Preparing the BBC for Creative Futures and Digital Britain.

Ensuring it has the technology to remain relevant to licence fee payers and their evolving needs.

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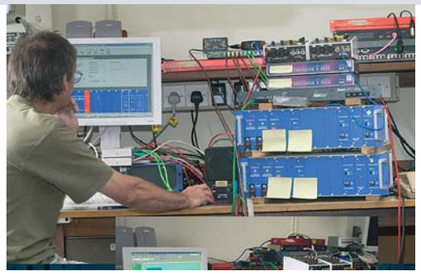
Foreword by Huw Williams, Head of Research & Innovation








A new name

This review reflects a year of important changes, with the renaming of our parent division to Future Media & Technology (FM&T), reflecting its role in transforming how the BBC uses technology. The focus of our work is moving beyond digital broadcasting to incorporate the changing world created by the convergence of broadcasting and the new media technologies.

We have been joined during the year by the BBC's Future Media Innovation and Information & Archive research teams, whose work is introduced in this Review.

So we are now BBC Research & Innovation (BBC R&I).

Huw Williams
Head of Research & Innovation

Our achievements

I would like to pick out some of our significant achievements during the past year.

Encouraged by the increasing sales of HD-ready televisions, we helped the BBC prepare for the BBC's HD test transmissions, which began in summer 2006 on the three main digital platforms, terrestrial, satellite, and cable. While we await a decision on the BBC's launch of a service, we continue to help fine-tune the system, to ensure that the public sees the best possible results from this improved technology.

It is now nearly nine years since we helped to put public digital TV broadcasts on air in the UK (not forgetting DAB three years earlier), and later this year the Digital Switchover will begin in earnest. Although the BBC's spectrum planners themselves are no longer part of the department, we continue to advise on methods of technical assistance for our viewers, in particular the more vulnerable groups. We also work to ensure the BBC continues to make efficient use of its radio spectrum allocations, both for its broadcasts and its internal communications.

One of the themes that run through our work is that our audiences no longer simply restrict themselves to our linear television and radio broadcasts. In fact some rarely now watch or listen in this way. We have contributed to new developments such as iPlayer, new forms of interactive content on our digital broadcasts, Freeview Playback and other ways for our audiences to control their own viewing. While the PC and 3G phone might be obvious alternatives to the TV, another exciting prospect is using games consoles to create new forms of interactive story telling.

We continue to support our colleagues in production, with innovative solutions to make routine tasks easier and to encourage creative programming. The *Piero* sports graphics system won the award for Innovation in Content Creation at IBC 2006.

It is worth remembering that none of this technology will work reliably for consumers, or for the electronic media industry as a whole, unless the right technical standards are in place. We put significant effort into proposing, arguing and supporting standards, both within the UK and internationally, and value the contacts we make through our collaborative work.

Governance

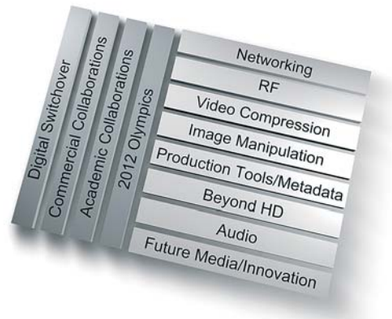
A new governance structure has been introduced to link the work of BBC R&I closely to the business, formalising an innovation 'funnel' to nurture new ideas and research areas and their development into products. The link to the business is provided through regular Technology Executive Conferences, which set strategic technical priorities across the BBC and find sponsors for our projects. A newly created Research Board approves and oversees our workplan, deciding which research should be continued, and when and where it is appropriate to transfer it to open source or commercial developments.

The year ahead

Our work continues, concentrating on eight main research themes, with four long term projects that work across them – Digital Switchover, the challenges of the 2012 Olympics, and our academic and industrial collaborations.

I note as we finish writing this Review that the first products using our *Dirac Pro* open-source video compression codec are about to be shown at the prestigious NAB broadcasters' exhibition and conference in Las Vegas. We are also very close to trialling the delivery of digital TV and radio channels to 3G mobiles, bringing the BBC's programmes to our audience on the move.

In the coming year BBC R&I will be key to a number of major BBC projects and initiatives most notably Freesat, iPlayer, further enhancements to Freeview, HD, and helping to define Web 2.0 services.



This translates into 14 separate portfolios of research, each with its own portfolio manager:

Production Magic, Wireless Connectivity, Future Broadcast Technologies, Blue Sky/Future Technologies, External Projects, Programme Production Technology, Interactive TV, Internet Distribution, Digital TV, Metadata Systems, Search & Navigation, Networking & Grid Technologies, Metadata Delivery & Standards, and RF Transmission & Reception.

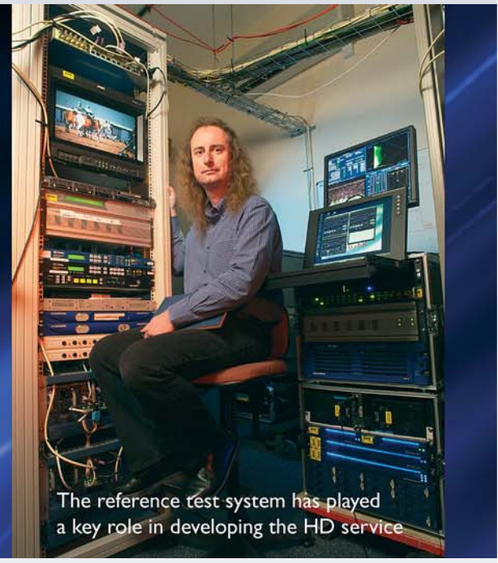
High Definition Television

Many BBC programmes are already made in HD, and the amount will increase over the next few years as studios and other equipment are upgraded as part of the normal replacement cycle. The cost of HD production is becoming closer to SD, and it may soon be difficult to obtain SD production equipment. The BBC also has to protect its sales to other broadcasters. This is a valuable source of income, particularly from North America, where HD content is now insisted upon. HD production also ensures the BBC has a reasonable stock of programmes to show on a service, although a decision on a launch has yet to be taken.


World Cup 2006


Bleak House

Terrestrial HD STB/Display Compatability Testing


The reference test system has played a key role in developing the HD service

In summer 2006 the BBC began broadcasting high definition television as a technical trial on digital satellite, on Telewest digital cable, and to a closed user group on digital terrestrial television in the London area. The trial began with coverage of the World Cup from Germany. This was rapidly followed by other outside broadcast events including Wimbledon and some of the Proms, together with a range of recorded HD programmes shown at peak times.

The trial has posed many challenges, and we are taking a leading role by providing advice and assistance to BBC Sport, BBC Resources, Red Bee Media and Siemens, and collaborating with equipment manufacturers. HD technology is still relatively immature, and the entire signal chain from contribution, through production and post-production to play-out and distribution, has to work at much higher bandwidths and bit rates. The reference test system that we maintain at Kingswood Warren for digital television development is crucial. It enables us to give advice based on practical experimentation in a controlled and repeatable environment on matters such as picture quality, bit rates, coding parameters, picture/sound timing, multi-channel audio, and subtitles. We have led the work to edit the relevant DVB standard to enable subtitles at HD resolutions.

On satellite, the transponder with the most appropriate coverage for the trial was already full with standard definition services. A method had to be devised to move these into newly acquired satellite capacity (the BBC's seventh transponder) without disturbing the service to the viewers. As on previous occasions, this was a collaborative effort between us, Siemens and BBC Distribution. At the same time, the BBC took the opportunity to expand its provision of interactive streams for a temporary period, allowing full interactive coverage in standard definition of Wimbledon and the World Cup, in addition to the simultaneous HD coverage of these events.

For the cable trial, we provided technical support to BBC Distribution in discussions with Telewest and helped on a number of technical matters such as specifying interfaces and trouble-shooting at the start of the trial.

For the terrestrial trial, we defined the technical requirements for the HD set top boxes that were to be provided to the trialists, assessing a large number of submissions from manufacturers in response to a tender. The short timescale, five months, and cost constraints meant that only a limited set of features could be built into the boxes. We therefore issued a list of essential requirements, in particular being able to receive Dolby Digital surround sound, and a longer list of desirable features, for example, reception of standard definition Freeview broadcasts.

Boxes from two manufacturers were shortlisted, on a combination of technical capability and price. We helped these manufacturers finalise the design of their boxes in time for the trials.

Trialists were required to possess displays that conformed to the EICTA 'HD Ready' standard. Such displays are fitted with either an HDMI or a DVI connector for the HD signal. Because these are relatively new interfaces, we carried out compatibility tests between a selection of typical HD Ready displays and the trial boxes, finding almost all pairings to be compatible. We also took the opportunity to measure picture overscan, to recommend a safe visible area for captions and other graphics.

'Generally, the responses were positive, particularly concerning picture quaility'

Objectionable changes in loudness were found when switching between programmes using Dolby Digital and MPEG Layer II audio coding. We found this effect was being introduced by the mechanisms for signalling and modifying audio levels in Dolby Digital, and we are now working with manufacturers to reduce it.

Appreciation of HDTV has two main aspects, programme content and technical quality. Clearly, our professional interest is in the latter! Comprehensive questionnaires were put out by BBC Marketing, Communications and Audiences, and trialists were also able to post comments on a private web forum. Generally, the responses were positive, particularly concerning picture quality, and there was also a call for more programmes with surround sound. Critical comments included an occasional lack of lip synchronisation, and some pops and clicks on the sound, these being due to teething troubles with the technical systems.

Over a few days in October 2006 we deliberately varied two technical parameters; bit rate, between three different values, and the broadcast standard, between 1080i and 720p. From comments solicited on the web forum we found that some trialists were aware of reductions in bit rate in both the 1080i and 720p modes. A second longer series of tests has just been completed.

The latest upgrade to the video data-compression coder is being tested to assess the improvement in coding efficiency.

The BBC now needs to ensure that the technical requirements of an HD service can be met. The trial highlighted a number of areas where the specification needs more work to ensure that manufacturers can produce compatible receivers. The DTG has started to address this, and we are actively contributing on aspects such as the detailed syntax for the video encoding, system signalling, and requirements for receiver video and graphics processing.

What will replace HD?

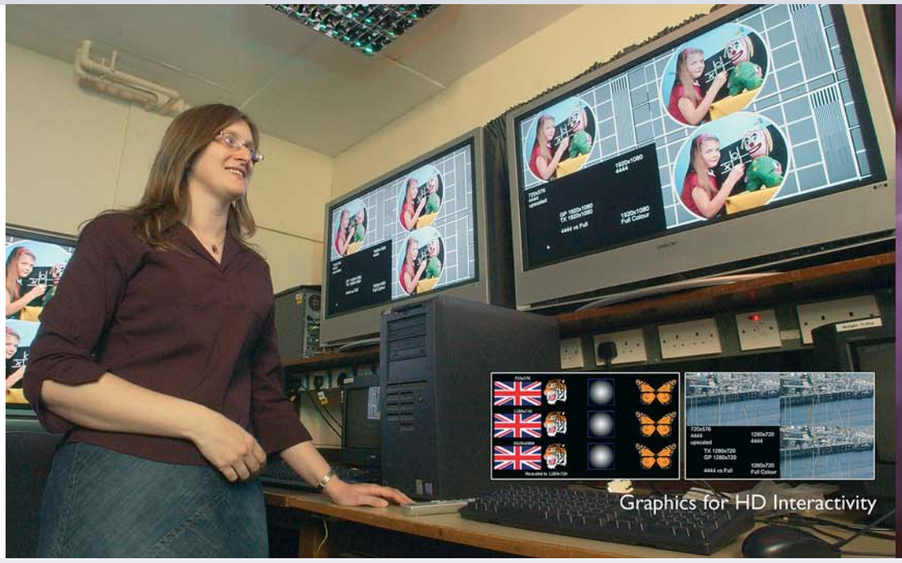
It is not too early to ask this question. Even though HD broadcasting has barely begun, the basic research was started more than 20 years ago. Will the future be ultra-HD, 3D-TV, or something else? While it is clear that there is a continuing quest for ever higher quality pictures and sound, as can be seen from 4k digital cinema, equivalent to 2048 vertical lines, and NHK's 4096-line Super HiVision system, there are serious difficulties in delivering this to the home.

Or will ultra-HD become a means to an end? There are benefits for programme production in starting with such high-quality material. If it is used correctly, it can help maintain HD quality at the end of the production chain, and this encourages more elaborate processes, such as the 'Production Magic' described later.

Currently we are exploring the state of research worldwide and investigating opportunities for collaboration with other organisations.

Interactive Television for the **On-demand World**

The majority of the interactive services that the BBC has delivered to date have been based on content delivered over a unidirectional broadcast path. This path is shared with the main television pictures and sound, access services, schedule information and other data, and this generally limits the interactive content to relatively modest text and image files. However, two receiver technologies, mass local storage and broadband connectivity, can not only radically improve the nature of interactive content but also the way viewers can access it.



The HD screen shot sections above show the effects of rescaling SD text and the importance of anti-aliasing.

The top two sections of poems were rendered for SD and then rescaled to the size required for HD leaving them slightly 'blurred'. The poem sections below were rendered directly into the HD resolution and are clearer.

The poem sections on the left were rendered using only white and black pixels whilst those on the right are anti-aliased, introducing shades of grey thus smoothing the outline.

Convergence of Broadcast and Broadband Delivered Content

- A Broadcast video/audio from broadcast network
- B Application acquired from carousel in broadcast network
- C Menu item details acquired using HTTP over IP network
- D Application acquired using HTTP over IP network
- E Broadcast video/audio from multicast over IP network

With mass storage available in the receiver, large amounts of data can be downloaded, perhaps at low speed overnight or at any other time when broadcast capacity is available. The interactive services can then include richer graphics and even audio-visual clips.

To explore the possibilities, the BBC has been working in partnership with Cabot Communications, a supplier of digital TV software technologies, to extend the capabilities of a standard consumer digital TV recorder. The extensions allow the recorder to download and store MHEG-5 applications for on-demand access and to allow these applications to schedule conventional recordings.

This has allowed the BBC to undertake a three-month technical trial, with 300 of the modified recorders issued to members of the public. The consumer proposition for this was a 'catch-up TV' service, where the recorder automatically records a selection of BBC programmes from the broadcast schedule. These are then made available for on-demand access via a rich graphical user interface written in MHEG-5 and enhanced with downloaded video clips.

'The extensions developed to support the trial open up exciting possibilities for enhanced television services, such as DVD-style extras providing "the making of..." or "an interview with..."'

The extensions developed to support the trial open up exciting possibilities for enhanced television services, such as DVD-style extras providing 'the making of...' or 'an interview with...'. We have successfully tested some examples of this in the laboratory, and are starting to include them in the technical trial.

The BBC is gaining valuable experience through the trial on the practicalities of running this type of service and work is underway to explore how to standardise the extensions that enable them.

The number of homes with broadband Internet connections is growing rapidly, and BBC R&I has been looking at how a receiver with both an aerial input and a broadband connection might combine content from both sources. Some initial ideas developed by the BBC were shown at IBC 2006. The demonstration showed text, graphics and video delivered over a broadband connection, using unicast and multicast, viewed alongside conventional broadcast-delivered content.

However, adding broadband access to set-top boxes and TVs in an open market such as Freeview presents a number of challenges. Home ADSL installations vary from a modem connected directly to a single PC, to complex networks with firewalls. Connections come with a range of connection speeds, often with usage restrictions and no guarantee of the quality of service. BBC R&I is working with the industry on how to deal with these issues, through the DTG Interaction Channel Working Group.

The portable content format

The BBC provides interactive television on a number of different digital TV platforms. This is a challenge because each platform follows a different set of technical standards for interactivity, and the BBC therefore has to produce several versions of every piece of interactive content.

This problem is not new, and the BBC has been exploring 'author once, publish to many' approaches for over five years. The result, in collaboration with other organisations, is a new DVB standard, the Portable Content Format (PCF).

The PCF, published by ETSI in January 2006, is being embraced by the BBC as both an authoring format and as an input format for platform-specific publication processes (often called more simply, 'transcoders'). It is also hoped that PCF can make it easier to take in interactive content from third parties, reducing both the 'time to air' and the management costs.

Interactivity at HD

Larger displays and greater screen resolution gives HD television a 'wow' factor that is hard to resist. But what part do interactive services play alongside HD programmes? The BBC is researching ways to broadcast and present interactivity efficiently on HD, as far as possible with an awareness of the technology within HD receivers, but perhaps needing to influence it too.

Initially, HD programmes could make use of the interactive services transmitted for SD, such as BBCi and the popular television multiscreen services such as Wimbledon tennis. But how best should an HD receiver reproduce this content? Is it acceptable simply to render it at SD and then re-scale, or would it be better to have intelligent software rendering it directly at HD?

Beyond this some interactive services could benefit from being authored specifically for HD. This could be as straightforward as providing images at HD resolution, so that no up-conversion is required, or redesigning to make use of the extra resolution and the larger screen.

We continue to work with other interested parties, to consider the impact of such ideas on the broadcast stream, in terms of need for additional capacity,

'BBC R&I aims to make the viewer's experience more reliable and consistent'

and on the receivers, in terms of memory and processing demands.

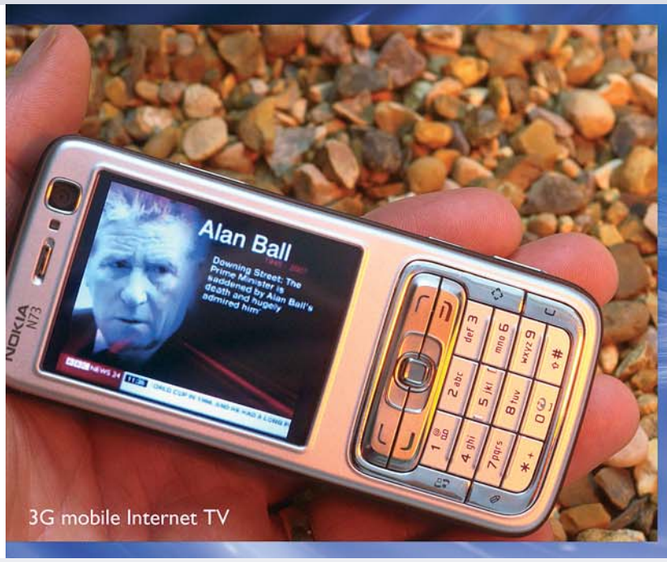
Interoperability on DTT

Freeview transmissions conform to a set of published technical standards that the BBC helps to write. This allows any manufacturer to produce digital terrestrial television receivers for the UK. However, the lack of a single platform operator and the open market in receivers continue to present a conformance and interoperability challenge, particularly in the context of interactivity. This can lead to receivers failing to display some interactive content correctly.

BBC R&I plays a major role in the way that the BBC resolves this, by working closely with individual manufacturers and across the industry, through bodies such as the DTG MHEG Interoperability Group. Through this it aims to make the viewers' experience more reliable and consistent.

Online, On-demand, and **On the Move**

The end of television delivered as a scheduled broadcast service has been widely predicted for some years now, with little evidence to back up the claim. The VCR allows viewers some freedom from the broadcasters' programme schedules, but most models are notoriously difficult to program, generate a stack of tapes, and will only record one channel at a time. A new breed of on-demand technologies is finally emerging that we believe will disrupt the status quo in a more profound way.



3G mobile Internet TV


Hi-speed DWDM optical networking


IPTV on Apple TV


Internet streaming encoders

Some broadcasters may view the new technologies as a threat to existing business models. The concept of advertising 'spots' is particularly at risk when the viewer can order individual programmes or simply skip through unwanted content. The BBC, on the other hand, is embracing this new non-linear landscape as an opportunity to exploit its content to the full. We can serve our licence fee payers better by allowing them to watch our programmes when they want to, not just at the times we choose to schedule them.

The BBC has been streaming audio-visual media on the Internet for some years. Indeed, the BBC was pivotal in the development of these types of services. The Radio Player service, based on technology originally developed by BBC R&I, has proved popular and demonstrated a clear consumer demand for 'listen again' services. The challenge in the present Royal Charter period is to provide an equivalent 'watch again' service for television.

Television is a greater technical challenge than radio. The unicast streaming technology used to deliver the Radio Player service does not scale to the high bit rates and file sizes demanded by television. Colleagues in BBC FM&T developed a peer-to-peer Internet download service for distributing large media assets to personal computers for the 'iMP' trial of 2005/2006.

'We can serve our licence fee payers better by allowing them to watch our programmes when they want to...'

True video-on-demand services stream programme content in real time to a set-top box or personal computer via a broadband connection. The viewer selects programmes from an electronic catalogue and can start watching immediately; unlike near-video-on-demand there is no need to wait until the next showing starts. The on-demand receiver can even be combined with a digital TV recorder to provide the best of both worlds.

The digital TV recorder is a digital TV receiver that records onto a high capacity hard disc drive instead of tape. In addition to the usual VCR functions, programmes can be paused and resumed when watching 'live', and recordings can be viewed before they are complete. The digital electronic programme guides make recordings easy to set up, and if suitable extra signalling is included in the broadcast, the machine can be set to record entire series just as easily as single programmes. The recording time can even adjust itself automatically if the schedule changes. On the latest models part of the capacity can be reserved for recordings selected by the service provider ('push-video-on-demand').

Download services offer programme content over a broadband connection to be stored for later viewing. Although usually associated with personal computers, these services have also been demonstrated with broadband-connected set-top boxes. The content is encrypted and the viewing permission can be set to expire after a fixed period.

The BBC iPlayer is a unified online player, to find and play on-demand and live-streamed audio and video.

In 2004 we set up a public trial of live multicast streaming. Multicast uses the routers inside the network to duplicate the streams of data packets rather than sending separate streams all the way from the head end to each recipient. Such trials promote the roll-out of multicast, by encouraging users to set up their home equipment to receive it, and Internet service providers to set up their networks to carry it.

This trial ran successfully until August 2006, at which time the rights we had negotiated for distribution of the content expired. It is now to be developed into a full broadband 'iPlayer' service, following the approval of the BBC Trust.

Research continues on other delivery methods for on-demand video content, beyond the iPlayer environment and looking at future home networks delivering the same content transparently to the TV, PC, or mobile devices.

Syndicating on-demand content

The BBC intends to syndicate on-demand content to cable operators, IPTV service providers, and 3G mobile phone networks, rather than delivering direct to these operators' customers.

Each of these platforms uses a different combination of technologies, some of them proprietary. BBC R&I has helped BBC Distribution to design the technical facilities for preparing the content for the various platforms.

The distribution system will be operated by the BBC's playout contractor Red Bee Media. It is envisaged that a common content ingest and media management system called the On-Demand Production System (ODPS) will be shared with the broadband iPlayer to avoid needless duplication of effort. The infrastructure can acquire live programmes in real time as well as the more conventional method of ingesting tapes or files ahead of linear transmission. A suite of encoders will then convert the content into the appropriate format for each platform. The resulting media files will be staged to a 'neutral drop-off zone' operated by our technology partner Siemens, from where the operators will retrieve them.

Metadata is sent direct to the platforms. This metadata will populate the content guides, and will include extras such as artwork relating to the programmes and promotional trailers; most on-demand platforms allow a sequence of promotional items to be played automatically before and after the programme that the viewer has selected. We hope to establish a profile of *TV-Anytime* for the metadata that is acceptable to all parties.

Convergence of walled gardens and the Internet

Video-on-demand is an emerging battleground for established organisations to test their resolve in maintaining old business models when Internet start-up companies start to offer similar services; cable companies and telcos are building 'walled garden' video-on-demand systems to combat the pressure from Internet delivery of a broader, potentially more attractive set of content. The BBC's public service remit means it is providing content to carriers in both camps, as well as direct delivery though projects like iPlayer.

TV and Radio on 3G mobiles

Early in 2007 the BBC was given approval to launch trials to deliver BBC TV and Radio channels to a number of 3G mobile operators. The trial will be launched in April 2007 on Orange, Vodafone and 3, and to meet this tight timescale it has been necessary to reuse the technical infrastructure already deployed for the multicast trial. This will be replaced in due course, to allow for expansion of the trial to more operators and to include a wider range of BBC digital TV services and content,

At first, the trial will be carrying three BBC TV channels – BBC One, BBC Three, and BBC News 24 – and about eight Radio channels, all streamed live. It will be receivable on most modern 3G phone models, although usage may incur a charge from the user's mobile phone operator.

Users will receive the appropriate regional variant of BBC One, depending on their location when calling in. (The BBC Three and BBC News 24 channels have no regional variations.) Some schedule data is carried, to display programmes titles and synopses.

Each video signal is encoded at 100 kbit/s, using H.264 coding. The image is clipped slightly to suit the narrower usable aspect ratio of the typical mobile phone screen. The audio is encoded using AMR (adaptive multi-rate coding), which is already widely used on mobile phones. AMR is however optimised specifically for speech, and we hope later to move to AAC coding to improve the overall sound quality and make a further saving in bit rate.

Transmission is by the conventional mechanism used for IP streaming to mobile devices. At present a separate stream is set up for each viewer. The mobile phone operators may decide to change this in future, although the number of simultaneous calls to the same TV or radio channel within a single mobile phone cell may not always justify a different arrangement.

'Early in 2007 the BBC was given approval to launch trials to devliver BBC TV and Radio channels to a number of 3G mobile operators.'

Because any 3G phone that can receive the service will also have Internet access, it is not essential to embed the inter-active content that accompanies the digital broadcasts. The same information, and more, can be obtained from the BBC website. Having a mix of content may be a catalyst for the way data services to mobile phones are charged.

Freeview Playback

Freeview Playback brings a set of new features and the mark of quality assurance to the free-to-air Digital TV Recorder market. It is the first major change to the Freeview platform since the introduction of seven-day programme guides. Getting the service on air at the end of 2006 was the culmination of work that started for BBC R&I more than two years ago.

Freeview Playback is much more than a marketing exercise. It is underpinned by significant enhancements to the signalling that accompanies DTT programmes. These enhancements were developed by BBC R&I in consultation with other broadcasters, industry, metadata aggregators, and colleagues in BBC Marketing, Communications & Audiences. This wide collaboration was essential because the data to support Freeview Playback runs through the whole broadcast chain.

An initial phase of the work was to agree an amendment to the UK guidelines for broadcaster and receiver equipment interoperability, to describe how Freeview Playback would work 'under the hood'. This was coordinated and edited under the auspices of the DTG by BBC R&I, and relied on our long term involvement with other standards bodies such as DVB.

To bring Freeview Playback to the viewer substantial changes were needed to the DTT technical systems. All electronic programme information for the UK DTT platform is generated by a system called the central collator, now owned and operated by our technology partner Siemens. When this came due for replacement BBC R&I made sure that the new system would be capable of supporting Freeview Playback; our involvement in the replacement continued right through to the final stages of systems integration and testing. The central collator dated from the start of digital broadcasting, and it was a major achievement when this broadcast critical system was successfully changed over while services remained on-air.

Once the new system was in place the necessary extra metadata had to be generated and new feeds arranged to supply it. As the acknowledged experts in this area, BBC R&I advised the BBC's metadata supplier on suitable solutions. The Freeview Playback metadata is compliant with the *TV-Anytime* standard.

The BBC was the first broadcaster to transmit Freeview Playback information. A commitment has been made by the other UK DTT broadcasters to follow suit. This co-operation is encouraging manufacturers to produce the receivers, a market we expect to expand during Digital Switchover. The first two models have been available since December 2006. The features provided by Freeview Playback have also been recognised in Scandinavia, where the 'NorDig' broadcasters plan to implement the same underlying signalling.

The business relationships established through Freeview Playback continue, and are expected to lead to further developments. Currently, we are working on a new feature called 'trailer booking', which allows a Freeview Playback viewer to book a recording while watching a trailer for the programme.

- Accurate Recording – a Freeview Playback recorder continually monitors broadcaster information to control the start and end of a recording and does not just rely on a pre-published time.
- Series linking – a Freeview Playback recorder can automatically identify and record programmes from the same series. There is no longer the need to rely on recording the same time and channel each week or to try to match programme titles.
- Repeat identification – when the viewer wants to record programmes that overlap, the recorder can check if the clash can be avoided by recording a repeat.
- Split programmes – this feature addresses a long term issue of programmes transmitted in multiple parts, for example a film split by the news. Viewers often fail to record the second part of the programme. Freeview Playback ensures nothing is missed.
- Recommended viewing – the recorder can offer the viewer other programmes to record, related to other recordings that have been made.
- Compliance – before carrying the Freeview Playback logo, a recorder must pass a rigorous set of tests to demonstrate it complies with the technical standards and features.

Serving Our **Audiences** – User-centred Research

How do we stay in touch with our audiences? How do we ensure that what we produce is relevant to them? How do we help them navigate the current maze of media offerings?

This set of projects is pursuing a number of ideas, under the general heading of user-centred research. It also includes our behavioural science work, where we try to understand the basic human needs that drive media behaviour, and to assess their impact on our audience.

Discovering content

Content is becoming easier to access, but harder to find. There are more devices supporting even more types of media, and there are more ways to deliver it to the viewer. In addition, viewers are expecting more from media – they want links between related items, and they want to navigate instantly to the parts that most interest them.

This is changing how we describe and provide our content. And of course it's not just about BBC content – our audience are contributing more, not just in terms of images, audio and video but also opinions, facts and data.

In order to encourage innovation in the methods of discovering our content we are continuing to supply feeds of electronic programme data based on the *TV-Anytime* standard to the developer community on BBC Backstage. We have created a simple means for developers to query this data via a publicly available experimental Web Application Programming Interface (API).

The Web API allows developers to create third party tools and 'widgets' to display schedule information for all our channels. We have been experimenting with how we can combine the data and stored content to provide interesting means of finding content, creating a simple 'player' that combines live video/audio streams with programme information in a webpage.

Content packaging

The success of Podcasting – downloadable audio programmes – suggests that people like to acquire content for later consumption. However, the playback is very basic, with limited opportunities for enhancements or to promote other services and content.

The idea behind content packaging is to replace the download of individual items with a personalised content package, based on the profile of the user. The presentation of the content is created by the content provider, in the appropriate format for the playback device, using a player or browser application.

We have developed two demonstrators for content packaging, the first designed for mobile phones, the second for high-end platforms such as laptops. We are using these demonstrators to develop further ideas and test their usability.

Games consoles

One of the BBC's primary goals is to reach and serve the entire British audience. A growing group that are seen by many to be under-served by the BBC are computer games enthusiasts. This group tend to feel that their game platform is the primary platform for relaxation and entertainment, rather than the TV; the BBC is felt to be insignificant, if not irrelevant. One way to reach this audience is to provide content for their platforms of choice, using the content grammars that are familiar to them.

As a first step we are assessing our existing content, to find what is most appropriate editorially and technically for games consoles. We have successfully demonstrated play-out of live streamed BBC video on Playstation2™ and Playstation3™ consoles, using an open source player, and we are now looking to cover a broader range of consoles. We are also considering how the BBC's portfolio of web-based games can be adapted for console play.

Interactive story-telling

With the benefit of this experience with games consoles we can start to try new concepts. We are researching how to bring the BBC tradition of rich narrative into this domain, looking at how to author and deliver truly interactive, open-ended stories. We are taking part in an EU-funded project, *CALLAS*, which is exploring combining emotion-sensing interfaces with interactive narrative techniques to produce a 'bardic interactive storytelling engine'.

This work is highly experimental and in its early stages, and it is difficult to predict what might emerge. Early ideas centre on having a narrator with whom the viewer or viewers interact by speaking. The story is driven by the outcome of these interactions, with the system working from not only what is said but also how it is said. Virtual actors could be used for the narrator and the cast, so that action need not be pre-recorded. Each viewer or group of viewers will therefore see a different story unfold.

Mass participation

Our audience's ability to send content to us, as demonstrated by the waves of mobile phone images we receive when major news stories break, shows the willingness of our audience to participate.

We are involved in a three year DTI-funded collaborative project called, very appropriately, '*Participate*'. This project is exploring the convergence of online and broadcast media to create new kinds of mass participatory events where a broad cross-section of the public contributes and shares content. This might be centred on one of the large outdoor displays the BBC operates from time to time, for example.

We are working with BBC Future Media Innovation and BBC Production to define some of the narrative aspects of the initial trials. We are trying out potential technologies to allow large numbers of people to access the system simultaneously, even when on the move without compromising technical quality.

Behavioural science

Participate is a good example of the need to understand human behaviour – how do people engage with a public event such as the one just described? Our immediate challenge in *Participate* is to decide how to measure this, and what metrics one might use.

Behavioural science factors, such as usability, accessibility, user experience and interaction design are now common and critical features of the mainstream BBC business. We are continuing to support a number of projects across the BBC, including switchover and new interactive platforms.

Image classification

Opening up the BBC to user-generated content creates a practical problem in sorting the large volumes that can be submitted in a short space of time. The material is often topical and must be dealt with quickly.

We have been working on a project to classify user-generated content to allow rapid selections to be made. This work is a collaboration between ourselves and the University of Surrey.

We hope that ranking submitted images by their similarity to wanted images, clustering related images together, might achieve quite good results while being relatively simple to achieve. A more elaborate technique, which might ultimately achieve better results, is to generate metadata by object recognition. Although we started here with mathematical methods, we are now exploring techniques that try to emulate the recognition processes in the human brain.

Production **Magic**

We are developing a range of production tools that harness the power of computer image processing to analyse a scene in 3D. With these tools, we can insert virtual objects into a live scene, generate a new view of a real scene from a virtual viewpoint, or automatically steer a camera or spotlight to follow a person around the set.

This work ranges from relatively short-term projects for immediate production needs, through to longer-term fundamental research that could lead to radical changes in the way programmes are made. It may also lead to new forms of 3D or immersive content that go well beyond what is possible today.

Inserting graphics into live images

Whenever a production team plans to insert a virtual object into an image, the graphics system needs to know precisely how the camera is moving, so that the virtual object can be rendered in the correct place in every frame. Although there are several tools available commercially for doing this in post-production, live (or as-live) operation is more difficult. For studio-based productions, it is usually necessary to shoot in a studio equipped with a camera tracking system, such as the *free-d* system we developed some years ago, which uses markers mounted on the ceiling. For other kinds of production, such as outside broadcasts or shoots on location, new solutions are needed.

We have been working with several European companies and universities in the MATRIS project to develop markerless camera tracking using naturally-occurring features in the scene. This three-year project was funded by the EU's 6th Framework Programme, and finished in January 2007. In addition to tracking directly from the camera images, the project also developed an inertial sensor, and looked at the use of an auxiliary camera fitted with a fish-eye lens. Both of these techniques can improve the accuracy and stability of the tracking. We coordinated the project demonstration at IBC 2006, which attracted the interest of several potential licensees.

'In September 2006, the Piero *system won an IBC Innovation Award, in recognition of its range of novel features that came out of BBC R&I work.'*

As a part of our work in the MATRIS project, we developed a method that measures camera movement by tracking the lines on a football or rugby pitch. This has been licensed to Red Bee Media as a part of the *Piero* sports graphics system, and is now in regular use by the BBC and a number of other broadcasters around the world. In June 2006 the system was used in High Definition for the Football World Cup, and for the first time it used a method to automatically lock onto the pitch lines when starting to track.

In some applications, it is useful for a presenter to be able to pick up a virtual object, rather than it being fixed in the studio or on the ground. We previously developed and licensed a system known as *MixTV*, which tracks a specially-patterned card which a presenter can move, so that a virtual object can be rendered on top of it. In April 2006, a version of the system was used in a three-month trial by BBC Jam, the BBC's broadband learning service for five to 16 year olds. This allowed users to interact with virtual 3D objects in real time, using their own hands rather than a mouse or a keyboard.

We have been working with BBC News to develop a system that tracks the cameras using an array of marker patterns placed on the walls of the studio or on other parts of the set. This avoids the expense and complication of installing a dedicated tracking system, and can be used in almost any location. Another approach being investigated is to display the marker arrays on an existing rear-projection system, so they can easily be switched off when virtual graphics are not required. The system could also be used in conjunction with hand-held markers to allow both fixed and moveable virtual graphics to be shown.

iview – capture of 3D scenes and generation of virtual views

We are leading a DTI-funded collaborative project called *iview*, to develop methods to capture action from events such as a football match in 3D and to provide a 360 degree free-viewpoint video replay of the action. During the replay the position of the virtual camera can be moved freely and crucial moments of a game can be seen from viewpoints which are not normally open to a real camera. BBC Sport has an obvious application for such a system, as it would allow them to fly a virtual camera around the pitch, giving a new way of presenting key moments. It could also generate top-down views for tactical analysis, or views as seen by a linesman, player or referee.

In its first year, *iview* applied techniques formerly developed for use in a chroma-key equipped studio for use outdoors. New and robust techniques were required for calibration of the cameras, keying and generation of the 3D models of the action. First tests in collaboration with BBC Sport and BBC Outside Broadcasts were carried out for football using either a set of specially mounted fixed cameras or just the cameras normally present. From the fixed camera set, virtual camera positions (such as the goal keeper's view) can be generated to provide new insights into the game that are not possible to achieve otherwise. Current work is focussing on tests with HD cameras.

The processing and generation of the 3D model of the action is currently carried out off-line, but options for real-time processing are being investigated. The replay uses image-based rendering methods that can be implemented at interactive rates on standard PCs. One goal of *iview* is to stream the replay data to an interactive platform such as a games console so that the user can determine his or her preferred viewpoint. We are also looking at applications in sports other than football, and in other programme genres including studio-based programmes.

Tracking people and objects in 3D

By tracking people in a scene, it is possible to automate some production processes. We have been investigating applications involving the automatic control of lights, by tracking the positions of the camera and presenter. The ability to automatically keep a presenter lit as he or she moves around a studio offers the prospect of reducing the overall level of lighting needed, whilst ensuring that a sufficient level of light is used. This is especially useful to satisfy the requirements of HD production where maintaining a good depth-of-field becomes particularly important. Working to requirements from BBC News, we have demonstrated a prototype system that can do this using information from the cameras. The system then adjusts the lighting by controlling the direction, beam width and brightness of a number of motorised spotlights.

We have also been investigating the use of audio location techniques to track the position of people. We have built a real-time demonstrator that uses two

pairs of microphones to estimate the location of a speaking person, using time delay analysis. This could be used to locate and track a TV presenter, or members of a studio audience when they speak, or in outdoor sporting events to help automate camera framing and shot selection.

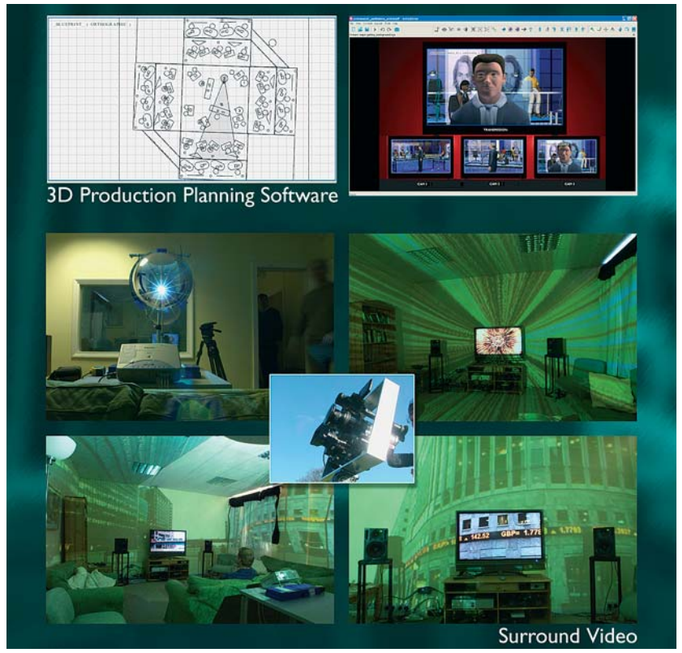
Although these developments are part of our long-term work to create new ways of making programmes, the technology we develop along the way can also be rapidly deployed to address short-term problems. One example of this was a requirement for a simple way of gathering votes from an audience. We developed a system to identify a hand-held baton and determine its orientation, so audience members could vote by holding their baton either vertically or horizontally. The batons were covered in a highly retro-reflective material, illuminated by a ring of LEDs around the camera lens, allowing the system to operate independently of the ambient light level.

Surround video

We have been looking at ways to use imaging technologies to present new forms of content to our audiences. Most people are already familiar with the concept of surround sound, where additional speakers are deployed around the room, fed by additional sound channels. We have been investigating whether a similar approach could be applied to video.

Rather than simply looking at the use of a very large screen display, we have investigated the concept of augmenting an existing conventional display with an image projected onto the walls and ceiling of the room. The projected image is generated in such a way as to extend the field-of-view of the existing display, helping to provide a 'context' for the main image, such as additional motion cues. We recorded a range of sequences with two rigidly-coupled cameras, one fitted with a conventional lens and the other with a wide-angle fish-eye lens. The image from the first camera was shown on a flat-panel display, whilst the image from the second was projected onto the walls and ceiling, using a projector and a spherical mirror. Real-time image processing was used to compensate for the distortion introduced by the fish-eye lens and projection system, ensuring that it aligned in position and scale with the image on the flat panel display. We also investigated several methods of synthesising a surround image from existing content, shot without a secondary camera.

Initial tests have been very promising, with audiences reporting a much greater sense of immersion.



3D production planning software

The quality and ease of use of 3D computer modelling has now reached the point where we can use it for pre-production planning. We are working with some of the developers of this software to see how it can best be applied to making production more creative and to reduce costs. We have started with studio layout and set design, although there are also other potential applications such as training.

Producers can test different options in a virtual space, helping them to make effective choices earlier in the production process. Our relationships with the software developers have allowed us to model real studio facilities such as cameras and cranes. This enables producers to see the exact shots they will get using particular equipment, so they can hire in without over-specifying.

Some programme makers have tried out the set design process. They found it not only useful in visualising the design, but also in communicating their ideas to others in the team. Decisions can be converted to floor plans for creating and building the real set. The virtual model is also easier to store than the traditional card-board models, and can be retrieved, for re-use or as a reference for the next series.

D-3 **Videotape** Preservation System

The BBC Television and Radio archives are among the largest collections of broadcast content in the world. They contain more than 300,000 hours of radio and 600,000 hours of television, and these figures grow daily.

The archives hold content on a variety of recording formats, which reflect technological advances made over the years. Great importance is placed on being able to retrieve content of any age, and it is often necessary to maintain access by transfer of content held on old formats to newer ones, because of physical media decay or obsolescence of replay equipment. Transfers must be done in real time with human supervision, because a sub-optimum replay or poor conversion will irreparably damage the content. With such a sizeable archive, this can be costly.

In an attempt to improve matters, the advantages of migrating to file-based formats have been explored. When content is held as a data file the content format is no longer dictated by the storage medium, and in future it should be easier and faster to move to a new storage medium, perhaps at the touch of a button. Content on file servers is more accessible than that held on videotapes stored on shelves. Quality degradation ought no longer to be an issue because true digital clones can be produced from data files.

'The system uses open standards wherever possible, to avoid technology 'lock-in' and to ensure that the files can continue to be accessed and understood.'

Content held on D-3 videotape is next in line for preservation. The D-3 format is only 16 years old but is no longer supported by its manufacturer. The BBC holds about 380,000 D-3 tapes (some copied from the earlier analogue two-inch quadruplex format) and 100,000 have been selected for content retention.

We have devised a system to capture the content from the D-3 tapes, and to augment it automatically with metadata.

The system is based around a high-end PC with an SDI capture card and specially developed software. D-3 is a digital composite PAL format, and BBC-designed Transform PAL decoders are used to give the best possible video quality. The captured signal is written into an MXF (material exchange format) file, together with descriptive and technical metadata that the system collects automatically from the BBC's 'INFAX' records – for example, programme and series names, transmission date and duration. The system also adds the error log from the tape replay, and analyses the video signal for picture flashes and certain spatial patterns, to note the level of compliance against OFCOM recommendations for photosensitive epilepsy. It also produces a low bit rate 'browse quality' copy of the content, and includes software for performing quality checking of the MXF file.

The system uses open standards wherever possible, to avoid technology 'lock-in' and to ensure that the files can continue to be accessed and understood. All the software written by the BBC in this work has been released as open source. This is to promote interoperability and to encourage further development by other parties, in particular to exploit the features of MXF for searching the content.

Initially the files are to be stored on LTO-3 data tape. When costs permit, they may be moved to file-servers. Up to ten programmes can be stored on each tape, a forty-fold saving on physical space over D-3, even though the video data is held uncompressed. LTO-3 is by far the most popular data tape format on the market, and is supported by a number of manufacturers. It has an open architecture, and Ultrium, the consortium responsible for the LTO-3 standard, has decreed that new generations of the data tape drives must be able to read tapes from at least the previous two generations.

Programme Production

Our emphasis has continued to be on exploiting commodity IT hardware so that the cost of equipment used for production can be brought down.

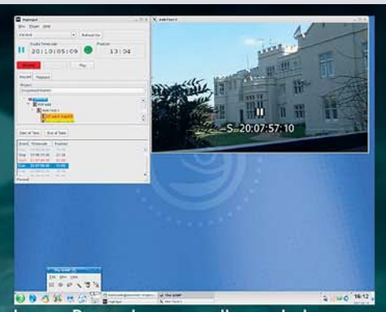
Where, in the past, four videotape recorders might have been used in a studio, the trend of increasing computing power means that a single mid-range PC can now perform this entire task.

This capability will bring about a dramatic change to the way programmes are recorded and pass through the production chain. Hence, we are continuing to work closely with colleagues in programme production, so that we can understand their requirements and see how the potential of the new technology can best be exploited.

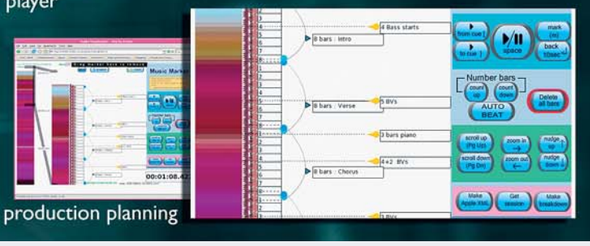

Mediaharmony file server


Production control room at Elstree studios


Ingex tapeless recorder


Ingex Recorder controller and player


Programme recording for ***BAMZOOKi***


Music production planning

Planning for music shows

Our work in previous years has produced a production planning system aimed at making the preparation of the camera script for a music show more efficient. It uses beat tracking to link the music breakdown to the lyrics and then to a standard video editing package, to allow camera shots to be planned against the music. Once the planning is complete a camera script is produced automatically.

We have now refined the software and developed quicker ways of working with it. We have encouraged more widespread testing of this improved version by production assistants and directors to see if the benefits can be achieved in practice. This has brought some mixed responses. However, interest is growing and after a little guidance and 'hands-on' experience, some directors are now trying the system with a view to using it for their productions.

In working more closely with production teams, we have also come to understand better what they require for different types of music show. This has led us to develop a more straightforward system where only a relatively simple annotation needs to be added. This is typical of shows that have a large number of musical items, where full planning of each would be too time-consuming. As well as beat and bar indications, our simpler system allows markers with comments to be added anywhere in the music breakdown, and the standard production script is later generated from this.

We now have music production teams testing this simpler system, and we hope to be able to work with them on some major music productions over the forthcoming year.

Tapeless recorder

We have made several enhancements to the tapeless recording system that we trialled last year with the BBC Children's programme ***BAMZOOKi***.

We have now produced a tapeless recorder capable of recording four video and 16 audio channels simultaneously, compressing them in real-time to the required production format (typically DVCPro50 or Avid '2 to 1'), and storing them as MXF files. Although a PC equipped with dual-processors, and each with dual-cores, is required to achieve this, the overall cost is on a par with a mid-range server and is dominated by four SDI capture cards. By equipping the recorder with 2 Tbytes of hard disc, it can record for up to two or three days in a studio.

Low cost server

A further development of this work has been a video server based on the widely-used *SAMBA* file system. This offers a way in which a low-cost server can be used to share content across a cluster of edit suites that are using either Avid or Apple editing software.

There are two difficulties in sharing content in this way, which we have been able to overcome by exploiting the virtual file system extension capabilities within *SAMBA*. Firstly, each Avid editing client expects exclusive use of the external storage. Shared access by multiple Avid clients leads to conflict, as each one attempts to create its own database files to index the video content that it finds. Our configuration of the server's virtual file system keeps these files separate, so no conflicts arise.

The second obstacle is that not all editing systems can work directly with MXF files – for example, Apple's Final Cut Pro. To overcome this, we have implemented on-the-fly unwrapping of the MXF files within the *SAMBA* server. This again exploits the virtual file system extensions of *SAMBA*, but in this case, when the original MXF files are accessed by the editing system, the server removes the outer 'MXF' layers and provides only the encoded content, e.g. DVCPro50, from within. In this way, the MXF files held on the server appear to the editing system as DV encoded files, which it can then use directly.

The next stage in the production flow is to make the recorded content available in a convenient way within the editing system. To achieve this, we are making use of the AAF ('Advanced Authoring Format') standard. When required, an AAF file is produced which contains the details of all the MXF files recorded in the studio over the interval of interest. Opening the AAF file in the editing system then populates the editing 'bin' with this content, making it immediately available for editing.

Additionally, for multi-camera productions (where each camera view is recorded simultaneously), the resulting recordings are automatically grouped together, which saves time by avoiding the manual step of grouping and synchronising the recordings within the editing system itself.

A typical multi-camera production method is to produce a 'Main' recording, which includes cuts between the cameras performed by the vision mixer, and separate, isolated recordings of some cameras ('Isos'). These latter recordings may be used in the editing of the programme to give different views, e.g. an audience reaction shot, when appropriate. However, a drawback of this method is that the timing of the cuts done as the recording is underway may not be ideal and slight trimming in post-production may be desirable. We can offer this capability by recording the timings of the cuts applied by the vision mixer, and from these, creating corresponding edit entries in the AAF file. When this AAF file is opened, the editing timeline will show the original camera recordings with the edits between them, which can then be trimmed where necessary.

To understand better how these developments perform in practice, we are working alongside the production team for the BBC programme ***Eastenders***, recording with our tapeless system in parallel with their normal tape-based process. It is too early to have clear results but the advantages of easy access to the recordings are obvious, with immediate replay into the control room and studio being a notable benefit. In the edit suites, rapid access to the recordings also saves significant time. In this case, the use of the MXF standard for recordings is a particular advantage as the files can be used directly within the editing system, eliminating the need for a file import stage. Although not as time consuming as ingesting from tape, file import would still slow down the process and reduce efficiency.

Editing from P2 memory cards

Another development was at the request of BBC Sport. For the coverage of World Cup 2006 they needed to be able to edit content from Panasonic P2 camera memory cards in an Avid editor, and transfer the edited version back to a P2 card for playout on location. This last step was proving impossible because of the way MXF is used on P2 cards. After studying the problem, we were able to produce an application to perform the necessary conversion and copy back to the card. The application

was used with great success, and means our production colleagues can now work more flexibly with P2 cameras.

We have made our software available as open source so that others can benefit and share in its development. These packages, along with related software, can be found at the 'Ingex' project page http://ingex.sourceforge.net/

This work is described further in a paper that was presented at IBC 2006, where we also demonstrated the complete system in the New Technology Campus.

As our work in this area progresses, we are continuing to explore with other programme production teams how we can work with them to improve our mutual understanding of the requirements and benefits of tapeless production techniques.

Floorman

Floorman is a wireless picture monitor developed by BBC R&I which may be used in one of two ways, with different technology for the two applications. We are now seeking to license the two versions.

- On the studio floor or on location, by a producer/director, usually in preparing and rehearsing multiple camera shots. It is planned to commission a manufacturer to produce and install a licensed system in a BBC studio. This will be available for use by production teams, to allow further assessment of its market potential.
- By a presenter at a live outside broadcast, for reviewing the action on which they will be commenting. Our prototype has been used regularly by horse racing presenter Clare Balding, and BBC Outside Broadcasts are currently using it for a market trial. If the trial is successful we will enter into technical discussions with a manufacturer to hand over licensed designs.

Timed text and subtitle multicasting

This covers our work in handling subtitles and similar text information where timing details are also included. The work is in two main areas.

Firstly, we have been providing the software tools to convert broadcast subtitle files to the formats required for use by the iPlayer, and for programmes provided online via bbc.co.uk. Subtitles used in each of the trials of iPlayer have been originated in this way and we have continued to refine the conversion process as the user requirements have evolved.

Secondly, we have continued to participate in the 'Timed-Text' working group of the World Wide Web Consortium ('W3C'), which is in the late stages of developing a standard for carrying timing details with text. This is applicable not only to subtitle exchange but also production processes, e.g. associating scripted text or indexing details with the recording of the content.

Building on this latter work, we are working within an AAF Association and EBU subtitling adhoc group which is producing a standard means for conveying subtitles in AAF and MXF files. This is based on the forthcoming W3C timed-text Recommendation but further work to specify details within the AAF and MXF standards has also been required to complete this functionality.

Radio Spectrum for Production

We are looking at ways for the BBC to continue to improve and expand its use of digital radio cameras despite changes in the spectrum we license from OFCOM.

The past year has seen great changes and challenges for wireless production, with the closure of our favoured band for PMSE (Programme Making and Special Events), 2500 to 2690 MHz. This loss of spectrum together with the increased popularity of radio cameras, the risk of yet more losses, increasing spectrum costs and the desire to make programmes in HD are presenting real challenges to the industry. Alternative spectrum between 2 GHz and 3.5 GHz is now being used instead, but this spectrum is fragmented and congested. Interference from high power CDMA services is causing concern at many sites.

An additional worry is the spectral purity of higher power COFDM systems that use these microwave bands. Commercially available systems have been measured, and some found to radiate excessive out-of-band energy in the adjacent channels. This limits adjacent channel operation, effectively halving the number of full performance channels that can be used at any one time.

allowing broadcasters to make better use of the limited PMSE spectrum that remains available.

Growth in broadcast applications, and the competing demands for 2 GHz spectrum from mobile and WiMax applications, is prompting us to consider a move to higher microwave bands. Initial work at 10 GHz has identified implementation, link budget and Doppler issues. We are now focussing on the 7 GHz band, working in collaboration with UK manufacturers on a solution for next generation HD Wireless Production. It is planned to exploit MIMO research work, described later, to provide new technology for PMSE use in these new microwave bands.

'We are now focussing on the 7 GHz band, working in collaboration with UK manufacturers on a solution for next generation HD Wireless Production.'

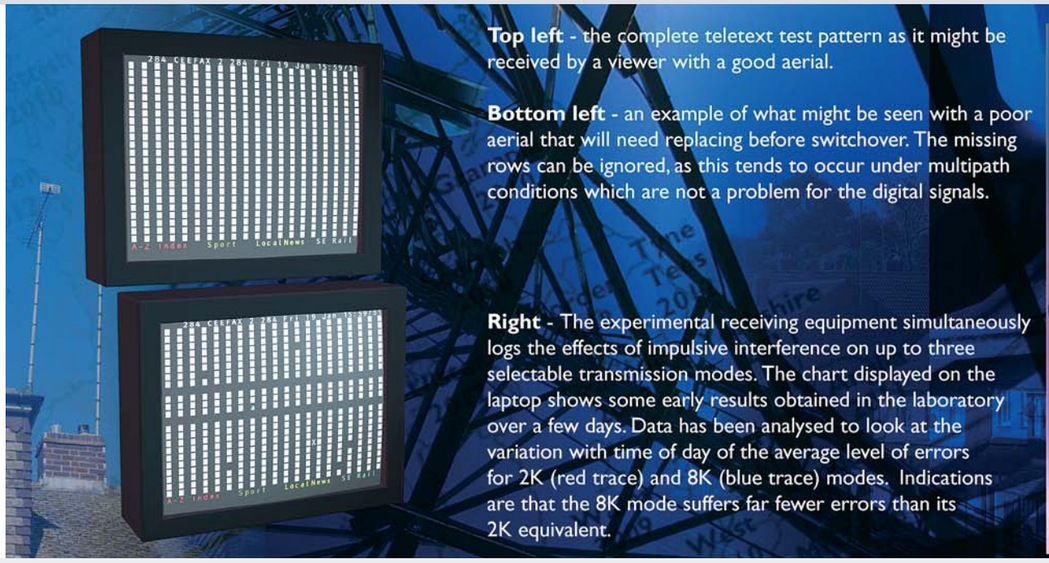
BBC R&I has been working closely with JFMG Ltd (the company that manages the spectrum on OFCOM's behalf for programme making and entertainment uses) to identify these problems and alert the relevant manufacturers.

A measurement programme also looked at protection ratio issues and the effects of 3G CDMA cellular services on current receivers. By working with industry in this way, we hope to improve the performance of commercial equipment

Digital TV – **Switchover**

From autumn 2007, UK broadcasters including the BBC will start to switch off their analogue terrestrial television signals. This process, known as 'Digital Switchover', will take place progressively across the UK, and is expected to be complete by 2012.

During this process the two digital terrestrial television (DTT) multiplexes the BBC operates are expected to migrate from 16-QAM to 64-QAM modulation, with a consequent increase in deliverable bit rate, and our services will inevitably continue to develop and evolve. We have also been asked to accommodate services from several other public service broadcasters in our multiplexes.



Top left - the complete teletext test pattern as it might be received by a viewer with a good aerial.

Bottom left - an example of what might be seen with a poor aerial that will need replacing before switchover. The missing rows can be ignored, as this tends to occur under multipath conditions which are not a problem for the digital signals.

Right - The experimental receiving equipment simultaneously logs the effects of impulsive interference on up to three selectable transmission modes. The chart displayed on the laptop shows some early results obtained in the laboratory over a few days. Data has been analysed to look at the variation with time of day of the average level of errors for 2K (red trace) and 8K (blue trace) modes. Indications are that the 8K mode suffers far fewer errors than its 2K equivalent.

To these ends a significant re-engineering of our digital television delivery system has been started which will result in greater multiplex efficiency and network resilience. It will also greatly simplify both the procedures involved in Switchover and the BBC's general ability to make technical changes to its digital services. We have contributed to the technical design of the new system, working with our technology partner Siemens and colleagues in BBC Operations. We are making extensive use of our digital TV test system to evaluate suitable techniques and technologies, modelling various multiplex occupancies to assess picture quality and strategic flexibility (the ability to change the composition of the multiplex for new services or service components, or to enhance or transfer existing ones).

Helping the viewers

As the analogue transmitters are switched off, many digital transmitter powers will be increased and the digital coverage is predicted to be similar to the current analogue coverage, approaching 100%. However, it is estimated that about 10% of domestic aerial installations will need attention to receive the digital transmissions. It is therefore important to give the best possible guidance to viewers to help them decide if their aerial needs to be checked.

The reception of existing analogue broadcasts can be a very useful guide to the condition and effectiveness of a domestic aerial installation, and we have been researching several techniques based on this. We first tried a test pattern that was designed to become less apparent as signal quality fell. Whilst this technique showed the correct average trend – those with good aerials tended to correctly identify the pattern – there was too much spread on individual results to give a reliable indication.

We have now created a test pattern using teletext. This gives an objective result, because the pattern is either received correctly or with obvious errors. The pattern has been designed to be as resistant as possible to delayed image interference (otherwise known as 'multipath' or 'ghosting'), which normally affects teletext reception significantly, but which the digital television transmissions are designed to ignore. It also appears to be reasonably tolerant of co-channel analogue signals.

Tests have been successful, with errors starting to show just at the point where an aerial installation ought to be checked. The test signal is about to be transmitted nationwide on the four original analogue services. (It would not be appropriate to transmit it on the analogue 'five' service, as the transmitter powers are at lower levels than for the other services, and the results would be misleading).

Our work in this area forms a part of the overall work being conducted within the Digital Reception Prediction Group run by DigitalUK, the non-profit organisation leading the process of digital TV switchover in the UK.

The digital switchover assisted help scheme

For the elderly and those with disabilities, Digital Switchover will present significant challenges. In September 2006 the UK Government announced the Digital Switchover Assisted Help Scheme, also known as the Targeted Help Scheme. This will offer people over 75 and those with significant disabilities help in the form of new receiving equipment, installation and follow-up support. Central to the scheme will be the procurement of equipment designed particularly for these vulnerable viewers, to promote accessibility to digital services for everyone.

Building on specific needs identified by the Consumer Experts Group (representing the elderly and those with disabilities) and in consultation with the DCMS, DTI, Digital UK and receiver equipment manufacturers, we have collated and produced a set of core requirements. These are intended to maximise ease-of-use for the great majority of those eligible for help, without unduly prescribing any particular implementation that might be offered in a process of open tendering, and without stifling ingenuity and innovation.

After a period of consultation the DCMS has published an invitation to tender for the supply of equipment on the basis of these requirements. (The 2006 Core Receiver documents are available on the UK government's digital switchover website: www.digitaltelevision.gov.uk).

Following the Licence Fee settlement, the BBC and DCMS are currently negotiating the commercial details of administering the Assisted Help Scheme, whilst some of the technical details of satisfying the Core Requirements are under discussion in various industry fora.

Impulsive interference

Experience has shown us that the effects of impulsive interference need to be allowed for when specifying or designing systems for digital terrestrial television. Impulsive interference can come from a wide variety of sources, for example car ignition systems, electric motors, light switches or room thermostats. Typically, it breaks the picture up into a mosaic of blocks, or causes a momentary loss of sound.

We have developed a receiver that measures the effects of impulsive interference against two key transmission parameters, signal level and transmission mode. The receiver can be left logging its results on a laptop PC over many days, to allow us to build up a statistical model.

The assembly of a pair of these receivers has only recently been completed, and the next stage will be to deploy them in domestic environments to make measurements under a range of conditions. Tests in the laboratory have already confirmed one expectation concerning transmission modes. There is a significant benefit in terms of resistance to impulsive interference by switching from the 2000 carrier mode ('2K') to the 8000 carrier mode ('8K'), which we hope will be one of the changes implemented during switchover.

Mobile and handheld television broadcasting

We have maintained a watching brief across the various emerging technologies that could be used for mobile and handheld television broadcasting, and provided advice and guidance where appropriate. If mobile transmissions are implemented using a cellular network radiating in the spectrum released by switching off analogue television, there is the possibility for interference to existing digital television reception. We have made measurements to analyse the conditions under which such interference will occur. We have kept the relevant standards organisations (mainly the DTG and EICTA) informed of our results and this should allow the effects from this type of interference to be minimised.

Digital TV – **Architectures**

Freesat

The BBC has been investigating the potential for a free satellite service, to complement Freeview in areas where DTT is currently unavailable. From our experience of launching Freeview we know that most of the technical building blocks for a free satellite service already exist. However there are significant differences between DTT and DSAT that we are having to take into account. Another important part of our work has been to define appropriate behaviour for different classes of receiver (for example, some receivers may have storage or be capable of decoding HD transmissions) and to consider the test requirements for each of these. Currently the decision on the future of Freesat is under review by the BBC Trust.

Centralisation of coding and multiplexing

The BBC is planning to centralise the equipment that codes and multiplexes its digital TV services. In advance of this, we have taken a significant role in the testing, configuration and technical sign-off for coding and multiplex equipment in BBC Scotland's new headquarters in Pacific Quay. This experience is proving valuable even though we know the technology will advance in the meantime. During the coming year, working with our technology partners Siemens, we will be setting up a new test-bed at Kingswood Warren to explore the options for the architecture and equipment for the centralised system.

DTT Multiplex B re-engineering

In summer 2006 the BBC decided that BBC Parliament should be played out on DTT in full screen, instead of the quarter-screen 'red button' service that had been operating since the launch of Freeview. The only way to do this without sacrificing the picture quality of all the services in our Multiplex B was to change the coding and multiplexing system for newer and more efficient equipment. This meant going to another supplier for all the major technical functions, including the primary encoding of the video and audio components, the multiplexing, and the capacity switching. Capacity switching was being used to carry CBeebies during the day and BBC Four at night, using the same capacity. With the new equipment it proved possible to extend these time-sharing arrangements to other services, in particular to make some capacity available for the trial of BBCi catch-up. The improved efficiency of the new equipment has also allowed the BBC to increase the number of News Loops from two to four. We modelled a number of different options to help our colleagues in BBC Distribution decide on the final capacity allocations, before helping to plan the changeover and put it into effect.

Designing for change

When Nicam stereo sound and teletext were added to analogue television broadcasts, this could not be done within the existing signal standards. Although the changes were made successfully, considerable engineering ingenuity was needed and there were constraints on what could be achieved. Viewers had to buy new TVs if they wanted the new features, and the extra signals had to be added in a way that did not affect reception on existing sets.

When the DVB standard (the international standard for digital television broadcasting) was drawn up, the engineers responsible made sure it could be extended in a systematic way to incorporate new features. The standard also defined a 'multiplex' structure that makes it possible to add, modify and rearrange TV channels and other broadcast components. This means that for many of the changes viewers do not have to replace their receiving equipment. Changes are picked up by digital TV receivers automatically, or by 'rescanning' or downloading new internal software.

The BBC continually exploits this flexibility to develop its digital services. Since the original launch, BBC R&I have helped to develop a number of new features, including interactive services, enhanced electronic programme guides, new regional broadcasts, and audio descriptions of programmes for visually-impaired viewers.

However, a great deal of planning is needed even for a small change, especially as we always try to avoid any loss of service. BBC R&I continues to carry out some of the development work, and to give advice and practical assistance. Using our experience and our specialised test facilities, we make sure new features work as intended, any new equipment is suitably chosen, and the best use continues to be made of the digital multiplex capacity.

Audience Research

How do you measure audience viewing figures when your audience has many ways of watching your programmes? This is the challenge facing BBC Marketing Communications & Audiences, with broadband and mobile phone access becoming increasingly popular and time-shifted viewing getting easier. Programmes are augmented with subtitles, interactive content, and electronic programme guides, and we need to track usage of these too, if we are to understand our audiences properly.

The ARENA project

The BBC has joined with nine other media organisations in Europe in a European Union collaborative project, ARENA, to try to devise a system that produces audience figures consistently across all these services and platforms. [Note that viewing data is collected only from household members and individuals who have their given informed consent to allow this.]

ARENA is planning four field trials on different platforms, linked through a common audience data collection system. The BBC has a particular interest in one of these field trials, on the new BT-Vision platform where we supply some of the on-demand content, as well as operating two of the DTT multiplexes also receivable through the BT-Vision 'V-box'.

This is an ambitious project, and the processes will be simulated before the system itself is built. Our work so far has been to establish the business and functional requirements for cross-platform audience research, talking to other organisations too to try to predict how services will develop. The project has used this information to create a formal data model. Our work is now to ensure that the model is a good representation of the real-world situations and that it is tested correctly – the eventual outcome from the other partners will be software that can be ported into set-top boxes or the platform operators' distribution systems.

Audiences for interactive services

At the request of BBC MC&A, and in parallel with the formation of ARENA, we have been developing an idea to measure 'red button' interactive TV usage on our digital television services. This uses a small 'index mark' added to each page of interactive content, created by the video rendering engine in the digital set-top box or digital TV using instructions conveyed as part of the interactive page description sent to the receiver. Last year, we produced a specification for the index mark on the basis of laboratory tests, and the Broadcasters Audience Research Board (BARB) commissioned a prototype detector from their technical contractor AGB-Nielsen. About 200 of these detectors have now been installed in the homes of existing BARB panel members (these are households that have agreed to have their viewing patterns monitored by BARB), for a limited trial. With the co-operation of other UK broadcasters, the index marks were added to some interactive content on terrestrial and satellite broadcasts, and also on to a digital cable system. Tests in collaboration with AGB-Nielsen were successful, after some minor adjustments to accommodate variations in the different signal chains.

The index mark is designed to be just off-screen on the majority of television sets, and indeed, no complaints about visibility were received, although potentially all digital receivers will reproduce it, not just those in the BARB trial. BARB is currently re-tendering its technical contracts and a decision on the use of this technique will depend on the outcome of this process.

Audio watermarking

Audio watermarking, i.e. hiding information in the programme sound, has been tried unsuccessfully for radio audience measurement in previous years. The systems offered have been found to produce unacceptable impairments to the sound quality. Finally, this year, a system that had been tested several times before was found to have been improved sufficiently to be inaudible in our laboratory assessments. On-air trials were able to start with much less worry about the possible negative impact than has been the case previously.

DAB and Digital Radio Mondiale

AAC coding and DAB+

BBC R&I submitted one of several proposals in response to the WorldDMB* call for contributions for adding a more efficient audio coding system to DAB. The work was co-ordinated by the WorldDMB Technical Committee in a collaboration across Europe, Asia, North America and Australasia.

Our proposal was adopted by WorldDMB after a careful analysis of all the competing solutions and after field tests carried out in the UK and Australia.

The result is DAB+, announced in March 2007. We have taken responsibility for standardising DAB+ through ETSI.

The main part of the proposal is an option to use high-efficiency AAC coding for radio broadcasts, creating capacity that could be used for more stations, interactive services or surround-sound broadcasting. Audio quality is improved at lower bit rates, and an improved error correction scheme gives slightly greater coverage, quicker tuning and no relative timing delays between stations.

For the BBC this work is decidedly long term, to ensure that technical standards that may one day allow us to introduce new services are carefully considered before being agreed. While countries that have yet to launch DAB could opt immediately for DAB+, the BBC remains committed to its MPEG Audio Layer II broadcasts. It is well aware of its responsibility to its listeners, many of whom will only recently have bought new DAB radios.

* Formerly the WorldDAB Forum.

Digital Radio Mondiale

Digital Radio Mondiale (DRM) offers clear, high-quality audio and data services on the long, medium and short wave bands. DRM is now a fairly mature standard and there are many hundreds of hours of transmissions on-air.

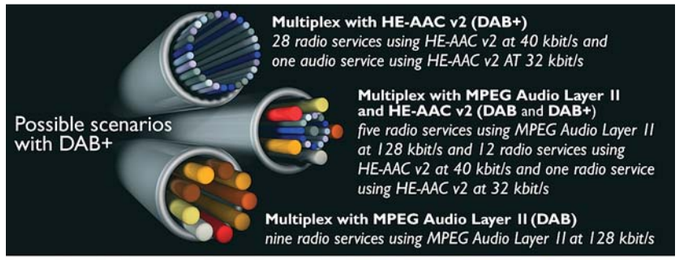
Consumer receivers are crucial to the large-scale uptake of DRM, and are beginning to become available. We have driven this development in two key ways.

Firstly, all the current receivers are based on code which we originally developed and licensed to manufacturers, and we continue to support our licensees with their implementations.

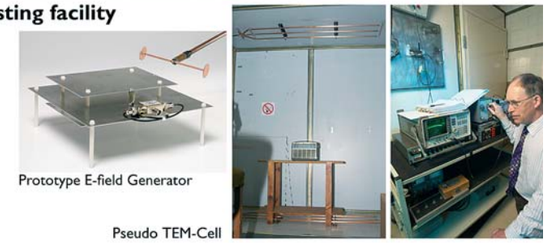
Secondly, we have built up an extensive receiver testing facility at Kingswood Warren, allowing us to perform tests including sensitivity, selectivity and linearity. In particular we have been able to expose receivers to known field strengths in order to determine if they will work in the field with the signals that broadcasters plan to deliver. This has revealed a number of shortcomings in the early prototypes, and we have worked closely with manufacturers to improve their performance.

We have also continued our development of receiver algorithms, looking particularly into the possibility of seamless AFS (alternative frequency switching). This could enable a low-cost receiver with only one front-end to take advantage of the benefits of multiple-frequency transmissions, which we have previously demonstrated with our dual-front-end diversity receiver.

Whilst the BBC World Service is our main customer for DRM, we have recently helped BBC Distribution to prepare for a consumer trial of DRM on medium-wave, being carried out in partnership with BBC Radio Devon and National Grid Wireless. We have given advice based on our long experience of DRM as well as providing monitoring stations for the trial. As part of this we have developed a monitoring receiver network to allow reception conditions in various locations to be observed in real time.



Receiver testing facility



Prototype E-field Generator

Pseudo TEM-Cell

Kamaelia

Kamaelia is the software toolkit we created for exploring on-line delivery methods for the BBC's archives. How do you make the BBC's considerable archives available on-line to, say, 20 million households at once, especially if they all want to watch something different? The solution needs to be scalable, acceptable to organisations that have rights over content the BBC holds, and flexible enough to exploit changes in technology.

We started to develop *Kamaelia* about two years ago, and at the end of 2005 BBC Radio & Music Interactive had used it to produce a prototype system for transcoding all BBC radio output.

Over the past year, we have created a television equivalent for BBC New Media. This was a significant piece of work needing a large number of optimisations to produce a scalable system. Since then *Kamaelia* has been used in a number of other projects. Tools for re-framing video for mobile devices were created for researchers looking into mobile delivery. A system was created for capturing BBC broadcast content, storing it, transcoding for different bit rates, and preparing it for peer-to-peer transfers. A rather different application, cross-site white-boarding to allow people in different locations to collaborate more easily, was quickly created, then expanded to include audio and made peer-to-peer aware with local remixing for scalability.

We continue to move *Kamaelia* out of the laboratory and into the wider BBC, academia and industry. We have given talks at a number of high profile conferences for software development, and we ran a workshop in Brussels for interested collaborators. We mentored a number of students during Google's Summer of Code 2006, resulting in tools for peer-to-peer online distribution, 3D user interfaces, and proofs of concept for trusted communications. This also proved that *Kamaelia* can be learnt and used effectively in a very short period of time by the average developer.

Our next steps are to consolidate *Kamaelia*'s core and to increase testability, looking for a similar level of verifiability to hardware. We are also aiming to make some aspects of *Kamaelia* to the non-programmer – we want to take the graphical construction tools that are used in *Kamaelia* to sketch new systems, and extend them to create the code directly.

Because *Kamaelia* is open source, this enables everyone from schools and colleges through to enterprising members of the public, to use it to create applications including ones to repurpose our content to serve their needs.

To collaborate with us, visit http://kamaelia.sourceforge.net/Home

Kamaelia, parallelism and concurrency

Distributing the BBC Archive content online is an inherently parallel process. Large numbers of people are simultaneously searching and downloading material, and this is a huge test of a distribution system, both its hardware and software.

Software engineers define concurrency as the real or apparent running of multiple processes at the same time. Modern computers, particularly professional machines and games consoles, have multiple processor cores, whereas computer software has its roots in single processors and sequential processes. The reason that concurrency has been made to work is down to putting fundamental rules in place.

Kamaelia was developed by BBC R&I to make an online distribution system straightforward to create and easy to maintain. A happy side effect is that it can be used to develop other applications for communication where the biggest problems arise from parallel processes. It is this aspect that we are now exploiting, and encouraging others to exploit by making *Kamaelia* open source.

Networks for Programme Production

Modern programme production tools no longer consist of specialised broadcast hardware interconnected by coaxial cables. They are now almost invariably computer applications running on PCs, and they use file-based media storage rather than tape. As a result, IT network connections are now an essential part of any production system.

Media files can be extremely large, putting patterns of demand on an IT network quite unlike conventional IT traffic. BBC R&I has for a number of years investigated the problems this brings, and worked with suppliers, manufacturers, and standards bodies to establish solutions.


Audio over IP

IT networks are usually packet switched, and their properties are significantly different from the circuit switched networks we have traditionally used to carry our signals. Being primarily designed for regular IT traffic, they do not always perform as well when faced with large media-content files. Over recent years we have bought or developed a number of highly specialised test tools, and we are continually studying the latest offerings to judge if the claims made are justified as far as media production is concerned. One of our developments is a software application that can be ported out to multiple PCs to simulate a busy production office or even an entire site. We are now investigating next-generation multicast streaming protocols, and, with HD production in mind, the performance of 10 Gbit/s IP routers.

Through this work, we ensure the BBC understands the issues surrounding network provision, and specifies appropriately from our technology supply partners. We regularly feed back the results of our tests to manufacturers, or do tests with them, to help tune products for media use. We have also found it important to take part in the work of the relevant Standardisation bodies, because of the strong influence that standards have on the design of IT equipment.

We also run a number of research and innovation projects:

PRISM

We lead the DTI collaborative project PRISM, which is applying distributed-computing 'GRID' techniques to media production. Although the project itself will finish at the end of 2008, it is part of our longer term work to try to streamline and enhance the technical processes in programme production. The other aspect of the work is to encourage standardised interfaces, so that production tools will work together even if chosen from different suppliers. PRISM will publish the interfaces it develops as a set of open specifications.

As a simple example of what PRISM is seeking to achieve, imagine creating a documentary programme from content which has been shot over a period of years on different systems. It would help if the editing system applied any necessary format conversion automatically, without the operator needing to intervene to take decisions or start the process. With GRID, the editing system could delegate the tasks of comparing formats and making the conversions, especially if the content was being retrieved from remote locations.

A more challenging example is adding a formal description of media content as it goes into repositories. Descriptive metadata is important for searching and retrieval. It is however extremely labour-intensive to create, and this is a definite disincentive. One of the partners in PRISM has considerable expertise on machine-interpretation of images, and we are very interested to find out if their techniques can be applied here. The interpretation is not entirely automatic, but needs only a small amount of prompting on context from a human operator. It is nevertheless computationally intense, and can benefit from GRID techniques. PRISM aims to demonstrate a scalable high performance system built on a standard IT core.

PRISM is working closely with BBC Northern Ireland, and will be tested in conjunction with a number of programmes that they produce.

WiFi for TV programme production

WiFi is rapidly becoming a de facto standard for connecting Media Centre computers to TVs and audio systems. This is not an application WiFi was originally designed for, but some additions to the standard have made it just about suitable for domestic use. We have been looking with a number of companies at other ways of extending the standard, to allow us to use WiFi in TV production.

WiMax

WiMax is similar to WiFi, but works at higher powers and has greater range and capacity. Its transmission in the 5.8 GHz band is licence-exempt, and we have carried out a series of tests to see if it could be used for ad-hoc contribution and distribution links. Transmissions at this frequency can be affected by buildings, so WiMax uses COFDM to benefit from reflected signals.

We arranged for a transmitter aerial to be installed on a mast on high ground in North London, and mounted a receiver aerial on a 10 m mast on a radio van. Tests at points chosen at random within 5 km of the transmitter all gave a throughput of at least 10 Mbit/s, and some achieved 20 Mbit/s. These bit rates are all adequate for high-quality contribution and distribution circuits.

We then moved to the Westminster area, where BBC News are trying to find a quick and economical way of setting up links back to their local studio. UrbanWiMax, a company that provides Internet services for business users, provided us with a temporary bidirectional link. Their WiMax network has a nominal maximum capacity of 4 Mbit/s (limited by the backbone rather than the WiMax itself), and is intended to provide spot capacity and diversity from cable connections. It covers most of the locations in Westminster that BBC News regularly use.

This is a much more built-up area, and tests with the radio van showed some locations where no signal was received. However, where a signal was obtained, in most instances it would support up to 2.7 Mbit/s video and 192 kbit/s audio streamed simultaneously, definitely acceptable for news reports where a lower picture quality is acceptable and a video bit rate of about 1 Mbit/s is usually considered adequate. We also noted that the audio quality exceeded our expectations even when reduced to 64 kbit/s.

Audio over IP

In 2004 some of the BBC's local radio stations started to exchange audio content over standard IP networks, using broadband ADSL connections. We were asked to help when it was found that some codecs were more affected by network conditions than others, and that codecs from different manufacturers did not always work together. This was worrying – we were hoping that IP technology would be an easy replacement for ISDN lines when these start to disappear.

We have therefore carried out a series of investigations, running tests on a range of commercial codecs. We are now working to establish an interoperability standard and a recommendation of good operational practices. This work is being done through the EBU, under whose authority the standard and recommendations will be published, with help from IRT in Germany and Sveriges Radio. (Sweden is already faced with losing all ISDN services in the next two years). It is intended to produce a reference codec with which to test commercial products for compliance.

Radio Systems

The BBC is a major user of radio frequency spectrum, not just for its public broadcasts but also for many internal purposes such as wireless cameras, wireless microphones, and passing signals back from outside broadcasts. Spectrum is a scarce resource, and we are constantly looking for techniques to make more efficient use of it, as these three pieces of work demonstrate.

MIMO

MIMO stands for Multiple-Input-Multiple-Output and refers to a wireless system with more than one transmitter and receiver, all operating on the same frequency but with each transmitter carrying a different signal. Each receiver picks up a mix of the transmissions, depending on propagation conditions and the placing and polarisation both of its aerials, and those at the transmitters. If the receivers can determine the mixes in the form of a mathematical matrix, their outputs can be passed through the inverse of this matrix to recover the original transmissions. In the experimental system described here, the receivers calculate the matrix by measuring the pilot tones already present in the DVB-T signals.

The increased capacity is obtained at a cost. Depending on the amount of mixing, the received signal-to-noise ratios can be worse than for a single transmitter and receiver, and this might reduce range or require more transmitter power.

MIMO

MIMO is a method for increasing the capacity of a radio link by running multiple transmissions on the same frequency. To investigate its potential BBC R&I has produced a prototype MIMO system using two transmitters and two receivers, with the transmissions based on DVB-T. An experimental pair of 50 W ERP transmitters has been installed at a site near Guildford. A survey vehicle has been equipped to investigate the coverage for both fixed and mobile reception. The transmitters can be switched remotely between dual-polarised or co-polarised transmission, to explore different configurations. We are doing this work in collaboration with OFCOM, Arqiva and National Grid Wireless within a new group set up for the purpose and chaired by the BBC, known as the Advanced Terrestrial Transmission Study Group, or ATTSG.

Initial results using 64QAM rate 2/3 modulation suggest that the coverage of dual-polar DVB-T MIMO is very nearly as good as that obtained for DVB-T itself, with a data throughput of 48 Mbit/s compared to 24 Mbit/s for the standard system.

Because MIMO is one option that is being considered for updating DVB-T, the results of this investigation are being made available to the DVB-T2 technical working group (described opposite).

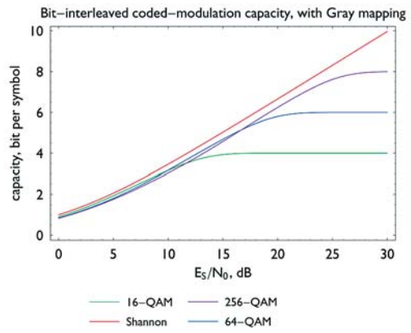
On-channel repeater

BBC R&I has developed an on-channel repeater for the DAB and DVB-T frequency bands. This device, first shown by the BBC at IBC in 2005, allows a relay station to re-transmit a signal on the same frequency as it is received. This is normally difficult because the receiving antenna almost inevitably picks up some of the signal from the transmitting antenna, causing howl-round. The on-channel repeater is particularly useful for filling 'holes' in the service area of a transmitter, or extending the range.

We have protected the key technology with a number of patents, and we have issued a licence to use the algorithm to a major transmitter manufacturer. More enquiries for licences have been received both from the UK and overseas and are currently being processed.

Trials have been carried out in collaboration with network providers in the DAB band, with additional DVB-T trials scheduled for the near future. Information regarding the behaviour of the system in complex single-frequency networks (SFNs) has allowed refinements to be made to the algorithms.

This year has seen the original system enhanced in a number of ways to improve signal-to-noise ratio and the ability to track rapidly time-varying coupling paths. So much so, in fact, that the system has been lab tested at 2.5 GHz in a PMSE (Programme Making & Special Events) radio-camera mid-point application. The results are very promising and we are close to having a solution to offer for this application. This would minimise the number of PMSE operations needing two frequencies at a time when this spectrum is likely to become increasingly expensive.



In trying to squeeze more capacity out of the precious UHF spectrum, the DVB-T2 project is bound by theoretical limits to what can be achieved. The Shannon capacity limit is well known; however, it is sometimes forgotten just how idealised it is. Once certain choices are made, such as picking a particular combination of constellation and bit mapping, more detailed application of Shannon's information theory shows that rather less capacity is then achievable, even in an ideal case. This graph serves as a benchmark for studies of error-correcting codes together with the possible addition of higher-order constellations like 256-QAM to the system.

DVB-T2

In 2006 BBC R&I submitted a paper to DVB, proposing the formation of a Study Mission to consider updating the standard for digital terrestrial television transmissions. The proposal was accepted and we were asked to lead the study, which identified several technologies that could be used to increase both efficiency and ruggedness.

We were then asked to lead a DVB technical study group to continue the technical analysis, in parallel with another group preparing the commercial requirements. The work of these groups is still underway. Currently it appears that a modest increase in capacity could be achieved through the use of advanced error correction codes, such as those used for DVB-S2, together with some changes to the underlying transmission system to eliminate other minor inefficiencies. Although a significantly greater increase in capacity (i.e. double or more) could probably be achieved through the use of MIMO this would require changes to both the transmitter aerial and the viewers' receiver aerials.

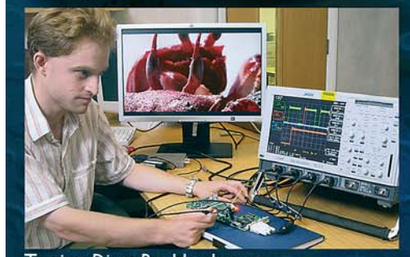
The commercial attractiveness of these options is still being studied. Existing digital viewers would need to buy new set-top boxes or digital TVs, so the introduction of a new standard might have to be incorporated into the launch of a new service, for example HD on DTT.

It is expected that a first draft of a specification for fixed and portable reception will be completed around the beginning of 2008, with a further specification for mobile receivers following later.

Video **Compression** – *Dirac* and *Dirac Pro*

Almost everywhere video is handled digitally some form of data compression is applied. Although satisfactory forms of compression exist for most applications, some are subject to restrictive or expensive licensing arrangements. This can increase our costs, and potentially the cost to our audiences in receiving our programmes. The BBC as a publicly funded body is in a unique position to develop open compression technology where it has a specific need, and to make that technology freely available. For example, the BBC's Open Archive initiatives will be making content available over the Internet, and we would like to be able to supply free software to schools and other educational bodies.

Dirac algorithm development



Testing *Dirac Pro* Hardware

Dirac Pro Hardware Products

Dirac team

Testing *Dirac Pro* hardware

Dirac

Over the past few years we have drawn on practical experience that dates back to the 1960's to develop an advanced video compression system called '*Dirac*'. Although we originally intended *Dirac* for high resolution images and high bit rates, its wavelet-based compression technique has proved suitable for applications from over 1 Gbit/s down to below 100 kbit/s. It is comparable with the latest standards H.264/MPEG-4 AVC and VC-1.

Dirac is open source, relies on no other parties' intellectual property, and can be used without payment of royalties. Its potential uses range from low resolution coders for mobile phones and Internet distribution of video clips through to HDTV and beyond with ultra-high resolution Digital Cinema. *Dirac* works under Linux and on Apple Mac PCs as well as Microsoft Windows. The ability to work on different operating systems is important to the BBC's plans for 'On Demand' TV via the iPlayer and streaming content over the Internet.

During the past year we have continued to improve *Dirac*. The algorithm has been made more efficient and easier to implement. A detailed specification has been published and open-source software made available to allow anyone to develop implementations. A second implementation, called Schrödinger has been optimised for speed although because of this it is somewhat harder to use as a basis for further development. Both implementations can decode standard definition TV in real time, with Schrödinger able to do this even on average specification PCs.

Measuring video quality

The technical quality of television pictures has been a frequent topic for discussion, even before the launch of the regular service. The debate continues, now largely over digital TV and latterly, HD.

Amongst the early broadcasts of the current HD trial were live programmes covering the FIFA World Cup from Germany. The broadcast arrangements were going to be complex using a chain of up to four MPEG-2 contribution links followed by transmission to the home using H.264 compression. Knowing that passing video signals through cascaded compression systems can cause extra picture degradation we simulated the entire chain. By experimenting with bit rate settings we were able to measure the video quality that would be achievable at home and recommend a number of improvements.

This was perhaps an extreme example, but any production chain will include a number of different compression systems between camera and broadcast, and there may also be format conversions. Because of the range of compression systems now available there is more than ever a need for a reliable and standardised method for measuring video quality.

Measuring video quality is an area we are continuing to research. In the coming year we plan to establish a test-bed to investigate and provide specialist advice on video quality within the BBC. We are continuing our programme of evaluating compression codecs and investigating issues of concatenated coding, focusing mainly on acquisition and production. We are contributing to collaborative work on this topic within the EBU.

Dirac Pro

We have now produced an implementation specifically for higher bit rates, which we have named *Dirac Pro*. It shares many features with *Dirac* and is most suitable above 100 Mbit/s.

Dirac Pro's initial application was to transport 50 frames/second (fps) HD signals on the same cables and infrastructure as conventional 25 fps HDTV. Video at 50 fps conveys a more 'fluid' motion and the BBC plans to move to this higher quality standard over the next few years. It is particularly suitable for sports coverage in HD, and could be used for the 2012 Olympic Games. *Dirac Pro* provides the 2:1 compression, sometimes known as 'Mezzanine' compression, with almost no loss in quality.

Another application of *Dirac Pro* is the transmission of HDTV signals between studios and production centres, using the existing distribution infrastructure. This requires more compression but *Dirac Pro* is sufficiently flexible to achieve this with little loss in quality. Many other applications of *Dirac Pro* are also possible, in programme production using networked infrastructure ('desktop production') and also in digital cinema production. *Dirac Pro* was successfully demonstrated to film makers in January 2007 at the Hollywood Post Alliance.

Dirac is attracting considerable interest both from within the BBC and from other organisations. It was demonstrated publicly at IBC 2006, where content from the BBC's HDTV trial was compared favourably with satellite broadcasts using H264 at the same bit rate.

We are currently formally standardising *Dirac Pro* through the SMPTE. A draft of the specification, referred to as VC-2, has been submitted and we are now waiting for it to be ratified. Establishing the standard will encourage equipment manufacturers to incorporate *Dirac Pro* into their products. An implementation of *Dirac Pro*, developed jointly with our commercial partner NuMedia Technology, will be launched at NAB 2007.

Where next?

We now regard our original implementation as a reference and have released it to several universities as a development platform. We are collaborating with them to exploit *Dirac* further and push the boundaries of video compression.

As 3D displays move closer to reality, both for the home and mobile devices, we are working with the University of Surrey to develop methods for compressing 3D video content. These techniques also help in modelling motion in conventional 2D images, and could help in improving compression there.

Brunel University are adapting *Dirac* technology to produce bitstreams that can withstand poor quality transmission systems and the effects of network congestion, avoiding the complete collapse in quality that bedevils conventional compression techniques.

As bit rates are pushed ever harder, it becomes increasingly difficult to maintain picture quality. Because the relationship between encoder control mechanisms and perceived quality is very poorly understood, encoder designers rely on ad-hoc, indirect, techniques to avoid quality collapsing when encoders are stressed. Manchester Metropolitan University have embarked with us on a project to incorporate psycho-visual modelling techniques into video encoder designs to manage video quality directly, using *Dirac* software as a test-bed.

Audio Compression

Audio bit rate reduction

A study has been made of MPEG Audio Layer II coding to find out how good it would be if an optimal coder could be developed. A 'genetic' coder was devised that could explore the myriad permutations of encoding that could be applied to each 24 ms frame of audio. The coder worked more slowly than real time but it was possible to record the results and listen at normal speed. The work was presented in a paper to the AES European Convention in 2006. We concluded that the potential for further improvement was marginal, the best coders already being close to the performance of the genetic coder.

There is always pressure to reduce the bit rates of the audio signals on DAB to make room for new features. MPEG Audio Layer II coding is adjustable only in moderately coarse steps in bit rate, and it is difficult to make reductions without compromising the audio quality. BBC R&I has continued to be closely involved in the assessment of proposed changes.

Multi-channel audio

BBC R&I took part in a major series of subjective tests organised by the European Broadcasting Union's B/MAE (Multi-channel Audio Evaluation) project group. In the first set of tests the subjective quality of multi-channel audio bit rate reduction systems such as Dolby Digital Plus, High Efficiency AAC MPEG Surround, and DTS was carefully assessed. These are systems that are, or could soon be, used for broadcast or Internet distribution of high quality surround sound, with or without accompanying video.

Early results were presented by IRT at the EBU's Forecast '06 conference. A paper has been written by BBC R&I together with colleagues from the EBU and IRT, and is to be presented at the 122nd AES convention. The conclusions reveal interesting performance evolution over the ten years since the previous comparable tests. With non-critical material, modern coders can achieve results as good as their predecessors but at a significantly lower bit rate. However, maintaining consistently high quality still requires the same, relatively high, bit rates.

Independent component analysis

Independent component analysis is a technique for splitting a sound signal into its component parts, and dealing with each one separately. As a simple example a duet might be split into the sounds of the two instruments, which in this instance would clearly be easiest from a stereo recording. We are fascinated by the applications that could be developed from this fundamental technology. A joint project is being set up with the University of Salford to examine how it might be applied in real broadcast audio environments.

Digital Rights Management

The Internet revolution encourages media businesses to find new ways to exchange content with their customers and between themselves. Digital Rights Management (DRM) is important in controlling and protecting these exchanges. However, some of the systems in use are proprietary, and as the number of connections multiplies, failure to develop interoperable solutions could be a major obstacle to the growth of the industry.

The requirements of DRM vary from limiting access, through 'copy control', to much more flexible permissions. In some cases DRM is used simply to protect the integrity of the content or authenticate authorship rather than limit distribution or collect remuneration.

BBC R&I has been working with partners in industry and academia to develop open DRM solutions. We have supported the broadcast technology providers through the DVB organisation as they specify the technologies for protecting content delivered over broadcast networks.

We also participate in the Digital Media Project (DMP) as it develops specifications and builds software prototypes from its 'Primitive DRM Tools'. These smaller DRM related functions can be used to assemble a variety of value chains according to individual business needs. The DMP aims to provide the technological means and organisational framework to allow participation in the media industry both by large content distributors and individual media creators wishing to distribute content with varying degrees of security. The DMP specifications bring a more inclusive model for all players in the value chain, from authors, performers, adapters and producers through to content providers and home users.

'The DMP aims to provide the technological means and organisational framework to allow participation in the media industry by both large content distributors and individual media creators wishing to distribute content with varying degrees of security.'

More recently we have begun working with a large group of academics and industrial partners within a mature and established project, funded partly by the European Union, that has developed a platform for cross media production and distribution; AXMEDIS.

In working with these international groups to develop and consider the issues of deploying DRM solutions we have come to a closer understanding of how our industry is changing and can change further to meet the demands of our modern world. By working with the wider industry we are better placed to control our own future and meet the needs of a new type of audience in the new digital age of broadcasting.

Collaborative **Projects**

BBC R&I works closely with other broadcasters, industry and universities in order to maximise the effectiveness of our research effort, to share knowledge, gain early insights, and influence emerging new systems and standards. Collaboration ranges from funding of students through to participation in major projects, many part-funded by government or the European Union.

We are pleased to acknowledge the effort and support given by all the collaborators and funding bodies mentioned in this review.

The BBC

Our research and innovation builds up a depth of knowledge in a technology, usually before it starts being rolled out as an application. When the BBC needs to deliver the technology our expertise is invaluable to a successful deployment. There are numerous examples in this Review where we are providing advice and active assistance, ranging from very visible projects such as the Digital Switchover and the test transmissions of HD, to more esoteric work on programme production and transmission technologies.

Other broadcasters

The European Broadcast Union is a central co-ordinating body that brings like minded organisations together, and many of our contacts with other European broadcasters are through its technical working groups. Extending our view outside Europe is also important, for new systems are often introduced first on other continents, HDTV being the best recent example. We have developed stronger links with, for example NHK in Japan and CCTV in China. These different cultures traditionally view technologies differently from Europe and we can learn from this. Also these areas, together with India, have a very strong technical capacity and are influential in world markets, and the consumer marketplace.

Universities

Our links with Universities are numerous. As well as direct links, we also have DTI sponsored projects and many informal contacts. The academic knowledge which this brings can underpin any development of a new service or system.

Collaboration in Europe

We contribute to NEM, the Networked Electronic Media initiative, with the aims of influencing and guiding the research agenda for the European Union's Framework programme of research. This is an association of experts in the technology of media and their insight and guidance is an important pre-competitive indicator of future directions that the industry is taking.

A number of our research projects are enhanced by joining consortia funded under the European Union's Framework 6 research programme. This allows us to contribute and gain from projects that are typically budgeted at many millions of Euros.

ARENA
www.ist-arena.org

Arena is part funded by the European Union. It is exploring methods of measuring and aggregating audience figures on mobile phones, broadband connections and video recorders, as well as the conventional digital platforms. Arena runs for three years and is due to finish in December 2008. We are supported in this project by colleagues from BBC Marketing Communications and Audiences.

AXMEDIS
www.axmedis.org

AXMEDIS is part funded by the European Union. The project provides an open solution which builds on technologies and tools to reduce costs and increase efficiency for the production, protection, management and distribution of content.

CALLAS
www.callas-newmedia.eu/

CALLAS is part funded by the European Union. The New Content Paradigms area focuses on building upon the BBC tradition of rich narrative. We are researching how to bring this BBC quality into the interactive domain, looking at techniques for both authoring and play-out of truly interactive ('open-ended') stories. CALLAS is combining the use of emotion-sensing interfaces with interactive narrative techniques to produce a 'bardic interactive storytelling engine'.

iview
bbc.co.uk/rd/projects/iview

We lead this DTI-funded project which is developing methods to capture action from events such as a football match in 3D and to provide a 360 degree free-viewpoint video replay of this action, as if from a virtual camera.

MATRIS
www.ist-matris.org

MATRIS was part funded by the European Union, and finished in January 2007. It developed markerless camera tracking technology that used naturally-occurring features in the scene. It also developed an inertial sensor and looked at the use of an auxiliary camera to improve the tracking. We coordinated the project demonstration at IBC 2006, which attracted the interest of several potential licensees.

Participate
www.participateonline.co.uk

Participate is a three-year DTI-funded collaborative project. It is exploring the convergence of pervasive, online and broadcast media to create new kinds of mass participatory events where a broad cross-section of the public contributes and shares content.

PRISM

We lead this DTI-funded project which is developing workable production services based on GRID distributed computing techniques.

Standards

The BBC has always worked in a so-called horizontal market where many players can share the same technology for different business purposes. The only way we can make this work is by adopting standards. Standards define almost every part of the broadcast chain, from before the capture of images and sound, all the way through to the display and loudspeakers at home. We therefore make a serious effort to help standards bodies to create proposals which will work well for public service broadcasters and in a complementary way to the commercial goals of private industry.

Some standards endure for many years, otherwise we would find it difficult to operate. However, the situation is always fluid because of new consumer devices and services, technical developments and changes in business processes. New standards and additions to existing ones frequently need to be progressed, and the pace of change is accelerating.

In the early days standards were set nationally. For the past twenty years or so, we have seen a steady movement towards international and global bodies. But there is still no dominant body with responsibility for all the standards that are used in broadcasting, and indeed we now find there are standards from the telecommunications and IT industries that are equally relevant to our business. This means we often have to follow work through several standards bodies to ensure we have the right tools for us at the end.

Because of our pro-active approach to standards, engineers from BBC R&I are frequently invited to join standardisation groups, recognising not just their technical contribution, but the fair and reasonable balance we are able to broker when discussions become fractious and commercial. In many groups we are also asked to take the chair.

There are a number of other standardisation bodies and organisations, for example MPEG, the TV-Anytime European Users Group, and some technical groups in the EBU and SMPTE, where we hold membership or otherwise follow the proceedings, to make sure the BBC's interests are not being compromised.

Where possible we would like to see standards that are:

Open
The standard is fully described in documents that are obtainable by anyone, so that any competent engineer can read the specification and recreate the technology.

and

Free
Or at least available on reasonable terms. Even a small charge for each instance of a standard being used can add up, given the volume of the BBC's output and size of our audiences. Worryingly, we are starting to see instances of royalties being demanded after a standard has been committed to.

International

Digital Video Broadcasting Project (DVB)

The Digital Video Broadcasting Project (DVB) is a consortium of over 260 companies and other organisations developing global standards for the delivery of digital television and data services. Their work has now extended beyond broadcasting to the convergence of Internet and mobile systems in the home. DVB specifications are offered to ETSI, CENELEC, the EBU, or the ITU to create the standards themselves.

BBC R&I has been instrumental in a number of DVB standards.

DVB MHP IPTV specification

The DVB Multimedia Home Platform (MHP) is an advanced platform for interactive TV. This year DVB has completed an IPTV profile for the MHP.

We contributed and edited the TV-Anytime parts of the specification, based on our earlier work in the myTV and Share-it collaborative projects. This allows the MHP to provide rich programme guides based on information delivered via broadband IP.

DVB-CPT

The first elements of the DVB Copy Protection & Copy Management (DVB-CPCM) were released in November 2005 as the DVB 'Blue Book'. This includes the DVB CPCM Reference Model and Usage State Information (USI) – an interoperable description format for the copy control conditions associated with protected content.

DVB-GBS

This group defines the carriage and signalling of data and SI (including TV-Anytime) in the DVB transport stream.

DVB-SUB

We chair this group on subtitling, for which we recently rewrote the relevant standard to enable subtitles at HD resolutions.

DVB-T2

We lead the technical study group, developing an updated specification for DVB-T to improve transmission efficiency and ruggedness.

ID3.org

ID3.org is a group which has been defining methods of tagging audio files with descriptive information or metadata. We have developed an addendum to the ID3 specification for the visually impaired, that allows an audio description of the textual information to be hidden inside the main audio file.

The Digital Media Project (www.dmpf.org)

The Digital Media Project (DMP) is a non-profit Association. Its mission is to promote the successful development, deployment and use of digital media that respects the rights of creators and rights holders to exploit their works, the wish of end users to fully enjoy the benefits of digital media and the interests of value-chain players to provide products and services.

The DMP has wherever possible used existing technologies, for example MPEG-21, as the basis for a number of primitive functions. It is finalising the third release of its interoperable DRM platform specification IDP-3.

SMPTE and the AAF Association

The Society of Motion Picture and Television Engineers is based in the USA and has produced many relevant standards. We are active members of the SMPTE and the AAF Association, as they continue their work in refining standards relevant to television production. Our interest for this work lies mainly in the file formats used for capture and storage of content in tapeless production systems.

We are a participant in several SMPTE projects: Reg-XML, which is developing an XML representation of MXF and AAF, SMPTE 410M, which is developing the building blocks for incorporating other data, such as subtitles, in an MXF file and SMPTE 377M which is currently revising the core MXF standard. We are also working on the SMPTE metadata elements and groups registers which hold the definitions of the metadata carried in MXF and AAF. Additionally, we chair the SMPTE AAF Object Specification group, which is taking on the technical responsibility for the AAF specification.

We are similarly closely involved with the AAF Association, having a member on the Board of this trade body, and we lead its engineering programme. The AAF Association has, to date, been the group developing the AAF standard but with the technical responsibility for this being passed to the SMPTE, its work is now becoming more user and workflow focussed. Reflecting this change, the AAF Association has renamed itself as the Advanced Media Workflow Association.

We have also been highly active in a SMPTE working group standardising the Media Dispatch Protocol for coordinating file transfer of content between production centres over IP networks, including the Internet. The group has made good progress, and this work will result in an important standard allowing the BBC to share content with its production partners in an open way.

Our video coding technique Dirac is also being standardised within the SMPTE.

Audio Engineering Society (AES)

Most of the digital interfaces used in the audio industry are based on standards managed by the Audio Engineering Society.

We have contributed to two standards that have recently been ratified. AES 51 supports delivery of ATM cells over ethernet. AES 52 puts unique identifiers into AES 3 transport streams, so that media managers can handle them much as they do pre-recorded audio files, automatically tying them to metadata for example. AES 52 also opens the possibility of automatic routing.

AES 47, the audio-over-ATM standard extensively used in the BBC, has recently been re-ratified following a routine five-year review.

WorldDMB Forum and DRM Consortium

There are many new platforms to deliver radio content that was once the preserve of analogue AM and FM technologies. The emerging technologies, such as DRM and DAB+, are seen as competitive by some and as complementary by others to our existing digital platforms. Our international presence in the world can also create conflicts between the domestic agendas of different countries. By engaging with a number of international fora, such as the WorldDMB Forum (formally WorldDAB), the DRM Consortium and conferences across Europe, Asia and the Americas, we have been able to put forward the positive and promote a reasoned co-operation between technologies that support our core values. This has ensured our continued success in bringing clarity to the messages delivered to our listeners from the companies that design and sell digital radios in all our markets.

Institute of Electrical and Electronics Engineers (IEEE)

The IEEE has a wide range of standards under its remit. The main areas of interest to us are the wired and wireless networking standards, where the IEEE has become the body preferred to ETSI.

We are participating in the IEEE 802.11 standardisation process, with a particular interest in IEEE 802.11n, whose ratification is now not expected until late next year. We hope to influence the work so that new standards will enhance the potential of WiFi for video production.

Standards continued

W3C
The World Wide Web Consortium (W3C) develops interoperable technologies to lead the web to its full potential. We are members of the 'Timed-Text' working group.

International Electrotechnical Committee
The IEC prepares standards for electrical, electronic and related technologies. In some respects it overlaps work in ETSI, IEEE and CENELEC, among others. Usefully, it seeks to lay down performance bounds, for example, the sensitivity one can expect from certain types of radio receiver, to ensure that systems work effectively.

CENELEC
CENELEC, the European Committee for Electrotechnical Standardisation prepares voluntary standards for electrical and electronic goods and services. The most immediate relevance to our work is their influence on the specifications of receiver performance.

Europe

European Telecommunications Standards Institute (ETSI)
ETSI is the dominant European body with responsibility for broadcasting and telecommunication standards. Most of the broadcast standards we use are standardised in ETSI, including DAB, the DVB suite of standards, and TV-Anytime.

European Broadcasting Union (EBU)
The EBU is no longer the prime body for creating broadcast standards as it was in the days of MAC and NICAM. It has now changed its role to act as a consensus-building body, ensuring that public service broadcasters in Europe are able to develop a common viewpoint. Much of the EBU's formal documentation is published and then referenced in other standards.

The EBU organises this work into a series of technical groups, and we contribute to all of these.

EBU Group B/MAE
We have recently taken part in a series of subjective quality tests organised by this group, which evaluates multi-channel audio coding technologies.

EBU Group N/ACIP
Set up early in 2006, this group is developing an interoperability standard for equipment for audio contributions over IP, in cooperation with manufacturers. It is building a test engine for verifying commercial equipment against the standard, and is also compiling a set of recommendations for operational practice.

EBU Group N/CNCS
This group, which we chair, has been running for a number of years and is now contributing to an IEC group developing a common control standard for network connected broadcast and media production.

EBU Group N/VCIP
This is a new group set up at the start of 2007, with similar aims to N/ACIP but for video contributions over IP.

EBU Group P/CP
This is an interdisciplinary group, analysing common processes in TV production, to answer the increasing demand for economical systems integration. It is mostly concerned with file-based production and its related metadata issues.

EBU Group P/Display
We chair this group which is addressing the supply of professional TV monitors, used by all broadcasters to ensure consistent picture quality and colorimetry. CRT (cathode ray tube) TVs are now almost unobtainable, and the new flat panel technologies work in very different ways, not only from CRTs but also from one another. There are parameters to specify which simply did not exist with CRTs, or which could be taken for granted because the CRT TVs all worked in the same way. This group liaises closely with the SMPTE and the UK DTG.

National

Digital TV Group (DTG)
The Digital TV Group is an industry association for digital television in the UK. This group defined the profile of the DVB standards which are now used for all Freeview services, and has a laboratory which is able to test compliance of consumer equipment with those standards. BBC R&I engineers have worked closely with the Digital TV Group to set the standards.

Now the group is concentrating on high definition television, radio spectrum issues, mobile TV, and domestic systems.

BBC Information & Archives

BBC Information and Archives (I&A) became part of FM&T in January 2007.

The project team working within I&A is responsible for several internal delivery projects, with a forecast capital expenditure for 2007-8 of some £2.4 M. These projects are closely linked to the BBC's Digital Media Initiative, the creation of processes and technology that will allow the BBC to produce and deliver content entirely digitally and without the use of tape. There can be no effective use of tapeless content across the BBC without a digital archive at the centre.

A significant part of I&A's project work is done in collaboration with other organisations:

Spoken Word
Spoken Word is a five-year Digital Libraries Content project that started in August 2003. It is jointly sponsored by the UK Joint Information Systems Committee and the US National Science Foundation. The purpose is to allow BBC radio archive content (and other audio) to be accessible online to UK university students. It is the only direct mechanism to get archive content into the higher educational sector, and has given us valuable experience of 'digital repositories' and associated access technology, all of which is useful for BBC's iPlayer and for Open Archive initiatives. The other partners are the Glasgow Caledonian University, Northwestern University, Chicago, and Michigan State University.

PrestoSpace
PrestoSpace started in February 2004 and has just passed its third review. It is a large EU Integrated Project with 38 partners, running for four years. It is a 'public value' project; the BBC and its technology partners know how to preserve audiovisual content efficiently, using a factory approach (for example the BBC Archive Radio Digitisation project at Maida Vale). Our knowledge and standing in audiovisual preservation means that the rest of Europe's audiovisual collections look to us for guidance. PrestoSpace is the mechanism whereby the knowledge and approach of BBC and partners can be made available to all audiovisual archives – to make preservation work 'better, faster and cheaper'.

A number of other collaborations have recently begun, part-funded by either the DTI or the European Commission.

AVATAR
AVATAR is part funded by the DTI. It is defining IT storage solutions optimised for audio visual content and data from oil and gas exploration. It began in November 2006 and finishes in 2009.

ESTASTAR
ECTASTAR is part funded by the DTI. It is devising architectures to access exabytes of storage at terabit/s rates. It began in November 2006 and runs for two years.

SEMEDIA
SEMEDIA is part funded by the EU. It will develop techniques, environments and tools for media labelling, searching and retrieval from very large collections of heterogeneous data. It started in January 2007 and finishes in 2009.

Video active
Video Active is part funded by the EU. It is putting historical and heritage television material onto a shared, public website, and providing tools to support finding material in different languages. It started in September 2006 and runs for three years.

Other I&A projects are:

Computer Assisted Indexing
Computer Assisted Indexing is a semi automated indexing and taxonomy management tool for cataloguing and retrieving BBC archive material.

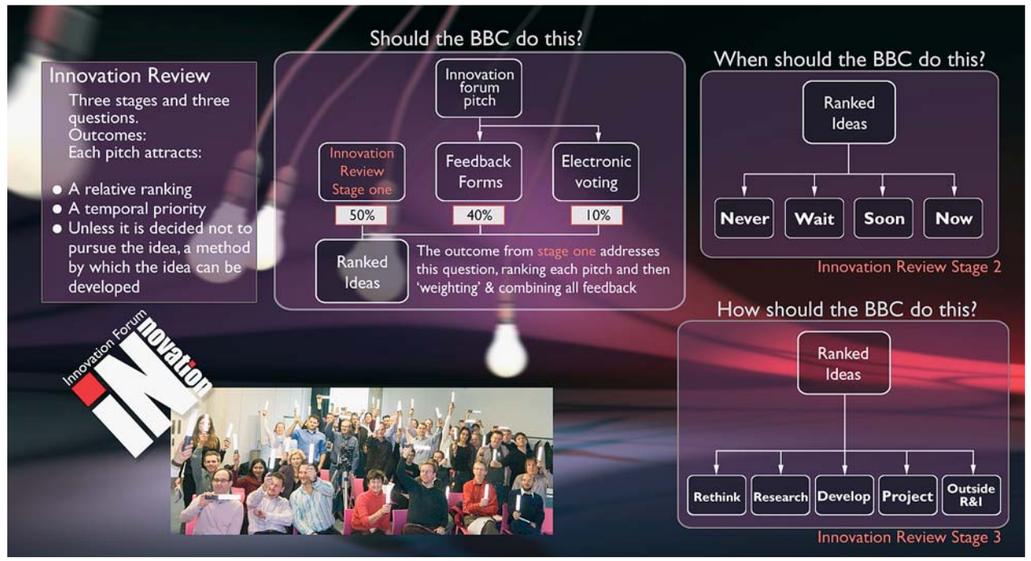
Off Air Compliance Recording
Off Air Compliance Recording is the replacement of the VHS-based system for legal compliance recording of BBC TV transmissions with an automated system that will also capture interactive elements (from a concept developed by BBC R&I).

Radio Digital Archive
Radio Digital Archive is the capturing of selected BBC radio output and related metadata, with the ability to search and retrieve as digital files.

Online Ordering
Development of new systems for online ordering of TV viewing material and music within the BBC, and for delivering commercial music direct to BBC users.

The **Innovation** Forum

In January 2007 we held our first FM&T Innovation Forum at the Science Museum's Dana Centre. The Forum will meet three times per year and is part of the innovation process that FM&T uses to discover, develop and implement its most important innovative ideas. It acts as a focus to trigger and socialise proposals as well as the start of the peer review process.



The day-long event saw many interesting and varied ideas presented, including proposals to mount a high quality camera on athletes, use a Nintendo Wii controller to operate production systems, and put wind turbines on BBC premises. An audience of around eighty technologists attended and used the optical voting system developed by the Production Magic team to give immediate feedback after each presentation. Delegates also completed feedback forms for a more considered view on the proposals. Following each Forum a more structured review process takes place, with volunteers discussing each idea in depth. Ideas that have been presented to the New Ideas Symposia, the forerunner to the Forum, are also considered alongside those from the Forums.

April 2007 will see the start of work to build a Rapid Prototyping and Research Centre (R-PARC) at Kingswood Warren. This will be a wholly configurable space with generic equipment plus 'per project' specialist technologies, as required by the ideas flowing through the Centre. The aim is to spend short but intense periods of time researching and developing ideas, perhaps creating prototypes or demonstrators or investigating proofs of concept.

Huw Williams hosted the event and also presented the inaugural Innovation Awards:

Surround video project
Jigna Chandaria
Paul Debenham
Stephen Jolly
Tim Sargeant
Graham Thomas
Bruce Weir.

Audio navigation visualisation project
Andrew Mason.

Augmented reality
Adrian Woolard.

New Ideas Symposium team
Michael Evans
Matt Hammond
Stephen Jolly
Alia Sheikh.

Future Media **Innovation**

The Future Media Innovation team aims to provide the BBC with product and service ideas from internal and external innovation networks. It aims to develop and support wide ranging and efficient innovation networks, and to drive new products into the business. Our current work is based on developing tools for engaging with innovators outside the organisation, loosely grouped in four sectors – corporate partners, academia, independent digital media production companies, and 'lead users'. Here are some details about projects aimed at these sectors.

Participate
www.participateonline.co.uk

Participate explores convergence in pervasive, online and broadcast media to create new kinds of mass-participatory events in which a broad cross-section of the public contributes to, as well as accesses, contextual content – on the move, in public places, at school and at home.

Participate is a three-year collaborative project supported by the DTI and EPSRC blending expertise in online services, ubiquitous computing, broadcast media, sensors, pervasive gaming and events, and education. Our partners are BT, Microsoft Research Cambridge, Blast Theory, ScienceScope, University of Nottingham and the University of Bath.

The consortium is working together to develop scalable solutions for managed events and campaigns that engage and motivate participants over sustained periods of time. We are developing tools for the public to author, share and discuss content using their own devices, and for professionals and experts to collate and edit contributions for publication over broadcast and interactive channels.

The BBC is working with a range of partners to develop a series of trials and events based on the theme of 'the environment' capturing and contributing information about their local environment to build a national picture across the UK.

Arts & Humanities Research Council (AHRC) Partnership
The aim of this partnership has been to discover whether there was scope for a long term partnership between our two communities, if there was a demand for enabling effective knowledge transfer and delivering mutually beneficial research, and how that research could turn into joint projects with a mutual strategic fit. The response after three initial summits was overwhelmingly positive and showed that a specialist arts and humanities academic community which has a deep understanding of the drivers and inhibitors of change is an untapped resource for insight, expertise, and ideas for BBC FM&T.

After the successful summits (documented at http://tell.memore.info) a joint funding call for collaborative projects was announced in January 2007. Over 60 applications were received and 26 made it to a shortlist. Five of these have now been chosen to go forward for joint funding, giving clear indications that there is a strategic fit for both communities.

Once the projects have begun we will be monitoring progress, disseminating outcomes and measuring success and impact on the business within both communities. This type of partnership is a first for the BBC and the AHRC and, should it prove successful, there will be further funding calls. Meanwhile, we are developing a sophisticated online brokerage tool which will track all the existing relationships as well as helping to develop new ones. We will be holding more summits in autumn 2007.

BBC Backstage
Backstage.bbc.co.uk is the developer/designer network from the BBC. It is an opportunity for the BBC to engage with the external developer community, offer some of the data and services the BBC produces, and share them with third party, non-commercial developers.

Over the last year we have gone out to developer communities all over the country in a series of meet-ups, events and university tours. We have established partnerships with O'Reilly, Yahoo!, The Obvious and the Guardian. We've launched our new in-depth podcasts and started on a process to allow the BBC much more flexibility in regards to development and prototyping into the near future. Our next major project is the Yahoo!/BBC Backstage 'Hackday' – a huge event involving over 400 developers at Alexandra Palace on 16 and 17 June, 2007 – more details at www.hackday.org

BBC Innovation Labs
http://open.bbc.co.uk/labs

BBC Innovation Labs is a process for working with the independent media production companies on early-stage prototypes for new products and services. The process has three stages: open days where BBC commissioners describe their strategic needs and the briefs for the Labs; an open submission process on the Labs site; and a five-day residential workshop where the companies work with BBC and external mentors to develop their ideas.

After successful pilots in 2005/6, we worked with ten regional partners to deliver four Labs in 2006/7, covering Scotland, North England, South England and London. This year's Labs were launched with 13 open days in cities across these regions, and we received over 500 proposals. These were filtered down to 40 ideas that were developed over the five-day Labs, with 18 ideas being selected for further development.

More Information

What to do if you want to know more.

This Annual Review has deliberately been aimed at a broad readership. As a consequence, the articles are considerably shorter than they might otherwise have been, and we have avoided going into deep technical detail.

For those who wish to learn more about any of the projects, there are several places you can find more. We have moved away from paper documentation, and now rely on the Internet to deliver our output. This makes it much easier for everyone to gain access to our work. You can find details of our projects on our website.

Website: bbc.co.uk/rd

Projects

Many of the projects at BBC R&I have a special set of pages, either on our website, or hosted by others such as our collaborative partners or SourceForge. The aim is to be open about our work whenever possible.

White Papers

We publish reports and tutorials about our work as a series of White Papers.

Our papers are published in places such as journals and conferences. We have a policy to retain copyright wherever possible on these publications. This allows us to offer these works as White Papers too, making all our output accessible in one place.

Lectures

We receive many invitations to lecture. Our intention is to try to inform a wide range of interested groups, from the high level professional conferences and seminars, to small local specialist interest groups.

Whenever the lecture is being given in a public event, we try to publicise it in advance through our website.

Index

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