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Speech processing, Transmission and Quality aspects (STQ); Implementation of QoS parameter measurements according to ETSI EG 201 769

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Speech processing, Transmission and Quality aspects (STQ).

The present document provides guidance for practical implementations of the measurement methods as defined in EG 201 769 [1] in order to establish the QoS parameters listed in the EG 201 769 [1].

The intention of the present document is to highlight critical aspects of the parameters, to provide additional information for use under practical measurement conditions and to provide guidance on how to achieve a balanced approach taking into account the ONP principles.

The information in the present document is based on practical experiences learned when implementing the ONP QoS Parameters and setting up precise measurement methods that take into account specific technical and operational characteristics of national telecommunication networks.

The background of the present document is to share information on how to implement the ONP QoS parameters and to indicate possible risks that may lead to inadequate conclusions on the quality as perceived by the user. Thus by using EG 201 769 [1] in combination with this Technical Report, the scope of the parameters and the limits within they can be used in a useful and meaningful manner are better understood.

1 Scope

The present document contains additional information and guidance on the harmonized definitions and measurement methods specified in EG 201 769 [1].

The purpose of the present document is:

- to highlight aspects of the parameters that have been found to need further clarification;
- to provide additional information for use under practical measurement conditions; and
- to provide guidance on how to achieve a balanced approach taking into account the ONP principles.

The present document takes account of experience in the use of parameters by some operators and regulators.

Each of the parameters as defined in EG 201 769 [1] was analysed separately in order to prepare the present document. All additional information and explanations that was found to be useful was then collected in the present document. Information of a more general nature may be found in the annexes and is valid for all or several QoS parameters. The intention of the present document is to provide useful and easy to use guidance for practical implementations of the measurement methods.

Clause 4 contains general considerations on the scope, application and publication of QoS parameters according to EG 201 769 [1]. Clause 5 gives additional implementation information for three parameters of EG 201 769 [1]; but for the other parameters no urgent need for guidance on implementation was found to be necessary. However, the general considerations in clause 4 and the annexes are also related to these parameters.

The present document does not to invalidate the text of EG 201 769 [1], but provides additional advisory text. Hence the present document should be understood as an informative delta document to EG 201 769 [1] and used in this way.

2 References

For the purposes of this Technical Report (TR), the following references apply:

[1] ETSI EG 201 769: "Speech Processing, Transmission and Quality Aspects (STQ); QoS parameter definitions and measurements; Parameters for voice telephony service required under the ONP Voice Telephony Directive 98/10/EC".

[2] ETSI EG 202 057-2: "Speech Processing, Transmission and Quality Aspects (STQ); User related QoS parameter definitions and measurements; Part 2: Voice telephony, Group 3 fax and modem data services".

[3] ITU-T Recommendation E.425: "Internal automatic observations".

[4] ITU-T Recommendation Q.850: "Usage of cause and location in the Digital Subscriber Signalling System No. 1 and the Signalling System No. 7 ISDN User Part".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in EG 201 769 [1] and the following apply:

carrier selection: call set-up mechanism where the user requests a call set-up via a service provider who is not the provider of the access network the user is connected to

NOTE: There are three forms of carrier selection:

- **Open Call by call selection:** The subscriber dials a carrier access code to indicate which service provider is to set up the call. Any user may use the service of the open call by call provider without having to register with the provider on before hand. (The user is billed by the access network provider.) This form of carrier selection is provided in Germany.
- **Closed Call by call selection:** The subscriber dials a carrier access code to indicate which service provider is to set up the call. In order to be allowed to use the service the user must be registered and the service must be activated by the provider prior to the call request.
- **Preselection:** The subscriber informs his access network operator which service provider is to set up all his long-distance calls, unless call by call selection is made.

carrier access code: code that the subscriber may or must dial before the national (significant) number, so that the call is set up by the service provider of his choice

stakeholder: party having an interest in the level of quality of a service

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACD Automatic Call Distribution
DTMF Dual Tone Multi-Frequency
IN Intelligent Networks
ISDN Integrated Services Digital Network
NTP Network Termination Point
ONP Open Network Provision
PSTN Public Switched Telephone Network
SS7 Signalling System No 7
VTD Voice Telephony Directive 98/10/EC

4 General considerations

4.1 Services covered

The service definitions in EG 201 769 [1] are clearly defined and there is no need for further explanations. The influence of the inclusion of calls to mobile destinations, however, is often underestimated. Depending on the proportion of calls to mobile destinations, the statistics of a service provider might be significantly influenced. In order to give a rough survey on the implications see the following notes.

The services covered are voice telephony services according to the definition given by the VTD, namely calls originated from a fixed network termination and terminated at another network termination point. Thus when measuring the QoS parameters calls from the PSTN to GSM have to be included.

The measurement methods of the QoS parameters ask for aggregated statistics, however the performance for PSTN to PSTN and PSTN-to-GSM calls is significantly different and therefore it is recommended that measurements are made separately for these two cases and then the results are combined with weightings that take account of the relative volumes of each type of traffic. This approach will provide a better understanding of the issues if the performance measured is poor.

Because of the differences in performance between the two types of traffic, the performance of networks that carry different proportions of each type of traffic is not comparable. The ONP standard could be revised at some future date to require separate reporting for each type of traffic to improve comparability.

There are two further problems with fixed to mobile calls:

- if the called mobile is not available, the call may be diverted to a voice mailbox with a much shorter call set-up time;
- the signalling or ringing tone information may not indicate that the call has reached the mobile (e.g. in many cases the ringing tone is presented when the call set-up has reached the GSM network even though it has not yet reached the called mobile).

These problems will distort measurements made with real traffic. Where measurements are made with test calls, care should be taken to ensure that the calls are not terminated in voice mailboxes.

4.2 Non standard levels of QoS

In EG 201 769 [1] it is stated that statistics should only be provided for the standard level of QoS for each parameter. In general the standard level is intended to be the level that would be covered by a universal service obligation.

In cases where an operator is offering a different level of quality and is nevertheless required to use these parameters for reporting, it is recommended that the operator should indicate in conjunction with its results what level of quality it aims to offer. Where different levels of quality are intended, the comparability of the results is affected.

4.3 Split reporting for directly- and indirectly-serviced customers

Several parameters are based on the number of fault reports. The fault report behaviour of users is significantly influenced by the kind of service, i.e. direct or indirect, they are using. Annex A provides detailed information on problems caused by the use of fault reports as the basis for QoS parameters.

Due to the above mentioned significant influence, it is recommended that statistics are reported separately for direct- and indirect-services, as well as aggregated statistics.

4.4 Sampling and test calls

The choice of adequate test calls, i.e. geographical locations of origin and destination of calls as well as traffic variations, is a crucial point with respect to the comparability and validation of the statistics to be calculated for the measured parameters.

Further information on this topic is to be found in Annex B, additional information on comparability issues is to be found in the next subsection.

4.5 Comparability

The following issues may affect the comparability of the measurement results:

- Measurement methods may be implemented differently.
  (e.g. use of real traffic vs. test calls, choice of representative connections)
- Measurements based on signalling information may be unreliable because the signalling systems are not implemented in a fully standardized manner (see annex D).
  (e.g. different uses of cause values)

- Where the parameters are measured based on the number of customer complaints; service providers may have different strategies for handling customer complaints (e.g. call centres, ACD, trouble ticket systems) and these strategies will have significant influence on resulting statistics (e.g. long delays in answering calls to a customer complaint line will suppress the number of recorded complaints).
- Different types of customer may react differently to quality of service problems and this will influence results; (e.g. business customers have different fault report behaviour, origins and destinations of call related parameters may vary).
- Fault report rates for direct and indirect services are likely to show significant differences because of the different fault report behaviour for these services.
- Service offers that claim to be similar may differ in terms of significant service features/aspects.

NOTE: The parameters were selected for 'standard' service offers and other parameters may be needed for non standard services.

4.6 Publication of QoS parameters

Where measurements are made and published, an explicit reference to EG 201 769 [1] and any specific additional specifications should be given so that readers can be made aware of the background of the definitions and measurement methods. The reader should be enabled to understand the meaning, purpose and areas of application of the QoS parameters.

It is important that the reader is aware of the scope of the parameters and with that of the correct application of the QoS statistics, otherwise there is a high risk that the measurement results are misinterpreted. A fair and justified comparison of the published data of different service offers, i.e. quality aspects of different telecommunication services, is only possible if the data is strictly used according to the scope of the defined QoS parameters and is verified by a third party auditor.

Stakeholders who publish QoS statistics should provide additional and explanatory text in order to facilitate the understanding of the statistics. It may be assumed that a reader who is interested in comparable QoS statistics and QoS parameters of different nature is willing and capable to understand technical and operational background information on telecommunication services. A balanced approach should be used taking into account on the one hand the need for easy understandable information and on the other hand the requirement of correctly edited data derived from the measurements.

5 QoS parameters

Table 1 was copied from EG 201 769 [1]. It gives an overview on the ONP parameters, the respective measurement methods and application to direct and/or indirect services. For detailed information on the parameters the respective subclauses of clause 5 of EG 201 769 [1] should be consulted.

Table 1: Summary of QoS Parameters

Parameter	Measure	Measurement Method	Application to direct and/or indirect services
5.1 Supply time for initial connection	Time to supply 95 % and 99 % in elapsed days, and %age by agreed date Hours for taking orders and stated accuracy for appointments	All actual	Direct only
5.2 Fault rate	Faults/access line/year	All actual	Direct and indirect with separate reporting
5.3 Fault repair time	Time to repair 80 % and 95 %, and %age on target date for faults on access lines Time to repair 80 % and 95 %, and %age on target date for all other faults Hours for reporting faults and stated accuracy for appointments	All actual All actual	Direct only Direct and indirect with combined reporting Direct and indirect with combined reporting
5.4 Unsuccessful call ratio	% for national and international calls (separately)	All or sample or test calls	Direct and indirect with combined reporting
5.5 Call set-up time	Time for mean and 95 % for national and international calls (separately)	All or sample or test calls	Direct and indirect with combined reporting
5.6 Response times for operator services	Mean time to answer % answered within 20 seconds	All or sample	Direct and indirect with combined reporting
5.7 Response time for directory enquiry services	Mean time to answer % answered within 20 seconds	All or sample	Direct and indirect with combined reporting
5.8 Public pay-telephones in working order	% in full working order	All or sample	n/a
5.9 Bill correctness complaints	%	All actual	Direct and indirect with combined reporting

In the following clauses critical aspects of some of the parameters given in EG 201 769 [1] are highlighted and additional information is provided for use under practical measurement conditions. The text given under the clauses should be understood as addition to the original definitions and measurement method in EG 201 769 [1] and should only be read in combination with EG 201 769 [1].

The parameters *Fault rate per access line*, *Fault repair time* and *Bill correctness complaints* of EG 201 769 [1] are measured by determining the number of user fault reports/complaints. In annex A information on the influence of user fault reports on the statistics is given.

5.1 Fault rate per access line

This parameter is inappropriate for indirect service providers since:

- the most critical issue is faults on the access line and this is relevant only to direct service providers;
- the indirect operator does not provide the access lines, and the alternative of the number of service registrations does not provide comparability since it is not a consistent indicator of the traffic generated. For example many indirect service providers may have a large number of dormant customers who have used the service for a period but no longer use it regularly, yet have not terminated their accounts. The existence of these customers would distort the results significantly.

It is recommended that this parameter is reported only by direct service providers.

5.2 Unsuccessful call ratio

Useful additional information in order to measure this parameter may be found in the following annexes:

- Annex B provides guidance on the selection of representative samples and test calls;
- Annex C provides general information on real traffic monitoring and test calls;
- Annex D provides an algorithm to decide on the success of an call attempt by analysing of SS7 information, namely Cause Values;
- Annex E explains the relationship between the accuracy of the estimator of the unsuccessful call ratio and the number of calls to be observed.
  This is related to another approach given in EG 202 057-2 [2] in order to determine the necessary number of observations. The basic idea is that the number of observations may be chosen by the reporting operator and will determine the absolute accuracy to be given with the results. For detail see EG 202 057-2 [2].

5.3 Call set up time

One basic problem when measuring the call set-up time is the correct determination of the starting point of the measurements. In analogue access systems in many cases overlap signalling is used, which makes it difficult to determine the starting point since the network may start the call routing process as soon as it has received sufficient digits for the initial number analysis.

When overlap signalling is used the measuring party has to know when the network starts routeing the call, i.e. the number of digits of the subscriber number that must be at least transmitted to the network. This number depends on the setting of the switches and therefore this information is normally only available at the access network provider.

If the measurement methods are not implemented precisely, i.e. for different accesses and also for different networks specific starting points for the measurements have to be defined, the presence of overlap signalling may lead to anomalous results, e.g. ISDN call set-up are significantly higher (more than 100 %) than analogue ones.

Therefore additional information should be reported on how the measurements have been made and that some problems in comparing results have to be accepted. These factors may distort any comparisons between the performance of analogue and digital systems.

NOTE: See also EG 202 057-2 [2] where a revised measurement method for call set-up times may be found.

Useful additional information in order to measure this parameter may be found in the following annexes:

- Annex B provides guidance on the selection of representative samples and test calls;
- Annex C provides general information on real traffic monitoring and test calls.

6 Conclusions

The present document has given additional information on the use of the QoS parameters in EG 201 769 [1]. The usefulness of this information depends to some extent on the purpose for which the parameters are used.

In principle the parameters may be used for various purposes such as:

- Specifying the level of quality of service in customer telecommunication service contracts or in the description or terms and conditions of the service.
- Comparing the quality of service of different service providers.
- Comparing the quality of service aspects of different service offers.
- Preparing long term studies on the quality of service aspects of a specific service.

The issues of using the parameters in a specific situation become evident when considering the range of possible applications.

On the one hand the parameters might be used for the information of the user in order to allow for a fair comparison of different service offers available at the market. Then the comparability of the statistics is crucial. The parameters would have to be established by a variety of (ideally all) service providers. The definitions and measurement methods would then have to cover all possible types of services, technology and network structures.

Especially if the parameters are applied to a highly developed market the application is a complex task. All kinds of direct and indirect services as well as the interworking between them have to be taken into account, while a high comparability of the statistics and usefulness to the naïve user has to be maintained under all circumstances.

If on the other hand the parameters are used to e.g. assess specific quality aspects - covered by the parameters - of a universal service, the task becomes far less complicated. Then the parameters are predominantly used for regulatory/administrative purposes and not for user information/customer protection. Then the establishment of QoS statistics is comparatively easy, because one has probably only to consider one network and service, whose technology and service structure remains stable over a long period. Therefore the definitions and measurement methods may be less sophisticated.

Because the Guide contains options and alternatives for some parameters and their measurement, the way in which the Guide should be applied will require some further specification for each particular application if a high level of comparability is to be achieved. Furthermore the way in which the parameters should be applied to services and networks with particular technical and operational practices (e.g. particular methods of handling fault reports) will need to be specified. For regulatory purposes, these additional specifications would normally be made by the National Regulatory Authority.

The information in the present document is intended to provide a basis for the elaboration of such specific measurement specifications. The main principles, however, are given by EG 201 769 [1] and should be maintained.

Annex A: User fault reports

In the following clauses general information is provided on what aspects need to be taken into account when using QoS parameters based on user fault reports. Due to the complexity of the issues no unique solution may be given. When measuring these QoS parameters stakeholders should be aware of the influences of user fault reports on the resulting statistics.

The measurement of the majority of the QoS parameters is based on the assessment of the number of user fault reports. The fault reports serve as an indicator of the quality level as perceived by the user. The basic idea is that the higher the number of fault reports is the lower is the level of QoS of the specific parameter.

There are, however, several aspects that heavily influence the usability of fault reports as quality level indicator and the meaningfulness of the resulting statistics. First of all one has to consider aspects related to the assessment of fault reports and secondly the users" fault report behaviour has to be taken into account.

Assessment of fault reports

The definitions and measurement methods are based on the assumption that users may make fault reports by letter, telephone or directly at service providers sales office. All fault reports made have to be counted. Since each service provider has a different strategy for accepting fault reports, the number of fault reports a service provider receives depends not only on users" satisfaction of the service, but also on the possibilities and easiness of making fault reports.

The basic problem with fault reports is that the harder it is for the user to make fault reports, the less fault reports he will make, i.e. he will only report significant faults like e.g. access line out of order. As a result the service provider will receive only a few fault reports. Hence, in a worst case scenario, he will have according to the QoS parameters a high quality service even though the majority of his customers is dissatisfied with the service. Giving that the original intention of the publication of QoS statistics is at risk, namely informing users on quality before they conclude contracts with providers.

So when using QoS parameters based on fault reports one has to take into account whether a service provider offers multiple and easy-to-use possibilities for making fault reports, e.g. availability of call centres (via freephone numbers), local contact points, email, fax and internet addresses. This is especially valid for QoS statistics giving an overview on a variety of service providers in one area.

In most cases users will make fault reports via a call centre. Since service providers are using different call centres strategies to handle faults where a significant number of customers are affected (e.g. failure of a local exchange), this also influences the QoS statistics.

In call centres fault reports are normally handled by the use of 'trouble ticket systems'. In the case of severe faults the QoS statistics based on fault reports are influenced significantly by the set up of the call centre; various aspects need to be considered e.g.:

- call centres may be congested and therefore not all reports are received;
- automatic announcements within the ACD system explaining that a fault has been detected and is being corrected may deter the caller from making an additional fault report;
- trouble ticket systems may only count one fault, and not the number of user fault reports, for a specific category of fault.

This will reduce to some extent the comparability of the statistics that are collected, but these distortions cannot easily be avoided.

Fault report behaviour

For QoS parameters based on fault reports, user should in theory report each fault that they perceive. In this way the results would be representative and allow for fair comparison of different providers. Users however tend to report only faults that are significant, annoying and that would prevent them from using a specific service or supplement service. In principle there should not be a problem because it may be assumed that the user fault report behaviour is similar for all services.

But this assumption seems only to be valid when comparing the same kind of services, e.g. only direct services. With indirect providers, callers may not bother to report faults to the indirect provider but will use another indirect provider or the direct provider instead. This is extremely valid for services offered via *open call by call selection*, but also to some extent for *closed call by call selection*. Thus the number of fault reports for indirect operators may be artificially low, i.e. indicating a very good service. Also callers may have many subscriptions with indirect provider that they no longer use in practice which would cause an artificially high number of subscribers, resulting in a quality increase also. These are some reasons why separate reporting is required for direct and indirect services and care should be taken when comparing direct services with indirect services.

Annex B: Guidance on the selection of representative samples and test calls

Where sampling and test calls are used the approach should ensure that the results adequately reflect the QoS perceived by customers for the period under review. The following aspects need to be taken into account; the list only contains general information and should be understood as a rough overview rather than a detailed description. The selection of representative samples and test calls is a process that is heavily influenced by specific technical and operational conditions of the measurement task. Therefore a detailed guidance cannot be given.

- The test program should be dedicated to the parameter that is to be measured.
- In cases where the measurements are performed by parties other than the network provider (third parties) it must be ensured, that all relevant information that may influence the results is at hand. Normally only the network operator is aware of specific technical characteristics of the network access, software implementations, routing etc. Depending on the parameters measured often additional information is needed in order to obtain comparable results. This is also valid for measurements of connections over more than one network (e.g. indirect services).
- Samples and test calls should ensure that traffic variations during the measurement period are taken adequately into account.
- The choice of adequate origin and destination NTPs for setting up test calls may be based on the national/international numbering plan or on traffic patterns/distribution or on geographic coverage.
- Depending on the kind of network(s) under study, i.e. fixed, mobile or combinations of them, network specific characteristics and user behaviour need to be taken into account.
- Network performance measurements are often based on the analysis of signalling information or on tones. When using such kind of information the measuring party must know in detail what kind of signalling system and/or tones are used in the network(s) under consideration. Especially any deviations to existing standards must be known e.g. the use of delta specifications to ITU-T Recommendation Q.850 [4].
- Measurements of parameters such as call set up time should take account of whether the calls are terminated on a user terminal or a function such as a mail box within the network. Such parameters will also be affected by some supplementary services (e.g. call forwarding). Also the performance for different number ranges may be different e.g. number translation services such as free phone and shared cost services may have increased call set up times.

Annex C: Real traffic monitoring versus test calls

Network performance related parameters like unsuccessful call ratio and call set-up time are measured either by using test calls or by monitoring real traffic (or by a combination of both). Both methods have their advantages and disadvantages. Real traffic monitoring is on the one hand a low cost alternative but on the other hand the measuring party has no influence on the call details (termination, services, IN etc.) and therefore reproducibility is affected and results may be less reliable. Whereas test call measurements are more complex and expensive but on the other hand they are reproducible, i.e. it is exactly known what is measured.

It is up to the measuring party to decide which approach should be taken in order to establish the required statistics.

In the following list several aspects that have to be considered are given:

- With real traffic monitoring terminal related effects are unknown;
  (en bloc vs. overlap dialling, DTMF vs. decadic dialling)
- With real traffic monitoring terminating NTPs are unknown;
  (depending on the geographic coverage of the measurements long observation times may be needed in order to achieve a fair distribution; especially foreign destinations may not provide enough calls for a secure statistical basis; call forwarding, ported numbers, voice boxes etc. may distort results)
- Signalling information or tones may not be used in accordance with the standards and it may be impossible to find out what each network is using since routing tables may be altered frequently.
- Test call measurement set-up needs careful choice of originating and terminating NTPs (see also annex B). Normally the number of test calls is rather low compared to real traffic monitoring, therefore the representativity of test calls is very important.
- If the measurements are performed by a party other than the access network provider, special care must be taken that all relevant information concerning the access is known (signalling system, set-up of switches, tones etc.).
- For both measurement methods additional information has to be known preparation time to be spent prior to the final measurements. For test calls a precise measurement plan has to be set-up in order to establish a reliable statistical basis. Real traffic monitoring has to rely on several assumptions (set-up of switches in other networks, distribution of terminating NTPs, kind of terminals involved, traffic distribution) that have to be checked first. In practice this will be done on a sample based examination.

Annex D: Decision about the success of a call attempt

Deciding whether a call attempt is successful or not is relatively easy for test calls made from a user's premises, because the equipment simulates a customer and therefore it can decide in a similar way (indicators are: answer from far end, busy or ringing tone).

In practice, the measurements are normally made by machines. For real traffic measured at exchanges, user tones are not available and another source of information is needed. This should be the Signalling System No. 7 between the switches. This Annex defines a simple, but appropriate, form of an algorithm based on the information element Cause Value (see ITU-T Recommendation Q.850 [4]).

In principle, the Cause Values are not very reliable, because their setting (in the switches) in a living network may not be always correct. Normally they should be used as described in ITU-T Recommendation Q.850 [4] but it is in each operator's own responsibility. For these reasons, the proposed algorithm contains only a minimum set of Causes that are very frequently used:

The algorithm reads:

A call which ends with the Cause
16 Normal call clearing, or
17 User busy, or
18 No user responding, or

19 No answer from user (user alerted)
should be added to the total number of call attempts.

A call which ends with the Cause
34 No circuit/channel available, or
38 Network out of order, or
41 Temporary failure, or
42 Switching equipment congestion, or
44 Requested circuit/channel not available, or
46 Precedence call blocked, or
47 Resource unavailable, unspecified
should be added to the total number of call attempts and should be added to the total number of unsuccessful calls.

A call which ends with the Cause
31 Normal, unspecified, and its duration is 1 second or longer
should be added to the total number of call attempts.

A call which ends with the Cause
31 Normal, unspecified, and its duration is less than 1 second
should be added to the total number of call attempts and should be added to the total number of unsuccessful calls.

A call that ends with any other Cause should be ignored.

If any other Cause arise in a remarkable amount (e.g. >1 %) the network operators should negotiate how to handle it.

This algorithm is a recommendation. An alternative algorithm is described in ITU-T Recommendation E.425 [3].

Annex E: Relationship between the accuracy of the estimator of the unsuccessful call ratio and the number of calls to be observed

This annex explains that there is a four sided relationship between:

- the percentage of unsuccessful calls;
- the number of observations used in the measurements;
- the statistic interval (accuracy) required of measurements;
- the confidence level of that interval;

and gives guidance on how operators should determine the number of observations that they need to make.

E.1 Theory

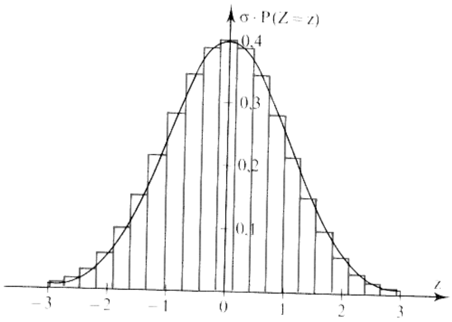
In general, any measurement can provide only an estimate of the quantity being measured. Therefore a measurement is performed several times to build up an average out of all the individual measurements. The measured values make up an interval and it is assumed that the real value μ - which is most probably neither the average nor any one of the measured values - lies inside this interval. In the following some mathematics is provided to show the relationship between:

- the average of the measured quantity (in the case of this document the quantity is the percentage of unsuccessful call ratio *p)*;
- the number of measures;
- the statistic interval (later in this annex called accuracy); and
- the confidence (probability) that the real value lies inside the interval (95 % is assumed throughout this annex).

The starting point of the considerations is the assumption that the single measured values are distributed according a normal distribution around μ. This can be seen in a histogram (the pillars in the left picture). This assumption is correct for most natural processes, which are the result of a combination of individual more detailed processes.

If the number of values is sufficient (see Laplace criteria below) the pillars can be approximated by the Gaussian density distribution $\varphi(z)$ - also called "Normal distribution". At the maximum of the function (at z=0) lies μ. The values of the abcissa are the multiple of the standard deviation σ. The area beneath the graph can be interpreted as the totality of all possible (obtained by experiment) values. (i.e.:

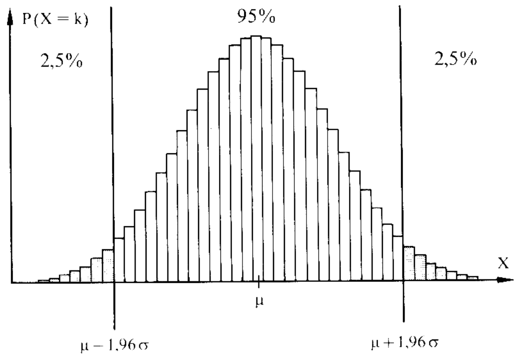
$$\int_{-\infty}^{\infty} \varphi(z)dz = 100\,\%\,) \qquad (1)$$



For a measurement according to the normal distribution it is known that 95 % of the measured values are lying in the interval:

[μ-1,96σ;μ+1,96σ] around μ. This results, with formula (1), from:

$$\int_{\mu-k\sigma}^{\mu+k\sigma} \varphi(z)dz = 95\% \Rightarrow k = 1{,}96 \qquad (2)$$



Now, one can easily say that the relative accuracy is Δ*p*/*p*, and - looking at the diagram - it is 1,96 σ/μ

NOTE: The unit of σ and μ is "number of unsuccessful calls".

This leads to:

$$\frac{1{,}96\sigma}{\mu} = \frac{\Delta p}{p}. \qquad (3)$$

By combining this equation (3) with the formulas $\mu = np$ and $\sigma^2 = np(1-p)$, which are valid since we assume that the binomial process can be approximated to a normal distribution, one obtains the absolute accuracy

$$\boxed{\Delta p = 1{,}96\sqrt{\frac{p(1-p)}{n}}} \qquad (4)$$

which is the same formula as in Annex C of EG 201 769 [1].

By dividing formula (4) by *p* one obtains the relative accuracy:

$$\boxed{\Delta p \big/ p = 1{,}96\sqrt{\frac{(1-p)}{pn}}} \qquad (5)$$

Because of the approximation of the binomial by the normal distribution, the number of observations must be "large" which is defined by the Laplace criterion, $\sigma^2 > 9$. Therefore the number of observations, *n*, should always exceed 9/(*p*(1-*p*)). These limits are given in table X.

Table X: Minimum number of observations, n, for proportions of unsuccessful calls, p

p	n >
0,5%	1 809
1%	909
2%	459
4%	234

E.2 Guidance

There is a trade-off between the accuracy (statistic interval) to be achieved and the number of observations needed and higher accuracy involves additional costs. The difficulty is that this trade-off itself depends on the percentage of unsuccessful calls that is being measured;

- For a given **relative** accuracy, **more** observations are needed when the percentage of unsuccessful calls is lower;
- For a given **absolute** accuracy, **fewer** observations are needed when the percentage of unsuccessful calls is lower.

When contracts for interconnection are prepared, the parties need to decide whether to specify:

- Absolute accuracy;
- Relative accuracy; or
- Number of observations.

and they also need to state that they are using 95 % confidence (or a different specified level).

Practices vary and relative accuracy is quite commonly used. However operators who are unfamiliar with statistics could be unaware of the implications in terms of numbers of observations and hence costs if they specify high accuracy and have good performance. Therefore it is recommended that either the number of observations should be specified in the contracts, or an upper limit to the number of measurements should be specified.

When making measurements to achieve a specific accuracy, operators should therefore proceed by first obtaining a rough estimate of the proportion of unsuccessful calls so that they can use this value to calculate the number of observations required for a given accuracy. This rough estimate can be obtained either by making some initial observations or by using past data.

For relative accuracy, a value of 10 % (= $\Delta p/p$ = 0,1) is commonly used. This value leads, with equation (5), to the equation:

$$n = 384\left(\frac{1}{p} - 1\right) \qquad (6)$$

which can be used to calculate the number of observations needed. Some values calculated with this formula are given in table Y:

Table Y: Number of observations, *n*, for proportions of unsuccessful calls, *p*, for 10% relative accuracy

p	N
0.5%	76 416
1%	38 016
2%	18 816
4%	9 216

History

Document history		
V1.1.1	October 2002	Publication