ENG INF

The quarterly for BBC engineering, technical and operational staff

SPRING 1992 No. 48

DAVENTRY CLOSES

The Daventry transmitting station officially closed on 29th March, 1992, at an historic ceremony attended by current and former staff of the station.

Bert Gallon (Chief Engineer, Transmission and Project Services) adds:
When the idea of inviting staff and former staff to a closure ceremony was first mooted, it was anticipated that somewhere between 100 and 120 people would turn up. The reality was just under 500. Staff, ex-staff along with their wives and husbands and, in some cases, children, travelled from all corners of the UK. It was a very enjoyable day. The air was thick with the greetings of old friends and with fond rememberances stretching back, in some cases, to the early 1930s, and the inevitable sadness that the oldest of the BBC's Transmitting Stations was being taken out of service.

The station staff had mounted an exhibition charting Daventry's history from its opening in 1925. Photographs, newspaper and magazine articles, photocopies of correspondence, circuit diagrams, staff lists and reams of anecdotes lined the walls interspersed with technical memorabilia of Daventry's proud past. It certainly prodded memories and settled one or two differences over "what and who was here and when".

There was a special feature about the station on the World Service *News Desk* programme — the final transmission from Daventry — and a thank you to the Daventry staff in the closing announcement, for their efforts over 67 years before Bill Bird switched off Sender 2 ... and an era ended.

Tributes were paid to the staff for their commitment and dedication and to the town of Daventry for having us. Entertainer, Stanley Unwin, recalled some happy memories of his time at Daventry and Councillor John Shepherd, Chairman of the Daventry District Council and Councillor Alf Goodridge, Mayor of Daventry, both expressed their sadness at the station's closure and presented plaques to Bill Bird and to the Corporation as a memento of the occasion.

The Buffet Lunch followed and a task that appeared to be comparable with the feeding of the 5,000 was executed with commendable efficiency — typical of Daventry you might say. Shirley Dennay, wife of Director of Engineering, Bill Dennay (an ex-member of the Daventry staff) cut the celebratory cake — the creation of Sylvia, wife of Senior Antennae Engineer, Peter Wagstaff. By late afternoon, throats slightly sore, feet aching a little, the goodbyes began and Daventry transmitting station was silent for the first time in 67 years. The dismantling process started in earnest the next day. This should be completed by the end of the year and yet another "occupation" of the historic Borough Hill site will come to an end.

A brief history of the station by Tony Ratcliff starts on page 21.

BBC Transmission

The Daventry masts in 1989

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ENG INF

Edited and designed by EID, Room 3402, White City. Tel: White City (07) 24316

Editor	Mike Meyer
Secretary	Tracy Quinn
Graphic Artist	Paul Ashton May

Typeset by Townsend Typesetter Ltd of Worcester, with additional material by Giselle Austin of EID.

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As *Eng Inf* is an internal BBC magazine, it would be appreciated if no reference was made to it in articles, magazines, etc, published outside the BBC.

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Stories for the Summer issue should be forwarded to the editor by Friday 15th May, 1992. The deadline for the Autumn issue is Friday 14th August, 1992.

Transmitter News

The following services have opened, changed or closed since our last issue:

New TV relays

Foxdale	Isle of Man
Haden Hill (Halesowen)	West Midlands
Worlds End (Chelsea)	London

Addition of BBC2 (Scotland)

Sandale	Cumbria

Addition of Nicam Stereo

Divis (BBC1)	Belfast

New FM Stations

Calne	Wiltshire
Carnmoney Hill	Country Antrim
Darwen	Lancashire
Egford Hill (Frome)	Somerset
Luddenden	West Yorkshire
Porth	Mid Glamorgan

Radio 1 on FM

Douglas	Isle of Man
Les Platons	Jersey

Radios 1 and 4 on FM

Llangollen	Clwyd

Completion of FM re-engineering

Rosemarkie	Highland

FM frequency changes

Les Platons	Jersey

MF closures

The ***Radio 3*** mf network (1215 kHz/1197 kHz) closed on the 28th February, as the frequencies are required by the Radio Authority for the second national commercial radio network (INR2).

Additionally, the following BBC Local Radio frequencies have been relinquished to the Radio Authority for INR2 and ILR use in the future:

Radio Cleveland	1548 kHz
Radio Gloucestershire	603 kHz
BBC Hereford & Worcs.	819 kHz
Radio Northampton	1107 kHz
Radio Nottingham	1521 kHz
Radio Oxford	1485 kHz

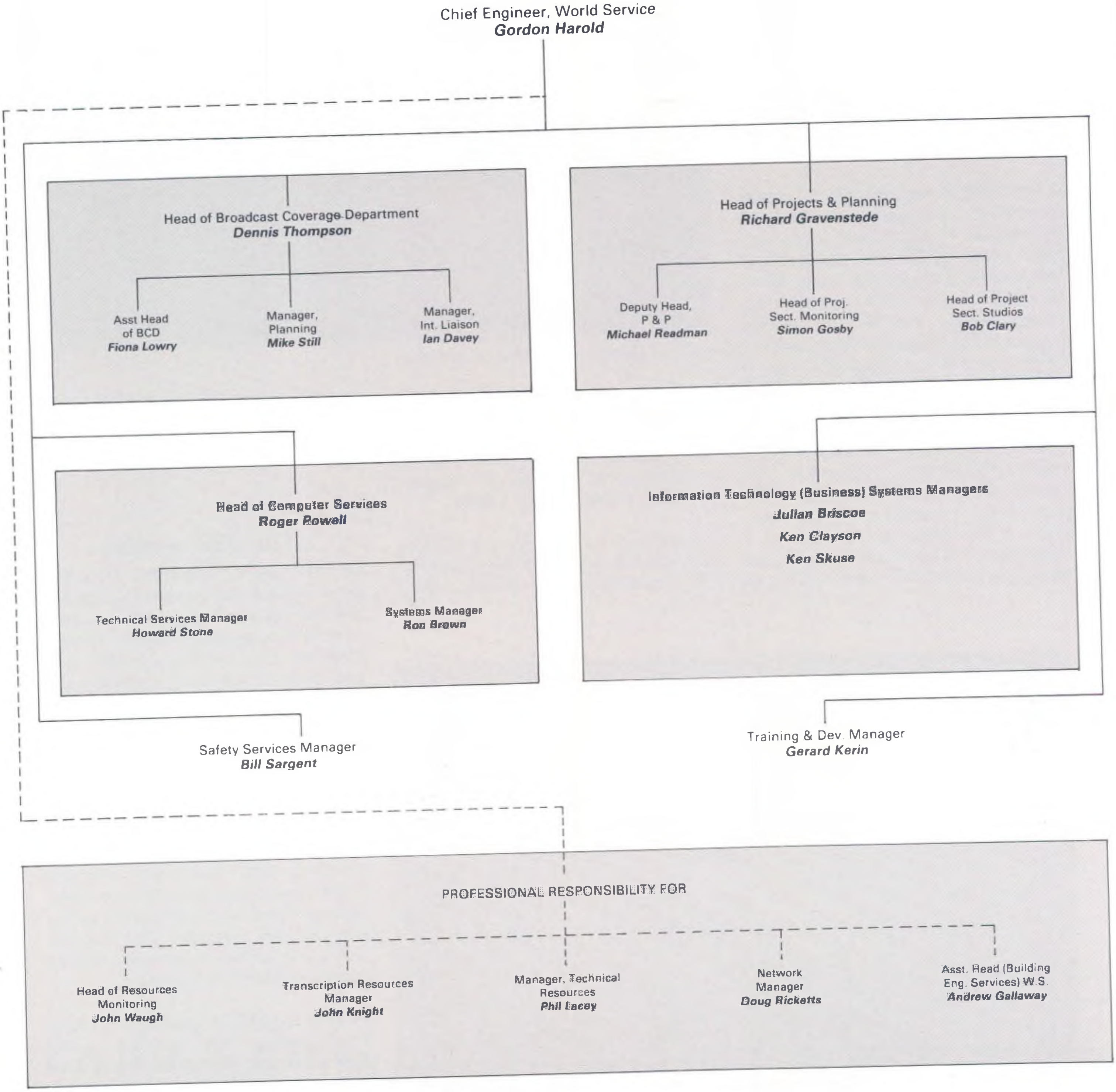
HF closures

After nearly 67 years of service, the Daventry HF station closed on 29th March.

REGIONAL BROADCASTING

The new English regions from 1st April

FAMILY TREES
World Service Engineering

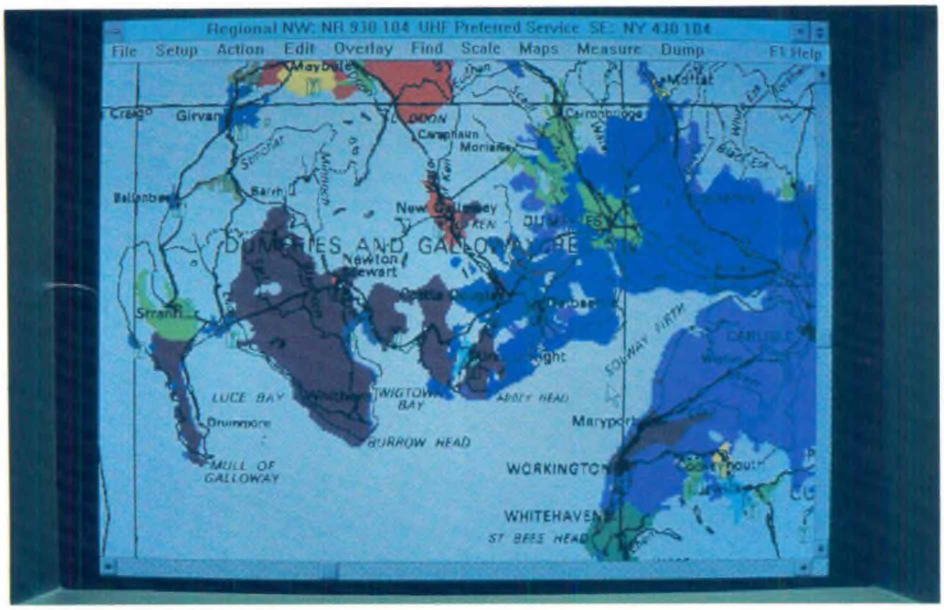


World Service Engineering — 8th April 1992

RESEARCH DEPARTMENT
The *Wings* computer system

Mark Lee describes the *Wings* system which is used by Research Department and EID to display transmitter coverage information on a computerised map.

For many years, Research Department has predicted and stored transmitter coverage data on computer. In the past, the only way of displaying this data in a graphical form was to use a pen plotter to produce a 'hard copy' on transparent film, which could then be overlaid on a printed map. More recently, developments in the personal computer world — particularly on the speed, storage and display fronts — have offered the possibility of displaying the data in a more flexible 'interactive' manner.



Mike Meyer

Preferred uhf coverage around the Solway Firth.

In late 1989, a company called Systems Options — in conjunction with Research Department — developed a package called ***Wings*** (**WIN**dows **G**eographical **I**nformation **S**ystem) that runs under Microsoft Windows. In its original form, Wings enabled the user to overlay features in the form of symbols, links or areas on to a screen image of a map. It could also store data associated with each occurrence of a feature type.

Symbols are features that have a single geographical location; transmitters, for instance. ***Links*** are jointed lines (eg roads, power lines, etc) which connect symbols together, and ***areas*** are defined by a closed set of links. The Wings user can display (in a 'dialog box') data relating to a particular feature, simply by moving the onscreen pointer to that feature and then clicking the mouse button. The software uses National Grid Reference (NGR) co-ordinates as its frame of reference, providing a resolution of 1 metre.

In conjunction with Systems Options, Research Department developed a number of extensions to the standard Wings package, particularly so that the system could display existing coverage information (which is to a resolution of ½ km).

Mike Meyer

Terrain heights in northwest Wales.

The EID system

In 1990, a requirement arose from EID for an on-line and easy-to-use display of FM transmitter coverage information, to be used in conjunction with the ***Radio 2 Helpline.*** This telephone service operated between May and September that year, when Radio 2 lost its mf network to Radio 5 (see ***Eng Inf*** No 42).

What was wanted was a system that could be used by a Helpline operator who had no special knowledge of the transmitter network (eg, a Radio 2 Presenter). By typing in a place name, the user would be presented with information showing which transmitter(s) served that location, together with a list of frequencies for the four national networks. The response time had to be fast enough to be used for answering telephone enquiries.

To meet the EID requirement, the basic Wings package was extended in two principal areas. Firstly, the Wings ***Find*** feature was modified to use place names and grid references extracted from the Ordnance Survey 1:50,000 scale gazetteer, which we obtained on a tape suitable for use with the RD MicroVAX computer.

The second and more elaborate extension was the development of the ***coverage overlay*** feature. The data representing transmitter coverage was stored in a series of files, each containing information for a 100 km grid square (at a resolution of $\frac{1}{2}$ km). This data was then used to provide different coloured 'overlay' squares on the screen map, according to which transmitter was preferred within that grid square. The system also had to return frequency information about the received transmitter(s) when the user clicked the mouse at a point on the screen map.

For the EID system, five levels of coverage were created, thus providing information on up to five transmitters at any location, ranked in order of preference. The order of preference for a given $\frac{1}{2}$ x $\frac{1}{2}$ km square was as follows:

1. Relay stations, if any, providing a field strength of more than 60 dB, youngest first;
2. Main stations providing a field strength of more than 60 dB, oldest first;
3. Relay station, if any, providing a field strength of 54 to 60 dB, youngest first;
4. Main stations providing a field strength of 54 to 60 dB, oldest first.

Squares where no transmitter provides a field strength of 54 dB or more were considered to be unserved, and left blank. (Field strengths are measured in dB relative to 1μV/m at 10 metres above ground level.)

The EID Wings system was set up in good time for the launch of the Radio 2 Helpline in June 1990, and proved to be very successful. Development has continued since then and among the features now available are:

1. The ability to zoom in or out on the map display (which required that the background maps be regenerated at improved resolution).
2. The ability to specify the coverage colour and shading style for each transmitter.
3. A display giving coverage information on uhf television transmitters.
4. A display showing terrain height (which was created from the $\frac{1}{2}$ km resolution terrain database used at RD for propagation predictions).

Less obvious developments provide greater flexibility in the construction of overlays and in the handling of features and the data associated with them.

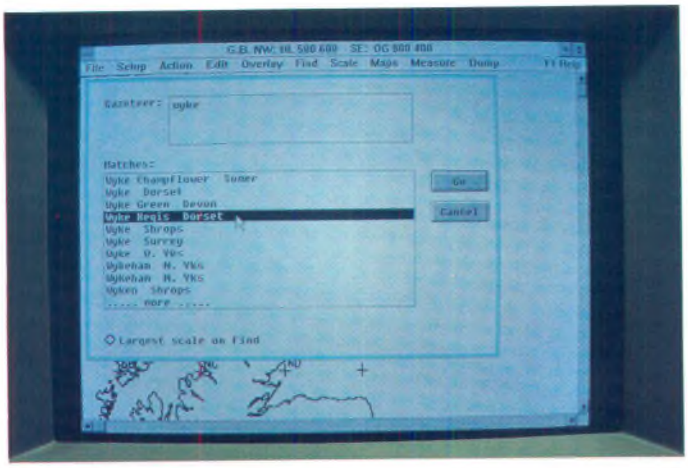
Similar Wings 'outstations' have been installed in some of the regions, for the use of engineering staff who have to deal with transmitter coverage enquiries.

System requirements

Although Wings will run with less, the minimum requirements for satisfactory performance are:

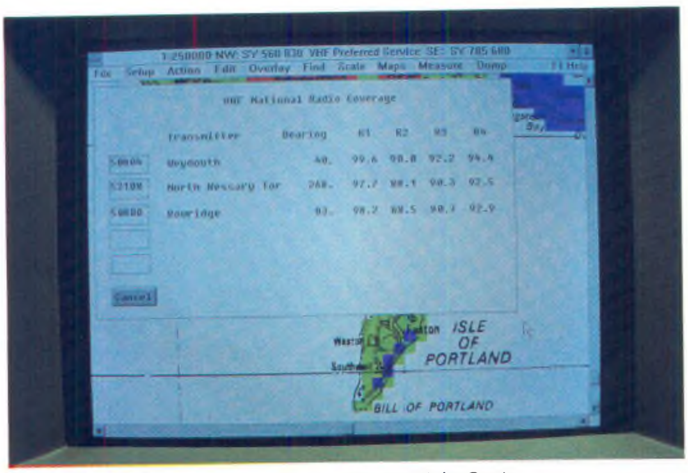
- ★ A 386 or 486 processor, the faster the better
- ★ Microsoft Windows 3.
- ★ At least 2 Mbytes of memory, so that Windows can run in 386 Enhanced mode.
- ★ A mouse.
- ★ VGA colour graphics.

The size of hard disk required is governed largely by the map scales wanted (as described below). This storage may however be on a remote file server; EID's system currently comprises two Apricot Qi 350 computers — with 118 Mbyte hard disks — acting as file servers, networked to ten Apricot Xen-S 200 diskless workstations.

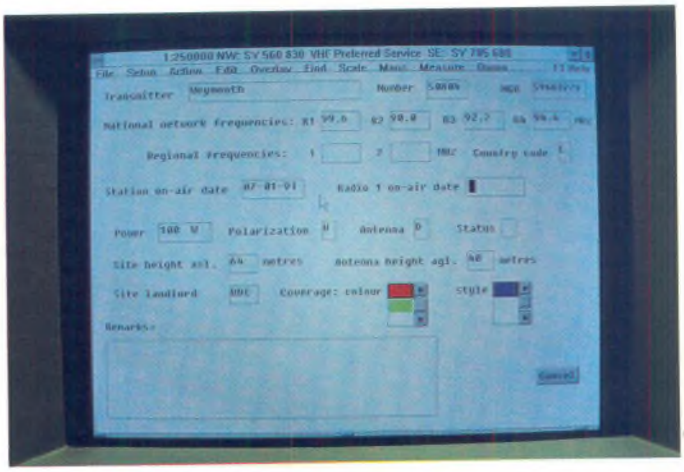


(a) Searching for Wyke Regis near Weymouth.

(b) Preferred FM coverage in the Wyke Regis area.



(c) Preferred FM frequencies at a location in Wyke Regis.



(d) Details of the Weymouth FM transmitter.

Mike Meyer

The RD system

At Research Department, Wings is developing into a useful tool for the display of many sorts of geographically-related information. For instance, coverage overlays have been generated showing channel availability for various types of in-band transmission for radio microphones, OB links etc. These correspond to the paper maps of Great Britain and Northern Ireland which are currently available, but the ability to view the information at a larger scale reveals more detail and allows the user to make a more accurate assessment of channel availabilities at a given location.

Map files

The heart of the Wings system is of course the background map, on top of which the user's information can be displayed.

This map is created by scanning one or more conventional maps on an image scanner, to produce image data files. Wings can then import these files to build up a continuous screen map, displayed at a frame size specified by the user. To place a map image correctly in the grid system, the user specifies the grid references of the corners of the area to be added and, with the mouse, points and clicks on the corresponding points on a screen display of the map image. Wings can then scale and rotate the image as necessary, to add it to its map.

More than one map type can be defined, to provide multiple levels or scales of display; for example, an outline map of the whole country, a 1:1,250,000 scale map to look at large areas and a 1:250,000 scale map for more detail. Map sheets may be selectively added where required.

In a sustained effort last May and June, Research Department scanned all the available Ordnance Survey maps for Great Britain and Ireland at the 1:1,250,000, 1:625,000, 1:250,000, 1:126,720 and 1:50,000 scales. This was done using a large scanner, hired from Systems Options, that could handle a whole map sheet in one go.

The total disk space required to store these scanned images is around 2 Gigabytes. (The amount of storage space required is roughly proportional to the area of the paper map but depends, to some extent, on the amount of detail in the maps.) The storage medium we use is a ***rewritable optical disk*** which can store 500 Mbytes on either side, and is removable, Thus two such disks cover the whole country down to a scale of 1:50,000.

Wings maps are stored in compressed form; the complete set at Research Department occupies nearly 600 Mbytes — of which 500 Mbytes is the Great Britain 1:50,000 series maps. To further save on space requirements, one or more map scales can be omitted. Thus, for example, the complete set of map files for Great Britain and Ireland down to the 1:250,000 scale occupies 'only' 52 Mbytes; it is this map set which is currently available at EID and the other outstations.

Overlay files

The information describing a Wings overlay is stored in a small file known as an ***Overlay Description File*** (ODF). This contains a list of the features (eg transmitters, motorways, etc) to be included in the overlay, together with colour and style information for each feature. It may also contain the name of a file — the ***Header Description File*** (HDF) — which contains the basic information required by Wings to shade in the display.

The HDF is a short text file which tells Wings where the coverage data files are located; from which feature the colour and fill style information should be read; and lastly, the names of one or more ***Coverage Directory Files*** (CDFs). Each CDF represents one level of coverage, and the user can specify which one is used to colour the screen display.

Each CDF contains a list of coverage data files. For each data file, the CDF specifies the geographical area covered by the file and the cell size (usually 500 or 1000 metres). It also gives the name of a translation table (XLT) file for each data file. The coverage data files contain one byte of data per cell. Wings translates the one byte codes into, for instance, transmitter numbers which it can then look up in the transmitter data.

Networking

The ethernet network at RD has recently been extended to cover Service Planning, thus enabling us to store map files and coverage data files on a central Unix computer.

Using Sun PC-NFS software, any PC on the network can now access files held on the central Unix machine — as if they were on an extra local disk drive. Thus, for instance, the Service Planning engineers have access to all maps down to the 1:50,000 scale without requiring an optical disk drive on their PC. They are also able to carry out field strength prediction calculations on the central machine and display the results on their PC at any desired map scale. This is a first step towards what might be described as 'interactive' or 'on-line' planning.

The open architecture of the Wings program will ultimately allow coverage information concerning a new transmitter proposal to be displayed with a few simple keystrokes. Data concerning the new transmitter (NGR, mast height, erp, channel numbers/frequencies, etc) will be entered into a Wings dialog box by the user, causing a prediction program to be run on the central Unix machine which, in turn, will prepare coverage displays for use by Wings at Research Department. EID and the other outstations will however continue to be updated only periodically (by means of a streaming tape carrying the updated information).

As a system, Wings is continually developing in response to the requirements of many users outside the BBC as well. One particularly interesting example is the London Ambulance Service for whom Systems Options has developed an interface to the Securicor Datatrak vehicle-tracking system. This enables the controllers to monitor in real-time the position and status of ambulances and see the information displayed on a screen map.

In conclusion, Wings is but one example of the type of application now becoming possible as a result of the advances in cheap, fast computing power — for both computation and graphical display control. Territory that was previously the preserve of experts using very expensive and elaborate graphics terminals, connected to even more expensive mainframe computers, is now becoming accessible to the general user with a desktop PC.

Mark Lee
Service Planning Section
Research Department

WALES
New TV continuity suites

Bob Head describes two new television continuity suites which recently opened in Broadcasting House, Cardiff.

In the regions, television continuity suites are usually staffed by an announcer and an assistant. Their task is to put together the regional output of local and network programmes, linked by symbols and trails which stamp the transmitted programmes with their regional identity.

Bob Head

Continuity A nearing completion.

The main difficulty in regional continuities is following London's network output. Due to the nature of the work — speaking, reading scripts and operating a sound and vision mixer — the facilities available to the announcers must be 'user friendly', requiring as little searching for controls as possible.

The original mixer in Cardiff was of the 'knob-a-channel' type, with a quadrant fader per vision and sound channel. It is much liked by announcers, as operation entirely by feel is easy; the control of fade rate and crossing between channels is totally flexible.

The mixer replacement project was undertaken by PID Tel and, with the above points in mind, the original manufacturers of the 'knob-a-channel' mixer were approached to produce further units. Since these mixers are unique to the BBC, and the company had been taken over by a larger firm with a policy of not manufacturing 'specials', they declined to provide further units.

We also looked at standard mixers but there are few Presentation mixers available — with combined video and audio operation — and none lend themselves to operation by feel. Investigations revealed that other broadcasters are happy with standard mixers, but they operate with more staff; this was not an option that could be considered in Cardiff.

Mixer Design

After research by PID Tel, in consultation with the announcers, the possibility of using a preset/transmission type mixer — with some form of memory facility to assist with junctions — was studied.

Normal practice before junctions is to rehearse the transitions. Thus, if the new mixer could learn the required events and the type of transition required from the panel controls, then operation during the junction could be much simplified.

A specification — PID113 — was written, based on the above ideas. This included a 32-input matrix, input sync and phase detection circuitry, a vision processing amplifier, stereo audio paths and a number of monitoring systems. Several companies were approached to develop the mixer and the contract was placed with Pro-Bel.

They have built the mixer around standard matrix cards, using a Grass Valley 100 vision mixer to perform video transitions. A number of advantages accrue from utilising standard modules: speed of maintenance; ready availability of spares, etc. Few special parts where required as the 'customising' could mainly be carried out by the software control system. One essential requirement was a master transition fader, to allow speed of crossfading/wiping to be determined easily.

The control panels were designed by PID Tel, using 'cardboard' prototypes, and engineered by Pro-Bel.

The resulting mixers are much liked by presenters, allowing artistic wipe transitions into programmes — which would never have been possible with the old style mixers — and one-fader operation using the memory facility.

Project Execution

In order to allow the installation work to proceed, a temporary facility had to be established. This was constructed by PID Tel in a quality check room adjacent to the Communications Centre, utilising borrowed equipment. Credit must go to the announcers and assistants for working in very cramped conditions during this period.

The building and electrical work in the continuities was carried out by local companies, under the direction of Bill Smale (Engineering House Services Supervisor, Wales). The replacement continuity desks were designed by PID Tel, and constructed by a local carpentry firm. This involved constructing a complete mock-up, to establish the best ergonomic layout.

The opportunity was also taken to rebuild the talkback and sound monitoring systems in both the continuities. These were designed by PID Tel, and built by an outside company. The monitor stacks were completely re-designed, as the new Pro-Bel mixer required a different layout of picture monitors. The new stacks are of all-steel welded construction, built by Colin Newman of the mechanical workshops in Cardiff.

BBC Wales now has two up-to-date television continuites, with provision for interfacing to the new Network Transmission Area, currently being built in London.

The project team were: David Dunmall and Richard Clark of PID Tel; wiremen Graham Jardine and Brin Walters; and acceptance engineers Peter Full and David Williams from BBC Wales.

Bob Head, Project Leader
Central Systems Group
PID Tel

ELECTRONIC GRAPHICS
Part 2: digital formats

Continuing our series on Electronic Graphics, Mike Winston examines the main digital formats used by both the television and the graphics industries

The digital component coding standard used in the television industry is ***4:2:2 YUV*** which is a member of the family of digital standards known as EBU Recommendation 601. The 4:2:2 YUV standard — summarised in the accompanying box — is widely used for stills stores, as there is very little requirement for these devices outside the television industry. Thus Slidefile, Quantel DLS and Aston Wallet all use the 4:2:2 YUV standard (often referred to as ***EBU Rec 601*** or simply ***Rec 601***).

However, painting systems are another matter. As they are employed widely throughout the graphics industry, many different formats have been used depending on their cost and development history.

RGB or YUV?
YUV has been used almost universally in stills and animation stores since before Rec 601 was specified. However, working in the 4:2:2 YUV standard has a number of disadvantages for picture generating and processing equipment:

1. It is an inefficient system containing many non-valid values. 24-bit YUV has 16,777,216 possible combinations (2^{24}) but, in a Rec 601 system, over 14,000,000 are illegal! (ie one or more of the equivalent RGB values lie below black or above white level). The remaining $2\frac{1}{2}$ million values fill the whole of the colour space but the quantising steps are bigger, compared with 24-bit RGB, and their size varies between colours.
2. Processing YUV is more complicated because the Y channel differs from the U and V channels in hardware and software. Avoiding illegal colours is a constant problem with no simple algorithm to check them. Every Y value has a different range of allowed U and V values, and the valid U and V ranges are functions of each other.
3. The reduced bandwidth of U and V causes problems when scaling and filtering pictures. This could be solved by 4:4:4 sampling but that defeats the main benefit of YUV.

As the price of semiconductor and disk memory has fallen in recent years, the advantages of 4:2:2 YUV for a painting system have become less significant. Hence, most new painting systems now use RGB internally, including storage on the disk. Provided the sampling rate is 13.5MHz, it is simple to transform to the Rec 601 YUV format for interfacing with other equipment.

Mike Meyer

Quantel Paintbox in The Late Show's graphics area.

Graphics displays
There is a big demand for graphics displays in the computer industry and these are obviously not constrained by broadcast television standards. This has led to a plethora of different line and field rates which are of little use to the broadcast industry. Frame stores are typically 512 x 512 pixels, 1024 x 1024, 2048 x 2048, 1280 x 1024, etc.

Early devices used for broadcasting often came from a computer background and similarly had frame stores based on binary numbers. Active picture areas of 512 x 512 and 1024 x 512 pixels are still in use today.

Frame stores with 512 x 512 pixels were especially popular in the USA: 512 x 512 fits neatly into the 525-line/60Hz standard, with a few spare lines, and the horizontal resolution of 512 pixels is just about adequate for the lower NTSC video bandwidth. Some of these machines were exported to Europe and, although they had been modified to work to the 625-line/50Hz standard, they sometimes still had the same size of frame store; thus it was not possible to use all 576 lines!

1024 pixels-per-line was used by the BBC for a number of in-house devices, mainly because the Computer Graphics Workshop had a digital system that worked at this resolution (ICON). The old Network Clock and EAGLE-based equipments also worked on this standard.

European standards
1024 pixels-per-active-line requires an unnecessarily high sampling rate (around 19 MHz). A more obvious choice is to pick a value which gives the same resolution horizontally and vertically, ie ***square pixels***. (Square pixels also have the advantage of making picture manipulation, especially rotations, more convenient to compute.)

A 625-line/50Hz raster has 576 active lines and an aspect ratio of 4 x 3. Thus, with 576 pixels vertically, the number of square pixels required horizontally is 576 x 4/3 = 768, which corresponds to a sampling rate of about 14.8MHz.

For some years, this format of ***768 H x 576 V pixels*** has been the graphics standard in Europe for 625-line/50Hz systems. However, the subsequent introduction of Rec 601 with 720 pixels-per-digital-active-line has posed a problem for some manufacturers.

Those fully committed to the broadcast industry adopted the ***720 H x 576 V*** format as soon as it seemed likely to become a standard. But manufacturers who see broadcasting as only part of their market are torn between the graphics and broadcast standards. They regard 702 pixels-per-active-analogue-line (see the accompanying box) as an undesirable drop in quality but, now that Rec 601 has caught on, they are being forced in this direction to satisfy their broadcast customers. It is ironic that often the most elaborate and expensive machine in a manufacturer's range is the one aimed at broadcasters, and so has the lower resolution. Some machines are offered in either standard, to suit both markets.

Bits-per-pixel

The number of bits-per-pixel has a large effect on the hardware and software required in a painting system, and is one of the main factors which determines its cost. The standards in use are:

32-bit

This is the largest size of pixel store in general use and is the standard for all new broadcast machines.

Eight bits are used for each of the three colour components (usually RGB) and the remaining eight bits are used to define a key or transparency level. Such a system is capable of storing and processing any broadcast-quality television picture, along with a linear key signal.

24-bit

As above , but without the key plane.

Both Artfile and the Quantel Paintbox are described as 24-bit but, strictly-speaking, this is incorrect because they are 4:2:2 YUV systems, ie alternate pixels are Y (8 bit) only.

16-bit

This is an unusual choice of standard but it is sometimes provided in computer graphics, as a compromise between 8- and 32-bit systems.

The usual arrangement is a 1-bit key plane and fifteen bits allocated to RGB, either 5:5:5 or 5:6:4. With 32,768 pixel values, a good representation of a 'real' picture is possible. However, the frame store capacity required is the same as for a 24-bit 4:2:2 system (which is a better choice for broadcast applications).

8-bit

Each pixel is represented by one byte. This means only 256 (2^8) different codes are possible but, by using a technique called ***colour mapping***, they can represent any colours you like. In other words, the whole range of possible colours in a 24-bit system is available, but only 256 different ones can be used simultaneously.

The mapping of the 256 pixel codes to the many possible colours is held in a colour look-up table. The values in the table are filled in automatically as the artist works, and this continues until all 256 values are used. The technique is often referred to as ***painting by numbers.***

An 8-bit system cannot handle 'real' pictures since any input from an analogue video source has to be quantised to only 256 values. However, 256 colours are often more than enough for electronically-generated artwork and, since 8-bit systems are by and large the cheapest, they are popular in the commercial and business video market.

The BBC designed FLAIR system, one of the first painting systems produced, was 8-bit (see ***Eng Inf*** No 7).

Although 8-bit machines are limited, painting by numbers offers the facility of ***colour cycling*** which is not possible on the other systems. This can be used to create simple animations (as we'll see in a later part of Electronic Graphics).

The standard painting systems in the BBC are all 24-bit (Paintbox and Artfile) but there are some cheaper devices in use, eg the Spaceward Super Nova (8-bit) and the G2 Masterpiece (based on a BBC Master computer) which is used on 'Crimewatch' for maps and diagrams.

Mike Winston
Central Systems Group
PID Tel

4:2:2 YUV

EBU Recommendation 601 is a family of digital coding standards of which ***4:2:2 YUV*** is the most commonly used at present. Some of its main features are:

Components:	Y, U and V
Sampling rate:	13.5 MHz (for Y) 6.75 MHz (for U and V)
Quantising level:	8 bits for each of Y, U and V (although there is growing interest in the use of 10 bits)
Bitrates:	Y = 13.5 MHz x 8 bits = 108 Mbit/s U = 6.75 MHz x 8 bits = 54 Mbit/s V = 6.75 MHz x 8 bits = 54 Mbit/s
	Total = 27 MHz x 8 bits = 216 Mbit/s
Pixels per digital active line:	720
Pixels per analogue equivalent line:	702
Aspect ratio of pixels:	1.09:1

Note that the digital active line is longer than the analogue active line (53.28μs compared with 51.95μs) and that the pixels are not square.

Strictly speaking, U and V are colour difference signals weighted by the factors used in Pal coding. The weighting factors used in ***4:2:2 YUV*** are different and so, more accurately, the components should be referred to as Y, C_b, and C_r.

ELECTRONIC GRAPHICS

Paint systems in use

Complementing our five-part series on Electronic Graphics, Andrew Witham outlines the workings of a basic paint system, with illustrations provided by *The Late Show*'s integrated graphics facility which is also described.

Recent advances in technology have allowed graphic images to be stored digitally. This, together with the ability to perform arithmetic functions quickly, has offered new opportunities for the processing or manipulation of pictures in the electronic domain.

Basic paint systems

A simple installation could consist of just a copy stand camera, as a means of acquiring images, and a paint system to process these images.

Modern copy stands generally use industrial CCD cameras. Although these tend to be lower in resolution than broadcast cameras, they have a very stable geometry. This is important because, when several images are combined (some of which may have been generated electronically), any error due to suspect picture geometry can become very apparent. Furthermore, pictures taken from the copy camera do not usually constitute the final image; they are often manipulated in some way during composition, thus reducing the need for good resolution at source.

The paint system itself could be either a Quantel Paintbox or one of the similar devices listed in Electronic Graphics Part 1 (***Eng Inf*** No 47).

Much of the artist's work — processing and manipulating the original image — makes use of electronic ***cut and paste*** techniques: stencils are created to define a specific area of the copied picture, either for cutting out or to limit the extent of some other process. The technique is illustrated by the sequence shown opposite.

Finished pictures are then copied to a suitable transfer medium, such as a Slide-file tape, for taking to the studio or post production suite, prior to transmission.

More complex areas may use a multiplicity of graphics devices and this is where ***interfacing*** becomes important.

Interfacing

Electronic images can be transferred around a graphics environment by a variety of methods; either ***analogue*** (RGB or YUV) or ***digital*** (Rec 601 or via a removable disk).

Since analogue signal distribution is needed for monitoring and eventual transmission, it is usually much cheaper for the entire system infrastructure to be analogue. Most equipment is supplied with analogue connections, even though their internal workings are digital. Analogue transfer is usually acceptable — so long as the number of passes is small and the system has been carefully set up and maintained. However, as systems get larger with greater scope for transfer of pictures, the problems of using analogue become harder to contain.

Part 3 of Electronic Graphics (***Eng Inf*** No 49) will develop the theme of interfacing, including the introduction of the Rec 656 digital standard (***Ed.***)

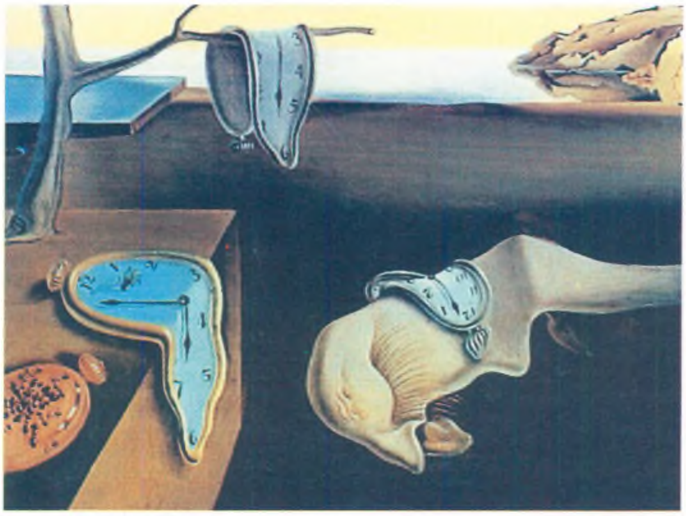
PAL coding

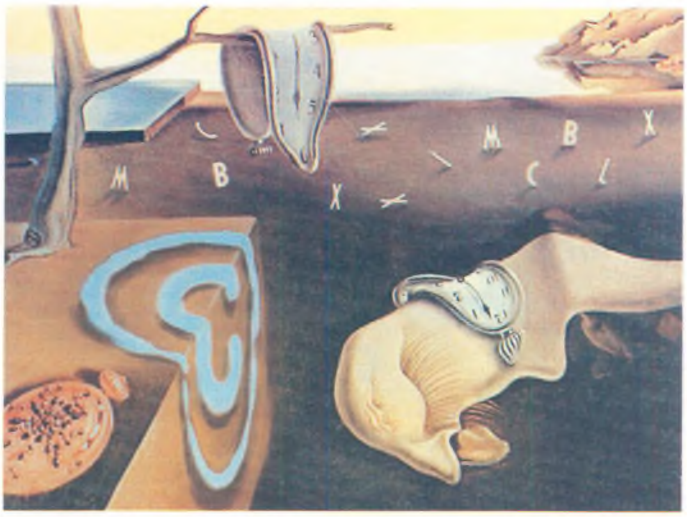
Graphics systems do not use PAL in the main signal path as the code/decode cycle would add unacceptable degradations. However, at the end of the day, all our output is PAL-coded for transmission and this can expose unforeseen problems — such as PAL 'footprint's' from source material which was originally decoded from PAL. For this reason, PAL-coded signals are often used for ***monitoring*** in graphics systems: the operator can then be alert to problems before they go on-air.

The Late Show

Developments in electronic techniques have allowed the production of graphics to become more closely integrated with the rest of the programme production process. Images can be taken directly from studio cameras or tape and, after processing, be 'handed back' for inclusion in a VT edit session or for direct transmission.

Graphics areas are now being built to service programmes that demand this more-immediate integrated approach.





The Late Show

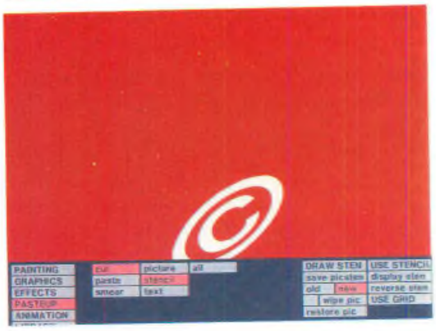
Salvadore Dali's "Persistence of Memory (Soft Watches)" on the left has been 'adjusted' by a Paintbox to give the image on the right. The designer used individual cutouts for each of the background letters, then used 'airbrush' functions to paint over a clockface and generate the 'C'. (Graphic Designer: Mina Martinez.)

(a)

(b)

(c)

(d)



(e)

(f)

The sequence on the left shows the simple steps in producing an image on a Paintbox. The original picture of the radio, illustration (a), was taken from VT while the copyright symbol 'C', shown in (b), was taken from a copystand camera after angling the symbol to match the perspective of the radio.

In (c), the artist is altering the appearance of the original picture using a 'colourmap'. In (d), the copyright symbol has been used to generate a stencil or key, displayed in red, which in turn has been used to cut out a piece from another picture, in this case a white field.

In (e), the two images just created are combined. Then, the cutout 'C' is placed in its final position, at 45% of its density, and the letters "BBCMCMXCII", generated by an Aston Caption, are added by a similar process to obtain the final result shown in illustration (f). The whole process took just a few minutes. (Graphic Designer: Keith Haynes.)

One such example is ***The Late Show*** which has its own graphics and VT facilities on the first floor of the East Tower at Television Centre. A range of material is required for the programme including title sequences, stills, short moving sequences, captions etc. There are four programmes a week, plus a weekly compilation and other 'spin-off' programmes, requiring four full-time designers.

The Late Show's graphics area has to satisfy a set of flexible needs; it has to work closely with the VT Edit suites as well as the studio, for both recording and live transmission. The principal equipment includes a camera mounted on a copy stand, a Quantel Paintbox fitted with a 'Ramcorder', a Quantel DLS stills store and an Aston Caption machine.

The Ramcorder stores thirteen seconds of real-time video in RAM, allowing the Paintbox to be much quicker at generating and manipulating short moving sequences. Images can be recorded from and played to a VT machine in a nearby suite. The Aston Caption is used for supplying anti-aliased captions to the VT edit suites and the production studio, as well as for combining with material in the graphics area.

The system allows material to be generated on the Paintbox independently of material being offered to VT or the studio. Thus, transmission or recording do not inhibit the production of graphics work. The stills store and Caption outputs are coded before being sent to the studio, where they are considered as the output devices for the area.

The programme has standardised on the Betacam VT format (analogue component video) for both studio and PSC location work. Apart from any other production benefits, this format allows transfers with graphics without additional PAL code/decode cycles.

The graphics area shares an RGB analogue matrix with the adjacent VT suites which can access any piece of equipment via the matrix. VT machines also appear as matrix sources which provides for easy transfer of material. Much of the programme is made in the edit suites and it is just as important to incorporate graphics at this stage as during live transmission.

My thanks go to the graphics staff of The Late Show who produced the illustrations accompanying this article.

Andrew Witham
Central Systems Group
PID Tel

The Late Show

Mike Meyer

General view of The Late Show's graphics area.

TELECOMMUNICATIONS
Part I: optical routeing

In this first part of a short series on Telecommunications in the BBC, David Russell looks at the merits of optical fibre as a transmission medium, and outlines its role in the future of network provision.

This article is concerned with medium and long distance transport of ***television**** signals for contribution and distribution purposes. It looks at methods of transport; the type of signals to be carried; the necessary bandwidths/bit-rates required for transmission (today and tomorrow); the inevitable need for digital systems; and the practicalities, regulations and costs which govern the choices. It then draws these threads together into a network architecture for the future, for which ***optical fibre*** is the prime constituent.

To whet your appetite, a paraphrase from a standard text† tells us that ***'fibre will carry several gigabits, requiring far less repeaters than coaxial cable (and digital radio) for a given bit-rate; and is lighter, smaller and cheaper than coaxial cable and immune from RFI, (it also does not suffer from propagation fades)'***. But first of all, here is a short background to network provision in the BBC.

Coaxial cable
Early studio-to-transmitter links, and contribution links between studios in the London area, relied on 1-inch diameter coaxial cables. These provided high-quality, low-loss circuits (many still exist) but they suffered all the well-known problems:

* Only baseband analogue (PAL) signals could readily be carried
* Degradations increased with distance, despite the use of successive equalisers
* They were only available from BT and therefore a constant drain on BBC finances
* The bandwidth was limited although, with sophisticated carrier equipment and equalisation, some circuits could carry two vision channels
* They were very expensive to install

** Television in this context includes modern complexes of video, audio, DC-SIS, teletext, VITS plus data, BBC Select coding and VBI talkback — not to mention tomorrow's HDTV and PAL Plus coded waveforms.*

† Telecommunication Transmission Handbook, ISBN 0 471 08029-2.

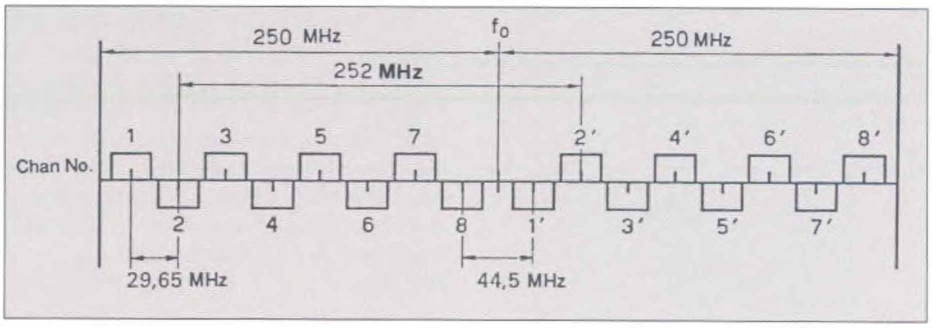


Fig 1: rf channel arrangements for fixed-link systems in the 6 GHz band.

BAND	2GHz	4GHz	6GHz	7.5GHz	8GHz	11GHz
Number of Channels	6 each way	6 each way	8 each way	8 each way	8 each way	11 each way
	"CONCEPT TOTAL" =		47 VISION CIRCUITS EACH WAY			

Fig 2: if all the spectrum available on a trunk radio-link route is used, a 'concept' total of 47 vision circuits each way is possible.

Analogue radio links
The early television networks used long-distance radio links, again provided by BT. They were used in conjunction with local cable circuits to cover the distances needed for the network.

BT analogue radio links produce much higher quality point-to-point circuits than coaxial cable, and form the distribution and contribution networks we use today. But analogue degradation — increasing with distance — still applies; occasional fading causes outages; and total capacity — originally not fully used — is limited today with the increasing demands put on the radio spectrum.

Fig 1 shows the rf channel-stacking arrangement for fixed-link communications systems in the 6 GHz band. Note how, in concept, it could allow for eight 2-way vision channels to be transmitted. Referring now to Fig 2, a maximum of only ***forty-seven*** 2-way vision channels are available, conceptually, in the six fixed-link bands between 2 and 11 GHz. (In practice, many of these are needed for trunk telephony and data signals.) Thus, when all the frequency allocations have been used on a particular route, expanding the signal bandwidth (eg for HDTV) or the number of signals transmitted (eg more contribution circuits) is just not possible.

Digital radio links
Digital radio can offer 'denser packing' but at the expense of complexity, cost, and more difficult propagation problems (which reduce the inter-hop distances allowed, thus increasing costs again).

Public Telecommunications Operators (PTOs) use standard frequency blocks to carry digital telephony and data over their trunk routes. Sophisticated modulation schemes are needed to carry vision signals over these links — an example being ***Digital 64QAM*** (64-state Quadrature Amplitude Modulation) which can transport coded-PAL signals at bit-rates of 140 Mbit/s within a 30 MHz channel. Less-complex modulation systems exist but they use more bandwidth and reduce the number of channels available. Also, radio systems at bit-rates higher than 140 Mbit/s are used by PTOs abroad but are not cost-effective for trunk hops greater than 30 km.

Self-provision of radio links is now possible and, where allowed, can provide a saving — if the capital cost over a realistic lifetime is less than the 'total rental from BT' over those years. There are sixty or so BBC-provided radio links in service today, making for revenue savings of around 25% of the total vision network expenditure.

Fibre development

The development of multimode and monomode fibre systems over the last ten to fifteen years is well documented — most long-distance fibres nowadays being of the latter type. Early problems — such as launching and receiving the energy efficiently using narrow fibre bores; alignment and jointing of fibres; transmission losses; mechanical strains involved in laying, etc — have been largely overcome.

Analogue systems using laser diode transmitters and photo detectors are commonly in use by PTOs but as the electronic elements are not 'dramatically linear', digital systems now predominate: optical fibres allow a very high intrinsic bit-rate, and very high switching speeds (sub nanosecond) can be obtained from modern electronic components.

Current systems

Digital systems currently in use by PTOs operate at standard bit-rates of around 565, 140 and 34 Mbit/s, although the newer Synchronous Digital Hierarchy (SDH) arrangements at 622, 155 Mbit/s, etc, will soon become available. The basic network building block at present is the 140 Mbit/s multiplex which can carry 1,920 telephone circuits or one PAL television channel (using straightforward PCM coding techniques).

Using currently-available equipment, a standard *fibre* link can carry four multiplexed TV signals at a bit-rate of 565 MBit/s.

Stabilised, spectrally-pure, laser carriers operate at nominal frequencies of around 300 THz (terahertz), ie 300 x 10^{12} Hz, which correspond to wavelengths of about one micrometre (see Fig 3). A modulating bitstream of 565 Mbit/s produces a carrier dispersion of around 300 MHz which is just 0.0001% of the nominal carrier frequency. The modulated carrier is thus a very 'narrow band' signal in spite of its vast capacity.

Near-future systems

Digital laser systems operating at 2.4 Gbit/s have been demonstrated in the laboratory and are starting to appear in commercial service. (At 2.4 Gbit/s, a single fibre can carry sixteen 'conventional' TV channels.)

The next generation of laser carrier equipment will work at around 9 Gbit/s (64 television channels) and, with all-optical repeating amplifiers (using erbium-doped fibre sections powered by coupled lasers), will be as reliable as systems to date but faster.

Wavelength-domain-multiplexing (WDM), which was described in ***Eng Inf*** No 43, is another significant development. Although commercial WDM equipment is available for up to four different wavelengths at present, when the total bandwidth of 850 to 1,550 nanometres is considered (and bearing in mind that carriers differing in wavelength by just 4 to 5 nanometres can be separated), many more wavelength components will be possible if the combining losses can be overcome.

My estimate is that a single fibre will be able to carry around sixteen wavelengths, which will lead to ***one 9 Gbit/s fibre being able to transport around one thousand television channels!*** Compare this with the forty-seven vision channels which would be available if all the current radio-link channels were used (Fig 2).

Over and above all this, there are now conventional long-haul cables which contain either 4, 24 or 96 fibres. The conclusion is very obvious: fibre has almost unlimited bandwidth, certainly enough for very many users. However, with commercial economics to the fore, these fibre cables will only be laid between locations where many users require the facilities, ie along conventional communications routes between city centres — using roads, railway tracks, canals, National Grid earth conductors, etc, to keep down the civil engineering costs.

Satellites

Often seen as an available alternative to fibres (as indeed they are for international point-to-point traffic), satellites really make economic sense for point-to-multipoint (in the limit, broadcasting) and multipoint-to-point communications. They are still spectrally limited, suffer from not inconsiderable delays and use much more expensive terminal apparatus than fibres.

In the BBC context, currently-viable uses are: the broadcasting of Network Radio; single-programme-source World Service Television; and sequential SNG (Satellite News Gathering) contribution signals. However, terrestrial contribution and distribution via regional centres are not so viable — due to the need for multiple signals to be carried at peak hours, which may cause system overload for single transponders and excessive cost for multiple coincident transponder rental.

Bit-rates

Traditionally, tariffs on digital circuits (whether coaxial cable, radio link or satellite channel) have depended on the bit-rate used, because demand could only be controlled in that way.

This has led to the production of bit-rate reduction codecs of very considerable complexity (ameliorated to some extent by large scale integration) which can, for example, distribute two high-quality stereo channels at a bit-rate of around 128 kbit/s (eg MUSICAM). Similarly, conventional PAL vision signals can be coded at 34 Mbit/s (eg the ETSI standard DCT television codec). However, the capital costs of these complex codecs are high, and usage in the BBC's existing network and maintenance infrastructure would be more involved than that of 140 Mbit/s codecs.

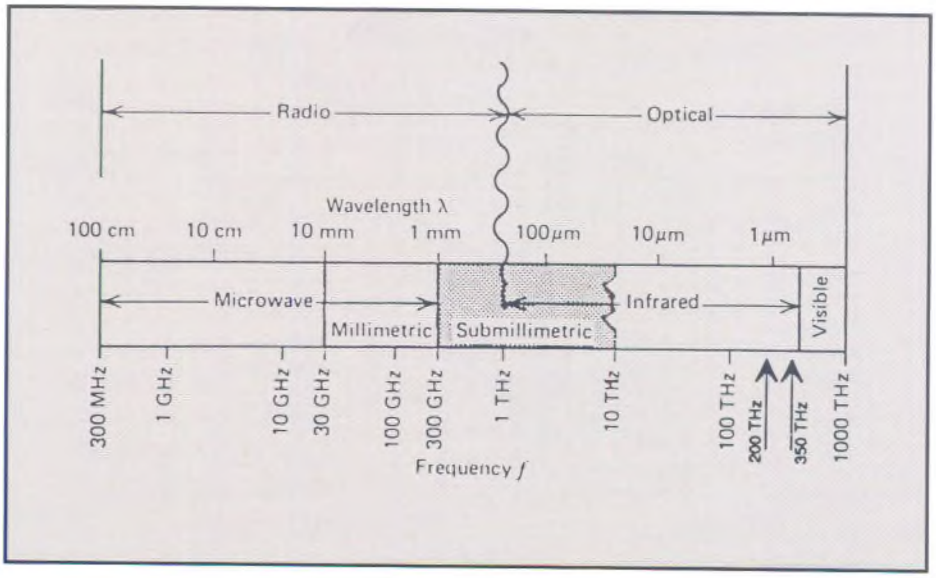


Fig 3: the fibre frequency band is between 200 and 350 THz.

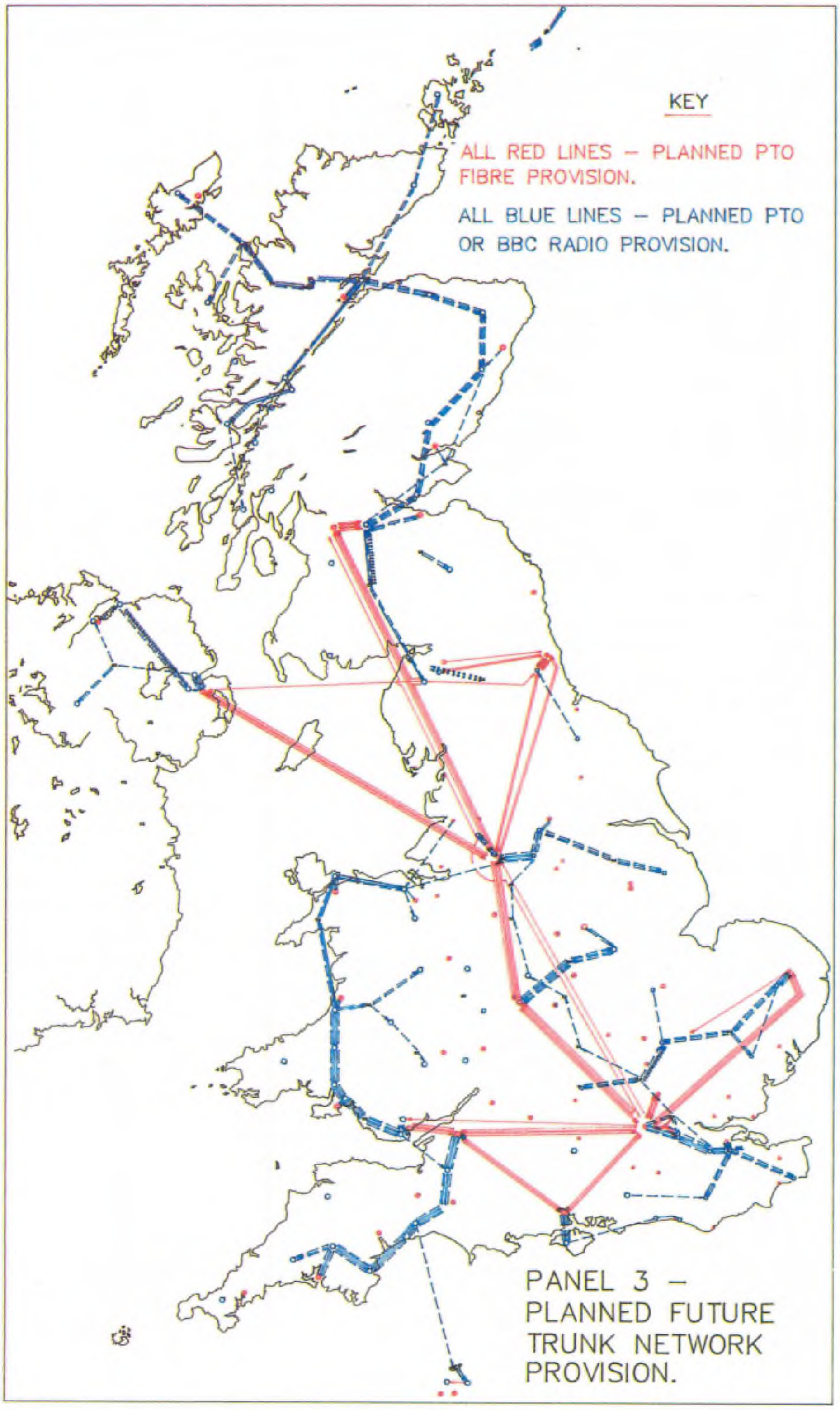
But at the same time, the bit-rates available for a given cost on PTO fibre circuits are increasing vastly. Thus, in order to expand the market to fill this capacity, prices may be forced down. The balance point is a moving target, as now discussed.

Economics

Supply

Where a monopoly supply exists, control of costs by a customer is very difficult. The only savings come from efficient modulation/bit-rate reduction schemes which allow 'more to be squeezed through a fixed-cost pipe'. Thus, thirteen linear PCM radio channels were previously carried on a vision circuit; with the advent of NICAM III, twenty-four channels can now be carried for the same cost on the same bearers. Also, self-provision of radio links can produce savings, given the BBC's wealth of tall masts allowing line-of-sight propagation.

Competitive supply, with several PTOs entering the field, will lead to greater choice and corresponding price reductions if there is a big enough market. This is a dynamic situation where a significant market increase could produce considerable price reductions on trunk routes where demand is high.



A concept trunk network for the future.

Costs

If fibre is such good value, why doesn't everbody install it? The answer is that they generally do nowadays — where regulations permit on a ***local*** basis (eg within a studio, a building site or a whole complex like an oil refinery). But civil engineering costs can be enormous and this is the biggest cost factor of any fibre ***trunk*** network.

Even if regulations were completely liberal, it would really take 'code powers' to be able to guarantee producing a continuous fibre circuit over virtually any distance in the UK. (Code powers are issued to PTOs and like bodies to enable them to insist on way-leaves for circuits over private and public land.) Thus, PTOs are needed to provide trunk circuits between the large conurbations where demand for the large bandwidths available from fibre is greatest. To the BBC, therefore, the use of fibre ***trunk*** networks will be an operating, rather than a capital, expenditure.

For routes with lesser demands, radio links are still economic (if frequencies are available) and it may be profitable to pursue more self-provision in future.

Bit-rate reduction (with its increased complexity and large capital costs) has to be weighed against decreasing raw bandwidth costs, noting that if high bit-rate signals are carried 'cheaply' on fibre to the major network nodes, it may be very consumptive of spectrum to feed such signals via radio links to the transmitters.

In the limit, I believe bit-rate reduction will save money and should be employed ***if*** it can maintain BBC presentation quality at least as good as today's. While we can squeeze today's 216 MBit/s PAL television (Rec 601) into 34 Mbit/s, tomorrow we should be able to squeeze 1152 Mbit/s HDTV (Rec 709) into 140 Mbit/s and thus save on circuit rental costs.

Future network

Weighing up all the factors, a ***fibre core network*** between major studio nodes (in large cities) will present a future-proof, flexible base for contribution/distribution circuits. It will probably be rented from a PTO and should be free of bit-rate reduction, unless the price is prohibitively high.

From the core nodes to the end points, ***radio-link spurs*** should be employed (especially to transmitters with relatively-easy access). These links should use bit-rate reduction to conserve bandwidth, and should be self-provided where possible to give further savings.

A concept network showing these elements is shown opposite.

Other factors, not discussed here, will also have a bearing on the kind of networks that we will use in the future: for example, new signal types (such as BBC Select, PAL Plus); the availability of open fibre (dark fibre); open bit-rates or analogue signal presentation to the PTOs. Also, which of the existing or emerging PTOs will provide best value for money — using different fibre routes — is a further factor to be considered. TED is taking all of these into account in planning for tomorrow's networks and, no doubt, future articles in ***Eng Inf*** will report on developments.

GPT Telephone Cables Ltd

20-fibre cable with flame-retardant outer sheath.

Finally, I should like to thank Paul Gill and Richard Greenhalf of TED for their assistance in providing some of the data for this article.

David Russell, Project Manager
Broadcast Networks, TED

DIGITAL HDTV

RD demonstration at WARC 92

Research Department recently collaborated with other EBU members — from France, Germany, Italy and Spain — to mount a demonstration of digital HDTV broadcasting by satellite to more than five hundred of the delegates at the World Administrative Radio Conference in Malaga, Spain. Nick Tanton takes up the story ...

At the conference (known as WARC-92), much of the interest of the broadcasting community was focused on agenda items concerned with satellite broadcasting. In addition to seeking provision for spectrum to implement satellite ***sound*** broadcasting services in Europe (ie DAB), the EBU made a strong case for a new 600 MHz wide allocation of spectrum between 20 and 30 GHz, for Europe and Africa, to be used for future ***digital HDTV*** satellite broadcasting services. The demonstration had been devised to support the European case.

Preliminary EBU studies indicated that an allocation of width 600 MHz would allow for about twelve 140 Mbit/s HDTV channels per satellite orbit position. The low protection ratios which digital emission techniques allow make it possible, firstly, to use each hand of polarisation for a different signal and, secondly, to completely reuse the channels allocated to a satellite in the adjacent geostationary orbit position. Using contemporary video compression techniques, a bit-rate of 140 Mbit/s allows 'near studio quality' HDTV to be reproduced in the home.

Prior to the demonstration, a 22-minute compilation was made of excerpts from various European HD productions (including the BBC's ***The Prince of the Pagodas*** and ***Wimbledon Tennis***) using Research Department's HD editing suite.

In Malaga, the demonstration programme was played into sophisticated real-time compression equipment, designed to reduce the raw bit-rate of HDTV from over 1000 Mbit/s to a mere 140 Mbit/s. After QPSK modulation, the resulting signal was passed through a satellite simulator — which modelled the performance of an up-link, satellite transponder and down-link — before being demodulated and reconstructed, and displayed as studio-quality HDTV on projectors and monitors.

The excerpts chosen also enabled diverse approaches to sound for HDTV to be demonstrated; mono, stereo, 5-channel and 7-channel multi-channel sound were reproduced. This also helped to demonstrate the potential flexibility which digital emission methods can bring to new services.

The 140 Mbit/s HDTV codecs used for this demonstration represent state-of-the-art technology. One of the two codecs used has been developed by Research Department in collaboration with two other European partners, as part of the RACE HIVITS project.

Continuing developments in video compression should allow further reductions in the necessary data-rate for HDTV secondary distribution; this will enable more channels to be provided or, alternatively, may be used to make the broadcast signal more rugged, to achieve better link margins or to enable smaller receiving aerials to be used.

Following the demonstrations, the EBU team at Malaga held a football match in which Retevision and the BBC beat the combined forces of RAI, IRT and the EBU by 15 goals to 7.

After much discussion, the conference agreed an allocation ***600 MHz wide*** for digital HDTV satellite broadcasting in ITU Region 2 (Europe and Africa). It lies in the frequency band which Europe had requested, ie ***between 21.4 and 22 GHz.***

Nick Tanton
Digital Systems Section
Research Department

NORTH REGION
Lightweight link units

Neil Baker and Garth Jeffery describe a new type of link vehicle for News & Current Affairs, based at Leeds and Newcastle. Also described, by Ian Gordon, are the associated link facilities which have been installed at the Pontop Pike transmitter, one of two such link sites currently operating in North Region.

In line with North Region policy, Leeds and Newcastle are improving their coverage of News & Current Affairs. Part of the plan includes additional resources to increase news gathering, and live injects into programmes. Mast-head receiving sites at Holme Moss (South Yorkshire) and Pontop Pike (County Durham) have been installed — the Pontop Pike installation is described later — and future expansion in North Yorkshire and Cumbria is a possibility.

The link vehicles

Manchester local programmes already have access to a Land Rover fast-response vehicle. However pressure on this single resource led to the development of additional lightweight link units (LLUs) for Leeds and Newcastle. Investigations culminating at IBC in September 1990 suggested that a panel van would be the ideal solution to the problem and, during this exhibition, contacts were established with a number of suppliers and installers.

The project was handled jointly between TED's Broadcast Communications Section (BCS), at Warwick, and North Region who designed and installed the video/audio systems using engineering staff from Leeds and Newcastle together with local contractors. BCS placed the main contract with I P K Broadcast Systems Ltd, of Reading, who originally developed similar vehicles for Sky Television and Thames TV. However significant modifications have since been made to the rf and generator power systems.

The result has been a versatile and 'user friendly' LLU, based on a VW LT45 diesel panel van. The coachwork by Spectra is excellent and the staff comfort-factor good.

Particular consideration has been given to safety, based on previous experience with Land Rovers and the Thames van. A sophisticated interlock system has been installed which prevents movement of the vehicle, raising of the mast or powering of rf equipment, etc — if the vehicle is in an unsafe mode. Also on top of the mast is an anemometer which triggers an alarm whenever the wind speed exceeds 50mph, thus warning the operator to lower the mast.

These are the first link vehicles in the BBC to be based on Volkswagen LT45 panel vans. They have been converted to include a 12 metre pneumatic mast, which supports a permanently-rigged shf dish antenna. This allows rapid deployment and operation — from within the vehicle — of the 7GHz shf transmitter (one vision plus two high quality audio channels) and the radio telephone equipment.

A 240V, 50Hz, 5kVA petrol generator is included and is capable of providing the entire power demand of the vehicle, with some surplus for feeding out to ancillary equipment. This generator has proven to be exceptionally quiet and vibration free. All power sources are controlled from a power board which provides comprehensive monitoring and switching facilities.

The interior of the vehicle has been converted to a high standard and includes technical equipment bays, a desk and seating. The roof has been equipped with a platform and handrails to allow its use as an elevated camera platform, or to receive shf signals when the vehicle is being used as a midpoint for longer double-hop links.

The mast-top assembly is equipped with a remotely-controlled pan & tilt mechanism and a 0.6m dish antenna (linear polarised). OBs operating in the 7GHz band would normally use 1.2m dishes at vehicle roof height but their size makes them impractical aloft a 12m mast. Consequently the transmitter remains inside the vehicle, its output being routed via coaxial cable to the mast-top assembly where it is amplified by some 30dB to approximately 5 watts. The system thus approaches the maximum erp permitted from any OB dish (40dBW), thereby achieving a similar range capability to that of a main-line link, but with the added benefit of being 12m aloft (a great help in built-up environments).

The base-band equipment includes Beta SP replay machines, PSC injection facilities and a choice of dual-channel SIS or analogue audio. There is sufficient space for extra facilities to be provided (including video editing and camera control) as the unit develops.

As well as its obvious use for TV News gathering, the vehicle will be able to mount live television OBs — when used in conjunction with the Leeds/Newcastle MCU (Mobile Control Unit) — or operate as a stereo links unit for local radio. The vehicle requires only a single driver-operator, and a comprehensive training programme has been developed by Manchester to familiarise engineers and TOs at both Leeds and Newcastle with its use.

Currently there are two of these units in North region, based at Leeds and Newcastle. However, discussions are taking place with other BBC departments with a view to providing further vehicles to this design.

Neil Baker, Project Engineer
Broadcast Comms. Section, TED

Garth Jeffery
Manager, Prog. Services & Eng.
Newcastle

Pontop Pike

Pontop Pike now has OB receiving facilities similar to those existing at Holme Moss, thus greatly improving the Region's response to emerging news stories in the Newcastle editorial area.

A 1.2m rotatable receiving dish has been installed on the Pontop Pike mast, at a height of 104m, and feeds a single shf receiver with provision for a second. The technical equipment is installed in a new OB room which has been created in what was previously a store area at the transmitting station, thus allowing independent access to the OB facilities.

An omni-directional aerial is located just above the shf dish and provides a 10kHz audio circuit for programme co-ordination, via a uhf reverse-bearer transmitter with high power amplifier.

The incoming vision feed is routed via the existing vision matrix at Pontop Pike to the Newcastle contribution circuit, or to BT for onward routeing by protection circuits. The audio is routed back to Newcastle on existing music lines, via a simple switcher.

All OB facilities can be controlled locally in the OB room, and from Newcastle BH via a remote-control system, similar to that in use at Bristol Royal Fort, using software developed by CME Systems to a TED specification.

The remote-control system consists of a standard PC-based workstation in the Technical Apparatus Room at Newcastle BH, and a serial link — operating over either a four-wire circuit or a phone-line — to a CME Systems outstation at Pontop Pike. This equipment uses standard bus-based control cards to interface with the various OB facilities.

The system is operated by mouse-driven colour displays that mimic the remote equipment. Configuration and screen editors have been provided, allowing customisation and inevitable changes to take place. Various alarms are incorporated and a log of these is kept, allowing faults during unmanned periods to be recorded.

The system incorporates a database to store the bearings from Pontop Pike of up to 10,000 possible LLU sites around the region. Thus, the shf antenna can be panned automatically to a preset compass bearing. For increased flexibility, the database can also accept a National Grid Reference as an input and calculate its bearing from Pontop Pike.

Ian Gordon, Project Engineer
Broadcast Comms. Section, TED

NETWORK RADIO

Three Neve 66 desks installed

Three studios in Broadcasting House have just been equipped with Neve 66 desks, as described here by Martin Bravery and Tim Mountain.

The three new desks were ordered to replace ageing BBC 'GP desk' installations. They are custom configurations of a standard product and include twelve mono and twelve stereo channels, four stereo groups, and facilities for handling four stereo outside sources. Comprehensive aural and visual monitoring allow complete quality control.

All channel gains and routeings can be memorised and recalled by the onboard computer. A Neve routeing matrix (which replaces the old BBC Tape control panel) is also integrated into the desk computer, thus allowing sources and destinations to be memorised and recalled.

The installations were carried out by Neve and feature PCs for the control of the BH Outside Source Router and a comprehensive array of record/playback machinery and effects devices.

The first desk was installed in the Studio Operations Training Suite, to familiarise Studio Managers with its use; the other two have been installed more-recently in Studios S3 and 6C which are used for general programme production.


David Darby

The Neve 66 desk in the control room of Studio Suite S3 — looking through to the studio.

Studio Suite S3

Studio Suite S3 has been created in the large studio area of S2, using a construction technique marketed and installed by KFA Ltd.

Three fully-finished rooms — comprising two studios plus the Neve control room — have been built to KFA's standard design. The contract included all the electrical work and ventilation plant, and was completed during a very short on-site construction period. The basic shell was erected in only five days and is constructed principally from prefabricated sand-filled panels.

This proprietary construction technique has successfully provided a quiet studio environment in the sub-basement of BH (which is notorious for underground train noises) and complements the 'high tech' nature of the Neve installation.

Martin Bravery, Project Manager
and Tim Mountain
Radio Projects

RESEARCH DEPARTMENT
Controlled reflection zones

Bob Walker describes a new approach to control room acoustics, based on controlled reflection zones.

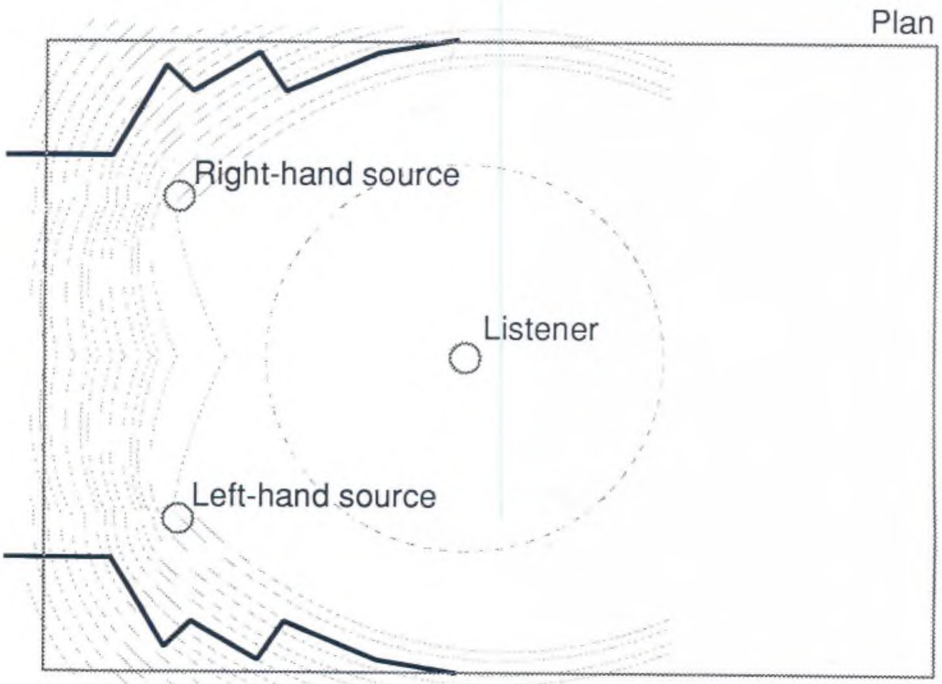
In the very earliest days of sound control rooms (cubicles), the acoustic designer attempted to mimic the final listening environment. Indeed, studies were carried out into typical living room conditions, in order to obtain numerical values for the reverberation time; the values actually obtained were within the region 0.6 to 0.8 seconds. However, various arguments about increased accuracy of listening, and more analytic conditions, ensured that the design target for control rooms was somewhat lower at about 0.3 to 0.4 seconds.

That approach survived essentially until the advent of stereophony. Then, with the emphasis on exact and objectively-accurate image localisation, the disturbing effects of early reflections became apparent. Strong discrete reflections — in the period up to about 20ms after the arrival of the direct sound — cause distortion of the perceived sound stage and significant image shifts. Beginning in about the early or mid-1960s, acoustic treatment was applied selectively to control these reflections. The extent of this control appears to have increased progressively up to the present time.

Unfortunately, the complete control of reflections in this way leads to very large total quantities of acoustic treatment and extremely 'dead' rooms; measured reverberation times of less than 0.15s are now frequently encountered. If this could be interpreted statistically (which is not possible because the sound field is usually far from diffuse), it would correspond to a mean absorption coefficient for the whole room of about 60%. This large amount of acoustic treatment is very expensive in terms of capital cost, installation cost, and space within the room. It also leads to rooms which, for the occupants, are extremely oppressive.

The tendency now is for image localisation to be less technically exact (many sources are 'panned' into artificial locations) but to retain a high degree of ***apparent*** image definition. For most programmes, the listener has no knowledge about the physical location of the sources, except for traditional orchestral music performances. (Even then, the listener is unaware of the conceptual seat location.) It is perhaps now even more important that the stereo illusion is clear and consistent from room to room.

In recent years, commercial control room design has been dominated by several fashions which have been more or less time-sequential. These have all been based on less uniform distributions of acoustic treatment. The most recent is the concept of placing the listener in a so-called ***reflection-free zone:*** actually, a region of the room where reflection amplitudes are rather less than they would have been otherwise.



Control Room design using reflection-free zones.

The underlying principle is the use of re-direction and diffusion to reduce the reflection amplitudes in the vicinity of the listener. By this means it is possible, in principle, to both improve the stereo image sharpness and make the stereo effect independent of the room. Because the key factor in achieving this is the use of non-absorbing surfaces, a 'dead' acoustic is not an inevitable consequence and, indeed, the acoustician has considerable freedom in the choice of reverberation time. This removes the 'oppressive' feeling and makes communication within the room easier and more comfortable. Also the control room more closely approaches the listener's room conditions (in at least one respect).

The ***controlled reflection zone*** in the control room is achieved by building curves or multiple-angled sections into the front wall and the front part of the side walls and ceiling.

RD experiments

A project was started in December 1990 at Research Department to find out whether this approach had any real acoustic or other benefits and, if so, to study ways of achieving the results at reasonable costs — both financial and in terms of the potentially-wasted room volume.

A prototype room was constructed in the Acoustic Test Room at Kingswood Warren using simple timber-framed, plasterboard-covered surfaces. The first results from this room were very promising and, after the installation of enough acoustic treatment to reduce the overall reverberation time to about 0.5s, was demonstrated to and assessed by users' representatives, architects and managers.

Their reactions were generally favourable, sufficiently so to encourage further tests and developments. One question raised was the preferred value of overall reverberation time. At about 0.5s it was long enough to affect the perceived sound quality, although arguably still representative of the listener's environment. There was also considerable interest from architects and project leaders in the aesthetic implications of these newer designs. In saving large amounts of acoustic treatment, it is likely that such designs could be competitive, in terms of cost, with those of the present time.

The angled, reflecting surfaces may also have other benefits. In the past, glazed surfaces such as observation windows have been tolerated out of necessity, despite their generally detrimental acoustic properties. With a ***controlled reflection design*** (CRD), any of these surfaces may be windows, cupboards or doors.

Much of the paraphernalia associated with a modern control room — for example clock patresses, indicator lights, computer monitors, etc — may be hidden behind glass panels, thereby tidying up both the acoustic and the aesthetic aspects of the room. The surfaces must of necessity be hard and may therefore be more serviceable, longer-lasting and easier to keep clean. It is also likely that they will be intrinsically more fire-resistant than many of the treatments currently employed.

The completed test room was eventually assessed by a number of Group 5 Studio Managers, with the possible object of using the design principles in the basement of London Broadcasting House, for the refurbishment of some control cubicles. Two different reverberation times were tested — 0.5 and 0.35s. The reactions of these SMs was generally very favourable, with a significant preference for the shorter reverberation time. The decision was then made by Network Radio to use the design for the cubicles of B12, B13 and B14.

The design presents a new challenge for interior designers, namely, to coordinate the acoustic and aesthetic requirements with the other physical requirements such as ventilation, technical equipment layout, etc. One immediate benefit is the additional potential for observation windows — B13 and B14 will have two windows totalling nearly 3m width, instead of the single 1.5m wide window previously provided. This will permit better sight-lines from both the operator's and the producer's positions.

Bob Walker
Sound Section
Research Department

The acoustic test room at Kingswood Warren with an experimental reflection-free zone.

WORLD SERVICE
The EDiT computer system

Roger Powell describes the Editing, Distribution and Translation system (EDiT) which entered service at Bush House in January.

World Service has long been in the forefront of using computers for the handling of news and script material. Since 1977, the Bush House ***Electronic Distribution System*** (EDS) has linked together the newsroom, central supply departments and Language Services via a network of 150 VDUs and 130 printers. Whilst this system has been incredibly reliable (less than 0.1% down time), the one failing was that the original concept was on too small a scale; by the mid-eighties, it was very evident that a larger replacement system would be needed.

Between 1985 and 1989, considerable thought went into the design of a new system, culminating in a detailed design brief. Another bespoke system would cost nearly £20m and take a minimum of four years to achieve. This timescale was felt to be totally unsatisfactory, as the need to replace the EDS was becoming very urgent. Thus, the strategic decision was taken to base a solution on proven existing commercial systems, setting a timescale of 12-15 months.

The system chosen is, in effect, an enhanced version of the Basys newsroom computer system, examples of which are already in use in News & Current Affairs at Television Centre in London and elsewhere in the regions. Although the Basys system could provide word processing in Romanic* languages, it could not do so in the non-Romanic ones such as Arabic, Mandarin, etc.

To overcome this problem, PCs have been provided for users of non-Romanic languages, as an adjunct to the Basys system. These PCs are networked to file servers which provide access to the Basys system but at the same time offer multi-lingual word-processing facilities.

Design philosophy

The prime requirement was to reliably link together some 900 terminals and 400 printers in the three wings of Bush House, and to provide links with the outside

** In computer-speak, a Romanic language is one which can be typed on a standard Qwerty keyboard* world using telephone, telex and packet-switched networks, as well as agency wires. Within each wing, all equipment is connected, either directly or indirectly, to local area networks (LANs). Optical fibres link the individual LAN branches in such a way that they behave as a single very-extensive network. Full redundancy is employed with cross-links to ensure no 'single point of failure'.

The main Basys application runs on three VAX 6310s, each with 1 Gbyte of storage. These machines are linked together to 'mirror' the data. RV20 optical WORM drives are provided for back-up of the database. Two smaller processors (VAX 3100) are located in another wing to provide emergency back-up in the event of a major failure in the computer room. All processors are fed through uninterruptible power supplies (UPS), which gives time for the diesel generator to run up and maintain power. Terminal devices are served through concentration devices (CCUs), which are distributed and networked to the main processors.

The (non-Romanic language) PCs form their own logical network, using a VAX 4000 resilient host running VMS and DEC Pathworks. Over four hundred PCs run a networked version of the DOS-based package ***Multi-Lingual Scholar*** in a Windows environment. The VAX 4000 also provides a gateway for external communications such as telex, X.25 and X.400 mail.

Connections are also provided to the Monitoring Service at Caversham and to other BBC Basys systems. A comprehensive dial-in facility is provided so that WS correspondents anywhere in the world can file information remotely from laptop computers.

Gandalf system

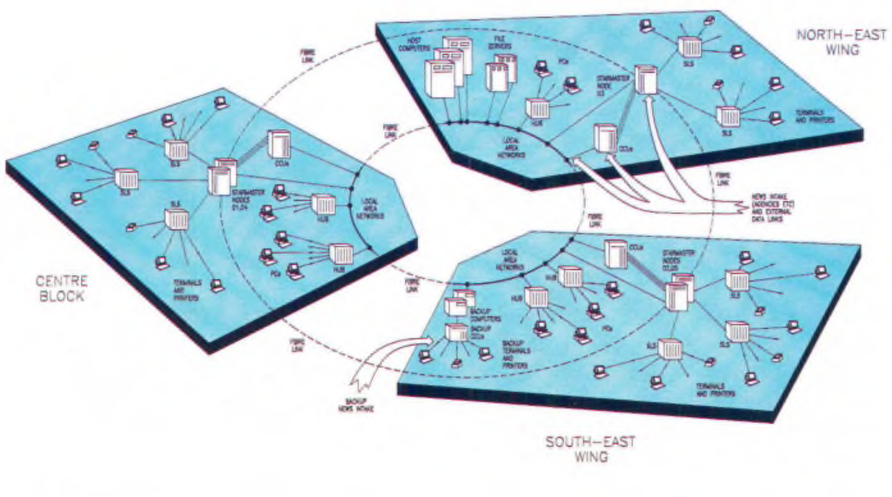
Access to the main Basys system was required for over 900 terminals, together with nearly 400 printers. To improve cost effectiveness, a smaller number of CCU ports than this has been provided; the ports are allocated terminals — on a first come, first served basis — via data switches known as ***Gandalf Starmaster*** nodes, as shown in the diagram opposite.

Printers are also routed through the Starmaster, but on a fixed allocation. The Starmaster provides intelligent printer sharing — queuing any conflicting print jobs from the Basys terminals and the PCs, as necessary.

There are five Starmaster nodes in total: one in the NE Wing computer room; and two in each of Centre Block and SE Wing where there are a larger number of terminals. All nodes are inter-connected by fibre-optic links, forming the Gandalf ***Bus Link Utility*** (BLU) ring.

Terminals and printers are connected to the Starmaster nodes via Gandalf ***Subscriber Logic Shelves*** (SLSs) which are strategically located in various parts of Bush House. Each SLS provides several RS423 ports for local terminals and printers and is linked back to its node via fibre optic cable. The Starmaster carries out all the format and protocol conversions necessary for linking various devices.

Each SLS is co-located with a ***Chipcom Hub*** which provides a maximum of ninety-six ports for PCs located nearby; each PC is connected to a hub via a single-station version of ethernet known as ***10Base-T***, which carries baseband data at 10 Mbit/s on unshielded twisted-pair cable.



EDiT system concept.

Technical Publications

The cabling scheme allows either RS423 or ethernet devices to be connected via the same office-block wiring.

Fibre links and rings

Two fibre-optic rings — each consisting of a pair of fibres — interconnect the three wings of Bush House; fibres offer the advantages of physical security, freedom from electo-magnetic and radio-frequency interference, and high-speed data transfer. One ring carries the Gandalf BLU links; the other is for a ***Fibre Distribution Digital Interface*** (FDDI) system.

FDDI is an accepted international standard for data networking. It operates at a speed of 100 Mbit/s — well in excess of ethernet speeds (10 Mbit/s) — and thus, at Bush House, provides 'transparent' interconnection of the ethernet branches. The FDDI ring uses a pair of 62.5/125m multimode fibres, operating at a wavelength of 1300nm. One fibre acts as the primary ring; the other as a back-up, should the main ring or one of the concentrators fail.

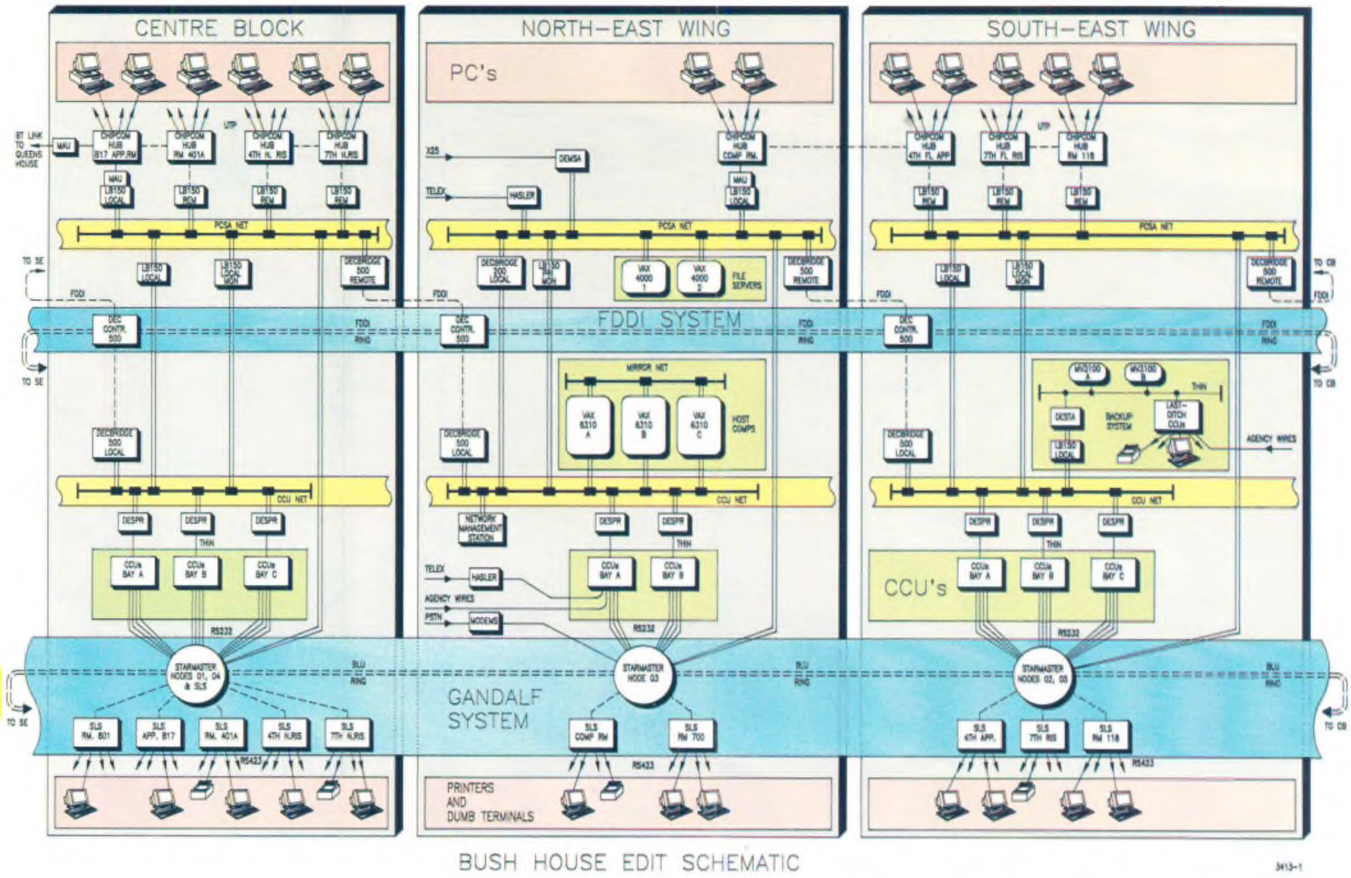
The Gandalf BLU ring operates at a maximum bit-rate of 'only' 10 Mbit/s and, unlike the FDDI ring, is uni-directional. Hence, the pair of fibres making up the Gandalf ring together provide clockwise and anticlockwise data transmission.

Implementation

The logistics of implementing a 900-terminal system — with over two thousand users to train — should not be underestimated. Not only had all users to undergo a 2-day training course, but also their offices were redesigned to take account of best work practices and workstation ergonomics.

Some seventy 'change managers' were nominated to aid this process, and to provide local support during the changeover (which occurred on 5th January). The actual switch to EDiT went remarkably well, mainly due to the EDiT system being available fully-supported for the previous two months to establish user confidence. Well over a hundred World Service staff were directly involved in the design and implementation of the system.

Roger Powell
Head of Computer Systems
World Service



Schematic diagram of EDiT.

Technical Publications

DAVENTRY
A brief history

As reported on page 1, Daventry ceased broadcasting on 29th March. The station has served the BBC very well over 67 years, as described here by Tony Ratcliff.

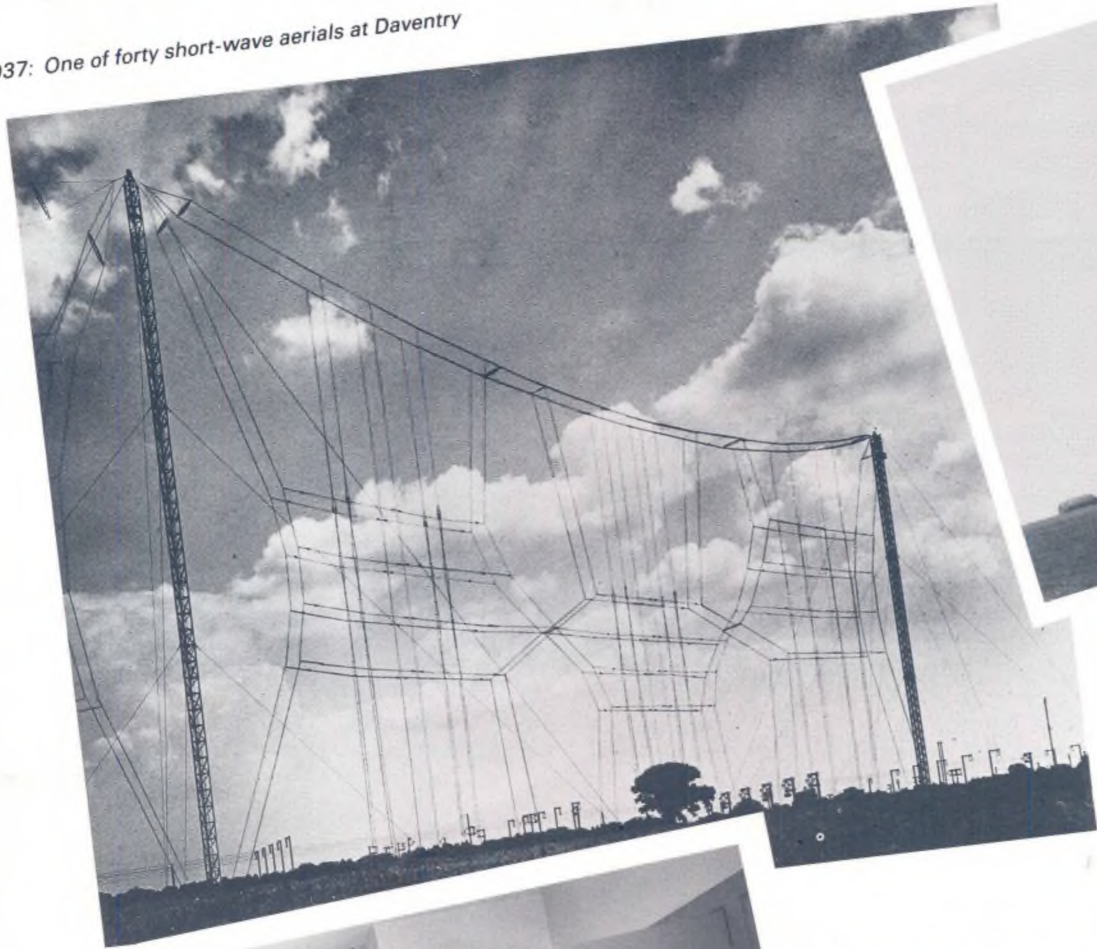
The first long-wave transmitter designed for broadcasting was opened on 27th July 1925 by a party led by the Post Master General and including the BBC's Director General, John Reith, and Chief Engineer, P P Eckersley. It was at Borough Hill near Daventry and BBC transmissions have continued there for nearly 67 years, until the 29th March this year. This may not be the end of an era, but it is certainly the end of a very significant chapter in the history of broadcasting in this country.

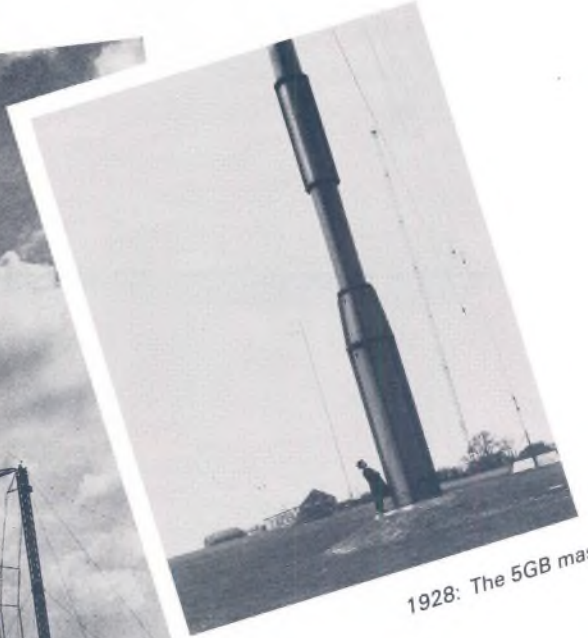
It was only a few years prior to Daventry's opening that the first tentative attempts to 'broadcast' to an audience had been made. Perhaps the first in the UK was in 1920 by Marconi, from Chelmsford, with a recital of songs by Dame Nellie Melba. By 1922, several companies who were manufacturers of wireless apparatus had set up transmitters; notably Marconi in London with 2LO, the Radio Communication Company in Manchester with 2ZY and the Western Electric Company in Birmingham with 5IT.

A single company was established to be responsible for these transmissions and, by 1924, the ***British Broadcasting Company*** had installed a further six main stations and eleven relay stations. All of these radiated on the medium-wave band. It is interesting to note that, because output power was at most about 1kW and because there were no permanent linking lines nor recording equipment available, the BBC's first service was 'local radio'. Daventry's long-wave station, 5XX, with an output power of 25kW, was the first to radiate a National Programme and had an 85% population coverage.

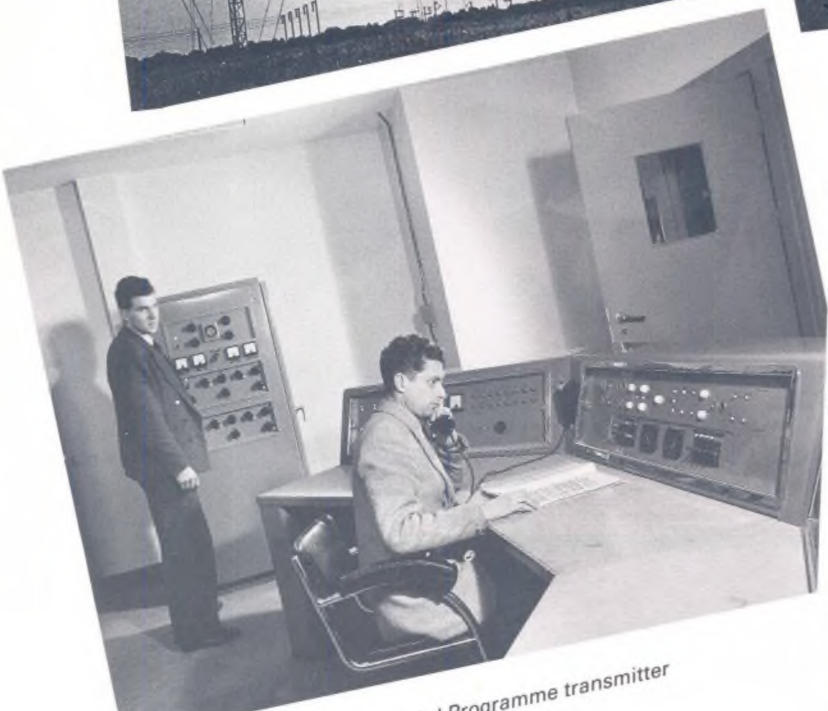
The idea of a high power long-wave station in the middle of England had been conceived by P P Eckersley, and it was he who was responsible for the next major development at Daventry. This was the start of the Regional Scheme, and involved the design and installation of a high power medium-wave transmitter which, with 5XX, would provide a choice of programmes for the Midlands.

1937: One of forty short-wave aerials at Daventry

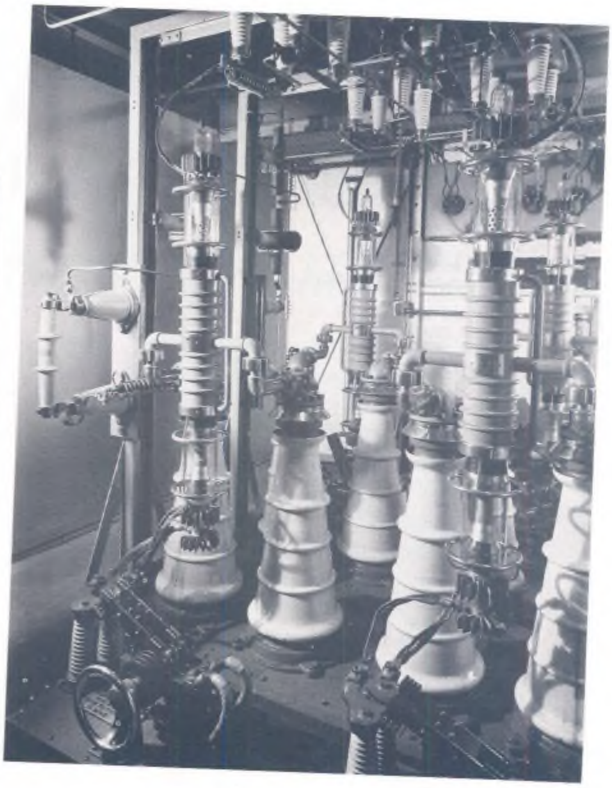




1928: The 5GB mast

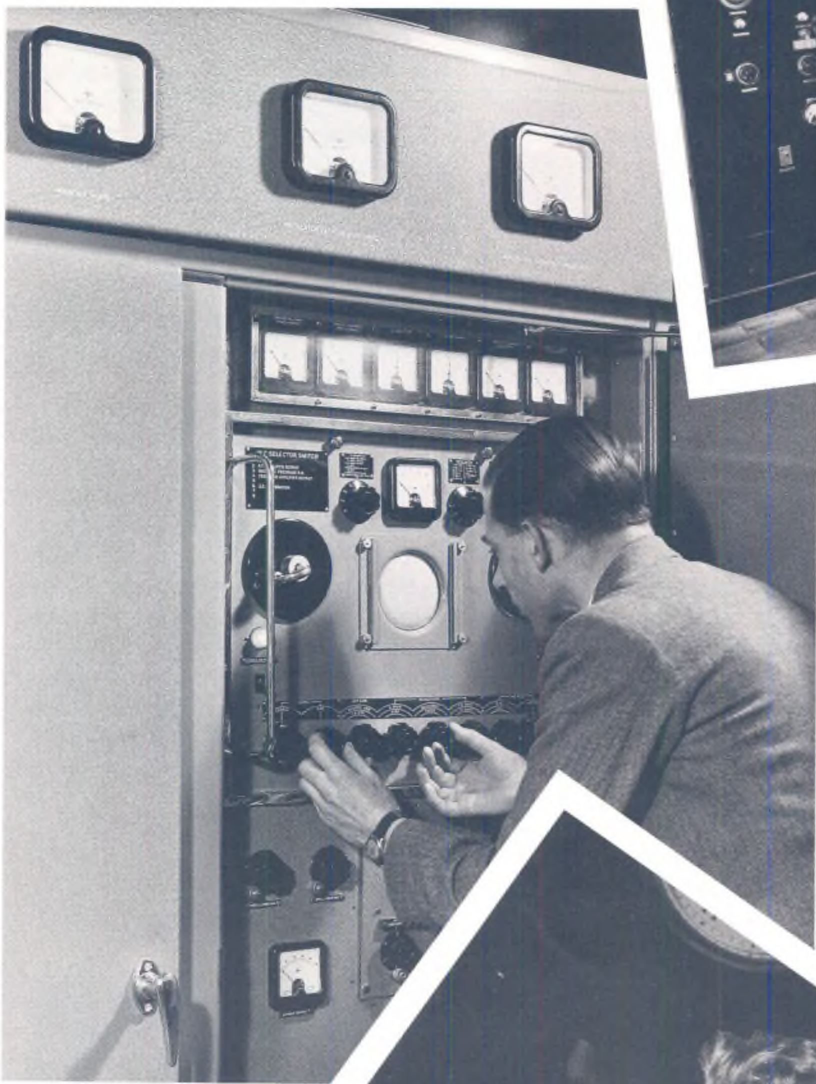


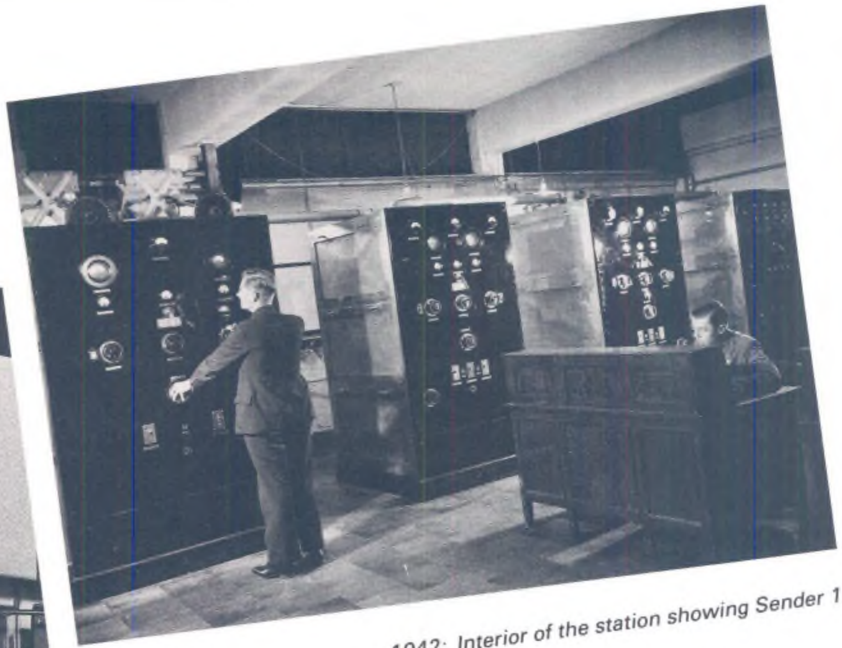
1950: The control desk of the Third Programme transmitter



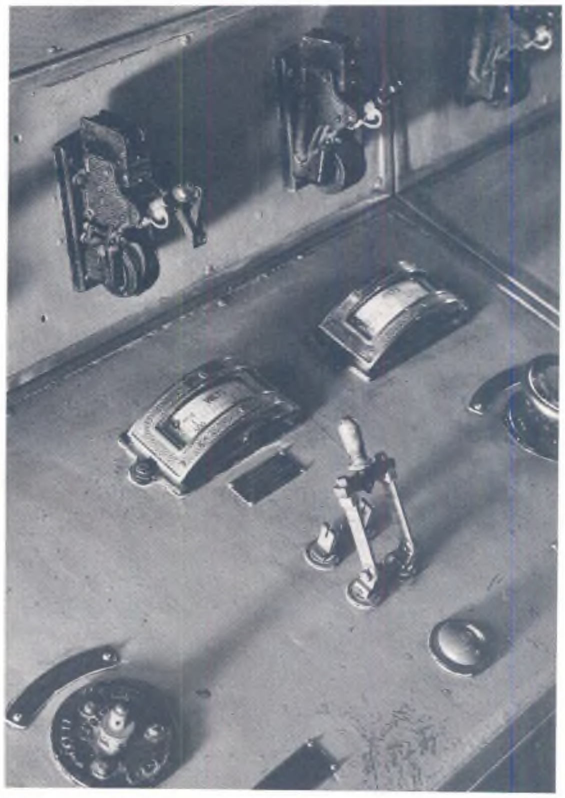
1941: The main modulator of Sender 7

1950: The Third Programme transmitter

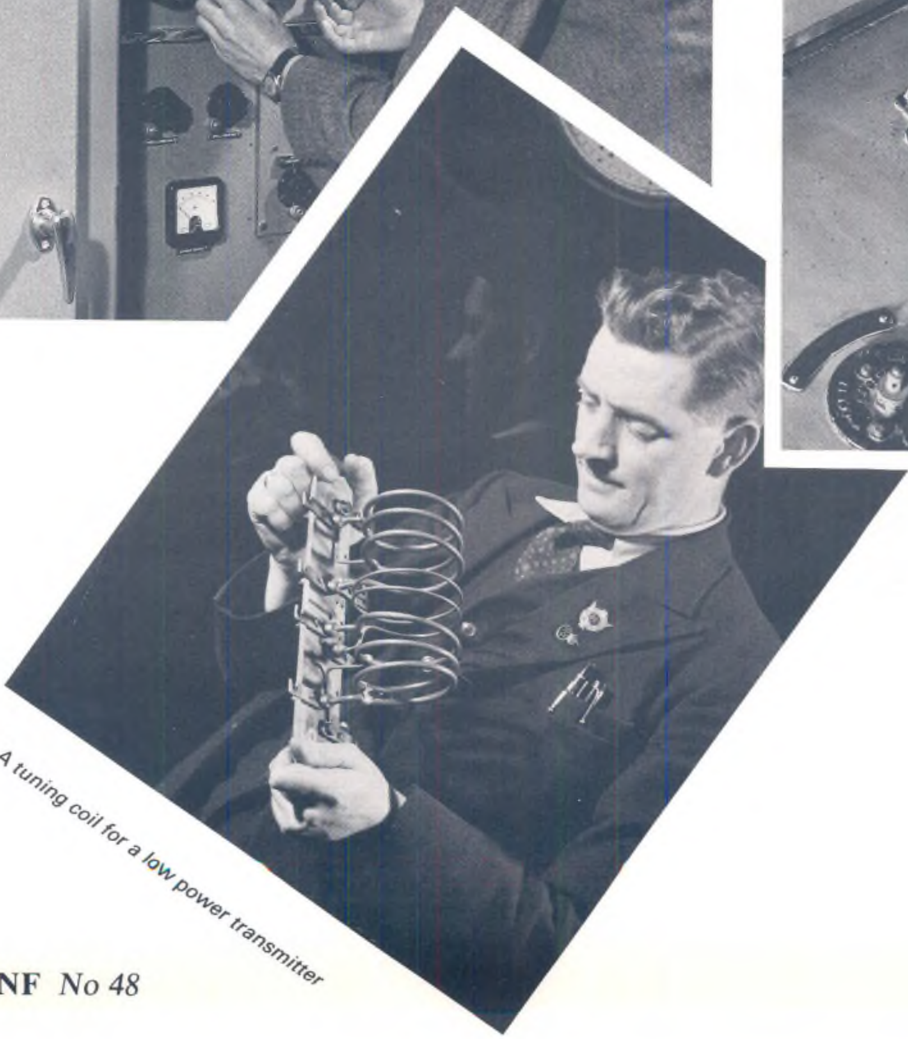




1942: Interior of the station showing Sender 1



1932: The emergency trip switch of the long-wave transmitter



1942: A tuning coil for a low power transmitter

Continued from previous page.

At the time, no such transmitter was available from manufacturers so the BBC produced its own design. Some preliminary work was done by Ashbridge and Kirke but it was B N MacLarty who went to Daventry towards the end of 1926 and, with the help of T C Macnamara, built 5GB. This transmitter was powered into aerial for the first time on 5th May 1927 and provided the first alternative programme for the Midlands on 21st August that year, with an output power of 30kW. This was a remarkable achievement with many design problems overcome in a few short months. It is perhaps significant that the first BBC Charter came into force on 1st January 1927, whilst MacLarty was working away at Daventry, for it was this kind of development that enabled the growth of the Corporation and the broadcasting industry that we know today.

Both long and medium-wave services were transferred to Droitwich in 1934 and 1935 respectively. However, by that time short-wave transmissions had started.

Short-wave broadcasts

In the 1920s and early 1930s, there was considerable debate about the need for a short-wave service to the Dominions and Colonies. How should it be financed and would it be effective? In 1927 the BBC initiated tests by Marconi on an experimental transmitter whose call sign was G5SW. Despite reception problems, these proved popular and on 13th January 1932, the BBC agreed to fund a service from Daventry. The sum approved was £50,000 and this provided the Empire building, two 15kW STC transmitters and an aerial system to five zones — Australasia, India, South Africa, West Africa and Canada. Transmissions started on 19th December 1932, in time for King George V's Christmas Day broadcast.

From the start of transmissions to the early years of the war, there was continual development and expansion. This was given added impetus by the rise to power in 1933 of Hitler and the use Germany was making of short-wave for propaganda purposes.

The war years

By 1940 there were eleven transmitters at Daventry with outputs of up to 100kW, and the fundamentals of short-wave broadcasting by the BBC had been established.

Daventry's contribution during the war years was considerable and not limited to the short-wave transmissions. The GEE system of navigational aids for the RAF — which was radiated from Daventry — required accurate pulse repetition frequencies for a vhf transmitter. It was fortunate that the EiC at that time, D C Birkinshaw, and some of his staff had worked on television at Alexandra Palace. Their knowledge of pulse techniques gave Daventry — which became the master station in the Eastern Chain — a well-earned reputation for reliability.

Until the outbreak of war, Daventry had operated the 'Air-Met' service for Civil Aviation, using a 1kW transmitter on 250 kHz. This was brought back into service for war-time communications and as a navigational beacon for the RAF.

Even 5XX was not too old for active service. The 'Old Gentleman', having been used in the Overseas Service long-wave group, was transferred to Air Ministry service in January 1945 using Morse transmissions.

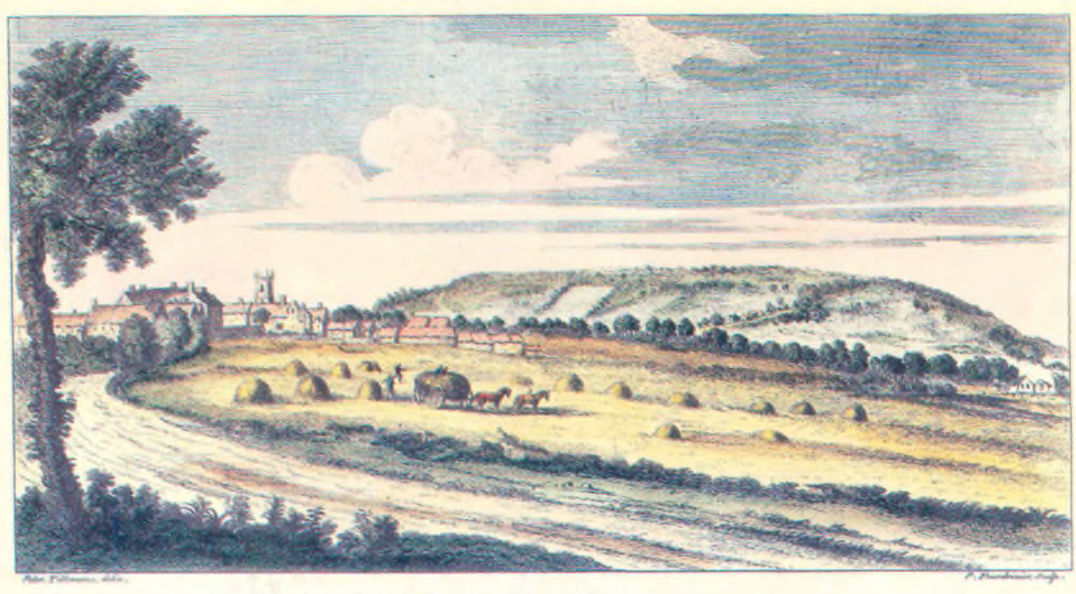
The post-war period

After the war, developments continued. In 1951 the 5XX building became the T3 building, following the installation of a high power 150kW medium-wave transmitter to carry the Third Programme. This was an early and important step in the remote control of an unattended station.

The short-wave equipment underwent major re-engineering in 1960 and again in 1985, when there were two other developments at the station. Firstly, the old 5XX building took on yet another role and name when it became the Tape Reclamation building. Secondly, Daventry took over responsibility for maintaining the domestic sound and television transmitters in that part of the Midlands, and East Anglia.

Daventry is our oldest transmitter site. Because of this, and because of the many developments that have gone on there, it has probably played a greater part in the history of the BBC than any other. There can be little place for sentiment in today's world of hard decisions, but the many Engineers who spent time at Daventry, including some who have moved to other departments and higher places, will have a tinge of regret that there will be no more BBC transmissions from the old Hill Fort.

Tony Ratcliff
Sp Asst to CET&PS (Retired)



The Prospect of Daventre and Burrough Hill July 1719