Standards for Business

ETSI White Paper No. 3

Achieving Technical Interoperability - the ETSI Approach

Authors:

Hans van der Veer (Alcatel-Lucent)
Anthony Wiles (ETSI Secretariat)

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European Telecommunications Standards Institute
F-06921 Sophia Antipolis Cedex, France
Tel +33 4 92 94 42 00   Fax +33 4 93 65 47 16
info@etsi.org   www.etsi.org

About the authors

Hans van der Veer

Hans van der Veer is currently Director of Standards; responsible for the Europe co-ordination of Alcatel-Lucent's standardization policy activities. He is also a member of the ETSI Board, where he is champion for the strategic topic of interoperability. His past activities include:

- 1972-1984: Development and System Engineering of digital switching systems with ITT (BTMC in Belgium) and Philips' Telecommunications Industries (The Netherlands). Participated in CCITT (later ITU-T) SG11 and SG18 standardization activities.
- 1984-1985: Supervised a 5ESS System Engineering Group (ISDN, SS#7) with AT&T Network Systems International (The Netherlands).
- 1985-1992: Responsible for the Product Management of Intelligent Networks in the EMEA region. Participated in ITU-T SG11 and ETSI Technical Committees NA and SPS standardization activities.
- 1992-2003: Responsible for the Global Strategic Standardization group with Lucent Technologies EMEA. Appointed as Vice-Chairman of ETSI TC NA in 1992. Chairman of ETSI TC NA in 1998 until its merger with TC SPS. Vice-Chairman of ETSI Technical Committee SPAN from 1999-2003. ETSI Project TIPHON Chairman from 2001-2003. Appointed to ETSI Board in 2003.

Anthony Wiles

Anthony Wiles is the Director of the Centre for Testing and Interoperability (CTI) at ETSI (formerly the Protocol and Testing Competence Centre or PTCC). He has many years experience in both data- and telecommunications with particular expertise in the specification of communication protocols and the development and application of advanced testing techniques. Prior to joining ETSI Anthony was with Telia Research and Ericsson (EllemTel), heading Telia's Requirements Engineering Laboratory in Stockholm.

Anthony was deeply involved in the development of the widely used testing methodology, ISO/IEC 9646. He was leader of the ETSI Specialist Task Force that developed the increasingly popular test language TTCN-3. He is author/co-author of over 10 refereed journals and conference papers and has organized and chaired several international conferences, the most recent being TESTCOM 2003 and the International TTCN-3 User Conferences of 2004 and 2005.

Anthony's current technical activities include the development and application of new testing methodologies oriented to complex systems such as the IP Multimedia Subsystem (IMS), including the use of TTCN-3 for test control and automated interoperability testing.

Achieving Technical Interoperability
– the ETSI Approach

Edition 3

April 2008

This White Paper presents an overview of the approach of ETSI (The European Telecommunications Standards Institute) to ensure interoperable standards. It provides a short description of the meaning of Technical Interoperability followed by an analysis of the implications that this has on standardization. Of special interest is the growing impact that multi-organizational standardization has on interoperability.

The goal of ETSI is to ensure that instances of non-interoperability are not caused by poor or insufficient standardization. This White Paper describes the various processes and engineering principles applied by the ETSI membership in the development of Information and Communication Technologies (ICT). Attention is given to the importance of sound project management, good specification techniques, validation and testing. A short introduction to various types of testing is given, culminating in an insight into how combinations of these methods may be applied to address interoperability issues in complex ICT systems.

ETSI initiatives on interoperability such as the appointment of an Interoperability Champion, and the work of its Technical Committees (TC) such as TC MTS are also presented. The White Paper describes the significant effort the ETSI membership puts into testing and validation activities supported by the Centre for Testing and Interoperability (CTI) and ETSI Plugtests™ events.

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Foreword

The current and future eCommunications market can be described as a convergent multimedia market with an increasingly complex structure. Within this market we are faced with an unpredictable, sometimes fragmented, market development (e.g. open network versus walled garden approach, intelligent networks versus dumb networks) where potential barriers to achieving interoperability may be emerging. Additionally, within the present competitive environment, the risk of non-interoperability is increasing because of (e.g.) small windows of opportunity due to fast evolution of technology, or the use of non-open standards.

Against this background there is an ever-increasing awareness of market players and regulators that mass-market development requires interoperability based on open standards. Additionally, the end-user appreciates more choice, but expects certainties.

The main aim of standardization is to enable interoperability in a multi-vendor, multi-network, multi-service environment. The absence of interoperability must not be the reason why final services for which there is great demand do not come into being.

ETSI is very much aware of these developments and market demands. It knows what the inhibitors to interoperability are that can be encountered during the standards development process. This White Paper gives an overview of the approach that ETSI has taken to address these inhibitors to interoperability and how the institute ensures that interoperable standards of high quality and relevance to the marketplace are developed.

Hans van der Veer

ETSI Board Member and Interoperability Champion

Achieving Technical Interoperability
– the ETSI Approach

1 What interoperability means to ETSI

There is no single definition of the word interoperability: even at ETSI the term has different meanings in different contexts (see, for example, the Terms & Definitions database at http://webapp.etsi.org/Teddi/). However, the following definitions are probably the closest to a common understanding within the ETSI community and collectively capture the meaning of the term as used in this White Paper:

> "*Interoperability is the ability of two systems to interoperate using the same communication protocol*" from ETSI Project TIPHON (now closed).

Or the definition of interoperability of Next Generation Networks (NGN) from ETSI's Technical Committee TISPAN:

> "*Interoperability is the ability of equipment from different manufacturers (or different systems) to communicate together on the same infrastructure (same system), or on another while roaming*"

Or in the context of the 3rd Generation Partnership Project, 3GPP[1]:

> "*the ability of two or more systems or components to exchange data and use information*"

Recently, we have seen the emergence of different categories of interoperability, for example: ***technical interoperability***, ***syntactical interoperability***, ***semantic interoperability*** and ***organizational interoperability****.* We shall not attempt to define these terms here but the following descriptions may help the reader to draw his or her own conclusions.

Technical Interoperability is usually associated with hardware/software components, systems and platforms that enable machine-to-machine communication to take place. This kind of interoperability is often centred on (communication) protocols and the infrastructure needed for those protocols to operate.

Syntactical Interoperability is usually associated with data formats. Certainly, the messages transferred by communication protocols need to have a well-defined syntax and encoding, even if it is only in the form of bit-tables. However, many protocols carry data or content, and this can be represented using high-level transfer syntaxes such as HTML, XML or ASN.1[2]. Generally, ETSI is a user rather than a definer of generic syntaxes with a few notable exceptions, such as the definition and use of Concrete Syntax Notation (CSN) in the GSM specifications.

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[1] 3GPP is a collaboration between standards organizations, industry associations and individual companies to develop globally-applicable specifications for 3rd Generation mobile communications.

[2] These terms, and others, are defined in the Glossary at the end of this White Paper.

Semantic Interoperability is usually associated with the meaning of content and concerns the human rather than machine *interpretation* of the content. Thus, interoperability on this level means that there is a common understanding between people of the meaning of the content (information) being exchanged.

Organizational Interoperability, as the name implies, is the ability of organizations to effectively communicate and transfer (meaningful) data (information) even though they may be using a variety of different information systems over widely different infrastructures, possibly across different geographic regions and cultures. Organizational interoperability depends on successful technical, syntactical and semantic interoperability.

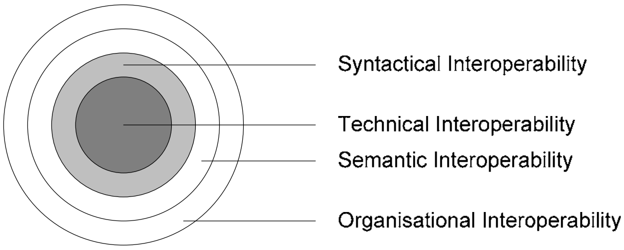


Figure 1: Different levels of interoperability

This White Paper is restricted to discussing technical interoperability and, where appropriate, syntactical interoperability. The term interoperability will be used here to mean either or both of these types of interoperability. It does not include semantic or organizational interoperability.

Often the terms *interworking* and interoperability are used to mean the same thing. There is no hard and fast rule. In the opinion of the authors it may be useful to restrict the word interworking to mean interoperability between similar, but not identical, communication systems such as networks using different technologies, possibly via some form of interworking function such as a gateway.

2 Typical symptoms of non-interoperability

Before showing how ETSI ensures interoperable standards it may be useful to take a quick look at what ***non-interoperability*** is. In the case of two (or more) communicating entities the symptoms of non-interoperability are obvious:

It (whatever it is) doesn't work (as expected).

The 'as expected' is important here. Sometimes systems work exactly as the standardizers intended but are being used for tasks for which they were never designed and subsequently *appear* not to work well. If standards are adapted or used beyond their original context, then it is important that the consequences for interoperability are fully understood and addressed. This is especially pertinent in the environment of multi-organizational standardization.

It also worth noting that some systems are intentionally non-interoperable. This is not a technical issue and will not be discussed further in this White Paper – suffice to say that such situations exist.

In engineering terms, non-interoperability can be summarised by the following responses from one or more of the communicating parties:

Where are you?   What did you say?   Why did you do that?

The **'where are you?'** scenario is probably the most irritating. Examples of this type of scenario are the inability of wireless-enabled headsets that cannot talk to one's laptop, or a network component that becomes deadlocked during a critical download.

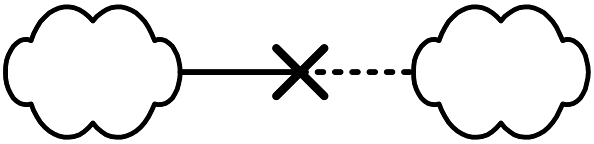
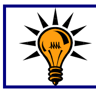


Figure 2: Where are you?

This may happen because of a flaw in a protocol standard or it could occur because of some internal condition on the part of one of the entities, such as a lack of system resources. Both cases obviously result in a breakdown in communication but the point to note is that the first instance can be prevented through well-specified standards. On the other hand, no amount of standardization can prevent the second instance. But we *can* detect and rectify the error through rigorous testing, preferably based on standardized tests or interoperability events.



Protocol standards must ensure total internal consistency, robustness and efficiency. Testing ensures correct implementation.

NOTE: Of course, the second instance above could be prevented by good programming practices on the part of the implementer, but that is another issue!

The **'what did you say?'** scenario illustrates the case where we have communication mismatches, but not deadlock.

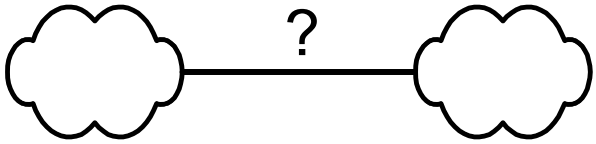


Figure 3: What did you say?

As an example, suppose that the standard has got the behavioural aspects of the protocol right but does not clearly specify some aspect of the format or content of the messages being exchanged. These ambiguities may vary from the very small (on the individual bit-level) to the very large (complete sections of messages).

Errors on the message level may not result in severe non-interoperability: robust protocols can often recover from these situations. But this is not always the case. Consider the example where retransmissions can be significant if repeated many times by large numbers of users working over a limited bandwidth. This may lead to access delays which the human users perceive as poor interoperability. A 'what did you say?' problem in the protocol has led to a 'where are you?' from the human user (or perhaps a less polite phrase)!

Clear, efficient and unambiguous specification of data formats and encodings go a long way to eliminating non-interoperability. Testing ensures correct implementation.

The third kind of non-interoperability response is illustrated by the **'why did you do that?'** scenario. In these cases one of the parties does something completely unexpected, either in the context of the communication or as some side effect.

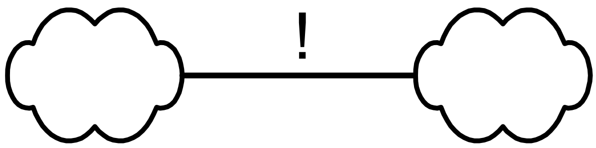


Figure 4: Why did you do that?

In the best case unexpected behaviour can be handled, indeed protocols should be designed to cope with the unexpected. In the worst case it can lead to unpredictable failure. Typically, this is the result of ambiguity, too much openness in a standard, or inadequately designed interfaces.

Protocols should be designed (repeat, designed!) to be flexible, robust and predictable. Uncontrolled evolutionary development of a protocol should be avoided.

3 Reasons why a standard may not be interoperable

Standards are driven by contributions from many individuals from a wide range of backgrounds, cultures and commercial positions. In practice, despite best efforts, there are often not enough resources to integrate these various contributions into a consistent, coherent whole.

Typical consequences of this can include:

Incompleteness: often specifications are incomplete (albeit unintentionally), aspects essential to interoperability are missing or are only partially specified.

Inadequate interfaces (reference points): it is not unusual for interfaces critical to interoperability to be inadequately identified or not clearly defined.

Poor handling of options: A standard may contain too many options, or the options are poorly specified. For example, there may be an imprecise understanding of the consequences if certain options are not implemented. Worse still, there may be inconsistencies – even contradictions – between various options;

Lack of clarity: There is a distinct skill in writing a good standard which should:

- be well structured;
- distinguish between what needs to be standardized and what does not;

but should not:

- mix concepts;
- specify the same thing in several different ways;
- be confusing;
- be too verbose;
- be too cryptic.

Poor maintenance: Lack of version control, unclear indications of exactly which requirements (mandatory and optional!) are covered by a certain release of a standard, and lax change request procedures can have a negative impact on interoperability.

Incomplete, unclear standards with poorly specified options can contribute to the biggest single cause of non-interoperability, namely that the unfortunate implementer is forced to make potentially non-interoperable design decisions on critical parts of the system based on a lack of information.

4 Interoperability and complex systems

The examples of non-interoperability in section 2 are quite basic and can usually be avoided in simple, stand-alone standards. However, it is becoming increasingly common for complex ICT systems to be specified by islands of standards rather than one monolithic block, as illustrated in figure 5.

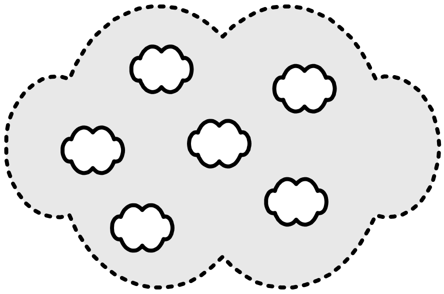


Figure 5: Islands of standardization

The resulting system is, inevitably, more complicated than the sum of the parts. Inevitable, because commercial pressures prohibit specification down to the finest detail, either through lack of resources or through a desire to leave certain issues open. It is simply too time-consuming and too expensive to standardize the entire system. Knowledge of how the system is supposed to work as a whole resides in the consciousness of the standardization community rather than in the standards themselves (which is a very good argument for active participation in standards development).

In a complex system, the non-interoperability issues illustrated in section 2 can have unpredictable effects which possibly appear far removed from the original cause and which can be very difficult to trace.

These problems are compounded in the case where there is no longer a single source for the different standards, as illustrated in figure 6. The standards may come from a variety of standards bodies, each with their own particular way of doing things. We shall call this *multi-organizational standardization*.

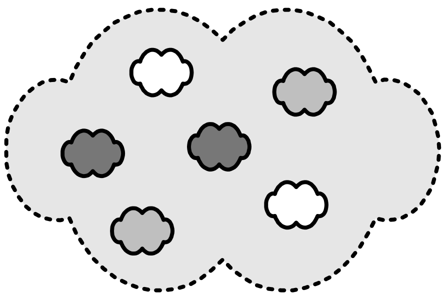


Figure 6: Standards islands with different owners

To complicate matters, each island in figure 6 may in itself be specified by a large number of standards (for example, the use of the Session Initiation Protocol, SIP, in IMS). As standardization becomes more fragmented in terms of the different standards bodies specifying components of a larger, more complex system (such as Next Generation Networks (NGN) being specified by ETSI TISPAN) the potential for non-interoperability increases and the issues of interoperability become far more critical. Thus, a clear specification of the interfaces of each of the standardized components is essential.

We can now add the following to our list of characteristics of why products based on some standards may not interoperate:

> **Lack of system overview**: in a multi-standard context the combination of standards and the options provided by those standards, if not well-specified and clearly cross-referenced, can prevent the implementer from having a clear overview of the system.
>
> **Using standards beyond their original purposes**: it is becoming more common for standards developed with one context in mind to be used in another. A well-engineered standard will be robust and flexible enough to make the transition. But in many cases changes or additions to the original specifications to make them suitable for the new environment bring compromises in interoperability. The risks of this occurring can be reduced if those changes are made in a considered and well-planned way: regrettably this is not always the case as things are often done in an ad-hoc manner. It is highly likely to happen if those changes are decided by individual implementers of the standard.
>
> **Varying quality**: each standards organization has its own rules and culture on how a standard is written and presented, and on the level of technical quality. This is probably unavoidable but it is often confusing for the implementers of those standards.

5 Building interoperability into ETSI standards

The goal of ETSI is to ensure that instances of non-interoperability are not caused by poor or insufficient standardization. This section provides an overview of ETSI's approach to producing interoperable standards.

We shall start by taking a look at the ETSI Standards Making Process (SMP). For a full description of the SMP visit http://portal.etsi.org/Chaircor/process.asp

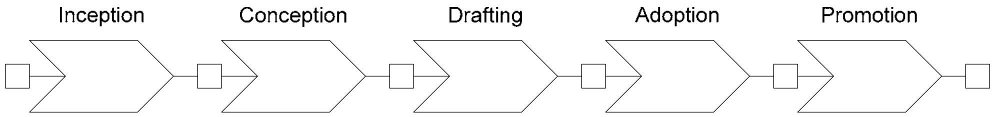


Figure 7: The ETSI Standards Making Process

It is the drafting phase which is of immediate interest to us. Standards need to be designed for interoperability from the very beginning of this phase. Interoperability is not something that will somehow get fixed at the end of the process. Ensuring interoperability is the red thread running through the entire ETSI Standards Making Process from day one. We call this *standards engineering.*

Let's see how the drafting of ETSI standards includes activities that impact interoperability, as illustrated in figure 8.

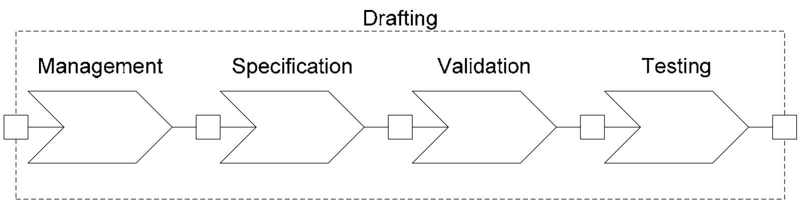


Figure 8: The drafting phase of the SMP

Feedback from the validation and testing activities is critical. This is introduced into the ETSI SMP as shown in figure 9.

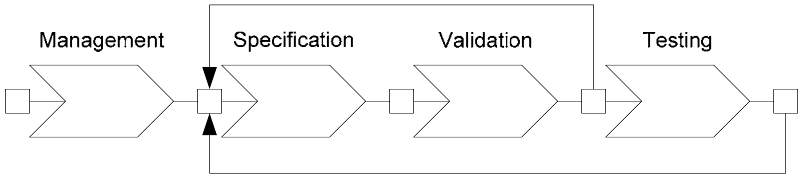


Figure 9: Feedback from validation and testing to base standards

While following procedures such as these does not necessarily solve all interoperability issues, the ETSI experience over many years has shown that through these activities we can go a long way towards eliminating basic interoperability problems at an early stage. This does not come for free, but the choice is obvious, either:

- a relatively cheap solution shared by the entire membership during standards development; or
- an expensive, retroactive fix (for each individual company) in full view of the market place.

The ETSI membership has clearly stated its preference for the former.

In practice, of course, these activities are not a purely sequential process. Standards development, product development, validation, the development of test specifications and the actual testing all go hand-in-hand and must be carried out in a timely manner. Figure 10 shows a typical time-line relationship between all these activities.

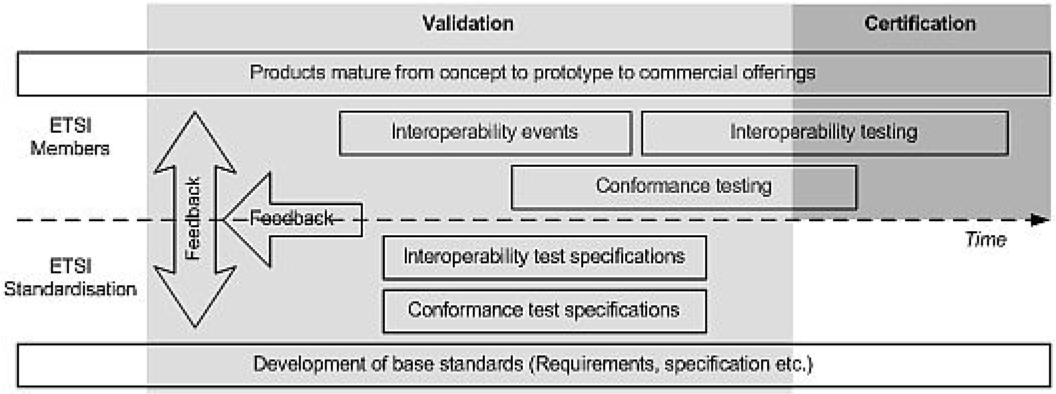


Figure 10: Relative time-line of standards development, validation and testing

The four steps of the drafting phase shown in figure 9, plus a maintenance phase that we shall see later, need to be planned and performed with interoperability in mind.

5.1 Manage for interoperability!

Managing for interoperability is not a technical issue. However, without good project management the value of technical smartness is diminished. Complex standardization activities, especially in the context of multi-organizational standardization, demand comprehensive project management.

Without this project overview and control many of the small details essential to achieving interoperability get overlooked: for example, ensuring consistency between user requirements and the base specification.

The ETSI Secretariat has teams of dedicated Technical Officers to support the Technical Committees and Working Groups and, where appropriate, to assist with matters of project management. For more details visit:

http://www.etsi.org

http://portal.etsi.org

http://www.3gpp.org/Support/support.htm

5.2 Specify for interoperability!

A standard is only one part of the design phase of an eventual product, but it is a critical part. A poor standard will inevitably lead to interoperability problems in real systems. ETSI, of course, has no influence over its members' internal design and implementation processes. What we can do is to try and link our processes and outputs as closely as possible to the working processes of our membership.

How that is done will often depend on the individual Technical Committee or Working Group. For example GSM and UMTS standardization has excellent experience of the classical *three-stage approach* to specification, where most protocol standards are developed (and published) in three distinct steps, as illustrated in figure 11.

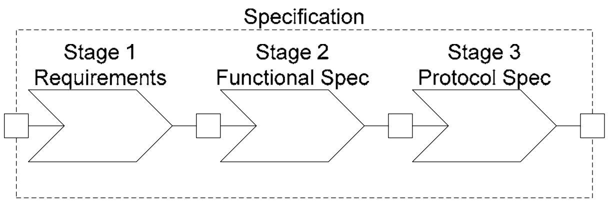


Figure 11: Example specification phase of the SMP

Designing for interoperability

Doing something well from the start does not have to be expensive. Practice has proven that it is cheaper in the long-run, but even in the short-term there are clear benefits. Rushed, corner-cutting, muddled-headed standardization efforts with repeated returns to square one are, unfortunately, an expensive, time-wasting reality. However, these are the exceptions, rather than the rule.

The ETSI support entities such as its Methods for Testing and Specification Technical Committee (TC MTS – see section 7.3) and the CTI (see 7.4) offer assistance and advice to ETSI Technical Committees and Working Groups on the application of pragmatic specification techniques and good working practices (including the three-stage approach) adapted, if necessary, for particular needs.

To avoid the kind of problems identified in section 2, advice is given on how to:

- develop clear requirements;
- develop a comprehensive architectural overview, including clear identification of interoperable interfaces;
- concentrate on specifying the right things, i.e. interoperable interfaces, and resist detailing internal implementation;
- use good protocol design techniques, such as
  - separation and description of normal behaviour and behaviour under error conditions;
  - full specification of options, including consequences of not implementing options;
  - development of (interoperability) profiles, where appropriate;
  - full specification of data (messages) and the encoding of that data;
- plan for validation and testing.

Solutions can range from the use of well-structured prose, with the correct and consistent application of the ETSI drafting rules (e.g. the use of the words *shall*, *should*, etc.), to the judicious application of modelling techniques, tools and languages such as:

- Unified Modelling Language (UML) for requirements specification;
- Message Sequence Charts (MSC) for the specification of information flows;
- Specification and Description Language (SDL) for detailed protocol specification;
- Abstract Syntax Notation (ASN.1) for defining message formats;
- Testing and Test Control Notation (TTCN) for writing test specifications.

ETSI has two entities whose role is to provide the Technical Committees and Working Groups with help, advice and resources on the specification and testing of interoperable standards

Technical Committee: Methods for Testing and Specification (MTS)

Centre for Testing and Interoperability (CTI)

See also section 7.

5.3 Validate for interoperability!

Validation of standards should be an integral part of the standards engineering process. It is impractical to prescribe a rigid process for performing effective yet economic validation, but there are a number of techniques available of which some, all or none may be applied as necessary. These various approaches are well-described in the pragmatic TC MTS guide on validation [1].

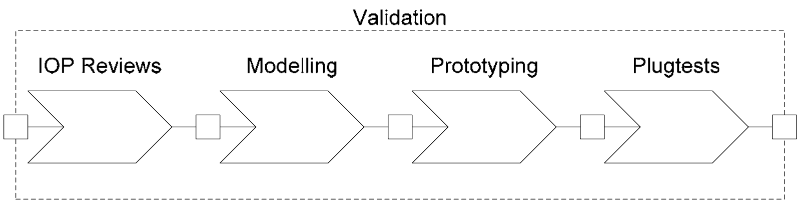


Figure 12: Possible phases of validation of base standards

Validation through technical reviews and simulation

Technical reviews (e.g. walk-throughs) and simulation through modelling or prototyping are typical early validation techniques. Modelling can include the use of UML and SDL, which can provide executable simulations of protocol behaviour. The use of Message Sequence Charts (MSC) is strongly encouraged. The ETSI Secretariat has the latest tool support for all these techniques.

Validation through interoperability events

Interoperability events provide an excellent opportunity to evaluate and debug early implementations of standardized technologies and (most importantly) to provide feedback to the standardization process.

*ETSI **Plugtests**TM events are organized for ETSI members and non-members alike. The primary aim is the validation of standards, especially in the context of multi-organizational standardization (see section 7.5).*

Validation of base standards through the development of test specifications

In many cases, development of test specifications provides early feedback to the base standards. As figure 10 shows, this feedback is most beneficial if test specifications are developed during the development of the base standard itself.

5.4 Test for interoperability!

The development of standardized test specifications is an integral part of the ETSI strategy for ensuring interoperability. There is no silver bullet. Testing will not eliminate all possible instances of non-interoperability, though it can do a lot to help. For example, the use of ETSI conformance test specifications in the Global Certification Forum (GCF) certification of GSM and UMTS handsets guarantees interoperability of these terminals over the air interface.

The question being asked by the ICT industry is no longer 'can we afford to test?' but rather 'can we afford not to test?'. The ETSI response is **'No! We cannot'**.

In the context of standardization ETSI focuses on the development of two types of test specifications, which reflect the principle: *test the components first, then test the system*, i.e.:

- conformance test specifications; and
- interoperability test specifications.

The differences between conformance testing and interoperability, and show they complement each other, are discussed in section 6.

Plan for validation and testing

The approach to testing and the accompanying test specifications needs to be considered at an early stage. A well-specified standard which is validated and for which there exist high-quality test specifications is more likely to lead to interoperable products. It is important, however, that development of test specifications and activities such as Plugtests are done in a timely manner. Which gives us two more lines for our interoperability mantra:

Plan for validation *and* ***Plan for testing!***

Test methodology

ETSI is a world leader in the development and application of testing methodologies, techniques and languages. Nearly all ETSI conformance test suites are developed according to ISO/IEC 9646 [2], recognized as *the* standard for conformity assessment. ETSI has also developed a similar methodology for interoperability testing [3] [4].

The basic activities in the development of test specifications are illustrated in figure 13 as a further detailing of the ETSI SMP.

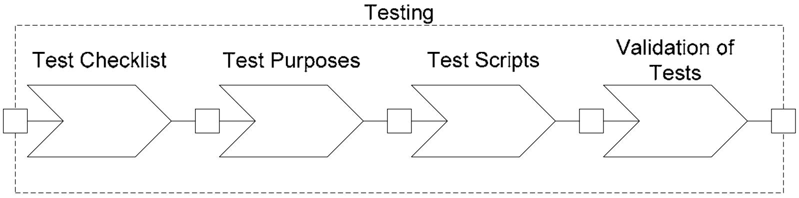


Figure 13: Various phases in test development

Checklists such as the Protocol Implementation Conformance Statement (PICS) or the Interoperable Functions Statement (IFS) can give early indications of static non-conformance or non-interoperability. The extraction of requirements from base standards into comprehensive Requirements Catalogues is proving to be a powerful complement to these checklists; especially when implemented as searchable on-line databases, for example the MTS IPv6 testing library at http://www.ipt.etsi.org/STF295-ph1/.

The test specifications are usually written in two stages: a short high-level description of the purpose of each test, that is, *what* is to be tested, and a full test script (code) of each test that can be compiled and run on a dedicated test system.

Where possible, ETSI validates the test code that it produces. In the most rigorous validation schemes all tests are compiled and executed on more than one test platform, usually in a commercial test laboratory or by recognized test tool suppliers. The tests are run against products to be tested from a range of different suppliers. Ongoing examples of this are the conformance tests for 3GPP UMTS and HiperMAN/WiMAX.

No test is released until validated, and a full validation record is kept. In many cases, this level of validation is required if the tests are to be used in a formal validation scheme (e.g. the GCF programme for the certification of GSM and UMTS handsets).

TTCN-3 — The internationally accepted test specification language TTCN-3 was developed by TC MTS with significant input from the ETSI PTCC. This flexible test scripting language has a wide range of applications, beyond ICT even. It can be used to specify many different kinds of test, including interoperability tests. For more details visit www.ttcn-3.org

5.5 Maintain for interoperability!

Methodical maintenance of base specifications and the corresponding test specifications is essential.

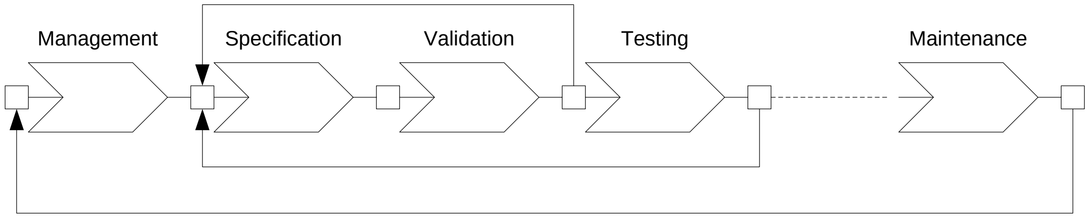


Figure 14: The maintenance phase in the SMP

Feedback to ETSI does not necessarily happen automatically. Care has to be taken that information learned by implementers does not get lost. One key factor in the life of a standard is maintenance and updating.

Once published, the standard enters the public domain (possibly global) and a much more extensive activity of scrutinization occurs. In general readers (users) of a standard are highly competent in the relevant technical area, and will critically read it line-by-line. Collection of feedback is particularly relevant and fruitful at this stage. Implementers and researchers may find there technical data related to their activities and will be likely to identify areas for improvement within the standard.

The feedback from this community of users (much wider than the original drafting group) is used to improve the quality of the published standard. However, in order that these updates are consistent and do not compromise the interoperability of the standard it is necessary that they are dealt with in a similar process to that of the original specification, including the stages of specification, validation and testing. That is, feedback needs to be captured, evaluated, and either accepted or rejected by the Technical Committee, and then integrated into a revision.

Methodical maintenance of an efficient feedback loop is a key asset to ensure that future revisions of the standard will better meet users' needs and therefore that its quality will undergo continuous improvement.

> NOTE: Beyond the quality improvement aspect of the feedback loop, the monitoring of its flow provides an excellent indicator of market acceptance for (and uptake of) a standard.

6 Conformance Testing and Interoperability Testing

Conformance testing concentrates on specific components in a system, often related to a single standard (or set of related standards). It is *unit* testing rather than system testing. Conformance testing is applied over open interfaces and checks for conformance to the requirements in a base specification or profile (standard).

Conformance tests are executed under controlled conditions using a dedicated test system. Specialized radio-based test systems (such as for GSM) can be expensive. Test systems for protocols running over widely available hardware (e.g. Ethernet/IP) are relatively cheap and may only require a compiler of a test language like TTCN-3 [5] together with some interface adaptation software.

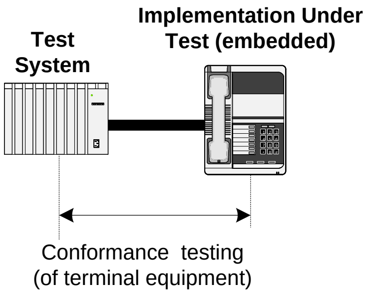


Figure 15: An example of conformance testing

One of the strong points of conformance testing is that the tester has a very high degree of control and observability. This means, for example, that we can explicitly test error behaviour by provoking abnormal scenarios. In this sense, a good conformance test suite will include aspects of robustness, something which interoperability testing (commonly known as IOT) cannot (explicitly) do.

In summary, conformance testing is thorough and accurate but limited in scope. It gives a high-level of confidence that key components of a device or system are working as they were specified and designed to do. But *a conformant component will not necessarily always interoperate with other components in a larger system*.

Interoperability testing (IOT)

IOT concentrates on a *complete* device or a collection of devices. It is *system* testing rather than unit testing. It is most commonly applied to end-to-end testing over networks. It shows, from the user's viewpoint, that functionality is accomplished (but not how).

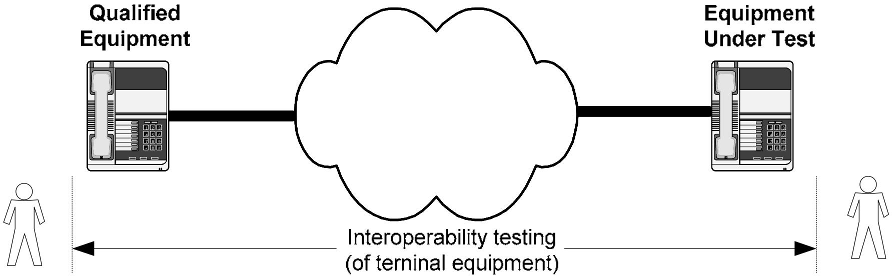


Figure 16: An example of interoperability testing

Because tests are usually run over whatever (human user) interfaces are available, there is far less observability and control than with conformance testing. In this sense, IOT is less thorough than conformance testing, but wider in scope. Interoperability testing gives a high-level of confidence that devices (or components in a system) will interoperate with other devices (components) against which it has been tested, but *it does not prove conformity (interoperating systems may not be conformant)*, neither does it guarantee interoperability with other devices not included in the testing process.

Interoperability testing does not require complex test systems, but if it is to be automated it may require some form of test drivers (simpler than full-blown test systems but not always trivial to implement).

Conformance Testing and IOT are complementary

Conformance testing and interoperability testing are complementary techniques. Many certification schemes require, for example, conformance testing as a prerequisite to interoperability testing (e.g. the Open Mobile Alliance or the WiMax Forum).

ETSI's experience is that, as a rule of thumb, the focus should be on conformance testing for protocols and lower-layer infrastructure, that a mixture of conformance and interoperability should be used for middleware and enablers, with the emphasis shifting to interoperability testing for services, applications and entire systems.

Combining interoperability testing with conformance verification

An approach that is becoming increasingly popular combines the two methods of testing. Terminal equipment applications are tested end-to-end (E2E) using either manual or automated interoperability tests. Various reference points are verified for conformance.

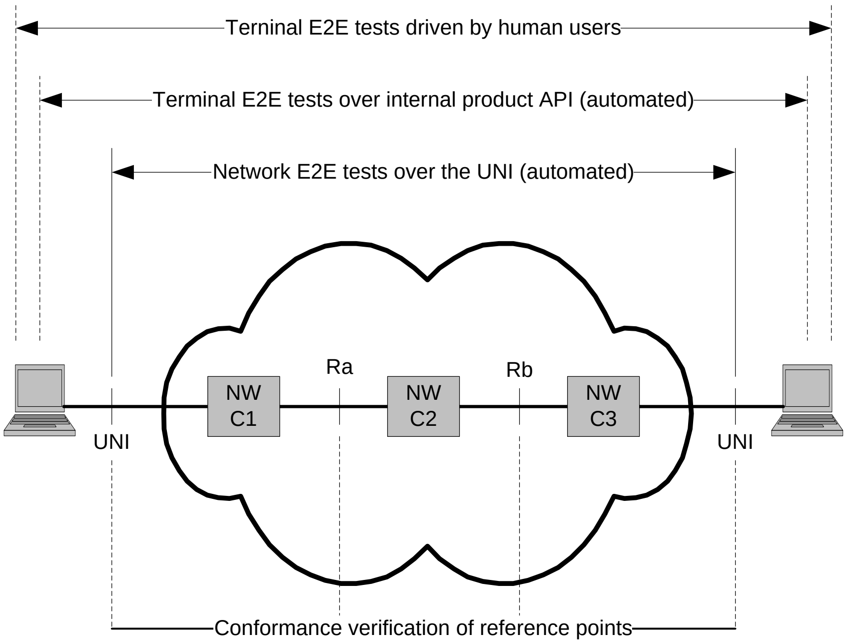


Figure 17: Interoperability testing with conformance verification

This is considered to be an economical solution to testing complex systems (networks). Critical components of the system (network) will have previously been conformance tested, but not necessarily all components. If the test verdicts are applied just at the endpoints then this is 'normal' interoperability testing. However, if verdicts are explicitly tied to the monitoring at the reference points then an additional level of conformance checking (verification) is added.

An example of this method applied to network interworking testing is illustrated in figure 18. In this case the end-to-end tests are performed manually, whilst the conformance verification is automated.

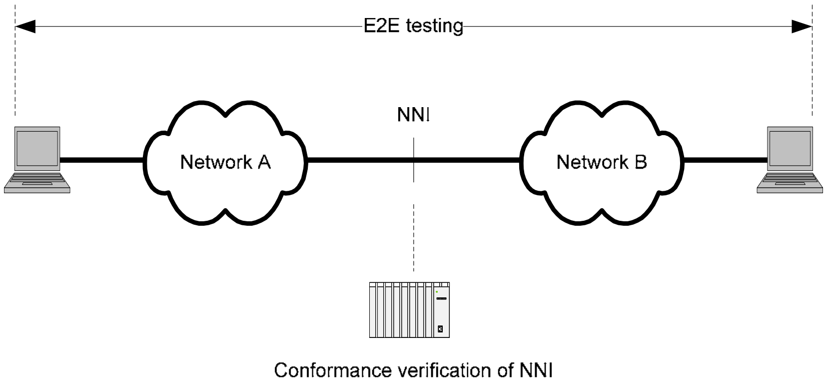


Figure 18: Network interworking testing

Developing test specifications

The ETSI membership puts a lot of effort and resources into the production of test specifications. These are generally developed by Specialist Task Forces under the direction and technical guidance of the CTI.

The large majority of tests are written in TTCN. Where possible the tests are validated, either in-house (as in the case of its IPv6 test specifications) or among the membership (e.g. GSM, UMTS). The level of validation will depend on resources and the availability of implementations to test against. Full validation can add up to 40% to the cost of the test specifications.

Certification

ETSI does not perform certification. However, many of our test specifications are used in external certification schemes such as GCF, the DECT Forum and the WiMax Forum.

7 Specific ETSI initiatives and support for interoperability

ETSI has a number of initiatives and support entities to enable the production of interoperable standards. These include:

- the appointment by the ETSI Board of a Champion for Interoperability;
- series of interoperability workshops;
- the well-established Technical Committee MTS;
- Testing services provide by our Centre for Testing and Interoperability; and
- ETSI Plugtests™.

7.1 Interoperability Champion

The ETSI Board has appointed an Interoperability Champion. This role includes chairing the ETSI ad hoc group on interoperability (IOP) in the ETSI Operational Co-ordination Group (OCG), which comprises the chairmen of the ETSI Technical Committees.

The IOP group's mission includes providing co-ordination for issues related to interoperability, in particular to serve as a steering group for the interoperability Specialist Task Forces of generic interest and to ensure alignment of the work of the CTI and the Plugtests events with the ongoing standards development work within ETSI. The group is also responsible for identifying relevant work outside ETSI, informing and stimulating appropriate activity in the ETSI Technical Committees, and ensuring effective liaison with the relevant external organizations.

Recommendations from this group are currently being integrated into ETSI's working practices and Secretariat tool support.

7.2 Workshops on interoperability

ICT markets have evolved considerably in the last decade and one of the most striking changes has been the increasing fragmentation of the ICT standards production market.

Despite this heterogeneity, the key concepts underlying standardization remain unaltered, i.e. a process to agree on open and interoperable specifications.

Today, the very meaning of those concepts, in particular the key issues of open standards and interoperability are being challenged. It would be very surprising indeed if this ever-increasing number of standards-setting initiatives retains a single definition of openness and interoperability.

In view of this, industry, standards bodies and policy-makers perceive a need to re-assess the meaning and implications of these issues.

Since May 2005 ETSI has held a series of conferences with a view to gathering global industrial companies, worldwide standardization practitioners and policy-makers, hearing their views on open standards and interoperability, and determining possible courses of action. These conferences have led to a number of practical steps being taken at ETSI that have included the creation of the OCG ad hoc group on IOP described above, the creation of an ETSI Board Interest Group on IMS testing and the production of this White Paper.

7.3 ETSI TC Methods for Testing and Specification

As standards and interoperability become crucial factors in market success, the way that standards are written becomes increasingly important. ETSI's aim is always to produce documents that are clear, easy to understand and easy to use. ETSI’s Technical Committee MTS provides the frameworks and methodologies necessary to enable the other ETSI Technical Committees and Working Groups to achieve this goal. MTS meetings are attended by experts from the major telecommunications companies of Europe. Most large international telecoms businesses operate their own competence centres or at least have dedicated staff responsible for testing and specification. These organizations make decisions about which specification languages to use, how to use them and how they are supported by various tools. They come to MTS meetings to ensure that ETSI develops complementary guidelines for the use of these languages within standards.

TC MTS has guides for the production of high-quality standards admirably summarised on-line in "Making Better Standards" at http://portal.etsi.org/mbs/

Also available in mini-CD format.

7.4 Testing Services

The ETSI testing services provided by the Centre for Testing and Interoperability are available to ETSI Technical Committees for the application of leading-edge specification, validation and testing techniques in ETSI deliverables. The task of the CTI is to help the ETSI membership produce the very best technical standards and test specifications possible. Working closely with TC MTS the CTI directly works together with the Technical Committee, Working Groups and individual experts on all aspects of standards engineering as described in this White Paper. A large part of the CTI work is to assist in the planning and development of conformance and interoperability test specifications. On a general note, the services provided include:

- test methodologies consulting, design and development;
- test specification consulting, design and development;
- planning for validation;
- interoperability events (Plugtests);
- operational interoperability programmes;
- interoperability services consulting;
- training in overall testing methodologies;

- specific TTCN-3 training;
- test tool engineering, frameworks and test solutions.

7.5 ETSI Plugtests™

ETSI Plugtests events cover a wide range of converging standards for telecommunications, Internet, broadcasting and multimedia.

Plugtests events are open to all types of companies, large or small, be they operators, vendors, designers, manufacturers, content providers or application providers. They do not have to be ETSI members. Standardization bodies, fora and interest groups may also attend.

Companies that participate in Plugtests events find that the events are effective in improving both the quality and features of their implementations, accelerating time to market thanks to early product debugging. The events provide a unique opportunity to meet partners and competitors, whilst the feedback from the events is extremely valuable to the standardization process.

In addition to the technical organization of an interoperability event (which typically includes such elements as customized test beds, test case set-up and test slot scheduling), the service deals with the overall event management, including website, online registration, hosting site negotiation, legal aspects, promotion and sponsorship. More information on Plugtests can be found at http://www.etsi.org/plugtests/calendar.htm

8 Some case studies

This section contains a few examples of the ETSI commitment in terms of funding and resourcing activities aimed at ensuring interoperable products.

8.1 Ensuring conformance and interoperability of 3GPP mobile terminals

Mobile terminals require global interoperability and roaming within 2G and 3G networks. Through practical experience 3GPP has decided that the most efficient and cost-effective way (indeed, the only *manageable* way) to reach this goal is to create a certification system for mobile terminals.

A certified mobile is tested to an agreed and continuously updated set of test cases. All test cases are developed, maintained and delivered by 3GPP and validated by a certification agreement group, such as GCF or the Personal Communication System Type Certification Review Board (PTCRB). The agreement group has the responsibility to ensure that each test case is performed on a range of commercially-available test equipment, providing compatibility between test facilities - whether in-house or third party.

The mobile test industry has chosen ETSI to develop and provide the continuously updated 3GPP test suites. 3GPP participants have committed themselves to this for the long term and maintain a budget of about 90 man-months per year for this task. Two thirds of the budget is provided through 3GPP funding, the remaining one third being provided by the individual 3GPP companies as a voluntary contribution, free-of-charge.

The funding supports a Specialist Task Force on a continuous basis. The STF is responsible for both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) technologies. To date, the task force has developed 12 test suites containing 600 test cases for FDD and another 400 for TDD. These test suites are maintained and delivered every three weeks and are deployed by GCF, PTCRB and the TD-SCDMA Industry Alliance (TDIA) for the mobile terminal certifications.

The ETSI/3GPP experience has been that this level of conformance testing guarantees interoperability of terminals over the air interface.

8.2 Testing for IPv6 Interoperability

Internet Protocol version 6 (IPv6) is the next generation Internet. It gives vastly increased address space and true end-to-end communication. It has improved security and mobility features and allows 'plug-and-play' connection to the network.

The complexity of implementing IPv6 technology and the relative openness of Internet Engineering Task Force (IETF) standards means that wide-ranging and effective testing of IPv6 products will be one of the key factors in ensuring the deployment, interoperability, security and reliability of the IPv6 infrastructure on which the success of e-Government, e-Business, e-Health, e-Learning and e-Procurement will eventually depend.

This ETSI TC MTS project (supported by the CTI), co-funded by ETSI, the European Commission (EC) and the European Free Trade Association (EFTA), is providing a publicly available test development framework as well as interoperability test packages for four key areas of IPv6: core protocol, security, mobility and transitioning (IPv4 to IPv6). The approach is based on flexibility and extensibility to facilitate testing of IPv6 products for interoperability in many contexts including development, procurement and certification schemes.

The project takes account of the needs of 3GPP and ETSI TISPAN, and is being carried out in close relationship with the “IPv6 Ready” testing and certification programme of the IPv6 Forum.

The project has a number of objectives. Fundamentally, it aims to produce publicly available (standardized) IPv6 interoperability test specifications and to reduce the cost of testing and test development through the standardization of an IPv6 test development framework and TTCN-3 library. In addition, it contributes to the implementation of the EC’s i2010 Action Plan, and seeks to strengthen the European influence in the IPv6 Ready certification program. Ultimately, the project endeavours to actively support and involve stakeholders in the standardization of IPv6 test specifications and the IPv6 certification process, and to contribute to the rollout of reliable and interoperable IPv6 network products.

8.3 HiperMAN/WiMAX test development and certification

WiMAX is a wireless broadband technology based on the IEEE 802.16 and ETSI HiperMAN open standards that combine cost-effective, interoperable equipment with advanced performance. To ensure that equipment conforms to the standards and is interoperable, the WiMAX Forum has established a certification programme that plays a central role in its efforts to promote the worldwide adoption of the technology.

Interoperability is the most immediate reason for a network operator or a subscriber to buy WiMAX Forum Certified equipment. However, certification brings additional advantages that extend well beyond interoperability and that create the basis for wide-scale adoption of the technology.

The WiMAX certification programme involves extensive protocol conformance testing, some interoperability testing and some radio testing. In addition the Forum is organizing a series of interoperability events (some organized by together with ETSI) where industry is working hard to detect and resolve interoperability problems.

The ETSI CTI (then PTCC) was chosen by ETSI’s TC BRAN and the WiMAX Forum to develop and validate the continuously maintained HiperMAN/WiMAX test suites.

9 Conclusions and future work

We have shown the importance that ETSI places on producing interoperable standards. The ETSI Standards Making Process and the concept of protocol engineering have served us well in the past, culminating in successful technologies such as GSM, UMTS, DECT and TETRA, to name but a few.

However, current ICT standardization is bringing its own unique issues of interoperability, well-demonstrated by the complexity and diversity of NGN. The challenge to ETSI is to continue to improve our Standards Making Processes without losing sight of the fact that we need to work in a practical, fast-moving environment, especially in the context of multi-SDO standardization. The ETSI membership is increasingly committed to providing resources and funding for interoperability and testing activities. Furthermore, the Institute will continue to ensure the availability of the very best, well-trained staff (across the whole Secretariat) to support the ETSI Technical Committees in the application of this process, at all levels.

Of particular interest in the immediate future will be interoperability issues of web services, middleware and complex configurations such as the IMS core network. We will look to utilize, and even enhance, the resources of the CTI services, especially in standardization related to Air Traffic Management, eCall, Radio Frequency Identification (RFID) and GRID.

10 Glossary

3GPP	Third Generation Partnership Project
ASN.1	Abstract Syntax Notation version 1
BRAN	(ETSI Technical Committee) Broadband Radio Access Networks
CSN	Concrete Syntax Notation
CTI	Centre for Testing and Interoperability
DECT	Digital Enhanced Cordless Telecommunications
EC	European Commission
EFTA	European Free Trade Association
ETSI	European Telecommunications Standards Institute
FCC	(ETSI) Fixed Competence Centre
FDD	Frequency Division Duplex
GCF	Global Certification Forum
GSM	Global System for Mobile Communication
HiperMAN	High Performance Radio Metropolitan Area Networks
HTML	Hypertext Markup Language
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IETF	Internet Engineering Task Force
IFS	Interoperable Functions Statement
IMS	IP Multimedia Subsystem
IOP	Interoperability
IOT	Interoperability Testing
IP (v4/v6)	Internet Protocol (version 4/ version 6)
ISO	International Organization for Standardization
MCC	(ETSI) Mobile Competence Centre
MSC	Message Sequence Chart
MTS	(ETSI Technical Committee) Methods for Testing and Specification
NGN	Next Generation Networks
OCG	(ETSI) Operational Co-ordination Group
PICS	Protocol Implementation Conformance Statement
PTCC	(ETSI) Protocol and Testing Competence Centre
PTCRB	Personal Communication System Type Certification Review Board
RCC	(ETSI) Radio Competence Centre
RFID	Radio Frequency Identification
SDL	Specification and Description Language
SIP	Session Initiation Protocol
SMP	(ETSI) Standards Making Process
STF	(ETSI) Specialist Task Force
TC	(ETSI) Technical Committee
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
TDD	Time Division Duplex
TDIA	TD-SCDMA Industry Alliance
TETRA	Terrestrial Trunked Radio
TISPAN	(ETSI Technical Committee) Telecommunications and Internet converged Services and Protocols for Advanced Networking
TTCN-3	Testing and Test Control Notation version 3
UML	Universal Modelling Language
UMTS	Universal Mobile Telecommunications System
XML	eXtended Mark up Language

11 References

[1] **ETSI EG 202 107** Planning for validation and testing in the standards-making process

[2] **ISO/IEC 9646** Conformance Testing Methodology and Framework, parts 1-7

[3] **ETSI TS 102 237** Generic approach to interoperability testing

[4] **ETSI TS 102 351** IPv6 Testing: Methodology and Framework

[5] **ETSI ES 201 873** Testing and Test Control Notation version 3, parts 1- 10