

# IEC 61850 Conformance Testing: Goals, Issues and Status

("IEC 61850 Conformance Testing: This One is Different"?)

Bruce Muschlitz

EnerNex Corporation

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## Abstract

The IEC 61850 communications standard promises to revolutionize substation automation with high-speed peer-to-peer messaging, object-oriented, structured data, and plug-and-play self-description. However, these benefits will not be realized if utilities cannot be sure that devices are compliant to the standard, or cannot issue bids without a simple means to specify the protocol.

The UCA International Users Group formed a testing committee to develop a suite of conformance test system documents which allow devices to be specified and tested against standardized tests. The testing laboratory at AEP's Dolan Test Lab has been validated by the Users Group to be permitted to issue Conformance Test Certificates. In fact, at least one protective relay has already been issued a certificate.

This first section of this paper discusses the key issues involved with creating a conformance test system based upon IEC standards. Those issues center upon:

- What are the expectations of the user and vendors?
- How to ensure privacy between testers and vendors while allowing users access to detailed test results?
- Do testers need to meet ISO 9000 before granting of qualifications?
- Will vendors be allowed to self-certify devices?
- How can you be certain that testers all use substantially similar methods?
- How much detail should be specified in the test (how much is "good enough")?
- What happens when interoperability problems are discovered between tested devices?

The second section of this paper discusses the present status of IEC 61850 testing. The conformance test centers, tested devices, and overall "lessons learned" are presented. One key aspect of the Conformance Test System was to make it relevant to the ultimate users. This means that the utilities need to see real value in specifying conformance tested products. Users expect that conformance tested devices will have no interoperability issues and are "plug-and-play". Unfortunately, real-world systems can never guarantee interoperability, they can only reduce the number of interoperability problems. Individual interoperability issues with real system will be discussed.

## Acronyms

<b>TCP/IP</b>	Transmission Control Protocol / Internet Protocol – basis for the Internet
<b>ISO</b>	International Standards Organization – publisher of international standards
<b>MMS</b>	Manufacturing Messaging Services – protocol supporting object-oriented data transfers that is the core of the client/server portion of IEC 61850.
<b>IED</b>	Intelligent Electronic Device – essentially any physical device which collects information and transmits it digitally.
<b>SCL</b>	System Configuration Language – XML-based mechanism for defining IED capabilities, IED configurations, and system-wide configurations.
<b>MICS</b>	Model Implementation Conformance Statement – a document specifying the data models implemented by a device
<b>SNTP</b>	Simple Network Time Protocol – an Internet-defined protocol for synchronizing the time within a device to that of a server.
<b>UCA IUG</b>	“UCA” International Users Group – a consortium of users, vendors, and consultants that provides support for the IEC 61850 standard
<b>XML</b>	Extensible Markup Language - popular file format for creating structured documents that are both human-readable and machine-readable.
<b>PICS</b>	Protocol Implementation Conformance Statement – a document specifying the capabilities and limitations of a device, usually based upon PICS template specified in a standard.
<b>GOOSE</b>	Generic Object-Oriented System Event – message system which allows broadcast of a subset of data within a device.
<b>QAP</b>	Quality Assurance Program – document specifying rules for testers, users, and vendors which allow the quality of the conformance test to increase.
<b>SMV</b>	Sampled Measured Value subsystem – portion of IEC 61850 allowing large quantities on raw data to be transmitted on a Local Area Network.

## Why is Testing IEC 61850 Different?

IEC 61850 is not “just another protocol”. It is a suite of protocols that, when used together, is radically different from other power industry protocols. Whereas most protocols strive to excel in one area or another, IEC 61850’s purpose is to excel in multiple areas simultaneously: reliability, flexibility of data access, configurability, speed, and ease of use. It attempts to do so by layering existing standards on top of one another.

The resulting complexity creates a standard that is very difficult to test for compliance. In particular, the features of layering, structured data, peer-to-peer messaging, data discovery, and LAN-based time synchronization create a challenge for the tester. The obstacles raised by each of these features are discussed separately in the sections that follow.

## ***Layering***

Layering and information hiding are important concepts to IEC 61850. Early discussions of the proposed standard centered upon the ability to obtain information from systems without the burden of actually identifying the device sourcing the data.

IEC 61850 partitions information in two ways: “vertically”, because the chores of communication are divided up according to the Open Systems Interconnect (OSI) model; and “horizontally” because different utility functions are scattered across the substation in “logical nodes” that may be implemented on different physical devices.

From a testing point of view, this firstly means that IEC 61850 is impossible to test without automated tools. While it was at least theoretically possible for a human being to “read” older serial protocols like DNP or Modbus from a hex dump of the message, IEC 61850 is opaque to human beings. This dependency means that the IEC 61850 conformance test system will need to address the issue of the reliability and accuracy of the software tools used for the testing.

Secondly, information hiding means that automated “data mining” tools are required to locate all of the information sources within a tested device. These tools need to review multiple directory and data definition sources including the server, logical device, logical node, and data object hierarchy levels.

## ***Structured Data***

Another key feature of IEC 61850 is the idea of structured data with human-readable names. For example, most IEDs will support an object named “A” (for Amperes) which contains several other objects within it (say, magnitude, phase angle, timestamp, description, and quality), some of which are optional and some of which may be extensions to the IEC 61850 standard.

Although IEC 61850 defines many standard data objects, it does not require that a device support all of those objects. It does, however, require that if a device supports a standardized function, it *must* be represented in a standardized way.

Additionally, IEC 61850 defines a standard mechanism, called “namespaces” that allows vendors to support additional objects alongside the pre-defined objects. Vendors may extend the standard provided that they visibly mark their extensions, and as long as their new data objects adhere to the IEC 61850 naming conventions.

This flexibility implies that testers need several new tools. Firstly, they need a mechanism to discover which optional objects are supported in a given IED. It must be able to determine whether an object or attribute is mandatory and evaluate it against the functionality the vendor claims to support.

Secondly, there must be a discovery mechanism for vendor-defined object supersets. It must be able to determine not only that an object is non-standard, but whether it nevertheless adheres to extension rules. The IEC 61850 namespace rules help with the former task, but not the latter.

## ***Peer-to-Peer, One-to-Many Messaging***

IEC 61850 supports two types of data transfers: one-to-one (client/server) and one-to-many (publish/subscribe). The one-to-one transfers use existing connection-oriented protocols and

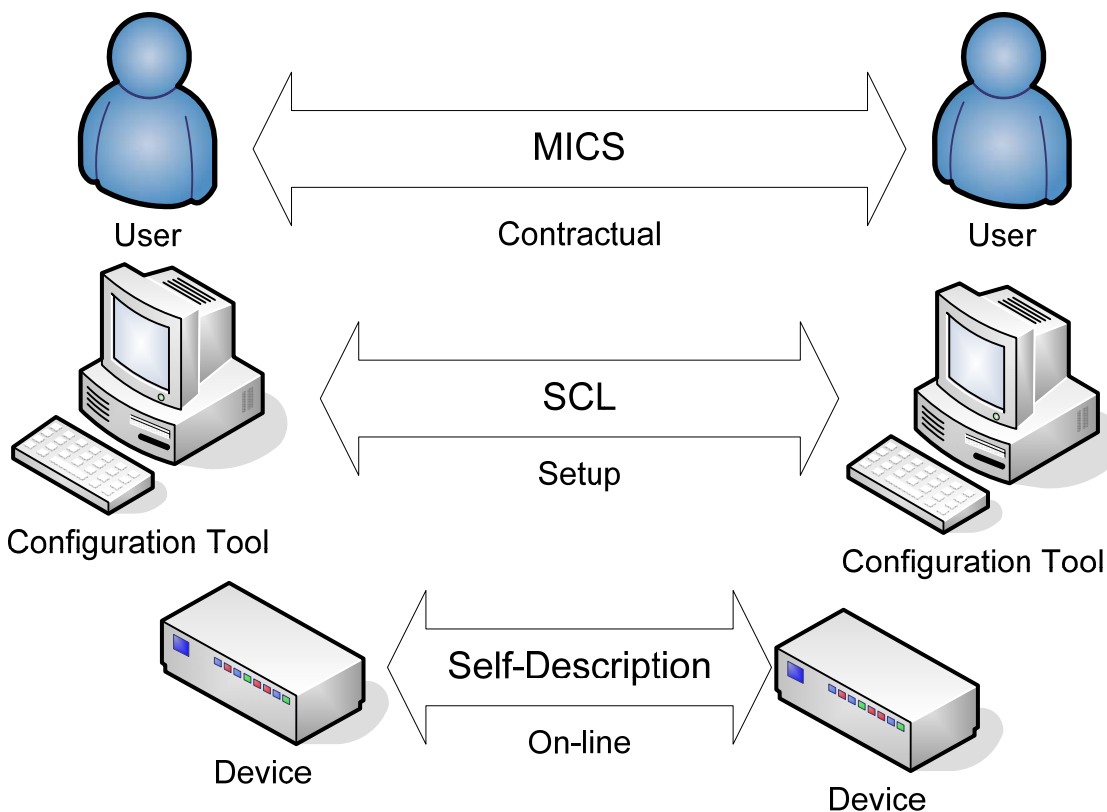
allow a one device to directly write or read information to/from another device. The one-to-many transfer model is new to IEC 61850 – it allows one device to “publish” information on a data bus without knowledge of which user (or users) may have “subscribed” to the transfer of that information.

While testing the one-to-one transfer is fairly simple (when the data arrives, simply measure the latency and check whether it’s what was asked for), the mechanism for doing this type of verification on one-to-many communications is fairly complicated. Vendors are given much freedom with the implementation details of one-to-many transfers, particularly with regard to the timing of re-transmissions.

From a user’s point of view, the mechanism must be at least as reliable as the one-to-one mechanism with minimal latencies under real-world conditions. The IEC 61850 specification helps in this area by defining “test” modes within the protocol, but good testing tools that take advantage of this capability are still missing.

### **Data Discovery**

IEC 61850 requires support for three parallel data discovery mechanism: Substation Configuration Language (SCL), Manufacturing Message Specification (MMS) self-description, and the Model Implementation Conformance Statement (MICS). These are illustrated in Figure 1 and discussed individually in the next several paragraphs.



**Figure 1** Data Discovery Methods

The IEC 61850 SCL is a “language-within-a-language”. It specifies a file format that permits devices to describe their capabilities and configurations to other devices. The conformance testing system uses this capability in two ways: IED object model discovery and test-specific device configuration.

However, SCL has features and limitations that complicate the testing process. Firstly, SCL does not specify all of the rules needed for compliance testing. For example, it does not identify whether an object is writeable or read-only. SCL also allows vendor-specific extensions to the SCL language. This flexibility complicates conformance testing since these extensions need to be validated. Another drawback is that the SCL definition, or schema, does not automatically enforce all the rules of SCL; some exist only as text in the specifications. These extra rules must be tested and enforced by a human being or the automated test system tools. Lastly, SCL is designed to be fairly efficient, permitting re-use of object and logical node definitions and reducing file sizes. However, many applications do not make use of this capability, producing large, unwieldy SCL files that place a further burden on the test system or tester.

At run-time, in the application layer, IEC 61850 provides a second entirely different mechanism for discovering what data a device can produce. An IEC 61850 client may request from the server a directory of object definitions. For IEC 61850 server devices, this parallel self-description mechanism needs to be tested against the SCL mechanism to determine whether they match. Vendors are permitted to use non-61850 data in their devices, but this type of data needs to be manually evaluated against the intent of the IEC 61850 standard. For IEC 61850 clients, the directory request messages must be tested for compliance with the standard.

Some issues to do with clients and self-description have not been addressed by the test system so far. Firstly, self-description can take considerable time and bandwidth. Do clients request the directory information at appropriate times and with reasonable levels of detail? Secondly, when a client gathers and makes use of self-description information, does it do so reliably, without making errors? The latter likely falls into the category of system testing or acceptance testing rather than compliance, but utilities should be aware of the issue.

The final method of data discovery, like SCL, is also a file. The IEC 61850 conformance test system requires that vendors provide a MICS, which specifies all of the specific data objects reported by the device. Where SCL is a technical document, the MICS is more of a contractual document. The document format for the MICS, however, has not yet been standardized. This means that the tester must (manually) encode all of MICS information into the test system so that they can be verified against both the SCL and the MMS directory mechanism.

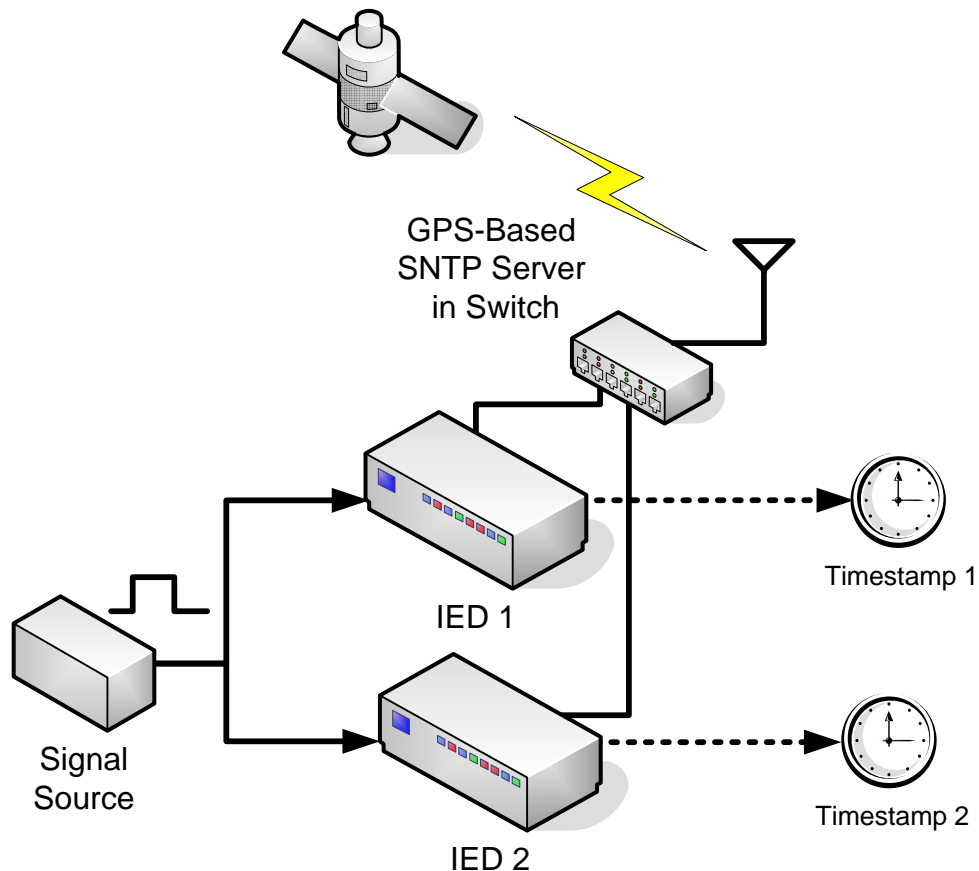
### ***Time Synchronization***

Another challenge of IEC 61850 is the time synchronization mechanism. The creators of the standard wisely chose an existing standard, the Simple Network Time Protocol (SNTP), rather than inventing a new protocol for the purpose.

However, SNTP does not define any accuracy requirements. It merely states that the client should use the “best” time source available. In contrast, IEC 61850 Part 5 defines the time synchronization accuracy required for various IEDs according to differing “classes” of time requirements. Some of these accuracy requirements stretch the limits of being able to determine the time itself in a device, much less being able to compare it against the time on another device.

Millisecond-level accuracy is relatively easy to verify, for instance, but sub-microsecond accuracies are very hard to confirm.

The best means of comparing time synchronization is to have two devices measure and timestamp the same electrical pulse after having their clocks synchronized, then compare the timestamps as shown in Figure 2.



**Figure 2 Time Synchronization Testing**

However, there are drawbacks with this method. Firstly, not all IEC 61850 devices have the necessary electrical inputs. Secondly, one is now measuring not just the synchronization mechanism, but also the signal measurement and timestamping mechanisms on the two devices. The method works best with two identical devices. Thirdly, if the time on the two devices was synchronized to a single server, one may be measuring *twice* the error in synchronization, not just the original error.

## **What are the Goals of IEC 61850 Conformance Testing?**

When designing the conformance testing system for IEC 61850, it was necessary to define the goals that the testing needed to accomplish. The real goal in conformance testing is to assure the user of a device that the device will meet the needs of the system. Hidden in this goal are the questions

- What are the users needs?
- What amount of testing detail will provide an adequate level of assurance?

These are both very difficult questions with no clear-cut answers.

### ***Why Test?***

One frequently asked question is “Why is conformance testing even necessary?” Users have become accustomed to vendor assurances that “the device works correctly” for many years. Utilities have contractual recourse if a device does not meet its manufacturers’ claims. What is so different about IEC 61850 that it requires a complex conformance test system? The answer to that is two-fold:

- **IEC 61850 is a new standard** with just a few manufacturers. When there are more alternatives available, the market will help ensure compliance. In the meantime, a testing program speeds up the market-building process by making compliance a testable feature and its results publicly visible.
- **IEC 61850 is very complex**, meaning that there are many things that can go wrong. The process of first detecting a problem, establishing its source, and ensuring a resolution is greatly speeded up when a formal testing and problem resolution process is in place.

The benefits of conformance testing include:

- **Assuring interoperability.** Successfully tested devices will have proven that they follow the most important IEC 61850 rules, which will help to eliminate costly disputes.
- **Providing bragging rights.** Vendors can proudly point out in marketing literature that they have a “stamp of approval”.
- **Reducing risk.** A utility may reject the purchase of untested devices because they represent too high a risk to the rest of their system
- **Ensuring reliability.** Vendors can use the results of conformance testing as part of their internal Quality Assurance Programs.
- **Encouraging credibility.** Use of the IEC 61850 standard is more likely to spread, thus reducing costs across the industry, if utilities have confidence that a pool of compliant devices is available.

### ***Goals of the Users’ Group***

The Utility Communications Architecture International Users’ Group (UCA IUG) formed a Testing Committee to review the collective needs of device users and device providers for Conformance testing. Part 10 of the IEC 61850 standard specifies the basic types of tests required to label a device “IEC 61850 conformant” but it leaves details of the tests open to interpretation. The Testing Committee’s mandate was to create a conformance test system compliant to all parts of IEC 61850 which would meet the needs of users.

The testing committee has created three major documents as the core of the test system:

- **The Accreditation Program.** This document specifies what conditions an organization must meet before it can claim to be a UCA IUG-recognized (accredited) IEC 61850 conformance tester.
- **Quality Assurance Procedures.** This document specifies the rules users and conformance testers must follow to ensure that interoperability issues discovered in real systems are prevented by improved wording in future versions of the specification.
- **Test Procedures.** This document contains detailed step-by-step rules for conducting conformance tests. These rules encode tests for not only normal operating conditions (positive tests) but also as many error conditions (negative tests) as possible. These test procedures reference the conformance testing specified in IEC 61850 Part 10.

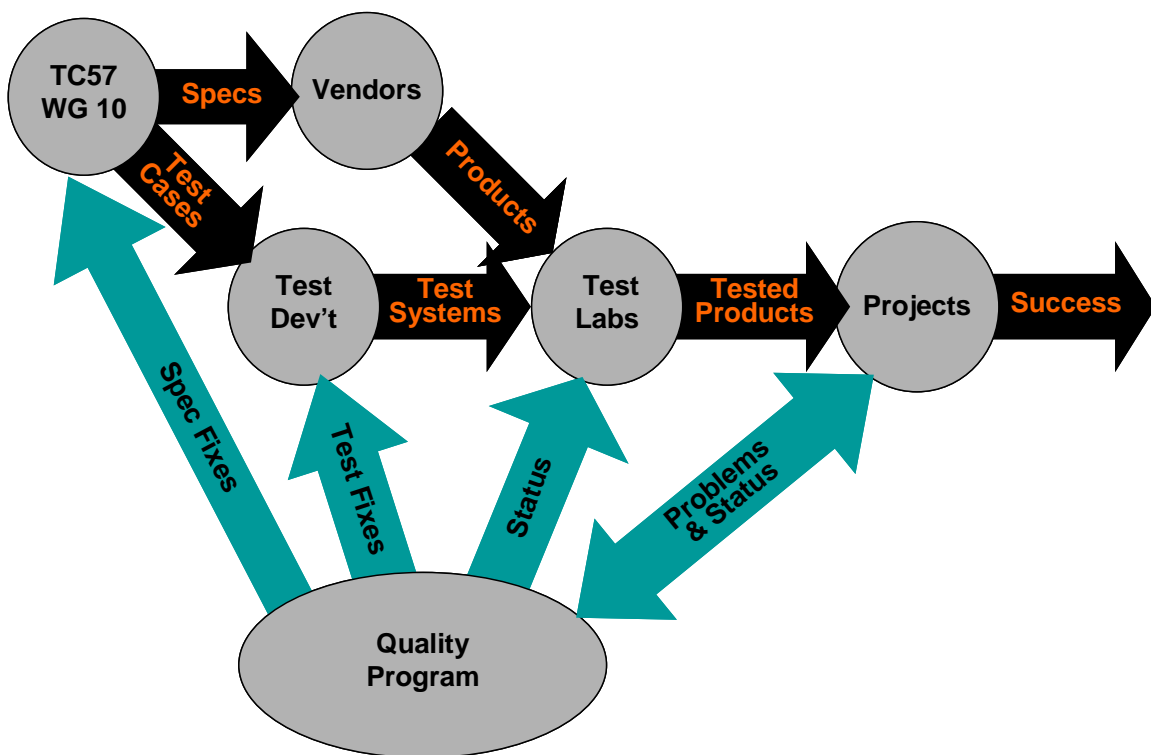


Figure 3 – The IEC 61850 Quality Program

As illustrated in Figure 3, these three documents form the core of an overall quality program for the IEC 61850 protocol suite. They essentially represent the goals the Users' Group wishes to achieve with the test system: to ensure users have access to qualified testers and a quality specification, and that the testers have adequate tools to do their job.

### Utilities' Goals

The utility user's expectations of a conformance test system can be summarized as "I expect everything to work, and I don't want to become an expert in IEC 61850".

Firstly, utilities want to specify interoperability, not spend hours doing it. The time has passed when utilities had the resources to keep an in-house staff of experts in all aspects of utility automation and data communications. These days, users expect that if they simply require devices to be certified, all devices will work together without embarrassing incompatibilities and finger-pointing among vendors. They assume that the users' group and the testing facilities have developed a test system which provides test coverage adequate to ensure consistent interoperability.

Utilities also expect that the test system will verify a minimal level of functionality. They expect that a certified system will be able to not just communicate, but do useful work. To discover that devices can talk together, but don't share a common subset of data or features, is an experience akin to the old saying, "the operation was a success, but the patient died".

Lastly, utilities expect that certification will ensure that future system extension can proceed smoothly without the need for further conformance tests. Backward compatibility is an issue that the UCA IUG will have to watch very closely.

To summarize, users of IEC 61850 already have enough to worry about, and expect conformance-tested devices to operate correctly in their system without intervention from them.

### ***Vendors' Goals***

Vendors invest in certification to ensure their products can be sold in a wider market, and therefore want a maximum return on the money invested. This goal has several implications.

Firstly, vendors need to be able to clearly understand what will be tested and what documentation will be needed. They need this information to estimate the cost of pre-testing and documentation. Realistically, test facilities must realize that vendors will provide the minimum documentation necessary needed to pass conformance testing. Therefore, the users' group must define the minimum documentation set very carefully. Vendors also need assurance that ongoing revisions to the test system are clearly explained so that there are no surprises after a test begins.

Secondly, testers will always be under time constraints. Vendors want testers to quickly complete the testing phase so that marketing material can be prepared with the "passed the test" notations, and sometimes so the vendor can get credit for milestones passed in a particular project. Vendors also want to minimize the cost of the tests, including both labor and any other costs such as tool or space rentals.

Thirdly, vendors have concerns when a hardware or software revision is required. Vendors recognize that upon issuance of a revision, devices may need to be conformance tested again. Two approaches to re-testing are available:

- Submit all changes to an external (third-party) conformance test for re-certification and accept the attendant costs.
- Execute in-house tests and declare self-certification on the assumption that users will accept this approach for "minor" device changes.

It is important that users accept self-certification for sufficiently minor changes. If utilities reject the possibility of self-certification, it is likely the amount of vendor innovation will be reduced because frequent re-certification would become prohibitively expensive.

In general then, the main goal of the vendor is to reduce the cost of certification. Test facilities therefore walk a careful line between the goals of the utility user and the goals of the vendor. Utilities want as thorough a test as possible, while vendors would prefer the absolute minimum. Fortunately, the two can agree, that the level of testing must ensure interoperability, because the process of resolving disputes and the resultant loss of time and money benefits neither party.

### ***What makes a complete test?***

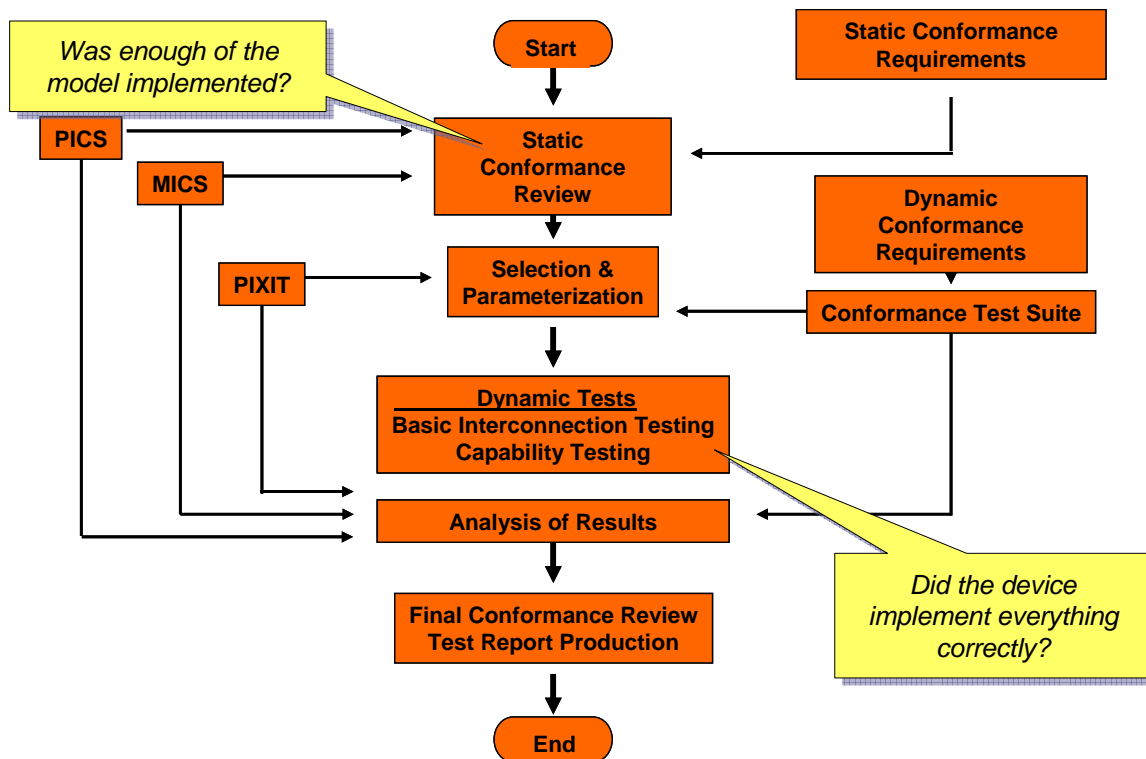
At one level, the answer to this question is simplistic. A test consists of connecting a simulated device to a real device and verifying that the real device behaves correctly. For example, a server is tested by applying stimuli from a simulated client.

However, a critical issue in defining a test suite is determining what level of detail a conformance test covers. There is always the temptation to include every possible test, but economic considerations must apply. For every test, there is a cost associated with it. This cost includes not only the actual cost of the device test, as discussed in the previous section. It also includes the cost of developing the specifications for that test and the cost of verifying that the test is correctly executed by each test facility.

The cost of qualifying test facilities cannot be discounted. Users and vendors alike expect that all test facilities will perform substantially identical tests on a particular tested device. If this assurance is lost, utilities would have the right to require multiple conformance tests for each device, just to ensure adequate test coverage. Clearly this would incur prohibitive expenses for all concerned.

With these factors in mind, the UCA IUG conformance tests are comprised of three steps, which are illustrated in Figure 4:

- **Documentation Inspection.** The first step is the inspection of the paperwork accompanying the conformance submittal. This documentation must include specific documents, including the MICS, PICS, and other specifications.
- **Static Testing.** The second step is verification that the documentation claims support for all mandatory features required by IEC 61850 and specified by the vendor-supplied documentation.
- **Dynamic Testing.** The third step is the actual stimulus-response probing of the device under test. This verifies that the device properly implements all the features claimed in its documentation. The probing includes both positive (valid message) tests and negative (invalid message) tests.



### Figure 4 The Conformance Testing Process

Some specific tests are excluded from the UCA IUG conformance test system at this time. Firstly, performance tests such as testing GOOSE messages for input-to-output latency are excluded because they are controversial and very expensive to execute. The problem with such performance tests is that it is very difficult to define a test process that will apply fairly to all possible hardware and software configurations. The performance goals defined in IEC 61850 Part 5 are somewhat vaguely defined and do not provide much help in this matter.

Secondly, substation-wide tests are excluded from UCA IUG testing because they require many-to-many testing. Aside from being very expensive, such system tests are necessarily very project-specific and fall under the category of acceptance testing rather than conformance testing. Some test facilities may choose to offer this service, but it should not be part of the UCA IUG system.

For similar reasons, there are no tests to confirm that a particular combination of implemented device features provides any useful functionality. Knowing this type of information would be very useful to utilities, but there are so many possible combinations and permutations, one could not design a generic test system to cover them all ahead of time.

Lastly, there are some categories of tests that have been excluded because the testing committee considered them lower priority and did not have the resources to include them in the first release. For instance the logging mechanism (journaling of data), GSSE (UCA2 legacy-mode one-to-many transfers), and SMV (exchange of raw data such as voltage samples between devices) have been left as future work items for the testing committee.

The question of what constitutes a valid and complete test, is therefore not as simple as it would seem at first. The UCA IUG has tried to be as fair in answering this question as possible.

## What Were the Key Issues in Developing a Test System?

In addition to the logistical problems of simply creating the tests, the UCA IUG encountered several issues while developing the test system that dealt with larger concerns. This part of the discussion describes a few of those issues.

### ***Privacy issues***

Although conformance testing in general is intended to be an open process, vendors need to be certain that information from the conformance tests is not exposed to potential competitors. The types of information deemed private include the specific capabilities of devices, their performance levels, and the occurrence of correctable test failures.

The issue of privacy arises, again, because of a difference in the goals of vendors and users. Utilities need to know as much information as possible, while vendors want to keep details away from competitors. To ensure this privacy, vendors may wish to withdraw features which fail conformance test without publicizing the test failures. They typically only want to report the conformance test results upon passage of the conformance test.

Generally, these concerns can be addressed through normal commercial channels between the vendor and the user. In order to control the privacy of the tests, vendors will require that some form of non-disclosure agreement exists with the tester. While the UCA IUG recognizes that the issue of privacy is important, they have chosen not to try to specify it.

### ***ISO 9000 tester compliance***

In order to guarantee the highest level of assurance that the conformance process is properly executed, the UCA IUG has determined that testers must have achieved ISO 9000 (or equivalently ISO 17025) certification in order to be considered a qualified test facility. The reason for this requirement is that ISO 9000 compliance allows for the UCA IUG quality procedures to become incorporated into the ISO 9000 process and therefore automatically become audited as part of the ISO 9000 process. The UCA IUG has minimal resources and could not perform auditing services itself. This measure ensures the quality of the test system without creating an additional huge auditing infrastructure.

The major issue concern with specifying ISO 9000 compliance is that there is a major cost to the vendors for that compliance. To alleviate this concern, the UCA IUG also allows a second level of tester certification which does not require ISO 9000 compliance. This is a compromise, because as noted previously, one of the goals of certification is to avoid complexity for the user of the system. Utilities will need to become educated about what this second level of certification means.

### ***Vendor self-certification***

Self-certification has become a hot topic in IEC 61850 conformance testing. It is controversial because of the conflicting goals of the parties involved. Vendors recognize that users need to know that each hardware or software revision functions correctly. Meeting this need would imply that full certification testing should be executed for each revision. Reality, however, shows that the fees for independent testing are much too high for vendors to incur on each and every revision. As a compromise, the testing committee has defined a level of vendor self-testing,

intended primarily for use on re-tests. Vendors plan to have major revisions tested by third-party tester but have minor revisions tested in-house.

Vendors assume that users will allow these minor revisions to be accepted without the third-party tests. The testing committee requires that *any* tests house, *including self-certifying entities*, certify that they follow all rules of ISO 9000 and agree to follow all of the testing committee rules. It is a private matter between the users and vendors whether these self-certificates will be acceptable proof of device conformance or whether independent testing will be required.

### ***Test facility equivalence***

Users of the test system require assurance that procedures followed by each test facility will be substantially identical. If users lose confidence in tester equivalence, then the users might determine that tester “A” executes tests “X” better than tester “B”, but tester “B” executes tests “Y” better than tester “A”. This could lead users to require tests from both testers in order to obtain adequate test coverage. This would be costly. More importantly, however, users may lose confidence in the test system or in IEC 61850 altogether. This could limit the spread of the protocol and all the benefits it could provide the industry.

The only way to avoid this scenario is to provide a method for each tester to prove that tests are executed in a substantially similar way. The test committee has done this by defining the three compliance documents and requiring assurance from the testers that they will follow the intent of these documents. The prime testers are also subject to periodic test committee audits, although as noted previously, the users’ group does not have many resources to perform such audits on a large scale.

Some test systems address the issue of equivalence by requiring the use of identical tools. Presently, the test committee purposely does not define tools which are required to be used for tests, but leaves the choice up to the test facilities. This has the advantage that innovation is allowed to proceed independently of the testing committee, but has the disadvantage that it becomes difficult to prove that similar test methods are in use.

Another major concern regarding test facility equivalence is that the vendor-supplied documents required for conformance testing have not yet been standardized. The two documents of concern are the PICS and MICS. Although the PICS document should be based upon templates in parts 7-2 and 8-1 of IEC 61850, most vendors only use part 7-2. Of more concern is the MICS document which specifies the object model within the device. Facilities currently only check that a MICS is supplied, and use it to determine what tests to perform. This object list needs to be compared with the other two object discovery mechanisms (MMS self-description and SCL) in order to ensure consistency. Without a standard for doing so, test facilities will need to check this consistency manually, if they do so at all.

### ***Testing Detail***

The testing committee has struggled with the determination of the amount of testing for each of the IEC 61850 features. This concern is largely driven by the expectations of the type of envisioned inter-operability issues which will be encountered.

For example, the exchange of GOOSE involves a number of timing, data dictionary, naming, and retransmission details. The committee has added many detailed tests of the timing and content of these messages.

Other portions of IEC 61850, such as object dictionary retrieval, have not received as much attention to the implementation details. The testing committee continues to examine the tradeoffs between testing time and test coverage.

Testers must be certain that the testing tools do not overly dictate the testing detail level. The intent of the test committee documents is that every tester implements exactly the same details of the test regardless of the level of test automation.

### ***Post-test interoperability resolution***

It is inevitable that interoperability problems will be discovered in devices which have been successfully conformance tested. These problems will normally be discovered by users, who have little interest in becoming experts at the interoperability issue. The resolution of these problems is part of the quality assurance program (QAP).

The QAP program allows a vendor or user to post resolution requests to the testing committee. If the resolution seems clear, the testing committee will issue an immediate ruling. If the resolution is less clear, then the question will be forwarded to the UCA IUG Technical Committee for resolution, which might then forward the request to the IEC WG10.

From the standpoint of the UCA IUG, the testing committee issues non-refutable rulings. However, in reality, the IEC WG10 has final ruling, since they control the base documents.

IEC 61850 is unique in defining this interoperability resolution process ahead of time. Other test systems have had to evolve a policy and process over a period of years.

## **Current Test System Status**

The UCA IUG test committee has only recently completed certification of the first test facility, KEMA (Netherlands). KEMA (Netherlands) performs testing at American Electric Power (AEP) Dolan test labs in Ohio, USA. KEMA uses a semi-automated test system which allows tests to run with little technician involvement but does not yet claim the ability to test all portions of part 10 of the standard.

### ***Test Facility Applications***

So far, there have not been many applications to become test facilities. The UCA IUG testing committee has received only one other certification testing request, from a European IED vendor to permit in-house self-certification.

Presumably, this vendor will use an independent test house for the first conformance test and execute self-certification for subsequent hardware or firmware revisions.

The testing committee expects a few other applications to be submitted, because several organizations have expressed interest. However, no other applicants have so far come forward.

## ***Lessons Learned***

The testing process is so new that the list of lessons learned is fairly small. However, one important issue is that testers have discovered that there are a huge number of IEC 61850 tests which can be run. It is imperative that the tests be automated in order to keep the test costs to a reasonable level.

It was expected that there would be post-test inter-operability issues which have arisen by the date of publication of this paper, but so far only one device (Siemens Siprotec 7SJ64 protective relay) has passed testing. Therefore there cannot yet, by definition, be any interoperability problems between tested products. Any future interoperability problems will be discussed during the presentation of this paper at Distributech 2006.

## ***Future Plans***

The UCA IUG testing committee plans to expand the scope of testing in the area of performance testing as outlined in IEC 61850 Part10. As noted earlier in this paper, performance testing is valuable but difficult to define. This work and processing new test facility applications will likely keep the testing committee very busy for the near future. The testing committee will also provide more specific guidance for the documents required prior to conformance testing.

## **Summary**

Any conformance testing system is a complex process. It must be careful to balance the goals of users against those of the vendors, which often conflict. Testing the IEC 61850 standard is even more complicated because it is significantly different from other standards. It specifies a wide range of system features and performance goals which far exceeds those of previous utility protocol efforts.

The UCA International Users' Group is taking comprehensive measures to address these issues. They have developed not just test procedures, but an overall quality process for the whole IEC 61850 standardization effort. By involving ISO 9000 procedures, they are bringing additional rigor to the process. The Users' Group is aided in its efforts by the history of the IEC 61850 standards effort, which has been one of widespread cooperation between disparate organizations.

Utilities and vendors can benefit from joining the Users' Group and becoming part of the process. Only through the involvement of a variety of organizations will IEC 61850 become a widespread success.