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**TELEPHONE NETWORK AND ISDN
QUALITY OF SERVICE, NETWORK MANAGEMENT
AND TRAFFIC ENGINEERING**

**FACSIMILE MEASUREMENT
METHODOLOGIES**

ITU-T Recommendation E.457

(Previously "CCITT Recommendation")

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation E.457 was prepared by ITU-T Study Group 2 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 19th of February 1996.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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SUMMARY

This Recommendation discusses various facsimile measurement methodologies focusing on G3 facsimile as defined by Recommendations T.4, T.6, T.30 and used on PSTN as defined by Recommendations F.180 and F.182. The Recommendation evaluates the advantages and disadvantages of intrusive (test-call based), non-intrusive, mixed-mode and terminal based measurements. Test planning aspects including planning approach, measurement topology, test location points, and some statistical aspects are also discussed.

FACSIMILE MEASUREMENT METHODOLOGIES

(Geneva, 1996)

1 References

The following Recommendations contain material relevant to this Recommendation.

- ITU-T Recommendation T.4 (1993), *Standardization of Group 3 facsimile apparatus for document transmission.*
- CCITT Recommendation T.6 (1988), *Facsimile coding schemes and coding control functions for Group 4 facsimile apparatus.*
- ITU-T Recommendation T.30 (1993), *Procedures for document facsimile transmission in the general switched telephone network.*
- ITU-T Recommendation F.182 (1993), *Operational provisions for the international public facsimile service between subscribers' stations with Group 3 facsimile machines (telefax 3).*
- ITU-T Recommendation E.450 (1993), *Facsimile quality of service on PSTN – General aspects.*
- ITU-T Recommendation E.451 (1993), *Facsimile call cut-off performance.*
- ITU-T Recommendation E.452 (1993), *Facsimile modem speed reductions and transaction time.*
- ITU-T Recommendation E.453 (1994), *Facsimile image quality as corrupted by transmission-induced scan line errors.*
- ITU-T Recommendation E.456 (1994), *Test transaction for facsimile transmission performance.*

2 Definitions

For the purposes of this Recommendation the definitions given in Recommendations E.450, E.451, E.452 and E.453 will be applicable.

3 Abbreviations

A glossary is presented in Recommendation E.450.

4 Introduction

The intent of this Recommendation is to provide an overview of facsimile measurement methodologies, their advantages and disadvantages, test planning and statistical aspects of measurements.

The measurement of facsimile service quality of networks can be accomplished by a variety of techniques including:

- 4.1** Intrusive test-call-based measurements using test machines meeting certain minimum requirements will be developed in the future.
- 4.2** Non-intrusive measurements based on live customer traffic monitored at a network interface using measurement equipment meeting certain minimum requirements will be defined in the future.
- 4.3** Mixed mode measurements involving test calls utilizing non-intrusive (protocol and analogue signal) monitoring for trouble shooting.
- 4.4** Terminal based measurements obtained from terminal reports meeting certain technical requirements.

In the following, we discuss these measurement methodologies in some detail.

5 Measurement methodologies

5.1 Test calls

Measurements using test-call-based methodology are typically carried out over an end-to-end path. The general test topology is shown in Figure 1. Usually, the test calls interface the network at a point similar to that of a typical subscriber.

It is recommended that the test calls follow the prescriptions listed below:

- 5.1.1 Test calls use test transactions defined in Recommendation E.456.
- 5.1.2 Performance parameters be measured as specified in Recommendations E.451, E.452, and E.453.
- 5.1.3 Test machines satisfy the minimum requirements. (To be developed.)
- 5.1.4 Statistical requirements are met (see clause 7).

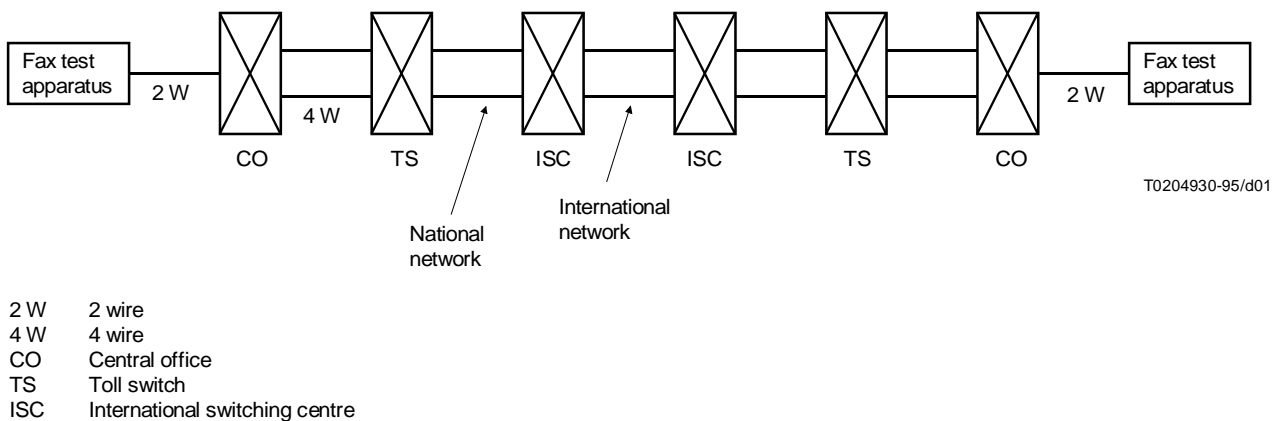


FIGURE 1/E.457

Example of intrusive measurement topology

5.1.5 Remarks

- a) Test calls provide a means for end-to-end performance characterization of networks in a controlled fashion.
- b) Test calls can be used for the comparison of performance of specific network services, network technologies, customer premises equipment, etc.
- c) Test calls are one of the faster methods of trouble-shooting a network problem or a network/terminal interaction problem.
- d) Test calls are costly in the sense that they use up network resources for testing purposes.
- e) Test calls provide only a limited view of the geographical diversity since it is usually not possible to provide and maintain a large number of test access points. From practical considerations, the test access points are located in major communication centres which presumably have a higher quality network performance than, say, the outlying areas.
- f) Test calls tend to produce performance results that are in general better than that observed in non-intrusive measurements because the impact of customer CPE malfunctioning and incompatibilities, poor quality access and egress networks, etc. is usually avoided.

- g) When conducting network tests, the prevailing conditions should be known to the maximum possible extent. For example, if the comparative performance of different media is being assessed, the network should be in its nominal state. If abnormal conditions occur (e.g. network under restoration) during tests, this data should be analysed separately.

5.2 Non-intrusive measurements

Usually, non-intrusive measurement systems monitor the performance of facsimile calls at a network concentration point such as a switch (Figure 2). However, it is possible to monitor facsimile performance non-intrusively at any point in the connection with the appropriate interface. In general, non-intrusive monitoring provides an end-to-end view of facsimile performance regardless of the measurement point. Some network equipment with FAX DEMOD and REMOD may be provisioned so that the G3 fax protocol messages are intentionally altered (e.g. limit the maximum speed) and the characteristics of facsimile transactions are changed as a result. In this case, the measurements should be analysed taking into account the effects of such equipment.

5.2.1 It is recommended that non-intrusive measurements be conducted using facsimile performance parameters that will be defined in the future.

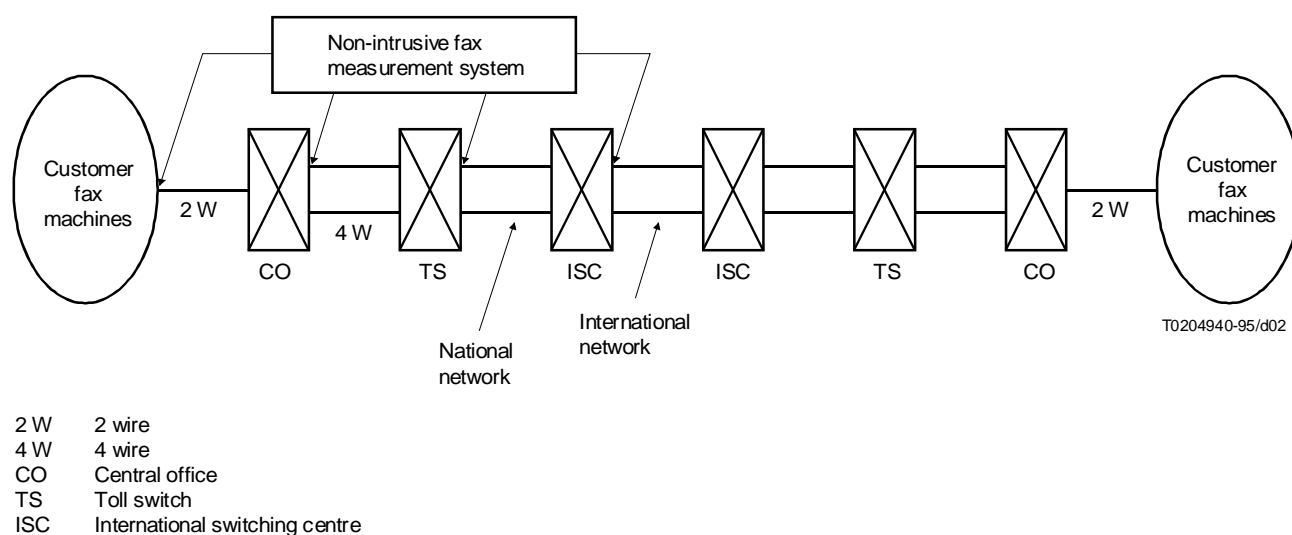


FIGURE 2/E.457

Example of non-intrusive measurement topology

5.2.2 Remarks

- Non-intrusive measurements provide a means for characterizing the end-to-end service quality of networks, including a variety of CPE interactions, customer settings and malfunctions.
- Depending on the capabilities of the equipment, non-intrusive measurements could also provide a comparison of the performance of specific network services, network technologies, CPE, etc.
- Such measurements are usually able to gather data quickly and in large volumes once the network arrangements for the data collection are completed. The ability to capture data is a function of the fax traffic volume and the number of channels that can be monitored simultaneously.
- Measurement costs are limited to costs for data collection and analysis, and network resources are not tied up for the purposes of testing.
- Measurements can provide a general view of tail network conditions depending on where the measurement point is located. If it is possible to associate the per call performance measurements with calling and called numbers, it is possible to obtain a very detailed view of tail network performances.

- f) Measurements produce results that are in general worse than those observed in test-call based measurements because of the CPE malfunctioning and incompatibilities, poor quality access and egress networks, etc.
- g) While non-intrusive measurements offer certain advantages, they do not permit the level of control that can be achieved using the test call methodology. For example, when sending test calls all transactions can use test transactions defined in Recommendation E.456 providing a very controlled test stimulus. Such control is not possible for non-intrusive measurements.
- h) When non-intrusive monitoring is conducted at a network concentration point, image quality parameters defined in Recommendation E.453 cannot be evaluated directly. However, ECM based metrics could be characterized which could serve as a surrogate for the image quality parameters defined in Recommendation E.453. Additionally, analysis of RTN and RTP signals can be used to give a general picture of image degradation due to transmission errors.

5.3 Mixed mode measurements

Mixed mode measurements may be used for specialized purposes such as trouble-shooting. In this case, test calls are launched from a test apparatus which could include a facsimile machine that is having problems of some kind. Non-intrusive equipment could be as simple as a T.30 protocol analyser or could be a more complex device capable of performing both T.30 and analogue signal characteristic measurements.

There are no specific requirements that pertain to these types of trouble-shooting measurements except that the measurements be technically sound.

5.4 Terminal based measurements

Facsimile terminals are capable of producing a variety of terminal reports indicating the success/failure of calls, call duration, some protocol information for failed calls, etc. The number and selection of items varies by manufacturer and model. These reports are more useful than having no information at all. However, there are no ITU standards for how this information is gathered by the machine. Therefore, caution should be exercised in interpreting the data from terminal reports. This is especially true for transaction times reported by terminals where considerable variations exist in the calculation of this parameter.

6 Test planning

Planning of a facsimile performance study should include careful consideration of the goals of the study, primary factors that are planned to be studied, secondary factors, interactions, statistical aspects, etc.

- a) The tests must be planned such that the results for the primary factors can be obtained without confounding those factors. In formulating the test plan, interactions that are likely to arise must be identified beforehand and the interpretations of the test results must include the possible effects of these interactions. For example, when comparing the facsimile performance on two types of transport media on the international segment, it is important to keep the tail network conditions as similar.
- b) Secondary factors such as time of day can often be important in network tests because the load on the networks, routing, etc. can be different during different periods. The sample plan should include these factors if it is likely that the results and their interpretation would be affected substantially.
- c) It is often useful to conduct a pilot study with a smaller sample size prior to conducting the full study. The pilot study can often provide guidance on what factors are important, what are the likely problems to be encountered or what the statistical considerations are likely to be, etc.
- d) Test machines used for intrusive testing should be carefully selected so that they have no known incompatibility problems, are representative of the facsimile terminal base, etc. They should meet the requirements which will be specified in the future.

7 Statistical aspects

Results of facsimile performance tests must be statistically valid and special care must be exercised to ensure that a sufficient number of samples are collected and the correct statistical analysis is employed. Depending on the questions to be studied, the test hypothesis must be formulated and the sample size estimates developed. There are a variety of texts that are available for this purpose and some of them are listed in the references. As an example, the sample size for estimating facsimile call cut-off ratios at a given level of accuracy is presented in Annex A. Additional details on statistical questions are proposed to be included in the facsimile QOS Handbook.

Annex A

Estimation of sample sizes for facsimile performance parameters

(This annex forms an integral part of this Recommendation)

The E-Series Recommendations “E.451: Facsimile call cut-off performance”, “E.452: Facsimile modem speed reductions and transaction time” and “E.453: Facsimile image quality as corrupted by transmission-induced scan line errors” define and formulate a number of dichotomous parameters expressed in terms of percentages. These parameters are frequently estimated by conducting field studies. To ensure the statistical validity of the end result, planners of facsimile field studies need to determine the minimum number of test calls (sample size) before conducting the experiment. Mathematically, this problem is classified under the statistical theory of determining the sample size, n , necessary to estimate the parameter of interest P with pre-specified margins of error, Δ at a given confidence level β . This annex provides a simple, practical stepwise procedure for determining the sample size n .

Procedure

The procedure will consist of the following six steps:

- Step 1: Specify the proportion (percentage) P that needs to be estimated.
- Step 2: Using past experience determine an estimated value for the parameter P and call it P_0 .
- Step 3: Specify the error tolerance limits (margins of error), Δ and the desired confidence level β (in practice usually one of the two confidence levels of $\beta = 90\%$ or $\beta = 95\%$ are used).
- Step 4: Using the desired confidence level, β , select the appropriate chart from an appropriate statistics reference, e.g. “Volume 12, How to Choose the Proper Sample Size, American Society for Quality Control, Statistics Division”.
- Step 5: Using the acceptable margin of error, Δ , determine the appropriate curve on the selected chart.
- Step 6: Using the P_0 as the value on the abscissa on the selected chart, determine the minimum sample size, n .

Illustration

A field study is being planned to estimate the facsimile call cut-off ratios for the facsimile service from location A to location B. The investigator requires a margin of error no more than $\Delta = 5\%$ at a confidence level of $\beta = 90\%$. It is estimated from past experience that the facsimile call success ratio for the facsimile service from location A to location B is 90%, i.e. P_0 is 10%. Then, the sample size is determined by the ordinate of the curve $\Delta = 5$ at the abscissa of $P_0 = 10$, see Figure A.1. This results in a sample of size $n = 100$ facsimile calls.

NOTE – The above procedures are designed for dichotomous parameters. For continuous parameters, such as transaction time, different procedures are needed. The reason is that the mathematical formulae derived for the dichotomous parameters do not apply directly to continuous parameters. Details for continuous parameters and other statistical issues will be found in the Handbook of Facsimile QOS.

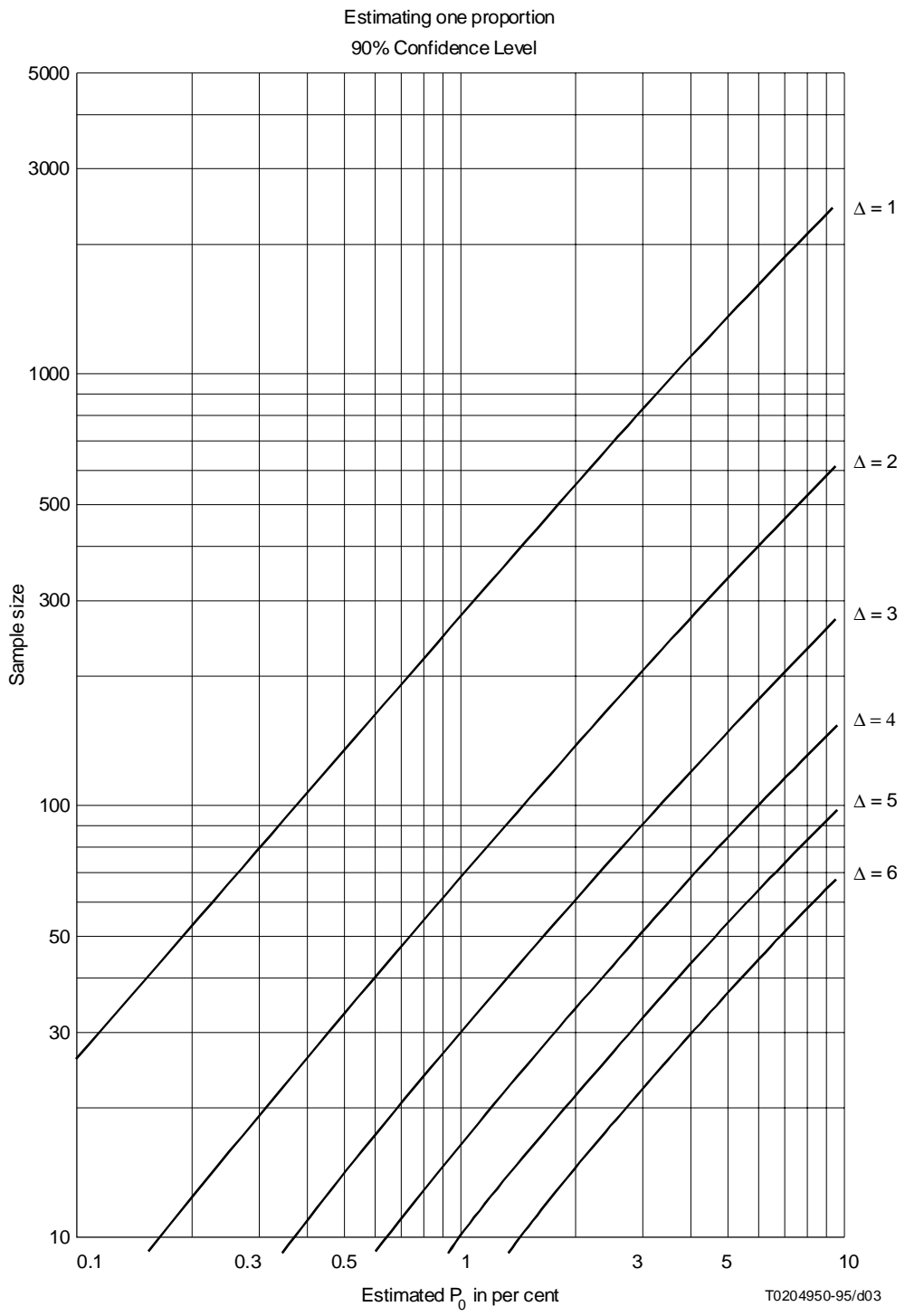


FIGURE A.1/E.457
Minimum sample size