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SERIES X: DATA NETWORKS, OPEN SYSTEM  
COMMUNICATIONS AND SECURITY

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## **ITU-T X.290-series – Supplement on generic approach to interoperability testing**

ITU-T X-series Recommendations – Supplement 4



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| Web security                       | X.1140–X.1149 |
| Security protocols                 | X.1150–X.1159 |
| Peer-to-peer security              | X.1160–X.1169 |
| Networked ID security              | X.1170–X.1179 |
| IPTV security                      | X.1180–X.1199 |
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| Countering spam                    | X.1230–X.1249 |
| Identity management                | X.1250–X.1279 |
| SECURE APPLICATIONS AND SERVICES   |               |
| Emergency communications           | X.1300–X.1309 |
| Ubiquitous sensor network security | X.1310–X.1339 |

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## **Supplement 4 to ITU-T X-series Recommendations**

### **ITU-T X.290-series – Supplement on generic approach to interoperability testing**

#### **Summary**

Supplement 4 to ITU-T X.290-series Recommendations defines the relevant principles, methodology and architectures to serve as a foundation for interoperability testing and the development of interoperability test suites.

#### **Source**

Supplement 4 to ITU-T X-series Recommendations was agreed on 19 September 2008 by ITU-T Study Group 17 (2005-2008).

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# CONTENTS

## Page

|      |                                                                  |    |
|------|------------------------------------------------------------------|----|
| 1    | Scope .....                                                      | 1  |
| 2    | References.....                                                  | 1  |
| 3    | Definitions .....                                                | 2  |
| 4    | Abbreviations and acronyms .....                                 | 3  |
| 5    | Types of testing .....                                           | 3  |
| 5.1  | Interoperability testing.....                                    | 3  |
| 5.2  | Conformance testing.....                                         | 4  |
| 5.3  | Combining interoperability testing and conformance testing ..... | 5  |
| 6    | Interoperability testing process overview .....                  | 6  |
| 7    | Basic concepts .....                                             | 6  |
| 7.1  | Means of testing .....                                           | 7  |
| 7.2  | Equipment under test (EUT) .....                                 | 7  |
| 7.3  | Qualified equipment (QE) .....                                   | 7  |
| 7.4  | System under test (SUT) .....                                    | 8  |
| 7.5  | Test interface .....                                             | 8  |
| 7.6  | Test driver.....                                                 | 8  |
| 7.7  | Test coordinator.....                                            | 9  |
| 7.8  | Interoperability test cases .....                                | 9  |
| 7.9  | Means of communication (MoC) .....                               | 9  |
| 8    | Generic interoperability test architectures .....                | 9  |
| 8.1  | Test architectures with a single QE .....                        | 9  |
| 8.2  | Test architectures with multiple QEs .....                       | 10 |
| 9    | Developing interoperability tests .....                          | 12 |
| 9.1  | Overview .....                                                   | 12 |
| 9.2  | Specify abstract architecture.....                               | 13 |
| 9.3  | Prepare draft IFS proforma.....                                  | 14 |
| 9.4  | Specify test suite structure.....                                | 15 |
| 9.5  | Write test purposes .....                                        | 15 |
| 9.6  | Write test cases .....                                           | 16 |
| 9.7  | Validate test cases.....                                         | 23 |
| 9.8  | Finalize IFS .....                                               | 23 |
| 10   | Interoperability testing process.....                            | 23 |
| 10.1 | Overview .....                                                   | 23 |
| 10.2 | Prepare for testing.....                                         | 24 |
| 10.3 | Testing .....                                                    | 26 |
| 10.4 | Write test report.....                                           | 27 |

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|                                                                        | <b>Page</b> |
|------------------------------------------------------------------------|-------------|
| Appendix I – Example IFS (Internet Key Exchange protocol, IKEv2) ..... | 28          |
| I.1    Introduction .....                                              | 28          |
| I.2    Instructions for completing the IFS proforma .....              | 28          |
| I.4    IKEv2 entities .....                                            | 29          |
| Appendix II – Example IFS (TIPHON Profile of SIP, Release 3) .....     | 34          |
| II.1   Introduction .....                                              | 34          |
| II.2   Instructions for completing the IFS proforma .....              | 34          |
| II.3   IFS proforma .....                                              | 35          |
| II.4   SIP entities .....                                              | 35          |
| Bibliography.....                                                      | 40          |

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## Introduction

This supplement provides a generic framework and methodology for interoperability testing of interconnected communication systems. The need for interoperability testing arises when it is required to demonstrate that two or more systems or system components are capable of communicating with each other. This supplement defines the relevant principles, methodology and architectures to serve as a foundation for interoperability testing and the development of interoperability test suites and is applicable to interoperability testing of protocols and also to interoperability testing of all areas of software.

This supplement is complementary to, and may be used in conjunction with, testing methodologies and test specification languages defined in related ITU-T Recommendations such as:

- ITU-T X.290 through ITU-T X.296, and
- ITU-T Z.161 through ITU-T Z.163

where the X.290-296 series addresses conformance and provides the methodology and framework for conformance, and the Z.161-163 series defines a general test scenarios description language for conformance testing and interoperability testing. A particularly related document in terms of its technical contents is Supplement 5 to ITU-T X-series Recommendations: ITU-T X.290-series: Supplement on interoperability testing framework and methodology, which deals with the foundational principles and issues that underlie specific interoperability testing approaches and on the basis of which interoperability testing approaches can be carried out and assessed. On the other hand, this Supplement 4 to the ITU-T X.290-series of Recommendations targets at providing a general guidance on the specification and execution of interoperability tests for communication systems in next generation networks (NGN). It is meant to be applied to communication equipment interoperability testing and in many places it gives specific guidance on how test suites can be written and interoperability testing can be carried out. In addition, Recommendations concerning ITU-T formal languages such as ASN.1, MSC, SDL and UML can be used in relation with this supplement for test data description, system behaviours and test scenarios descriptions, communication system modelling, and software modelling, respectively.

This supplement is intended to assist ITU-T study groups responsible for developing protocol specifications, conformance test suites and interoperability test suites. It is also intended as a guide to the developers of interoperability test suites, test tool developers and test operators with the objective of achieving a common framework for testing. Specification writers would understand non-interoperation phenomena and their causes better so that they can be more informed and prepared to write interoperable specifications. System developers would be helped in developing interoperable systems and services. Interoperability test suites developers would know how to write practically complete interoperability test suites (i.e., they would know what needs to be tested and would also know the gap between what should be tested and what can be tested). Test operators would get help in understanding the causes of interoperability problems and in finding out how to fix problems.

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## Supplement 4 to ITU-T X-series Recommendations

### ITU-T X.290-series – Supplement on generic approach to interoperability testing

#### 1 Scope

This supplement gives general guidance on the specification and execution of interoperability tests for communication systems. It provides a framework within which interoperability test specifications for a wide range of product types can be developed. The guidelines are expressed as recommendations rather than strict rules and leave enough freedom to allow test specifiers to adopt and adapt processes to suit each particular project while still ensuring that test specifications accurately reflect the requirements of the base standards and can be executed consistently across a range of configurations.

Interoperability testing is the structured and formal testing of functions supported remotely by two or more items of equipment communicating by means of standardized protocols. It is not the detailed verification of protocol requirements specified in a conformance test suite, neither is it the less formal development testing often associated with "plug-fest" and "interop" events (frequently referred to as "bake-offs").

Although some consideration is given within the methodology to the operating and reporting aspects of interoperability testing, the primary focus of this supplement is on the specification of interoperability testing architectures, test plans and test suites.

#### 2 References

- [ITU-T X.290] Recommendation ITU-T X.290 (1995), *OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – General concepts.*
- [ITU-T X.291] Recommendation ITU-T X.291 (1995), *OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – Abstract test suite specification.*
- [ITU-T X.292] Recommendation ITU-T X.292 (2002), *OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – The Tree and Tabular Combined Notation (TTCN).*
- [ITU-T X.293] Recommendation ITU-T X.293 (1995), *OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – Test realization.*
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- [ITU-T Z.161] Recommendation ITU-T Z.161 (2007), *Testing and Test Control Notation version 3: TTCN-3 core language*.
- [ITU-T Z.163] Recommendation ITU-T Z.163 (2007), *Testing and Test Control Notation version 3: TTCN-3 graphical presentation format (GFT)*.
- [ETSI TS 101 884] ETSI TS 101 884 V1.1.1 (2002), *Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON) Release 3; Technology Mapping; Implementation of TIPHON architecture using SIP*.
- [ETSI EG 202 107] ETSI EG 202 107 V1.1.1 (1999), *Methods for Testing and Specification (MTS); Planning for validation and testing in the standards-making process*.
- [IETF RFC 3261] IETF RFC 3261 (2002), *SIP: Session Initiation Protocol*.
- [IETF RFC 4306] IETF RFC 4306 (2005), *Internet Key Exchange (IKEv2) Protocol*.

### 3 Definitions

This supplement defines the following terms:

**3.1 conformance:** Compliance with requirements specified in applicable ITU-T X.290-series of Recommendations.

**3.2 conformance testing:** Testing the extent to which an implementation under test (IUT) satisfies both static and dynamic conformance requirements.

NOTE – The purpose of conformance testing is to determine to what extent a single implementation of a particular standard conforms to the individual requirements of that standard.

**3.3 device:** Item of software or hardware which either alone or in combination with other devices implements the requirements of a standardized specification.

**3.4 equipment under test (EUT):** Grouping of one or more devices which has not been previously shown to interoperate with previously qualified equipment (QE).

**3.5 interoperability:** Ability of two systems to interoperate using the same communication protocol.

**3.6 interoperability test suite:** Collection of test cases designed to prove the ability of two (or more) systems to interoperate.

**3.7 interoperability testing:** Activity of proving that end-to-end functionality between (at least) two communicating systems is as required by the base standard(s) on which those systems are based.

**3.8 Interworking function (IWF):** Translation of one protocol into another one so that two systems using two different communication protocols are able to interoperate.

**3.9 qualified equipment (QE):** Grouping of one or more devices that has been shown, by rigorous and well-defined testing, to interoperate with other equipment.

NOTE – Once an EUT has been successfully tested against a QE, it may be considered to be a QE, itself.

**3.10 system under test (SUT):** One or more QEs and an EUT.

**3.11 test case:** Specification of the actions required to achieve a specific test purpose, starting in a stable testing state, ending in a stable testing state and defined in either natural language for manual operation or in a machine-readable language (such as TTCN-3) for automatic execution.

**3.12 test purpose:** Description of a well-defined objective of testing, focusing on a single interoperability requirement or a set of related interoperability requirements.

## 4 Abbreviations and acronyms

This supplement uses the following abbreviations and acronyms:

|        |                                                                      |
|--------|----------------------------------------------------------------------|
| API    | Application Programming Interface                                    |
| EP     | End Point                                                            |
| EUT    | Equipment Under Test                                                 |
| GFT    | Graphical presentation Format for TTCN-3                             |
| IFS    | Interoperable Features Statement                                     |
| IUT    | Implementation Under Test                                            |
| IWF    | InterWorking Function                                                |
| MMI    | Man-Machine Interface                                                |
| MoC    | Means of Communication                                               |
| MoT    | Means of Testing                                                     |
| PICS   | Protocol Implementation Conformance Statement                        |
| QE     | Qualified Equipment                                                  |
| SIP    | Session Initiation Protocol                                          |
| SUT    | System Under Test                                                    |
| TIPHON | Telecommunications and Internet Protocol Harmonization Over Networks |
| TP     | Test Purpose                                                         |
| TPLan  | Test Purpose notation                                                |
| TTCN-3 | Testing and Test Control Notation version 3                          |
| TSS    | Test Suite Structure                                                 |

## 5 Types of testing

Equipment implementing standardized protocols and services can be formally tested in two related but different ways, each of which has benefits and limitations:

- conformance testing can show that a product correctly implements a particular standardized protocol:
  - establishes whether or not the implementation in question meets the requirements specified for the protocol itself. For example, it will test protocol message contents and format as well as the permitted sequences of messages;
- interoperability testing can demonstrate that a product will work with other like products:
  - assesses the ability of the implementation to support the required trans-network functionality between itself and another similar implementation to which it is connected.

Conformance testing in conjunction with interoperability testing provide both the proof of conformance and the guarantee of interoperation.

### 5.1 Interoperability testing

The term "interoperability testing" is often used in relation to the semi-formal testing carried out at multi-vendor events as part of the product development process. While such events, often referred to as "plug-fests", "interop" and "bake-offs", are valuable sources of information on the ability of



similar products to communicate, they generally do not offer the structured and, therefore, repeatable, testing that is an essential part of a certification scheme. For a certification (or branding or logo) scheme to be meaningful, it is necessary that interoperability testing is carried out in accordance with a comprehensive and structured suite of tests. In the context of this Supplement, it is exactly this type of testing which is referred to as "interoperability testing". For other types of schemes, such as those arranged between manufacturers for marketing or other purposes, this approach is still valid.

NOTE – It is possible that other organizations within the global standardization community will have interpretations of this term which differ to a greater or lesser extent.

The purpose of interoperability testing is to prove that end-to-end functionality between (at least) two communicating systems is as required by the standard(s) on which those systems are based.

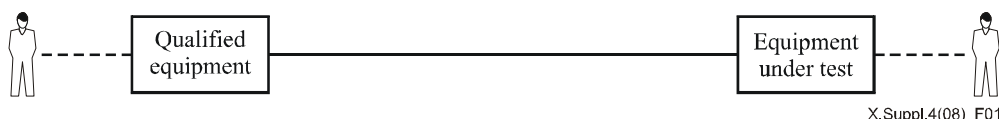


**Figure 1 – Illustration of interoperability testing**

The important factors which characterize interoperability testing are:

- the equipment under test (EUT) and the qualified equipment (QE) together define the boundaries for testing (Figure 1);
- the EUT and QE come from different suppliers (or, at least, different product lines);
- interoperability tests are performed at interfaces that offer only normal user control and observation (i.e., not at specialized interfaces introduced solely for testing purposes);
- interoperability tests are based on functionality as experienced by a user (i.e., they are not specified at the protocol level). In this context a user may be human or a software application;
- the tests are performed and observed at functional interfaces such as man-machine interfaces (MMIs), protocol service interfaces and application programming interfaces (APIs).

The fact that interoperability tests are performed at the end points and at functional interfaces means that interoperability test cases can only specify functional behaviour. They cannot explicitly cause or test protocol error behaviour.

## 5.2 Conformance testing

The purpose of conformance testing is to determine to what extent a single implementation of a particular standard conforms to the individual requirements of that standard.

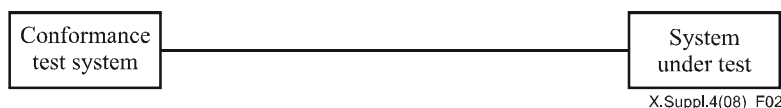


**Figure 2 – Illustration of conformance testing**

The important factors which characterize conformance testing are as follows:

- the system or implementation under test (SUT or IUT) defines the boundaries for testing (Figure 2);

- the tests are executed by a dedicated test system that has full control of the SUT and the ability to observe all communications from the SUT;
- the tests are performed at open standardized interfaces that are not (usually) accessible to a normal user (i.e., they are specified at the protocol level).

Because the conformance tester maintains a high degree of control over the sequence and contents of the protocol messages sent to the IUT, it is able to explore a wide range of both expected and unexpected (invalid) behaviour.

It is not within the scope of this supplement to define a conformance testing methodology. However, because interoperability testing and conformance testing complement one another, the reader of this supplement would be well-advised to study the established ISO conformance testing methodology defined in ITU-T X.290-series Recommendations as applied in all ETSI conformance test specifications.

### 5.3 Combining interoperability testing and conformance testing

Conformance and interoperability are both important and useful approaches to the testing of standardized protocol implementations, although it is unlikely that one will ever fully replace the other. Conformance testing is able to show that a particular implementation complies with the protocol requirements specified in the associated base standard. However, it is difficult for such testing to be able to prove that the implementation will interoperate with similar implementations in other products. On the other hand, interoperability testing can clearly demonstrate that two implementations will cooperate to provide the specified end-to-end functions but cannot easily prove that either of them conforms to the detailed requirements of the protocol specification.

The purpose of interoperability testing is not only to show that products from different manufacturers can work together, but also to show that these products can interoperate using a specific protocol. Without this additional aspect, interoperability testing could be considered to be almost meaningless. Within the context of standardization, it is of little interest to know that two products can interoperate unless there is a guarantee that they are connected together by means of a standardized protocol. It is, therefore, advisable to test the conformance of an implementation before testing for interoperability with other (similarly tested) implementations.

Although there are quite distinct differences between conformance testing and interoperability testing, it is valid to consider using the techniques together to give combined results. Such an approach will almost certainly involve some compromise and it is unlikely that it would provide the breadth and depth of testing that conformance and interoperability can offer when applied individually. However, some limited conformance testing with extensive interoperability testing, for example, may be useful in certain situations. The test configuration shown in Figure 3 permits complete interoperability testing to be undertaken while limited protocol conformance monitoring takes place.

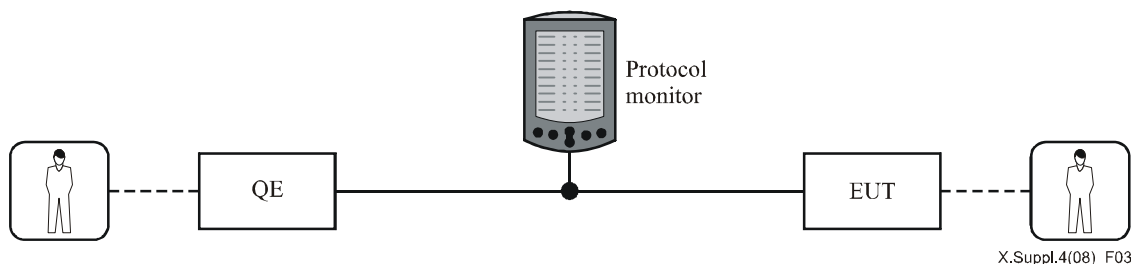


**Figure 3 – Interoperability testing with conformance monitoring**

While this arrangement cannot provide a complete proof of conformance, analysis of the protocol monitor output will be able to show whether protocol signalling between the EUT and the QE conformed to the appropriate standard(s) throughout the testing.

## 6 Interoperability testing process overview

This supplement provides users with guidelines on the main steps associated with interoperability testing. The intention is that the guidelines should be simple and pragmatic so that the document can be used as a "cook-book" rather than a rigid prescription of how to perform interoperability testing.

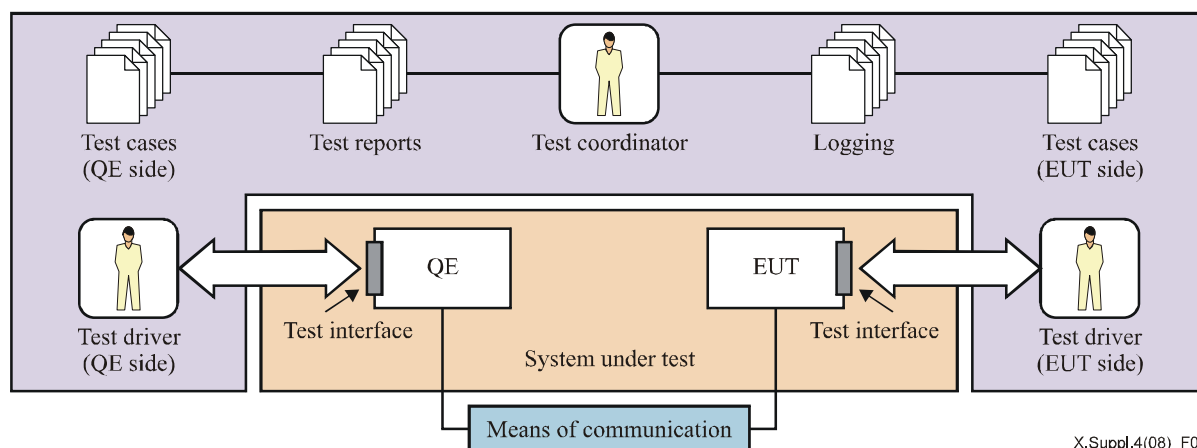
The main components of the guidelines are described in clauses 9 and 10, and are as follows:

- Development of interoperability test specifications, including:
  - identification of interoperable functions;
  - identification of abstract architectures;
  - specification of interoperability test suite structure and test purposes;
  - specification of interoperability test cases.
- The testing process, including:
  - test planning;
  - specification of test configurations;
  - execution of the tests;
  - logging results and producing test reports.

As their name implies, guidelines are only for guidance and the actual process followed should use and adapt whichever of these guidelines are most applicable in each particular situation. In some cases, this may mean the application of all aspects.

## 7 Basic concepts

Figure 4 illustrates the main concepts specified in this supplement. It shows the two main components of the methodology, namely, the means of testing (MoT) and the system under test (SUT). The MoT includes the roles of test drivers and a test coordinator, the interoperability test cases and mechanisms for logging and reporting. The SUT comprises the equipment under test (EUT) and the qualified equipment (QE). The means of communication (MoC) between the QE and the EUT is considered to be neither part of the SUT nor of the MoT.



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Figure 4 – Illustration of main concepts

## 7.1 Means of testing

The combination of equipment and procedures that perform the selection and execution of test cases is known as the means of testing (MoT). Test cases may be executed either by a human operator or by an automated program (see clause 7.6). The MoT should also be capable of logging test results and of producing test reports (see clause 10.4). The MoT includes neither the system under test nor the means by which devices in the system under test communicate.

## 7.2 Equipment under test (EUT)

In any interoperability testing architecture there will always be one connected item which is the subject of the test. This item is referred to as the equipment under test or EUT. Any single test configuration will only have one EUT. An EUT may be end-user equipment (such as a terminal), network equipment (such as a router) or a software application.

EUTs can be composed of any number of component parts, each of which is referred to as a device. This may be a physical device, a software package or a combination of the two. The simplest case is where the EUT is a single device.

The interconnection configuration between devices in an EUT is purely a matter for the supplier and is not prescribed in the test architectures, nor is it considered to be an explicit part of the interoperability test for that EUT.

An EUT will not have been previously tested successfully for interoperability in a similar configuration, although it may have been tested for conformance. While this methodology does not require previous conformance testing, it is recommended that this activity is performed, for the reasons mentioned in clause 5.3.

## 7.3 Qualified equipment (QE)

### 7.3.1 QEs and devices

When testing an EUT for interoperability, it is essential that the test architecture include equipment that has already been proven to interoperate with similar equipment from other suppliers. Such items are referred to as the qualified equipment (QE). Any single test configuration may have one or more QEs. A QE may be end-user equipment (such as a terminal), network equipment (such as a router) or a software application.

QEs can also be composed of a number of component parts, each of which is, again, referred to as a device. This may be a physical device, a software package or a combination of the two. The simplest case is where the QE is a single device. Thus, a QE is a collection of devices that, in a given configuration, has undergone and passed interoperability testing.

The interconnection configuration between devices in a QE is purely a matter for the test system implementer and is not prescribed in the test architectures.

Any given QE will have initially been tested as an EUT but, once the full range of interoperability tests have been successfully performed, it can be considered to be a QE. This methodology does not force an EUT to be tested against all possible QEs in the pool of QEs that may be available in a particular testing scheme. However, the likelihood of multi-vendor interoperability is increased if it can be demonstrated that a particular EUT interoperates with a large number of different QEs.

### 7.3.2 Designating the first QE

In cases of new and developing technologies, no qualified equipment is likely to exist. The first instance of interoperability testing for a particular scheme will involve two (or more) EUTs rather than a number of QEs and one EUT.