Verified and validated

ABB has its own system verification and vaildation center

STEPHAN GERSPACH, PETER WEBER – When the IEC 61850 standard was introduced, ABB not only implemented it in its product portfolio, but also established a system verification and validation center (SVC), to verify correct implementation. In this test center, each and every product, system component, application and tool is tested in a real-life system environment to demonstrate its specified functionality and performance. Complete systems are verified to ensure that they fully meet the requirements in terms of communication, integration, functionality, security and performance.

The purpose and scope of SVC is summarized in ➔ 1. The center does not only test individual devices, but also tests their integration into larger systems and furthermore provides support and understanding of the standard, leading to its improved integration and implementation.

Verification versus validation

The relative concepts of verification and validation are sometimes a cause of confusion.

Verification means:
- Is the product being built according to the original specification?
- Are the specified requirements being met?

Verification testing should thus be about the product's conformance to the original specification.

In SVC verification, all tests performed assure the product accords with the defined substation automation requirements. These requirements are defined and reviewed by a group of experts approximately once per year and have to be implemented in each ABB product.

Validation means:
- Is the right product being built?
- Is it meeting the operational need in the designated environment?

Tests performed as part of SVC validation focus on the behavior of the product in the specified system environment.

Both verification and validation are necessary throughout the product-development cycle ➔ 2.

UCAIug

The UCA[1] International Users Group (UCAIug) is a not-for-profit consortium of leading utilities and their supplier companies. UCAIug is dedicated to promoting the integration and interoperability of electric/gas/water utility systems through technology based on international standards. The group is an international organization and strongly supports open standards and the free exchange of information. One activity of UCAIug is the provision of a forum in which members coordinate their efforts in relation to the various technical committees. Although the group does not write standards as such, its activities affect the definition of standards as well as the implementation of testing and product certification programs. One focus has been on the "Communication Networks and Systems in Substations" section of IEC 61850.

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UCAIug complements the activities of international standards organizations. For example, UCAIug works closely with IEC. The convener of IEC TC57/WG10 (IEC 61850) is on several UCAIug committees and is an advisor to their board.

1 ABB's system verification and validation center (SVC)

All actions of the SVC are focused on the following targets:

- Ensure a common understanding for the system integration of products
- Ensure a common understanding for the engineering process.
- Aim at a consistent philosophy within ABB systems and products
- Identify and initiate the closing of gaps between system requirements and product features
- Improve the quality of the system solution in architecture, integration and performance
- Decrease demand for specialized expertise within a customer system project
- Build up integral know how in testing and system integration of third party products
- Reduce cost and execution time of customer projects

The SVC's purpose is to ensure the high quality of ABB's system automation system solutions and provide a platform for the exchange of experience between IEC 61850 experts within ABB.

The editor of the Testing Quality Assurance Program (QAP) was also the editor of Part 10, "Testing Requirements", of the IEC 61850 document. Furthermore, many members of TC57/WG10 are on UCAIug's Technical Subcommittee for the Resolution of 61850 Issues (Tissues). The group works closely with standards organizations to support technology transfer, resolution of issues and assists users in the testing and implementation of products. One major focus of UCAIug's charter is the Testing Quality Assurance Program (QAP).

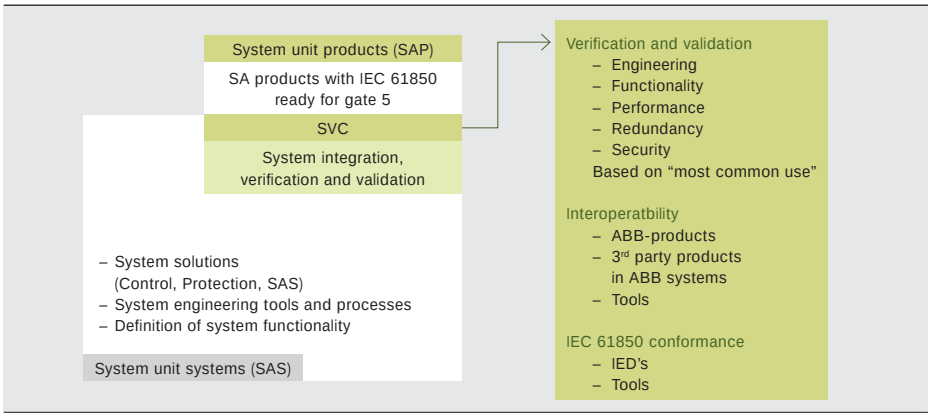
A recognized IEC 61850 conformance test center

UCAIug has qualified SVC as an IEC 61850 test facility and competence centre. SVC is thereby officially qualified to test and certify the IEC 61850 conformity of products and confer the users' group label to them.

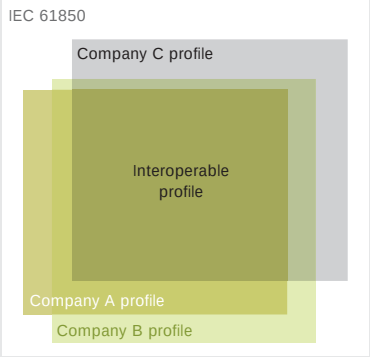
SVC is represented on UCA's IEC 61850 testing subcommittee. This strengthens the center's ability to support upcoming IEC 61850 test procedures and keeps it informed about UCA- and IEC-driven changes regarding IEC 61850 testing.

Footnotes
1 UCA: Utility Communications Architecture

2 Both verification and validation are part of the product-development cycle.



3 The fact that products conform to the standard does not guarantee interoperability.



Beyond conformance testing: system verification and validation

Once a product has passed conformance testing, it can be accepted for formal system verification and validation.

Interoperability

Interoperability testing is neither part of the scope of the standard nor is it tested by all UCAIug accredited test centers or in all procedures. However, the verification of conformance is a very important milestone.

An interoperability test looks at the dynamic interaction of at least two IEDs in a substation automation system covering (as far as possible) all potential configurations.

The fact that standard products from different suppliers or different products from the same supplier conform to the standard is in itself no guarantee for their interoperability. The reason for this is that communication profiles can differ.

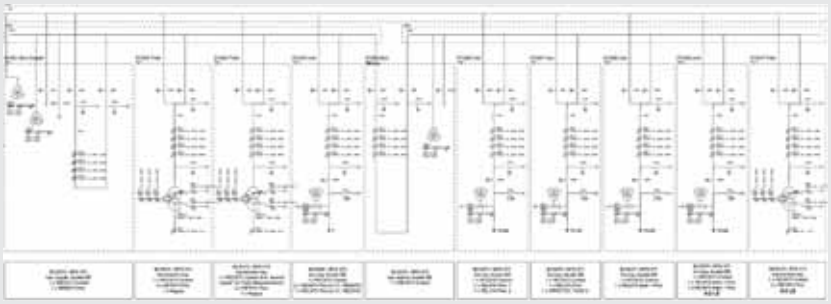
A communication profile defines the mandatory subset of a standard consisting of the selected options that are implemented. Thus various profiles from different products may conform to the standard but may still not be totally interoperable → 3.

It is the responsibility of the system integrator to check the interoperability of two or more products. The requirements for this are based on the conformance statements of the different products and the system functionality

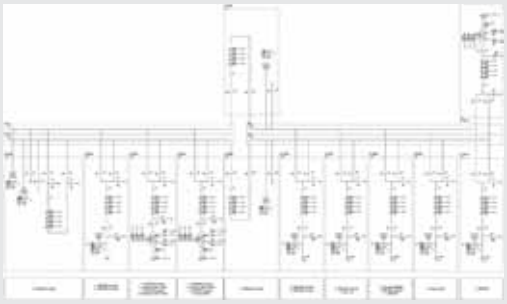
Various profiles from different products may conform to the standard but may still not be totally interoperable.

SVC system configuration – overview single lines

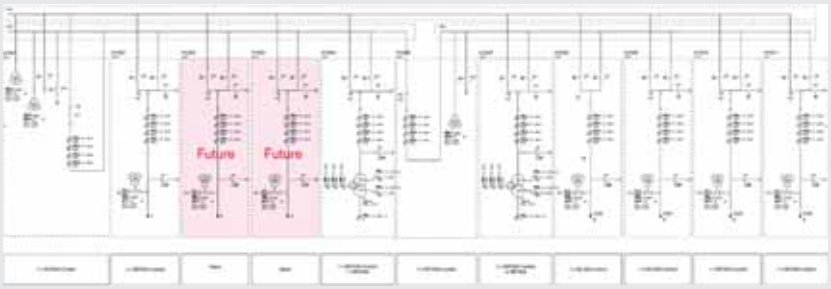
245 kV voltage level D1 transmission



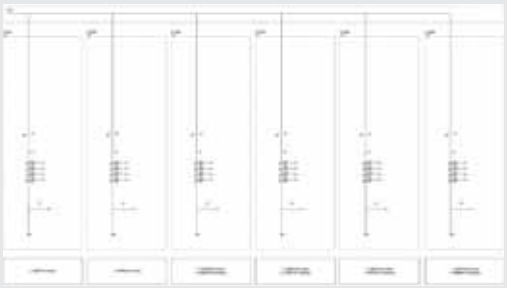
132 kV voltage level E1 sub transmission



33 kV voltage level H1 distribution



11 kV voltage level H1 distribution



All configurations are based on system unit solutions to ensure "most common use" of the IEDs/SAS

The goal of IEC 61850 is the interoperability of IEDs in SASs. The system test should therefore be part of R&D and conformance testing.

required. For example, one vendor might implement only GOOSE [2] and a second vendor might implement only GSSE [3]. Both devices would pass conformance tests but would not be able to interoperate.

An interoperability test looks at the dynamic interaction of at least two IEDs in a substation automation system (SAS) covering (as far as possible) all potential configurations. This is especially important for their interaction in executing distributed functions. Furthermore, it permits the verification of the performance of services provided by communication equipment such as switches (including delays caused). This test must be performed independently of specific projects as a kind of type test for the system. Such testing will reduce the risks for customer projects considerably. The interoperabillity of the different configuration and engineering tools (based on SCL and XML) is also imporant here. As a side effect, this testing also permits the system configuration tool and its interface with the product tools to be verified.

Test setup, SVC environment

The SVC installation represents all areas of ABB's system-automation activities from distribution to transmission applications (245 kV, 132 kV, 33 kV, 11 kV). All configurations are based on system-unit solutions to ensure "most common use" of the IEDs/SAS.

The primary process is completely simulated by process-simulation equipment. The related single-line diagrams are shown in ➔ 4.

From product to lifecycle testing of SA systems

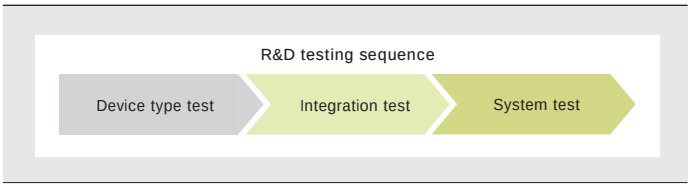
It is not possible to consider the lifecycle of any SAS without taking into account the lifecycles of all integrated products. The process of creating a substation automation system involves numerous tests, from the development and production of an individual IED to the completion of the system. Testing improves the quality and reduces costly risks both for the supplier and the users.

Footnotes

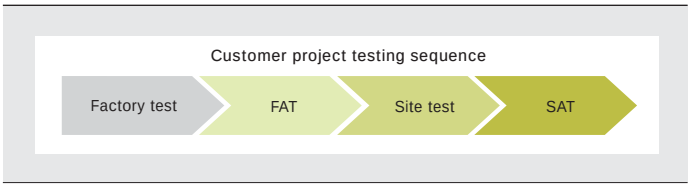
2 GOOSE: Generic Object Oriented Substation Event, A data-set format permitting the exchange of a wide range of possible common data.

3 GSSE: Generic Substation Status Event. In contrast to GOOSE this supports only a fixed data structure.

5 Testing sequence for product testing by R&D, performed independently of customer project



7 Testing sequence for customer project



6 Overview of R&D testing sequence

	Test related to	Pre-condition	Executed tests	Result
Device Type Test	Product	Specification and development of new functions … … based on an existing platform or … based on a new platform	Function and type tests are performed continuously by the R&D of the manufacturer The product with its functions is tested as stand-alone unit (“white box”) IEC 61850 conformance tests	Clearance for Integration Test
Integration test	Product	Device type tests are finalized successfully	Tests are performed in a small, well-defined and normally fixed IEC 61850 test system Test of IEC 61850 communications and verification of tools including commissioning and application engineering aspects Focus on the products and its interfaces to the rest of the system (“Black box”) IED configuration tool will be tested also regarding IEC 61850 aspects like generation and exchange of SCL Files	Clearance for System Test
System test	System	Integration tests are finalized successfully	– Verification of products with a clear focus on IEC 61850 system aspects – Tools and their interaction in the engineering process (exchange IEC 61850 SCL files) – Verification of the system under normal operation, avalanche and fault conditions (evaluation IEC 61850 system performance) – System-security testing.	Release for use in customer projects
Manufac-turing Test	Product	All tests up to system test finalized successfully	SW has dedicated manufacturing test	Product available for customer projects

The base for reliable in-house testing is the quality system of the manufacturer and supplier according to ISO 9001/9002 (as far as applicable). The life-cycle testing sequence can be divided into two parts:

– Testing independent of the customer-specific project, handled entirely by the R&D organization.
– Testing of configurations specific to the customer project, completely handled by the system supplier or system integrator in cooperation with the end-user.

Testing independent of the customer-specific project

The test sequence for the standalone product (which can be the device or the IED) starts with the device’s type test and ends with its integration test ➔ 5. The conformance test is the type test relating to standards such as IEC 61850. The successful passing of type tests is the prerequisite to begin integration testing. Integration testing involves testing the new product in a small and fixed test system. Type tests and integration tests are performed (as a minimum) by the product supplier and (if applicable and requested) by an independent test authority. Normally, the conformance of the IED is confirmed by the issuing of a certificate. In addition, routine tests or manufacturing tests performed in the production chain ensure a constant quality of delivered devices.

Several hundred IEDs can be simulated in the SVC, helping identify the limitations of SA Systems.

The goal of IEC 61850 is the interoperability of IEDs in SASs. Therefore, the sys-

8 Overview of testing sequence for customer project

	Test related to	Pre-condition	Executed tests	Result
Factory test	Customer project	All tests up to system test finalized successfully and products available for projects	Configuration of the full system Project assembled and pre-tested especially regarding project specific parts; parts not available in the factory are simulated on IEC 61850 network. Tests performed according to the agreed test plan.	The substation automation system is running as specified
Factory acceptance test (FAT)	Customer project	All factory tests are finalized successfully	System test witnessed by the customer	Clearance for shipping, commissioning and SAT
Site test	Customer project	FAT finalized successfully. All system components are installed.	Complete system goes into operation, fully functional including all connections to switchgear and remote systems and work places Last adaptations if needed	The complete substation automation system is running as specified
Site acceptance test (SAT)	Customer project	System commissioned on-site	Complete system will be witnessed by the customer.	System handed over to the customer, incl final SCD file!

tem test should also be part of the R&D testing sequence and conformance testing. However, as explained above, both the content of IEC 61850-10 and the detailed test procedures defined by the UCAIug only focus on IED (single product) testing. Today's conformance certificates are thus no guarantee for interoperability from a system perspective ➔ 6.

In summary: SVC takes care of that part of system testing not covered by the previous quality assurance steps.

Testing of configurations specific to customer-projects

The customer-project testing sequence ➔ 7 starts with the factory test. This is a project-related test that prepares the customized system for the factory acceptance test (FAT). Following the installation, site tests are carried out to prepare the system for the site acceptance test (SAT). The testing sequence for customer projects consists of project-related tests, based on the specification for the system ordered. Such tests are performed by the system supplier or system integrator and witnessed by the customer. These tests confirm that the delivered individual SAS is running as specified ➔ 8.

Successful operation of the test center

Following the planning and build-up phase, by mid 2005, SVC was ready for operation. In 2006, the center was qualified by the UCAIug for use as an IEC 61850 test facility and competence centre. SVC was the first manufacturer's test lab in the world to earn this level of qualification. It meets the high quality levels set out for common test procedures for all labs in accordance with IEC 61850-10 and the UCA Quality Assurance Program (Level A independent lab, Level B manufacturer's lab).

The SVC is an active member of UCA international users group and the IEC 61850 testing subcommittee. In 2007, SVC extended the test centre to fulfill new upcoming requirements. Besides the verification and validation of ABB products against IEC 61850-8-1, activities were extended to third party IED's, redundancy concepts, and IEC 61850-9-2.

Today the SVC test system comprises a considerable quantity of relays from ABB as well as from several other manufacturers. In addition, several hundred IEDs can be simulated, helping identify the limitations of SA Systems in terms of architecture, engineering processes, engineering tools, system functionality, system security and performance.

SVC helps ensure the high quality of ABB's IEC 61850 offerings through its verification and validation capabilities and provide a platform for the exchange of experience between IEC 61850 experts within ABB. SVC actively influences further IEC 61850 developments both within and outside ABB.

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