor. Sony was the first to sell an all-transistor monochrome TV in 1959. The US's Motorola was then first to market with a solid state transistor colour TV in 1966 but it was Hitachi in Japan who were first to sell it in volume. The Japanese then began to replace transistors with integrated circuits. They continually worked to improve design and began to encroach on US firms. Large scale integrated circuit technology (LSI) enabled semiconductor manufacturers to put more transistors on a single device quickly reducing the parts count. The Japanese were also faster at automating the production lines and Japan was able to offer a combination of low price and high quality consumer electronics.

The 1964 Olympics saw a large increase in television sales but broadcast engineers were disappointed at the quality of images and so became determined to develop higher definition television. To this end NHK, Japan's public broadcaster, along with a coalition of TV manufacturers developed Hi Vision, a hybrid analogue/digital system to give the viewer what video engineers term 'telepresence' (the sense of actually being there). The screen had a ratio of 5:3 and at least 1000 lines necessary to match the resolution of 35mm still photographs. 1125 lines was a good number as it would facilitate down conversion of HDTV to analogue NTSC and PAL/SECAM images.

With Hi Vision the Japanese had the challenge to take 30 MHz base band signal coming out of studio camera equipment and compress it so that it could be stored easily on VCRs and delivered economically on existing over-the-air cable and/or a satellite transmission system. In 1984 NHK announced a system code called MUSE that could reduce the bandwidth necessary for transmitting Hi-Vision signals to 8.1 MHz. This bandwidth though was still unacceptably high for Europe and the US consumer markets as it would make the cost of equipment to receive signals too high. For NHK who had already committed to broadcasting activities over DBS (Direct Broadcast Satellite), the fact that it was not compatible with terrestrial broadcasting was not a concern. MUSE Hi Vision also required a higher frame rate of 59.94 Hz (60 frames per second) to prevent flicker than the 50Hz common to PAL/SECAM, another issue preventing European integration.

Throughout the development process of MUSE Hi Vision, NHK were highly protective of the MUSE technology. Although this was intended to protect the Japanese it did nothing to aid global engineering collaboration to improve the solution. With this sort of approach it meant there was nothing else other regions could do except to work on a HD solution for themselves.

In 1989 NHK proposed the Muse Hi Vision standard as an international one to improve upon the analogue colour TV NTSC, PAL, SECAM and MAC standards. Japan's expectation for MUSE to be accepted as a global standard was because it was the first and only place manufacturing HDTV equipment at that time. When NTSC and PAL were adopted as global standards in Asia and US it was because they were the first analogue systems to be developed within their region. It was therefore natural that Japan being the first to develop HDTV would propose their standard. The Japanese started to build alliances with other key industries that would be needed to support a new standard. The movie industry would be purchasers of production equipment plus they also had vast libraries of high quality programmes which could be converted to HDTV.

Although initially MUSE Hi Vision was generally supported by global electronics bodies, there were groups concerned that this was about Japan consolidating their strength in the marketplace at the expense of the other players around the rest of the world. MUSE Hi Vision was eventually rejected by the Americans on the pretext for the need to develop an all-digital system. This was also reflected in the European decision to reject MUSE Hi Vision.

Europe: Protection by the EEC and private broadcast ingenuity

Although each European country controlled its own broadcasting affairs there was similarity in the approach taken. From the very outset, governments recognised the political, economic and security benefits to be gained from television and so had a guiding hand throughout its development. Countries had centralised public broadcasting monopolies that were run by semi-independent boards appointed directly or indirectly by governments or national legislature (major political parties). The broadcasting was financed by license fees and supplemented by advertising.

The 1980s saw a growth in the number of private broadcasters due to both technological development and increased pressure from consumers for a greater range of entertainment. On the defensive the public broadcasters mounted a campaign claiming that they protected cultural identities. There are two twists in the European approach to digital.

The power of the EEC

When Japan proposed their MUSE Hi Vision standard it was not the European electronics industry that were concerned but officials working for the European Economic Union (EEC) as it was their job to preserve European markets and to protect European industries from external competition. The EEC realised that if they agreed to the global standard proposed by the Japanese this could affect the protective nature of the EEC. Their response was to start subsidising research and offer development grants for EEC countries with a view to rapidly developing their own HDTV system. This evolved in the form of the MAC system.

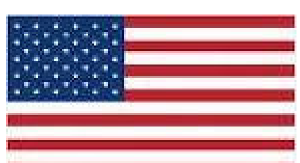
The HD MAC system (Multiplexed Analogue Components) was a digital and analogue transmission standard for satellite HDTV intended to replace PAL and SECAM, the main European standards. It was originally developed by the Independent Broadcasting Authority (IBA) in the UK for delivering high quality pictures via direct broadcast satellites that would be independent of European countries' choice of terrestrial colour coding standard. Although the HD MAC system was to start being used in 1995 it never came to fruition. Instead it was used for satellite broadcasts using only standard resolution and not HDTV because once the Americans had rejected MUSE Hi Vision, the Europeans also looked to develop an all-digital system. The writing was on the wall for MAC as a new system called DVB was being developed.

Public broadcasters' attempts to curb private broadcasters fail

In the UK in 1972, British Telecommunications (BT) was spun off from The Post Office to take control of public broadcasting and in 1974 satellite broadcasting began. In 1986 the BBC was restructured to make it more commercial and named BBC Enterprises. From this point BT only became involved in the primary distribution of BBC signals and no longer involved in programme creation or broadcast. In the same year, the Independent Broadcast Authority (IBA) awarded the contract for Direct Broadcast Satellite (DBS) to British Satellite Broadcasting (BSB) which subsequently had great difficulties due to high set up costs and delays building dishes and launching successful satellites. Due to the restrictive contracts that had been awarded by the IBA, BSB had their hands tied to use a new and expensive Hughes satellite using a PAL incompatible D-MAC standard.

Although this set up had been strongly influenced by the public broadcasters in a bid to try and have control over the incoming private broadcast competition, Rupert Murdoch's Sky Television services managed to out manoeuvre the system. Sky established themselves as the main competitor to BSB but in contrast Sky opted to use a less expensive medium power European Astra Satellite and to broadcast PAL signals. This meant their service cost was far less to consumers and Sky's market share began to take off.

In November 1990, unable to withstand the continued high set up costs, BSB merged with Sky to form BSkyB, 40% of which was owned by Rupert Murdoch's News Corporation. As BSkyB's audience share grew, the public broadcaster, the BBC tried to compete and in 1994 made an alliance with Pearson Plc to develop satellite channels. Despite this Sky continued to be the market leader.



United States: Pricing strategy at expense of technological development

By the end of the 1960s, the American television industry was a booming global leader but within ten years the country was in a defensive position due to competition from abroad and a lack of focus on advancing new technology.

In the 1970s, the US was developing video camera recorders (VCRs). Ampex Corp. was leading the field with their Instavideo machine but in 1972 they were in financial difficulty and had to cut their development plans for Instavideo. Large US firms such as RCA, Zenith and GE did not recognise the value of VCR to consumers and so did not step in to see the development continue. Japan on the other hand saw the value of the technology. They became the first to capitalise in camera and optical equipment. Coupled with their existing expertise in TVs and VCRs, the Japanese were in a strong position to develop new markets for camcorders and projection TVs.

As Japan's strength within the global market grew, America responded by competing on cost. They set up new production plants called Maquiladoras in Mexico. Initially this approach was successful in helping the US to compete but by focusing on price and less on developing technologies, this ultimately caused the decline of the US television marketplace. It was also helped by an imbalance in trading policies. Japan dumped high quantities of Japanese televisions on US markets yet trade barriers prevented the US from accessing Japanese markets by export or by establishing a US owned TV production plant in Japan.

When Japan proposed MUSE Hi Vision to be a global HD standard the US were concerned that it would be incompatible with NTSC receivers of which there were 140-160million. If they accepted, it would have meant a transition period to allow NTSC broadcast to also be received. To achieve this simulcasting, one 6MHz channel would be required to transmit NTSC and one 6MHz channel to transmit MUSE Hi Vision HDTV. This would use up valuable spectrum and from a broadcasters point of view would be more costly to broadcast two channels. There was also the issue that consumers would be required to purchase relatively expensive equipment (dishes, tuners and down converters) to receive HDTV and this would seriously restrict uptake.

By 1988 the Americans realised that by not keeping an eye on developing technology the US consumer electronics industry had been badly hit. Accepting any foreign standard for HDTV was perceived as the final straw for US consumer electronics so there was a push for an HDTV industrial policy to promote US owned firms back into a strong position in the global market place. At the time the Boston Consulting Group noted that demand for HDTV depended upon the availability of HDTV programming. It recommended that major subsidies and loan guarantee schemes be introduced to establish the required preconditions for the revival of US consumer electronics production and further that up front investments be made in developing HDTV programming and equipment required for transmission.

Whilst the television industry was debating, the American political landscape was changing. President George Bush's administration was against industrial support policy for specific industries. However, with the incoming Clinton administration they recognised the significance of Digital Convergence and became proponents for the development of the information super highway and the importance of television in that context.

In May 1993 all major competing US consumer electronics firms came together united under one banner, The Grand Alliance, to determine a digital high definition system. It took a further 4 years until the Federal Communication Commission (FCC) formally adopted a standard for Digital television called ATSC that also had the capacity for delivering digital HD known as DTV in the US. Over those four years, broadcasters came on board recognising HD as the answer to their falling audience shares. The computer industry, the newcomer to the debate was partially successful in having broadcasting evolved so that it could continue to play a role in TV development on the internet.

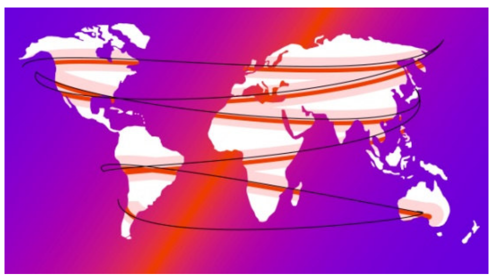
From 1997 HDTV was referred to as Advanced TV rather than HDTV as it was more than HDTV since the adoption of a packetised digital transport system and the international compression standards MPEG-2.

Reasons for Standards Divergence

Although there was some convergence on the adopted HDTV systems, the outcome was three different advanced digital television standards in three different regions - MUSE HiVision, DVB and DTV. The reasons for the divergence resulted from a mixture of influences:

1) Globalisation

Globalisation was affecting all the players in the television industry. National governments sought to protect domestic and international interests. For a growing number of companies the supply chains taking in different countries also needed to consider both domestic and international interests if they were to be successful. Between the 1980s and the end of the 1990s there was a dramatic change in the global marketplace as it changed from highly-competitive, fragmented economies to a relatively more harmonious global community which acknowledged the need for more open cooperation.



2) Perceived competition

Between the 1980s and 1990s there was a change in the perceived competitiveness of countries. In the early eighties Japan was globally dominant in consumer electronics but by the end of the 1990s East Asian producers in Korea and Taiwan had increased their competitive edge so that Japan no-longer held its dominant place in the market.

Japan although strong in consumer electronics had areas of weakness. Structural changes within the computer and telecommunications industries meant that computers were coming into the home environment creating home entertainment opportunities; however Japan was not as strong as the Americans in computing expertise. Furthermore, Japan's anti-trust policies and intellectual property protection, although initially developed to help their industry grow, in the end caused a degree of alienation as it encouraged other regions to develop their own systems if they could not work collaboratively. By the end of the 1990s, the Japanese recognised the need to participate in a more open forum if they were to compete in the new markets brought about by the Internet.

3) Institutions

In the United States, television was delivered by private broadcasters. In comparison in Europe and Japan there was a dominance of public broadcasting. In a bid to hold on to their control the public broadcasters aimed to secure the method of satellite broadcast that would protect them but in Europe they were out foxed by the private broadcaster BSkyB who developed their own systems and standards to enable the continued and highly successful growth of the company. Here the consumer played a strong determining role by opting for a greater breadth of entertainment offered by the private broadcasters. In the end the public broadcasters had to adapt their strategy to one similar to the US and embrace a collective approach by all contributors to the television industry and move towards digital standard for all.

4) The influence of the electronics industry

Until the late 1980s, the main influencers to standards in television had been the broadcasting networks, television station owners and TV programming forums. In the 1990s America's FCC policy to consider the interests of all the players in the television industry meant that relative newcomers to the table such as the computing and electronics industries had equal weight to the longer standing players when determining the standards.

5) Rise of the Internet and Digital Convergence

Whilst there was global agreement upon the phenomenon of digital convergence, there was variation in thought on the timescales with which digitalisation would affect change. Japan, having invested heavily in the hybrid analogue and digital MUSE Hi Vision system continued to pursue it believing that all digital technologies were a long way from being fully developed. However the high cost of equipment and slow uptake by consumers of MUSE Hi Vision HDTV in Japan meant that the all digital cause did come back to the fore for development.

The Outcome of Early Development of HDTV Systems in Japan, United States and Europe

All three regions developed systems to deliver digital signals over air (via terrestrial and satellite antenna) and using wired systems (cable and telephone networks). All three regions looked to develop the benefits of internet-like methods of transmitting digital data using the MPEG standards family for video compression and the use of packets or cells of video data that were compatible with Asynchronous Transfer mode (ATM) so that it opened up the telecoms networks. Whilst each region had developed its own standard and both the US and Europe had rejected the Japanese system, both DVB and DTV standards enabled the Muse Hi Vision signals to be received which meant that Japan could continue to develop its markets in Europe and the US.

It is perhaps worth mentioning at this point that in the case of broadcasting to fixed TV sets, the particular standard adopted by a country/region is not of great consequence so long as the market for televisions is large and hungry enough to be profitable and flourish. Consumers are not particularly concerned about the broadcast standards in their region as long as they get good picture quality and reception. The issue of broadcast standard does affect the consumer though when they decide to opt for television on a mobile device. Then their desire is to receive good picture quality and reception which ever country they are in whilst travelling. Whilst some standards are compatible, others are not.

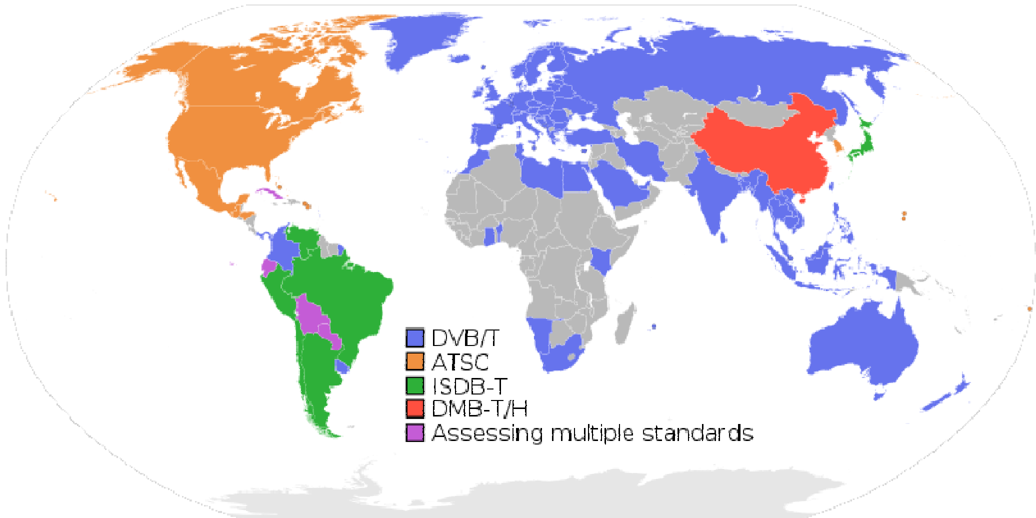
Due to globalisation and the growth of private broadcasters the pressure is high to sell and distribute programmes to as many countries as possible to sustain financial security. Programmes and films made in one country may be filmed to a broadcast standard that makes it unsatisfactory to be broadcast in another country. This is particularly the case with high definition interlaced formats as high quality motion compensated standards converters are not yet available although if using a progressive format there are some available techniques but the resource required to do this adds further financial implications.

Subsequent Standards Development throughout the World

The growth of digitalisation in the 1980s and 1990s had a monumental impact on the television industry and all its players. It was not technology alone though that crafted the future but the influence of the many regional and international bodies, all with varying agendas, that set the path for the standards that we have today. All the standards have strengths and weakness and each vies against the other to be adopted, extending geographic spread to increase economies of scale as well as standing within the global television industry.

Current Global Broadcast Standards

Digital Broadcast Standards			
	Broadcast Method	**Original**	**Enhancements**
DVB Family (Europe)	Satellite	DVB-S	DVB-S2
	Terrestrial	DVB-T	DVB-T2
	Cable	DVB-C	DVB-C2
	Handheld	DVB-H	DVB-HS (satellite)
ATSC Family (North America)	Terrestrial/Cable	ATSC	
	Mobile/Handheld	ATSC-M/H	
ISDB Family (Japan/South America)	Satellite	ISDB-S	
	Terrestrial	ISDB-T	
	Handheld	1-SEG	
	Cable	ISDB-C	
	Brazil	ISDB-Tb	
China Broadcast Standards	Terrestrial/Handheld	DBM-T/H	
	Terrestrial	ADTB-T	
	Handheld	CMMB	
	Terrestrial	DMB-T	
DMB Family (Korea) Handheld	Terrestrial	DMB-T	
	Satellite	DMB-S	
CODECs	Video	MPEG 2	
(Compressors and Decompressors)		MPEG 4	
	Audio	MP3	
		AC-3	
		AAC	
		HE-AAC	



ISDB-family

After the Americans rejected the digital/analogue hybrid MUSE HiVision as the HD standard, the Japanese also began developing all digital HD digital television system called ISDB which eventually replaced MUSE Hi Vision. Within the ISDB family are ISDB-S (satellite), ISDB-T (terrestrial), ISDB-H (Handheld), 1 Seg (terrestrial for mobile phones/handheld) and ISDB-C (cable). Where appropriate, all are capable of HDTV.

In Japan NHK were the first to broadcast by digital satellite (BS digital) and commercial broadcasting stations followed on 1 December 2000. Terrestrial digital broadcasting, using the ISDB-T standard began on 1 December, 2003. Analogue broadcasting in Japan will cease in 2011.

ISDB was also adopted by Brazil, which believed that for its broadcast environment ISDB offered preferred indoor reception quality when trialled against systems using other standards. Each digital standard system works within slightly different parameters; influenced primarily by the physical environment for operation in the country it was developed. Brazil's adoption of ISDB was also aided by the fact that the Japanese were prepared to incorporate new Brazilian technological developments to create ISDB-Tb or SBTVD, a specific standard created for Brazil. In 2009 other Latin American countries Argentina, Peru, Venezuela and Chile adopted ISDB and it is hoped others will adopt it in order to develop economies of scale for the South American ISDB broadcast industry. However in 2007, as the map above shows, Uruguay decided to adopt DVB-T and DVB-H as its new standard.

ATSC

ATSC was the result of a collaborative approach by US electronics companies under the banner of the Grand Alliance to deliver an all-digital broadcast standard for America and beyond. ATSC is optimised for a fixed reception in the typical North American environment. Its public launch was held on October 29, 1998, during the live coverage of astronaut John Glenn's return mission to space on board the Space Shuttle 'Discovery'. New developments within the ATSC family include a new service for conventional fixed DTV receivers, ATSC 2.0.

Until recently the availability of television on mobile devices has been difficult especially when travelling at speed as the ATSC transmission scheme was designed for highly directional fixed antennas.

In response to this Qualcomm seized the opportunity and developed its own mobile standard called MediaFLO, which is a competitor to the Korean T-DMB, the Japanese 1seg, the European DVB-H standards and latterly ATSC-H/M. It was first introduced on mobile devices in 2006. The "FLO" in MediaFLO stands for Forward Link Only, meaning that the data transmission path is one way, from the tower to the device. The transmission need not convey as high a resolution as would be needed for a larger display. In the United States, the MediaFLO system uses the frequency spectrum 716-722 MHz, which was previously allocated to UHF TV channel 55 before the digital switchover.

In 2009 ATSC eventually introduced ATSC-H/M to its family to deliver programming to handheld and portable devices overcoming the standards need for highly directional fixed antennas. In contrast to MediaFLO, it brings the benefit of new interactive television services and like all subsequent standards, it is backwards compatible so that it will work with existing hardware.

DVB Family

The MAC system was a hybrid of digital and analogue technology. When the Americans decided to choose an all-digital system, the Europeans realised that the MAC system was not going to take them into the future and so they too looked at developing an all digital system which is now known as Digital Video Broadcast (DVB). DVB standards are maintained by the DVB Project, an international industry consortium with more than 270 members.

DVB systems distribute data using a variety of approaches, including by satellite (DVB-S, DVB-S2 and DVB-SH; also DVB-SMATV for distribution via SMATV); cable (DVB-C, DVB-C2); terrestrial television (DVB-T, DVB-T2) and digital terrestrial television for handhelds (DVB-H,DVB-SH); and via microwave using DTT (DVB-MT), the MMDS (DVB-MC), and/or MVDS standards (DVB-MS).

DVB was based on the MPEG-2 standard. The DVB-S2 standard is based on the newer and more efficient MPEG-4 compression standards. DVB-H was introduced for the World Cup in Germany in 2006 and is officially endorsed by the European Union as the "preferred technology for terrestrial mobile broadcasting". Today DVB-SH (Satellite services to Handhelds), and DVB-H2 in the future, are enhancements to DVB-H providing improved spectral efficiency. Throughout all DVB standards highly efficient modulation techniques have been developed for further reducing bandwidth, and especially for reducing receiver-hardware and antenna requirements.

DTMB Family

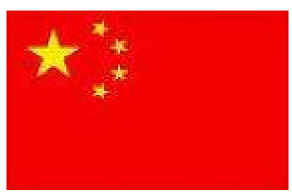
Today China is opening up to the World. The television industry in the People's Republic of China (PRC) has changed dramatically over the past 20 years to establish a complete system with high-tech program production, transmission and coverage. The largest and most powerful national television station 'China Central Television' has established business relations in more than 130 countries and regions. China is not only a significant source for technological advancement in the digital era but also a massive consumer market. With increased wealth and access to broadcast transmissions the anticipated sales in China are projected to boom over the coming years.

DMB-T/H or DTMB (Digital Terrestrial Multimedia Broadcast) standard was developed and adopted by the People's Republic of China (PRC), including Hong Kong and Macau . It is a mandatory standard that covers both fixed and mobile terminals and will eventually serve more than half of the television viewers in the PRC, especially those in suburban and rural areas.

Coming later to the digital debate than Japan, US and the UK, China had the benefit of being able to analyse the other standards around and select from each the aspects to incorporate in its own bespoke system. DTMB is the result of work at Jiaotong University in Shanghai (which developed ADTB-T, similar to ATSC, which coexists with DVB-T and Tsinghua University in Beijing which developed DMB-T, similar to T-DMB (see Korea). Each university had competed against the other in a race to provide the sole technology, but neither had the technical or political clout to achieve this. The outcome was to fuse both standard approaches with the TiMi 3 standard (developed by TiMiTech, a company formed by the Chinese Academy of Broadcasting Science). This collaboration with TiMiTech resulted from the need for backward compatibility, because the adoption of ADTB-T, DMB-T and DVB-T for HDTV transmissions via set-top boxes happened before the final draft of the DTMB standard was established. The standard is capable of transmitting "acceptable" signal quality for HDTV receivers moving at speeds up to 200 km/h due to time domain synchronous ODFM modulation. The standard also supports mobile digital TV service on handhelds.

Despite the advantages, there are also shortcomings. The R&D cost and complexity of IC chipsets for this standard will be higher, leading to more expensive receiver products. In addition, TV programs bought from overseas which are broadcast in digital TV format may have to do a signal conversion that suits the DTMB environment, as the DTMB standard is slightly different from the original DVB-T and ATSC standards, which again makes it less cost effective. Countries using DTMB include the Peoples Republic of China, Hong Kong, Macau, and experimentally Malaysia, Iraq, Jordan and Syria, Nicaragua, Cuba, Ecuador and Bolivia.

The policies show that by 2010, the annual sales of China's digital television sets and related products will reach RMB250 billion and the export volume will reach US$10 billion. By 2015, China's digital television industry scale and technology level will rank among the top in the world. It will become one of the world's largest bases for digital television set and key component development and production.



CMMB

China Multimedia Mobile Broadcasting (CMMB) is a more recent addition to Chinese standards developed in time for the 2008 Olympics in Beijing by the State Administration of Radio, Film and Television (SARFT). It is a mobile television and multimedia standard. There were five systems in the running to be adopted including DVB-H (Europe), Media-FLO (United States), T-DMB (Korea), DMB-TH (a digital TV spec modified for handheld developed by Tsinghua University) and CMB *(*Huawei*).*

The biggest rival to CMMB was T-MMB which caused controversy because although it had been selected as the preferred standard by the national mobile phone TV body, SARFT would not accept it since no broadcaster peer review had been undertaken. SARFT's control of programming and distribution in China gives CMMB a huge regulatory and cost advantage over T-MMB. A large industry alliance of 120 companies (including heavyweights such as Nokia, Motorola and Sony Ericsson, and Chinese firms like Lenovo, Huawei and ZTE) recognised

CMMB's clout in China and was prepared to back the standard. Another reason for not adopting T-MMB was that it, like some of the other proposed standards, contained some technologies that were patented outside of China and this would have meant hefty royalties having to be paid, possibly $6 per handset.

Unlike DTMB, CMMB has selective coverage of China, mainly the bigger cities, and it is unable to broadcast HD (1080i/1080p). The advantages of CMMB are that it is intended for small screen devices (such as GPS, PDA, Smartphone...) in a mobile scenario, while DTMB is intended for use on large screen devices (such as PC, LCD TV, PDP TV...) in a fixed setting. By early 2009, China Satellite Mobile Broadcasting Corporation (CSMBC) had completed CMMB network coverage in 113 cities. It is based on the Satellite and Terrestrial Interactive Multiservice Infrastructure (STiMi), developed by TiMiTech. CMMB is similar to Europe's DVB-SH standard for digital video broadcast from both satellites and terrestrial 'gap fillers' to handheld devices.

DMB Family

Digital Multimedia Broadcasting (DMB) is a digital radio transmission technology developed by South Korea for sending multimedia such as TV, radio and datacasting to mobile devices such as mobile phones. The World's first official mobile TV service started in South Korea in May 2005 and many have developed since making Korea the hotbed for mobile TV production and development. It can operate via satellite (S-DMB) or terrestrial (T-DMB) transmission. T-DMB works in vehicles travelling up to 120 km/h and can sustain broadcast availability in tunnels or underground areas. DMB has some similarities with the main competing mobile TV standard, DVB-H.

DMB is mainly used in South Korea but is also being considered in a number of countries. Trials are currently underway or planned in Norway, Germany, France, China, Netherlands, Indonesia, Italy, Canada, Malaysia and Mexico.

Internet TV and IPTV

Internet television is a television service distributed via the internet. Programmes are streamed over internet protocol (IP) networks by an Internet TV provider such as 'You Tube' but they have no control over the final delivery and so broadcast on a "best effort" basis where picture quality cannot be guaranteed.

IPTV, on the other hand, is 'the high end' of internet television where the broadcaster directly controls the "last mile" to the consumer's premises to maintain control over delivery, guaranteeing quality of service and offering enhanced user experience e.g. better programme guides, interactive services etc. To this end, IPTV has an on-going standardisation process and uses subscriber-based high speed access channels for delivery via set top boxes (STBs). The BBC iPlayer was early to market with the introduction of IPTV but they had to invest heavily to ensure the capacity will be there to meet future demand to allow HD video streaming, which takes 1.5 GB of data per hour of video.

Although similar, because of the differences between IPTV and Internet TV each has a slightly different audience profile and because of the exponential choice available to the viewer on the internet, we shall continue to see further fragmentation of television audiences.

In 2009 there were 28 million subscribers to IPTV generating revenues of $12billion. By 2013 some forecasts predict this will grow to 83million with revenues of $38billion. This would account for over 5% of the global digital TV household base. User rate growth is highest in China and India but revenue growth is highest in Europe and North America.

However, currently few countries have a very high speed broadband-enabled population. In Korea, broadband to 6 million homes has a connection speed of 100Mbits/s. In contrast in the UK, due to legacy networks, the connection speed is 3-5 Mbits/s which means the simultaneous provision of TV channels, VoIP (voice over internet protocol) and the internet may not be available until networks are updated.

Conclusion: Future Challenges for Television and Standard Development

Currently it is the development of infrastructures for broadcast rather than the development of technologies that is holding the industry back from realising the true potential of future digital television. Whilst globalisation has supported international industry synergies, there are still significant differences between the market stages in developed and developing countries. The legacy of broadcast systems that are already in place will have a degree of influence on the development and implementation of future technologies.

The 1980s and 1990s saw a major upheaval in the development of television mainly due to the digital convergence of the television, electronics and computing industries. The twenty years that followed saw the fallout of that with the development of digital broadcast standards for regions around the globe. Now we are at the beginning of another major event to hit the television industry with the development of Internet television. The future will depend on the seamless interoperability of digital telecoms systems, digital broadcast and the emerging home network environment.

There are three emerging areas for television broadcast development:

- Mobile hand-held devices offering TV
- The evolution of set top boxes to receive and transmit signals throughout the home using a range of technologies
- Further development of Internet TV as industry works out a viable business model.

The digital broadcast standards for high definition (HD) and standard definition (SD) television have been established and further standard developments will be enhancements of these foundation technologies. In relation to the internet and IP television, there is still the dilemma of what approach to take to ensure there is capacity for all the data traffic. Although subscriptions are still relatively small for IPTV, as subscriber numbers increase the demand for data transport will be immense. In order for the right number of frames per second IPTV requires minimum data speeds.

In the UK, limited connection speeds and bandwidth availability coupled with the growth of a large IPTV customer base would mean that the service quality could be impaired, so there needs to be an upgrade of the ISP networks as well as a review of home network wiring systems to enable the future growth of IPTV. We shall see the development of further standards to offer in-home, high-speed networks capable of delivering room-to-room HDTV. A current favourite is the G.hn standard which consolidates various fragmented home network standards into one common world-wide format connecting homes using existing wires.

Another method being considered is for an RF video layer to be deployed over the fibre to the home (FttH) network (based on IP technology) that allows TV to be delivered over the network separately from the IP-based services. However, is it necessary to commit to these costs when free-to-air TV is widely available via satellite? The advantage of RF-video is that it is a good value and reliable method of distribution that works with existing TV sets and the existing internal wiring in homes. It is excellent for real-time events (like sports and news) which attract a large percentage of viewers simultaneously. Of the options that will inevitably be presented the consumers will play a large role in determining successful uptake.

By 2013 analysis from Cantab Wireless predicts that the number of people receiving Mobile TV will reach 472 million with subscriber early growth anticipated to be strongest in Asia, especially in Korea and Japan. In March 2010, NBC announced at an international conference on Online Media Measurement (I-COM) that they are “seeing most mobile use in the home which is completely counterintuitive,” and they forecast that there will be a marriage of handheld devices rather than laptops or netbooks, to the future of TV internet user interplay.

Currently the consumer electronics industry is evolving the set top box. In the UK ‘BBC Interactive’ and in the US the development of ‘tru2way’ is forecasting a greater interactive multimedia offering for viewers. The likely end point for the STB though is for it to have the capacity to accept all signals from different networks run by pay TV, satellite, cable TV and telecommunications companies. Providers will connect satellite and broadband up to the home network with a number of STBs connected throughout the house so that the whole family can view all channels and access any shared content on any PC or TV. Taking this a step further, service providers will offer ‘home and away’ packages allowing subscribers a seamless interface to not only watch and record television in their home but on-the-go through their mobile devices.

The Hybrid Broadcast Broadband TV Consortium made up of SES, ASTRA, Humax, Philips and ANT software are establishing an open European standard called HbbTV for the development of hybrid STBs that will receive broadcast and broadband digital TV and multimedia applications with a single user interface. Despite the half second latency (the delay from when the signal is broadcast to when it is received) broadcasting high bandwidth applications such as IPTV is best done using satellite and it is predicted most IPTV growth will be achieved through hybrid networks.

The US has also developed an alternative to the set top box by incorporating the technology required into the television casing. In the US a credit card sized device called CableCARD has been developed which plugs directly into built-in slots on compatible TVs, DVRs and PCs enabling consumers to view and record digital cable television. These technologies were developed in direct response to requirements by the federal government’s Telecommunications Act of 1996 that cable companies allow non-cable company provided devices access across networks. To retain control the cable industry is keen to move away from the CableCARD model in preference of a downloadable security component.

Although there are examples of IPTV to be seen the debate has only just begun on what this will mean to the television industry. Television products are only just on the market capable of limited internet browsing and there is still much development to be done to combine the computer and television into one product. Although the solution seems simple, to combine a computer into a television, it remains to be seen if the consumer will find this attractive. For one, by incorporating a microprocessor with a television will increase the cost of televisions considerably (and that is before the cost of applications like Windows for the computer). At the moment this would be prohibitive for most consumers.

Computers and televisions provide different user experiences and their place in the home is likely to continue in different settings. In the US a Nielsen market research survey shows that whilst 99% of homes have a TV, only 75% of homes have a computer. However, those that do watch video-on-demand watch it on the television, not the computer. Of course in the UK with the recent introduction of the BBC's iPlayer, there will be a different user pattern emerging. Also, we are already seeing the growth of mobile TV applications within the home and we shall continue to see the pattern of use evolve.

A major issue for the development of free internet TV is that the business model does not work yet. Both private and public broadcasters need to find ways to bring in revenue streams through advertising and licensing. Advertisers will not pay the same for internet broadcast advertising as they do for the traditional forms broadcast. In preparation for the competition from IPTV, the pay TV industry is already taking steps for customer retention. To differentiate themselves they are offering 'Personalised TV' benefits whereby consumers can select video-on-demand and digital video recording.

The telecoms industry views internet TV as a revenue opportunity to help them compete against cable market growth. Television broadcast standards have historically been regulated differently to those defined by the telecommunications industry. Due to the convergence of these two fields, challenging regulatory issues will arise with IPTV allowing TV and video-on-demand to be transmitted over IP networks.

Whilst IPTV will play an important role in the future of television it is widely acknowledged by all that it is still in its infancy. It presents the industry with new dilemmas as did digitalisation when it was first introduced. We know from experience that change does not happen quickly. You just have to go back through previous eras of setting broadcast standards to know that the process can take decades of R&D, trials and public debate before agreement on the way ahead is taken. It took from the early 1970s to the early part of the 21st century for the digital switchover to be fully implemented. By the time it is complete there may be better understanding of how the technologies can complement each other. In addition, we will also have seen the full impact of HDTV on these technologies which will drive further development.

There remains unprecedented demand for digital television products, fuelled by the switch to digital. Conversion to digital TV involves replacing or upgrading nearly every piece of hardware equipment in the television industry, from television sets to the full international broadcast infrastructure. Demanding product designers look to the RF industry to enable TV on more consumer devices, with enhanced picture quality even in severe reception conditions coupled with the ability to support multiple digital standards as well as many different applications.

Companies like Elonics continue to work hand in hand with product manufacturers to deliver robust solutions capitalising on the global consumer thirst for television anytime and anywhere.

About Elonics - "Wireless Silicon for a Digital Age"

Elonics Ltd. is a fabless mixed-signal semiconductor company specialising in the design and development of multi-band radio frequency (RF) IC products. Founded in 2003 and based in Livingston, United Kingdom, Elonics has developed an innovative radio frequency architecture called DigitalTune™ that is the foundation for a family of re-configurable CMOS RF front end products.

Elonics innovative technology allows manufacturers to design high performance multi-band radio transceivers with unrivalled power consumption and low system cost. Elonics products are targeted at high volume portable consumer electronics applications that require wireless multi-media connectivity where size, performance, price and power consumption are paramount.

About Elonics' DigitalTune™ multi-band tuner technology
Conventional TV and radio tuners are intrinsically inflexible. Each broadcast standard has traditionally been served by separate radio receivers comprising an RF tuner and a digital demodulator. This makes them unable to meet the new challenges of today's cost conscious multi-tasking and multi-standard consumer products. The ideal solution is a single flexible RF tuner capable of receiving signals ranging from low MHz to GHz. The Elonics' DigitalTune™ multi-band tuner technology does exactly that, replacing the need for multiple tuners with a single re-configurable RF CMOS IC.

At the heart of Elonics tuner is DigitalTune™, a patent pending radio frequency architecture that uniquely allows each stage of the RF signal processing to be adjusted under digital control. This strategy has a number of benefits over traditional tuners that typically use analogue control voltages to manage the RF signal gain. As well as providing superior programmability and flexibility, it can be used to adjust the performance of the tuner for optimum linearity or noise figure according to the signal conditions. DigitalTune™ also helps overcome some of the inherent process limitations of CMOS, and allows Elonics to utilise its benefits to lower power consumption and silicon cost.

Website: www.elonics.com