DIGITAL FACSIMILE

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1. Introduction

This paper reviews the present position of the planning and implementation of digital facsimile systems in the WMO Global Telecommunication System, its Main Trunk Circuit and Regional Telecommunication Hubs, including Bracknell.

2. WMO Standards

2.1 Since 1970, a study group of the WMO Commission for Basic Systems (CBS) has been working on Digital Facsimile standards and, inter alia, during the 70's two redundancy reduction codes were discussed and recommended. At the CBS meeting in 1980, the CCITT,T.4. modified Huffman coding scheme was also recommended. This code is designed for use in commercial correspondence for transmitting A4 size documents. The essential features of the scanning and recording system were specified in the recommendations viz. 1728 picture elements (pels) along a 210mm horizontal line and either of two scanning pitches, 3.85 or 7.7 lines/mm.

2.2 The proportions of the A4 size format do not agree with the WMO analogue systems and, when a WMO digital facsimile chart is transmitted to a CCITT recorder, a small (2%) distortion is produced. This can be obviated if the document being sent is distorted, in a compensatory way, by the computer graphical plotters which normally produce these charts.

2.3 The transmission would be digital at either 4800b/s or 2400b/s.

2.4 In the design of facsimile redundancy reducing codes, the characteristics of the documents to be transmitted must be taken into account, that is to say, the number of black/white transitions and length between them. This was the case with the CCITT code which was designed for use with commercial correspondence. It was therefore gratifying to see the results of experiments performed by the

Japanese Meteorological Agency which show that meteorological charts coded with the same CCITT code were compressed in about the same ratio as these A4 size documents. (1)

3. Meteorological Digital Facsimile Codes

3.1 The three codes which have been recommended by WMO share the characteristic of reducing redundancy and thus shortening transmission time. Also they are run-length codes. Otherwise they are different in some fundamental aspects since the three designs have been optimised round different factors.

4. Code A - French Code

4.1 This is the oldest and only two-dimensional code. It takes into account the redundancy present in a vertical direction as well as horizontally along a scan line. This code was designed 10 or 12 years ago and the original hardware employed for coding and decoding was special-to-purpose with only limited storage facilities. Because of the relatively long processing time required to encode or decode each facsimile scan line, the recorders had a facility which allowed an occasional facsimile scan line time interval to contain no information signals. During this interval, the paper in the recorder would not be advanced and thus the coding system would have time to catch up and re-synchronise with the transmitter/recorders.

4.2 Typical compression ratios would be about 3:1.

4.3 The present French national domestic facsimile network uses this digital facsimile system.

5. Code B - American Code

5.1 Within the Washington National Meteorological Centre, the output of the numerical forecasting models is stored in a raster form in a 6-bit single dimension run-length code. This code was altered for WMO purposes by adding two bits to the original six-bit code word and character transparency was achieved.

5.2 The pseudo characters formed in this manner are quite acceptable to message switching computers which can then handle the digital facsimile "messages" which are used to send the chart information.

5.3 Although successful tests have been performed between Bracknell and Washington, the system of transferring facsimile along the Main Trunk Circuit (MTC) using American codes was never implemented because of lack of equipment.

5.4 Compression ratios achieved were about 2.5:1.

6. CCITT Code

6.1 This is a single dimension run-length code which uses a Huffman technique for producing the code words. The run-lengths of adjacent pels of either black or white are tabled into statistical frequencies. Those run-lengths which occur the most are allocated the shortest codewords whilst those which are least used have the longest codewords - rather like the allocation of a single dot to 'e', the most frequently occurring letter in English and a 4 element group to 'z' in the Morse Code.

6.2 Encoding of chart scan lines using this code is normally achieved by using "look-up" tables. Decoding of Huffman codewords uses a tree-following algorithm.

6.3 This code is not in use yet but will probably be used on the MTC(2) digital facsimile links some time in the future, as recommended by WMO.

6.4 Compression ratios with Huffman coding is about 5:1.

7. Near future plans for the American/European Sector of the MTC

7.1 Whilst the concept of a Main Trunk Circuit linking World Meteorological Centres and principal Regional Telecommunication Hubs suggests circuits of uniform transmission capacity carrying data of the same type between "on-trunk" centres, such is not the case. Between Washington and Moscow, there are 5 segments, only two of which have similar transmission characteristics. In fact, of the other 16 segments completing the Main Trunk Circuit, only one other pair of segments match.

7.2 On the only MTC segment which at present operates alpha numeric data/digital facsimile links, one channel is uncoded whilst the other is coded in French code B. This link between Paris and Offenbach consists of two 4800b/s channels multiplexed on to a 9600b/s modem.

7.3 One of the 4800b/s channels carries a French domestic digital facsimile broadcast from Paris to Offenbach whilst the other 4800b/s channel is occupied by uncoded digital facsimile, time multiplexed, with alpha numeric data. The Offenbach and Paris computers use the analogue facsimile/data switching message defined in the WMO GTS manual(3) for use on analogue facsimile/data, as the separation and recognition signals between streams of uncoded digital facsimile and alpha numeric data. It has been found empirically that a 4800b/s digital facsimile system will retain sufficient definition to provide as good charts as those produced by analogue methods. However, this is only applicable to black/white reproduction and the inability of the digital facsimile link to transmit half-tone satellite images has created some difficulties in implementing a complete digital facsimile path from Washington through Bracknell to Paris and Offenbach. It is expected that, despite these problems, an uncoded digital facsimile link between Washington, Bracknell, Paris and Offenbach will be in use in 1982.

8. UK Plans for digital facsimile

8.1 At Bracknell, the introduction of uncoded digital facsimile transmissions on the MTC will bring several advantages including a large reduction in manual operation of the magnetic tape recorders which are, at present, the means of storing and forwarding analogue facsimile charts to Offenbach and Paris.

8.2 As well as MTC operations, the Bracknell facsimile centre handles more than 1000 charts per day and is a source of two radio and five line broadcasts operating continuously throughout 24 hours. Some charts are relayed from other centres, but a large proportion of the total output of charts originates in COSMOS, the main Bracknell data processing computer.

8.3 For example, every hour a chart is plotted of UK hourly observations at up to 100 observing sites. The observations are taken on the hour but, because of delays, caused mainly by manual handling, the complete charts are not available at the outstations until 75 minutes later via the analogue facsimile network.

8.4 A useful contribution to the problem of getting charts to out-stations more quickly lies in the adoption of digital methods of transmission between COSMOS and AUTOCOM and the scheduled dissemination of charts using a computer.

8.5 Work on developing a software and hardware design has been undertaken using existing development facilities in Bracknell.

9. Bracknell Digital Facsimile Computer

9.1 The design of the Bracknell digital facsimile computer system includes storage, input and output in analogue form, digital input and output, control, automatic scheduling, coding and decoding in WMO Codes A, B and CCITT Modified Huffman code. Software to perform these functions has been written and tested.

9.2 The storage of charts will be in uncoded form on large discs with up to 24 hours storage. By storing in picture element form, the outputting routine will not be complicated by having to decode between fetching from store and outputting to line.

9.3 Since the analogue facsimile recorders in UK will remain in use for several years, the digital outputs from the computers will be converted to standard analogue facsimile signals complete with supervising tones, at each of the computers outputs. Specially designed digital to analogue convertors will be used.

9.4 Digital facsimile inputs and outputs will be available for such services as the MTC digital facsimile channel which, although it will initially transmit uncoded facsimile data, will later use modified Huffman code as agreed by WMO.[2] There will also be a digital link from COSMOS for the transmission of plotted chart information. Another digital connection will be made to a local fast matrix plotter for "quick look" facilities. The control and automatic scheduling of the system will be supervised by an operator from a monitoring position. This will provide the necessary flexibility to cope with unforeseen circumstances.

10. Future tasks which may be undertaken in the Bracknell digital facsimile computer will include the conversion of Grid Point Data to charts.

11. References

1. Experiment Report on the Study of a Coding Method of Coded Digital Facsimile in the Meteorological Facsimile Service - October, 1978 Japanese Meteorological Agency.
2. WMO CBS Working Group on GTS - 9th session, Geneva Final Report September, 1980.
3. Manual on the GTS - WMO, Geneva.