REPORT 956-2

DATA BROADCASTING SYSTEMS: SIGNAL AND SERVICE QUALITY, FIELD TRIALS AND THEORETICAL STUDIES

(Question 29/11, Study Programme 29C/11)

(1982-1986-1990)

1. Introduction

Data broadcasting systems utilizing television networks are already implemented in different countries for providing a multitude of services. The quality of these services depends on:

- the characteristics of the data transmission channel;
- the effect of these characteristics on the intended services.

To provide a suitable service, measurements on data transmission channels are necessary and appropriate methods have to be devised.

Part I of this Report deals with the measurement of the quality of broadcast digital data channels, Part II discusses the effects of the transmission channel on the service quality in the case of teletext*.

PART I

MEASUREMENT OF THE QUALITY OF BROADCAST DIGITAL DATA CHANNELS

1. General

Data packets inserted in some lines (data lines) of a video signal are corrupted, like the video signal itself, by noise and distortion. Given the digital nature of a data signal, the effects of these impairments are different from those produced on the analogue video signal and cannot be easily deduced on the basis of measurements carried out on conventional television test signals, such as described in Recommendation 473 (Insertion test signals) [CCIR, 1978-82a].

The quality of a digital data channel and the data acquisition circuit of its decoder may be defined in terms of percentage of data which, at the receiving site, are lost or discarded, or are accepted with errors. In this light, it is possible to define parameters representing loss or error ratios, some of which provide an indication of the performance of a data channel and the data acquisition circuit of its decoder irrespective of its use. Others refer only to particular applications, such as teletext.

In addition, the following analogue measurements can be carried out on a data signal:

- measurement of data levels,
- measurements related to eye pattern displays,
- measurement of decoding margin.

2. Digital measurements

2.1 *Data packet loss- and bit error ratios*

Digital data, inserted in a data line, consists of three parts:

- the initial run-in signal for bit synchronization;
- the framing code for byte synchronization;
- the data packet, which differs from system to system (see Recommendation 653).

* The terms "*teletext*" and "*broadcast videography*" are, at present, used interchangeably (see Appendix II to Recommendation 662).

In the case of certain data broadcasting systems, the data block is followed by a suffix for error-correction purposes.

Two impairments which can occur to the data packet [CCIR, 1978-82b, 1986-90] are:

- misinterpretation of the prefix, which results in the loss of the whole packet or a part of it, or its assignation to a wrong data channel,
- errors in the data block.

Since the data channel address is usually protected by special techniques (such as Hamming codes) the probability of a data packet being assigned to a wrong channel is usually very low. Thus, the most important parameter which quantifies the first type of impairment is the data packet loss-ratio. If the data packet does not contain a format description, it can be either totally lost or totally retained. In this case, the data packet loss-ratio can be simply defined as the percentage of transmitted data packets which has not been received. On the other side, when a format description is contained in the prefix, a misinterpretation of it can cause the loss of only part of the data, or the incorrect read-out of non-existing data. For this more complex case a convenient measurement method has not yet been proposed.

The second type of impairment (errors in the data block) is mainly characterized by the parameter "bit error ratio", defined as the percentage of the *received** bits that are affected by error. For the definition of a suitable error-correcting strategy, the knowledge of the statistical properties of errors may also be useful (for example, the probability of consecutive errors, or the distribution of errors along the data line).

2.2 *Measurements on particular data sequences*

It may be interesting, in order to investigate certain phenomena, to use fixed data sequences, so chosen as to be particularly sensitive to the distortions introduced by the system under test. An example of the fixed sequence is the "clock cracker", namely a sequence including as frequently as possible the maximum distance between transitions. This is used to test a type of clock-recovery circuit which makes use of all the data sequence, rather than solely the run-in sequence. It is also used to measure data levels [Croll, 1977].

Another example is a data sequence made of bytes, each of which contains a parity bit. This sequence allows the quality of the data broadcasting channel to be measured on a byte basis. It is also possible to make a rough estimate of the distribution of errors, which may be either random or concentrated on those bytes which produce a bit configuration particularly sensitive to inter-symbol intereference.

Measurements of various types of error and loss ratios in conventional and specially protected (bi-phase) teletext signals are described in [Cominetti *et al.*, 1976]. These parameters may also be calculated using a comprehensive mathematical model [Vardo, 1977; Cominetti *et al.*, 1978].

3. Analogue measurements

A list of analogue parameters relating to measurements of data levels and eye pattern of a data signal is given in Appendix I.

4. Data test signals

Various data test signals have been defined for digital and analogue measurements.

Pseudo-random sequences: These are used for the measurement of bit error-ratio and packet loss-ratio and for the display of eye pattern [Dublet, 1977; Noirel, 1978].

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* When a data block is lost, the contained bits are not taken into account when determining the bit error ratio.

Fixed data sequences: These are used for various purposes. An example is the sequence used in [Cominetti *et al.*, 1976] for the measurement of various types of error ratios and loss ratios. Another example is the "clock cracker sequence". This is a data line containing a character sequence including as frequently as possible the maximum distance between transitions. It is used to test the clock recovery circuit in the data receiver and to measure data levels [Croll, 1977; CCIR, 1978-82c and d].

Data pulse and bar: This signal is made up of an isolated data positive pulse, followed by a data bar (sequence of 1's), containing an isolated data negative pulse. It is used to obtain an eye-shaped diagram by superimposition of the two pulses, to measure data levels, and to analytically derive the eye pattern, in the presence of purely linear distortion [Croll, 1977].

Combined test sequence: A combination of clock run-in, data pulse and bar and a fixed data-sequence including all combinations of 7 successive bits, to provide a test half-line for inclusion in the field-blanking interval, complemented on alternate fields, has been illustrated [Holder, 1977].

REFERENCES

COMINETTI, M., D'AMATO, P. and STROPPIANA, M. [1978] Teletext: considerazioni teoriche sulla scelta del tipo di codifica e della velocità di trasmissione. *Elettronica e Telecomunicazioni*, **4**.

COMINETTI, M., D'AMATO, P. and ZETTI, G. [September, 1976] Piano di sperimentazione del Laboratorio Ricerche della RAI per i sistemi di trasmissione Teletext. Tavola Rotonda AEI "Trasmissione di informazioni scritte visualizzate su ricevitori televisivi" – Sorrento, Italy.

CROLL, M. G. [1977] Ceefax measurement techniques. BBC Research Department Report RD 1977/6.

DUBLET, G. [April-May, 1977] Les mesures de taux d'erreur en diffusion de données par paquets. *Radiodif.-Télév.*, **49**.

HOLDER, J. E. [July, 1977] Measurement of the transmission distortion of the Teletext signal. SERT symposium on electronic measurement and instrumentation.

NOIREL, Y. [July, 1978] DIDON, mesure de la qualité du signal de données. CCETT RSI/T/07/78.

VARDO, J. C. [1977] Effet des distorsions en diffusion de données. Première partie: Etude théorique. *Radiodif.-Télév.*, **49**.

CCIR Documents

[1978-82]: a. 11/8 (EBU); b. 11/2 (EBU); c. 11/11 (Germany (Federal Republic of)); d. 11/35 (UK).

[1986-90]: JIWP 10-11/5-65 (EBU).

APPENDIX I TO PART I

PROPOSED DATA SIGNAL PARAMETERS – CONCEPTUAL DEFINITIONS

1. *All-zeros level:* the level resulting from a continuous stream of "zero" pulses.

2. *All-ones level:* the level resulting from a continuous stream of "one" pulses.

3. *Mid-level:* the level midway between all-zeros and all-ones levels.

4. *Basic amplitude:* the difference between the all-zeros and the all-ones levels.

5. *Zeros overshoots:* the amount by which the peak value of the signal extends beyond the all-zeros level.

6. *Ones overshoots:* the amount by which the peak value of the signal extends beyond the all-ones level.

7. *Peak-to-peak amplitude:* the sum of basic amplitude, zeros overshoots and ones overshoots.

8. *Eye height:* in a noise-free data signal, the eye height reflects the smallest difference which may exist between any "zero" pulse and any "one" pulse over all signal sampling positions. It is expressed as a proportion of the basic amplitude. (In practice, the sampling positions depend on the type of clock used, which must be specified).

9. *Decoding margin:* in a non-return-to zero (NRZ) data signal the decoding margin reflects the greatest difference which may exist between extreme logical decision levels for a given bit error-rate, when the signal samples are referred to the run-in timing and equally spaced at the data rate. It is expressed as a proportion of a specified basic amplitude.

10. *Eye width:* in a noise-free data signal, the eye width is the interval over which true data results from comparison of the signal with a specified decision level. It is expressed as a proportion of the bit period.

11. *Proportional jitter:* in a noise-free data signal, the proportional jitter at a particular decision level is the proportion of the bit period not occupied by the eye width.

12. *Decoding threshold:* this term relates to a terminal which accepts an input data signal and which provides output characters primarily intended for display. For a given degradation of a particular input signal, the decoding threshold is the smallest acceptable decoding margin of the input signal, for a defined character failure ratio.

PART II

ASSESSMENT OF TELETEXT SERVICE QUALITY

1. Introduction

For a teletext service, the picture quality is as important a parameter as for television. It should be emphasized however, that the evaluation methods and criteria described in Recommendation 500, "Method for the subjective assessment of the quality of television pictures" do not cover all aspects of the teletext picture quality assessment. Relevant material on the subjective quality of alphanumeric and graphics pictures is also found in Annex VI to Report 405 [CCIR, 1978-82a].

Hitherto the influence of errors (appearing in the teletext transmission process) on picture quality has been the aspect of main interest, in this document provisionally called the "conformity" aspect. It might be expected that a global assessment will gain in importance as teletext services become established. Such a global assessment would also include the usefulness of the typographic facilities of the system and the display performance of the receiver and would be based on the properties of the human eye and mind. The effect of these principles on characters generated by systems other than the dot matrix system requires further study.

The following text discusses in a tutorial manner the various technical factors which have an influence on the picture quality. Information access, which is an important quality aspect of a teletext service, is discussed briefly. It is based on studies carried out within the EBU [CCIR, 1978-82b].

In [CCETT, 1981] a wider choice of criteria is proposed and the complementation of objective measurements by subjective assessments is suggested.

2. Picture quality characteristics

One tentative list of picture characteristics is:

- the typographic facilities provided by the system;
- the display quality provided by the display device;
- the "conformity" of the picture as received and displayed by the receiver, related to the picture that would be displayed by the same receiver if there were no errors in the received bit stream (i.e. there are no bit errors after the data acquisition process).

This classification could be appropriate when the technical causes for a quality defect or the limits for the attainable quality are to be analyzed.

The characteristics may be difficult to separate but "typographical facilities" is intended to reflect such items as: character sets, pictorial facilities, display attributes and page layout functions given in the system specification. "Display quality" is intended to reflect the influence of the picture generating and display circuits and the picture tube of the receiver, while the "conformity" is intended to reflect the influence of the transmission, error protection and coding/decoding processes.

Another classification of picture quality parameters could be appropriate when a global assessment of the picture quality is made through viewer tests and when there is no direct interest in separating the causes of the defects. Then such properties as legibility, reading speed and visual comfort could be appropriate. This type of assessment is described in [CCIR, 1978-82a, c].

2.1 *Typographical facilities provided by the system*

A teletext specification normally specifies in a detailed way which facilities are available to form the message to be conveyed. Some important facilities are:

- the character repertoire;
- the display format, i.e. the number of rows available on a page and the maximum number of characters per row;
- the display modes, e.g. normal, boxed or mixed display;
- the display attributes, e.g. background colour, character size and flashing display, and the way they can be used.

For systems using geometrical or photographical coding principles, additional characteristics of importance can be defined.

It should be observed that a service might not utilize all available facilities. Also, receivers might be in use which cannot fully exploit all facilities in the transmitted messages. These receivers should fall back on an appropriate substitution facility or the editor should provide a substitution.

2.2 *The dependence of the picture quality on the properties of the display device*

2.2.1 *General*

Some technical parameters such as character size, luminance levels, resolution, etc., could be measured by appropriate instruments at the face of the picture tube.

With the help of human observers, performance measurements could be made, based on psychophysical methods, which measure such aspects as recognition of representative stimuli and reading speed. Such measurements are absolute in the sense that the performance is not compared with the performance of a reference display device, but the method can be used in comparisons of display devices. Appropriate test pages should be used and the viewing conditions kept under control.

Teletext may sometimes be viewed under different conditions from television. The picture is also of a different nature, and the viewing conditions specified in Recommendation 500 might have to be revised when applied to teletext [CCIR, 1978-82a, c]. This concerns both ambient conditions such as viewing distance and room illumination and conditions of the display device itself, such as the luminance of the active and inactive parts of the screen.

2.2.2 *Technical factors of importance*

With the display formats defined in Europe (24 or 25 rows per page and 40 characters per row), it is possible to reproduce most of the alphanumeric characters with a satisfactory resolution, so that they can be easily identified by the viewer.

Apart from the factors mentioned above, the quality of the display also is influenced by several factors, some of which are mentioned below:

- resolution of the character matrix and its font;
- stability of the teletext display when a noisy television signal is received;
- use of internally generated non-interlaced scanning to eliminate flicker on the teletext display;

- use of a character rounding technique in order to improve the character shape. (This technique, however, can be implemented only with conventional television scanning or by means of special receivers, e.g. those conceived for compatible but higher quality type of television display without interlace flicker);
- use of multi-level RGB signals in character representation;
- variable character spacing.

2.3 *Conformity of the picture*

2.3.1 *Classification of conformity defects*

Transmission errors cause various forms of conformity defects. The nature of the defects and their frequencies of occurrence depend on several factors.

The relative severity of the defects depends in a complicated way on the content of the page, e.g. text or pictorial material, and its composition. An exhaustive study is therefore difficult. An attempt to list the various defects that are of interest for pages containing text gives the following result:

Layout defects:
- page loss,
- page interference,
- incomplete page,
- row loss,
- row interference,
- incomplete row,
- displaced row,
- displaced string of characters.

Display defects:
- incorrect character display (false or blank character),
- display of error symbols,
- incorrect display attributes*.

For mosaic pictures, it would be appropriate to describe the conformity defects in other terms. Alpha-geometric and alpha-photographic coded pictures would require a further set of terms.

For pages with text and where there is some redundancy, i.e. where the message could be understood even if some isolated characters (letters) were missing or incorrect, layout defects are the most serious because they may lead to the loss of many contiguous characters. For pages where there is no redundancy in the message, for example when a page contains a table giving numerical values, incorrect character display is a very serious form of defect.

2.3.2 *Factors influencing conformity*

Distortion of the signal waveform during the transmission process and interference from other sources result in bit errors in the output from the data acquisition circuits in the receiver. The error characteristics are a measure of the data channel quality. Lack of data channel quality causes conformity impairment, but the grade of impairment also depends on the transmission format, coding scheme and the error control provisions, both at the transmitting and receiving end.

2.3.2.1 *Data channel quality*

The quality of the digital data channel is usually expressed through its average data block loss ratio and the average error ratio of the bits in the received blocks. Measurement and specification of the quality are described in Part I of this Report and in Document [CCIR, 1978-82d].

* Some incorrect character size attributes might cause layout defects.

Experience shows [IRT, 1980] that errors may depend on the bit-patterns within the data block. Average bit error and data block loss ratios do not therefore always permit an accurate deduction of the performance of a receiver which is connected to the channel. The errors obtained also depend on the design of the data acquisition circuits, and therefore the performance assessed with one type of receiver or measuring instrument will not always predict the performance of another type. [IRT, 1980 and RAI, 1979] show that the relative merits of different designs depend on the type of waveform distortion prevailing.

These characteristics of the data channel, due to the data acquisition circuits of the receiver and preceding receiver circuits, have to be taken into account when test pages for conformity assessment are designed (see § 2.3.3.2).

2.3.2.2 *Transmission format and coding schemes*

Two basic transmission format principles are being used at present.

The fixed-format principle has a predefined relationship between the transmission format (i.e. the positions of the character codes on a television data line), a location in the page memory in the decoder, and for level 1 decoding, the display format (i.e. the position of the corresponding characters in the text rows). For fixed-format systems with "level 2 decoding", when the information complexity requires it, information supplementary to the "level 1" version of the page is transmitted with packet addresses corresponding to rows that are not displayed ("ghost rows"). The fixed-format principle is maintained since the addresses for the supplementary information and the associated character data are related to the transmission format.

In variable-format systems, the information is represented by a unique data stream, significant in itself (i.e. whether a code is "spacing" or "non-spacing" is defined by the codes themselves), and where separation between rows is given by a particular code (sequence). A variable-format system allows the transmitted information to be compressed.

Present teletext systems and proposed variants use a 7-bit or 14-bit code to describe the alphanumeric set. Mosaic and supplementary alphanumeric sets are obtained through videotex code extension techniques in variable-format systems. In fixed-format systems, special but related techniques are used, some of which are mentioned above.

Variable-format systems are sometimes regarded as more sensitive to layout defects than fixed-format systems, which rely on synchronization imparted by the television synchronization signals. However both fixed- and variable-format methods allow for the introduction of specific means for error correction through redundancy, obviously at some cost in transmission efficiency.

Experience with transmission of the fixed-format system operating at "level 2" has been gained and an analysis has shown that no loss of ruggedness occurs in comparison with operation at "level 1" [CCIR, 1978-82e].

Experience has been gained with a fixed format system for text, including ideographic characters, using photographic coding. Field and laboratory tests of a second generation system employing alpha-DRCS-photographic coding found little difference between fixed and variable transmission formats. The variable format was adopted because of its flexibility [CCIR, 1982-86].

2.3.2.3 *Error protection provisions* (see Report 1210)

2.3.3 *Assessment of conformity*

2.3.3.1 *Computer simulation*

The conformity under given conditions can be investigated through simulation methods. Thus, for a specified system, a statistical measure of the conformity could be calculated in the form of the relative probabilities of occurrence of the various defects by taking account of the error protection, data channel and page characteristics.

Simulation should be an efficient method both for optimizing the error protection provisions of a system or receiver and for assessing the conformity that would be obtained under given conditions.

As stated in § 2.3.2.1, experience indicates that the data channel quality might be difficult to specify in the form required by the simulation model.

2.3.3.2 *Test pages for conformity assessment*

Test pages could be used when simulation is not possible or when the representativeness of a simulation is to be checked. In addition to the representative pages that are needed in the latter case, the following two types of page could be of use:

2.3.3.2.1 *Test pages for assessing the quality of the data channel*

The quality should normally be measured by methods described in part I of this Report. When no special measuring instruments and signals are available, a rough assessment of the bit-error ratio can be made by observing a test page. The content of this page should be such that there is little risk of layout and display attribute defects occurring. This would mean that the page should comprise only characters of the GO set. For variable-format systems, some care might have to be taken to avoid codes and code sequences which a particular algorithm could decode as a control function when bit errors occur. Alternatively, the algorithm should not be used during the assessment.

The composition of the page should be such that errors are easily observed.

It could be of value to include those character sequences which are expected to be the most critical with respect to the characteristics of data acquisition circuits in use and the types of signal distortion encountered. Such a page could be said to be critical with respect to the distortion of the data signal waveform.

2.3.3.2.2 *Test pages for assessing the service quality in field trials*

A page of this type makes it possible to assess the influence of the data channel quality on the conformity of the displayed page. It should be composed so as to be more critical than a normal page with respect to layout and display attribute defects. Its actual content would depend on the system used and its typical error correction provisions. It would contain accented characters, mosaics, display attributes and layout functions to a great extent. More than one page might be needed to cover all critical points.

It might be difficult to define common test pages for different systems. Care has to be taken in the composition of the pages so that they test any combinations of decoder design principles, type of signal distortion and bit patterns that are particularly critical.

2.3.3.3 *Test pages for other purposes*

When a global assessment of the picture quality is to be made, the typographical facilities of the system and the quality provided by the display device have to be taken into account in addition to conformity aspects. The pages used should be representative for the service, or, for some types of assessment, critical with respect to legibility and visual comfort.

The teletext viewer would require means for verifying the correct function of his receiving installation. Test pages of the types described in § 2.3.3.2 could be used for this. Probably more than one page would be required to test all typographical facilities in the receiver.

There is also a need for appropriate test pages in industry and for maintenance purposes.

2.3.3.4 *Automatic methods*

It appears to be relatively simple to check the quality of reception, i.e. the data channel quality, by automatic methods. These could be based on the character parity check, a page check sum or on the regular transmission of a pseudo random bit sequence or other special signal. If the detection of the errors could be made at the display language level instead of at the transmission language level, a check of the conformity is obtained.

As the observation of test pages is a demanding task, automatic methods could be of great value both for the teletext service public and in technical studies.

2.3.3.5 *Conformity grades and assessment criteria*

Repetitive transmission is normally used and advantage is normally taken of this to provide error protection in the receivers. The assessment criteria that have been used hitherto and those that are proposed below therefore assume this. The criteria thus indicate that conformity could be a function of the access time.

When conformity is assessed with a test page of the second type in § 2.3.3.2, four grades of conformity with associated criteria are proposed:

Grade 4: there are no defects after the first acquisition of the page.

Grade 3: there are defects after the first acquisition of the page, but they disappear at the second acquisition.

Grade 2: there are defects after the first acquisition of the page, but they disappear after more than two acquisitions.

Grade 1: defects remain after successive acquisitions of the page.

The reliability of the assessment will depend on the number of "first acquisitions", i.e. samples, which are made. The grade obtained for a majority of samples should be stated. For grade 3, a larger number of samples appears necessary for a reliable assessment than for other grades.

Grade 4 could be said to reflect a conformity that would be regarded by the viewer as "normally perfect" or better. Grade 3 corresponds to a situation where correct display is obtained at the expense of an increased access time which could be accepted by some viewers. Grade 2 would provide a correct display after a normally unacceptably long access time, which, however, could be accepted in some applications of multiple-page memory decoders. Grade 1 differs from grade 2 in that the displayed page does not converge to a correct display.

The criteria are not based upon any graded scale of conformity impairments. They only very indirectly relate to the grade of conformity for the first acquired page by stating the number of repeated acquisitions that are necessary for the impairments to disappear.

Other criteria e.g. [BBC, IBA, IRT, 1975] have been used in field trials. They are:

Criterion A: no errors received in 10 s for entire data stream.

Criterion B: no visible errors in each of three consecutive new acquisitions of one page.

Criterion C: no visible errors remaining on the second writing of one page.

In general, satisfaction of these criteria will depend upon the coding strategy and will therefore correspond to different bit-error ratios for different teletext systems. It is desirable to establish the relationship between quality evaluation criteria such as B and C, and the bit-error ratio. Assumptions regarding the performance of the teletext decoder will then permit the establishment of acceptance limits for parameters such as eye height which allow the performance of the transmission path to be related to the bit-error ratio. Such a relationship has been studied in [Lucas, 1976].

3. Information access aspects

The amount of information that is available in a teletext service and the access time for a selected page are important aspects. A basic measure is the mean access time which is half the product of the number of pages in the transmission cycle and the mean page transmission time. To find the mean access time for a particular system, a representative set of pages for the service must be used as the basis for calculation of the mean page transmission time. Studies have been conducted [CCETT, 1982] on the assessment of the inconvenience caused by delay occurring between the user's request and the display of the requested information in the specific context of broadcast videography. First results, subject to confirmation, show that an access time of about 12 s corresponds to "slightly annoying". Moreover, the results obtained prove to be dependent on the semantic contents of the screens.

Other studies [Treurniet *et al.*, 1985] examined the relation between system response time and various degrees of viewer annoyance. The proportion of viewers "slightly annoyed" or worse (A_s) increased with the square root of observed delay:

$$A_s = 0.129 \cdot \sqrt{d} + 0.030$$

Corresponding equations for the proportion of viewers "moderately annoyed" or worse (A_m) and "very annoyed" or worse (A_v) were respectively:

$$A_m = 0.059 \cdot \sqrt{d} - 0.008 \text{ and}$$
$$A_v = 0.020 \cdot \sqrt{d} - 0.030$$

Multipages and other special page repetition patterns as well as use of multiple-page memories, make it more difficult to characterize the access time performance. Another factor is the relation between conformity and access time, as mentioned in § 2.3.3.5, which would mean that for a site with bad reception conditions, the access time would be longer than for a "good" site within the same transmitter service area.

Teletext system B includes a means of user friendly page access, together with a significant reduction in waiting time. The system includes, in each page, the facility to provide page address linking data for other page addresses. Associated with four of these links is an additional row of data for display. The editor can include prompting text in this row directing the user to one of four identified keys on the control unit. Operating such a key causes the linked page to be displayed by the single key stroke rather than the complete page number of 3 or 7 digits. Where a receiver decoder has multi-page storage, the linked pages are acquired automatically with each selected page and are thus available virtually immediately for display. This feature is known as "FASTEXT".

Results of field trials and theoretical studies are to be found in Report 956 (Volume XI, Part 1, Dubrovnik 1986).

REFERENCES

BBC, IBA, IRT [15-24 April, 1975] Teletext field trials in Bavaria. Available from the BBC or the IBA, London.

CCETT [1981] Evaluation de la qualité technique des services et systèmes de télétexte. Internal document of the CCETT, Rennes, (France) ref.: LAR/TVT/111/81/CS, CNR/EAS/15/81.

CCETT [1982] Les temps d'attente en télétexte. Internal document of the CCETT, Rennes (France) ref.: NT/CNR/VRE/36/82.

IRT (Institut für Rundfunktechnik) [1980] Vergleichender Videotext-Ausbreitungsversuch mit dem britischen Teletext- und dem französischen Antiope-Verfahren. (Comparison of videotext propagation experiments with the British Teletext and the French Antiope systems.) Technischer Bericht Nr. 21/80, Munich (Germany (Federal Republic of)).

LUCAS, K. [1976] Analysis and rationalization of teletext field trial results. Independent Broadcasting Authority (United Kingdom) E and D Report 116/76.

RAI [1979] A comparative analysis of strategies used in data and clock recovery circuits (GT V2 159). Internal document of the RAI Research Centre, Turin (Italy).

CCIR Documents

[1978-82]: **a.** 11/217 (Working Group 11/A); **b.** 11/237 (EBU); **c.** 11/68 (France); **d.** 11/325 (German Democratic Republic); **e.** 11/348 (United Kingdom).

[1982-86]: 11/30 (Japan).