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Foreword

This ETSI Technical Report (ETR) has been produced by the Methods for Testing and Specification (MTS) Technical Committee of the European Telecommunications Standards Institute (ETSI).

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

Introduction

In the context of ETSI, "Test Purposes" (TPs) are part of a test specification for a telecommunication standard (e.g. protocol, interface, telecommunication service), and will normally be produced by the group responsible for drafting the test specification. They should be defined in parallel with the Test Suite Structure document. The objective of the Test Purposes is to define, in prose, the objectives of each test as well as the logical way in which the tests are to be used.

This ETR addresses Test Purpose specification for formal testing and for informal testing. Since the requirements related to TP specification in a formal context differ slightly from those applicable to TP specification for informal testing, the two topics are dealt with in separate clauses.

This ETR has been developed to harmonize the Test Purposes produced by the different groups in ETSI. The need for harmonizing the styles in ETSI comes from the fact that:

- different styles may confuse the specifiers of ATSs;

- in order to meet quality criteria such as readability and homogeneity, it is necessary to harmonize the semantics of the wording used as well as the philosophy on which the test purposes are built;

- the ETSI groups developing Test Purposes are generally unfamiliar with conformance testing matters. A very open standard like ISO/IEC 9646 [2] and [3] leaves a lot of freedom and gives little practical guidance;

- ISO/IEC 9646 [2, 3] has been designed for OSI protocols. The ETSI context is slightly different. ETSI standards concern layered protocols (i.e. ISDN) which are conceptually close to the OSI ones but also covers telecommunication standards which do not obey the same concepts.

The criteria on which the guidance contained in this ETR is based were:

- readability for ATS implementors;
- ease of application to the different kind of ETSI standards; and
- ease of maintenance.

The purpose of this ETR is to provide answers to the pragmatic questions that TP specifiers are likely to ask.

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1 Scope

It is the objective of this ETSI Technical Report (ETR) to define the components to be produced when specifying test purposes.

This ETR should be used as a handbook by the specifiers of test purposes.

Its aim is not to be self-contained, but to be used in conjunction with the standard on methodology for protocol and profile conformance testing specifications, ETS 300 406 [1], which contains the basic definitions (and are therefore not duplicated here).

Use of this guide should not contradict the references listed in clause 2. The aim of this ETR is to provide guidance and clarification on the use of those references.

This guide has been designed to be applicable to any (tele)communications protocol.

The test of physical aspects, such as "layer 1", analogue measurements, EMC, is not covered by this style guide. However, it is thought that part of the test purpose methodology described here may be applied.

2 References

This ETR incorporates by dated and undated reference, provisions from other publications. These references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETR only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] ETS 300 406: (1995): "Methods for Testing and Specification (MTS); Protocol and profile conformance testing specifications; Standardization methodology".

[2] ISO/IEC 9646-1 (1995): "Information technology - Open systems interconnection - Conformance testing methodology and framework - Part 1: General concepts".

[3] ISO/IEC 9646-2 (1995): "Information technology - Open systems interconnection - Conformance testing methodology and framework - Part 2: Abstract Test Suite Specification".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETR, the terms defined in ETS 300 406 [1], ISO/IEC 9646-1 [2] and ISO/IEC 9646-2 [3] apply except where terms are redefined below.

base specification: A specification of a protocol, telecommunication service, interface, abstract syntax, encoding rules, or information object.

NOTE 1: This definition extends the definition in ISO/IEC 9646-1 [2], subclause 3.3.10, to telecommunication services and interfaces.

NOTE 2: A base specification is anything that can be profiled. A base specification is to be distinguished from a *profile*, which constrains optionalities in one or several base specifications.

NOTE 3: Confusion should be avoided between *base specification* (on which a profile can be based), and *reference specification*, which is the reference to a testing specification.

NOTE 4: This ETR does not deal with information objects.

implementation: The instance of the reference specification for which conformity to that reference specification is claimed.

reference specification: A standard which provides a base specification, or a set of base specifications, or a profile, or a set of profiles, and for conformance to which the ICS proforma and test specifications are written.

test purpose: A prose description of a well-defined objective of testing, focusing on a single conformance requirement or a set of related conformance requirements as specified in the base specification.

extended test purpose: A test purpose to be used in the context of informal testing when the executable test cases are directly derived from the information contained in the test purpose. In this case, the step of abstract test cases is skipped and the extended test purpose is made of the same elements as the test purpose but includes more detailed information. Typically, extended test purposes should be used for interoperability testing, performance testing, functional testing, etc.

formal testing: The execution of tests for which the test procedure as well as the verdict assignment process are totally deterministic. It implies, at least, two major constraints: the IUT are formally and clearly defined (i.e. access interfaces and IUT behaviour are defined in the base specification) and the type of tests to be run will lead to deterministic results. A typical example of formal testing is conformance testing.

informal testing: The execution of tests for which the verdict assignment process requires the use of external or informal elements of information. This situation will be frequently encountered in the areas of interoperability testing or functional testing where the verdicts depends on actual service rendition.

formal SDL: SDL specification which can be interpreted by a machine or a tool, e.g. for validation, simulation, or translation for execution.

3.2 Abbreviations

For the purposes of this ETR, the following abbreviations apply:

API	Application Programming Interface
ATC	Abstract Test Case
ATS	Abstract Test Suite
FDT	Formal Description Technique
IOP	InterOPerability
IUT	Implementation Under Test
ICS	Implementation Conformance Statement
LT	Lower Tester
MSC	Message Sequence Chart
PCI	Programming Communication Interface
PDU	Protocol Data Unit
(P)ICS	(Protocol) Implementation Conformance Statement
(P)IXIT	(Protocol) eXtra Information for Testing
SDL	Specification and Description Language
SUT	System Under Test
TP	Test Purpose
TSS	Test Suite Structure
TTCN	Tree and Tabular Combined Notation

3.3 Application of the notion of Test Purposes for the different types of testing

The notion of test purposes was originally introduced in the context of conformance testing. It is one of the essential components of the methodology defined in ISO/IEC 9646-1 [2] and ISO/IEC 9646-1 [3]. However, the concept of test purposes is also applicable in other testing areas (e.g. interoperability testing, performance testing, network integration testing, etc.)

This ETR makes a difference between TPs used in the contexts of *formal* and of *informal* testing.

In the case of formal testing, a test purpose consists of a prose description of the test which is theoretically independent of the abstract test method. This prose description is used as the technical basis of the abstract test case described in a more formal way (generally in TTCN).

In the case of informal testing, the test purpose is generally used to derive directly the executable test case. In this case, the step corresponding to the specification of abstract test cases is skipped. This requires a Test Purpose description which is more detailed than in the case of formal testing. In this context, and in order to make a difference between these two types of test purposes, TPs related to informal testing are called "Extended Test Purposes" in this ETR.

It will be noticed that the level of detail of the description is the main difference between TP for formal testing and TP for informal testing. Apart from this point concerning the detail of the description, another possible difference needs to be considered: in the case of informal testing: the absence of a step specifying the ATS makes it necessary to define the elements related to constraints in an additional step.

4 TPs for Formal Testing

4.1 Prerequisites

The use of this ETR to write Test Purposes assumes some initial knowledge, as indicated below.

In particular, this ETR does not provide an overview of what tests purposes are, and the context in which they apply. To get this very important information, it is recommended to read ISO/IEC 9646-1 [2], and particularly, ISO/IEC 9646-2 [3] and ETS 300 406 [1].

As indicated in the scope, this ETR is not self-contained and does not duplicate the information provided by ETS 300 406 [1] especially in the following domains:

- structure of the TSS;
- relationship between TPs and test method;
- combination of test purposes;
- TSS naming conventions.

The list above is indicative only.

4.2 What is a Test Purpose?

ISO/IEC 9646-1 [2], defines a test purpose as:

"A prose description of a **well defined** objective of testing, focusing on **single conformance requirement** or a **set of related conformance requirements** as specified in the appropriate OSI specification".

This definition calls for the following comments:

1) A "well defined objective" should be understood as a "*precisely* and *unambiguously* defined objective";

2) Usually, a test purpose concerns a single conformance requirement. However, in the following cases, it may concern a set of conformance requirements:

   a) when the test case concerns an aspect specific to a profile;

   b) when the size of the ATS demands a limitation of the number of test purposes. (This point is expounded upon in the clause dedicated to combined test purposes.)

3) The notion of test purpose, as defined in ISO/IEC 9646-1 [2] is applicable to non-OSI standards as well. (One of the objectives of this ETR is to define the conditions of application of this concept to Telecommunication standards.)

A test purpose may be viewed as the "abstract" description of the test to be performed - that is, the description of the test independent from any realization constraints.

A test purpose should comprise the following components:

TP Component	Status
identifier	Mandatory
reference to requirement	Mandatory
reference to selection criteria	Optional
initial condition	Mandatory
check(s) to be performed	Mandatory
verdict criteria	Mandatory
constraints	Conditional (note)
NOTE: Information related to constraints is mandatory in the case of test of defined values in general and parameter variation tests in particular. In other cases, this type of information is optional. According to the template used for the TPs, two different ways may be considered for providing information about constraints. The first one consists in adding the information related to constraints in the "Check to be performed" part of the TP; the second one consists in using the specific constraints part of the TP.	

4.2.1 Identifier of a Test Purpose

The role of the identifier part of the Test Purpose is to identify it unambiguously. In addition, it is supposed to establish the link between the Test Purpose and the relevant entry in the Test Suite Structure.

Guidance 1:

Test Purposes should be identified by the same referencing scheme as the Test Suite Structure.

4.2.2 Reference to the requirements

This reference indicates the subclause of the reference standard specifications in which the conformance requirement is expressed.

4.2.3 Reference to the selection criteria

This section of the test purpose is effectively relevant only in the case of TPs related to conformance testing. In other cases of formal testing, the necessity of this part of the TP is questionable.

This reference should relate to the PICS items (if any) and / or the PIXIT details (when the partial PIXIT is already available) related to the support of the element concerned by the purpose.

4.2.4 Initial conditions

The initial condition part should define precisely the expected state of the IUT at the beginning of the test. Ideally, the initial conditions should define observable external parameters in order to allow an unambiguous identification of the status of the IUT before starting the test. This point is important since it defines the constraints relating to the preamble of the test.

This is an essential part of the TP. It should be present in any TP, independent of the type of test to be run. The constraints expressed below are applicable to conformance testing as well as to any other type of testing since they concern the identification of the status of the IUT at the beginning of the test.

What should not be done:

Example 1:

Initial condition: Ensure that the IUT is in state "connection established".

In this example, there is no information concerning the way in which the test specifier can check that the IUT is in this state. If there is a semantic action linked to this state, the test purpose initial condition should identify it. If there is no semantic action linked to this state, that means that there is no external means of knowing if the IUT has reached it or even if this state is actually implemented in the state machine of the IUT.

Example 2:

Check response to an inopportune PDU in state "Sx".

In this example, the initial state is implicitly mentioned in the description of the check to be performed. Such a way is discouraged. A explicit indication of the initial state should be preferred.

What should be done

Example:

Ensure that the IUT is in state connection established (reception of a connect confirm on the LT on response to a connect request).

In this second case, there is an external event which can de observed and which allows the tester to be sure that the IUT is actually in the initial state.

Limit of application

The guidance expressed above concerns the "ideal" situation where a semantic action is associated with the state. There are states - for instance the idle state - for which, by their nature, no semantic actions may be observed.

4.2.5 Check(s) to be performed

This part of the test purpose should define the check(s) to be performed in an **explicit, exhaustive and unambiguous** manner. It is recalled that a given check can be performed in a test only if it is mentioned in the test purpose.

What should not be done:

Example:

Check valid behaviour of the IUT on reception of a badly encoded XX PDU.

In this example, there is no information concerning what is valid behaviour; therefore the ATS specifier will have to refer to the reference standard to identify all the possible valid behaviours in the case of the reception of a badly encoded XX PDU.

What should be done

Example:

Ensure that the IUT, on reception of a valid SETUP message with the Sending complete information element sends any of a CALL PROCEEDING, ALERTING or CONNECT message.

In this second case, the different possibilities of valid answer from the IUT are explicitly defined.

(The requirement expressed in this clause is applicable to any type of test.)

4.2.6 Verdict criteria

The verdict criteria should **explicitly** describe the observable events which will be used to assess the result of the test. However, the purpose of this part of the TP is to describe an event and not to assign a verdict. The ATS specifier should not have to interpret the indication of the test purpose for the verdict assignment part of the ATC.

The observable event may be direct or indirect; in other words, it may concern an action on another layer.

Example:

Check that the IUT, on receipt of an ABORT message, releases the connection.

In this case, the observable behaviour will not belong to the tested protocol, but will belong to the underlying one.

What should not be done:

Example 1:

Check that the IUT in state S1, on receipt of a valid connect request, enters state S2.

In this case, there is no actual indication of the verdict criteria. The reference to the state S2 is not sufficient. If there is no semantic action associated with this state, the test purpose should be skipped since the test will not be implementable. If there is a semantic action associated with this state, it should be indicated in the purpose.

Example 2:

Check that the IUT in state S1, on receipt of a valid connect request, sends a connect confirm and enters state S2.

In this case, there are two indications concerning the verdict criteria. The first one concerns an observable external event and the second one concerns a state transition. If the only semantic action related to this state transition is the sending of the connect confirm, the indication of this state transition should be removed from the expected result part of the test purpose. If a external event is associated with the state transition, it should be mentioned in the purpose.

What should be done

Example:

Check that the IUT in state S1, on receipt of a valid connect request, enters state S2 (sends a valid connect confirm).

In this case, the verdict criteria are clearly defined (the reception of a connect confirm).

4.2.7 Constraints

The constraints part of the test purpose should be considered differently in the case of a test of a defined value (for instance, of a parameter in the case of a parameter variation test) and in the case of other test purposes (for instance TPs related to state transition).

When the TP is not focused on a test of specific values, the TP specifier should carefully consider the advantage accruing from the addition of constraint information. The role of the test purpose is not to replace the abstract test case. ATSs written in TTCN offer a formal, unambiguous and efficient way to define constraints. The constraints defined in a test purpose will be, by nature, less formal and, in addition, may overlap with the ATS definition without any added value. It is therefore essential to include information related to constraints in the test purpose only when this has an actual added value concerning the definition, or the clarification, of the test objectives.

When the test purpose is focused on the check of the IUT behaviour for a specific value, the test purpose should contain at least the identification of the parameter, or more generally of the element to be checked and the indication of the specific value to be tested for. However, this information may be provided in the constraints part as well as in the part related to the description of the check.

4.3 How to produce Test Purposes

4.3.1 How to start

The conformance requirements are the basis of the test purpose definition. The role of the test suite is to check that the requirements of the reference specification are met by a given implementation.

Therefore, the first task to perform when starting the definition of the conformance tests of a standard is to review carefully the conformance requirements of the standard as well as their formalization in the PICS.

Several methods can be used for the definition of test purposes:

- starting from the TSS;
- starting from the requirements;
- starting from the specifications.

These three cases are presented below.

In addition, the case of definition of test purposes on the basis of specifications written using a formal description technique is considered in a specific part.

4.3.1.1 Starting from the TSS

In this case, the TP production process will be done in the following steps:

1) start with a skeleton of TSS corresponding to the basic guidance provided by ISO/IEC 9646-2 [3];

2) on the basis of the analysis of the conformance requirements, try to "store" the TP in the nodes of the TSS tree;

3) refine the TSS (this step is iterative);

4) check the coverage of the test suite.

Such an approach has a principal advantage in that it ensures that the different pre-defined groups of test have been considered. On the other hand, it is based on a theoretical view of the standard to be tested. It makes a functional approach to the test more difficult.

4.3.1.2 Starting from the requirements

In this case the TP production process will be done in the following steps:

1) identify all the conformance requirements of the reference specification;

2) identify the PICS entry(ies) corresponding to this (these) conformance requirements;

3) structure the conformance requirements into nested homogeneous groups, leading to the definition of a first TSS;

4) compare this first draft of TSS with the basic guidance provided by ISO/IEC 9646-2 [3] and identify the potential gaps; thus leading to an amended draft of the TSS;

5) define the test purposes which correspond to the conformance requirements or set of conformance requirements identified;

6) "feed" TSS tree with these TPs;

7) refine the TSS and the TP (this step may be iterative);

8) check the coverage of the test suite.

This way of proceeding is preferred to the previous one since it starts from the conformance requirements of the reference specification.

The TSS structure applicable to a given standard should not be defined a priori, but should be the result of the process of conformance requirements analysis.

Figure 1 illustrates this process.

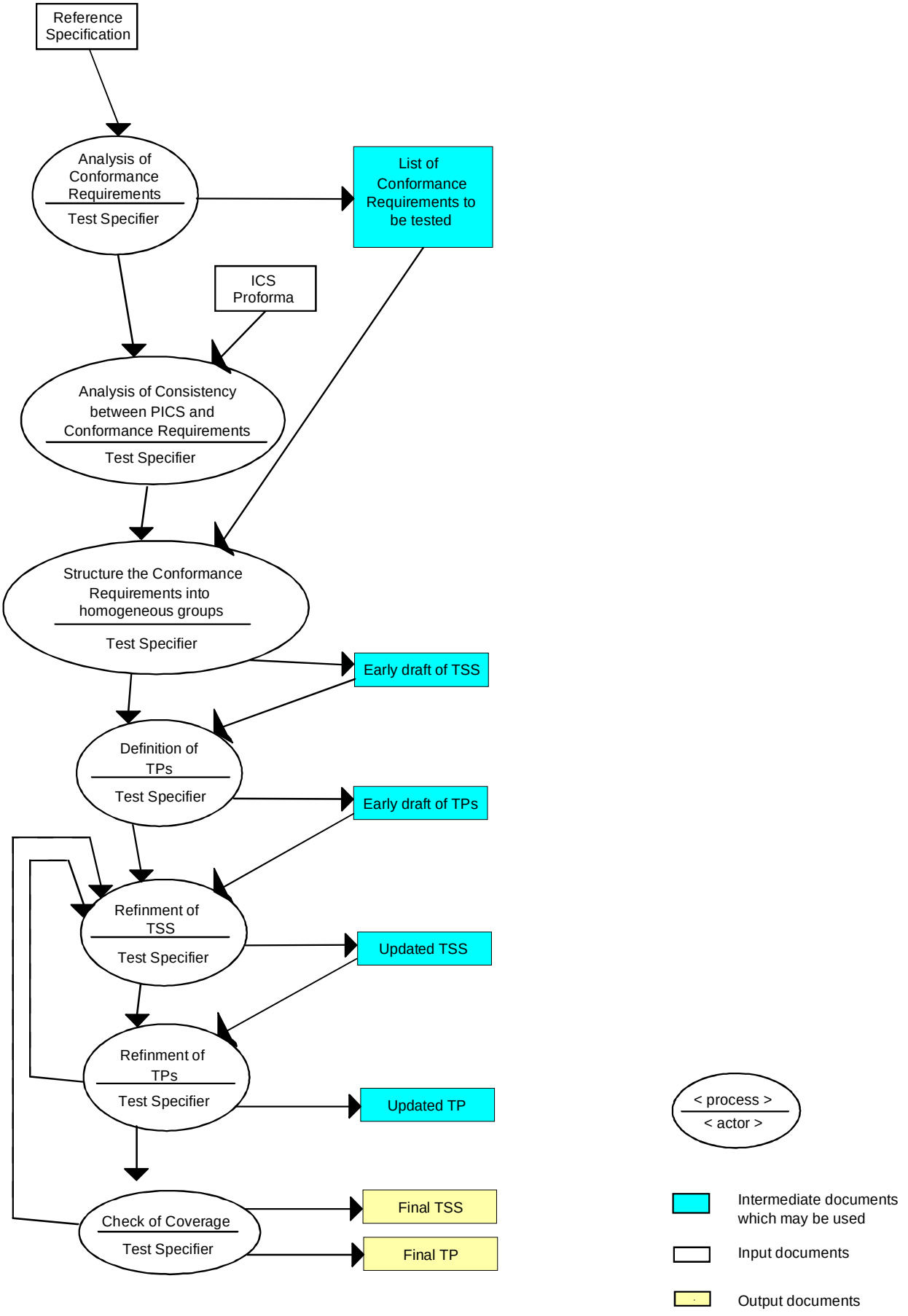

Figure 1: TP production process

4.3.1.3 Starting from the specifications

This may be considered as a variant of the previous method. It comprises the following steps:

1) identify the main functional aspect of the standard;

2) define "macro" test purposes corresponding to these functions;

3) derive actual test purposes from the "macro" ones;

4) "feed" TSS tree with these TPs;

5) compare this first draft of TSS with the basic guidance provided by ISO/IEC 9646-2 [3] and identify the potential gaps, leading to an amended draft of the TSS;

6) refine the Test suite structure and the test purposes (this step may be iterative);

7) check the coverage of the test suite.

This way of proceeding has been used with success in ETSI[1)]. It is specially recommended when the structure of the protocol to be tested is complex.

4.3.1.4 TPs specified on the basis of specifications defined using FDTs

Using FDTs such as SDL and the related tools to specify standards is a strong recommendation of TC-MTS. The use of these methods in ETSI is continuously increasing. This naturally raises the question of the integration of the processes of definition of the test purposes with the specification contained in the standard.

The definition of the tests purposes for a standard specified using an FDT (e.g. SDL) may be done using the same methods as in the case of the standard specified in prose:

- starting from the TSS;

- starting from the requirements;

- starting from the specifications.

In addition, the test purpose definition may also be done starting directly from the SDL specification. In general, this method is not the preferred one. However, in the case of some specific standards[2)], it may be opportune to mix this approach with that based on the requirements.

The SDL tool used in ETSI[3)] includes an ancillary tool which may generate MSCs on the basis of the SDT definition. This raises the question of the relationships between the test purposes and the MSCs. However, before considering this matter, it may be useful to recall what are the differences between test purposes and MSCs.

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1) When specifying the TP for the QSIG (signalling at Q reference point) protocols.
2) E.g. TETRA (trunked radio) standards.
3) SDC© Telelogic.

4.3.1.4.1 Limitation of MSC regarding TP requirements

Application of an MSC generated on the basis of SDL specification requires a formal SDL specification.

The use of MSCs derived from SDL specifications for test purposes is a valuable input although MSCs do not fully cover the elements required for TPs. The main limitations are:

1) MSCs do not include any definition of constraints. This prevents the use of MSCs solely for the definition of the check to be performed in the case of tests focused on the behaviour corresponding to specific values (for instance parameter variation tests).

2) MSCs may define initial conditions, but this definition will be a dynamic one. In the case of a complex standard, when the object of the test is quite deep in the SDL tree, the definition of the initial condition in an MSC will lead to the description of a large number of exchanges. In such a case, the preferred solution is a prose description of the initial condition which allows for a static approach instead of a dynamic one.

3) Concerning the verdict criteria, it is possible to define alternative exchanges using MSCs but this will require additional MSC diagrams. When several alternatives have to be considered, It will lead to a description of verdict criteria much more complex than a prose one. It is therefore recommended to limit the use of MSCs for verdict criteria to cases where they are simple enough not to necessitate several diagrams.

The following differences between TP and MSC may be noticed:

Component	Required by TP	Provided by MSC
identifier	Y	N
reference to requirement	Y	N
reference to selection criteria	Y	N
initial condition	Y	C (see note 1)
check(s) to be performed	Y	C (see note 2)
verdict criteria	Y	C (see note 3)
constraints	Y	N
NOTE 1: MSCs are able to specify initial conditions in a dynamic way only. In some cases (for instance when the exchange to be checked is quite deep in the tree structure), such a representation may be quite heavy. In such a context, a static representation should be preferred. MSCs are not applicable to static representation.		
NOTE 2: N for tests dedicated to checks related to specific values; Y in other cases.		
NOTE 3: MSCs may present different alternatives, but in this case, it will require several diagrams. In these circumstances, it would be clearer and simpler to define the verdict criteria in prose.		

4.3.1.4.2 Applicability of the tools available in ETSI

Ancillary tools of the SDL editors are able to provide MSC for subset of standards described using this technique. In the case of SDT™, which is the tool used in the ETSI context, the MSC validator trace is a tool able to generate MSC for a defined sub-tree of a standard specified in SDL.

This tool provides very valuable information since it is able to generate the expected sequence of PDUs, primitives, etc. corresponding to specific transition(s). The elements of information provided are naturally fully aligned with the protocol specification, and very easy to maintain.

The limitations concerning MSCs in general mentioned above are also applicable to the tool. However, The ongoing work in academic environments as well as in the tool manufacturers' labs plan to include the specification of constraints in the near future.

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4.3.1.4.3 Relationships between TPs and MSCs

As it is stated above, MSCs concern a limited number of the topics to be covered by a test purpose. Therefore it is difficult to conceive a schema in which the test purposes could be replaced by an MSC. Essential components, such as the constraint information (for instance for parameter variation tests) or reference to selection criteria, are not covered.

In addition, though MSCs may be used to provide information about initial conditions, checks to be performed or verdict criteria, they are not always sufficient.

The recommended strategy in the case where MSCs are used is to annex the MSC to the test purpose description. When the information provided by the MSC is sufficient for the description of the purpose, the TP template will only include the reference to the MSC. When additional information is required, it will be provide in prose in the TP template and a reference to the MSC will be added.

The use of MSCs should be limited to the elements for which they actually provide a clarification and a simplification of the TP description.

4.3.2 Development of the TSS and TP

The test purposes and the test suite structure should be developed in parallel.

After the development of the first draft of the TSS, it is important to review the assignment of the test purposes to the different groups as well as the structure of the TSS itself. Different constraints, which may be contradictory, have to be considered:

- the readability of the TSS may require simplification of the TSS structure in order to minimize the number of nested groups;

- the requirement of homogeneity of the groups of the TSS may justify splitting some groups.

4.3.3 Relationships between TPs and requirements

4.3.3.1 General guidance

The test purposes are derived from the conformance requirements. The analysis of the consistency between conformance requirements and PICS is an important step in the TP production process.

The role of conformance testing is to check that the conformance requirements are effectively met by the IUT. This is done by applying the relevant tests to the IUT. The test deselection process is based on the ICS and IXIT entries. An inconsistency between conformance requirements and ICS proforma may lead to the inability to deselect a test.

The work of TP definition is based on the conformance requirements and on the ICS content. Therefore, in order to simplify the work of the ATS specifier, the TP should refer as explicitly as possible to the ICS items it deals with (when relevant).

Guidance 2:

Since the ICS is one of the bases of the deselection process, the analysis of the consistency between conformance requirements and ICS is an important part of the TP production process.

Guidance 3:

The relationships between Test Purposes and the Conformance Requirements in the reference specification should be documented.

Guidance 4:

The Test Purpose should include a reference to the clause in the reference specification where the Conformance Requirement is expressed.

4.3.3.2 Coverage aspects

At the end of the TSS & TP definition process, the test specifier should check the coverage of the test suite defined. This task is quite easy to perform when the methodology of TP production has been followed. In this case, it is limited to a cross-check of the TP versus the ICS entries.

On the other hand, if the information related to the relationships among test purposes and ICS entries is not (implicitly or explicitly) included in the test purpose, the cross-checking may be extremely time-consuming.

Guidance 5:

> The Test specifier should check that any mandatory or optional item of the ICS is covered by at least a TP[4)].

4.3.3.3 Maintenance aspects

The maintenance aspects concern the alignment of the TP to subsequent versions of the reference specification.

Modification of the conformance requirements of the reference specification will directly impact the test purposes. If the relationships between test purposes and conformance requirements are documented, the effect of the modification will be limited. On the other hand, if these relationships are unclear or ambiguous, the workload related to the alignment of the TP to the new version of the reference specification will be significantly higher.

4.4 How to organize the Test Purposes

4.4.1 Generalities

The coverage aspects already mentioned have a quantitative dimension as well as a qualitative one. So far, only the quantitative aspects have already been considered.

It is important to check that the "density" of test purposes is homogeneous for the different aspects of the protocol. Practically, this mean that the different roles or major functions of the protocol should be covered by an equivalent density of test purposes (with respect to the complexity level of each of these components).

These elements related to the qualitative coverage are much more subjective than the elements concerning the quantitative one. Even if no metrics are available to measure this, the problem should be carefully considered by the test specifiers, since the degree of confidence the users will have in the test results will directly depend on it.

An other essential aspect which the test specifier should carefully consider is the size of the test suite. It is easier to define large test suites than reasonable ones. In the first case the production process is limited to the systematic application of rules defined in the testing standards. In the second case, the test specifier needs to consider the importance of any individual tests. It seems obvious that the basic capabilities have to be tested. However, the way in which they are tested is subject to discussion.

It may be opportune to combine a large number of mandatory basic capabilities in the same test. The drawback of such a strategy will consist in the fact that, in case of a failed test, the origin of the defect may be very difficult to identify. On the other hand, the main role of conformance testing is to evaluate the conformance of a given implementation and not to run debugging tests for the IUT provider (who will have other tools for that purpose).

In conclusion, the combination of test purposes for the mandatory capabilities need to be considered when there is a requirement for minimizing the test costs.

In the case of optional capabilities, the problem is of a different nature. Before taking the decision to combine the test purposes, the test specifier should carefully analyse the test de-selection conditions.

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4) This may be obtained through a combined TP.

Practically, the combination of test purposes which may be deselected according to different conditions (i.e. with different selection expressions) should be avoided.

It may be noticed that the combination of test purposes is easier when the TPs reference directly, or indirectly the ICS items concerned.

Another element which seriously constrains the size of the test suite are tests of inopportune or invalid situations. The number of valid behaviour tests (variation tests excluded) is limited and constrained by the complexity of the protocol. However, the number of invalid tests is, by nature almost unlimited. The test specifier must determine the number of invalid and inopportune tests which is "reasonable" for a given reference specification.

The notion of "reasonable number of tests" is highly subjective and context dependant. The test specifier has to take into account the resources available for the test specification task as well as for the future test derivation task.

In addition, the selection of the "invalid" tests to be included in the test suite should be made on the evaluation of the "most probable defects" which will be encountered. Ideally, such a task requires a good knowledge of the standard to be tested as well as a reasonable experience of the implementation constraints related to it.

4.4.2 Balance between different groups of test

Refer to ETS 300 406 [1].

4.5 How to combine Test Purposes

4.5.1 Why combine Test Purposes?

The main reason for combining test purposes is the economic one. When the number of test purposes belonging to a test suite is incompatible with the resources related to its specification and/or derivation, it is necessary to consider the reduction of the size of this test suite.

reducing the size of the test suite may be done by two means; the first one consists in dropping some of the tests. the second one consists in combining the test purposes.

The two methods have their own drawbacks,; the first one reduce the coverage when the second one increases the complexity of the test cases and makes the identification of the cause of a potential defect more difficult. when any individual aspect tested in a combined test is not satisfied the whole test is declared failed.

4.5.2 When to combine Test Purposes?

Refer to ETS 300 406 [1].

4.5.3 Methodological constraints

Refer to ETS 300 406 [1].

4.6 Editorial issues

4.6.1 TSS naming conventions

Refer to ETS 300 406 [1].

4.6.2 Example of TP structure

In order to harmonize the presentation of test purposes inside ETSI a template structure is proposed. Other structures may be employed according to the specific constraints of the standard concerned.

TP Part	TP Component	Component Status
Header	- TP Identifier	M
	- Reference of the subclause of the base specification containing the conformance requirement	M
	- ICS Item reference	O
	- Type of test	M
Initial Condition	- Semantic action corresponding to the initial condition or initial state when there is no related semantic action	M
Check Description	- Description of the stimulus with all the relevant information such as critical values of the parameters or sequence of PDUs, etc.	M
Verdict criteria	- Description of the expected direct or indirect reactions of the IUT with an exhaustive list of valid behaviours.	M

5 TPs for informal testing

5.1 Application of the notion of Test Purpose to informal testing

As mentioned in the introduction, the notion of Tests Purposes, which was defined for formal testing, is equally applicable to informal testing. The general structure of a test purpose would be similar in the two cases.

However, there is a significant difference between TPs for formal testing and TPs for informal testing. In the case of TPs for formal testing, the test purpose step will be complemented by the specification of the abstract test case in TTCN. Therefore, the objective of the test purposes in only to provide the ATS specifier with the information required to define the abstract test cases without ambiguity.

In the case of informal testing, the situation is slightly different. In the majority of the cases: the executable test cases will be implemented on the basis of the test purposes only.

The test purposes for informal tests should, therefore, be more complete than those for formal testing. This has lead to the introduction of the concept of extended test purposes. The following subclauses provide additional details concerning the aspects of extended test purposes which are more detailed than the corresponding aspects of TP in the formal domain.

5.2 Components of Test Purpose for informal testing

In the case of informal testing, the extended test purpose should be viewed as the unambiguous description of the test to be performed.

Since this type of purpose will cover the content of the purpose in the area of formal testing plus some of the aspects related to abstract test case itself, the part of the TP dedicated to the actual check as well as the part dealing with verdict criteria will have to be more detailed than in the case of formal testing. On the other hand, aspects such as selection criteria will be frequently unnecessary.

The content of the different components of the test purposes for informal testing are context dependent; that is, on one hand they depend on the nature of the test to be performed, but on the other hand they

relate to the test processing as well. In order to provide meaningful information, the majority of the examples present test cases as a whole; only few of them are focus on components of the test cases. The examples are provided in subclause 5.3.

The table below highlights the differences concerning TP components for formal and informal testing.

Table 1: Differences between TPs intended for formal and informal testing

TP Component	Informal Testing	Formal Testing
Identifier	Mandatory	Mandatory
Reference to requirement	Optional	Mandatory
Reference to selection criteria	Not applicable (see note 2)	Optional
Test Summary	Mandatory	Not applicable
Initial condition	Mandatory	Mandatory
Check(s) to be performed	Mandatory	Mandatory
Verdict criteria	Mandatory	Mandatory
Constraints	Conditional (see note 3)	Conditional (see note 1)

NOTE 1: The constraints part is mandatory in the case of test of defined values in general and parameter variation tests in particular. In the other cases, the constraint part is optional.
NOTE 2: Generally not applicable for informal testing. In particular cases, may be relevant to deselect tests corresponding to optional features of the standard.
NOTE 3: The constraints part is mandatory in most of the cases, but the definition of the constraints will be, generally, much more simple than in the case of formal testing.

5.2.1 Identifier of a Test Purpose

The characteristics of the identifier of the TP are similar in both formal and informal cases.

5.2.2 Reference to the requirements

This part of the test purpose is generally not relevant for informal testing. However, when informal testing is used to check a product against its specification, it may be pertinent to refer here the clause of the specification concerned.

This may be applicable in the area of acceptance testing or performance testing. It may be applicable as well to the domain of interoperability testing when the interoperability is checked against the IOP specifications.

5.2.3 Reference to the selection criteria

This component is generally not applicable to informal testing. However, in specific cases such as interoperability testing against a generic IOP specification, it may be relevant to offer the possibility of deselecting tests corresponding to optional features.

5.2.4 Test summary

Presents briefly and in prose the actual objectives of the test (what should be tested).

5.2.5 Initial conditions

In the case of informal tests, the initial conditions should describe the operation required to be performed to be in the relevant state at the start of the test.

Practically, this means that the initial condition part of the extended TP has the same role as the preamble of an abstract test case in the formal testing context. It will allow the test implementor to know what are the operations to be performed before starting the test.

5.2.6 Check(s) to be performed

The description of the check to be performed in the case of informal testing has to be much more detailed than in the case of formal testing. The rationale is similar to that applicable to the initial conditions.

However, for some types of test, for instance those relating to performance, this rule is not applicable. More generally, when the realization of the test will depend on characteristics of the implementation (e.g. interface availability) or when the test will be focus on service rendition aspects, the check will have to be expressed in general terms.

In all cases, even when the check is expressed in a general way, the observable behaviour should be precisely described.

Example 1:

Check that the relay is able to switch at least 100 frames per second

In this example, there is no possibility of being more precise without making any assumption on the implementation.

Example 2:

Check that the IUT recovers after a line failure.

In this second case, the check concerns the verification of a certain level of service "recovery after failure". The external event to be observed is the recovery.

5.2.7 Verdict criteria

In the area of informal testing, the verdict criteria should be exhaustive. In particular, the criteria applicable to grey areas should be defined. This means that the conditions which may lead to an inconclusive verdict - as well as those which will lead to a failure verdict - need to be described.

The definition of the conditions may be done in a general way (e.g. "any exception which will occur during the test will lead to an inconclusive verdict" or "the test will declared as "pass" if the implementation restarts after an interruption; it will declared as "fail" in any other case").

5.2.8 Constraints

The definition of constraints is essential to define the conditions of test.

The notion of constraint for informal testing is extremely broad. It may concern the size of the PDU (for instance for performance tests), the contents of the information (e.g. "any printable string") or some specific parameter values.

5.3 Examples of extended Test Purposes for informal testing

5.3.1 Example of functional test

In the example below, the extended test purpose may be considered as an abstract test case written in prose. All the types of information required for an ATC are provided.

The test summary section corresponds to the test purpose section of an ATC.

The initial condition corresponds to the preamble of an ATC.

The constraint part is of the same nature as the constraint part of an ATC.

The verdict criteria part contains the same type of logical information as that in an ATC.

Compared to a formal test written in TTCN, the functional tests offer the advantage of imposing fewer constraints. They allow more freedom in the derivation of the executable tests.

Test Identifier: FNC/LLC/RDT/02	
Type of Test:	**: Functional**
Version	**: 1.0**
Reference to requirements	**: RFC 1577 [1] § 4 & RFC 1483 [1] § 4.1**

Test Summary: To verify that both IUTs support LLC encapsulation sending InATMARP or ATMARP packets (LLC=0xAA-AA-03, oui=0x00-00-00, Ethertype=0x08-06)**.**

Initial Conditions:

1) Install the configuration with an InATMARP as requester and an InATMARP as responder connected over an agreed PVC.
2) Configure the requester by activating the IP software and deactivating the ATM interface.
3) Configure the responder by activating the IP software and making sure the responder ATM interface is activated.

Constraints:

1) IP_address_send, IP_address_receive, VP_send, VP_receive, VC_send, VC_receive.

Check to be performed:

1) Activate the ATM interface on the receiving end station.
2) The requester sends an InATMARP REQUEST to the responder with the address parameters (A_IP, A_ATM, B_IP, B_ATM)
3) The responder sends an InATMARP REPLY with the address parameters (A_IP, A_ATM, B_IP, B_ATM)
4) Check the encoding applied by the requester at PCO4 and the receiver at PCO3.

Verdict Criteria:

The message flow described in A2 and A3 is observed at PCO1 and PCO2. The first cell corresponding to each packet at PCO3 and PCO4 shall contain the initial content 0xAA-AA-03, 0x00-00-00, 0x08-06 --> PASS

Otherwise --> FAIL

Comments:

The directly connected end station is member of the same LIS and using LLC/SNAP encapsulation in AAL5 CPCS-PDU to send InATMARP REQUEST to the other end station. The receiver waits for InATMARP REPLY.

5.3.2 Example of interoperability test

In this type of test, the check is focused on the observation of a given behaviour of the implementations. In the context of interoperability, the implementations to be tested are generally unknown. This implies that the test description should be implementation independent and should concern only external observations.

The example below does not include any reference to requirements. However, in some cases, for instance, when IOP specifications are available, the reference to requirements may be provided;

The test summary section describes in general terms what is to be tested;

The initial condition corresponds to the preamble of the ATC; it indicates what should be the status of the system at the beginning of the test.

This example does not contain any constraint part. However, in other cases, for instance when the IOP test concerns the test of a specific parameter, the constraint part will be provided.

The verdict criteria part contains the same type of logical information as the in an ATC.

Test suites written in TTCN may also be used for IOP test. However, in this case, the implementations to be tested should be known and the characteristics of their exposed interfaces should be specified. This type of interoperability testing belongs to the category of formal testing and not to the category of informal testing.

Test Identifier: **R/CN/01**		
Type of Test:	**: Interoperability**	
Entities Concerned	**: RTS retry mechanism**	
Function Concerned	**: Restart after an abrupt stop.**	
Environment Explicitly Tested		Entity (ies) concerned
Hardware	None	RTS and Specific Retry Parameters
Software		
Specific Configuration	None	
Test Summary: Check that there are no IOP problems when the system is abruptly stopped and immediately restarted. The stop and restart operation should be performed at least 10 times. (This test should be run in nominal traffic conditions).		

(continued)

Initial Conditions:

1 Establish a nominal traffic between the switch and the local system.
2 Wait for the traffic stabilization (roughly 2 minutes).

Check to be performed:

Phase 1

1 Send a PDU type A of the maximum size.

Steps 2 to 5 will have to be performed 5 times.

2 After acknowledgement of the first synchronization point (to be identified with the protocol analyser), stop the switch.
3 Wait for a null traffic (to be checked with the protocol analyser).
4 Restart the switch.
5 Check that the recovery mechanisms re-establish the traffic after the last acknowledged synchronization point.
6 Wait for the completion of the PDU transfer.

Phase 2

1 Send a PDU type A of a size lesser than the synchronization point.

Steps 2 to 6 will have to be performed 3 times.

2 During the transfer, i.e. before the transmission of the "end activity" (to be identified with the protocol analyser), stop the switch.
3 Wait for a null traffic (to be checked with the protocol analyser).
4 Restart the switch.
5 Check that the recovery mechanisms re-establish the traffic.
6 Wait for the completion of the PDU transfer.

Postamble:

1 Clear the waiting queues of the switch.
2 Clear the waiting queues of the local system.

Verdict Criteria:

Phase 1:

The recovery mechanisms restart the traffic after the first synchronization point. --> PASS
Any other behaviour. --> FAIL

Phase 2:

The recovery mechanisms restart the traffic from the beginning. --> PASS
Any other behaviour. --> FAIL

Comments:

none

5.3.3 Example of performance test

In this type of test as well as in the previous one, the check is focused on the observation of a given behaviour of the unknown implementations. The test description should be implementation independent and limited to external observations (performance measurement). Performance tests are also performed in the more general context of acceptance tests.

Performance tests generally include a reference to the specification in which the performance requirement is expressed.

The test summary section describes in general terms what is to be tested; when performance tests are run in the context of acceptance testing, the test summary section is based on the clause of the specification of the system.

The initial condition corresponds to the preamble of the ATC; it indicates what should be the status of the system at the beginning of the test.

This example does not contain any constraint part. However, limited constraints - such as size of the PDUs - may be provided.

The verdict criteria part contains the same type of logical information as the in an ATC. However, it frequently refers to observation of external events or behaviour.

Test Identifier: **P/SW/L&SM**	
Type of Test:	**: Performance**
Reference to requirements:	**: Call for tender clause 9.5.8**
Function Concerned	**: None.**

Test Summary: Check that the switch supports a traffic of 10 PDU (Request) per second during 8 hours with local system A with an additional traffic of 5 PDU per second with each of the 7 simulators of local systems.

Initial conditions:

1 Check that the waiting queues of the switch, the local system and the simulators are empty.
2 Connect the traffic monitor and note the time stamp.

Check to be performed:

1 Establish a traffic of 10 PDU per second between the switch and the local system under test.
2 Establish a traffic of 5 PDU per second between the switch and each simulator.
3 After 8 hours stop the traffic.
4 Disconnect the traffic monitor and note the time stamp.
5 Check that the waiting queues of the switch are empty.
6 Check that the waiting queues of the local system are empty.
7 Check that the waiting queues of the simulators are empty.
8 Check on the traffic monitor that the number of PDUs exchanged between the switch and the local system is equal to (time stamp 1 - time stamp 2 * 10).
9 Check on the traffic monitor that the number of PDUs exchanged between the switch and each simulator is equal to (time stamp 1 - time stamp 2 * 5).

Verdict Criteria:

Waiting queues empty and actual traffic = that expected +/- 0,05%. --> PASS
Content of waiting queues < 1000 and actual traffic >= that expected - 0,04%. --> PASS
Content of waiting queues > 1000 and any exception --> INCONCLUSIVE
Actual traffic < that expected - 0,05%. and any exception --> INCONCLUSIVE
Otherwise --> FAIL

Comments:

Any interruption of the communication line, crash of the local system or of the simulators should be considered as an exception. Crash of the switch shall not be considered as an exception.

5.3.4 Example of robustness test

Robustness tests may concern one or several systems. Their objective is slightly different from that of the IOP tests. However, their general structure will obey the same rules, and the contents of the different parts of the extended test purpose will be of the same nature.

Test Identifier: **R/SW/01**	
Type of Test:	**: Robustness**
Function Concerned	**: None.**
Test summary: Check that the system supports an abrupt stop followed by switch over to the backup system without impact on the service rendition**.**	
Initial conditions: 1 Establish the connection between the system under test and the adjacent systems. 2 Establish a nominal traffic (5 requests per second). **Check to be performed:** 1 Abruptly stop the system under test. 2 Wait for 30 seconds. 3 Restart the system under test using the backup environment. 4 Check that the traffic restarts with each of the adjacent systems.	
Verdict criteria: Traffic restarts --> PASS Traffic does not restart due to an invalid behaviour of an adjacent system --> INCONCLUSIVE Otherwise --> FAIL	
Comments:	

5.3.5 Example of service test

Test Identifier: **CBR/AAL1/MAP/STR/TC32109**	
Type of Test:	**: Service**
Version	**: 1.0**
Configuration	**: Configuration 2**
Reference to requirements	**: ITU T I.363.X [9], §2.5.2.3 b**

Test summary: To verify that the offset pointer takes dummy offset value 127 if no structure boundary is being indicated.

Initial conditions:

1 Set up the CBR adapter to support 2,048 Mbits/s G.703 signal with G.704 frame structure.
Set up the VP/VC connection defined below. Establish a connection which defines the beginning of CRC-4 multiframe structure boundary between both CRC adapters.
Configure the responder by activating the IP software and making sure the responder ATM interface is activated.
Set-up CBR adapter to support G.704 signals with structure boundary synchronized at the beginning of CRC-4 multiframe.

2 Set up the ATE-1A to generate a G.704 structured data stream with CRC-4 multiframe structure. There are no requirements on the binary content of the 64 kbits/s time slots used.

3 Set up the ATE-2A to monitor AAL type 1 pointer values.

Constraints:

VPI provided by the network operator, VCI=48, PCR=2284 cell/s (2,240 Mbits/s), N=31
Stimulus from ATE-1: PRBS 2^{15} -1 pattern length.

Check to be performed:

1 Generate the G.704 predefined data pattern e.g. PRBS 2^{15} -1.
2 Monitor the pointer values with ATE-2A for more than 20 cycles.
3 Check the pointer value.

Verdict criteria:

PASS:

Sequence count cycle X-1: pointer is set at an AAL1 cell with SN 0, 2, 4 or 6.

Sequence count cycle X: No pointer at an AAL1 cell with SN 0, 2, 4 and no boundary detected, AAL1 cell with SN 6 carries pointer value 127.

Sequence count cycle X+1: pointer is set at an AAL1 cell with SN 0, 2, 4 or 6.

Otherwise --> FAIL

(continued)

Rational and comments:

If a frame structure with frame length of more than 375 octets is established a structure boundary will not be indicated at every AAL type 1 sequence count cycle. In this case dummy value 127 will be set.

Applicable to CBR adapter supporting services 2, 3, 4 and 5.

Sequence count cycle X is a detected sequence cycle, carrying no structure boundary

Service tests may be considered as IOP tests between several systems or between a system and a service provider where the exposed interface of the system under test is specified. This type of test could also be specified in TTCN.

The reference to requirements part can refer either to a standard or to the specification of the system(s) or of the service provided. In the example above, the ITU-T Recommendations are referenced.

The test summary section describes in general terms what is to be tested.

The initial condition describes the operations to be performed before the actual start of the system.

The constraint part specifies the minimum requirements on the PDU for the test to be run.

The verdict criteria part contains the same type of logical information as the in an ATC.

The comment part provides clarification on the test rationale.

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