



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Series A

Supplement 1

(09/98)

SERIES A: ORGANIZATION OF THE WORK OF THE
ITU-T

**Guidelines on quality aspects of protocol
related Recommendations**

Supplement 1 to
ITU-T A-series Recommendations

(Previously CCITT Recommendations)

ITU-T A-SERIES RECOMMENDATIONS
ORGANIZATION OF THE WORK OF THE ITU-T



For further details, please refer to ITU-T List of Recommendations.

SUPPLEMENT 1 TO ITU-T A-SERIES RECOMMENDATIONS

GUIDELINES ON QUALITY ASPECTS OF PROTOCOL RELATED RECOMMENDATIONS

Summary

This Supplement provides guidelines on the quality aspects of protocol related ITU-T Recommendation with the objective of:

- 1) improving the quality of protocol related Recommendations; and
- 2) helping to improve the interoperability of products based on these Recommendations.

In order to encourage the widest possible use of ITU-T Protocol Related Recommendations, it is important that these Recommendations are of the highest possible quality. Several aspects of Quality that play an important role for users of these ITU-T Recommendations have been selected for this purpose. These are: readability, completeness, correctness, consistency, unambiguity, implementability and testability.

Annex A of this Supplement contains a quality check-list to assist the developers of protocol related Recommendations in determining which sections of the Quality Guidelines have been addressed.

Source

Supplement 1 to ITU-T A-series Recommendations was prepared by ITU-T TSAG (1997-2000) and was approved under the WTSC Resolution No. 5 procedure on the 11th of September 1998.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the 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.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Introduction

In order to encourage the widest possible use of ITU-T Protocol Related Recommendations, it is important that these Recommendations are of the highest possible quality. Several aspects of Quality that play an important role for users of these ITU-T Recommendations have been selected for this purpose. They are: readability, completeness, correctness, consistency, unambiguity, implementability and testability.

Supplement 1 to A-series Recommendations

GUIDELINES ON QUALITY ASPECTS OF PROTOCOL RELATED RECOMMENDATIONS

(Geneva, 1998)

1 Scope

This Supplement covers the readability, correctness, completeness, consistency, unambiguity, implementability and testability aspects of quality of Protocol Related Recommendations and specifies a process which can assist in the development of higher quality Recommendations.

2 Purpose

The purpose of the quality guidelines is to serve as a reference to ensure a consistent, high quality standard of Protocol Related Recommendations and the same level of understanding of this subject by all Study Groups.

3 Objective

The main objective of this supplement is to improve the quality of ITU-T Protocol Related Recommendations and help to improve the interoperability of products which are based on these ITU-T Recommendations.

4 Field of application

The criteria and the process apply primarily to new Protocol Related Recommendations under development, but may be applied to the evaluation of the quality of the existing protocol related Recommendations.

The quality aspects should be applied by the relevant Study Groups beginning with the planning phase and continuing through all subsequent phases leading to approval of the Recommendation, and in some cases, through the implementation phase.

5 Definitions

This supplement defines the following terms.

5.1 formal description technique (FDT): Standardized languages e.g. SDL, MSC and ASN.1, and other techniques, e.g. GDMO, intended for formal specification of system behaviour, structure and data.

5.2 specification and description language (SDL): Internationally standardized formal language for specifying and describing real-time systems.

5.3 message sequence charts (MSC): Internationally standardized language for describing sequences of messages interchanged between system components and their environment.

5.4 abstract test suite (ATS): A test suite composed of abstract test cases.

5.5 abstract test case: A complete and independent specification of the actions required to achieve a specific test purpose, defined at the level of abstraction of a particular Abstract Test Method, starting in a stable testing state and ending in a stable testing state.

5.6 abstract test method: The description of how an Implementation Under Test is to be tested, given an appropriate level of abstraction to make the description independent of any particular realization of a Means of Testing, but with enough detail to enable abstract test cases to be specified for this test method.

5.7 executable test suite (ETS): A test suite composed of executable test cases.

5.8 executable test case: A realization of an abstract test case.

5.9 tree and tabular combined notation (TTCN): A standardized notation for specifying conformance test suites in a manner that is independent of test methods, layered software architectures or protocols and which reflects the abstract testing methodology defined in Recommendations X.290 and X.291.

5.10 validation: A process of checking a specification to ensure that it is syntactically and semantically correct and represents the intended behaviour.

5.11 conformance clause: A part of a standard or Recommendation which identifies what in the standard or Recommendation should be met in order to conform to the standard or Recommendation.

5.12 specification: Prescription of the design of an aspect of a product or a set of products.

5.13 implementation conformance statement (ICS): A statement made by the supplier of an implementation or system claimed to conform to a given specification, stating which capabilities have been implemented. The ICS can take several forms: protocol ICS, profile ICS, profile specific ICS, managed object ICS and information object ICS.

5.14 implementation extra information for testing (IXIT): A statement made by the supplier or an implementor of an IUT which contains or references all of the information (in addition to that given in ICS) related to the IUT and its testing environment, which will enable the test laboratory to run an appropriate test suite against the IUT. An IXIT can take several forms: protocol IXIT, profile IXIT, profile specific IXIT, and information object IXIT.

5.15 test tool: Hardware and/or software, excluding the test suite itself, used to carry out or assist in carrying out the testing required.

5.16 means of testing (MOT): Hardware and/or software, and the procedures for its use, including the executable test suite itself, used to carry out the testing required.

5.17 implementation under test (IUT): An implementation of one or more requirements specifications, being that part of a system which is to be studied by testing.

5.18 interoperability testing: Testing to assess the ability of two or more systems to exchange information and to make mutual use of the information that has been exchanged.

5.19 reference implementation: An implementation of one or more standards or specifications, against which a Means of Testing and test tools for those standards or specifications are tested for the purpose of validation of those Means of Testing or test tools.

6 Acronyms

This Supplement uses the following abbreviations.

ASN.1 Abstract Syntax Notation One

ATS Abstract Test Suite

ETS	Executable Test Suite
FD	Formal Definition
FDT	Formal Description Technique
IUT	Implementation Under Test
MOT	Means of Testing
MSC	Message Sequence Chart
PICS	Protocol Implementation Conformance Statement
PIXIT	Protocol Implementation Extra Information for Testing
SDL	Specification and Description Language
TTCN	Tree and Tabular Combined Notation

7 Developing high quality Recommendations

7.1 Overview of the quality aspects

In preparing new Recommendations or making an assessment of the quality of existing Recommendations, the following aspects should be considered:

Readability – This requires that a Recommendation is well structured and can be easily read and understood. This implies good use of the natural languages with adequate use of figures, examples and references.

Completeness – A Recommendation should be complete in the sense that it includes all parts necessary for its implementation. This includes clearly identified, precise and unambiguous specifications, and may include the Abstract Test Suite, the Protocol Implementation Conformance Statement Proforma and the Protocol Implementation Extra Information for Testing Proforma.

Correctness – Specifications should be error-free and represent the intended behaviour; this applies especially to the parts of the Recommendation expressed using formal description techniques.

Consistency – Different parts of the Recommendation or a set of related Recommendations should not contain contradictory information.

Unambiguity – A Recommendation should not be subject to different interpretations; implementations from different suppliers should be compatible; this is especially important where interoperability is required in a multi-vendor environment.

Implementability – A specification should not be unnecessarily complex. This means that the specification should permit only a minimum number of optional features, avoiding those options whose sole purpose is to achieve consensus. The specification should be based on the best technical solution.

Testability – If products are based on a specification contained in a Recommendation, it should be possible to test whether the product conforms to the specification.

7.2 Upfront identification

Each Study Group should identify upfront during the formulation of the Study Group Questions and subsequently in the development phase of Recommendations, which quality aspects need to be fulfilled based on market requirements. A check-list to facilitate this identification is contained in Annex A.

As a general guideline, all Recommendations that address the interoperability of equipment, networks, protocols or services should consider all quality aspects addressed here.

7.3 Formal Description Techniques

Formal specifications should be made available in machine-readable format to allow companies to use their facilities for simulation, validation, automatic code generation or other types of automatic processing, should they wish to do so.

Guidelines on the use of FDTs are contained in Recommendation Z.110. It provides criteria for their use and should, therefore, be taken as a reference in conjunction with this Supplement. It is planned to extend the scope of Recommendation Z.110 to cover a wider range of applications developed by groups such as, OMG, TINA-C.

Whenever a discrepancy between a natural language description and a FD, or between two FDs, is detected, the discrepancy should be resolved by changing the natural language description or the FDs without necessarily giving preference to one over the other(s).

7.4 Overview of the process

The quality of Recommendations is closely connected with the use of Formal Description Techniques (FDTs) and the use of computer-based tools. The main components of the quality process are formal specifications, validation of specifications and testing of prototype implementations. Figure 1 illustrates the complete process.

The main component of the process is the formal specification expressed using an FDT. In this process, a precise and unambiguous formal specification may first be produced from the natural language specification. The FDTs should be widely available, allowing the process to be largely automated using commercially available computer-based tools.

The second key component of the process is the specification validation step in which specification defects are detected and removed. Once the specification is verified, it can be used to produce two or more implementations by automatic generation of the implementation code to assess the ease of implementation and subsequently test the conformance and interoperability. The purpose of this is to ensure that the specification is error-free and describes the intended behaviour. At the same time, implementability of the specification can be verified and the conformance test suite developed and validated.

It is preferable to have the conformance test suites generated directly from the formal specification using software tools so that the individual test cases will be traceable to the specification.

8 Quality checks

Before approving each new Protocol related Recommendation (including Amendments, revised Recommendations, etc.), the quality check-list should be completed and made available to the Study Group meeting. This list will identify the level of compliance with the quality aspects.

9 Specific guidelines

9.1 Readability

Recommendations should be clear, well-structured and easily read and understood. This applies both to the natural language text and the formal specification. This applies to all Recommendations irrespective of whether they are protocol related or not.

Specifically, the functional purpose of the Recommendation should be clearly stated in natural language.

9.2 Completeness of Recommendations

9.2.1 Conformance section

In many cases, specification of mandatory requirements and optional features may be scattered throughout the Recommendation, often mixed with tutorial or explanatory text and examples. It is essential to identify and isolate each normative item in the Recommendation. For this purpose, all normative requirements and optional features should be summarized in a special section, i.e. the conformance clause of a Recommendation, indicating individual references to the parts in the Recommendation where the full specification is given.

9.2.2 Tools for completeness checking

For checking completeness, the following tools may be used:

- a) *Protocol Implementation Conformance Statement (PICS)*
For each relevant Recommendation, a PICS may be developed for use by the implementor of the Recommendation to declare what mandatory and optional features affecting interoperability have been implemented and which have not.
- b) *Protocol Implementation Extra Information for Testing (PIXIT)*
For each relevant Recommendation, a PIXIT may be specified to facilitate testing.
- c) *Managed Object Conformance Statement (MOCS)*
For each Recommendation specified using the Guidelines for the definition of Managed Objects (Recommendation X.722), a MOCS proforma based on Recommendation X.724 may be developed for use by the implementor of the Recommendation to declare what mandatory and optional features affecting interoperability have been implemented and which have not.

9.2.3 Testing methodology

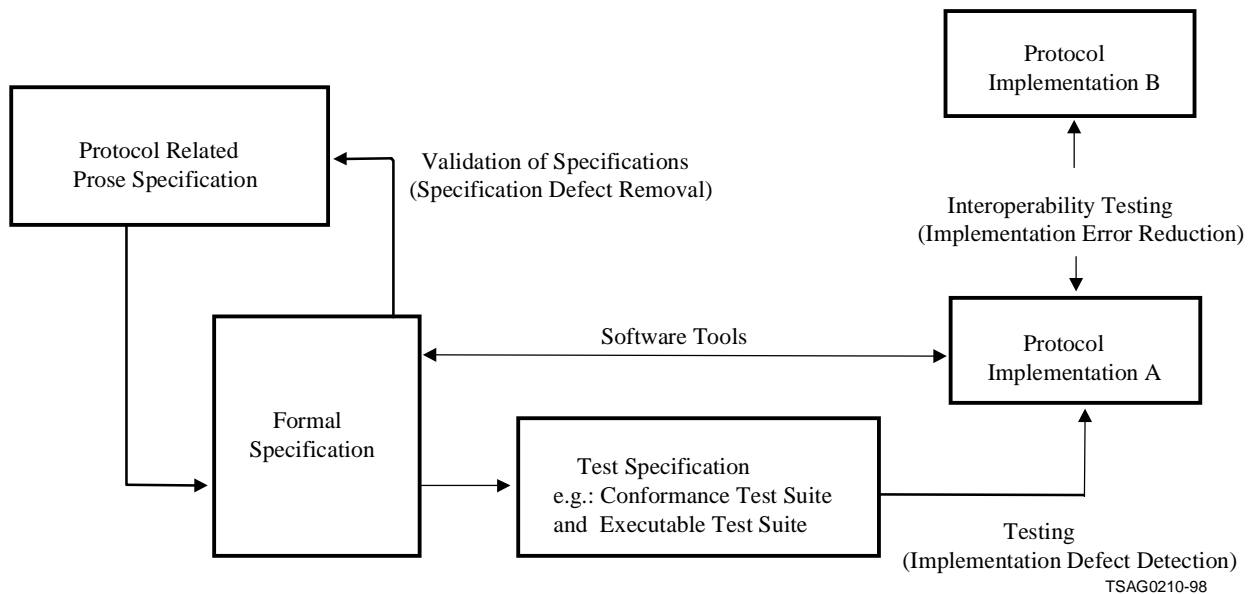
The check-list should indicate which testing methodology has been used. One such methodology is specified in the X.290 series of Recommendations.

9.3 Correctness

9.3.1 Validation of specifications

The overall validation process is illustrated in Figure 1. It consists of implementation, simulation and testing using commercial computer-based tools.

Examples of guidance for validation of specifications are given in Recommendation Z.110 and the Methodology Appendix of Recommendation Z.100. Validation could be done by the Study Group members through pilot projects within their own organizations.



NOTE 1 – Not all of the illustrated processes in Figure 1 are required for all protocols.

NOTE 2 – Several of the relations indicated by the arrows could be supported by software tools.

Figure 1 – Flow Diagram to illustrate the quality process

9.3.2 Abstract Test Suite (ATS)

For each relevant Recommendation, a corresponding Abstract Test Suite expressed in the standardized (Recommendation X.292) Tree and Tabular Combined Notation (TTCN) and in compliance with the X.290 series of Recommendations may be developed.

9.3.3 Publication phase

Specific steps should be taken through the publication phase to ensure the correctness of the published Recommendation.

9.3.4 Maintenance

Procedures are currently in place (Resolution 1) for identifying and correcting errors in approved Recommendations.

9.4 Consistency

Different parts of the Recommendation should not contain contradictory information. Whenever a discrepancy between a natural language and a FD, or between two FDs, is detected, the discrepancy should be resolved by changing or improving the natural language description or the FDs without necessarily giving preference to one over the other(s).

9.5 Unambiguity

A Recommendation should not be subject to different interpretations; implementations from different suppliers should be compatible; this is especially important where interoperability is required in a multi-vendor environment.

9.6 Implementability

9.6.1 Reduction of the number of options

Options reduce the chances of interoperability. The number of options should be reduced so that only the essential options are included and there are no redundancies.

9.6.2 Best technical solutions

Each Recommendation should be based on the principle of best technical solutions rather than a compromise solution to achieve consensus.

9.7 Testability

Testing interfaces, such as points of control and observation should be defined, for example, according to a standardized testing methodology and an appropriate Abstract Test Suite should be specified for each protocol. Reduced complexity of Recommendations is also essential for testability of implementations.

10 Use of tools in developing Recommendations

10.1 Early error detection

The use of commercial software tools, e.g. protocol validation, syntax check tools etc., in conjunction with formal description techniques during the development of Recommendations, is essential for early error detection and the development of a common view during the consensus process. The use of tools makes errors visible early, thereby resulting in substantial savings in later efforts to uncover and correct errors.

10.2 Timely Recommendations

The use of automated techniques is essential for timely production of Recommendations. These tools reduce the total time required to develop a Recommendation and the associated Abstract Test Suites.

10.3 Lower cost

Appropriate steps should be taken to reduce the cost to develop Recommendations. The use of computer-aided techniques and automation tools during the development of Recommendations will reduce the overall cost of developing Recommendations.

11 References

- [1] ITU-T Recommendations X.290-X.296, *OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications*.
- [2] ITU-T Recommendation Z.500 (1997), *Framework on formal methods in conformance testing*.
- [3] ITU-T Recommendation Z.100 (1993), *CCITT Specification and Description Language (SDL)*.
- [4] ITU-T Recommendation Z.105 (1995), *SDL combined with ASN.1 (SDL/ASN.1)*.
- [5] ITU-T Recommendation Z.110 (1996), *Criteria for the use of formal description techniques by ITU-T*.

- [6] ITU-T X.680- and X.690-series Recommendations, *Abstract Syntax Notation One (ASN.1)*.
 [7] ITU-T Recommendation Z.120 (1996), *Message Sequence Chart*.

ANNEX A

Quality Check-list for Protocol Related Recommendations

A.1 General Check-list

The following check-list is provided to assist the developers of protocol related Recommendations in determining which clauses of the Quality Guidelines have been addressed. See Table A.1

Table A.1 – Quality Check-list

Item	Quality Aspect	Reference	Addressed		
			Yes	No	N/A
1	Readability	9.1	Yes	No	N/A
2	Completeness	9.2	Yes	No	N/A
3	Conformance section	9.2.1	Yes	No	N/A
4	Completeness checking	9.2.2	Yes	No	N/A
5	Testing Methodology	9.2.3	Yes	No	N/A
6	Correctness	9.3	Yes	No	N/A
7	Validation of Specifications	9.3.1	Yes	No	N/A
8	Abstract Test Suite	9.3.2	Yes	No	N/A
9	Publication Phase	9.3.3	Yes	No	N/A
10	Maintenance	9.3.4	Yes	No	N/A
11	Consistency	9.4	Yes	No	N/A
12	Unambiguity	9.5	Yes	No	N/A
13	Implementability	9.6	Yes	No	N/A
14	Reduced number of options	9.6.1	Yes	No	N/A
15	Best technical solution	9.6.2	Yes	No	N/A
16	Testability	9.7	Yes	No	N/A
17	Use of tools	10	Yes	No	N/A
18	Early error detection	10.1	Yes	No	N/A
19	Timely Recommendations	10.2	Yes	No	N/A
20	Lower cost	10.3	Yes	No	N/A

A.2 Specific Check-list

In addition, to the quality check-list of Table A.1, a more specific set of questions is needed to:

- identify upfront what quality level should be aimed at;
- assess whether the quality goals have been met;
- distinguish between various levels of qualities;
- distinguish between different techniques to achieve quality;
- enable quality control across these techniques.

Specific questions

Natural language texts

- 1) Is readability of the text validated?
- 2) Does any label refer to items that do not appear in the Description Technique specification?
- 3) Are the required measures completed on the missing references?

Illustrations

- 4) Is the readability of the illustrations validated?
- 5) Do the illustrations use Description Technique notations only?
- 6) Does any label refer to items that do not appear in the Natural language texts?
- 7) Does any label refer to items that do not appear in the Description Technique specification?
- 8) Are the required measures completed on the missing references?

Description Techniques

- 9) Is use of Description Techniques required for the Recommendation?
- 10) Is one Description Technique only used?
- 11) Is a combination of Description Techniques used?
- 12) If yes, which techniques are used?
- 13) Are alphanumeric notations provided for the Description Techniques?
- 14) Are graphic notations provided for the Description Techniques?
- 15) Is the syntax of the Description Techniques formally specified?
- 16) Is the semantics of the Description Techniques formally specified?
- 17) Are mappings between the used Description Techniques formally specified?
- 18) Are the Description Techniques standardised?
- 19) If yes, which technique by which organization?

Description Technique specification

- 20) Is the Description Technique specification well structured?
- 21) Is completeness of the specification validated?
- 22) What testing methodology has been used for completeness validation?
- 23) Was the correctness of the specification verified?
- 24) Is consistency within the Description Technique specification validated?
- 25) What testing methodology has been used for consistency validation?
- 26) Is consistency to natural language texts and illustrations validated?
- 27) Is the specification unambiguous?

Completeness

- 28) Is the conformance clause specified in the standard?
- 29) Is the Protocol Implementation Conformance Statement (PICS) proforma specified?
- 30) Is the conformance Abstract Test Suite specified?
- 31) Is the conformance testing methodology specified?
- 32) Is the Protocol Implementation Extra Information for Testing (PIXIT) proforma specified?

Implementability

- 33) Are all not strictly needed options removed?
- 34) Is the best technical solution specified?
- 35) Is a computable algorithm provided for the specification?

Testability

- 36) Are test specifications needed for the Recommendation?
- 37) Are interoperability tests needed?
- 38) Are abstract test suites provided for the specification?
- 39) Are the abstract test suites produced automatically from the specifications?
- 40) Are testing facilities offered for implementations?

Implementation testing

- 41) Are implementation tests needed for the Recommendation?
- 42) What implementations are provided?
- 43) What implementations are tested by using the abstract test suites?
- 44) Is module testing undertaken?
- 45) Is system testing undertaken?
- 46) Is user testing undertaken?
- 47) Is interoperability testing undertaken?
- 48) What performance tests have been undertaken?
- 49) Are the performance measurements satisfactory?

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