BBC

Engineering

The History of

CEEFAX

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A Summary of the Steps leading to the Broadcast Teletext Specification of September 1976

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Preface

It is commonplace to remark on the speed of modern technological progress. Nevertheless, it was an outstanding achievement on the part of the BBC, the IBA and the British radio and electronics industry to develop the British teletext system (BBC's Ceefax and IBA's Oracle) from initial development of such a system, to the world's first regular public service in the four years between 1970 and 1974.

Such results were not achieved without great efforts by all concerned in developing and testing the system: in fact so much work was put into the project by the broadcasting authorities and the radio industry that this history has been written to identify and record the principal technical steps which led to the Broadcast Teletext Specification of September 1976, and to give the names of the individuals or organisations who suggested the steps.

The text is intended for readers familiar with the technicalities of the teletext system, and no description of its method of operation is therefore included.

Introduction

The first mention of the possibility of displaying data on the screens of domestic television receivers independently of (or in addition to) the normal television programme occurs in a note accompanying a memorandum on facsimile and dated 14 December 1970 from P. Rainger (then the BBC's Head of Designs Department) to the Chief Engineer, Research and Development. The note, entitled 'Notes on Electronic Methods of Domestic Data Displays' mentions the generation of alphanumeric characters and the storage of one line of script by electronic means. It envisages a magazine of thirty pages, which can be continuously updated, and a magnetic means of storing pages. The note says that the information for the display could be sent within the television waveform or over the telephone system: it thus anticipates the Teletext and Viewdata systems.

Teledata

In February 1971 a plan of work was agreed between the BBC's Designs and Research Departments aimed at putting on a press demonstration of such a display (known as Teledata at that time) by July 1972. One possible method of transmitting the information was discussed in a Research Department Technical Memorandum issued on 2 July 1971: by transmitting the data in binary digital form on a subcarrier around 30kHz in the sound channel of a television service it was concluded that an average bit-rate up to 15kb/s could be achieved without significant effect on the sound signal. A second Technical Memorandum, dated 10 November 1971, discussed the transmission of binary digital signals within the television waveform and concluded that such information could be transmitted on lines 15 and 328 during field blanking. By using biphase coding and a clock frequency of 2.5MHz a peak bit-rate of 2.5Mb/s (equivalent to an average bit-rate of 6.5kb/s) could be used: this is equivalent to 130 bits per active line, the standard used in the vertical interval communications equipment(ICE) which had been designed and tested by Designs Department between 1966 and 1968. Assuming that 10 bits would be needed to clock the system, 120 bits were available for characters. Thus a row of 15 characters each of 8 bits could be transmitted: this was felt to be inadequate.

At a meeting between representatives of the Designs and Research Departments on 5 November 1971 a co-ordinated programme of work was planned to determine the specification to be used in an experimental Teledata system. A patent application filed on 9 February 1972 by the BBC in the names of P. Rainger, I.D.B. Millar and F.G. Parker of Designs Department and entitled 'The Transmission of Alphanumeric Data by Television', and cognate with a later patent 'Teledata' naming the same inventors, described a system using non-return-to-zero coding (advocated by J.R. Chew of BBC Research Department) which enabled the bit-rate to be increased to 4.5Mb/s for the same resistance to noise. Thus by using lines 13, 14 and 326, 327 in the field blanking period it was possible to transmit rows of 32 8-bit characters. The patents described a system with 24 such rows and mentioned that page storage, requiring 6,144 bits, was possible using i.c. technology. Row-sequential and page-sequential systems were described together with the use of address codes for page and row. The first line in field blanking was used for address codes, bits for timing of data extraction, parity checks and for the first part of the text row: the second line was used for the remainder of the text row. This was, in fact, very largely the specification for the experimental service subsequently transmitted.

On 11 May 1972, a brochure entitled 'Teledata—a new Broadcasting Service' by P. Rainger was published. This outlined the facilities such a service was anticipated to be capable of providing.

Oracle

On 6 September 1972, P.R. Hutt of the IBA in his paper to IBC 72, 'A System of Data Transmission in the Vertical Field Interval of the Television Signal', described a system using lines 16 and 329 to carry 14 words of 8 bits each. He listed among 18 possible applications for the system 'transmissions of captions to special domestic receivers'.

Specification for Experimental Ceefax Service

The Teledata system was renamed Ceefax on 11 September 1972 and on 23 October the BBC announced the Ceefax system in a news release

which outlined a series of tests involving the radio industry and culminating in a series of test transmissions in the summer of 1973 to determine the standards needed for a permanent service. It was also featured in a television news bulletin.

At a meeting at BBC Research Department on 5 October 1972, a number of possible ways of transmitting Ceefax were discussed and it was concluded that existing transmitters offered significant limitations if additional carriers or sub-carriers on sound channels were to be adopted but that time-division-multiplex such as the use of lines in the field blanking period would cause no difficulty. The various transmission possibilities were listed in a Research Department Technical Memorandum.

On 4 January 1973, Ceefax was demonstrated in the television programme 'Tomorrow's World' and in February 1973 another Technical Memorandum, 'Ceefax—a Survey of Facilities', was published. This described A, B and C-type pages which also formed the subject of a patent application filed on 15 February under the title 'Improvements relating to Television Systems' (P. Rainger).

Tests were made by the BBC after normal broadcasting hours in March and April 1973 to determine which lines in the field blanking period to use for Ceefax. Lines 13, 14 and 17, 18 (and the corresponding lines in the alternate field) were possible and the tests showed that about 7% of television receivers with slow flyback or poor flyback suppression displayed the Ceefax pulses on the picture area if lines 13 and 14 were used. This did not occur if the later lines 17 and 18 were used.

In April 1973, the BBC released details of the specification for the experimental Ceefax service in a further Technical Memorandum and in the same month the IBA gave details of their Oracle system in a document entitled 'Broadcasting the Written Word'. Oracle used the same principles as Ceefax but differed from it in the following ways.

	Ceefax (1973)	Oracle (1973)
Format	24 rows of 32 characters	22 rows of 40 characters
Bit rate	4.5Mb/s	2.375Mb/s
Number of pages	32	50
Field-flyback lines used	two	one
Order of transmission	row-sequential	page-sequential
Type of secondary coding	non-return-to-zero	bi-phase

These announcements precipitated a very busy period for everyone concerned with the two systems. At a meeting between BBC and IBA engineers on 26 April 1973 the differences between the technical specifications of the two systems were discussed and this led to a regular series of meetings aimed at achieving a common system of transmission embodying the best features of both. Regular meetings also began with representatives of the radio industry, notably Mullard, GEC, RRI, Thorn and Decca. On 9 May, Mullard Central Applications Laboratory published a 'Comparison between Ceefax and Oracle' which was the basis for a Research Department Technical Memorandum published two months later with the same title. Also on 9 May, Ceefax was successfully demonstrated at an IEE lecture by P. Rainger and on 20 June 1973 both Ceefax and Oracle were demonstrated at an IEE Conversazione. In the meantime (23 May 1973) the character-rounding patent was filed by the BBC in the name of A. Roberts (Research Department) under the title 'Generation of Dot Matrix Characters on a Television Display'. During June 1973 the IBA published the paper 'The Format of the Insertion Data Signal'. As a result of the tests in March and April 1973 and as a means of simplifying Ceefax receiver design, the BBC published a revised specification for the experimental Ceefax system on 27 June 1973. It differed from the previous specification in that:

a) the lines carrying the Ceefax information were changed to 17 and 18,
b) the address codes were longer (8 bits) to make all address codes a standard length.

On 2 July 1973, BBC representatives attended a demonstration of Oracle at IBA headquarters and this included a graphics facility—a means of displaying any of six cells in each letter space by a dedicated bit of a 6-bit word.

The BBC experimental Ceefax service began on 16 July 1973 on BBC-2, transmitting 32 pages identical except for the page number. Each page consisted of 8 identical groups of 3 character rows (one in upper case, one in lower case and the third in symbols) and were transmitted according to the BBC specification.

Unified Standard

Around the middle of 1973, a committee of representatives from BBC, IBA and BREMA was set up. Its terms of reference were 'to examine the technical aspects of Ceefax and Oracle and to recommend a common data-broadcasting standard aimed at providing a reliable and high-quality service'. Further important points were that the receivers should not be too expensive, that the system should be rugged and that there should be a number of receiver options. The committee set up a working group of engineers representing the member organisations and this group held their first meeting on 20 July 1973.

The working group met at approximately monthly intervals but meetings also continued, outside the working group, between the BBC and representatives of the receiver manufacturers, and between the BBC and the IBA. To simplify receiver design the manufacturers were anxious to devise a system in which the data for a row of 40 characters could be transmitted on a single television line. This meant a higher bit-rate than was used in Ceefax or Oracle and in September there were requests from industry for tests using higher bit-rates.

On 28 September 1973 the first transmission of a magazine was made by the BBC, 32 different pages being transmitted. A core store was used for page storage and this was filled via paper-tape. The standards used were still those of the published specification.

In October and November 1973, the BBC compared the non-return-

to-zero (NRZ) and bi-phase systems of coding and concluded that in the presence of uhf impulsive noise NRZ offered approximately double the bit-rate for a comparable error-rate.

In November 1973, a representative of the Post Office joined the working group. Clearly it was desirable that the Post Office's Viewdata system should be compatible with the unified standards of data transmission being hammered out in the working group. Also in this month Mullard introduced a paper 'Decoder and Display Systems for Ceefax and Oracle'. A point repeatedly made by S.M. Edwardson of the BBC was that phase distortion in television receivers, e.g. overshoot, can cause inter-symbol interference in Ceefax reception and with the high bit-rates being considered this aspect of receiver performance is of particular importance: a simple equalising circuit was described that enabled a useful improvement to be made to the receivers then current.

On 28 December 1973 the IBA introduced a paper on compatible display systems for mixed alphanumeric and graphical symbols in colour. This initiated a series of discussions with the BBC on graphics inside and outside the working group and it soon became clear that the full potential of the graphics display possible in Ceefax and Oracle had not yet been realised.

In January 1974, S.M. Edwardson and A. Gee (BBC) published their article 'A Proposed New Broadcasting Service' in the SMPTE Journal: this described the system as specified in the previously-mentioned Technical Memorandum.

As requested by the receiver manufacturers in the working group, the BBC began a series of test transmissions on 15 January 1974 to determine the effect of raising the bit-rate. Initially bit-rates of 4.5Mb/s, 5.75Mb/s and 6.875Mb/s were used, but results were so encouraging at the highest rate that the intermediate rate was discontinued after mid-February. Tests at a large number of receiving sites in the service area of the Crystal Palace transmitter were made and the conclusion reached was that bit-rates up to about 7Mb/s could be used without a significant increase in difficulty of reception (see BBC Research Report 1975/12 'Ceefax uhf Trials'). The higher bit-rate

transmissions were known as 'Compressed Ceefax', because the data signals for the 32 characters were compressed into a shorter period.

In March 1974, BBC and IBA engineers reached agreement on the standards for a unified system and agreed to defer decisions on graphics until later. On 18 March the working group accepted the BBC/IBA suggestions but recommended an increase in the transmitted pulse amplitude from 50% to 70% of peak white level. The final wording of the specification was agreed at the seventh meeting of the working group on 29 April 1974. The principal features of the new standards were:

a) The bit rate was increased to 6.9375Mb/s permitting transmission of 40 characters per row in one television line: there were to be 24 rows per page.
b) A method of protecting addresses and control bits using Hamming codes (proposed by J.R. Chew, BBC) which gave correction of single errors and detection of double errors.
c) Transmission was to be page-sequential.
d) The pulse amplitude was to be 0.5V (71% of peak white).

The new unified system was eventually to include a number of other facilities which had been tested after discussion and experiment. The transmission and display of simple graphics was included, e.g. for weather maps, and the graphics display could be mixed with alphanumeric characters. The colouring and flashing of selected words of text was possible using special control characters. In addition, special control bits were included for certain applications such as selection of pages by clock-time control, news flashes, subtitles. Spare control bits were also available for future developments.

The data level for the existing BBC tests on the old standards was increased to 0.5V on 3 April, but on 15 April 1974 this series of tests was ended. On 22 April 1974, a week before the final agreement, transmissions of test pages began using the new unified standards (but with 6.875Mb/s bit-rate pending the arrival of 6.9375MHz crystals). Four kinds of page were transmitted, numbered 1 to 60: one kind contained only upper-case lettering, another only lower case, the third

only symbols and the fourth was filled with characters for which the pulse code consisted entirely of ones or entirely of noughts, designed to test the clock synchronism of the Ceefax receiver.

In May 1974 representatives from Texas Instruments had meetings with BBC engineers about the possibility of manufacturing l.s.i. chips for use in Ceefax and Oracle receivers.

On 13 September 1974, the interleaving patent of D.T. Wright (BBC) was filed under the title 'Improvements relating to Data Transmission'. This described the method of interleaving the data and protection bits of the Hamming codes used for the address and control bits in the unified standards.

The IBA formally launched the Oracle system at a press conference on 16 September 1974 and on the 18th of the month the Home Secretary, as the Minister responsible for Broadcasting, approved a two-year experiment using live material for Ceefax and Oracle.

In September 1974, the unified standards were published jointly by the BBC, IBA and BREMA. The document was entitled 'Specification of Standards for Information Transmission by Digitally-coded Signals in the Field-blanking Interval of 625-line Television Systems'. The unified system has since been given the generic title 'Teletext'.

Editorial unit

The BBC had taken the first step towards the formation of an Editorial Unit to originate Ceefax material on 1 January 1974. Colin McIntyre was appointed Ceefax Editor. Initially all he had were a photocopier, a typewriter and a telephone answering machine! Later the editorial work was carried out on equipment arranged on tables in the Standards Conversion Area at Television Centre.

Towards the end of 1974, the Editorial Unit was moved to a temporary suite on the sixth floor of Television Centre and four sub-editors and four research assistants were appointed. In April 1975, a move to a purpose-built suite on the seventh floor took place and a

Ceefax computer was brought into use, the core-store equipment remaining as back-up. At the end of 1975, the staff of the Editorial Unit was increased to nine sub-editors and three research assistants.

On 31 March 1976, the first Ceefax outstation was set up at Broadcasting House, for direct injection of sports and financial news.

Field trials in Germany and Sweden

A point which had been raised on a number of occasions during the deliberations of the working group was that the unified standard should be suitable for international use particularly in countries where the 625-line television transmissions are on vhf where impulsive and multipath interference was expected to be worse than on uhf bands. Following some preliminary visits to Germany in 1974 for discussions with IRT, a series of tests was carried out by a joint BBC/IBA/IRT team between 16 and 24 April 1975 on teletext signals radiated from the Wendelstein transmitter which serves a large area including Munich. Tests made at 43 different sites showed that perfect teletext reception was possible at nearly 90% of them. Moreover it was found that good teletext reception was possible at sites where television reception was unacceptably noisy. Wendelstein is a Band III transmitter using System B which has a 5.0MHz video passband (compared with 5.5MHz for the British System I) and 0.75MHz vestigial sideband (compared with 1.25MHz for System I).

Tests were also made in Stockholm with the assistance of a BBC engineer between 1 and 4 April 1975. Sweden also uses System B (vhf) and here too it was found that perfect or nearly perfect teletext reception was achieved at 16 of the 20 acknowledged difficult reception sites tested. The conclusion reached was that perfect teletext reception would be possible at 90% of the households served by the Stockholm transmitter.

Changes to the Specification

At the meeting of the working group on 28 May 1975, changes were agreed to the specification to make it more acceptable internationally.

The code table was amended to accord with ISO 646 '7-bit coded character set for information processing interchange' (with the British national options exercised) which is embodied in BS 4730 and has been adopted by CCITT as the International Alphabet No. 5. It was impossible to incorporate the 19 teletext control characters within the 32 control characters of ISO 646, so a code extension technique had to be presumed. It was appreciated that these changes would be a nuisance for a while because existing receivers would eventually have to be modified to work with the new control characters.

This was the final meeting of the working group which had now fulfilled its purpose. It was agreed however that further meetings would be necessary to put the agreed modifications into the specification and to decide on the spectrum of the transmitted pulses (to mention two obvious tasks). In fact the original working group was replaced by the following three groups:

Group A	to incorporate the agreed changes in the specification (a new member in this group was a representative from ITCA).
Group B	to liaise with semiconductor manufacturers (Texas Instruments had formally declared their commitment to produce l.s.i. chips for teletext receivers at a press conference on 6 May 1975).
Group C	to liaise with the Post Office on Viewdata (primarily on methods of connecting television receivers to the public telephone system).

On 5 August 1975, the BBC began using the new character code table on BBC-2 and regular transmissions using it started on 1 September 1975. BBC-1 and IBA continued with the original code table.

Another BBC patent application 'Improvements in Data Display Apparatus' (J.P. Chambers, Research Department) was filed on 17 November 1975. This described a method of extending the number of available characters which can be transmitted by a teletext system so as to include letters with accents such as the Norwegian ϕ and the

German ö. The system described enables any letter capable of being reproduced by the available dot matrix to be associated with a given character code so making the system more suitable for international use.

On 13 January 1976 Ceefax, Oracle and Viewdata were on display at the IEE/IERE/RTS colloquium on teletext at the IEE, Savoy Place. This was the first public appearance of Viewdata. The blue 'Specification of Standards for Broadcast Teletext Signals' was published jointly by the BBC, IBA and BREMA at the colloquium. This embodied the changes that had so far been agreed in the working group but a number of spaces were still available in the code table for future developments.

On 1 April 1976 the BBC and IBA switched to the new code table and from 23 May 1976 different material was used for the magazines on BBC-1 and BBC-2.

Data level

During June and July 1976 there were discussions in the working group on the amplitude of the transmitted teletext pulses (data level) and on the pulse shape.

There had been complaints from viewers that the teletext signals caused a buzz on the television sound channel. This occurred only with certain types of receiver which were susceptible to caption buzz but of course the data buzz was continuous and therefore more annoying. The data buzz was very dependent on data level and reducing the data level from 71% of peak white to 65% made a significant improvement. It was decided to recommend a data level of 66% with a tolerance of 60% to 72% (i.e. 0.46V ±0.04V) so that the level could be adjusted within limits to suit local requirements.

Pulse shape

In the early experiments teletext pulses had been of raised cosine (i.e. sine-squared) form but with the spectrum reduced from its nominal

7MHz to 5MHz to fit within the normal video passband. This truncation of the spectrum causes overshoots and inter-symbol interference but if the pulse-spectrum is given a cosine roll-off the response becomes zero at spacings which are multiples of the bit-rate so minimising interference. Experiments with the new pulse shape on BBC-1 in June 1976 showed that it gave a significant increase in service area compared with BBC-2. This pulse shape was described in a BBC Technical Memorandum in May 1976 and was accepted by the working group for inclusion in the final specification.

Control characters

On 1 September the working group finally reached agreement on a number of new control characters which had been under discussion for more than a year. These characters which filled the last spaces in the code table were:

a 'Graphics hold' character originally proposed by the BBC to eliminate black areas between colour changes.
a 'Double-height' character proposed by Mullard to allow this facility to be under editorial control.
a 'Background' character proposed by the BBC to permit use of any of the display colours as an alternative background to black.
a 'Separated graphics' character proposed by the IBA to introduce gaps between the otherwise contiguous cells of the graphics characters.

Final Specification

This was published by BBC/IBA/BREMA on 20 September 1976 under the title 'Broadcast Teletext Specification'. It embodied all the changes agreed in the working group and the code table was now complete, but the changes had been made in such a way that future transmissions would be compatible with teletext decoders based on the specification of January 1976. A number of the new control codes were receiver options, e.g. a receiver specifically designed to respond to the 'double-height' code would display the associated characters at twice the normal height, but other receivers would display them at normal height.

A black-and-white television receiver would similarly ignore all the colour information in teletext signals.

On 9 November 1976, Lord Harris of Greenwich, Minister of State, Home Office announced that the BBC and IBA had been authorised to continue transmission of Ceefax and Oracle until 31 July 1979, the date on which the present BBC Charter and IBA Act expire.

The Home Office has recently told the British Radio Equipment Manufacturers' Association that it regards Ceefax and Oracle as continuing services.