Final Report

2015 IEC 61850 IOP

September 27 – October 2, 2015

Brussels, Belgium

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1 Summary

This document provides information regarding the UCA sponsored IEC 61850 Interoperability test that occurred in Brussel, Belgium during the dates of September 27th - October 2nd 2015.

The target of that IOP was not only focused on demonstrating interoperability between devices that may have been demonstrated already in real projects, but also to focus on finding and addressing potential source of issues. To that end:

- The detailed result tables show test results for specific conditions and as such may not be applicable to user systems where interoperability may/may not still be achieved.
- Each participant was responsible to focus on achieving maximum test coverage with the numerous other vendors, to demonstrate specific combinations required by witnesses, or to tackle supposed source of issues to be even more interoperable future.
- Certified products and prototypes were part of the test. The test results provide an idea of the interoperability, but not necessarily an exhaustive overview of the possibilities on the market.
- Feedbacks and lessons learned from the IOP are expected to be improved in vendor tools and products in order to reach an even better interoperability in the next projects and IOPs.

There were 26 total participating companies in the interoperability testing.

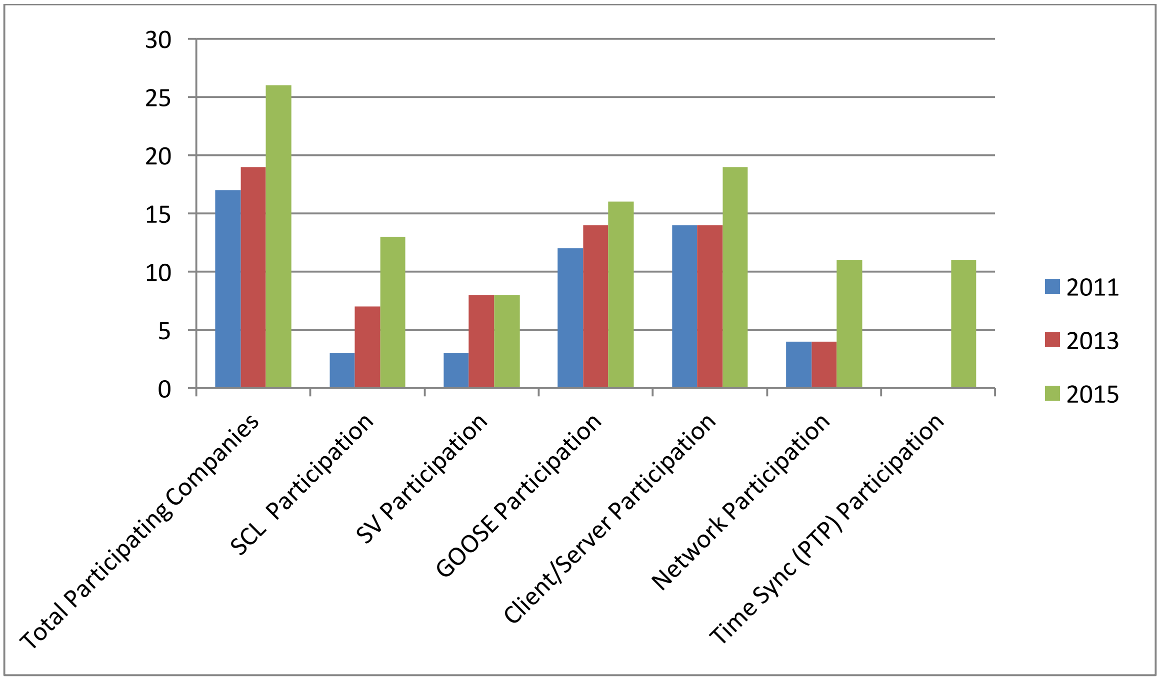


Figure 1: Comparison of Testing Participation

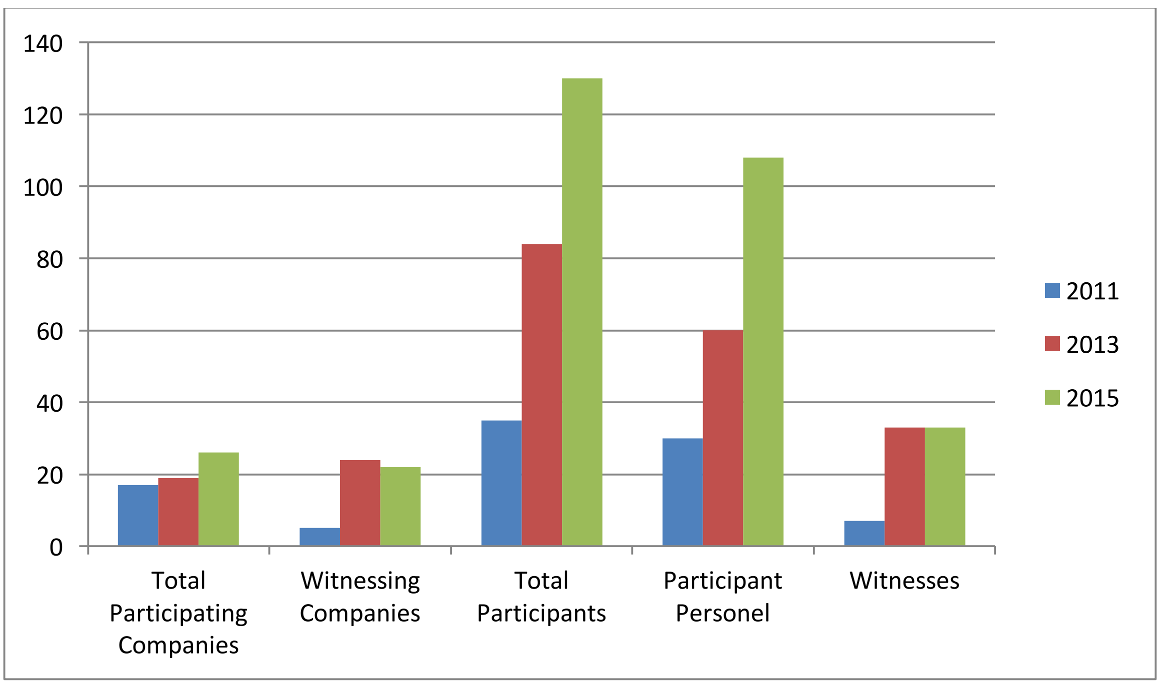


Figure 2: Participation increase in 2015

There were several 2015 participants that also participated in the 2011 and 2013 tests. These companies tended to be more prepared for the 2015 IOP as they had experienced more experience with the IOP. The 2015 participants are shown in following table indicating which IOP years they have actually participated in.

	Year of Participation		
Participant	2011	2013	2015
ABB		x	x
Alstom	x	x	x
ARC Informatique	x	x	x
CopaData			x
Doble			x
Efacec	x	x	x
General Electric	x	x	x
Helinks		x	x
Kalkitech			x
Koncar			x
Moxa			x
OMICRON		x	x
NovaTech			x
NR Electric			x
RTDS	x	x	x
RuggedCom (now Siemens)	x	x	x
Schneider Electric	x	x	x
Schweitzer Engineering Laboratories	x	x	x
Sertel Electronics			x
Siemens	x	x	x
Siemens/RuggedCom		X	x
SISCO	x	x	x
Subnet Solutions			x
Toshiba	x	x	x
Triangle Microworks	x	x	x
Vizimax			x
Xelas			x

Table 1: 2015 Participants and their participation in past IOPs

Each participating company had options to participate in the different test areas: SCL, Client/Server, GOOSE, Sampled Values, Time Synchronization, and Network testing. The following table shows the areas where the various participants have test results.

Participant	SCL	Client/ Server	GOOSE	SV	Time Sync	Networking
ABB	x				x	x
Alstom	x	x	x	x	x	x
ARC Informatique		x				
CopaData		x	x			
Doble			x	x	x	
Efacec	x	x	x			x
General Electric	x	x	x		x	x
Helinks	x					
Kalkitech	x	x				x
Koncar		x				
Moxa						x
OMICRON		x	x	x	x	x
NovaTech		x	x			
NR Electric	x	x	x	x	x	x
R.C. Bresler		x	x	x		
RTDS			x	x		
Schneider Electric	x	x	x			x
Schweitzer Engineering Laboratories	x	x	x	x	x	
Sertel Electronics					x	
Siemens	x				x	x
Siemens/RuggedCom					x	x
SISCO	x	x	x			
Subnet Solutions	x	x				
Toshiba	x	x	x			x
Triangle Microworks		x	x			
Vizimax				x	x	x
Xelas		x				

Table 2: Summary of Participants versus Test Areas

The following is a list of witnesses that participated in the 2015 IOP. The table also shows if the witnessing company has participated in other IOPs.

	Year of Participation		
Participant	2011	2013	2015
Centro de Investigação em Energia REN - STATE GRID			x
DNVGL		x	x
EDF	x	x	x
Elia		x	x
EMS/EMC		x	x

Entsoe		x	x
ENSO Test			x
EPRI		x	x
Entergy			x
FMTP Power AB			x
Hydro Quebec		x	x
It4Power		x	x
KERI		x	x
KTL		x	x
RED Electrica de Espana	x	x	x
RTE		x	x
Tesco Automation			x
Tuv Rheinland		x	x
Tuv Sud		x	x
UCA IUG	x	x	x
Zamerin		x	x

Table 3: 2015 Witnesses and their participation in past IOPs

As more IOPs occur, the ability to have the same companies/personnel participate allows building more core competency and more complex testing.

For any of the testing areas undertaken, there were a maximum number of test combinations. The maximum count does not include the combinations where a single vendor could test against its own products. However, in many situations for a particular test, the capability of the implementations does not allow for that combination to be tested.

Thus there is a difference in the maximum and the possible testing combinations. The percentage difference between the possible and maximum indicates the overall industry acceptance/capability for a given feature. The smaller the magnitude of the difference is, the more probably of the feature being supported by a client/server combination.

For each summary of testing there is a chart indicating the testing combinations. It shows the possible combinations and the difference.

Additionally, there is at least one test result chart that shows the number of tests possible, attempted, passed, and tests that were failures or had issues noted. The difference between possible and attempted gives an indication that there were resource constraints that prevented the possible number of tests from being executed. These constraints were typically hardware or participant personnel that prevented tests from being run in parallel.

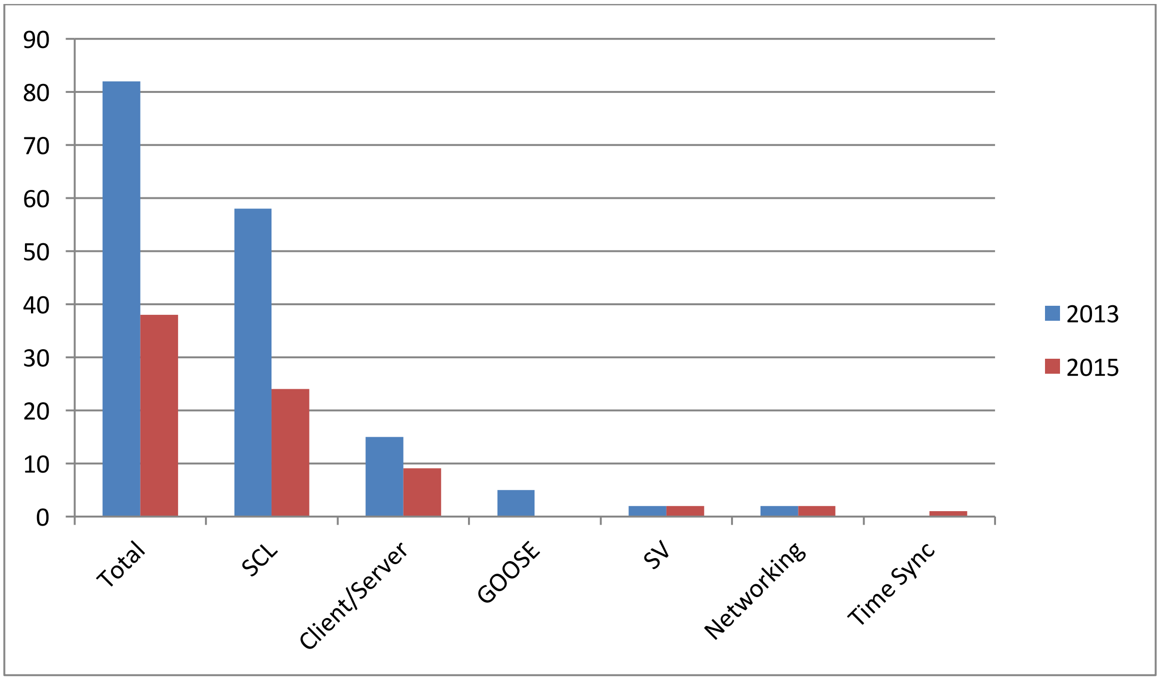


Figure 3: Categorization of Issues encountered

Table 4 shows the numeric information shown in Figure 3.

	Number of issues encountered	
Test Area	2013	2015
SCL	58	24
Client/Server	15	9
GOOSE	5	0
SV	2	2
Networking	2	2
Time Sync		1
Total Reported	82	38

Table 4: Tabular summary of issues reported

Figure 3 shows the number of logged issues versus testing area (e.g. SCL, Client/Server, etc.) versus the number of issues logged in 2013. However, a raw number comparison is not sufficient since several areas had more participating companies. Therefore, the ratio of issues/participating company may yield a better metric regarding the maturity of implementations.

A simple maturity index is:

1/ (<number of issues>/<participating companies>)

The calculated maturity indexes, as percentages, are show in Figure 4. The values for areas that had zero (0) issues have been set to a value of 120.

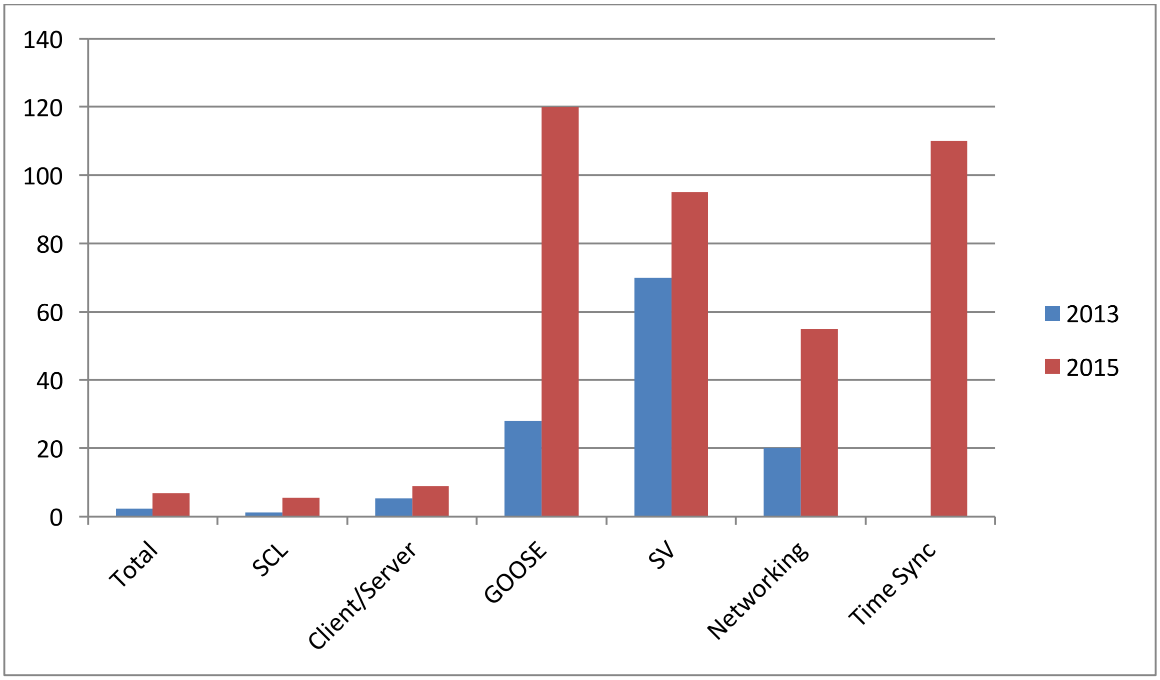


Figure 4: Maturity index to measure improvement

The percentage of improvement can be calculated and is shown in Table 5.

Maturity Index			
Category	2013	2015	Improvement (%)
Total	2.3	6.8	195
SCL	1.2	5.4	350
Client/Server	5.3	8.9	68
GOOSE	28	120	328
SV	70	95	36
Networking	20	55	175
Time Sync		110	

Table 5: Maturity index and improvement percentage

Table 5 shows improvement in maturity which is based upon the maturity of the IEC 61850 standards and vendor products. However, the numbers don't reflect the entire complexity. The improvement and preparedness was much better than the numbers reflect:

- SCL: This was the first IOP where several different types of exchanges were actually tested as well as the engineering of a combined Edition 1 and Edition 2 system.

- Client/Server testing had many more tests executed regarding Edition 1 and Edition 2 interoperability.

- GOOSE testing had many more tests executed regarding Edition 1 and Edition 2 interoperability.

- Sampled Value testing executed tests cases for IEC 61850-9 in addition to testing the UCA IUG 9-2 LE profile. This additional testing doubled the number of potential test cases that could be executed.

- Network testing was focused on PRP and HSR which are fairly new to the IEC 61850 standards whereas 2013 testing was focused on RSTP.

Several issues are worthwhile to mention in the summary section:

- There was one day of set-up allocated and then six (6) days of testing planned.

- Networks needed to be staged for 5 testing groups with independent networks for each group.

- UCA IOP 2015 network set up and maintenance was managed very well considering the unique size of the 2015 event.

- Reflecting that UCA IOP 2015 was the biggest IOP ever and related to growth of the UCA IOP since 2013 we have to take in consideration future wise to introduce a network setup over 2 days.

- Additionally dependent on test planning of each group, there will may be a necessity for major network reconfiguration and set up changes during to test plan schedule. The UCA IOP test group leads must calculate for the test plan schedule for each group certain timeslots where major network changes can be processed.

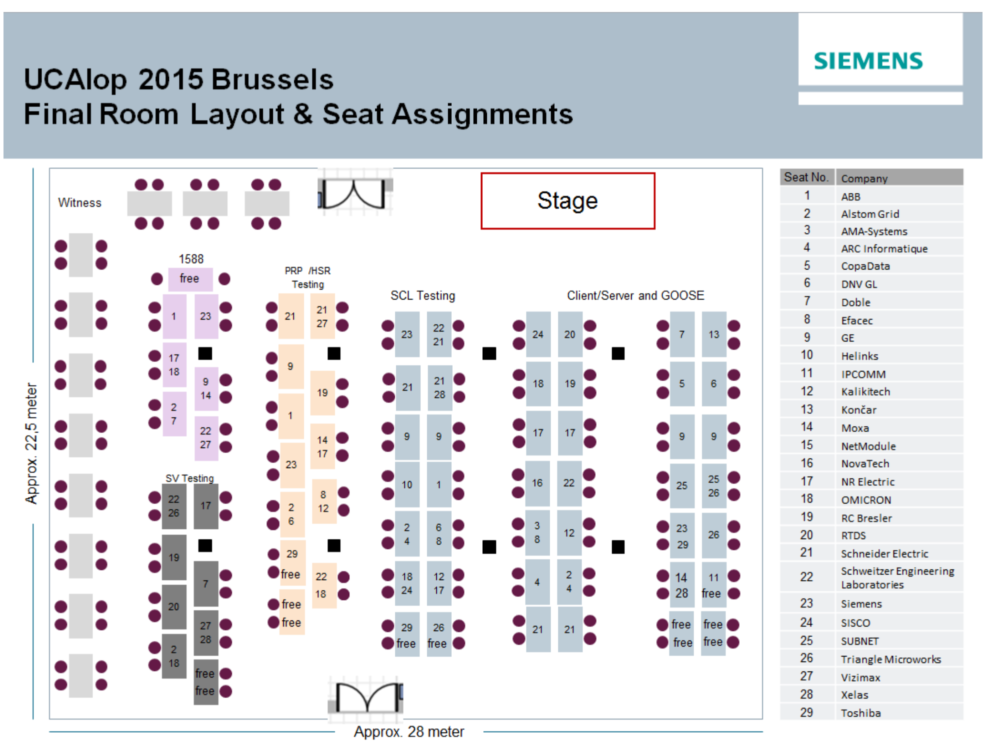


Figure 5: 2015 IOP Seating

Here is one example for only one testing group:

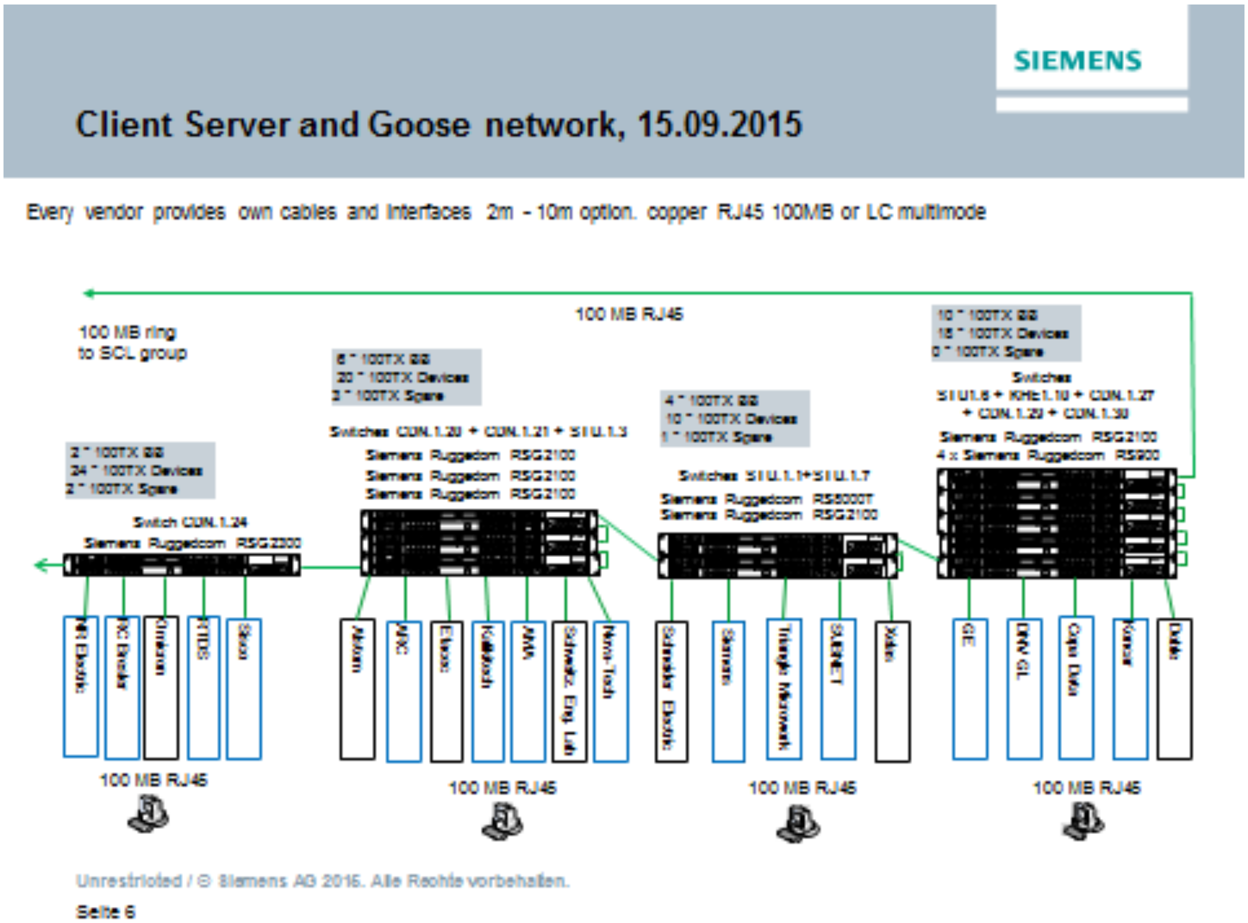


Figure 6: Example of network setup for Client/Server testing group

- Power: The hotel, initially, did not have enough power/distribution for participants. There were several power outages during the first day of testing. This decreased time that participants had in the GOOSE and Client/Server test areas. This point needs a clear communication from UCA to the hotel event management in terms of power requirement of the UCA IOP test room based on the power consumption plan. Additionally each participating company must bring sufficient power distribution cords and cables

- Although there were substantial commitments to the IOP, there was not enough equipment to allow execution of some multiple parallel tests. The future IOPs will either need to be longer, have more equipment, and/or scheduled days of testing.

The one day of set-up was not sufficient for the complex network set-up requested for the IOP, even though a single vendor was selected for the test network. The issue of network setup still persisted (e.g. reported from 2013 IOP). This decreased time that participants had in the GOOSE and Client/Server test areas.

- Although there were substantial commitments to the IOP, there was not enough equipment to allow execution of some multiple parallel tests. The future IOPs will either need to be longer, have more equipment, and/or scheduled days of testing.

1.1 Participating and Witnessing Companies

This section contains information regarding the participating and witnessing companies.

Figure 7: Picture of some of the participants and witnesses

The following table shows the participating companies.

Participating Companies		
Company	Logo	Contact Information
ABB	Power and productivity for a better world™ ABB	Roman Graf Global Product Manager IEC 61850 ABB Switzerland Ltd roman.graf@ch.abb.com www.abb.com
Alstom-Grid	ALSTOM	Dylan Jenkins dylan.jenkins@alstom.com

ARC Informatique		Fabien RIGAUD Marketing & Communication Manager f.rigaud@arcinfo.com www.pcvuesolutions.com
CopaData		Juergen Resch Industry Manager Energy JuergenR@copadata.com
Doble		Jun Verzosa JVerzosa@doble.com
EFACEC		Claudio Silva claudio.silva@efacec.com
GE		Alberto Huidobro Alberto.Huidobro@ge.com
Helinks		Joerg Reuter jr@helinks.com
Kalkitech		Vinoo Warrier vinoo@kalkitech.in
Koncar		Stjepan Sučić Stjepan.sucic@koncar-ket.hr
Moxa		Eleanor Huang Eleanor.Huang@moxa.com
OMICRON		Fred Steinhauser fred.steinhauser@OMICRON.at
NovaTech		Bryan Gehringer bryan.gehringer@novatechweb.com www.NovaTechWeb.com
NR Electric		Elvin Liu liux@nrec.com

R.C. Bresler		Nikolaev Ivan nikolaev_in@ic-bresler.ru
RTDS		Dean Quellette dean@rtds.com
Siemens		Cédric Harispuru Product Manager IEC 61850 cedric.harispuru@siemens.com www.siemens.com
Siemens-RuggedCom		Gerhard Wieserner gerhard.wieserner@siemens.com Amin Abdul amin.abdul@siemens.com Reinhard Besemer reinhard.besemer@siemens.com
Schneider Electric		Mario Jardim Marketing Manager mario.jardim@schneider-electric.com www.schneider-electric.com
Schweitzer		Tim Tibbals tim_tibbals@selinc.com
Sertel Electronics		Srinath Gopalan srinath.g@sertel.co.uk
Siemens		Cedric Harispuru cedric.harispuru@siemens.com
SISCO		Ralph Mackiewicz VP Business Development ralph@sisconet.com www.sisconet.com

Subnet Solutions		Mark Roberts mark.roberts@subnet.com
Toshiba		Koichi Hamamatsu Chief Specialist (Substation Automation System) koichi.hamamatsu@toshiba.co.jp www.toshiba-tds.com
Triangle Microworks		Jim Coats jcoats@TriangleMicroWorks.com
Vizimax		Marc Lacroix mlacroix@vizimax.com Jean-Sébastien Gagnon jsgagnon@vizimax.com
Xelas		Anton van der Burgt aburgt@xelas.com

Table 6: List of Participating Companies

The following table shows the witnessing companies.

Witnessing Companies		
Company	Logo	Contact Information
Centro de Investigação em Energia REN - STATE GRID		Nuno Silva: laura.eusebio@rdnester.com
DNVGL	The linked image cannot be displayed. The file may have been moved, renamed, or deleted. Verify that the link points to the correct file and location.	Bas Mulder: bas.mulder@dnvgl.com Richard Schimmel: Richard.Schimmel@dnvgl.com Niels Heijker: Niels.Heijker@dnvgl.com Gerard Akse: Gerard.Akse@dnvgl.com

EDF	Thierry Coste: thierry.coste@edf.fr Maxime Gillaux: maxime.gillaux@edf.fr Aurélie Dehouck-neveu: aurelie.dehouck-neveu@edf.fr
Elia	Grégory Huon: Gregory.Huon@elia-engineering.com Diederik Moers: diederik.moers@elia.be
EMS/EMC	Vladan Cvejić: vladan.cvejic@ems.rs Chief of Substation Control systems Substation automation Dpt vladan.cvejic@ems.rs www.ems.rs
Entsoe	Grégory Huon Gregory.Huon@elia-engineering.com
ENSO Test	Erik San Telmo: erik.santelmo@ensotest.com
EPRI	Paul Myrda Technical Executive pmyrda@epri.com www.epri.com
Entergy	Chan Wong: cwong@entergy.com
FMTP Power AB	Romain Douib: douib@fmtppower.com
Hydro-Québec	Eric Loiselle: loiselle.eric.2@hydro.qc.ca James Crook: Crook.james@hydro.qc.ca
It4Power	Christoph Brunner christoph.brunner@it4power.com

KERI		Woohyun Seo whseo@keri.re.kr
KETOP		Ran Zhang: zhangran@ketop.cn Chun He: hechun@ketop.cn Yin Qingwei: yinqingwei@ketop.cn
KTL		Ah Han: ahhan@ktl.re.kr
Red Electria		Carlos Rodrigues calrodriguez@ree.es
RTE		Patrick Hullier: patrick.lhuillier@RTE-FRANCE.COM Bastien Ilas: bastien.ilas@rte-france.com
Tesco Automation		Dustin Tessier: dtessier@tesco-group.co
TUEV Rheinland		Dirk Reufsteck: dirk.reufsteck@de.tuv.com
Tuv Sud		Peter Pfisterer: Peter.Pfisterer@tuev-sued.de
UCA IUG		Kay Clinard: kay@ucaiug.org Herbert Falk: herb@sisconet.com Bruce Muschlitz: Bruce.Muschlitz@novatechweb.co
Zamiren		Andre Maizener anjen.maizener@wanadoo.fr Daniel Griffel: daniel.griffel@zamiren.fr

Table 7: List of Witnessing Companies

1.2 SCL Testing Summary

The philosophy in 2015 was to not only validate the SCL file exchanges, but also the holistic approach with the IED communication (GOOSE and Client/server) based on the generated SCL files. The two (2) prevalent system engineering strategies, so-called top-down and bottom-up, both were tested. Additionally, the 2015 IOP was designed to test standard agreements regarding:

- Engineering, configuration, and co-existence of Edition 2 and Edition 1 tooling and devices.

  There are incompatibilities between IEC 61850-6 ED.1 and IEC 61850-6 ED.2. These incompatibilities represented a barrier for systems migrating towards or integrating with newer devices and tooling. IEC TC57 WG10 developed a set of recommendations regarding the engineering process to support both Edition 1 and Edition 2 engineering within an integrated system. The developed workflow is shown in Figure 8.

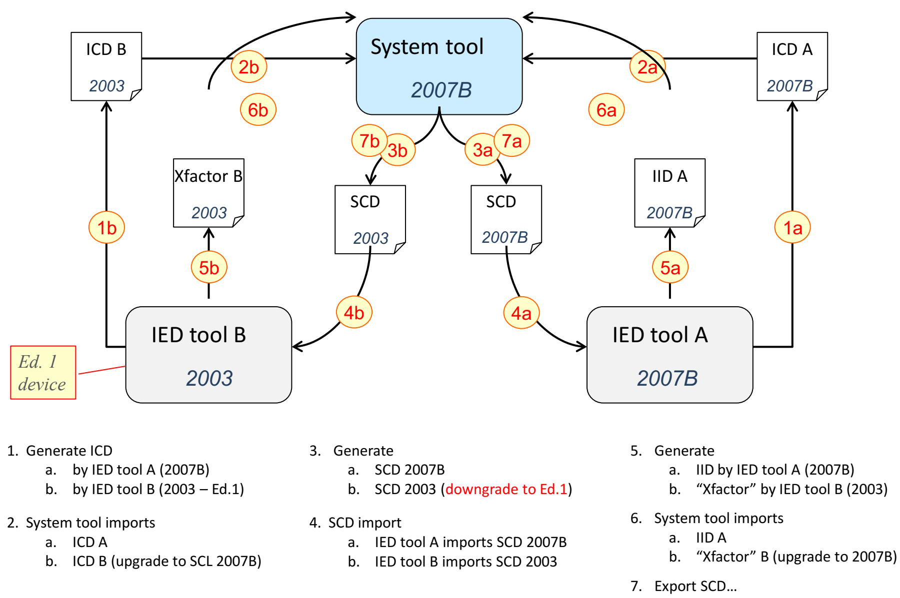


Figure 8: Engineering workflow for ED.1 and ED.2 integrated systems

  During the testing of this workflow, it proved successful and is currently being written into the IEC 61850-6 ED2.1.

- Agreements regarding subscriptions and reservations for Report Control Blocks, GOOSE subscriptions, and Sample Value subscriptions.

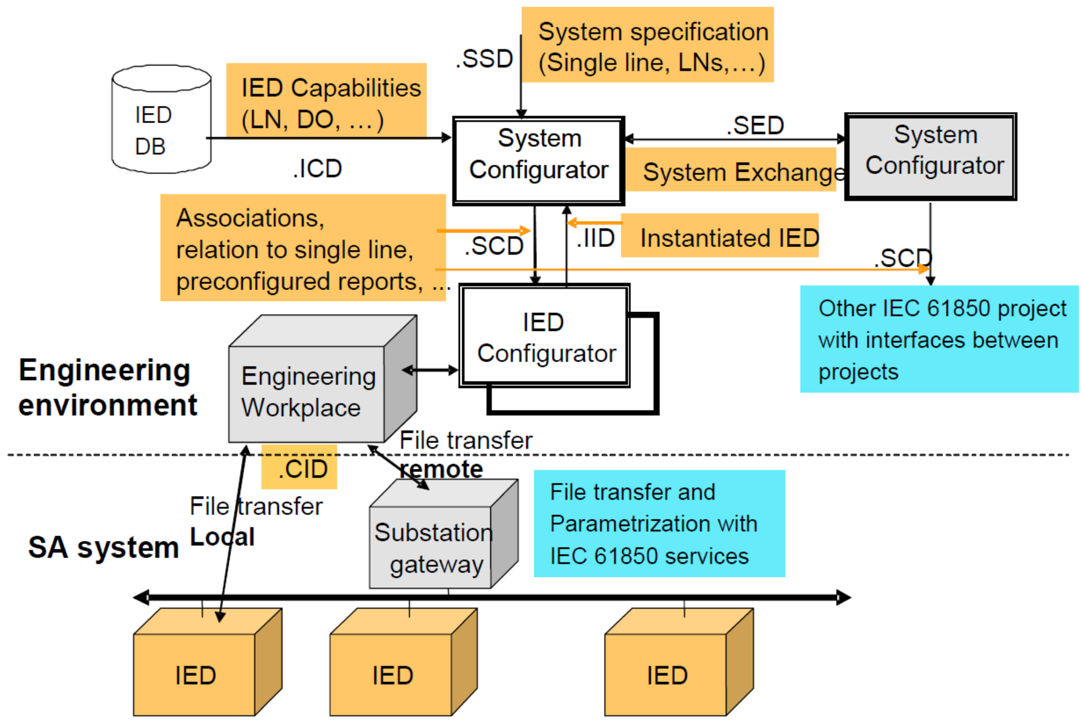


Figure 9: Reference model for information flow in the configuration process (from IEC 61850-6)

The Top-Down philosophy is the one that is documented in IEC 61850-6. This integration strategy starts with the creation of a Single Line Diagram (SLD). In addition to the SLD, system specifications are created, some of which specify what communication functionality is required. The SLD and specifications are then translated into an SCL System Specification File (SSD). The SSD is augmented, through imports or IED Capability Description (ICD) SCL files for individual IEDs. The System Configurator is then used to associate/instantiate Logical Nodes, control blocks, data sets, and subscriptions. The System Configurator outputs the System Configuration Description (SCD) file. This file is then imported by an IED Configurator. The IED Configurator can make minor changes to the IED related contents of the SCD and can then export the revised information as an Instantiated IED Description (IID) file. Additionally, the IED configuration is logically exported as a Configured IED Description (CID) file. The overall process starts with requirements and flows down through the engineering process and ends up configuring an IED. Thus the name of Top-Down was assigned.

Integration strategies exist which don't follow the top down approach. These strategies typically start with configuring an IED. The IED configuration information is provided to the System Configurator through the use of either IID or CID files. Since the IED Configuration is being used to initially configure the System Configurator, this strategy was named Bottom-up.

It is worthwhile to note that in Edition 2 of IEC 61850-6 only IID files are specified for the exchange from the IED Configurator to System Configurator. However, in Edition 1, it was the CID that was used for this exchange, but these conflicts with the definition of its use in Edition 2. However, to allow integration of Edition 1 devices into Edition 2 SCL files, this exchange is needed.

There were 24 issues reported regarding SCL. Several were misunderstandings, some required clarifications, some required Technical Issues (TISSUES) to be entered and resolved. In some cases, even though there was a misunderstanding, it was decided that the standard needs some amount of clarification. For these issues, the issues are included in both categories. At this time, most of the reported problems have been closed, but there are a few still remaining that need to be addressed by IEC TC57 WG10.

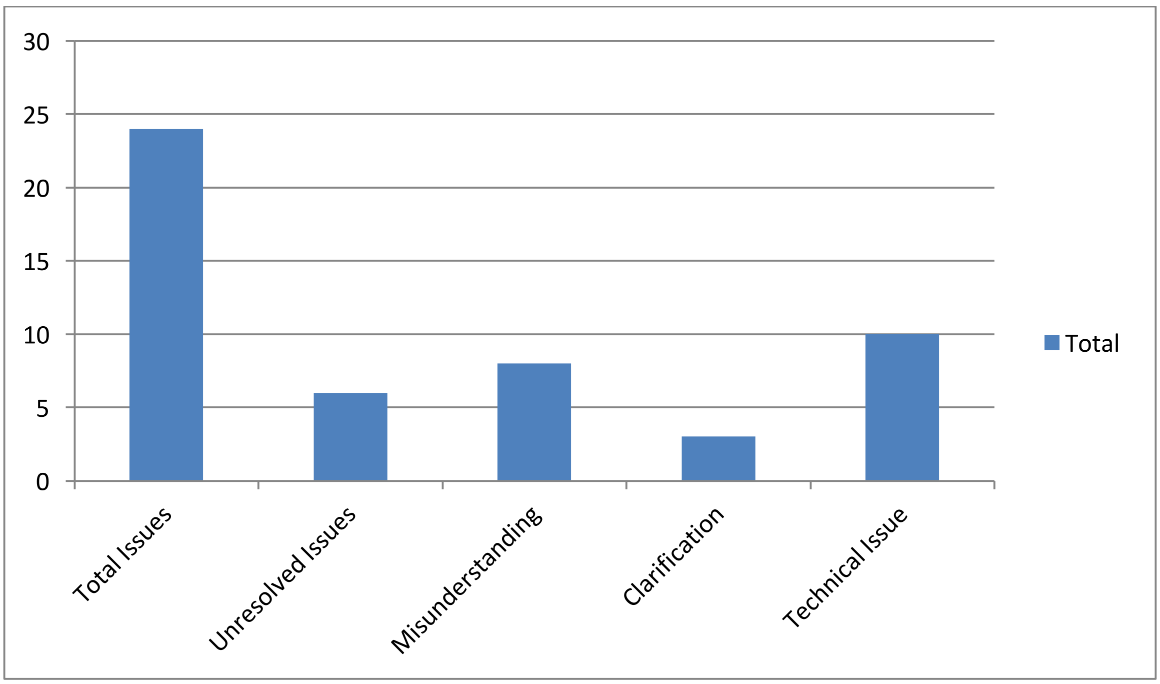
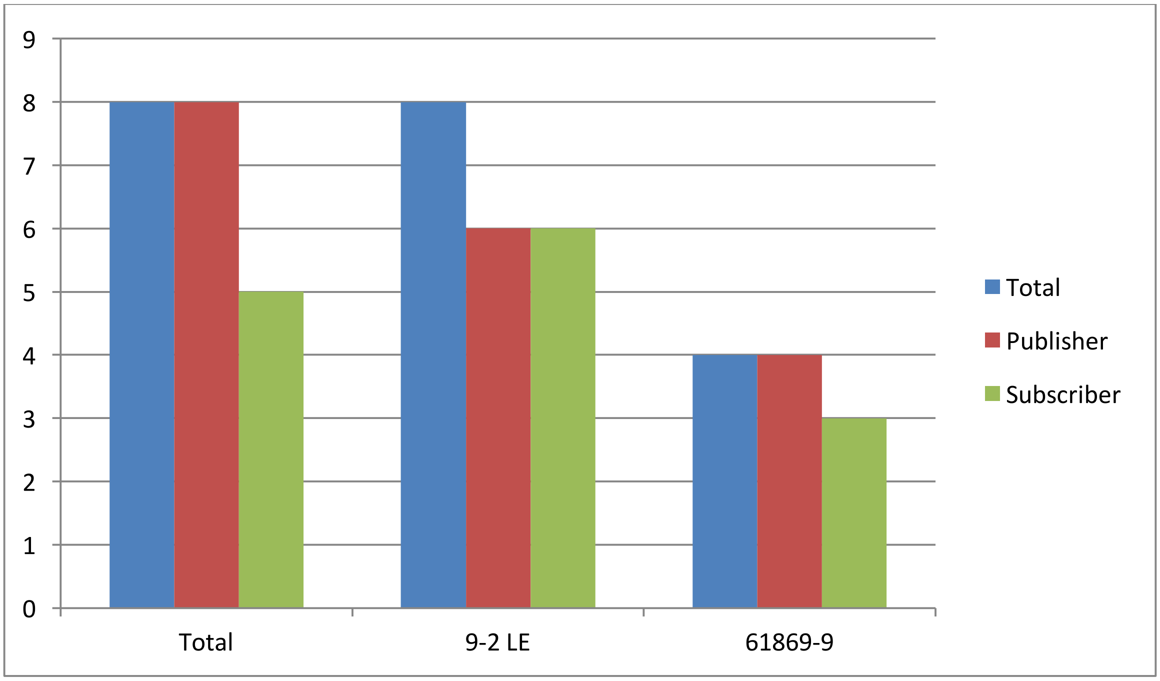


Figure 10: Distribution of SCL issues reported

1.3 Sampled Values Testing Summary

Sampled Value testing had two test campaign areas: UCA IUG 9-2LE and 61869-9. Of the eight (8) participating companies, seven (7) participated as publishers and six participated as subscribers. The participation was further divided by test campaigns.



There were 2 issues reported regarding Sampled Values. One (1) was a misunderstanding, one (1) required clarification, none required Technical Issues (TISSUES) to be entered and resolved. In some cases, even though there was a misunderstanding, it was decided that the standard needs some amount of clarification. For these issues, the issues are included in both categories. At this time, all of the reported problems have been closed, but there are a few still remaining that need to be addressed by IEC TC57 WG10.

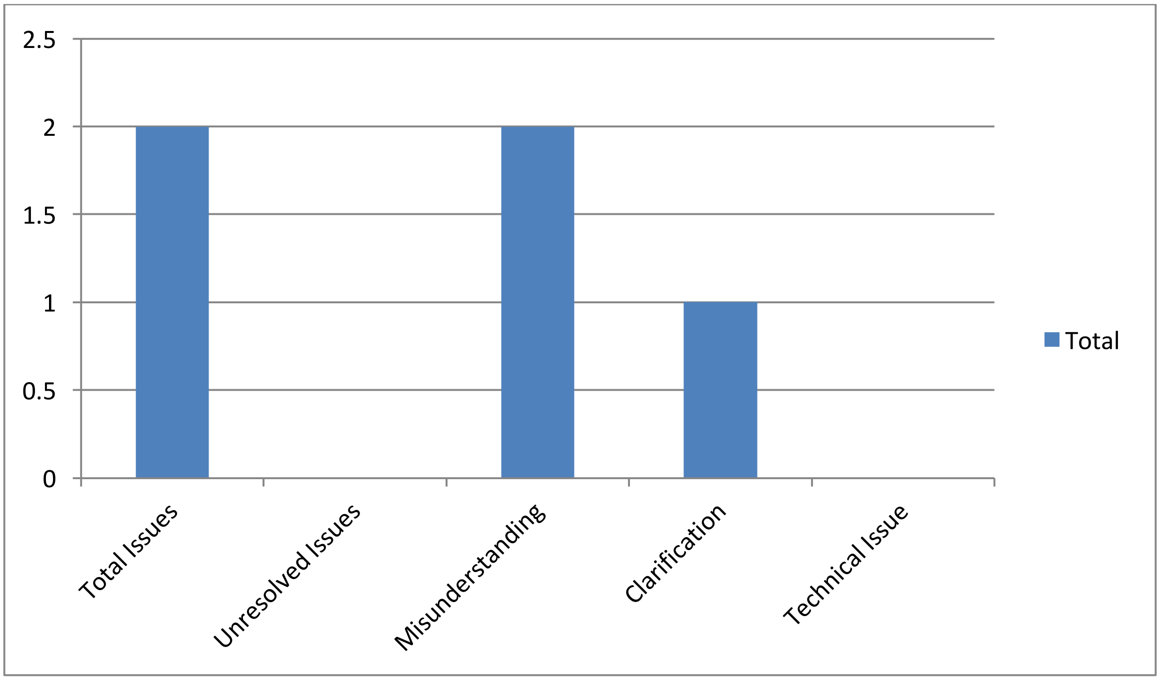


Figure 11: Distribution of Sample Value issues reported

1.4 GOOSE Testing Summary

There were 15 companies, with 20 implementations, that participated in the GOOSE testing. The 2015 implementations showed a shift towards support of Edition 2 and in many cases implementations that support both Edition 1 and Edition 2. The number of implementations that supported Edition 1 only decreased substantially. The number that declared support for Edition 2 only decreased slightly. This information is shown in Figure 12.

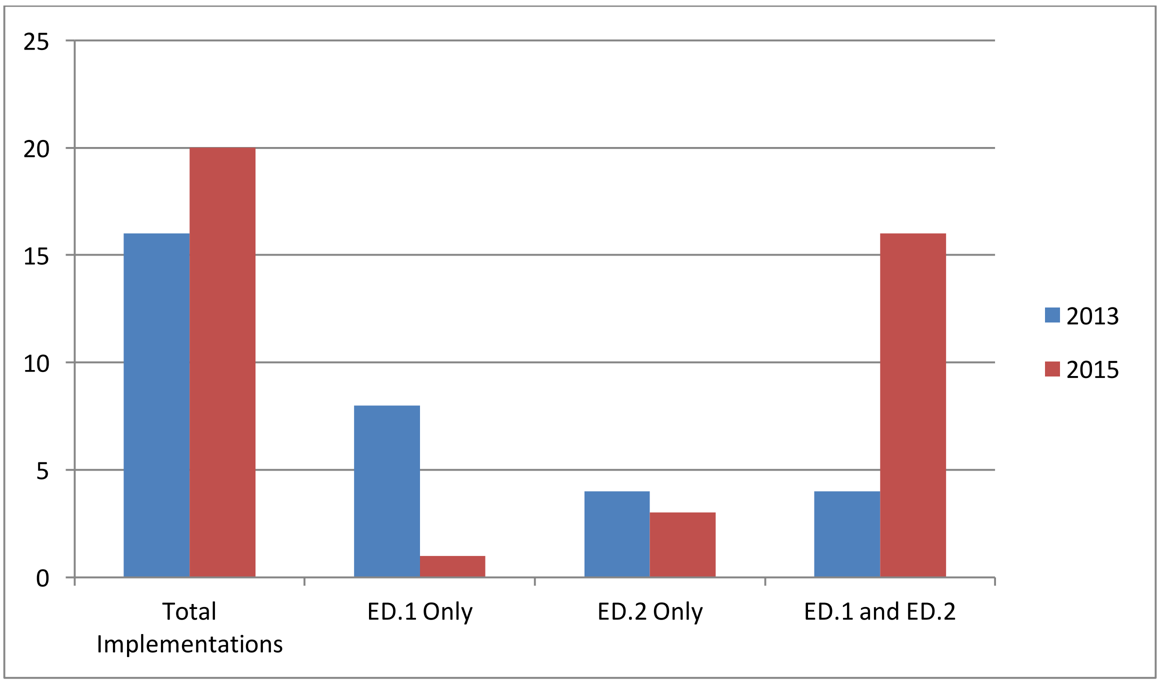


Figure 12: GOOSE participation by 61850 edition support

This shift indicates, and the fact that no issues were reported in regards to GOOSE, that implementations and the standard have reached a major level of maturity.

There were zero (0) issues encountered during GOOSE testing. This is another indication that the implementations have reached a good level of maturity.

1.5 Client/Server Testing Summary

There were 15 participating companies that participated in the Client/Server testing. These 15 companies provided 10 Client implementations and 17 Server Implementations to be tested. Many of the Client implementations claimed to be able to support interoperability with Edition 1 and Edition 2 servers. Fewer servers indicated that they could support either Edition 1 or Edition 2 models/services.

In comparison to 2013, the 2015 results indicate a definite shift towards IEC 61850 Edition 2 support.

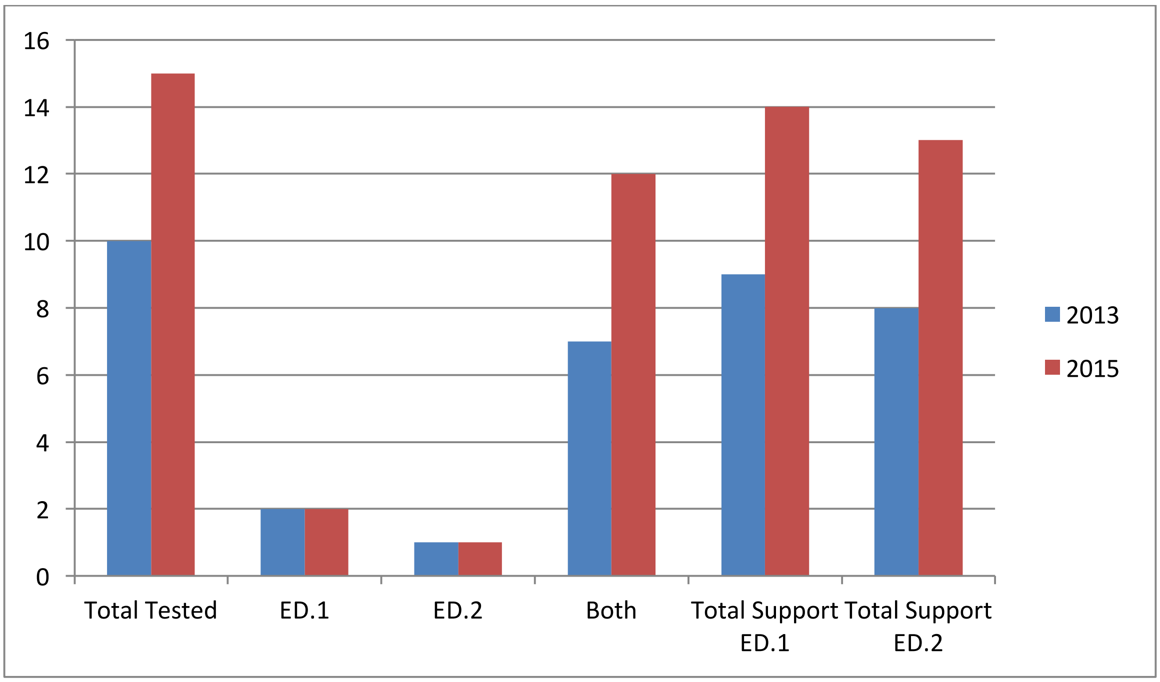


Figure 13: Edition 1 and Edition 2 Client support comparison

Figure 13 indicates an increased client support for Edition 2 while maintaining and increasing overall support for Edition 1. This indicates that users should be able to use the increase in client support for both versions for integration in mixed edition systems.

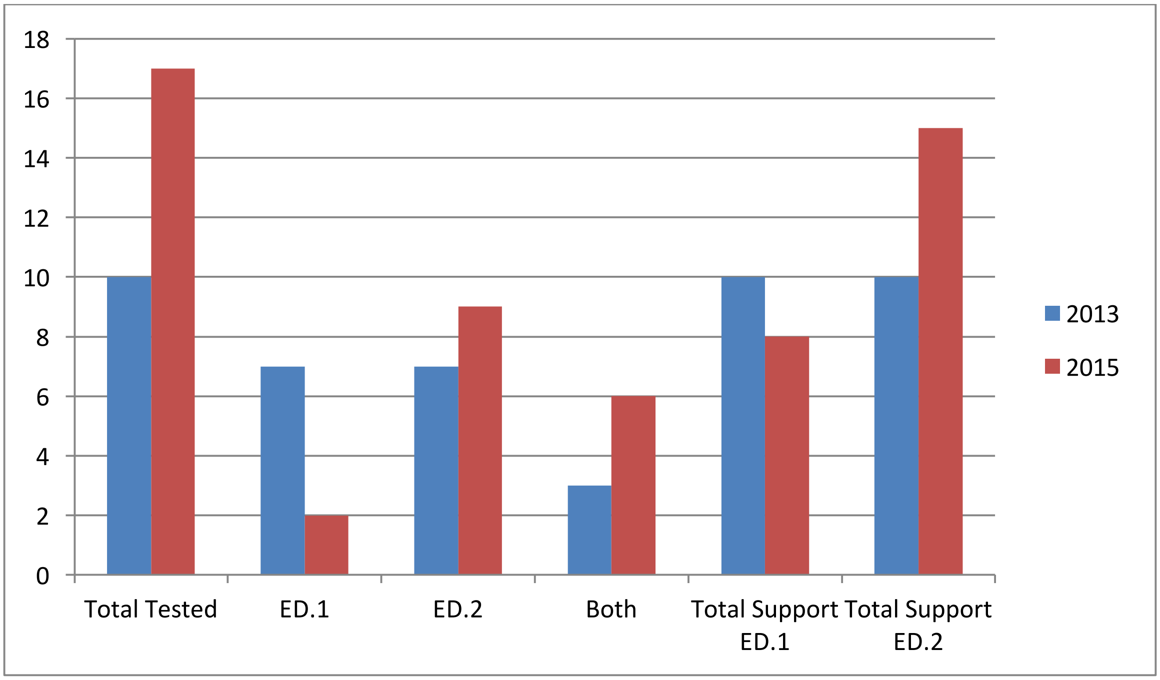


Figure 14: Edition 1 and Edition 2 Server support comparison

Figure 14 indicates an increased server support for Edition 2. It also shows that the number of Edition 1 servers tested decreased in 2015. This is probably due, in large part, to the emphasis on Edition 2 testing and new server products being tested.

There were 9 issues reported regarding Client/Server testing. Several were misunderstandings, some required clarifications, some required Technical Issues (TISSUES) to be entered and resolved. In some cases, even though there was a misunderstanding, it was decided that the standard needs some amount of clarification. For these issues, the issues are included in both categories. At this time, most of the reported problems have been closed, but there are a few still remaining that need to be addressed by IEC TC57 WG10.

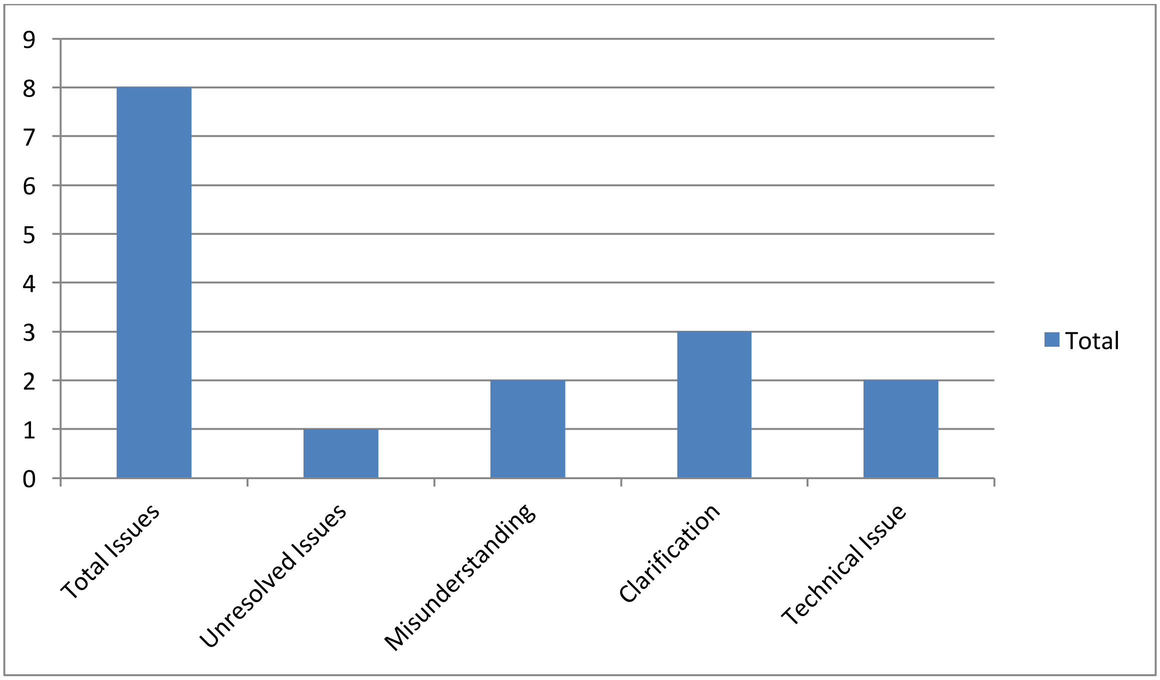


Figure 15: Distribution of Client/Server issues reported

1.6 HSR/PRP - Network Testing Summary

The purpose of the testing was to:

- Test interoperability of High Speed Redundancy (HSR) implementations (see
- Test interoperability of Parallel Redundancy Protocol (PRP) implementations
- Test hybrid network exchanges when:
    - PRP is connected to HSR
    - PRP connected to Rapid Spanning Tree Protocol (RSTP)
    - HSR connected to RSTP
- Performance testing of HSR (see
- Performance testing of network bridges (e.g. coupling)

There were 11 participants for the various tests were. The distribution of the participation is shown in

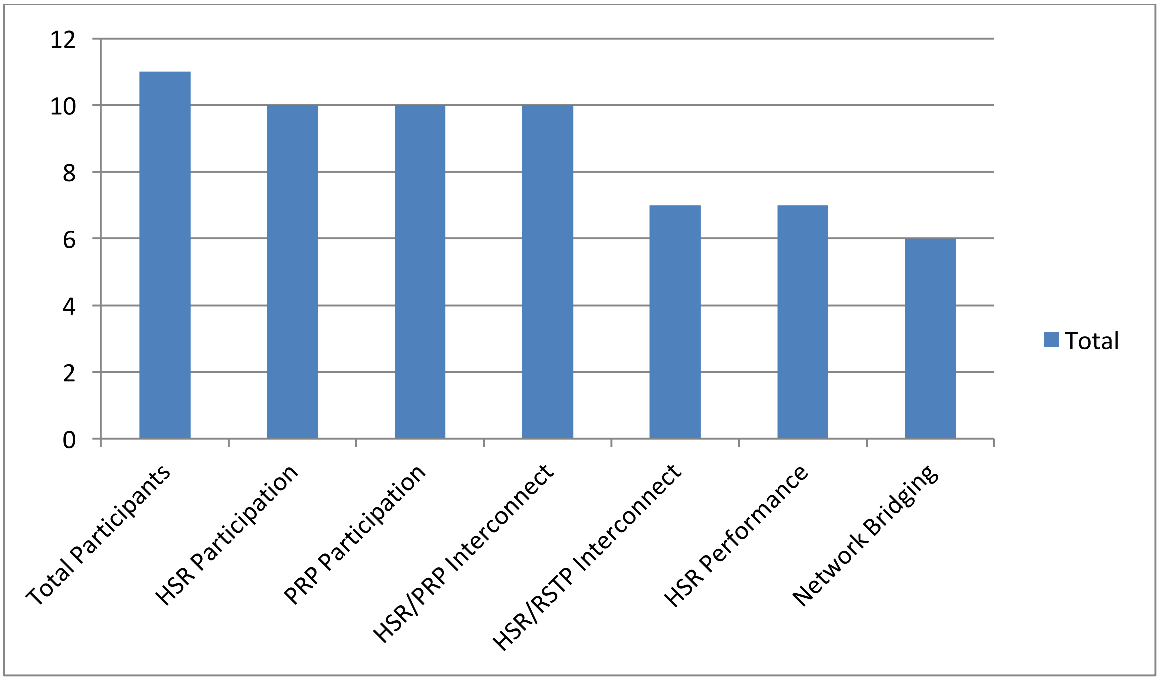


Figure 16: Distribution of test participation network testing

All of the HSR participants also had, and tested support, for PRP. This means, in general, that users can choose the Ethernet redundancy mechanism that is of their preference.

There were two (2) issues reported for network testing. One was a clarification. The other is still open and requires action to update the HSR standard. The lack of issues indicates a good level of maturity in the products tested.

1.7 PTP - Time Sync Testing Summary

There were 10 participating companies. Some companies participated in both the 61850-9-3 testing and the IEEE C37.238 testing. There was only NTP testing in the previous IOPs.

Of these 10 companies, 9 participated in 61850-9-3 testing and 7 participated in IEEE C37.238 testing. This indicates that there is good support for both versions. However, users should be specifying IEC 61850-9-3 compatible equipment.

There was a single issue reported during testing. It requests a clarification be placed in IEEE C37.238. The single reported issue was not unexpected and overall the products tested represented mature products.

2 SCL Testing

The following sections describe the SCL use cases, test cases, and test results for the 2015 IEC 61850 IOP. There were 13 companies that participated.

Note: There were special circumstances for this testing. Prior to the IOP, several decisions were made in order to clarify the use of SCL in regards to message subscription and referencing data for inputs. From a timing perspective not all companies were able to implement these agreements prior to the interop testing and therefore some tests required manual intervention or could not fulfill all of the testing requirements. Additionally, agreements regarding engineering co-existence of Edition 1 and Edition 2 were created prior to the interop such that not all vendors had time to implement the agreements.

The test cases are defined as:

Test Case 1	Bottom Up – Interoperability between SCT and ICT of Bay Level IED
Test Case 2	Top Down – Interoperability between SCT and ICT of Bay Level IED
Test Case 3	Reimport of IID file for modification during system engineering – interoperability between ICT and SCT
Test Case 4	Interoperability between ICT of station level device (gateway and HMI) and SCT
Test Case 5	Engineering exchange between two projects – interoperability between two SCT
Test Case 6	Interoperability between SCTs – Project realization with two SCT
Test Case 7	Interoperability between SCTs – Use of existing SCD file
Test Case E1	System specification with virtual IEDs and exchange between SSTs
Test Case E2	System design – specification with virtual IEDs and mapping to real IEDs in design
Test Case M1	Bottom Up – Interoperability between SCT and ICT of Bay Level IED
Test Case M2	Top Down – Interoperability between SCT and ICT of Bay Level IED
Test Case M3	System design – specification with virtual IEDs and mapping to real IEDs in design
Test Case M4	Interoperability between SCTs – Use of existing SCD file

The following companies participated in the following test cases with the role of SCT:

Test Case	1	2	3	4	5	6	7	E1	E2	M1	M2	M3	M4
Vendor													
ABB		x		x	x								
Efacec	x	x		x									
Helinks	x	x		x									
Kalkitech	x	x		x	x		x						
NARI	x	x	x	x		x							
Schneider	x	x	x	x			x			x		x	
Siemens		x		x	x		x			x			

Table 8: SCL Vendor Participation as System Configuration Tools

The following companies participated in the following test cases with the role of ICT:

Test Case	1	2	3	4	5	6	7	E1	E2	M1	M2	M3	M4
Vendor													
ABB		x								x		x	
Alstom	x	x	x	x									
Efacec	x	x	x	x									
GE		x		x									
Kalkitech													
NARI	x	x											
Schneider	x												
Schweitzer		x		x						x		x	
Siemens										x			
SISCO	x	x											
Subnet		x		x									
Toshiba	x												

Table 9: SCL Vendor Participation as IED Configuration Tools

The following companies participated as SSTs:

Test Case	1	2	3	4	5	6	7	E1	E2	M1	M2	M3	M4
Vendor													
Helinks								x					
Schneider								x					

Table 10: SCL Vendor Participation as System Specification Tools

2.1 General Information

2.1.1 Abbreviations

SCT System configuration tool according to IEC 61850-6

ICT IED configuration tool according to IEC 61850-6

XFactor Used to represent the IEC 61850-6 ED1 files that were exchanged from an ICT to SCT that were other than ICD files conform to the standard. In many situations, some vendors called these ICDs, CIDs, or SCDs

2.1.2 Tool Versions and TISSUES

2.1.2.1 Standard versions

In a first step, the test cases described further down in this document will be done in a setup where all tools and devices support the same edition and version of the standard and SCL. In a second step, tests with a mixed configuration will be done as well. The mixed configurations will be defined based on practical use cases.

2.1.2.1.1 Single Edition / Version tests

For the single edition / version tests, the following versions are foreseen:

	Ed 1 Test	Ed 2.1 Test
SCL language version / revision	2003A	2007B
Schema version	1.7	3.1
Data model version / revision	61850-7-4:2003	61850-7-4:2007A

The Schema files to be used can be found on the UCA Sharepoint under

IEC 61850 User Group > 61850 2015 IOP > IOP Test Documents > SCL Testing

2.1.2.1.2 Mixed configuration tests

For mixed configurations, the following practical use cases are considered:

(a) A future project that will be mainly done with Edition 2.1 of the standard, but there is a requirement to integrate some devices that do not support Ed 2.1
(b) An extension of an existing project that was realized with Edition 1 but for the extension, new devices only supporting Ed 2.1 need to be integrated.

For use case (a), the project will be designed with an Edition 2.1 SCT; for use case (b), the SCT needs to be upgraded to Ed 2.1 and it needs to be able to work based on its old Ed 1 design.

Some of the IEDs support Ed 2.1; the IEDs/ICT under test only supports Ed 1. This IEDs of Ed 1 needs to subscribe to a GOOSE message from an Ed 2.1 IED.

For this use case, the following versions shall be used:

	SCL version	Schema	Data Model
ICD or XFactor file from IED under test	2003A	1.7	61850-7-4:2003
ICD or IID file from other IEDs	2007B	3.1	61850-7-4:2007A
SCD for Ed 2.1 ICT	2007B	3.1	both (depending on IED)
SCD for Ed 1 ICT	2003A	1.7	both

NOTE: It cannot be expected that the Ed 1 IED can subscribe to a GOOSE message with a data object / data attribute in Ed 2.1 IED that is new in Ed 2.1

NOTE: If the SCT does a schema validation of the imported ICD or IID/XFactor files, it needs to do this validation either with Schema version 3.1 or with the appropriate schema version per import.

2.1.3 TISSUE support

For ICTs participating at the test, the TISSUES Implementation Conformance Statement of the IED shall be provided as part of the test.

2.2 The Test Scenario

This chapter describes the test scenario that is the basis for the SCL IOP test cases. The single line diagram has been created based on typical feeders from ENTSO-E members. To keep the configuration effort reasonable, the scenario has been limited to a minimum but it includes at least the elements to test the various issues associated with the IEC 61850 SCL based engineering process. These include:

- Instantiate IEDs from ICD files in a system tool (top down engineering process)
- Select data for reporting to a client during system engineering
- An application with GOOSE data exchange between various IEDs

- The possibility to have two projects and use SED files

2.2.1 The single line diagram

The single line diagram for the test scenario is shown in the figure below:

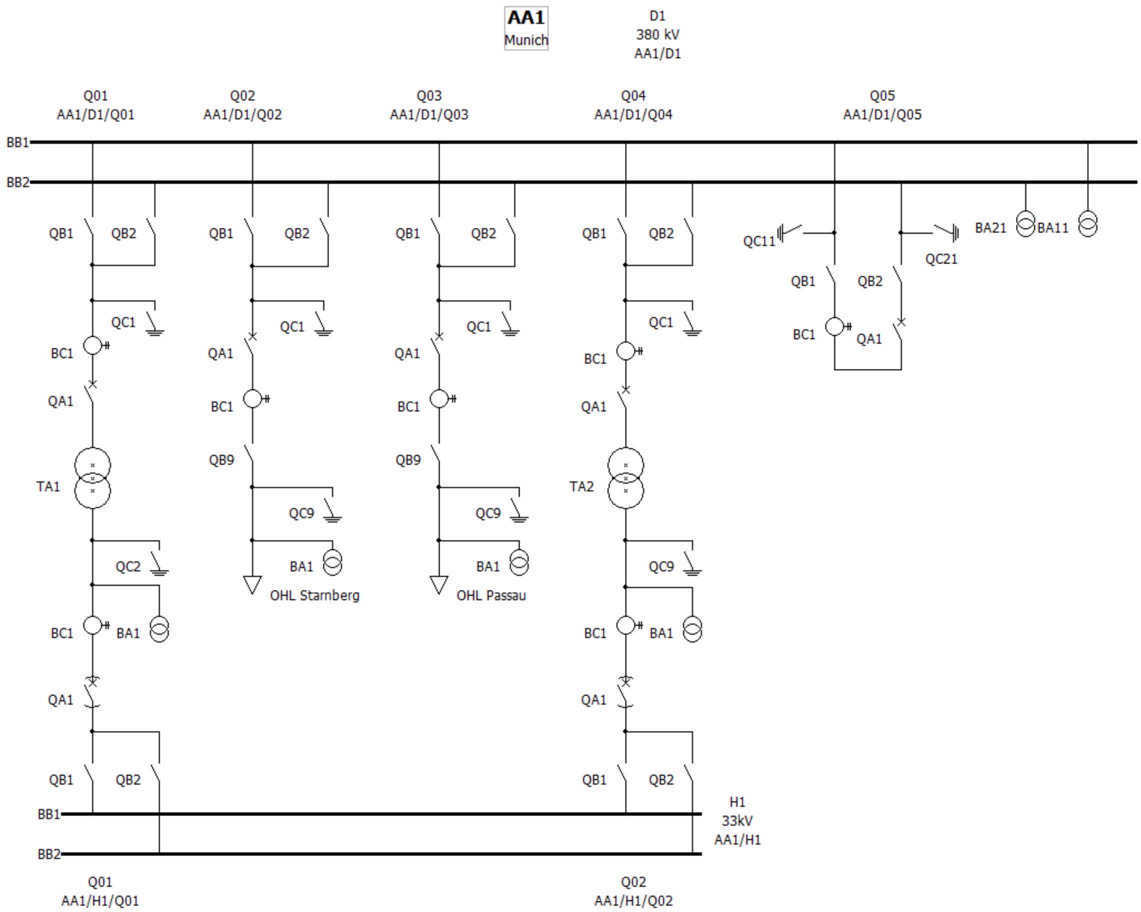


Figure 17 – Single Line Diagram

2.2.2 The devices

The following IEDs will be in the system:

- Station HMI
- Gateway
- For the bays of the HV part (voltage level D1):
    - One protection IED (AA1D1QnnFN1)
    - One bay controller (AA1D1QnnKF1)
    - One breaker interface device (**AA1D1Q01KF2**)
- For the bay of the LV part (voltage level H1)
    - One combined protection and control IED (AA1H1QnnFN1)

In the figure below is the system diagram with the various IEDs. The IP addresses will be specified later.

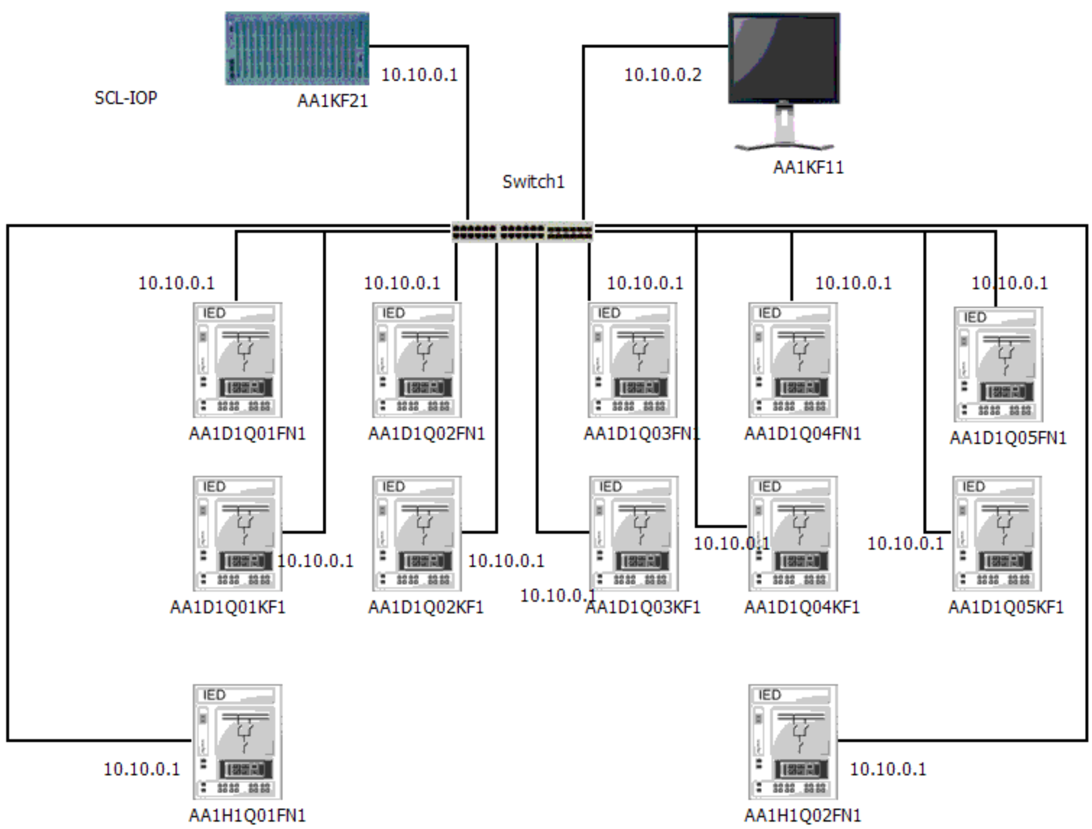


Figure 18 – System Diagram

2.2.3 The functions

The following distributed functions will serve as a basis for the engineering used to verify interoperability.

- Event reporting of selected information from all IEDs to the gateway and to the HMI with by default activation of the report
- Control of the breaker D1/Q01/QA1 from the HMI
- Breaker failure protection of the breaker D1/Q01/QA1 (details of the function are described in the next chapter)

In addition, the SSD file specifies the following functionality (note that these are only for the data models; the detailed functionality will not be designed as part of the IOP):

For all switches and circuit breakers

- Remote control capability and interlocking
- Breaker failure function for the circuit breakers

For the circuit breakers of the OHL bays Q02 and Q03:

- Synchrocheck (25)
- Autoreclosing (79)

For the OHL bays

- Measurements (voltage, current, active and reactive power)
- Distance protection (21)
- Directional Earth Fault (67N)

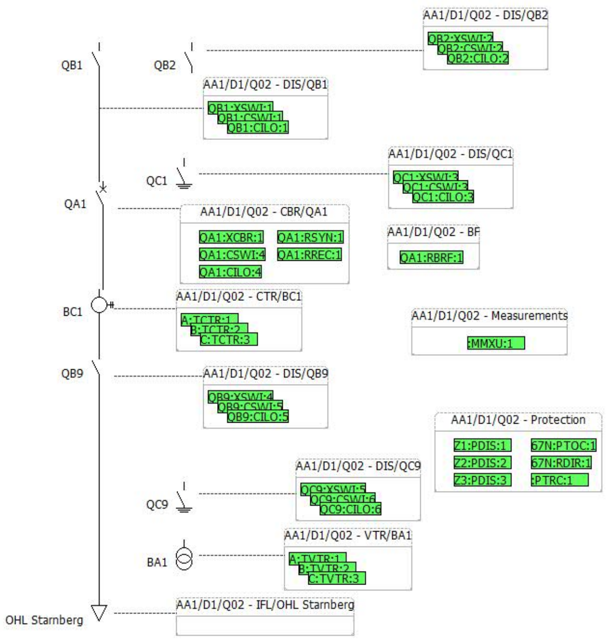


Figure 19 – OHL Bay

For the OHL Bay, the protection functions, the measurements, the CT and the VT will be allocated to the protection IED (AA1D1QnnFN1), the functions associated with the switches, the circuit breaker control, reclosing and synchrocheck and the breaker failure function will be allocated to the bay controller (AA1D1QnnKF1), the function of the breaker itself (LN XCBR) will be allocated to the breaker interface device.

For the transformer HV bays

- Measurements (voltage, current, active and reactive power)
- Differential protection (87T)
- Time overcurrent protection (51)
- Voltage control with tap changer

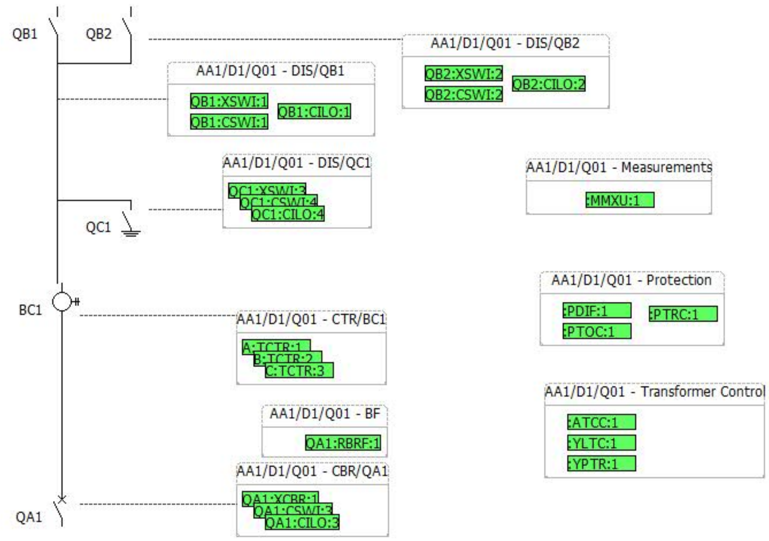


Figure 20 – Transformer HV Bay

For the Transformer HV Bay, the protection functions, the measurements, the transformer control and the CT will be allocated to the protection IED (AA1D1QnnFN1), the functions associated with the switches, the circuit breaker and the breaker failure function will be allocated to the bay controller (AA1D1QnnKF1), the function of the breaker itself (LN XCBR) will be allocated to the breaker interface device.

For the transformer LV bays

- Measurements (voltage, current, active and reactive power)
- Time overcurrent protection (51)

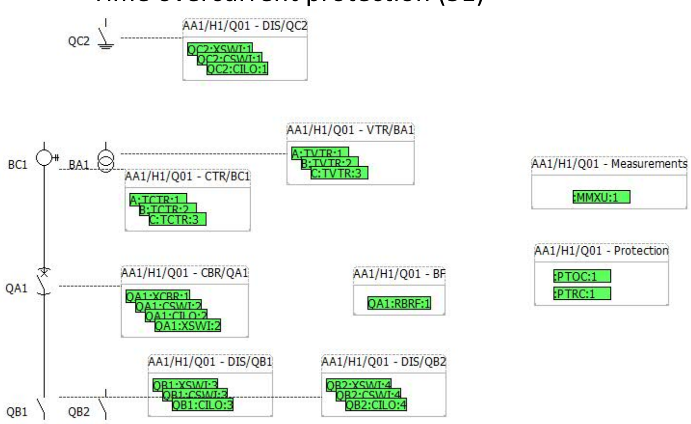


Figure 21 – Transformer LV Bay

For the bus coupler bay

- Measurements (voltage, current)

- Synchrocheck
- Time overcurrent protection (51)

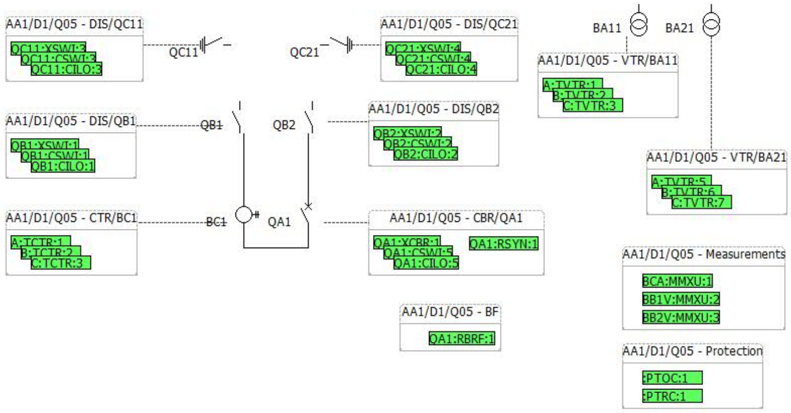


Figure 22 – Bus coupler Bay

2.2.4 The breaker failure function

For this test, it is assumed that the breaker failure function is realised in the control IED. The details of the function are described below:

2.2.4.1 Function overview

Name	Breaker Failure Protection (50BF) for D1/Q01/QA1
Description	The 50BF function is being initiated when a protection function tries to trip the circuit breaker D1/Q01/QA1. The 50BF function supervises the status of the breaker [D1/Q01/QA1] to open. If the condition is met within a time window, the 50BF function resets without any further action. Otherwise, 50BF function will send an external trip signal to all adjacent breaker controllers.
Actors	Protective relays that trips CB1: AA1D1Q01FN1 Bay controller implementing BF function: AA1D1Q01KF1 Breaker interface device AA1D1Q01KF1 Bay controllers for adjacent breakers AA1D1Q02KF1 AA1D1Q03KF1 AA1D1Q04KF1 AA1D1Q05KF1 AA1H1Q01FN1

2.2.4.2 Function description

Trigger	A trip of any protection function(s) by the transformer protection relay (AA1D1Q01FN1)
Components	The breaker failure function (LN RBRF), the local breaker QA1 (LN XCBR) and the adjacent breakers D1/Q02/QA1, D1/Q03/QA1, D1/Q04/QA1, D1/Q05/QA1 and H1/Q01/QA1 (LN XCBR)
Pre-conditions	The breaker D1/Q01/QA1 is closed but there is a fault that needs to be cleared by tripping this breaker.
Implementation assumption	A trip of the circuit breaker is considered as successful if the following criteria have been met: 1. Circuit breaker status, as indicated by auxiliary contacts (52a/b), is open; No supervision of current (RBRF.FailMod = "Breaker Status"). No local re-trip (internal trip) is done (RBRF.ReTrMod = "Off"). All protection functions including the 50BF function will require three-phase trip (single-pole trip is not allowed). Pole discrepancy or failure of a single phase is out of the scope of this test.
Post-conditions on success	The 50BF function successfully completes if any one of the following post-conditions is true: a) The circuit breaker D1/Q01/QA1 successfully opens to clear the fault within a period of time (RBRF.FailTmms), and the 50BF function automatically resets; **or** b) The circuit breaker D1/Q01/QA1 fails to open within a period of time (RBRF.FailTmms), the 50BF function issues an external trip to all adjacent breakers.
Post-conditions on failure	The 50BF function fails if any one of the following post-conditions is true: A. The circuit breaker D1/Q01/QA1 successfully opens to clear the fault, but the 50BF function issues an unwanted external trip; **or** B. The circuit breaker D1/Q01/QA1 fails to open, but the 50BF function does not issue the external trip to the adjacent breakers.

2.2.5 Overview on Test Cases and Test Setup

The following test cases will be considered:

1. Bottom up engineering; interoperability between ICT of bay level IEDs and SCT
2. Top down engineering, interoperability between ICT of bay level IEDs and SCT
3. Reimport of IID file for modification during system engineering; interoperability between ICT and SCT
4. Top down or bottom up engineering, interoperability between ICT of station level device (gateway and HMI) with SCT and with information from ICT of bay level devices available in the SCD file
5. Engineering of HV and LV part as two projects; interoperability between two SCT
6. Interoperability between SCTs: Project realization with two SCT
7. Interoperability between SCTs: Use of existing SCD file

NOTE: The difference between top down and bottom up engineering as assumed in this document is, that with bottom up engineering, IEDs are first instantiated in the ICT and they are then integrated into the SCD file by the SCT through the import of IID or XFactor files. While with top down engineering, it is assumed that the SCT starts with importing ICD files (which may or may not be preconfigured) and creating instances of the IEDs as needed; the ICT then imports the SCD file and supports the configuration of the IED instances that have been created by the SCT.

2.2.5.1 Test setup

The main purpose of the SCL IOP test is to verify interoperability between a pair of tools from two different vendors. However, the verification of what an ICT does, can in many cases only be done through the verification of the behaviour of the configured IED. Therefore a limited physical setup is required as well.

The physical testbed for the SCL IOP tests consists of the following:

- Supplied by test support
  - IEC 61850 browser as client
  - Simulation of IED AA1D1Q01FN1 (simulation of GOOSE message to initiate BF function)
  - Simulation of IED AA1D1Q01KF1 (simulation of breaker behaviour based on reception of GOOSE messages; simulation of GOOSE message with breaker position)
  - Simulation of IED AA1H1Q01FN1 (monitor reception of GOOSE message)
- Supplied by test partner "ICT"
  - The ICT
  - The IED AA1D1Q01KF1 that implements the breaker failure function (the bay control device)
- Supplied by test partner "ICT-clientDevice" (only test case 4)
  - The ICT
  - The client device (HMI or gateway); this replaces the IEC 61850 browser for test case 4
- Supplied by test partner "SCT"
  - The SCT

2.2.5.2 Functional requirements for the IED AA1D1Q01KF1

2.2.5.2.1 General

The IED used for the test shall have the following minimum functionality depending on the tests that shall be performed. The data model version support and minimum requirements on TISSUE implementation shall be as specified in chapter 2.1.2.

2.2.5.2.2 Breaker failure function

If the engineering of GOOSE shall be verified, the IED shall implement a breaker failure function (LN RBRF) with the following characteristics:

- Be able to be initiated by an external signal received through a GOOSE message
- Be able to send an external trip request as a GOOSE message
- Be able to use the breaker position only as a criteria (i.e. not require a current measurement)
- Be able to subscribe to the breaker position from the breaker IED via GOOSE
- Be able to directly do an external trip (no local re-trip in a first stage)

NOTE: Since the goal is to test engineering interoperability using standard functions of the IED, it is important that standard library elements of the IED can be used.

2.2.5.2.3 Breaker control

If the engineering of control function shall be verified, implement a simple control function for the breaker (CSWI/XCBR) with the following characteristics:

- Declare in the ICD / IID file the control model supported
- If the control model can be chosen (e.g. direct control or select before operate), accept the configuration through the SCD file from the system tool
- Be able to create a GOOSE message to the breaker IED for the operation and subscribe to a GOOSE message from the breaker IED to receive the position indication.

2.2.5.2.4 Reporting

If the engineering of reporting shall be verified, support at least either buffered or unbuffered reporting.

2.3 Test Case 1: Bottom Up – Interoperability between SCT and ICT of Bay Level IED

2.3.1 SCL use case

		System Design – Bottom Up approach
1	ICT-n	Preconfiguration of IED and creation of instances as needed with ICT-n
2	ICT-n	Export IID/XFactor files
3	SCT	Import SSD file
4	SCT	Import IID/XFactor files
5	SCT	create binding of IEDs to process in single line diagram
6	SCT	design data flow required to implement protection and control schemes
7	SCT	design data flow required for local HMI implementation
8	SCT	design data flow required for SCADA communication
9	SCT	design communication parameters
10	SCT	export SCD file
11	ICT-n	import SCD file
12	ICT-n	detail engineering IED-n
13	ICT-n	create CID-n or private configuration file
14	ICT-n	export IID/XFactor file with updated ExtRefs
15	SCT	import updated IID/XFactor files
16	SCT	update data flow based on updated ExtRefs
17	SCT	create updated SCD file

NOTE: step 14 to 17 is needed if ExtRefs are supported and updated by the ICT.

2.3.2 Purpose of the test

1	To verify that SCT can import IID/XFactor files of IEDs and use those to create a valid SCD file.
2	The ability of an ICT, to accept modifications in the communication section (e.g. Subnet name, IP address), IED section (e.g. LN attribute lnType), and data type template section (e.g. LNodeType attribute id) as they are required to build a consistent SCD file.
3	To verify the ability of an ICT, to accept configurations of report control blocks and data sets from an SCD file as long as they are within the limits declared as part of the capabilities in the service section and or PIXITS.
4	To verify the ability of an ICT to accept configurations of GOOSE messages from an SCD file as long as they are within the limits declared as part of the capabilities in the service section and or PIXITS.
5	To verify that the ICT can import and use GOOSE subscription information from other IEDs contained within the SCD file.
6	To verify the ability of an ICT to accept configurations of initial values of parameters and CF attributes through the SCD file within the limits declared as part of the capabilities in the service section, declared through the valKind attribute and or PIXITS.

2.3.3 Test setup

Test Case ID	SCL.1
Test Case Name	Bottom-up, interoperability between ICT of bay level IEDs and SCT
Participant SCT	SCT tool with the scope to engineer the whole substation
Participant ICT	ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File - IID/XFactor files for all the other IEDs and the HMI and Gateway
Participant SCT	Prepares - SCT with SSD and IID/XFactor files from test support already processed (SICS S23, S41)
Participant ICT	Prepares - ICT with IID/XFactor files for IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 prepared (SICS I11-I16, I114) (Note: IED AA1D1Q01KF1 is the IED that will be physically present in the test)
Post-condition on success	
The test is passed when the ICT is deemed to have accepted the revised SCD file. This includes GOOSE subscription to the IED contained within the pre-built SCD file. The verification will be made based on the configuration downloaded from the ICT to the IED in the testbed environment as described below.	
Testbed	
As described in chapter 2.2.5.1	

2.3.4 Test case description and results

In order to provide the results, several tables of results are provided. There are different combinations of SCTs and ICTs in each table. In order to provide easy access to the results, the following is provided so that readers can determine the result table that is of interest.

SCT	Efacec	Helinks	Kalkitech	NARI	Schneider
ICT					
Alstom	Table 12				
Efacec		Table 12	Table 13		
NARI				Table 12	
Schneider					
SISCO				Table 13	
Toshiba		Table 12			Table 13

Table 11: SCL Test Case 1 - Company Test Result Lookup Information

Results							
			SCT	**NARI**	**Efacec**	**Helinks**	**Helinks**
			ICT	**Efacec**	**Alstom**	**Efacec**	**Toshiba**
	Test Step	**Verification**					
A	Engineering with SCT						
A0	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		See later	Have to check the file later on	Ok	OK
A1	SCT imports IID/XFactor files for IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 and adds these IEDs to the design	SCT is able to import IID/XFactor files	☐ S11 – S15 S111	OK	OK	OK, N3	OK

			Results				
			SCT	NARI	Efacec	Helinks	Helinks
			ICT	Efacec	Alstom	Efacec	Toshiba
	Test Step	**Verification**					
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	Ok	OK
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	Ok	Ok	OK
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK	Ok	OK
A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK	Ok	Ok	OK
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56	Not supporte d by the SCT	Not allowed by IED	Ok	Not allowed by IED
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK	OK	Ok	OK
B	SCD File inspection						

Results							
			SCT	**NARI**	**Efacec**	**Helinks**	**Helinks**
			ICT	**Efacec**	**Alstom**	**Efacec**	**Toshiba**
	Test Step	**Verification**					
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK	Ok	OK
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	Ok	Ok	OK
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK	OK	Ok	OK
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S35, S56	OK	OK	Ok	OK
B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	OK	Ok but manually added	OK
B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK	Ok	OK
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK	N1	Ok	OK
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	Not supporte d	Ok	Ok	OK

Results							
			SCT	**NARI**	**Efacec**	**Helinks**	**Helinks**
			ICT	**Efacec**	**Alstom**	**Efacec**	**Toshiba**
	Test Step	**Verification**					
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53	OK	Not allowed by IED	Ok	Not applicabl e
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		See later	Let's check it later on	Complet e with schema validatio n errors	OK
C	Engineering with ICT						
C1	ICT imports SCD file	ICT is able to import SCD file and use it for IED AA1D1Q01KF1	☐ I21, I22	OK From now see test case 3 with same vendors.	OK	N2	OK
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43		OK		
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐		OK		
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐		OK		
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation			OK		

Results							
			SCT	NARI	Efacec	Helinks	Helinks
			ICT	Efacec	Alstom	Efacec	Toshiba
	Test Step	**Verification**					
D	Verify IED behaviour						
D0	verify step A2	Connect with a test client to the IED	☐		Ok		
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐		Ok		
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28		Ok		
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210		Ok		
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28		Ok		
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers	☐		Ok		
E	Update SCD file						
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐				
E2	Update data flow based on updated ExtRefs						
E3	Export updated SCD file		☐				
F	SCD file inspection						
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐				
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation					

Results						
		SCT	**NARI**	**Efacec**	**Helinks**	**Helinks**
		ICT	**Efacec**	**Alstom**	**Efacec**	**Toshiba**
Test Step	**Verification**					

N1 - ALSTOM IID file includes “<Protocol mustUnderstand="true" />” in GSEcontrol field. This could cause the ordering issue when SCT adds the attributes.

N2 - Errors in Helinks SCD and EFACEC is unable to import. A datatype from client LN was missing.

N3 - Test aborted due to SCT problem: data type conflict resolution with no predefined enumerate.

Table 12: SCL Test Case 1 - Result Set 1

	Results					
			SCT	**Kalkitech**	**NARI**	**Schneider**
			ICT	**Efacec**	**SISCO**	**Toshiba**
	Test Step	**Verification**				
A	Engineering with SCT					
A0	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK	OK	OK
A1	SCT imports IID/XFactor files for IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 and adds these IEDs to the design	SCT is able to import IID/XFactor files	☐ S11 – S15 S111	OK	OK	OK, N7
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	OK
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	OK	OK
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK , N5	OK, N8
A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	N1	OK , N5	OK,N11

Results						
			SCT	Kalkitech	NARI	Schneider
			ICT	Efacec	SISCO	Toshiba
	Test Step	**Verification**				
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56	N2	IED does not support	Not supporte d.
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK	OK	Export OK.
B	SCD File inspection					
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK	OK
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	OK, N9
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK	OK	OK
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S35, S56	OK	OK	OK
B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	OK	OK

Results						
			SCT	**Kalkitech**	**NARI**	**Schneider**
			ICT	**Efacec**	**SISCO**	**Toshiba**
	Test Step	**Verification**				
B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK	OK
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK	OK	OK
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	OK	Not configure d in SCT.	OK
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53	OK	IED does not support	
B1 0	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		Schema validatio n errors occurs	N6	OK
C	Engineering with ICT					
C1	ICT imports SCD file	ICT is able to import SCD file and use it for IED AA1D1Q01KF1	☐ I21, I22	OK,	Ok	N10
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	N4		
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK		

Results						
			SCT	Kalkitech	NARI	Schneider
			ICT	Efacec	SISCO	Toshiba
	Test Step	Verification				
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐	OK		
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK		
D	Verify IED behaviour					
D0	verify step A2	Connect with a test client to the IED	☐		OK	
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐			
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28		Report generate d (GI)	
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210		IED does not support	
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28			
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers	☐			
E	Update SCD file					
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐			
E2	Update data flow based on updated ExtRefs					
E3	Export updated SCD file		☐			
F	SCD file inspection					
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐			

Results						
			SCT	Kalkitech	NARI	Schneider
			ICT	Efacec	SISCO	Toshiba
	Test Step	**Verification**				
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation				

N1 - At the first try the clientservices for goose subscription parameters was missing in the IID file, the tool didn't want to create the subscription. But the file was modify to permit the subscription cause the IED is really able to do it

N2 - OK only for FailTmms (others not supported)

N3 - Import works but some errors appear but the ICT is able to handle the file.

N4 - The IID has placeholders to accept external signals in certain logical nodes, according to the latest agreements, the SCT Tool is supposed to map signals only to this predefined placeholders. This constraint was not yet supported by the SCT.

N5 - SCT does not verify the service capabilities.

N6 - One error: Substation desc="Brussels" name="AA1" sxy:x="4" sxy:y="4"> sxy was unbound and was an implementation error in the SCT.

N7 - SCD structure prepared. Import of IID passed with warnings (RptId, AppId was the same – not unique). Detected by the validator.

N8 - Existing DataSet/RPT updated. Verified that ICD is not allowing DS creation.

N9 - OSI parameters not present in IID.

N10 – SCD could not be imported.

N11 - Control APPID (can be created but it is made by system to be unique). APPID Is not needed to be unique if it is sent to different subscribers.

Table 13: SCL Test Case 1 - Result Set 2

2.4 Test Case 2: Top Down – Interoperability between SCT and ICT of Bay Level IED

2.4.1 SCL use case

		System Design – Top Down approach
1	ICT-n	Preconfiguration of ICD file with IED tool as needed
2	ICT-n	Export ICD file
3	SCT	Import SSD file
4	SCT	Import ICD files
5	SCT	create instances of the IEDs and the binding of IED instances to process in single line diagram
6	SCT	design data flow required to implement protection and control schemes
7	SCT	design data flow required for local HMI implementation
8	SCT	design data flow required for SCADA communication
9	SCT	design communication parameters
10	SCT	export SCD file
11	ICT-n	import SCD file
12	ICT-n	detail engineering IED-n
13	ICT-n	create CID-n or private configuration file
14	ICT-n	export IID/XFactor file with updated ExtRefs
15	SCT	import updated IID/XFactor files
16	SCT	update data flow based on updated ExtRefs
17	SCT	create updated SCD file

NOTE: step 14 to 17 is needed if ExtRefs are supported and updated by the ICT.

2.4.2 Purpose of the test

1	To verify that SCT can import ICD files of IEDs and use those to create a valid SCD file.
2	The ability of an ICT, to accept modifications in the communication section (e.g. Subnet name, IP address), IED section (e.g. LN attribute lnType), and data type template section (e.g. LNodeType attribute id) as they are required to build a consistent SCD file.
3	To verify the ability of an ICT, to accept configurations of report control blocks and data sets from an SCD file as long as they are within the limits declared as part of the capabilities in the service section and or PIXITS.
4	To verify the ability of an ICT to accept configurations of GOOSE messages from an SCD file as long as they are within the limits declared as part of the capabilities in the service section and or PIXITS.
5	To verify that the ICT can import and use GOOSE subscription information from other IEDs contained within the SCD file.
6	To verify the ability of an ICT to accept configurations of initial values of parameters and CF attributes through the SCD file within the limits declared as part of the capabilities in the service section, declared through the valKind attribute and or PIXITS.

7	The ability of an ICT to accept instantiations of IEDs based on ICD files through an SCD file.

2.4.3 Test setup

Test Case ID	SCL.2
Test Case Name	Top-down, interoperability between ICT of bay level IEDs and SCT
Participant SCT	SCT tool with the scope to engineer the whole substation
Participant ICT	ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File - ICD files for all the other IEDs and the HMI and Gateway
Participant SCT	Prepares - SCT with SSD and ICD files from test support already processed (SICS S23, S41)
Participant ICT	Prepares - ICT with either one ICD files for all bay controllers of the HV bays or one ICD for bay controller of HV transformer bay (IED AA1D1Q01KF1 and AA1D1Q04KF1) and a second ICD file for bay controller of OHL bay (IED AA1D1Q02KF1 and AA1D1Q03KF1) prepared (SICS I11-I16, I114) (Note: IED AA1D1Q01KF1 is the IED that will be physically present in the test)
Post-condition on success	
The test is passed when the ICT is deemed to have accepted the revised SCD file. This includes GOOSE subscription to the IED contained within the pre-built SCD file. The verification will be made based on the configuration downloaded from the ICT to the IED in the testbed environment as described below.	

2.4.4 Test case description and results

In order to provide the results, several tables of results are provided. There are different combinations of SCTs and ICTs in each table. In order to provide easy access to the results, the following is provided so that readers can determine the result table that is of interest.

	SCT Company						
ICT Company	ABB	Efacec	Helinks	Kalkitech	NARI	Schneider	Siemens
ABB		Table 16	Table 17	Table 17	Table 18	Table 18	Table 18
Alstom	Table 15		Table 16			Table 19	
Efacec	Table 15					Table 19	
GE						Table 15	Table 19
NARI	Table 15		Table 17	Table 18			
Schweitzer		Table 16	Table 17			Table 20	
SISCO	Table 16						
Subnet						Table 20	

Table 14: SCL Test Case 2 - Company Test Result Lookup Information

Results							
			SCT	**Schneider**	**ABB**	**ABB**	**ABB**
	Test Step	**Verification**	**ICT**	**GE**	**Alstom**	**Efacec**	**NARI**
A	Engineering with SCT						
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation			OK	OK	OK
A1	SCT imports ICD files for HV bay controllers and creates the instances of IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1	SCT is able to import ICD files and to create instances	☐ S11 – S15 S111	OK	OK	OK	OK
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	OK	OK
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	OK	OK	OK
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	See test case 4 with Schn GE and SUB done the same day	OK	OK	OK

			Results				
			SCT	Schneider	ABB	ABB	ABB
	Test Step	**Verification**	**ICT**	**GE**	**Alstom**	**Efacec**	**NARI**
A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK	OK	OK	OK
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56		Not allowed by the IED		Not Supported
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK		OK	OK
B	SCD File inspection						
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK	OK	OK
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	OK	OK
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK	OK	OK	OK
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK	OK	OK	OK

Results							
			SCT	Schneider	ABB	ABB	ABB
	Test Step	**Verification**	**ICT**	**GE**	**Alstom**	**Efacec**	**NARI**
B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	OK	OK	OK
B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK	OK	OK
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK	OK	OK	OK
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	OK	OK	OK	OK
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53				Not supported
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK	OK	OK
C	Engineering with ICT						
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	N1	N2		OK

			Results				
			SCT	**Schneider**	**ABB**	**ABB**	**ABB**
	Test Step	**Verification**	**ICT**	**GE**	**Alstom**	**Efacec**	**NARI**
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK			OK
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK			OK
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐				OK
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation					OK
D	Verify IED behaviour						
D0	verify step A2	Connect with a test client to the IED	☐	OK			OK
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐	OK			OK
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28	OK			OK
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210				OK
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28	OK			OK

			Results				
			SCT	**Schneider**	**ABB**	**ABB**	**ABB**
	Test Step	**Verification**	**ICT**	**GE**	**Alstom**	**Efacec**	**NARI**
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers		OK			OK
E	Update SCD file						
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐				OK
E2	Update data flow based on updated ExtRefs						OK
E3	Export updated SCD file		☐				OK
F	SCD file inspection						
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐				OK
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation					OK
N1 - ICT didn't like a private field inside a dataset field. Problem was manually corrected. **N2 – Undiagnosed problem occurred.**							

Table 15: SCL Test Case 2 - Result Set 1

Results							
			SCT	ABB	Efacec	Efacec	Helinks
	Test Step	Verification	ICT	SISCO	ABB	Schweitzer	Alstom
A	Engineering with SCT						
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation		OK	OK	OK	OK
A1	SCT imports ICD files for HV bay controllers and creates the instances of IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1	SCT is able to import ICD files and to create instances	☐ S11 – S15 S111	N1	OK	OK	OK
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	OK	OK
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	SCT does not support feature	Not supported	OK
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	N2	OK	OK	OK

Results							
			SCT	**ABB**	**Efacec**	**Efacec**	**Helinks**
	Test Step	**Verification**	**ICT**	**SISCO**	**ABB**	**Schweitzer**	**Alstom**
A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK	N6	OK	OK
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56			Not supported	Not allowed by IED
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK		OK	OK
B	SCD File inspection						
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK	OK	OK
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	OK	OK
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK		Not supported	OK
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK	OK	OK	OK

Results							
			SCT	ABB	Efacec	Efacec	Helinks
	Test Step	Verification	ICT	SISCO	ABB	Schweitzer	Alstom
B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	OK	OK	OK
B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK	OK	OK
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK	OK	OK	OK
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	OK	OK	OK	OK
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53		Not allowed by IED		Not allowed by IED
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK	OK	OK
C	Engineering with ICT						
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	OK	OK, N8	OK	OK

Results							
			SCT	ABB	Efacec	Efacec	Helinks
	Test Step	**Verification**	**ICT**	**SISCO**	**ABB**	**Schweitzer**	**Alstom**
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK, N3		N9	OK
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	N4		OK	OK
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐			OK	OK
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation				OK	OK
D	Verify IED behaviour						
D0	verify step A2	Connect with a test client to the IED	☐	OK		OK	OK
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐				OK
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28	N5			OK
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210				OK
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28				OK

			Results				
			SCT	ABB	Efacec	Efacec	Helinks
	Test Step	**Verification**	**ICT**	**SISCO**	**ABB**	**Schweitzer**	**Alstom**
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers					OK
E	Update SCD file						
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐				
E2	Update data flow based on updated ExtRefs						
E3	Export updated SCD file		☐				
F	SCD file inspection						
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐	OK			
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation					

N1 - (problem in ldNs: 2010 revision that is not compatible (needs to be 2007). Manually changed to 2007B.
N2 – Initially ABB SCT cannot create Dataset because of internal mechanism (parametrisation of import profile needed). Allocation done to HMI Client.
N3 -No binding available in ICT.

N4 - GCB mechanism not working, RCB mechanism rejecting Enabling.

N5 – Undiagnosed problem occurred.

N6 - Bug with GOOSE control block name finding matching GSE section in connected AP – fixed outside the tool – implementation issue.

N8 – SCT reimported SSD to recreate Substation section.

N9 - ICT tool did not use ExtRef. It only used GOOSE CntlBlock for references

Table 16: SCL Test Case 2 - Result Set 2

			Results				
			SCT	Helinks	Helinks	Helinks	Kalkitech
	Test Step	**Verification**	**ICT**	**NARI**	**Schweitzer**	**ABB**	**ABB**
A	Engineering with SCT						
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation		OK	OK	OK	OK
A1	SCT imports ICD files for HV bay controllers and creates the instances of IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1	SCT is able to import ICD files and to create instances	☐ S11 – S15 S111	OK	OK	OK	OK
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	OK	OK
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	OK	OK	OK
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK	OK	OK
A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK	OK	OK	OK

A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56	OK	Not supported by IED	Not supported by ICT	Not supported by ICT
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK	OK	OK	OK
B	SCD File inspection						
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK	OK	OK
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	OK	OK
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK	OK	OK	OK
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK	OK	OK	OK
B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	OK	OK	OK
B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK	OK	OK
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK	OK	OK	OK

B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	OK	OK	OK	OK
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53	Not supported by IED.		OK	Tool does not support
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK	OK	OK
C	Engineering with ICT						
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	OK	OK	OK	OK
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK	N2	OK	OK
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK	OK	OK	OK
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐	N1	N3	OK	OK
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK	N4	OK	OK
D	Verify IED behaviour						
D0	verify step A2	Connect with a test client to the IED	☐	OK		OK	OK
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐	OK		OK	OK

D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28	OK		OK	OK
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210	OK		Not supported by ICT	Not supported by ICT
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28	OK		OK	OK
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers		OK		OK	OK
E	Update SCD file						OK
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐			OK	OK
E2	Update data flow based on updated ExtRefs					OK	No updated ExtRefs
E3	Export updated SCD file		☐			OK	
F	SCD file inspection						
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐			OK	
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation				OK	

N1 – MAC address was changed manually in order to comply with expected range.

N2 - Goose receiving is configured manually (drag and drop from a list of published GOOSE)

N3 - Export a IID, the ExtRef/intAddr is not updated

N4 - “version” and “revision” attributes in SCL are not present

Table 17: SCL Test Case 2 - Result Set 3

			Results				
			SCT	**Kalkitech**	**NARI**	**Schneider**	**Siemens**
	Test Step	**Verification**	**ICT**	**NARI**	**ABB**	**ABB**	**ABB**
A	Engineering with SCT						
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation		N1	OK	OK	OK
A1	SCT imports ICD files for HV bay controllers and creates the instances of IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1	SCT is able to import ICD files and to create instances	☐ S11 – S15 S111	OK	OK	OK	OK
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	OK	OK
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	OK	OK	OK
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK	N4	OK

A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK	OK	OK	OK
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56		Not supported by ICT	Not allowed in ICT	IED does not support
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK		OK	OK
B	SCD File inspection						
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK	OK	OK
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	OK, N5	OK
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK	OK		OK
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK, N2	OK		OK
B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	N3		OK

B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK		OK
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK	OK		OK
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	OK	OK		SCT does not support
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53			Not supported	IED does not support
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK	OK	OK
C	Engineering with ICT						
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	OK	OK	OK	OK, N8
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK	OK	OK	OK
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK	OK		OK
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐	OK	OK		OK
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK	OK	OK	OK
D	Verify IED behaviour						

D0	verify step A2	Connect with a test client to the IED	☐	OK	OK	OK	OK
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐	OK	OK	N6	OK
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28	OK	OK		OK
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210	OK	Not supported by ICT of ABB		IED does not support
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28	OK	OK		OK
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers		OK	OK	OK	OK
E	Update SCD file						
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐	OK	OK	N7	N9
E2	Update data flow based on updated ExtRefs			OK	OK	OK	OK
E3	Export updated SCD file		☐	OK	OK		OK
F	SCD file inspection						
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐	OK	OK	OK	OK
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK	OK	OK

N1 – Original IEDName in ICD was not “Template”

N2 - Because in Service section for Configurable DS modify=false, we have problem to reengineer Dataset that has been created by SCT. SCT is not allowed to change it after export and reimport of SCD file.

N3 - Unable to create an HMI

N4 - Verified by tool that KF2 is not allowing reporting.

N5 - OSI parameters are not in ICD file thus it is expected that SCT should maintain that. It hasn’t. Problem fixed with importing IID file.

N6 - Control Issued from Client simulation, but problems with simulation (roundtrip GOOSE is seen in Wireshark, issued Control is seen and rejection with LastAppError, but Simulator is not seeing those GOOSE messages)

N7 - Import with errors (substation level is having connectivity Nodes that are not connected) SCT should see this as error (to report as warning and ignore it at import).

N8 – Warning was generated about “English not being supported”.

N9 – SCT generated undiagnosed error.

Table 18: SCL Test Case 2 - Result Set 4

			Results				
			SCT	**Siemens**	**Schneider**	**Schneider**	**Schneider**
	Test Step	**Verification**	**ICT**	**GE**	**Efacec**	**Alstom**	**GE**
A	Engineering with SCT						
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation		OK	OK	OK	
A1	SCT imports ICD files for HV bay controllers and creates the instances of IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1	SCT is able to import ICD files and to create instances	☐ S11 – S15 S111	N1	OK	OK	OK
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	OK	OK
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	OK	OK	OK
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK	OK	See test case 4 with Schn GE and SUB done the same day

A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK		OK	OK
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56	Not supported	OK	Not supported by IED	
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK		OK	OK See test case 4 with Schn GE and SUB done the same day
B	SCD File inspection						
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK	OK	OK
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	OK	OK
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK	OK	OK	OK
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK	OK	OK	OK

B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	OK	OK	OK
B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK		OK	OK
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK		OK	OK
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	Not supported (ExtRef only)		OK	OK
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53			OK	
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK		OK	OK
C	Engineering with ICT						
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	N2, N3	OK	OK	N4
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	Manually	OK	OK	OK
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	Manually	OK	OK	OK
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐	OK		OK	

C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK		OK	
D	Verify IED behaviour						
D0	verify step A2	Connect with a test client to the IED	☐	OK	OK	N5	OK
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐		OK	OK	OK
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28		OK	OK	OK
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210				
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28			OK	OK
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers				OK	OK
E	Update SCD file						
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐		OK	OK	
E2	Update data flow based on updated ExtRefs				OK	OK	
E3	Export updated SCD file		☐		OK	OK	
F	SCD file inspection						
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐			OK	
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation				OK	

N1 - Late binding not. N2 - Error occur during import (message related too private sections). Should ignore. N3 – Import of .scd failed. Where can dataset and GCB/RCB need to be created. N4 – ICT could not import SCD with private data within a dataset. N5- The ICT removes the ClientLN and also the IEDname in the GOOSE control block.

Table 19: SCL Test Case 2 - Result Set 5

			Results				
			SCT	Schneider	Schneider		
	Test Step	Verification	ICT	Schweitzer	Subnet		
A	Engineering with SCT						
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation		OK	OK		
A1	SCT imports ICD files for HV bay controllers and creates the instances of IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1	SCT is able to import ICD files and to create instances	☐ S11 – S15 S111	OK	OK		
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK		
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	OK		
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK		

A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK	OK		
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56	Not supported			
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK	OK		
B	SCD File inspection						
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK		
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK		
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK	OK		
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK	OK		
B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	OK		

B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK		
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK	OK		
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	OK for GOOSE	OK		
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53	No parameters modified in A6	OK		
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK		
C	Engineering with ICT						
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	OK	OK		
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK	Latter binding done. No configurati on needed.		
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK	OK		
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐	OK	OK		

C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK	OK		
D	Verify IED behaviour						
D0	verify step A2	Connect with a test client to the IED	☐	OK	OK		
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐	OK	OK		
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28	OK	OK		
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210		OK		
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28	OK	OK		
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers		OK	OK		
E	Update SCD file						
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐	OK	OK		
E2	Update data flow based on updated ExtRefs			OK	OK		
E3	Export updated SCD file		☐	OK	OK		
F	SCD file inspection						
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐	OK	OK		
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK		

Table 20: SCL Test Case 2 - Result Set 6

2.5 Test Case 3: Reimport of IID file for modification during system engineering – interoperability between ICT and SCT

2.5.1 SCL use case

		Reimport of IID
1	SCT	Exports SCD file
2	ICT-n	imports IED configuration into ICT from SCD file
3	ICT-n	User modifies the data model (e.g. add or remove a data object
4	ICT-n	exports IID file with changed configuration
5	SCT	imports IID file
6	SCT	integrates IID changes into system configuration; i.e. it updates the IED section and use the added data object as required
7	SCT	exports SCD
8	ICT	imports SCD

2.5.2 Purpose of the test

1	To verify the ability of an ICT to import an SCD file, do modifications of the data model and re-export the IID file with no changes to areas that are in the scope of the SCT.
2	To verify the ability of an SCT to import an IID file and to update a IED section in the already partly configured substation based on the import

Note: This test is similar to test case 1, but the assumption is that the IID / XFactor file of IED AA1D1Q01KF1 is not complete; i.e. the data object RBRF.OpEx (or the whole LN RBRF) is missing. This is discovered in the middle of the engineering process. The modification of the data model will be made in the ICT and a reimport of the model into the SCT is made through the IID file.

2.5.3 Test setup

Test Case ID	**SCL.3**
Test Case Name	Reimport of IID file for modification
Participant SCT	SCT tool with the scope to engineer the whole substation
Participant ICT	ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File - IID/XFactor files for all the other IEDs and the HMI and Gateway
Participant SCT	Prepares - SCT with SSD and IID/XFactor files from test support already processed (SICS S23, S41) -
Participant ICT	Prepares - ICT with IID/XFactor files for IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 prepared (SICS I11-I16, I114) - In ICT for AA1D1Q01KF1, the signal RBRF.OpEx is missing

2.5.4 Test case description and results

Results					
			SCT	NARI	Schneider
	Test Step	Verification	ICT	Efacec	Alstom
A	Engineering with SCT				
A1	Engineering of the system up to step A4 of test case 1 (chapter 2.3.4)			OK	
A2	SCT exports SCD file	SCT is able to produce SCD file at any time in the design process	☐ S61. S62, S64, S66, S67	OK	
B	SCD File inspection				
B1	verify that the SCD file corresponds to test case 1 with steps A1 to A4 done		☐	OK	
B2	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK	
C	Data model modification with ICT				
C1	ICT imports SCD file	ICT is able to import SCD file	☐ I21, I22	OK	OK
C2	Missing data object is added with ICT. Already used data objects and control blocks are not allowed to be modified			OK	OK
C3	ICT exports the IID		☐ I35	OK	OK
D	IID inspection				

	Results				
			SCT	NARI	Schneider
	Test Step	**Verification**	**ICT**	**Efacec**	**Alstom**
D1	Verify step C2	Verify that already engineered information like datasets and report control blocks or IP addresses have not been changed.	☐ I35	OK	N1
D2	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK	OK
E	Continue engineering with SCT				
E1	Import IID file in SCT and update data model	SCL is able to import the file and update the data model only; keeping already engineered elements	☐ S110	OK	OK
E2	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK	OK
E3	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK	OK
F	SCD File inspection				
F1	verify step E2	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK
F2	verify step E2	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S36, S56	OK	OK

			Results		
			SCT	NARI	Schneider
	Test Step	Verification	ICT	Efacec	Alstom
F3	Verify step E2	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	Not supported	OK
F4	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK
G	Engineering with ICT				
G1	ICT imports SCD file	ICT is able to import SCD file and use it to configure IED AA1D1Q01KF1	☐ I21, I22	OK	OK
G2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK	OK
G3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK	OK
H	Verify IED behaviour				
H1	verify step E2 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE	☐ I25 – I28	OK	Not implemented in the IED
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers	☐	OK	OK
N1 - The ICT remove the ClientLN and also the IEDname in the GOOSE control block.					

Table 21: SCL Test Case 3 Results

2.6 Test case 4: interoperability between ICT of station level device (gateway and HMI) and SCT

2.6.1 SCL use case

		Interoperability between station level ICT and SCT
1	SCT	Add a ClientLN to an instance of a report control block
2	ICT-Client	Imports SCD file
3	ICT-Client	Prepares data structures to receive information configured in SCD file
4	ICT-Client	Configures behavior of control objects in HMI according the ctlModel supported by the IED.

2.6.2 Purpose of the test

1	The ability of an ICT for a client device, to use the information from an SCD file for its engineering – example for an HMI to decide based on the value of ctlModel which control mechanism to use.
2	The ability of an ICT / IED to provide parameters and CF attributes and the ability of a ICT / client to use that information – example scaling of analogue values
3	The ability of an ICT for a client device, to accept subscriptions from reporting configured by the SCT.
4	The ability to manage preconfigured clients for buffered reporting

Note: This is an extension of test case 1 by adding the client ICT and the client instead of the IEC 61850 browser. If this test is execute in addition to SCL.1, the IED – in step C2 – only needs to be configured with regard to the client / server communication (reporting / control).

2.6.3 Test setup

Test Case ID	**SCL.4**
Test Case Name	Interoperability between station level ICT and SCT
Participant SCT	SCT tool with the scope to engineer the whole substation
Participant ICT	ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Participant ICT-cl	ICT tool for the client with the client. The client is preferably an HMI. If the client is a gateway, additional equipment needs to be provided by the test participant such that data received can be verified and controls can be sent to the IEDs.
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File - IID/XFactor files for all the other IEDs
Participant SCT	Prepares - SCT with SSD and IID/XFactor files from test support already

	processed (SICS S23, S41) -
Participant ICT	As test case 1 (chapter 2.3.3)
Participant ICT-cl	Prepares - IID file for HMI and Gateway
Post-condition on success	
The test is passed when the client successfully receives the information configured in the report control block and is able to control the breaker of the IED AA1D1Q01KF1.	

2.6.4 Test case description and results

In order to provide the results, several tables of results are provided. There are different combinations of SCTs and ICTs in each table. In order to provide easy access to the results, the following is provided so that readers can determine the result table that is of interest.

SCT Company							
ICT Company	ABB	Efacec	Helinks	Kalkitech	NARI	Schneider	Siemens
ABB		Table 24					
Alstom			Table 24				
Efacec						Table 23	
GE						Table 23	
Schweitzer		Table 23					
Subnet						Table 24	

Table 22: SCL Test Case 4- Company Test Result Lookup Information

Results						
			SCT	**Schneider**	**Schneider**	**Efacec**
	Test Step	**Verification**	**ICT**	**GE**	**Efacec**	**Schweitzer**
A	Engineering with SCT					
A1	steps A1 to A3 according to test case 1 (chapter 2.3.4)			See test case 2 results	OK	Ok
A2	SCT imports IID/XFactor files for gateway and HMI and adds these to the design		☐ S11 – S15 S111	OK	OK	Ok
A3	SCT adds the gateway and HMI to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	Ok

Results						
			SCT	Schneider	Schneider	Efacec
	Test Step	**Verification**	**ICT**	**GE**	**Efacec**	**Schweitzer**
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED)	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK	Ok
A5	SCT configures clientLN and trgOps for report control block and creates subscriptions for client		-	OK	OK	Ok
A6	SCT configures breaker control for AA1/D1/Q01/QA1			Not supported		
A6	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK	OK	N1
B	SCD File inspection					
B1	verify step A2	In the SCD file, verify that two IED sections have been added for the gateway and the HMI	☐	OK	OK	Ok
B2	verify step A3	In the SCD file, verify that the HMI and gateway have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	Ok
B3	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK	OK	Ok
B4	verify step A5	In the SCD file, verify that the ClientLN and data subscription are configured	☐ S36 – S39, S56	OK	OK	Ok
B5	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK	OK

	Results					
			SCT	Schneider	Schneider	Efacec
	Test Step	**Verification**	**ICT**	**GE**	**Efacec**	**Schweitzer**
C	Engineering with ICT for the IED					
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	OK	OK.	Ok
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	N1	OK	OK
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK	OK	Ok
D	Engineering with ICT for the client / gateway					
D1	ICT imports SCD file	ICT is able to import SCD file	☐ I21, I22	OK	OK	N1
D2	Final HMI / Gateway engineering as required	ICT uses information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK	OK	N2
D3	ICT configures the gateway / HMI	Gateway / HMI can be configured	☐	OK	OK	
E	Verify system behaviour					

Results						
			SCT	Schneider	Schneider	Efacec
	Test Step	Verification	ICT	GE	Efacec	Schweitzer
E1	Gateway or HMI connects to the IED	Verify that the connection is established automatically by the client based on the configuration	☐	OK	OK	
E2	verify step A4 / A5	Verify that gateway can enable its reserved report control blocks	☐	Not tested	OK	
E3	Initiate breaker operation from the client	Verify that the breaker operates	☐	N2	OK	
N1 - Checked File Name: ClientLN missing lnInst attribute in LLN0. N2 – ICT failed to pick up the correct report subscriptions.						

Table 23: SCL Test Case 4 Results – Set 1

Results						
			SCT	Efacec	Helinks	Schneider
	Test Step	Verification	ICT	ABB[1]	Alstom	Subnet
A	Engineering with SCT					
A1	steps A1 to A3 according to test case 1 (chapter 2.3.4)			OK	OK	OK
A2	SCT imports IID/XFactor files for gateway and HMI and adds these to the design		☐ S11 – S15 S111	OK	OK	OK
A3	SCT adds the gateway and HMI to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	OK

[1] ABB provided ICD files only for the test.

Results						
			SCT	Efacec	Helinks	Schneider
	Test Step	**Verification**	**ICT**	**ABB**[1]	**Alstom**	**Subnet**
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED)	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK	OK
A5	SCT configures clientLN and trgOps for report control block and creates subscriptions for client		-	OK	OK	OK
A6	SCT configures breaker control for AA1/D1/Q01/QA1			N1	OK	
A6	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK	OK	OK
B	SCD File inspection					
B1	verify step A2	In the SCD file, verify that two IED sections have been added for the gateway and the HMI	☐	OK	OK	OK
B2	verify step A3	In the SCD file, verify that the HMI and gateway have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	OK
B3	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK	OK	OK
B4	verify step A5	In the SCD file, verify that the ClientLN and data subscription are configured	☐ S36 – S39, S56	OK	OK	OK
B5	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK	OK

Results						
			SCT	Efacec	Helinks	Schneider
	Test Step	**Verification**	**ICT**	**ABB[1]**	**Alstom**	**Subnet**
C	Engineering with ICT for the IED					
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	N2	OK	OK
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43		OK	OK
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐		OK	OK
D	Engineering with ICT for the client / gateway					
D1	ICT imports SCD file	ICT is able to import SCD file	☐ I21, I22		OK	OK
D2	Final HMI / Gateway engineering as required	ICT uses information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43		OK	OK
D3	ICT configures the gateway / HMI	Gateway / HMI can be configured	☐		OK	OK
E	Verify system behaviour					

Results						
			SCT	Efacec	Helinks	Schneider
	Test Step	**Verification**	**ICT**	**ABB[1]**	**Alstom**	**Subnet**
E1	Gateway or HMI connects to the IED	Verify that the connection is established automatically by the client based on the configuration	☐		OK	OK
E2	verify step A4 / A5	Verify that gateway can enable its reserved report control blocks	☐		OK	OK
E3	Initiate breaker operation from the client	Verify that the breaker operates	☐		OK	OK
N1 - Control model is fixed and not configurable by SCT. N2 - SCT does not support/declare the substation section. ICT crashes.						

Table 24: SCL Test Case 4 Results – Set 2

2.7 Test case 5: Engineering exchange between two projects – interoperability between two SCT

2.7.1 SCL use case

		Engineering exchange between projects
1	SCT-1	Exports an SED file having one IED with data flow engineering right
2	SCT-1	Modification of data with respect to the exported IED is blocked
3	SCT-2	Imports SED file
4	SCT-2	Engineering of GOOSE subscription between imported IED and own IED
5	SCT-2	Exports an SED file containing both IEDs
6	SCT-1	Imports SED file
7	SCT-1	Exports SCD file

2.7.2 Purpose of the test

1	The ability to exchange information through SED files
2	The ability to configure the subscription of a GOOSE message from project A within IED(s) of project B

2.7.3 Test setup

Test Case ID	SCL.5
Test Case Name	Engineering exchange between projects
Participant SCT	SCT-1 tool with scope project A and respective IEDs
Participant SCT-2	SCT-2 tool with scope project B and respective IEDs, engineering of a GOOSE subscription with an IED of project A
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File - IID/XFactor files for all the other IEDs
Participant SCT	- SCD with project A IEDs (IED1, IED2)
Participant SCT-2	- SCD with project B IEDs (IED3)
Post-condition on success	
The test is passed when SCT-1 is deemed to have accepted the SED file from SCT-2. This includes the GOOSE publishing/subscription information for an IED of project B. The verification will be made based on the content of the resulting SCD file.	

2.7.4 Test case description and results

			Results			
			SCT A	Kalkitech	ABB	ABB
	Test Step	Verification	SCT B	ABB	Kalkitech	Siemens
A	Export of SED from SCT-1					
A 1	SCT-1 imports SCD of project A	Verify that it contains at least two IEDs (one server and one client) in a SubNetwork with addresses, and data flow from IED2 (server) to IED1 (client).	☐	OK	OK	OK
A 2	Export an SED file for IED2 (server) with data flow engineering right		☐	OK	OK	OK
A 3	Check the exported file against the XML schema	The XML schema test is successful. The relevant parts of Substation section and Communication section are contained in the SED file.	☐	OK	OK	OK
A 4	Check that the access rights for IED1 (client) is fix, and for IED2 is dataflow	In the SED the correct engineering rights are added at the IED engRight attribute, and the IED owner information set to the system identification (ID of system project SCD header). The SCT-1 shows the	☐ S81 S83	OK	OK	OK

			Results			
			SCT A	Kalkitech	ABB	ABB
	Test Step	**Verification**	**SCT B**	**ABB**	**Kalkitech**	**Siemens**
		IED engineering right as ‘fix’.				
A 5	Try to modify IED2 data sets	SCT-1 does not allow the modification; the IED engineering right is shown as ‘fix’	☐ S83	OK	OK	OK
A 6	Try to modify IED name of IED2	SCT-1 does not allow the modification; the IED engineering right is shown as ‘fix’	☐ S83	OK	OK	OK
A 7	Try to modify IED2 by importing an ICD or IID file	SCT-1 does not allow the modification; the IED engineering right is shown as ‘fix’	☐ S83	OK	OK	OK
A 8	Try to delete IED2	SCT-1 does not allow the deletion; the IED engineering right is shown as ‘fix’	☐ S83	OK	OK	OK
B	Engineering with SCT-2					
B 1	SCT-2 imports SCD of project B	Verify that it contains at least one IED3 different from project A	☐			
B 2	Import the SED file from step A2		☐			
B 3	Engineer the data flow from the imported IED2 to the existing IED3 (GOOSE)		☐			
B 4	Export an SED file from SCT-2 containing the imported IED2 as well as IED3		☐			
C	Import of SED from SCT-2 into SCT-1					

			Results			
			SCT A	Kalkitech	ABB	ABB
	Test Step	Verification	SCT B	ABB	Kalkitech	Siemens
C 1	SCT-1 with project A (after steps A1-A8) imports SED file from step B4		☐			
C 2	Check that IED2 and the data flow engineered from/to IED3 are contained	The imported IED3 and the imported data flow between IED2 and IED3 (GOOSE) are shown in SCT-1	☐ S82			
C 3	Check that the IED2 previously exported with data flow right now again has full engineering right within the project	SCT-1 allows again to modify IED2 related data (sets)	☐ S82			
C 4	Export SCD file from SCT-1	Verify that this SCD includes the GOOSE publishing/subscription information for IED3	☐			

Table 25: SCL Test Case 5 Results

2.8 Test Case 6: Interoperability between SCTs – Project realization with two SCT

2.8.1 SCL use case

		System Design
1	SCT-2	Exports a SCD with IEDs from a vendor A and partly configured data flow and communication sections
2	SCT-1	Imports SCD file
3	SCT-1	Adds the missing IEDs
4	SCT-1	Completes data flow required to implement protection and control schemes
5	SCT-1	Completes communication parameters
6	SCT-1	Exports SCD file
7	SCT-2	Imports SCD file and finalizes the engineering and configuration of the vendor A IEDs

Note: The use case here is not directly described in IEC 61850-6 but provides a practical use case that exists in the real world today where a vendor tool (a mixture of ICT and SCT; denominated as SCT-2 in the test case) exports an SCD file with multiple IED instances and potentially already preconfigured communication.

2.8.2 Purpose of the test

1	To verify that SCT-2 can export an SCD file containing vendor A devices and that this SCD file can be imported by SCT-1.
2	To verify that SCT-1 can make changes, e.g. add vendor B devices, engineer further the configuration, export the modified SCD file and that this SCD file can be imported by SCT-2 without any manual configuration.

2.8.3 Test setup

Test Case ID	SCL.6
Test Case Name	Interoperability between SCTs
Participant SCT	SCT-1 tool with the scope to add the remaining IEDs and configure the peer to peer signals of IED AA1D1Q01KF1 with the other IEDs
Participant SCT-2	SCT-2/ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File - IID/XFactor files for all the other IEDs
Participant SCT	-
Participant SCT-2	SCD with IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1
Post-condition on success	
The test is passed when SCT-2 is deemed to have accepted the complete SCD file from SCT.	

This includes the communication addresses and GOOSE publishing/subscription information for IED AA1D1Q01KF1. The verification will be made based on the content of the SCD file.
Testbed
As described in 2.3.1.

2.8.4 Test case description and results

Results				
			SCT	NARI
	Test Step	Verification	ICT	Kalkitech
A1	SCT-2 exports SCD file	SCT-2 is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK
A2	SCT-1 imports SCD file	SCT-1 is able to import SCD file without any manual editing	☐	OK
A3	SCT-1 imports ICD/IID/XFactor files for remaining IEDs	SCT-1 is able to import ICD/IID/XFactor file	☐ S11-S15 S111	OK
A4	SCT-1 adds remaining IEDs to the already existing subnetwork and engineers the communication		☐ S21 S22	OK
A5	SCT-1 associates the LNs in the new IEDs to the related LNs in the single line diagram / substation section		☐ S43	OK

Results				
			SCT	NARI
	Test Step	Verification	ICT	Kalkitech
A6	SCT-1 configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function for D1/Q01/QA1 (if supported by IED)		☐ S36 – S39, S56	OK
A7	SCT-1 exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK
A8	SCT-2 imports SCD file	SCD file is accepted without any manual editing	☐	OK
B	SCD File inspection			
B2	verify step A3	In the SCD file, verify that IED sections have been added for the additional IEDs		OK

Results				
			SCT	NARI
	Test Step	Verification	ICT	Kalkitech
B3	verify step A4	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S21 S22	OK
B4	verify step A5	In the SCD file, verify the association of the LNs from the new LNs with the respective LNs in the substation section	☐ S43	OK
B5	verify step A6	In the SCD file, verify that the data subscription is configured (from IED AA1D1Q01FN1)	☐ S37 – S39, S56	OK

Results				
			SCT	NARI
	Test Step	Verification	ICT	Kalkitech
B6	verify step A6	In the SCD file, verify that GOOSE control block and data sets are configured (to IEDs AA1D1Q02KF1, AA1D1Q03KF1, AA1D1Q04KF1, AA1D1Q05KF1 and AA1H1Q01FN1	☐ S31 - S36, S56	OK

Table 26: SCL Test Case 6 Results

2.9 Test Case 7: Interoperability between SCTs – Use of existing SCD file

2.9.1 SCL use case

		System Design
1	SCT-2	Exports the SCD file
2	SCT-1	Imports the SCD file
3	SCT-1	Modifies the project configuration
4	SCT-1	Exports SCD file

2.9.2 Purpose of the test

1	To verify the ability of a SCT to reuse the SCD file of an already designed project from another SCT for future modifications in the design
2	To verify the portability of single line diagrams between SCTs

Note: This test can use SCD files produced in SCL.1 or SCL.2 as a starting point.

2.9.3 Test setup

Test Case ID	SCL.7
Test Case Name	Interoperability between SCT – Use of existing SCD file
Participant SCT-2	SCT-2 tool used for the design of the substation
Participant SCT	SCT-1 tool used for future modifications
Pre-conditions (Preparation done prior to IOP)	
Test Support	Delivers - Tool to create CID files - Modified IID/XFactor file for AA1D1Q01FN1 with an additional LN PTOC2
Participant SCT-1	-
Participant SCT-2	Prepares - SCD of the whole design
Post-condition on success	
The test is passed when SCT-1 can import the SCD file, do the modification and the result is functionally identical except the modifications that have been made. This is verified through CID files produced by a tool supplied from testing support.	

2.9.4 Test case description and results

			Results				
			SCT1	**Kalkitech**	**Kalkitech**	**Schneider**	**Siemens**
	Test Step	**Verification**	**SCT2**	**Schneider**	**Siemens**	**Kalkitech**	**Kalkitech**
A	Engineering with SCT-1						
A1	SCT-1 imports SCD file	SCT is able to import SCD file without any manual editing	☐	OK	OK	OK	OK, N1
A2	SCT-1 imports IID/XFactor file of modified IED	SCT is able to import IID/XFactor file	☐ S11-S15 S111	OK	OK	OK	N2
A3	SCT-1 associates new LN to single line diagram / substation section		☐ S43	OK	OK	OK	OK
A4	SCT-1 exports SCD file		☐ S61. S62, S64, S66, S67	OK	OK	OK	OK
B	SCD File inspection						
B1	verify A2	In the SCD file, verify that the data model of IED AA1D1Q01FN1 contains the new LN	☐	OK	OK	OK	OK
B2	verify A3	In the SCD file, verify the association of the new LN to the single line diagram / substation section. It shall be associated at the same hierarchical level as	☐	OK	OK		OK

			Results				
			SCT1	**Kalkitech**	**Kalkitech**	**Schneider**	**Siemens**
	Test Step	**Verification**	**SCT2**	**Schneider**	**Siemens**	**Kalkitech**	**Kalkitech**
		PTOC1.					
C	compare CID files						
C1	produce CID file of IED AA1D1Q01FN1 (IED sending the GOOSE message) and IED AA1D1Q01KF1 (IED subscribing the GOOSE message) from the original SCD and from the new SCD			OK	OK		OK
C2	Compare CID files for IED AA1D1Q01FN1	Verify that GOOSE messages are identical and that the new LN is in the data model	☐	OK	OK		OK
C3	Compare CID files for IED AA1D1Q01KF1	Verify that ExtRefs and that the GOOSE configuration of the subscribed GOOSE (in IED section of IED AA1D1Q01FN1) are identical	☐	OK	OK		OK
N1 - When configuring trigger options, SCT1 tool crashed. N2 – Manually fixed SCD file to bind all signals at DA level.							

Table 27: SCL Test Case 7 results

2.10 Test Case E1: System specification with virtual IEDs and exchange between SSTs

2.10.1 SCL use case

		System Design
1a	SST-1	Exports the SSD file for one bay type (including virtual IEDs)
1b	SST-2	Creates template for second bay type (including virtual IEDs)
2	SST-2	Imports the SSD file
3	SST-2	Creates the substation from the two templates
4	SST-2	Defines the signal flow for the substation
5	SST-2	Exports SSD file

Note: The same test can be run in parallel with exchanged roles between the two SSTs

2.10.2 Purpose of the test

1	To verify the ability of an SST to create a bay template with virtual IEDs
2	To verify the ability of an SST to import and use bay templates with virtual IEDs from other SSTs

2.10.3 Test setup

Test Case ID	SCL.E1
Test Case Name	System specification with virtual IEDs and exchange between SSTs
Participant SST-1	SST-1 tool used to produce a bay template
Participant SST-2	SST-2 tool used for the design of the substation
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - Detailed specification for SSD file (function modelling; virtual IEDs)
Participant SST-1	Prepares - SSD with template of the TF HV Bay including signal flow to gateway / HMI
Participant SST-2	Prepares - SSD with template of OHL Bay including signal flow to gateway / HMI
Post-condition on success	
The test is passed when exported SSD file is validated against schema and confirmed to have in its structure both bay templates	

2.10.4 Test case description and results

Results				
			SST1	Helinks
	Test Step	Verification	SST2	Schneider
A	Export of SSD from SST-1			
A1	SST-1 exports SSD file		☐	OK
B	Inspection of SSD file			
B1	Verify substation section	Inspect substation section to include the elements specified	☐	OK
B2	Verify virtual IEDs in IED sections	Inspect IED section and verify data model of virtual IEDs to be in line with specification	☐	OK
B3	Verify binding	Inspect binding of LNs in substation section to virtual IED	☐	OK
C	Create Substation Specification in SST-2			
C1	Create instances of own bay templates for OHL bays			OK
C2	Import SSD file for TF HV bay	Import successful	☐	OK
C3	Create instances for TF HV bay			OK
C4	Add additional bays without template			
C5	Define signal flow between IEDs for functions			OK
C6	Export SSD file			
D	Inspection of SSD file			
D1	Verify step C1	In the SSD file, verify the two bays D1/Q01 and D2/Q02	☐	OK
D2	Verify step C3	In the SSD file, verify the two bays D1/Q01 and D1/Q04	☐	

Results				
			SST1	Helinks
	Test Step	Verification	SST2	Schneider
D3	Verify step C4	In the SSD file, verify the bays D1/Q05 and H1/Qxx	☐	
D4	Verify step C5	In the SSD file, verify the ExtRefs and the GOOSE control blocks	☐	

Table 28: SCL Test Case E1 results

2.11 Test Case E2: System design – specification with virtual IEDs and mapping to real IEDs in design

2.11.1 SCL use case

		System Design – top down with virtual IEDs
1	ICT, ICT-b	Preconfiguration of ICD file with IED tool as needed
2	ICT	Export ICD file
3	SCT	Import SSD file
4	SCT	Import ICD files
5	SCT	create instances of the IEDs and the mapping of IED instances to virtual IEDs in design
6	SCT	update data flow required to implement protection and control schemes to match the real IEDs
7	SCT	update data flow required for local HMI implementation to match the real IEDs
8	SCT	update data flow required for SCADA communication to match the real IED
9	SCT	design communication parameters
10	SCT	export SCD file
11	ICT, ICT-b	import SCD file
12	ICT, ICT-b	detail engineering IED-n
13	ICT, ICT-b	create CID-n or private configuration file

2.11.2 Purpose of the test

1	To verify the ability of an SCT to deal with an SCD file with pre-configuration using virtual IEDs
2	To verify the ability of ICTs to accept configurations from an SCD file

2.11.3 Test setup

Test Case ID	SCL.E2
Test Case Name	System design with virtual IEDs and mapping to real IEDs
Participant SCT	SCT to produce the design
Participant ICT	ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Participant ICT-b	ICT tool for the IEDs AA1D1Q01FN1, AA1D1Q02FN1, AA1D1Q03FN1 and AA1D1Q04FN1 with IED AA1D1Q01FN1
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File with virtual design done in test E1 from a SST other than the Participant SST - ICD files for breaker controller and the HMI and Gateway
Participant SCT	-

Participant ICT	Prepares - ICT with either one ICD files for all bay controllers of the HV bays or one ICD for bay controller of HV transformer bay (IED AA1D1Q01KF1 and AA1D1Q04KF1) and a second ICD file for bay controller of OHL bay (IED AA1D1Q02KF1 and AA1D1Q03KF1) prepared (SICS I11-I16, I114) (Note: IED AA1D1Q01KF1 is the IED that will be physically present in the test)
Participant ICT-b	Prepares - ICT with ICD for transformer bay protection (Note: IED AA1D1Q01FN1 will be physically present and the only functionality required is to generate a trip signal towards breaker D1/Q01/QA1)
Post-condition on success	
The test is passed when the ICT is deemed to have accepted the revised SCD file. This includes GOOSE subscription to the IED contained within the pre-built SCD file. The verification will be made based on the configuration downloaded from the ICT to the IED in the testbed environment as described below.	

2.11.4 Test case description and results

	Test Step	Verification	ok SICS	Remarks / Observations
A	Engineering with SCT			
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation		
A1	SCT imports SSD file	SCT is able to import SSD file	☐	
A2	SCT imports ICD file for HV bay controllers and creates the instances of IED AA1D1Q01KF1 and maps it to the corresponding virtual IED of the SSD	SCT is able to import ICD files and to create instances and map it to virtual IED	☐ S11 – S15 S111	
A3	SCT imports ICD file for HV TF bay protection and creates the instances of IED AA1D1Q01FN1 and maps it to the corresponding virtual IED of the SSD	SCT is able to import ICD files and to create instances and map it to virtual IED	☐ S11 – S15 S111	
A4	SCT creates subnetwork and adds the IEDs modifying possibly predefined addressing information as required		-	
A5	SCT configures datasets and report control blocks based on the data flow configured in the virtual design (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	
A6	SCT configures GOOSE control blocks and associated datasets to implement the signal flow defined in the virtual design	verify that tool does not provide capability to configure / change dataset and GOOSE control block if	☐ S56	

		not allowed by IED	
A7	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56
A8	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67
B	SCD File inspection		
B1	verify step A2 and A3	In the SCD file, verify that IED sections have been added for these IEDs	☐
B2	verify step A4	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22
B3	verify step A2 and A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43
B4	verify step A5	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56
B5	Verify step A5	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361
B6	verify step A6	In the SCD file, verify that the data	☐

		subscription is configured (input section)	S37 – S39, S56
B7	verify step A6	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56
B8	Verify step A6	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361
B9	verify step A7	In the SCD file, verify that the parameters are initialized	☐ S53
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation	
C	Engineering with ICT		
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐
C5	Check IID files	Run IID file through various SCL checkers and validators; report	

		results for documentation	
D	Engineering with ICT-b		
D1	ICT-b imports SCD file	ICT-b is able to import SCD file and create the instances of the IED AA1D1Q01FN1 in the ICT-b	☐ I21, I22
D2	Final IED engineering as required	ICT-b uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43
D3	ICT-b configures the IED AA1D1Q01FN1	IED can be configured	☐
D4	ICT-b exports IID file	ICT-b is able to produce IID file with updated ExtRefs	☐
D5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation	
E	Verify IED behaviour		
E0	verify step A2	Connect with a test client to the IED AA1D1Q01KF1	☐
E1	Verify step A6	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐
E2	verify step A5	Verify that reports are sent from IED AA1D1Q01KF1 to the test client with the content as configured by the SCT	☐ I25 - I28
E3	verify step A7	Read the parameters from RBRF with the test client; verify the values	☐ I210
E4	verify step A2	Connect with a test client to the IED AA1D1Q01FN1	☐
E5	verify step A5	Verify that reports are sent from IED	☐

		AA1D1Q01FN1 to the test client with the content as configured by the SCT	I25 - I28
E6	verify step A6 1. In IED AA1D1Q01FN1 trigger GOOSE message to initiate BF	Verify RBRF.Str to become TRUE	☐ I25 – I28
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers	
F	Update SCD file		
F1	SCT imports IID/XFactor file	SCT is able to import IID file	☐
F2	Update data flow based on updated ExtRefs		
F3	Export updated SCD file		☐
G	SCD file inspection		
G1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐
G2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation	

Table 29: SCL Test Case E2 results

2.12 Test Case M1: Bottom Up – Interoperability between SCT and ICT of Bay Level IED

2.12.1 SCL use case

		System Design – Bottom Up approach
1	ICT-n	Preconfiguration of IED and creation of instances as needed with ICT-n
2	ICT-n	Export IID/XFactor files
3	SCT	Import SSD file
4	SCT	Import IID/XFactor files
5	SCT	create binding of IEDs to process in single line diagram
6	SCT	design data flow required to implement protection and control schemes
7	SCT	design data flow required for local HMI implementation
8	SCT	design data flow required for SCADA communication
9	SCT	design communication parameters
10	SCT	export SCD file
11	ICT-n	import SCD file
12	ICT-n	detail engineering IED-n
13	ICT-n	create CID-n or private configuration file
14	ICT-n	export IID/XFactor file with updated ExtRefs
15	SCT	import updated IID/XFactor files
16	SCT	update data flow based on updated ExtRefs
17	SCT	create updated SCD file

NOTE: step 14 to 17 is needed if ExtRefs are supported and updated by the ICT.

2.12.2 Purpose of the test

1	To verify that SCT can import IID/XFactor files of IEDs and use those to create a valid SCD file.
2	The ability of an ICT, to accept modifications in the communication section (e.g. Subnet name, IP address), IED section (e.g. LN attribute lnType), and data type template section (e.g. LNodeType attribute id) as they are required to build a consistent SCD file.
3	To verify the ability of an ICT, to accept configurations of report control blocks and data sets from an SCD file as long as they are within the limits declared as part of the capabilities in the service section and or PIXITS.
4	To verify the ability of an ICT to accept configurations of GOOSE messages from an SCD file as long as they are within the limits declared as part of the capabilities in the service section and or PIXITS.
5	To verify that the ICT can import and use GOOSE subscription information from other IEDs contained within the SCD file.
6	To verify the ability of an ICT to accept configurations of initial values of parameters and CF attributes through the SCD file within the limits declared as part of the capabilities in the service section, declared through the valKind attribute and or PIXITS.

2.12.3 Test setup

Test Case ID	SCL.1
Test Case Name	Bottom-up, interoperability between ICT of bay level IEDs and SCT
Participant SCT	SCT tool with the scope to engineer the whole substation
Participant ICT	ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File - IID/XFactor files for all the other IEDs and the HMI and Gateway
Participant SCT	Prepares - SCT with SSD and IID/XFactor files from test support already processed (SICS S23, S41)
Participant ICT	Prepares - ICT with IID/XFactor files for IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 prepared (SICS I11-I16, I114) (Note: IED AA1D1Q01KF1 is the IED that will be physically present in the test)
Post-condition on success	
The test is passed when the ICT is deemed to have accepted the revised SCD file. This includes GOOSE subscription to the IED contained within the pre-built SCD file. The verification will be made based on the configuration downloaded from the ICT to the IED in the testbed environment as described below.	

2.12.4 Test case description and results

	Results					
			SCT	Schneider	Schneider	Siemens
	Test Step	Verification	ICT	ABB	Siemens	Schweitzer
A	Engineering with SCT					
A0	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK	OK	OK
A1	SCT imports IID/XFactor files for IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 and adds these IEDs to the design	SCT is able to import IID/XFactor files	☐ S11 – S15 S111	OK	OK	N4
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	OK	OK	
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	OK	OK	Only for ICT vendor relay is configured device to speed up
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK	OK	N5, N6, N7

Results						
			SCT	Schneider	Schneider	Siemens
	Test Step	**Verification**	**ICT**	**ABB**	**Siemens**	**Schweitzer**
A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK	OK	OK
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56	Not supported		Not supported
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	N1	OK	OK
B	SCD File inspection					
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐	OK	OK	OK
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK	OK	N4
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK	OK	

	Results					
			SCT	Schneider	Schneider	Siemens
	Test Step	Verification	ICT	ABB	Siemens	Schweitzer
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S35, S56	OK	OK	OK
B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK	OK	N5, N6, N7
B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK	OK	OK
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK	OK	Not supported
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	OK	OK	OK
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53			
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK	OK	
C	Engineering with ICT					
C1	ICT imports SCD file	ICT is able to import SCD file and use it for IED AA1D1Q01KF1	☐ I21, I22	OK	N3	OK, N8

Results						
			SCT	Schneider	Schneider	Siemens
	Test Step	**Verification**	**ICT**	**ABB**	**Siemens**	**Schweitzer**
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK		N9, N10

Results						
			SCT	Schneider	Schneider	Siemens
	Test Step	Verification	ICT	ABB	Siemens	Schweitzer
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK		CID is produced by ICT. Error loading .CID in the IED. Two corrections needed in the .CID file : 1. Goose Rev confrev ="1" 2. ICT added the namespace within the privates instead of keeping them within the SCL top node. It leads to issues during IID update in SCT. With corrections, relay->OK End of the validation because many manual modifications.

Results						
			SCT	Schneider	Schneider	Siemens
	Test Step	**Verification**	**ICT**	**ABB**	**Siemens**	**Schweitzer**
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐	OK		CID file renamed IID.
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK , N2		OK : SCL checker ICT didn't increment the revision of "H" item of attribute of history section.
D	Verify IED behaviour					
D0	verify step A2	Connect with a test client to the IED	☐	OK		
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐	OK		
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28	OK		
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210	OK		
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28	OK		
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers	☐	OK		
E	Update SCD file					
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐	OK		N11, N12

Results						
			SCT	Schneider	Schneider	Siemens
	Test Step	**Verification**	**ICT**	**ABB**	**Siemens**	**Schweitzer**
E2	Update data flow based on updated ExtRefs			OK		
E3	Export updated SCD file		☐	OK		
F	SCD file inspection					
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐	OK		
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation		OK		

Results					
		SCT	Schneider	Schneider	Siemens
Test Step	Verification	ICT	ABB	Siemens	Schweitzer

N1 – manual correction required to remove “”.

N2 - ICT didn’t increment the revision of “H” item of attribute of history section.

N3 – Unresolved error prevented further testing.

N4 - IP address and IED name were not provided in IID/CID.

N5 – There were restrictions to where the DataSet could be defined.

N6 – Standard needs to define the conversion of Edition 1 services to Edition 2 services.

N7 – ICT vendor had a single Control Model for the entire IED.

N8 - ICT relocates all datasets under the Logical Device CFG LN0.

N9 – Several warning generated: 16 characters limit is exceed for GCB name. “/” characters not supported for GOOSE name and report ID.
Goose Rev confrev =“0“not supported.

N10 – Manual mappings and bindings required.

N11 – ICT didn’t increment the history version. Therefore, SCT did not import the file.

N12 – Private information needed to be removed.

N13 – IntAdr(s) are not updated by ICT.

Table 30: SCL Bottom-up test case M1 results

2.13 Test Case M2: Top Down – Interoperability between SCT and ICT of Bay Level IED

Note: No testing occurred for this test case.

2.13.1 SCL use case

		System Design – Top Down approach
1	ICT-n	Preconfiguration of ICD file with IED tool as needed
2	ICT-n	Export ICD file
3	SCT	Import SSD file
4	SCT	Import ICD files
5	SCT	create instances of the IEDs and the binding of IED instances to process in single line diagram
6	SCT	design data flow required to implement protection and control schemes
7	SCT	design data flow required for local HMI implementation
8	SCT	design data flow required for SCADA communication
9	SCT	design communication parameters
10	SCT	export SCD file
11	ICT-n	import SCD file
12	ICT-n	detail engineering IED-n
13	ICT-n	create CID-n or private configuration file
14	ICT-n	export IID/XFactor file with updated ExtRefs
15	SCT	import updated IID/XFactor files
16	SCT	update data flow based on updated ExtRefs
17	SCT	create updated SCD file

NOTE: step 14 to 17 is needed if ExtRefs are supported and updated by the ICT.

2.13.2 Purpose of the test

1	To verify that SCT can import ICD files of IEDs and use those to create a valid SCD file.
2	The ability of an ICT, to accept modifications in the communication section (e.g. Subnet name, IP address), IED section (e.g. LN attribute lnType), and data type template section (e.g. LNodeType attribute id) as they are required to build a consistent SCD file.
3	To verify the ability of an ICT, to accept configurations of report control blocks and data sets from an SCD file as long as they are within the limits declared as part of the capabilities in the service section and or PIXITS.
4	To verify the ability of an ICT to accept configurations of GOOSE messages from an SCD file as long as they are within the limits declared as part of the capabilities in the service section and or PIXITS.
5	To verify that the ICT can import and use GOOSE subscription information from other IEDs contained within the SCD file.
6	To verify the ability of an ICT to accept configurations of initial values of parameters and CF attributes through the SCD file within the limits declared as part of the capabilities in the service section, declared through the valKind attribute and or PIXITS.
7	The ability of an ICT to accept instantiations of IEDs based on ICD files through an SCD file.

2.13.3 Test setup

Test Case ID	SCL.2
Test Case Name	Top-down, interoperability between ICT of bay level IEDs and SCT
Participant SCT	SCT tool with the scope to engineer the whole substation
Participant ICT	ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Pre-conditions (Preparations done prior to IOP)	
Test Support	Delivers - SSD File - ICD files for all the other IEDs and the HMI and Gateway
Participant SCT	Prepares - SCT with SSD and ICD files from test support already processed (SICS S23, S41)
Participant ICT	Prepares - ICT with either one ICD files for all bay controllers of the HV bays or one ICD for bay controller of HV transformer bay (IED AA1D1Q01KF1 and AA1D1Q04KF1) and a second ICD file for bay controller of OHL bay (IED AA1D1Q02KF1 and AA1D1Q03KF1) prepared (SICS I11-I16, I114) (Note: IED AA1D1Q01KF1 is the IED that will be physically present in the test)
Post-condition on success	
The test is passed when the ICT is deemed to have accepted the revised SCD file. This includes GOOSE subscription to the IED contained within the pre-built SCD file. The verification will be made based on the configuration downloaded from the ICT to the IED in the testbed environment as described below.	
Testbed	
As described in chapter 2.2.5.1	

2.13.4 Test case description and results

No testing occurred for this test case.

	Test Step	Verification	ok SICS	Remarks / Observations
A	Engineering with SCT			
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation		
A1	SCT imports ICD files for HV bay controllers and creates the instances of IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1	SCT is able to import ICD files and to create instances	☐ S11 – S15 S111	
A2	SCT adds the new IEDs to the already existing subnetwork modifying possibly predefined addressing information as required		-	
A3	SCT associates the LNs in the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 to the related LNs in the single line diagram / substation section		-	
A4	SCT configures datasets and report control blocks with the data required to be transmitted to the gateway and to the local HMI (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	

A5	SCT configures signal flow, GOOSE control blocks and associated datasets to implement the breaker failure protection function and breaker control for D1/Q01/QA1 (if supported by IED)	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56
A6	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56
A7	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67
B	SCD File inspection		
B1	verify step A1	In the SCD file, verify that four IED sections have been added for these IEDs	☐
B2	verify step A2	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22
B3	verify step A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56

B5	Verify step A4	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361
B6	verify step A5	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56
B7	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56
B8	Verify step A5	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361
B9	verify step A6	In the SCD file, verify that the parameters are initialized	☐ S53
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation	
C	Engineering with ICT		
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐

C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐	
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		
D	Verify IED behaviour			
D0	verify step A2	Connect with a test client to the IED	☐	
D1	Verify step A5	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐	
D2	verify step A4	Verify that reports are sent to the test client with the content as configured by the SCT	☐ I25 - I28	
D3	verify step A6	Read the parameters from RBRF with the test client; verify the values	☐ I210	
D4	verify step A5 1. Simulate GOOSE message to initiate BF	Verify RBRF.Str to become TRUE (if DO is present in model)	☐ I25 – I28	
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers		
E	Update SCD file			
E1	SCT imports IID/XFactor file	SCT is able to import IID file	☐	
E2	Update data flow based on updated ExtRefs			
E3	Export updated SCD file		☐	
F	SCD file inspection			
F1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐	
F2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation		

Table 31: SCL Top Down test case M2 results

2.14 Test Case M3: System design – specification with virtual IEDs and mapping to real IEDs in design

Note: No testing occurred for this test case.

2.14.1 SCL use case

		System Design – top down with virtual IEDs
1	ICT, ICT-b	Preconfiguration of ICD file with IED tool as needed
2	ICT	Export ICD file
3	SCT	Import SSD file
4	SCT	Import ICD files
5	SCT	create instances of the IEDs and the mapping of IED instances to virtual IEDs in design
6	SCT	update data flow required to implement protection and control schemes to match the real IEDs
7	SCT	update data flow required for local HMI implementation to match the real IEDs
8	SCT	update data flow required for SCADA communication to match the real IED
9	SCT	design communication parameters
10	SCT	export SCD file
11	ICT, ICT-b	import SCD file
12	ICT, ICT-b	detail engineering IED-n
13	ICT, ICT-b	create CID-n or private configuration file

2.14.2 Purpose of the test

1	To verify the ability of an SCT to deal with an SCD file with pre-configuration using virtual IEDs
2	To verify the ability of ICTs to accept configurations from an SCD file

2.14.3 Test setup

Test Case ID	SCL.E2
Test Case Name	System design with virtual IEDs and mapping to real IEDs
Participant SCT	SCT to produce the design
Participant ICT	ICT tool for the IEDs AA1D1Q01KF1, AA1D1Q02KF1, AA1D1Q03KF1 and AA1D1Q04KF1 with IED AA1D1Q01KF1
Participant ICT-b	ICT tool for the IEDs AA1D1Q01FN1, AA1D1Q02FN1, AA1D1Q03FN1 and AA1D1Q04FN1 with IED AA1D1Q01FN1
Pre-conditions (Preparations done prior to IOP)	

Test Support	Delivers - SSD File with virtual design done in test E1 from a SCT other than the Participant SCT - ICD files for breaker controller and the HMI and Gateway
Participant SCT	-
Participant ICT	Prepares - ICT with either one ICD files for all bay controllers of the HV bays or one ICD for bay controller of HV transformer bay (IED AA1D1Q01KF1 and AA1D1Q04KF1) and a second ICD file for bay controller of OHL bay (IED AA1D1Q02KF1 and AA1D1Q03KF1) prepared (SICS I11-I16, I114) (Note: IED AA1D1Q01KF1 is the IED that will be physically present in the test)
Participant ICT-b	Prepares - ICT with ICD for transformer bay protection (Note: IED AA1D1Q01FN1 will be physically present and the only functionality required is to generate a trip signal towards breaker D1/Q01/QA1)
Post-condition on success	
The test is passed when the ICT is deemed to have accepted the revised SCD file. This includes GOOSE subscription to the IED contained within the pre-built SCD file. The verification will be made based on the configuration downloaded from the ICT to the IED in the testbed environment as described below.	

2.14.4 Test case description and results

			SCT	Schneider
			ICT-1	ABB
			ICT-2	Schweitzer
	Test Step	**Verification**	**ok SICS**	**Remarks / Observations**
A	Engineering with SCT			
A0	Check ICD files	Run ICD file through various SCL checkers and validators; report results for documentation		OK
A1	SCT imports SSD file	SCT is able to import SSD file	☐	OK
A2	SCT imports ICD file for HV bay controllers and creates the instances of IED AA1D1Q01KF1 and maps it to the corresponding virtual IED of the SSD	SCT is able to import ICD files and to create instances and map it to virtual IED	☐ S11 – S15 S111	OK
A3	SCT imports ICD file for HV TF bay protection and creates the instances of IED AA1D1Q01FN1 and maps it to the corresponding virtual IED of the SSD	SCT is able to import ICD files and to create instances and map it to virtual IED	☐ S11 – S15 S111	OK
A4	SCT creates subnetwork and adds the IEDs modifying possibly predefined addressing information as required		-	OK
A5	SCT configures datasets and report control blocks based on the data flow configured in the virtual design (if supported by IED) including configuration of ClientLN and trgOps	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED	☐ S56	OK

			SCT	Schneider
			ICT-1	ABB
			ICT-2	Schweitzer
	Test Step	Verification	ok SICS	Remarks / Observations
A6	SCT configures GOOSE control blocks and associated datasets to implement the signal flow defined in the virtual design	verify that tool does not provide capability to configure / change dataset and GOOSE control block if not allowed by IED	☐ S56	OK
A7	SCT configures values for parameters of the breaker failure function like FailMod, ReTrMod and FailTmms (if supported by IED)	verify that tool does not offer to change parameter if not allowed	☐ S56	
A8	SCT exports SCD file	SCT is able to produce SCD file	☐ S61. S62, S64, S66, S67	OK
B	SCD File inspection			
B1	verify step A2 and A3	In the SCD file, verify that IED sections have been added for these IEDs	☐	OK
B2	verify step A4	In the SCD file, verify that the IEDs have been added in the communication section to the already existing subnetwork together with the other IEDs	☐ S22	OK
B3	verify step A2 and A3	In the SCD file, verify the association of the LNs from these IEDs with the respective LNs in the substation section	☐ S43	OK

			SCT	Schneider
			ICT-1	ABB
			ICT-2	Schweitzer
	Test Step	Verification	ok SICS	Remarks / Observations
B4	verify step A5	In the SCD file, verify that the report control blocks and data sets are configured	☐ S31 – S36, S56	OK
B5	Verify step A5	In the SCD file, verify that the clientLN element is configured for the report control blocks	☐ S361	OK
B6	verify step A6	In the SCD file, verify that the data subscription is configured (input section)	☐ S37 – S39, S56	OK
B7	verify step A6	In the SCD file, verify that GOOSE control block and data sets are configured	☐ S31 - S35, S56	OK
B8	Verify step A6	In the SCD file, verify that IEDName elements are configured for GOOSE and SV messages	☐ S361	OK
B9	verify step A7	In the SCD file, verify that the parameters are initialized	☐ S53	
B10	Check SCD file	Run SCD file through various SCL checkers and validators; report results for documentation		OK
C	Engineering with ICT			
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the IED AA1D1Q01KF1 in the ICT	☐ I21, I22	N1

			SCT	Schneider
			ICT-1	ABB
			ICT-2	Schweitzer
	Test Step	Verification	ok SICS	Remarks / Observations
C2	Final IED engineering as required	ICT uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured	☐	OK
C4	ICT exports IID file	ICT is able to produce IID file with updated ExtRefs	☐	OK
C5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		OK
D	Engineering with ICT-b			
D1	ICT-b imports SCD file	ICT-b is able to import SCD file and create the instances of the IED AA1D1Q01FN1 in the ICT-b	☐ I21, I22	OK
D2	Final IED engineering as required	ICT-b uses the subscription information from SCD Note: verification to be done by witness during test by observing what needs to be done in the IED tool by the engineer to create the binding of incoming eternal signals to internal signals	☐ I213, I42, I43	OK
D3	ICT-b configures the IED AA1D1Q01FN1	IED can be configured	☐	OK

			SCT	Schneider
			ICT-1	ABB
			ICT-2	Schweitzer
	Test Step	**Verification**	**ok** **SICS**	**Remarks / Observations**
D4	ICT-b exports IID file	ICT-b is able to produce IID file with updated ExtRefs	☐	N2
D5	Check IID files	Run IID file through various SCL checkers and validators; report results for documentation		
E	Verify IED behaviour			
E0	verify step A2	Connect with a test client to the IED AA1D1Q01KF1	☐	Ok
E1	Verify step A6	Operate the breaker D1/Q01/QA1 through AA1D1Q01KF1.CSWI	☐	Ok
E2	verify step A5	Verify that reports are sent from IED AA1D1Q01KF1 to the test client with the content as configured by the SCT	☐ I25 - I28	Ok
E3	verify step A7	Read the parameters from RBRF with the test client; verify the values	☐ I210	
E4	verify step A2	Connect with a test client to the IED AA1D1Q01FN1	☐	Ok
E5	verify step A5	Verify that reports are sent from IED AA1D1Q01FN1 to the test client with the content as configured by the SCT	☐ I25 - I28	Ok
E6	verify step A6 1. In IED AA1D1Q01FN1 trigger GOOSE message to initiate BF	Verify RBRF.Str to become TRUE	☐ I25 – I28	Ok
	2. simulate breaker to remain closed	analyse GOOSE message sent by IED to trip adjacent breakers		Ok
F	Update SCD file			
F1	SCT imports IID/XFactor file	SCT is able to import IID file	☐	Ok

			SCT	Schneider
			ICT-1	ABB
			ICT-2	Schweitzer
	Test Step	**Verification**	**ok SICS**	**Remarks / Observations**
F2	Update data flow based on updated ExtRefs			Ok
F3	Export updated SCD file		☐	Ok
G	SCD file inspection			
G1	Verify step E2	In the SCD file, verify that the ExtRefs of IED AA1D1Q01KF1 are updated based on what has been returned by the IID file for IED	☐	Ok
G2	Check SCD files	Run SCD file through various SCL checkers and validators; report results for documentation		Ok
N1- Problem due to reason that ABB is checking LdNs inside Data Model section. Will be manually bypassed (replacing 2007A with 2003). New file - SCT_SCLM3RSLT_SCHN_ABB_SEL_20151001_2003_FixedNs.scd. Again Tool crashed – fixed by importing only IED without substation section. **N2- No intAddr for SEL IED.**				

Table 32: SCL System Design test case M3 results

2.15 Test Case M4: Interoperability between SCTs – Use of existing SCD file

No testing occurred for this test case.

2.15.1 SCL use case

		System Design
1	SCT-2	Exports the SCD file
2	SCT-1	Imports the SCD file
3	SCT-1	Modifies the project configuration
4	SCT-1	Exports SCD file

2.15.2 Purpose of the test

1	To verify the ability of a SCT to reuse the SCD file of an already designed project from another SCT for future modifications in the design
2	To verify the portability of single line diagrams between SCTs

Note: This test can use SCD files produced in SCL.1 or SCL.2 as a starting point.

2.15.3 Test setup

Test Case ID	SCL.7
Test Case Name	Interoperability between SCT – Use of existing SCD file
Participant SCT-2	SCT-2 tool used for the design of the substation
Participant SCT	SCT-1 tool used for future modifications
Pre-conditions (Preparation done prior to IOP)	
Test Support	Delivers - Tool to create CID files - Modified IID/XFactor file for AA1D1Q01FN1 with an additional LN PTOC2
Participant SCT-1	-
Participant SCT-2	Prepares - SCD of the whole design
Post-condition on success	
The test is passed when SCT-1 can import the SCD file, do the modification and the result is functionally identical except the modifications that have been made. This is verified through CID files produced by a tool supplied from testing support.	

2.15.4 Test case description and results

No testing occurred for this test case.

	Test Step	Verification	ok SICS	Remarks / Observations
A	Engineering with SCT-1			
A1	SCT-1 imports SCD file	SCT is able to import SCD file without any manual editing	☐	
A2	SCT-1 imports IID/XFactor file of modified IED	SCT is able to import IID/XFactor file	☐ S11-S15 S111	
A3	SCT-1 associates new LN to single line diagram / substation section		☐ S43	
A4	SCT-1 exports SCD file		☐ S61. S62, S64, S66, S67	
B	SCD File inspection			
B1	verify A2	In the SCD file, verify that the data model of IED AA1D1Q01FN1 contains the new LN	☐	
B2	verify A3	In the SCD file, verify the association of the new LN to the single line diagram / substation section. It shall be associated at the same hierarchical level as PTOC1.	☐	
C	compare CID files			

C1	produce CID file of IED AA1D1Q01FN1 (IED sending the GOOSE message) and IED AA1D1Q01KF1 (IED subscribing the GOOSE message) from the original SCD and from the new SCD			
C2	Compare CID files for IED AA1D1Q01FN1	Verify that GOOSE messages are identical and that the new LN is in the data model	☐	
C3	Compare CID files for IED AA1D1Q01KF1	Verify that ExtRefs and that the GOOSE configuration of the subscribed GOOSE (in IED section of IED AA1D1Q01FN1) are identical	☐	

3 Sampled Value Testing

The testing of Sampled Values was divided into testing for the UCA IUG 9-2LE profile and 61869-9 (the IEC profile). There were a total of 8 participating companies.

The following vendors participated in the following roles for each test campaign.

Publishers			
Vendor	Product	9-2 LE	61869-9
Alstom	MU320	x	
Doble	F6150	x	x
NR Electric	PCS-222	x	
OMICRON	DANEO 400		x
RTDS	GTNET-SV	x	x
Schweitzer	401U	x	
Vizimax	AMU	x	x

Subscribers			
Vendor	Product	9-2LE	61869-9
Alstom	P841	x	x
NR Electric	PCS-902	x	
OMICRON	DANEO400	x	
RC Bresler	TOP300	x	x
RTDS	GTNET-SV	x	x
Schweitzer	401L	x	

Table 33: SV Publisher and Subscribers

3.1 References

Reference A	IEC 61850-9-2:2011	Communication networks and systems for power utility automation - Part 9-2: Specific communication service mapping (SCSM) - Sampled values over ISO/IEC 8802-3
Reference B	IEC 61869-9 ED.1	Instrument Transformers - Part 9: Digital Interface for Instrument Transformers
Reference C	UCA IUG	IMPLEMENTATION GUIDELINE FOR DIGITAL INTERFACE TO INSTRUMENT TRANSFORMERS USING IEC 61850-9-2

3.2 UCA IUG 9-2LE Profile Publisher/Subscriber

The purpose of the Sampled Value testing was to test implementations of UCA IUG 9-2LE profile.

The participants in the SV testing were:

Publishers	
Vendor	Product
Alstom	MU320
Doble	F6150
NR Electric	PCS-222
RTDS	GTNET-SV
Schweitzer	401U
Vizimax	AMU

Subscribers	
Vendor	Product
Alstom	P841
NR Electric	PCS-902
OMICRON	DANEO400
RC Bresler	TOP300
RTDS	GTNET-SV
Schweitzer	401L

Table 34: Participants in 9-2LE Testing

3.2.1 Publishing of 9-2 Data

UseCase: The Publisher must be capable of configuring the data stream according to the 9-2LE implementation guideline [Ref.C].

The following test cases shall be used to verify that the Publisher is capable of producing a data stream according to the 9-2LE guideline.

3.2.1.1 Configuration of the PUBLISHER

The publisher should be able to configure the data stream properly according to the implementation guideline. However all subscribers may not use the identical parameters to filter for the 9-2 data.

If the publisher can produce a SCL file that describes the configuration of the device it should be validated by using a simple schema validation.

The validation tool chosen for the interop was Notepad++. It can be obtained from: https://notepad-plus-plus.org/. The XML plugin 2.4.6 must be loaded in order to actually perform XML validation.

3.2.1.1.1 Test Procedure

1. Obtain the Publisher's ICD or IID file
2. Open the file with Notepad++.
3. If the file has an xsi:schemaLocation statement, remove the statement.
4. Save the file into the directory where the SCL 2007B schema is store.
5. Choose the Validate Now option from the XML Tools plugin menu.
6. Record if the SCL file passes or fails the validation.

3.2.1.1.2 Test Results

Vendor	Product	Pass(P)/Fail(F)/Comment(N)
Alstom	MU320	P
Doble	F6150	
NR Electric	PCS-222	
RTDS	GTNET-SV	P
Schweitzer	401U	P
Vizimax	AMU	P

Table 35: SV 9-2LE Publisher SCL Test Results

3.2.1.2 Validation of Published Data

This test is intended to ensure that the appropriate information is being published in the DataStream.

3.2.1.2.1 Test procedure

1. Set-up the publisher
2. Using Wireshark, validate that the appropriate DataStream information is present.

3.2.1.2.2 Test Results

Publisher						
Vendor	Alstom	Doble	NR Electric	RTDS	Schweitzer	Vizimax
Product	MU320		PCS-222	GTNET-SV	401U	AMU
Object						
Ethernet Source	Pass	Pass	Pass	Pass	Pass	Pass
Ethernet Destination	Pass	Pass	Pass	Pass	Pass	Pass
VLAN 802.1 tags		Pass	Pass			
APPID	Pass	Pass	Pass	Pass	Pass	Pass
noASDU	Pass	Pass	Pass	Pass	Pass	Pass
svID	Pass	Pass	Pass	Pass	Pass	Pass
smpCnt	Pass	Pass	Pass	Pass	Pass	Pass
confRev	Pass	Pass	Pass	Pass	Pass	Pass
smpSynch	Pass	Pass	Pass	Pass	Pass	Pass
PhsMeas1 (ch1-8)	Pass	Pass	Pass	Pass	Pass	Pass
Quality (ch1-8)	Pass	Pass	Pass	Pass	Pass	Pass

Publisher						
Vendor	Alstom	Doble	NR Electric	RTDS	Schweitzer	Vizimax
Product	MU320		PCS-222	GTNET-SV	401U	AMU
Metered nominal 50 Hz	Pass	Pass	Pass	Pass	Pass	Pass
Metered nominal 60 Hz		Pass				Pass

Table 36: SV 9-2LE Publisher DataStream Validation Test Results

3.2.2 Subscription of 9-2 Data

UseCase: Subscribers must be able to obtain information (e.g. data) from Publishers according to the 9-2LE implementation guideline [Ref. A].

The following test cases shall be used to verify that the Subscriber is capable of reading a data stream according to the 9-2LE guideline.

3.2.2.1 Configuration of the SUBSCRIBER

The subscriber should be able to configure themselves to subscribe to the data stream being produced by the publisher.

3.2.2.1.1 Test procedure

1. Set-up the Subscriber by consuming a SCL with the above publisher
2. Use subscriber diagnostics to verify that the published telegram is being received

3.2.2.1.2 Test Results

	Publisher							
Subscriber	Vendor	Alstom	Doble	NR Electric	RTDS	Schweitzer	Vizimax	
Vendor	Product	MU320	F6150	PCS-222	GTNET-SV	401U	AMU	
Alstom	P841			N1	N1		N1	
OMICRON	DANEO400							
NR Electric	PCS-902	P					P	
RC Bresler	TOP300	P		P	P	P	P	
RTDS	GTNET-SV							
Schweitzer	401L				P		P	
N1 – Subscriber does not accept CID files.								

Table 37: SV 9-2LE Subscriber Configuration Test Results

3.2.2.2 Loss of DataStream

Prerequisites: Success (e.g. Pass) of Start of Telegram onto the network (3.3.6.1).

Expected Results: Analogue values lost (physically disconnected ETHERNET connection or publisher operating mode configured to OFF) shall not cause IED to mal-operate.

3.2.2.2.1 Test Procedure

1. The subscriber is properly configured to receive the SV telegram and the publisher is sending DATA onto the network
2. The SV subscriber is receiving the SV telegram
3. The SV publisher is disconnected from the network
4. The SV subscriber does not misoperate.

3.2.2.2.2 Test Results

	Publisher						
Subscriber	Vendor	Alstom	Doble	NR Electric	RTDS	Schweitzer	Vizimax	
Vendor	Product	MU320	F6150	PCS-902	GTNET-SV	401U	AMU	
Alstom	P841		P	P	P		P	
OMICRON	DANEO400		P					
NR Electric	PCS-902	P	P		P		P	
RC Bresler	TOP300	P	P	P	P	P	P	
RTDS	GTNET-SV		P				P	
Schweitzer	401L			P	P		P	

Table 38: SV 9-2LE Subscriber Loss of Data Detection Test Results

3.2.2.3 Start of DataStream

Prerequisites: Success (e.g. Pass) of Start of Telegram onto the network) after Loss of Telegram test.

Expected Results: Analogue values provided and shall not cause IED to misoperate.

3.2.2.3.1 Test Procedure

1 The subscriber is properly configured to receive the SV telegram and the publisher is sending DATA onto the network
2 The SV publisher is re-connected to the network
3 The SV subscriber receives the values and does not misoperate.

3.2.2.3.2 Test Results

	Publisher							
Subscriber	Vendor	Alstom	Doble	NR Electric	RTDS	Schweitzer	Vizimax	
Vendor	Product	MU320	F6150	PCS-902	GTNET-SV	401U	AMU	
Alstom	P841		P	P	P		P	
OMICRON	DANEO400		P					
NR Electric	PCS-902	P	P		P		P	
RC Bresler	TOP300	P	P	P	P	P	P	
RTDS	GTNET-SV		P				P	
Schweitzer	401L			P	P		P	

Table 39: SV 9-2LE Subscriber Re-establishment of DataStream Test Results

3.2.2.4 *Subscription of Datastream*

The subscriber should be able to configure themselves to subscribe to the data stream being produced by the publisher. This may be done with or without the assistance of an SCL file.

3.2.2.4.1 Test procedure

1. Set-up the Subscriber by consuming a SCL with the above publisher
2. Use subscriber diagnostics to verify that the published telegram is being received
3. Determine which attributes in the DataStream are known by the subscriber and validate values.

The items validated

3.2.2.4.2 Test Results

Subscriber: RCBresler TOP300						
Publisher						
Vendor	Alstom	Doble	NR Electric	RTDS	Schweitzer	Vizimax
Product	MU320	F6150	PCS-902	GTNET-SV	401U	AMU
Object						
Ethernet Source	Pass		Pass	Pass	Pass	
Ethernet Destination	Pass	P	Pass	Pass	Pass	Pass
VLAN 802.1 tags			Pass			
APPID	Pass	Pass	Pass	Pass	Pass	Pass
noASDU	Pass	Pass	Pass	Pass	Pass	Pass
svID	Pass	Pass	Pass	Pass	Pass	Pass
smpCnt	Pass	Pass	Pass	Pass	Pass	Pass
confRev	Pass	Pass	Pass	Pass	Pass	Pass
smpSynch	Pass	Pass	Pass	Pass	Pass	Pass
PhsMeas1 (ch1-8)	Pass	Pass	Pass	Pass	Pass	Pass
Quality (ch1-8)	Pass	Pass	Pass	Pass	Pass	Pass

Table 40: SV 9-2LE Subscriber/Publisher DataStream Interoperability - RC Bresler

Subscriber: Schweitzer 401L					
Publisher					
Vendor	Alstom	NR Electric	RTDS	Schweitzer	Vizimax
Product	MU320	PCS-902	GTNET-SV	401U	AMU
Object					
Ethernet Source			Pass		Pass
Ethernet Destination			Pass		Pass
VLAN 802.1 tags					
APPID			Pass		Pass
noASDU			Pass		Pass
svID			Pass		Pass
smpCnt			Pass		Pass
confRev			Pass		Pass
smpSynch			Pass		Pass
PhsMeas1 (ch1-8)			Pass		Pass
Quality (ch1-8)			Pass		Pass

Table 41: SV 9-2LE Subscriber/Publisher DataStream Interoperability - Schweitzer

Subscriber: NR Electric PCS-902					
Publisher					
Vendor	Alstom	Doble	RTDS	Schweitzer	Vizimax
Product	MU320	F6150	GTNET-SV	401U	AMU
Object					
Ethernet Source	Pass	P	P	P	P
Ethernet Destination	Pass	P	P	P	P
VLAN 802.1 tags			-	-	-
APPID	Pass	P	P	P	P
noASDU	Pass	P	P	P	P
svID	Pass	P	P	P	P
smpCnt	Pass	P	-	-	-
confRev	Pass	P	P	P	P
smpSynch	Pass	P	P	P	P
PhsMeas1 (ch1-8)	Pass	P	-	-	-
Quality (ch1-8)	Pass	P	-	-	-

Table 42: SV 9-2LE Subscriber/Publisher DataStream Interoperability - NR Electric

Subscriber: Alstom P841					
Publisher					
Vendor	Doble	NR Electric	RTDS	Schweitzer	Vizimax
Product	F6150	PCS-902	GTNET-SV	401U	AMU
Object					
Ethernet Source	P	P	P	P	P
Ethernet Destination	P	P	P	P	P
VLAN 802.1 tags					
APPID	P	P	P	P	P
noASDU	P	P	P	P	P
svID	P	P	P	P	P
smpCnt		P	P	P	P
confRev	P	P	P	P	P
smpSynch	P	P	P	P	P
PhsMeas1 (ch1-8)		P	P	P	P
Quality (ch1-8)		P	P	P	P

Table 43: SV 9-2LE Subscriber/Publisher DataStream Interoperability - Alstom

Subscriber	RTDS	GTNET-SV
Publisher		
Vendor	Doble	Vizimax
Product	F6150	AMU
Object		
Ethernet Source	P	
Ethernet Destination	P	P
VLAN 802.1 tags		
APPID	P	P
noASDU	P	P
svID	P	P
smpCnt	P	P
confRev	P	P
smpSynch	P	P
PhsMeas1 (ch1-8)	P	P
Quality (ch1-8)	P	P

Table 44: SV 9-2LE Subscriber/Publisher DataStream Interoperability - RTDS

Subscriber: OMICRON DANEO 400		
Publisher		
Vendor	Doble	
Product	F6150	
Object		
Ethernet Source	P	
Ethernet Destination	P	
VLAN 802.1 tags		

APPID	P	
noASDU	P	
svID	P	
smpCnt		
confRev	P	
smpSynch	P	
PhsMeas1 (ch1-8)	P	
Quality (ch1-8)	P	

Table 45: SV 9-2LE Subscriber/Publisher DataStream Interoperability - OMICRON

Subscriber: Schweitzer 401L		
Publisher		
Vendor	NR Electric	
Product	PCS-222	
Object		
Ethernet Source	P	
Ethernet Destination	P	
VLAN 802.1 tags		
APPID	P	
noASDU	P	
svID	P	
smpCnt		
confRev	P	
smpSynch	P	
PhsMeas1 (ch1-8)		
Quality (ch1-8)		

Table 46: SV 9-2LE Subscriber/Publisher DataStream Interoperability –Schweitzer

3.2.2.5 SmpSynch

This test case validates the behavior of the publisher when its time source is removed.

Pre-requisites: IEC 61850-9-2:2011 Table 14 and 2015-05-19 Working Draft IEC 61869-9

A merging unit or test set/simulator shall state in the protocol implementation extra information for testing (PIXIT) the maximum time required to achieve synchronization on merging unit power up and on resynchronization. Most test set/simulator(s) will not publish SV data until a test sequence is initiated.

Expected Results: The captured packets file should contain correct SmpSynch.

The Publisher shall be able to set the SmpSynch flag.

0= SV are not synchronised by an external clock signal.

1= SV are synchronised by a clock signal from an unspecified local area clock.

2= SV are synchronised by a global area clock signal (time traceable).

5 to 254= SV are synchronised by a clock signal from a local area clock identified by this value.

3.2.2.5.1 Test Procedures

1. The SV source is powered up
2. Upon power up if SV data is published it shall indicate 0 for no longer than the maximum time required to achieve synchronization.
3. Upon synchronization the SV data will indicate a smpSynch = non-zero value
4. The time source is disabled
5. The publisher will go into holdover mode and continue to publish SV data for until the holdover duration is exceeded. The minimum holdover duration shall be 5 s under stable temperature conditions.
6. Once the publisher has exceeded the holdover duration the SV data will indicate a smpSynch = 0
7. The time source is re-enabled
8. After the re-synchronization period the SV data will indicate a smpSynch = non-zero value

3.2.2.5.2 Test Results

	Publisher							
Subscriber	Vendor	Alstom	Doble	NR Electric	RTDS	Schweitzer	Vizimax	
Vendor	Product	MU320	F6150	PCS-222	GTNET-SV	401U	AMU	
Alstom	P841		P	P	P		P	
NR Electric	PCS-902	P	P		P		P	
OMICRON	DANEO400		P					
RC Bresler	TOP300	N1	P		N2	P	P	
RTDS	GTNET-SV		P				P	
Schweitzer	401L				P		P	

N1 – There was no synchronization source in testing, so there was no ability to effect on SmpSynch in publisher.

N2 – Subscriber did not recognize the default value when field was not present. The problem was that the publisher represented the default value by removing the value from the PDU (per ASN.1). However, 9-2LE expects the field to be present even for a default value.

Table 47: SV 9-2LE Subscriber SmpSynch Test Results

3.2.2.6 Quality

This test case validates that the publisher ability to properly provide a test bit.

Expected Results: The SV telegram should contain the q.quality test bit and Simulation flag equal true.

3.2.2.6.1 Test Procedure

1. The SV publisher is publishing data
2. The SV publisher test flag is changed to indicate the SV telegram is being published by a test device
3. The SV data is examined using Wireshark and the SV telegram should have the 8th octet set in Reserved 1
4. The SV publisher is publishing data
5. The SV publisher quality test.bit is changed to indicate the SV telegram can be used by applications in test or test/blocked
6. The SV data is examined using Wireshark and the SV telegram should have the quality test.bit set

3.2.2.6.2 Test Results

	Publisher							
Subscriber	Vendor	Alstom	Doble	NR Electric	RTDS	Schweitzer	Vizimax	
Vendor	Product	MU320	F6150	PCS-222	GTNET-SV	401U	AMU	
Alstom	P841		P	P	P	P	P	
NR Electric	PCS-902	P	P		P	N2	P	
OMICRON	DANEO400		P					
RC Bresler	TOP300	P	P		P		P	
RTDS	GTNET-SV		P				P	
Schweitzer	401L				N1		P	
N1 – Values did not change. N2 – Could not change quality values								

Table 48: SV 9-2LE Subscriber Quality Test Results

3.3 Testing for 61869-9 Publisher/Subscriber

The purpose of the Sampled Value testing was to test implementations of IEC 61850-9-2:2011 that comply with the implementation profile specified in IEC 61869-9.

The participants in the SV testing were:

Publisher	
Vendor	Product
Doble	F6150
OMICRON	DANEO 400
RTDS	GTNET-SV
Vizimax	AMU

Subscriber	
Vendor	Product
Alstom	P841
RC Bresler	TOP300
RTDS	GTNET-SV

Table 49: Participants in IEC 61869-9 Testing

3.3.1 Test Cases

The following section contains the abstract test descriptions as well as test results. The tests include:

- Validation of SCL files of publishers.
- Several test cases regarding the ability of publishers and subscribers to interoperate.
- Testing of optional features

3.3.2 SCL Validation

If the publisher can produce a SCL file that describes the configuration of the device it should be validated by using a simple schema validation.

The validation tool chosen for the interop was Notepad++. It can be obtained from: https://notepad-plus-plus.org/. The XML plugin 2.4.6 must be loaded in order to actually perform XML validation.

3.3.2.1 Test Procedure

1. Obtain the Publisher's ICD or IID file
2. Open the file with Notepad++.
3. If the file has an xsi:schemaLocation statement, remove the statement.
4. Save the file into the directory where the SCL 2007B schema is store.
5. Choose the Validate Now option from the XML Tools plugin menu.

6 Record if the SCL file passes or fails the validation.

3.3.2.2 Test Results

Vendor	Product	Pass(P)/Fail(F)/Comment(N)
Doble	F6150	
OMICRON	DANEO 400	
RTDS	GTNET-SV	P
Vizimax	AMU	P

Table 50: SV 61869-9 Publisher SCL Test Results

3.3.3 Configuration of Subscriber via SCL for a single publisher

The subscriber should be able to configure themselves to subscribe to the data stream being produced by the publisher.

Pre-requisites: IEC 61869-9 clause 6.903.2 variants to be supported are F4000S1I4U4 and F4800S1I4U4 XML Schema is 2007B.2014-01-22.

If the publisher does not provide an SCL file, this will be noted in the test results.

3.3.3.1 Test procedure

1 Set-up the Publisher and configure according to F4000S1I4U4
2 Set-up the Subscriber by consuming a SCL with the above publisher
3 Use subscriber diagnostics to verify that the published telegram is being received
4 Set-up the Publisher and configure according to F4800S1I4U4
5 Set-up the Subscriber by consuming a SCL with the above publisher
6 Use subscriber diagnostics to verify that the published telegram is being received.

3.3.3.2 Test Results

	Publisher						
Subscriber	Vendor	Alstom	Doble	OMICRON	RTDS	Vizimax	
Vendor	Product	MU 320	F6150	DANEO 400	GTNET-SV	AMU	
Alstom	P841	P		N1			
RC Bresler	TOP300			P			
RTDS	GTNET-SV		P			P	
N1- The Subscriber does not accept CID Files							

Table 51: SV 61869-9 Subscriber Configuration Test Results

3.3.4 Subscription of multiple Telegrams from the network

Pre-requisites: IEC 61869-9 clause 6.903.2 variants to be supported are F4000S1I4U4 and F4800S1I4U4 XML Schema is 2007B.2014-01-22.

If the publisher does not provide an SCL file, this will be noted in the test results.

3.3.4.1 Test procedure

1 Set-up the Publisher and configure according to F4000S1I4U4
2 Set-up the Subscriber by consuming a SCL with more than one publisher
3 Use subscriber diagnostics to verify that the published telegrams are being received
4 Check LSVS for proper indications if it is supported.
5 Set-up the Publishers and configure according to F4800S1I4U4
6 Set-up the Subscriber by consuming a SCL with the above publishers
7 Use subscriber diagnostics to verify that the published telegram is being received
8 Check LSVS for proper indications if it is supported.

3.3.4.2 Test Results

	Publisher			
Subscriber	Vendor	Doble	OMICRON	RTDS
Vendor	Product	F6150	DANEO 400	GTNET-SV
Alstom	P841		P	P
RC Bresler	TOP300		P	P
RTDS	GTNET-SV	P		

Table 52: SV 61869-9 Subscriber Multiple DataStream Test Results

3.3.5 Subscription when identical telegram is published with wrong APPID

Pre-requisites: IEC 61869-9 clause 6.903.2 variants to be supported are F4000S1I4U4 and F4800S1I4U4 XML Schema is 2007B.2014-01-22.

The subscriber PIXIT must be reviewed to determine if this is a valid test for the subscriber. If the subscriber uses the APPID to identify the telegram then the subscriber shall identify and use the correct telegram.

3.3.5.1 Test procedure

1. Set-up the Publisher and configure according to F4000S1I4U4.
2. Set-up the Subscriber by consuming a SCL with the above publisher.
3. Use subscriber diagnostics to verify that the published telegram is being received.
4. Set-up the second Publisher and configure with identical parameters except the APPID is different.
5. Start publishing the second telegram.
6. Use subscriber diagnostics to verify that the published telegram is being received.

3.3.5.2 Test Results

	Publisher			
Subscriber	Vendor	Doble	OMICRON	RTDS
Vendor	Product	F6150	DANEO 400	GTNET-SV
Alstom	P841		P	P
RC Bresler	TOP300		P	P
RTDS	GTNET-SV	P		

Table 53: SV 61869-9 Subscriber Reaction to Incorrect APPID Test Results

3.3.6 Loss or Start of Telegram onto the network

The following test cases validate the behavior of the subscriber upon subscription disruption and re-establishment from a secondary source.

3.3.6.1 Start of Telegram onto the network

This test case validates that a subscriber can subscribe to the expected publisher. It is similar to the test specified in 3.3.3.

Pre-requisites: Subscriber must be configured via SCL or manually.

Expected Results: Analogue values start up (start-up of the telegram from nothing onto the network) shall not cause IED to mal-operate protection.

3.3.6.1.1 Test Procedure

1. The subscriber is properly configured to receive the SV telegram but the publisher is not sending data.
2. The SV publisher starts to publish data.
3. The SV subscriber receives data and operates properly.

3.3.6.1.2 Test Results

	Publisher				
Subscriber	Vendor	Doble	OMICRON	RTDS	Vizimax
Vendor	Product	F6150	DANEO 400	GTNET-SV	AMU
Alstom	P841		P		
RC Bresler	TOP300		P	P	
RTDS	GTNET-SV	P			P

Table 54: SV 61869-9 Subscriber DataStream Detection Test Results

3.3.6.2 Loss of Telegram from the network

This test case validates that a subscriber can properly detect the loss of a publisher's data stream.

Prerequisites: Success (e.g. Pass) of Start of Telegram onto the network (3.3.6.1).

Expected Results: Analogue values lost (physically disconnected ETHERNET connection or publisher operating mode configured to OFF) shall not cause IED to mal-operate.

3.3.6.2.1 Test Procedure

1. The subscriber is properly configured to receive the SV telegram and the publisher is sending DATA onto the network
2. The SV subscriber is receiving the SV telegram
3. The SV publisher is disconnected from the network
4. The SV subscriber does not misoperate.

3.3.6.2.2 Test Results

	Publisher				
Subscriber	Vendor	Doble	OMICRON	RTDS	Vizimax
Vendor	Product	F6150	DANEO 400	GTNET-SV	AMU
Alstom	P841		P	P	
RC Bresler	TOP300		P		
RTDS	GTNET-SV	P		P	P

Table 55: SV 61869-9 Subscriber Detection of DataStream Loss Test Results

3.3.6.3 Start of 2nd Telegram with different source MAC

This test case validates that a subscriber can properly process the data stream from a different SV source (e.g. secondary source). This test case does not validate the behavior of the subscriber if there are two identical SV streams being published simultaneously to the same destination address, but from two different source MAC addresses.

Prerequisites: Success (e.g. Pass) of Loss of Telegram from the network (3.3.6.2).

Expected Results: Analogue values start up (start-up of the 2nd telegram from nothing onto the network) shall not cause IED to mal-operate protection.

3.3.6.3.1 Test Procedure

1. The subscriber is properly configured to receive the SV telegram and the publisher is sending DATA onto the network
2. The SV subscriber is receiving the SV telegram
3. A second SV publisher starts to send identical telegram but with a different source MAC onto the network
4. The SV subscriber does not misoperate.

3.3.6.3.2 Test Result

	Publisher			
Subscriber	Vendor	OMICRON	RTDS	Vizimax
Vendor	Product	DANEO 400	GTNET-SV	AMU
Alstom	P841		P	
RC Bresler	TOP300	P	N1	
RTDS	GTNET-SV			
N1 – Subscriber did not recognize the second MAC address. Configuration did not reflect the addition of the second publisher.				

Table 56: SV 61869-9 Subscriber Detection of Different MAC Address Test Results

3.3.7 Optional Testing of Publisher Capabilities

This section details tests and test results for optional tests regarding the capabilities of publishers.

3.3.7.1 Validation of the capability of the Publisher to provide optional information

Expected Results: The captured packets file should match the configuration/setup i.e. Ethernet source, Ethernet destination, VLAN tags, noASDU, svID, ConfRev, etc. AppID shall always be 4000 hex.

3.3.7.1.1 Test Procedure

1. The publisher is properly configured according to the SV configuration matrix and is sending DATA onto the network
2. Use Wireshark to capture the SV data packets
3. Examine the data packets and verify that they match the configuration

3.3.7.1.2 Test Results

	Publisher			
Subscriber	Vendor	OMICRON	RTDS	Vizimax
Vendor	Product	DANEO 400	GTNET-SV	AMU
Alstom	P841	P	P	
RC Bresler	TOP400	P	P	
RTDS	GTNET-SV			P

Table 57: SV 61869-9 Subscriber/Publisher DataStream Interoperability Test Results

3.3.7.2 Publisher's Telegram with multi-cast outside of recommended range

This test case validates the capability of a publisher and subscriber to operate within a MAC address range that is not recommended in IEC 61850. It should be noted that the following recommendation from IEC 61850 is informative and not normative.

Table B.1 – Recommended multicast addressing example

Service	Recommended address range assignments	
	Starting address (hexadecimal)	Ending address (hexadecimal)
GOOSE	01-0C-CD-01-00-00	01-0C-CD-01-01-FF
GSSE	01-0C-CD-02-00-00	01-0C-CD-02-01-FF
Multicast sampled values	01-0C-CD-04-00-00	01-0C-CD-04-01-FF

Expected Results: The captured packets file should match the configuration/setup i.e. Ethernet source, Ethernet destination, VLAN tags, noASDU, svID, ConfRev, etc. AppID shall always be 4000 hex.

3.3.7.2.1 Test Procedure

1 The publisher is properly configured according to the SV configuration matrix but the multi-cast is set to one outside the recommended range and is sending DATA onto the network.
2 Use Wireshark to capture the SV data packets.
3 Examine the data packets and verify that they match the configuration.

3.3.7.2.2 Test Results

	Publisher				
Subscriber	Vendor	Doble	OMICRON	RTDS	Vizimax
Vendor	Product	F6150	DANEO 400	GTNET-SV	AMU
Alstom	P841		P	P	
RC Bresler	TOP300		P	P	
RTDS	GTNET-SV	P			P

Table 58: SV 61869-9 Subscriber MAC Address Range Test Results

3.3.7.3 Publisher SmpSynch

This test case validates the behavior of the publisher when its time source is removed.

Pre-requisites: IEC 61850-9-2:2011 Table 14 and 2015-05-19 Working Draft IEC 61869-9

A merging unit or test set/simulator shall state in the protocol implementation extra information for testing (PIXIT) the maximum time required to achieve synchronization on merging unit power up and on resynchronization. Most test set/simulator(s) will not publish SV data until a test sequence is initiated.

Expected Results: The captured packets file should contain correct SmpSynch.

The Publisher shall be able to set the SmpSynch flag.

0= SV are not synchronised by an external clock signal.

1= SV are synchronised by a clock signal from an unspecified local area clock.

2= SV are synchronised by a global area clock signal (time traceable).

5 to 254= SV are synchronised by a clock signal from a local area clock identified by this value.

3.3.7.3.1 Test Procedures

1. The SV source is powered up
2. Upon power up if SV data is published it shall indicate 0 for no longer than the maximum time required to achieve synchronization.
3. Upon synchronization the SV data will indicate a smpSynch = non-zero value
4. The time source is disabled
5. The publisher will go into holdover mode and continue to publish SV data for until the holdover duration is exceeded. The minimum holdover duration shall be 5 s under stable temperature conditions.
6. Once the publisher has exceeded the holdover duration the SV data will indicate a smpSynch = 0
7. The time source is re-enabled
8. After the re-synchronization period the SV data will indicate a smpSynch = non-zero value

3.3.7.3.2 Test Results

	Publisher				
Subscriber	Vendor	Doble	OMICRON	RTDS	Vizimax
Vendor	Product	F6150	DANEO 400	GTNET-SV	AMU
Alstom	P841			P	
RC Bresler	TOP300		P	P	
RTDS	GTNET-SV	P			P

Table 59: SV 61869-9 Subscriber SmpSynch Interoperability Test Results

3.3.7.4 Publisher detection of Quality (q.test)

This test case validates that the publisher detects and conveys quality changes properly.

LNMode XXXX.Mod	**LDMode** LLN0.Mod	**LNBeh** (read only) XXXX.Beh	**LNBeh Value**
on	on	on	1
on	on-blocked	on-blocked	2
on	test	test	3
on	test/blocked	test/blocked	4
on	off	off	5
on-blocked	on	on-blocked	2
on-blocked	on-blocked	on-blocked	2
on-blocked	test	test/blocked	4
on-blocked	test/blocked	test/blocked	4
on-blocked	off	off	5
test	on	test	3
test	on-blocked	test/blocked	4
test	test	test	3
test	test/blocked	test/blocked	4
test	off	off	5
test/blocked	on	test/blocked	4
test/blocked	on-blocked	test/blocked	4
test/blocked	test	test/blocked	4
test/blocked	test/blocked	test/blocked	4
test/blocked	off	off	5
off	on	off	5
off	on-blocked	off	5
off	test	off	5
off	test/blocked	off	5
off	off	off	5

Table A.1 – Values of mode and behaviour

Value	Mode	
1	on	The application represented by the LN works. All communication services work and get updated values
2	on-blocked	The application represented by the LN works. No output data (digital by relays or analogue setting) will be issued to the process. All communication services work and get updated values. Data objects will be transmitted with quality "operatorBlocked". Control commands will be rejected. See note below Table A.1.
3	test	The application represented by the LN works. All communication services work and get updated values. Data objects will be transmitted with quality "test". Control commands with quality test will be accepted only by LNs in "test" or "test-blocked" mode. "Processed as valid" means that the application should react in the manner what is foreseen for "test".
4	test/blocked	The application represented by the LN works. No output data (digital by relays or analogue setting) will be issued to the process. All communication services work and get updated values. Data objects will be transmitted with quality "test". Control commands with quality test will be accepted only by LNs in TEST or TEST-Blocked mode.
5	off	The application represented by the LN doesn't work. No process output is possible. No control command should be acknowledged (negative response). Only the data object Mod and Beh should be accessible by the services.
NOTE The Mod ="blocked" from edition 1 is changed in edition 2 to "on-blocked".		

MODE/BEHAVIOUR	on	on-blocked	test	test/blocked	off
Function behind LN	ON	ON	ON	ON	OFF
Output to the Process (Switchgear) via a non-IEC 61850 link for example wire (typical for X...,Y... and GGIO LNs)	YES	NO	YES	NO	NO
Output of FC ST, MX (issued independently from Beh)	value is relevant q is relevant	value is relevant q = operatorBlocked	value is relevant q = test	value is relevant q = test +operator-Blocked	value is irrelevant q = invalid
Response to (Normal) Command from Client (a+ / a- acknowledgement)	a+ pos. ack.	a- neg. ack.	a- neg. ack.	a- neg. ack.	a- neg. ack.
Response to TEST Command from Client (a+ / a- acknowledgement)	a- neg. ack.	a- neg. ack.	a+ pos. ack.	a+ pos. ack.	a- neg. ack.
Incoming data with q=normal	Processed as valid	Processed as valid	Processed as valid	Processed as valid	Not Processed
Incoming data with q=operatorBlocked	Processed as blocked	Processed as blocked	Processed as blocked	Processed as blocked	Not Processed
Incoming data with q=test	Processed as valid	Processed as invalid	Processed as valid	Processed as valid	Not Processed
Incoming data with q=test+operatorBlocked	Processed as invalid	Processed as invalid	Processed as blocked	Processed as blocked	Not Processed
Incoming data with q=invalid	Processed as invalid	Processed as invalid	Processed as invalid	Processed as invalid	Not Processed
Non-IEC 61850 binary (relay, contact) inputs and analogue (instrument transformer) inputs	Processed	Processed	Processed	Processed	Not Processed

Expected Results: The SV telegram should contain correct quality test.bit.

3.3.7.4.1 Test Procedure

1. The SV publisher is publishing data
2. The SV publisher quality test.bit is changed to indicate the SV telegram can be used by applications in test or test/blocked
3. The SV data is examined using Wireshark and the SV telegram should have the quality test.but set

3.3.7.4.2 Test Results

	Publisher				
Subscriber	Vendor	Doble	OMICRON	RTDS	Vizimax
Vendor	Product	F6150	DANEO 400	GTNET-SV	AMU
Alstom	P841		P	P	
RC Bresler	TOP300		P	P	
RTDS	GTNET-SV	P			P

Table 60: SV 61869-9 Subscriber Quality Interoperability Test Results

3.3.7.5 *Publisher ability to provide simulation bit*

This test case validates that the publisher ability to properly provide a simulation bit.

Expected Results: The SV telegram should contain the Simulation flag. The Publisher must be able to set the S: Simulate flag for the identification of messages where both real messages and simulated messages must coexist on the same network.

3.3.7.5.1 Test Procedure

1. The SV publisher is publishing data
2. The SV publisher simulation flag is changed to indicate the SV telegram is being published by a test device
3. The SV data is examined using Wireshark and the SV telegram should have the 8^{th} octet set in Reserved 1

3.3.7.5.2 Test Results

	Publisher			
Subscriber	Vendor	Doble	OMICRON	RTDS
Vendor	Product	F6150	DANEO 400	GTNET-SV
Alstom	P841		P	P
RC Bresler	TOP300		P	P
RTDS	GTNET-SV	P		

Table 61: SV 61869-9 Subscriber Simulation Bit Interoperability Test Results

3.3.7.6 Publisher ability to provide *proper Quality and Simulation bits*

This test case validates that the publisher ability to properly provide simulation and quality bits.

The reason for the test is as follows:

> Assume you perform a test on a protection in a live system. That protection will receive a simulated message instead of the still active operational message from a merging unit. The protection will issue a trip, and may be associated to that a GOOSE message that includes the data object PTRC.Tr that is used to initiate breaker failure function in another device. In order to prevent that breaker failure function to start, the PTRC.Tr.q.test needs to be set to TRUE. In order that this happens, the protection function of the device under test needs to be set to test mode. In order that this function that is in test mode (besides being in simulation and receiving simulated messages) uses the sampled values, they need to be flagged with the test bit as well. So in fact the SV message from the test equipment not only has the simulation flag active, it as well has all the relevant quality marked as test.

Expected Results: The SV telegram should contain the q.quality test bit and Simulation flag equal true.

3.3.7.6.1 Test Procedure

1. The SV publisher is publishing data
2. The SV publisher simulation flag is changed to indicate the SV telegram is being published by a test device
3. The SV data is examined using Wireshark and the SV telegram should have the 8th octet set in Reserved 1
4. The SV publisher is publishing data
5. The SV publisher quality test.bit is changed to indicate the SV telegram can be used by applications in test or test/blocked
6. The SV data is examined using Wireshark and the SV telegram should have the quality test.bit set

3.3.7.6.2 Test Results

	Publisher			
Subscriber	Vendor	Doble	OMICRON	RTDS
Vendor	Product	F6150	DANEO 400	GTNET-SV
Alstom	P841		P	P
RC Bresler	TOP300		P	P
RTDS	GTNET-SV	P		

Table 62: SV 61869-9 Subscriber Quality and Simulation Bit Interoperability Test Results

3.3.7.7 Publisher of SV Telegrams with Specified Values

This test validates the conversion of specific signals into digital values by the publisher.

Expected Results: The SV telegram should contain the correct values for the 8 voltage and current channels. With the following scaling configuration:

MU configuration data:
VT Ratio: 100000 V: 100 V
CT Ratio: 1000 A: 1 A

3.3.7.7.1 Test Procedure

1a. For merging units, inject balanced 3-phase voltages and currents into the DUT.
Frequency = 50 Hz, VA = 100 V @ 0 deg, and IA = 1 A @ 0 deg.
The merging units should publish the primary values.
1b. For test sets, publish the specified values of voltages and currents directly.
2. The SV data is examined using tools that capture sampled values and display the sign waves and phasor values (amplitude and phase angle) of voltages and currents.
The published values of voltages and currents from the merging unit or test set should match the specified values

3.3.7.7.2 Test Results

	Publisher				
Subscriber	Vendor	Doble	OMICRON	RTDS	Vizimax
Vendor	Product	F6150	DANEO 400	GTNET-SV	AMU
Alstom	P841		P	P	
RC Bresler	TOP300		P	P	
RTDS	GTNET-SV	P			P

Table 63: SV 61869-9 SV Telegrams with Specific Value Test Results

3.3.8 Optional Testing of Subscriber Capabilities

This section details tests and test results for optional tests regarding the capabilities of subscribers.

3.3.8.1 Subscriber capability to process SmpSynch

Expected Results: This test case validates that the subscriber processes the smpSynch flag according to its PIXIT declaration.

3.3.8.1.1 Test Procedure

The test procedure in clause 3.3.7.3 is followed for the publisher.

Results are checked based upon the subscriber's PIXIT.

3.3.8.1.2 Test Results

	Publisher				
Subscriber	Vendor	Doble	OMICRON	RTDS	Vizimax
Vendor	Product	F6150	DANEO 400	GTNET-SV	AMU
Alstom	P841		P	P	
RC Bresler	TOP300		P	P	
RTDS	GTNET-SV	P			P

Table 64: SV 61869-9 Subscriber SmpSynch Processing Test Results

3.3.8.2 Subscriber ability to process quality changes

Expected Results: If the DUT is under test mode, it will trip; if it is in mode test/blocked, it will not trip, but still process and activate DAs with FC, ST, and MX.

3.3.8.2.1 Test Procedure

1. The subscriber/device under test LN.Beh.stVal is set to test or test/blocked (test mode) the application represented by the LN will accept and process the publisher's data.

3.3.8.2.2 Test Results

	Publisher			
Subscriber	Vendor	OMICRON	RTDS	Vizimax
Vendor	Product	DANEO 400	GTNET-SV	AMU
Alstom	P841	P	P	
RC Bresler	TOP300		P	
RTDS	GTNET-SV			P

Table 65: SV 61869-9 Subscriber Quality Processing Test Results

3.3.8.3 Subscriber LPHD.Sim and Subscription Monitoring tests

The following clauses detail subscriber test cases related to the processing of its LPHD.Sim value and that SV subscription monitoring through LSVS is proper.

3.3.8.3.1 LPHD.Sim and Subscription Monitoring (LSVS)

Expected Result: The subscriber properly processes the value of LPHD.Sim when the value is set.

3.3.8.3.1.1 Test Procedure

1. The publisher and SV subscriber are functioning properly
2. The SV subscriber uses the SV telegram, indications should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=false

3.3.8.3.1.2 Test Results

	Publisher			
Subscriber	Vendor	OMICRON	RTDS	Vizimax
Vendor	Product	DANEO 400	GTNET-SV	AMU
Alstom	P841	P	P	
RC Bresler	TOP300	P	N1	
RTDS	GTNET-SV			P
N1- Could not be execute due to lack of a MMS Client in the test area. This was required by the subscriber to set LPHD.Sim				

Table 66: SV 61869-9 Subscriber LPHD.Sim Processing Test Results

3.3.8.3.2 Subscriber proper processing of publisher Simulation bit: Simulation Data is not present

The purpose of this test is to validate that the subscriber can still use datastreams with SIM=false even if the subscriber has been set to allow processing of simulated data.

Expected Results: Subscriber properly process publisher streams.

3.3.8.3.2.1 Test Procedure

1 The publisher and SV subscriber are functioning properly
2 The SV subscriber uses the SV telegram indications should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=false
3 The SV subscriber is put into LPHD1.St.Sim.stVal=true
4 The SV subscriber continues using the SV telegram, indications should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=false

3.3.8.3.2.2 Test Results

	Publisher			
Subscriber	Vendor	OMICRON	RTDS	Vizimax
Vendor	Product	DANEO 400	GTNET-SV	AMU
Alstom	P841	P	P	
RC Bresler	TOP300	P	N1	
RTDS	GTNET-SV			P
N1- Could not be execute due to lack of a MMS Client in the test area. This was required by the subscriber to set LPHD.Sim				

Table 67: SV 61869-9 Subscriber LSVS Processing with No Simulation Data Present Test Results

3.3.8.3.3 Subscriber proper processing of publisher Simulation bit: Simulation Data is present

The purpose of this test is to validate that the subscriber can still use datastreams with SIM=true.

Expected Results: Subscriber properly process publisher streams.

3.3.8.3.3.1 Test Procedure

1. The publisher and SV subscriber are functioning properly
2. The SV subscriber uses the SV telegram indications should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=false
3. The SV subscriber is put into LPHD1.St.Sim.stVal=true
4. The SV subscriber continues using the SV telegram, indications should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=false
5. A second identical SV telegram is published by a test device and the simulation flag is set “true”
6. The SV subscriber now will use the test SV telegram, indication should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=true (The SV subscriber will now only use SV telegrams with the simulation flag set true)

3.3.8.3.3.2 Test Results

	Publisher			
Subscriber	Vendor	OMICRON	RTDS	Vizimax
Vendor	Product	DANEO 400	GTNET-SV	AMU
Alstom	P841	P	P	
RC Bresler	TOP300	P	P	
RTDS	GTNET-SV			P

Table 68: SV 61869-9 Subscriber LSVS Processing with Simulation Data Present Test Results

3.3.8.3.4 Subscriber proper processing of publisher Simulation bit

The purpose of this test is to validate that the subscriber can still use datastreams with SIM=true transitions to false.

Expected Results: The test set or MU is publishing SV telegrams with the Simulation flag set “true” and then is stopped. The subscriber shall decode the simulated telegrams and continue to look for the simulated telegrams even if they are stopped. The DUT can only use the real telegrams once the DUT root LD LPHD.Sim.stVal is set to “false”.

3.3.8.3.4.1 Test Procedure

1. The publisher and SV subscriber are functioning properly
2. The SV subscriber uses the SV telegram indications should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=false
3. The SV subscriber is put into LPHD1.St.Sim.stVal=true
4. The SV subscriber continues using the SV telegram, indications should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=false
5. A second identical SV telegram is published by a test device and the simulation flag is set "true"
6. The SV subscriber now will use the test SV telegram, indication should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=true (The SV subscriber will now only use SV telegrams with the simulation flag set true)
7. The test SV telegram is removed from the network
8. The SV subscriber continues to look for the test SV telegram
9. The test SV telegram has been turned OFF (step 7). LSVS1.St.stVal=false, indication should be LSVS1.SimSt.StVal=true
10. The SV subscriber is put into LPHD1.St.Sim.stVal=false
11. The SV subscriber will resume using the original SV telegram, indications should be LSVS1.St.stVal=true, LSVS1.SimSt.StVal=false)

3.3.8.3.4.2 Test Results

	Publisher			
Subscriber	Vendor	OMICRON	RTDS	Vizimax
Vendor	Product	DANEO 400	GTNET-SV	AMU
Alstom	P841	P	P	
RC Bresler	TOP300	P	P	
RTDS	GTNET-SV			P

Table 69: SV 61869-9 Subscriber LSVS Processing with No Simulation Data Present Transition Test Results

4 GOOSE Testing

The following company products were tested as part of the GOOSE testing. There were a total of 16 participating companies.

Company	Product	ED.1	ED.2
Alstom	P645	x	x
Bitronics	M871	x	x
CopaData	Zenon	x	
Doble	F61850SV	x	x
EFACEC	S220-S		x
GE	850		x
	F650		x
	F60		x
NR Electric	PCS-902	x	x
OMICRON	CMC-353	x	x
	IEDScout	x	x
	ISIO 200	x	x
RTDS	GTnet-GSE	x	x
RC Bresler	TOP300	x	x
Schneider	P145	x	x
Schweitzer Electric	RTACH	x	x
SISCO	AX-S4 61850	x	x
Toshiba	GRL200	x	x
Triangle	TTN	x	x
	DTM	x	x

Table 70: Participating companies and products for GOOSE testing

Table 70 shows the products and IEC 61850-8-1 versions that were declared to be supported.

The IEC 61850-8-1 standard has a set of recommended multicast addresses for GOOSE publications. Some implementations, in the past, have assumed that this is the only allowed range for GOOSE. In order to verify more flexible configuration capability, the assignments of destination MAC addresses divided into recommended and outside the recommended range.

Company	Recommended	Non-Recommended	
	01-0C-CD-01-00-zz	81-FF-FF-01-xx-yy	
	zz range	xx	yy range
	0-9	1	2-254
Alstom Grid	10-19	2	2-254
	20-29	3	2-254
Efacec	60-69	7	2-254
GE	70-79	8	2-254
	90-99	10	2-254
OMICRON	110-119	12	2-254

Company	Recommended	Non-Recommended	
	01-0C-CD-01-00-zz	81-FF-FF-01-xx-yy	
	zz range	xx	yy range
RTDS	130-139	14	2-254
Schweitzer Electric	160-169	17	2-254
	170-179	18	2-254
SISCO	180-189	19	2-254
Triangle Microworks	190-199	20	2-254
Toshiba	200-209	21	2-254
	210-209	22	2-254

Table 71: GOOSE assigned destination MAC Addresses

All GOOSE publication/subscription tests were supposed to be executed with destination MAC addresses in both ranges (e.g. recommended and non-recommended). However, due to time constraints, only the recommended ranges were used primarily.

In IEC 61850-8-1, the default VLAN for SV is VLAN ID 0. The VLAN ID that was supposed to be tested with was 4000 (decimal). However, due to switch configuration issues, the desired VLAN ID could not be used for testing. All testing was performed with VLAN ID 0. The use of alternate VLAN usage should be a topic for future IOP tests.

The actual test results utilize the following notations:

Label/Color	Meaning
P	Test combination passed
F	Test combination failed
I	Test combination had an inconclusive result.
Nx	Indicates that there was a notation created during testing. “x” is the number of the notation.
	Indicates that testing the combination was skipped since the implementations were from the same vendor
	Indicates that an implementation did not declare support for the capability being tested.
	Version of Both was indicated on test report.

Table 72: Legend for GOOSE test results

4.1 SCL

The publishing participants were required to provide either Xfactor (e.g. ED.1 CID files) or IID SCL files containing the GOOSE configuration information. These files were used to configure the subscribers. Unlike the structured SCL tests, no SCD was required for the configuration, although allowed.

The SCL files should provide a minimum of 2 GOOSE control blocks. One Dataset for a GOCB should contain FCDAs while the other contains DataSet members that are FCDs:

- The FCDA DataSet should contain:
    - single point status: stVal and q
    - double point status: stVal and q
    - double point: stVal and q
    - a measurement value: mag.f and q
- The FCDA DataSet should contain:
    - A DataSet member that has a functional constraint of ST
    - A DataSet member that has a functional constraint of MX

There is an optional test for a DataSet whose contents are both FCDA and FCD based. The constraints on this DataSet can be found in the definition of the actual test case (see page 4.3

Although there were no actual SCL test cases defined, or recorded, some minor issues were found in the exchange and use of SCL during GOOSE testing. These were typically minor in nature and have been captured as part of the issues found in section 8.1 .

4.2 Exchange a GOOSE with FCDAs

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	Procedure: A publisher shall publish a DataSet whose members are FCDA. The dataset should contain as many information types as possible from the definitions above.
Expected Result:	Subscriber provides confirmation that the GOOSE was received and that the information was properly interpreted. The mechanism to provide this verification for the witness observation is subscriber specific.

4.2.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set.

Set 1	Set 2	Set 3
Alstom	NR Electric	SISCO
CopaData	OMICRON	Schweitzer
Doble	RTDS	Toshiba
Efacec	RC Bresler	Triangle Microworks
GE	Schneider	
Novatech/Bitronics		

Table 73: GOOSE Publishers and Result Set Membership

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2			P	**P**		**P**	
Doble	F61850SV	P						
EFACEC	TPUS220 ED.2	P						
GE	850 ED.2							
	F650 ED. 1, ED. 2	**P**	**P**					
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2						**P**	**P**

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
RC Bresler	TOP300 ED. 1, ED. 2							**P**
Schneider	P145 ED. 2				**P**	**P**		
Schweitzer	RTACH ED. 1, ED. 2							**P**
SISCO	AX-S4 61850 ED. 1, ED.2							
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both					**P**		

Table 74: Results for FCDA exchange via GOOSE – Set 1

	Publisher						
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2		**P**				
Doble	F61850SV						
EFACEC	TPUS220 ED.2						**P**
GE	850 ED.2						**P**
	F650 ED. 1, ED. 2				**P**		
NR Electric	PCS-902 both				**P**	**P**	
OMICRON	ISIO 200 ED. 1, ED.2				**P**		
RTDS	GTnet-GSE ED. 1, ED.2	**P**		**P**			
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2	**P**			**P**		
SISCO	AX-S4 61850 ED. 1, ED.2				**P**	**P**	
Toshiba	GRL200 ED.1, ED.2				**P**		
Triangle Microworks	TTN ED. 1, ED. 2				**P**		
	DTM both			**P**			

Table 75: Results for FCDA exchange via GOOSE – Set 2

			Publisher					
		Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
	Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
	Alstom	P645 ED.2						
	Doble	F61850SV						
	EFACEC	TPUS220 ED.2	**P**					
	GE	850 ED.2						**P**
		F650 ED. 1, ED. 2						
	NR Electric	PCS-902 both		**P**				
	OMICRON	ISIO 200 ED. 1, ED.2						**P**
	RTDS	GTnet-GSE ED. 1, ED.2	**P**	**P**		**P**	**P**	
	RC Bresler	TOP300 ED. 1, ED. 2	**P**					
	Schneider	P145 ED. 2						
	Schweitzer	RTACH ED. 1, ED. 2						
	SISCO	AX-S4 61850 ED. 1, ED.2			**P**	**P**		
	Toshiba	GRL200 ED.1, ED.2						
	Triangle Microworks	TTN ED. 1, ED. 2						
		DTM both						

Table 76: Results for FCDA exchange via GOOSE – Set 3

4.3 Exchange a GOOSE with a combination FCD and FCDA

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	Procedure: A publisher shall publish a DataSet whose members contain at least one FCD and one FCDA. The FCDA shall not be contained in the FCD. The dataset should contain as many information types as possible from the definitions above...
Expected Result:	Subscriber provides confirmation that the GOOSE was received and that the information was properly interpreted. The mechanism to provide this verification for the witness observation is subscriber specific

4.3.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set. See Table 73 for details.

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2			**F**	**P**		**P**	
Doble	F61850SV	P						
EFACEC	TPUS220 ED.2	P						
GE	850 ED.2							
	F650 ED. 1, ED. 2	**P**	**P**					
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2						**P**	
RC Bresler	TOP300 ED. 1, ED. 2							
Schneider	P145 ED. 2				**P**			
Schweitzer	RTACH ED. 1, ED. 2							
SISCO	AX-S4 61850 ED. 1, ED.2							**P**
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both					**P**		

Table 77: Results for a combination FCD and FCDA exchange via GOOSE – Set 1

	Publisher						
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2		**P**				
Doble	F61850SV						
EFACEC	TPUS220 ED.2						**P**
GE	850 ED.2						**P**
	F650 ED. 1, ED. 2				**P**		
NR Electric	PCS-902 both					**P**	
OMICRON	ISIO 200 ED. 1, ED.2						
RTDS	GTnet-GSE ED. 1, ED.2	**P**					
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2	**P**					
SISCO	AX-S4 61850 ED. 1, ED.2				**P**	**P**	
Toshiba	GRL200 ED.1, ED.2				**P**		
Triangle Microworks	TTN ED. 1, ED. 2				**F**		
	DTM both						

Table 78: Results for a combination FCD and FCDA exchange via GOOSE – Set 2

	Publisher						
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2	**P**					
GE	850 ED.2						**P**
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both		**P**				
OMICRON	ISIO 200 ED. 1, ED.2						**P**
RTDS	GTnet-GSE ED. 1, ED.2	**P**			**P**	**P**	
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2			**P**	**P**		
Toshiba	GRL200						

		Publisher						
		Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
	Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
		ED.1, ED.2						
	Triangle Microworks	TTN ED. 1, ED. 2						
		DTM both						

Table 79: Results for a combination FCD and FCDA exchange via GOOSE – Set 3

4.4 GOOSE Test Bit

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	**No test description was provided** **Procedure:**
Expected Result:	A GOOSE test bit was present

4.4.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set. See Table 73 for details.

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2			**F**				
Doble	F61850SV	P						
EFACEC	TPUS220 ED.2							
GE	850 ED.2							
	F650 ED. 1, ED. 2							
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2							
RC Bresler	TOP300 ED. 1, ED. 2							
Schneider	P145 ED. 2							
Schweitzer	RTACH ED. 1, ED. 2							
SISCO	AX-S4 61850 ED. 1, ED.2							
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both							

Table 80: Results for GOOSE test bit – Set 1

	Publisher						
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						**P**
GE	850 ED.2						**P**
	F650 ED. 1, ED. 2				**F**		
NR Electric	PCS-902 both				**P**	**P**	
OMICRON	ISIO 200 ED. 1, ED.2				**P**		
RTDS	GTnet-GSE ED. 1, ED.2	**P**		**P**			
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2	**P**			**P**		
SISCO	AX-S4 61850 ED. 1, ED.2				**P**	**P**	
Toshiba	GRL200 ED.1, ED.2				**P**		
Triangle Microworks	TTN ED. 1, ED. 2				**P**		
	DTM both						

Table 81: Results for GOOSE test bit – Set 2

		Publisher					
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both		**P**				
OMICRON	ISIO 200 ED. 1, ED.2						**P**
RTDS	GTnet-GSE ED. 1, ED.2		**P**				
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2						
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 82: Results for GOOSE test bit – Set 3

4.5 Detection of TAL Expiration

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	It is a local issue on how to accomplish this (e.g. pulling the publisher's cable or setting the Enable to false). Procedure: The transmission of the published GOOSE is interrupted.
Expected Result:	The subscribing IED detects TAL expiration and gives some local indication.

4.5.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set. See Table 73 for details.

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2			**P**	**P**		**P**	
Doble	F61850SV	P						
EFACEC	TPUS220 ED.2	P						
GE	850 ED.2							
	F650 ED. 1, ED. 2	**P**	**P**					
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2						**P**	
RC Bresler	TOP300 ED. 1, ED. 2							
Schneider	P145 ED. 2				**P**	**P**		
Schweitzer	RTACH ED. 1, ED. 2							
SISCO	AX-S4 61850 ED. 1, ED.2							**P**
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both					**P**		

Table 83: Results for Time Allowed to Live expiration detection – Set 1

		Publisher					
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2		**P**				
Doble	F61850SV						
EFACEC	TPUS220 ED.2						**P**
GE	850 ED.2						**P**
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both				**P**	**P**	
OMICRON	ISIO 200 ED. 1, ED.2				**P**		
RTDS	GTnet-GSE ED. 1, ED.2	**P**		**P**			
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2	**P**			**P**		
SISCO	AX-S4 61850 ED. 1, ED.2				**P**	**P**	
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2				**P**		
	DTM both			**P**			

Table 84: Results for Time Allowed to Live expiration detection – Set 2

		Publisher					
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2	**P**					
GE	850 ED.2						**P**
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both		**P**				
OMICRON	ISIO 200 ED. 1, ED.2						**P**
RTDS	GTnet-GSE ED. 1, ED.2	**P**	**P**		**P**	**P**	
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2			**P**	**P**		
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 85: Results for Time Allowed to Live expiration detection – Set 3

4.6 GOOSE Control Blocks

4.6.1 Enable of Transmission

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	It is a local issue on how to accomplish this (e.g. setting the Enable to TRUE). Procedure: A client changes the enable of a GOOSE control block (GoEna) from FALSE to TRUE.
Expected Result:	The subscribing IED detects the delivery of the GOOSE and gives some local indication.

4.6.1.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set. See Table 73 for details.

	Publisher						
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2				**F**		**P**	
Doble	F61850SV							
EFACEC	TPUS220 ED.2	P						
GE	850 ED.2							
	F650 ED. 1, ED. 2	**P**	**P**					
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2						**P**	
RC Bresler	TOP300 ED. 1, ED. 2							
Schneider	P145 ED. 2				**P**	**P**		
Schweitzer	RTACH ED. 1, ED. 2							
SISCO	AX-S4 61850 ED. 1, ED.2							
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both					**P**		

Table 86: Results for GOOSE Control Block enabling – Set 1

	Publisher						
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						**P**
GE	850 ED.2						**P**
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both				**P**		
OMICRON	ISIO 200 ED. 1, ED.2				**P**		
RTDS	GTnet-GSE ED. 1, ED.2	**P**		**P**			
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2	**P**			**P**		
SISCO	AX-S4 61850 ED. 1, ED.2				**P**		
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2				**P**		
	DTM both						

Table 87: Results for GOOSE Control Block enabling – Set 2

	Publisher						
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both		**P**				
OMICRON	ISIO 200 ED. 1, ED.2						**P**
RTDS	GTnet-GSE ED. 1, ED.2	**P**	**p**		**P**	**P**	
RC Bresler	TOP300 ED. 1, ED. 2						
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2				**P**		
Toshiba	GRL200 ED.1, ED.2						

	Publisher						
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 889: Results for GOOSE Control Block enabling – Set 3

4.6.2 Disable of Transmission

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	It is a local issue on how to accomplish this (e.g. setting the Enable to false). Procedure: A client changes the enable of a GOOSE control block from TRUE to FALSE.
Expected Result:	The subscribing IED detects TAL expiration and gives some local indication.

4.6.2.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set. See Table 73 for details.

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2				**F**		**P**	
Doble	F61850SV							
EFACEC	TPUS220 ED.2	P						
GE	850 ED.2							
	F650 ED. 1, ED. 2	**P**	**P**					
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2						**P**	
RC Bresler	TOP300 ED. 1, ED. 2							
Schneider	P145 ED. 2				**P**	**P**		
Schweitzer	RTACH ED. 1, ED. 2							
SISCO	AX-S4 61850 ED. 1, ED.2							
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both					**P**		

Table 89: Results for GOOSE Control Block disabling – Set 1

		Publisher					
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						**P**
GE	850 ED.2						**P**
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both				**P**		
OMICRON	ISIO 200 ED. 1, ED.2				**P**		
RTDS	GTnet-GSE ED. 1, ED.2	**P**		**P**			
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2	**P**			**P**		
SISCO	AX-S4 61850 ED. 1, ED.2				**P**		
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2				**P**		
	DTM both						

Table 900: Results for GOOSE Control Block disabling – Set 2

		Publisher					
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both		**P**				
OMICRON	ISIO 200 ED. 1, ED.2						**P**
RTDS	GTnet-GSE ED. 1, ED.2	**P**	**p**		**P**	**P**	
RC Bresler	TOP300 ED. 1, ED. 2						
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2				**P**		
Toshiba	GRL200						

	Publisher						
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
	ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 910: Results for GOOSE Control Block disabling – Set 3

4.7 Simulation Bit

4.7.1 Ability to process data with simulation bit true

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This involves the test set and is a precondition for the following tests. Procedure: 1 The GOOSE publisher is publishing data. 2 The GOOSE publisher simulation flag is changed to indicate the GOOSE telegram is being published by a test device.
Expected Result:	The GOOSE data is examined using Wireshark and the GOOSE telegram should have the 8th octet set in Reserved 1...

4.7.1.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set. See Table 73 for details.

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2			**P**				
Doble	F61850SV							
EFACEC	TPUS220 ED.2							
GE	850 ED.2							
	F650 ED. 1, ED. 2							
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2							
RC Bresler	TOP300 ED. 1, ED. 2							
Schneider	P145 ED. 2							
Schweitzer	RTACH ED. 1, ED. 2							
SISCO	AX-S4 61850 ED. 1, ED.2							
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both							

Table 92: Results for data processing with simulation bit true - Set 1

		Publisher					
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2		**P**				
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both				**P**		
OMICRON	ISIO 200 ED. 1, ED.2				**P**		
RTDS	GTnet-GSE ED. 1, ED.2	**P**		**P**			
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2						
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2				**P**		
	DTM both			**P**			

Table 93: Results for data processing with simulation bit true - Set 2

	Publisher						
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both		**P**				
OMICRON	ISIO 200 ED. 1, ED.2						**P**
RTDS	GTnet-GSE ED. 1, ED.2		**P**				
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2						
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 94: Results for data processing with simulation bit true - Set 3

4.7.2 Transition from using simulated information to non-simulated information.

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	The subscriber/device under test (DUT) has to support the optional DO LPHD.Sim in order to accept and process the publisher's data. The DUT must include a way (GUI, MMS or other) to put the DUT root LD LPHD.Sim.stVal is set to "true". The DUT may include the LN LGOS and indicate when simulated data is being received. Procedure: 1 The publisher and GOOSE subscriber are functioning properly. 2 The GOOSE subscriber uses the GOOSE telegram, indications should be LGOS1.St.stVal=true, LGOS1.SimSt.StVal=false. 3 The GOOSE subscriber is put into LPHD1.St.Sim.stVal=true. 4 The GOOSE subscriber continues using the GOOSE telegram, indications should be LGOS1.St.stVal=true, LGOS1.SimSt.StVal=false.
Expected Result:	There is no test set publishing any GOOSE telegrams with the Simulation flag set "true" only the real telegrams are present. The subscriber shall continue to decode the real telegrams. Subscriber to provide sim status per implementation.

4.7.2.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set. See Table 73 for details.

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2							
Doble	F61850SV							
EFACEC	TPUS220 ED.2							
GE	850 ED.2							
	F650 ED. 1, ED. 2							
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2							
RC Bresler	TOP300 ED. 1, ED. 2							
Schneider	P145 ED. 2				**P**			
Schweitzer	RTACH ED. 1, ED. 2							

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
SISCO	AX-S4 61850 ED. 1, ED.2							
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both							

Table 95: Results for transition from simulated to non-simulated information – Set 1

	Publisher						
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2		**P**				
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both				**P**		
OMICRON	ISIO 200 ED. 1, ED.2				**P**		
RTDS	GTnet-GSE ED. 1, ED.2	**P**		**P**			
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2						
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 96: Results for transition from simulated to non-simulated information- Set 2

	Publisher						
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both		**P**				
OMICRON	ISIO 200 ED. 1, ED.2						**P**
RTDS	GTnet-GSE ED. 1, ED.2		**P**				
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2						
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 97: Results for transition from simulated to non-simulated information – Set 3

4.7.3 Ability to ignore data with simulation bit true

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	Procedure: 1 The publisher and GOOSE subscriber are functioning properly. 2 The GOOSE subscriber uses the GOOSE telegram indications should be LGOS1.St.stVal=true, LGOS1.SimSt.StVal=false 3 The GOOSE subscriber is put into LPHD1.St.Sim.stVal=true 4 The GOOSE subscriber continues using the GOOSE telegram, indications should be LGOS1.St.stVal=true, LGOS1.SimSt.StVal=false 5 A second identical GOOSE telegram is published by a test device and the simulation flag is set "true" 6 The GOOSE subscriber now will use the test GOOSE telegram, indication should be LGOS1.St.stVal=true, LGOS1.SimSt.StVal=true (The GOOSE subscriber will now only use GOOSE telegrams with the simulation flag set true) 7 Subscriber to provide sim status per implementation.
Expected Result:	The test set is publishing GOOSE telegrams with the Simulation flag set "true". The subscriber shall decode the simulated telegrams. Subscriber to provide sim status per implementation. The mechanism to provide this verification for the witness observation is subscriber specific.

4.7.3.1 Test Results

For legibility, test results have been separated into three result sets. The subscribers are listed in all sets, but the publishers vary per set. See Table 73 for details.

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Alstom	P645 ED.2							
Doble	F61850SV							
EFACEC	TPUS220 ED.2							
GE	850 ED.2							
	F650 ED. 1, ED. 2							
NR Electric	PCS-902 both							
OMICRON	ISIO 200 ED. 1, ED.2							
RTDS	GTnet-GSE ED. 1, ED.2							
RC Bresler	TOP300 ED. 1, ED. 2							
Schneider	P145 ED. 2							

	Publisher							
	Company	Alstom	CopaData	Doble	EFACEC	GE		Novatech/ Bitronics
Subscriber Company	Product	P645 ED. 2	Zenon 7.50 ED. 1	F61850SV ED.1,ED.2	TPUS220 ED. 2	850 ED. 2	F650 ED. 1, ED. 2	M871 ED. 2
Schweitzer	RTACH ED. 1, ED. 2							
SISCO	AX-S4 61850 ED. 1, ED.2							
Toshiba	GRL200 ED.1, ED.2							
Triangle Microworks	TTN ED. 1, ED. 2							
	DTM both							

Table 98: Results for ignoring data with simulation bit true – Set 1

	Publisher						
	Company	NR Electric	OMICRON		RTDS	RC Bresler	Schneider
Subscriber Company	Product	PCS-902 ED.1, ED.2	CMC-353 ED. 1	ISIO ED.1, ED. 2	GSE ED. 1, ED. 2	TOP300 ED. 1, ED. 2	P145 ED. 2
Alstom	P645 ED.2		**P**				
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both				**P**		
OMICRON	ISIO 200 ED. 1, ED.2				**P**		
RTDS	GTnet-GSE ED. 1, ED.2	**P**		**P**			
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2						
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 99: Results for ignoring data with simulation bit true – Set 2

	Publisher						
	Company	SISCO	Schweitzer		Toshiba	Triangle Microworks	
Subscriber Company	Product	AXS4 ED. 1, ED. 2	RTACH ED. 1, ED. 2	751 ED. 2	GRL200 ED. 1, ED. 2	TTN ED.1, ED. 2	DTM ED. 1, ED. 2
Alstom	P645 ED.2						
Doble	F61850SV						
EFACEC	TPUS220 ED.2						
GE	850 ED.2						
	F650 ED. 1, ED. 2						
NR Electric	PCS-902 both		**P**				
OMICRON	ISIO 200 ED. 1, ED.2						**P**
RTDS	GTnet-GSE ED. 1, ED.2		**P**				
RC Bresler	TOP300 ED. 1, ED. 2	**P**					
Schneider	P145 ED. 2						
Schweitzer	RTACH ED. 1, ED. 2						
SISCO	AX-S4 61850 ED. 1, ED.2						
Toshiba	GRL200 ED.1, ED.2						
Triangle Microworks	TTN ED. 1, ED. 2						
	DTM both						

Table 100: Results for ignoring data with simulation bit true – Set 3

5 Client Server Specific Results

There were a total of 19 participating companies who brought 32 implementations for testing. Implementations consisted of Clients and Servers. These categories were further divided by the edition of IEC 61850 that they supported. Table 101: Participating companies and products for client testing and Table 102 show the mix of editions based upon client and server implementations.

Company	Product	ED.1	ED.2
ARC Informatique	PcVue	x	x
CopaData	Zenon	x	x
Efacec	AS	x	x
GE	D400	x	x
Kalki	SYNC3000	x	
Koncar	PROZA-net	x	x
NR Electric	PCS-902	x	x
OMICRON	IEDScout	x	x
RTDS	MMS Voygeur	x	
Schweitzer Eng Lab	RTACH	x	x
SISCO	AXS64-61850	x	x
SUBNET	Substation Server		x
Triangle Microworks	DTM	x	x
	Hammer	x	x
XELAS Energy	61850 Energy Management	x	x

Table 101: Participating companies and products for client testing

Company	Product	ED.1	ED.2
Alstom	P645		x
Novatech/Bitronics	M660	x	x
	M871		x
	PPX2		x
Efacec	TPUS220		x
GE	F650		x
	850		x
	C60		x
Kalki	SYNC3000	x	
NR Electric	PCS-902	x	x
OMICRON	ISIO 200	x	x
RTDS	GTNETx2_GSE	x	x
Schneider Electric	MiCOM P145	x	x
Schweitzer Eng Lab	421-5	x	
SISCO	AXS64-61850	x	x
Toshiba	GRL200	x	x
Triangle Microworks	DTM		x
	Anvil		x

Table 102: Participating companies and products for server testing

Figure 23: Client/Server implementations versus 61850 Edition

Of the products that were tested as clients, support of Edition 1 only was 13%. However, there were 80% of the clients that supported both Edition 1 and Edition 2. Therefore, overall support for Edition 1 was 93%. 6% of the clients declared only Edition 2 support. However, overall support was 86% due to dual support clients. This support provides a good indication that mixed mode system support (e.g. Edition 1 and Edition 2) is viable from a client perspective and should be able to protect their current investment in Edition 1 systems while migrating towards Edition 2 systems.

Of the products that were tested as servers, support of Edition 1 only was 11%. However, there were 35% of the servers that supported both Edition 1 and Edition 2. Therefore, overall support for Edition 1 was 46%. 52% of the servers declared only Edition 2 support. However, overall support was 88% due to dual support servers. These percentages indicate a shift towards IEC 61850 Edition 2 support but still indicate that vendors continue to support Edition 1.

The actual test results utilize the following notations:

Label/Color	Meaning
P	Test combination passed
F	Test combination failed
	Test combination was not attempted
I	Test combination had an inconclusive result.
NS	Not Supported
Nx	Indicates that there was a notation created during testing. "x" is the number of the notation.
	Indicates that testing the combination was skipped since the implementations were from the same vendor
	Indicates that an implementation did not declare support for the capability being tested.
	Version of Both was indicated on test report.

Table 103: Legend for Client/Server test results

5.1 SCL

5.1.1 Client imports Server addressing information from SCL file

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: The client will configure the network addressing necessary for communicating with a server by extracting the network configuration information from the SCD file.

Procedure:

1. Run IID file through various SCL checkers and validators; report results for documentation
2. Testing begins without any client configuration of a server.
3. Client selects the server (IED) with which the test is being conducted from the SCD file using local means.
4. The client shall configure the network addressing information that is necessary for it to enable communications with the selected server to be established

Expected Result:	Client establishes a Two-Party Application Association (TPAA) with the server.

5.1.1.1 *Test Results*

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set.

Clients		Servers
Set 1	Set 2	
ARC Informatique	SISCO	Alstom
CopaData	Subnet	Efacec
Efacec	Triangle Microworks	GE
GE	Xelas Energy	Kalkitech
Kalkitech		NovaTech/Bitronics
Koncar		NR Electric
NR Electric		Omicron

Omicron	RTDS
RC Bresler	Schneider Electric
RTDS	Schweitzer
Schweitzer	SISCO
	Toshiba
	Triangle Microworks

Table 104: Client/Server Result Set Membership

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P		P		
	EFACEC	TPU S220 ED.2	P	P		F						P
	GE	F650 ED.2						P			P	
		850 ED. 2							P		I	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2						P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	P	F	P	
	SISCO	AXS64-61850 ED. 1, ED.2						P	P			
	Toshiba	GRL200 ED.1, ED.2						I				
	Triangle Microworks	DTM ED. 2							P	P		
		Anvil ED.2									P	

Table 105: Client/Server results for SCL configuration of network addressing – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	F				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 106: Client/Server results for SCL configuration of network addressing – Set 2

5.1.2 Configure Server Object Models in Client derived from SCD (using CID/IID information)

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: The client will configure the server object model namespace by extracting the Logical Node and corresponding data template information from a SCD file. Note: the activity of passing test 11.1 (Configure Server Network Addressing in Client derived from SCD) may have resulted in the configuration of the namespace at the same time. In that case, the test procedure shall be deemed to have already been executed and the expected results can be observed. A separate import of the same SCD file for both test cases (11.1 and 11.2) is not required.

Procedure:

1. Testing begins without client configuration of the server Logical Node and Data namespace.
2. Client selects the SCD file for the server with which this test is being conducted.
3. The client shall configure the server namespace for the IED selected from the SCD file

Expected Result: The client shall be configured with the server namespace that corresponds to the actual server as observed by executing ACSI Read services of various FCDs and/or FCDAs over a TPAA as supported by both the client and the server.

5.1.2.1 *Test Results*

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P		P		
	EFACEC	TPU S220	P	P		F		P				P

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		ED.2										
	GE	F650 ED.2						P			P	
		850 ED. 2							P		P	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							I			
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both		I					I		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2						P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2						P	P			
	Toshiba	GRL200 ED.1, ED.2	P					I				
	Triangle Microworks	DTM ED. 2					P		P	P		
		Anvil ED.2									P	

Table 107: Client/Server results for Client configuration of Server objects via SCD - Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 108: Client/Server results for Client configuration of Server objects via SCD - Set 2

5.1.3 Equivalency of Server Object Models using SCD Configuration vs. ACSI Based Discovery

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: This test will verify that a server IED namespace configured by the client using an SCD file (11.2) is equivalent to the server IED namespace configured using ACSI based discovery services.
Procedure:
1. Test case 11.2 is successfully executed and passed between the client and server.
2. The client is configured to establish a TPAA with the server without configuration of the server namespace.
3. The client establishes a TPAA with the server.
4. The client and server execute the GetServerDirectory, GetLogicalDeviceDirectory, GetLogicalNodeDirectory, GetDataDirectory, GetDataDefinition, and GetDataSetDirectory services as necessary to configure the client with the server object model namespace.

Expected Result: The namespace configured during test case and that configured via ACSI services are equivalent.

5.1.3.1 *Test Results*

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P					I		P		
	EFACEC	TPU S220 ED.2	P	P		P		P				
	GE	F650 ED.2						P			P	
		850 ED. 2							P		P	

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							I			
	NR Electric	PCS 902 ED. 1, ED. 2		P		I		P			P	
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both		P					I		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2						P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2						P	F			
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2							P	P		
		Anvil ED.2									P	

Table 109: Client/Server results for Client configuration of Server Equivalency – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			F		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		F		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	F			
		Anvil ED.2					

Table 110: Client/Server results for Client configuration of Server Equivalency – Set 2

5.1.4 Configure Server Object Models in Client using SCL Files Containing a Single Server

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: This test addresses the situation of using SCL files to configure clients with the server IED object model namespace independent of whether or not the server IED is accessible to the client over the network (off-line configuration) or in the case where a substation design has not yet been completed (no SCD is available). In this case, the client will configure the server IED object model namespace by extracting the Logical Node and corresponding data template information from a CID File for Edition 1 devices (also known as an "x-factor" file) or an IID file for Ed.2.

Procedure:

1. Testing begins without client configuration of the server IED Logical Node and Data namespace.
2. Client selects the CID/IID file for the server IED with which this test is being conducted.
3. The client shall configure the server IED namespace using the selected CID/IID file.

Expected Result: The client shall be configured with the server IED namespace that corresponds to the ICD file that was imported.

5.1.4.1 *Test Results*

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P		P		
	EFACEC	TPU S220 ED.2	P	P		F		P				P
	GE	F650 ED.2						P			P	

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		850 ED. 2		P							P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							I			
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both		P					I		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2		P				P	F		P	
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2		P			P	P		P		
		Anvil ED.2									P	

Table 111: Client/Server results for Client configuration of Server objects via SCL IID/CID files – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both	P				
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 112: Client/Server results for Client configuration of Server objects via SCL IID/CID files – Set 2

5.1.5 Verifying SCL and ACSI Object Model Equivalence

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: This test verifies whether the servers object model corresponds to the SCL object model. Additionally the test verifies that the client detects mismatches between SCL file and ACSI object model in server.

Procedure:

1. Testing begins without client configuration of the server IED Logical Node and Data namespace.
2. Start the server and compare the server object model with SCL instance data for the following attributes:
   a. Verify the "nameplate" data attributes like vendor and configRev
   b. Verify the instance data for ctlModel, sboTimeout, sboClass
   c. Verify the DataSet contents
   d. Verify the RCB instance data like confRev, intgPd, bufTime, datSet, TrgOps and OptFields
3. Modify the SCD file and configure mismatches for the data attributes listed above.
4. Client selects the SCD file for the server IED with which this test is being conducted.
5. The client shall configure the server IED namespace using the selected SCD file.
6. The client establishes a TPAA with the server.
7. Client reads the data model.

Expected Result: The server shall expose the instance values as stated in the SCL file. The client shall read the ACSI data model and data instances and report/react on mismatch for

1. NamPlt$configRev
2. ctlModel
3. RCB$confRev or alternatively DataSet and RCB contents

5.1.5.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P					P		P		
	EFACEC	TPU S220 ED.2	P	P		P		P				P
	GE	F650 ED.2						F			P	
		850 ED. 2							P		P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							I			
	NR Electric	PCS 902 ED. 1, ED. 2				P		P			P	P
	RC Bresler	TOP 300 ED. 2						P			P	
	OMICRON	ISIO 200 2.0 Both							I		P	
		IEDscout 4.10 ED. 1, ED. 2						I	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P					P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	F	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2						P	F		P	
	Toshiba	GRL200 ED.1, ED.2						I				
	Triangle Microworks	DTM ED. 2						P				
		Anvil ED.2									P	

Table 113: Client/Server test results for Report Control Block Subscriptions for SCD file – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		F		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both	P				
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	F			
		Anvil ED.2					

Table 114: Client/Server test results for Report Control Block Subscriptions for SCD file – Set 2

5.1.6 Configure RCB Subscription(s) from SCD

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: This test verifies whether the SCT creates SCD based on the ICD/IID files provided by client and server: IEDs provide an ICD/IID file

- IEC61850 Client with its IP address
- IEC61850 Server

- SCT is configuring reports
  - Based on server service capabilities:
    - New DataSets can be added, or existing can be changed
    - New RCB can be added, or existing attributes can be changed
  - Available ClientLN can be mapped to configured RCBs
    - Information about ClientLN added to the RCB, e.g. similar to <ClientLN IEDname="Client" apRef="S1" ldInst="LD0" lnClass="ITCI" lnInst="1" desc=""/>
    - Input section with Extref can be added to the LN of the Client
- SCT is providing SCD file to ICT of Client tool

Procedure:

1. SICT of Client tool is configured with the IP address provided.
2. ICT of Client tool is importing data:
   a. Configured data are imported
      i. If the IP address is found, those RCBs and associated data are imported/used
      ii. If another IP address is found, those RCBs are not imported/used
      iii. If no IP address is defined, if datasets have not been imported with another RCB yet, those RCBs are imported and can be used.
   b. If DynDataSet service is supported, additional data can be imported
3. ICT is loading the server
4. The Server has the RCB and the dataset as configured:

a. RCB has an Owner attribute filled in with the IP address of the configured Client

Expected Result:	The Client is connecting to the server, enabling the reports with the configured attributes and retrieving reports according to the RCB settings.

5.1.6.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P							P		
	EFACEC	TPU S220 ED.2				P		I				
	GE	F650 ED.2									P	
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2		P								P
	RC Bresler	TOP 300 ED. 2		F				P			P	
	OMICRON	ISIO 200 2.0 Both		P					P			
		IEDscout 4.10 ED. 1, ED. 2		P				P				
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P					P				
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2				P			I		P	
	SISCO	AXS64-61850 ED. 1, ED.2						P				
	Toshiba	GRL200 ED.1, ED.2	P									

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Triangle Microworks	DTM ED. 2		P						P		
		Anvil ED.2									P	

Table 115: SCL test results for Client/Server model mismatch – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2			P		
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 116: SCL test results for Client/Server model mismatch – Set 2

5.2 Reads

A number of IOP problems encountered in 2013 (as well as reported user feedback, including Entso-E), stemmed from the fact that some implementations access data only in terms of Objects where other implementations access only attributes. As combinations of these devices result in interoperability issues, this section shall verify reading data at the various levels.

5.2.1 Reading of an FCD

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1. Client issues a read of LLN0.Beh

Expected Result:	The client value of the server's LN0.Beh.stval (FC=ST) shall match.

5.2.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2	P	P				P	P			P
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1						P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							P			

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	NR Electric	PCS 902 ED. 1, ED. 2		P				P			P	P
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2		P				P	P		P	
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2						P	P	P		
		Anvil ED.2									P	

Table 117: Client/Server test results for reads of FCDs – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 118: Client/Server test results for reads of FCDs – Set 2

5.2.2 Reading of an FCDA

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1 Client issues a read of LLN0.Beh.stVal

Expected Result: The client value of the server's LN0.Beh.stval (FC=ST) shall match.

5.2.2.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P					P	P	P		
	EFACEC	TPU S220 ED.2	P	P				P	P			P
	GE	F650 ED.2						P			P	
		850 ED. 2							P		P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2				P		P			P	P
	RC Bresler	TOP 300 ED. 2						P			P	
	OMICRON	ISIO 200 2.0 Both							P		P	
		IEDscout 4.10 ED. 1, ED. 2						P	P			
	RTDS	GTNETx2_GSE										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P					P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P					P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2						P	P		P	
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2		P				P	P	P		
		Anvil ED.2									P	

Table 119: Client/Server test results for reads of FCDAs – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both	P				
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 120: Client/Server test results for reads of FCDAs – Set 2

5.2.3 Float32 Value Read

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: This test verifies the ability of the client to select a float attribute from the server's model.
Procedure:
Client is to read a float at the DO, DA, and leaf node levels:

1. Client issues a read of (for example) MMXU1.PhV [MX]
2. Client issues a read of (for example) MMXU1.PhV.phsA.cVal [MX]
3. Client issues a read of (for example) MMXU1.PhV.phsA.cVal.mag.f [MX]

Expected Result: The client value of the server's Floating-point value shall match within possible rounding errors...

5.2.3.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2	P	P				P	P			P
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		M871 ED. 2										
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2		P				I	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2		P				P	P		P	
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2						P	P	P		
		Anvil ED.2									P	

Table 121: Client/Server test results for reads of Float32 value - Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both	P				
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 122: Client/Server test results for reads of Float32 value - Set 2

5.3 Alternate Access

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This test verifies the client value matches the server's value within possible rounding error. Procedure: 1 Perform GetDataValues on data with a member with an FCD that causes Alternate access to be used.
Expected Result:	The client value of the server's value shall match within possible rounding

5.3.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2						P				
	EFACEC	TPU S220 ED.2						P				
	GE	F650 ED.2						P			P	
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1						P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2						P			P	
	RC Bresler	TOP 300 ED. 2						P				
	OMICRON	ISIO 200 2.0 Both										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		IEDscout 4.10 ED. 1, ED. 2						P				
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2						P				
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2						I				
	SISCO	AXS64-61850 ED. 1, ED.2						P			P	
	Toshiba	GRL200 ED.1, ED.2						I				
	Triangle Microworks	DTM ED. 2		P				P		P		
		Anvil ED.2									I	

Table 123: Client/Server test results for Alternate Access – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P				
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902					

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
		ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both	P				
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 124: Client/Server test results for Alternate Access – Set 2

5.4 DataSets

5.4.1 Static Datasets

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This test will verify a read can be done of a dataset selected from a predefined list of datasets (From server IID). Procedure: Perform GetDataSetValues on any predefined dataset.
Expected Result:	The client values for the members of the data set should match those of the server.

5.4.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2	P						P			P
	GE	F650 ED.2						P			F	
		850 ED. 2							P		P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2				P		F			P	P
	RC Bresler	TOP 300 ED. 2						P			P	
	OMICRON	ISIO 200 2.0							P		P	

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		Both										
		IEDscout 4.10 ED. 1, ED. 2						P				
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P					P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2						P	P		P	
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2						P	P	P		
		Anvil ED.2									P	

Table 125: Client/Server test results for reads of predefined DataSets – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both	P				
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 126: Client/Server test results for reads of predefined DataSets – Set 2

5.4.2 Array Indexing

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This test will verify a read can be done of a dataset selected from a predefined list of datasets (From server IID). Procedure: Perform GetDataSetValues on a dataset that defines an FCDA using the indexing feature. For example, (taken from part 6): <FCDA ldInst="C1" lnInst="1" lnClass="PVOC" doName=" TmASt " fc="SP" daName="curvPts(2).xVal" ix="2"/> <FCDA ldInst="C1" lnInst="1" lnClass="MHAI" doName="HPhV.phsAHar(3)" fc="MX" daName="mag" ix="3"/>
Expected Result:	The client values for the members of the data set should match those of the server.

5.4.2.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2								P		
		Anvil ED.2									I	

Table 127: Client/Server test results for reads using Array Indexing – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 128: Client/Server test results for reads using Array Indexing – Set 2

5.4.3 Arrays of DO's

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This test will verify a read can be done of a dataset selected from a predefined list of datasets (From server IID). Procedure: Perform GetDataSetValues on a dataset that has an FCD that contains members from CDC HMV or HWYE
Expected Result:	The client values for the members of the data set should match those of the server.

5.4.3.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2		P								

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2								P		
		Anvil ED.2									I	

Table 129: Client/Server test results for reads of Arrays of DO's – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2					
		Anvil ED.2					

Table 130: Client/Server test results for reads of Arrays of DO's – Set 2

5.5 Dynamic Datasets

5.5.1 FCD Create Dataset

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This test will verify a dataset can be created on a server and deleted on the server by the client. Procedure: 1 Create a Dynamic DataSet with at least 4 members. With at least one member being an FCD. 2. Read the DataSet. 3. Delete DataSet just created
Expected Result:	1. DataSet on server is defined correctly. 2. The client values for .the members of the data set should match those of the server. 3. DataSet is deleted from server.

5.5.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1				P		P				

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										
	RC Bresler	TOP 300 ED. 2		I				P			P	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2						P	P		P	
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2		P				P	P	P		
		Anvil ED.2									P	

Table 131: Client/Server test results for creating/deleting server datasets by client (FCD) – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 132: Client/Server test results for creating/deleting server datasets by client (FCD) – Set 2

5.5.2 FCDA Create Dataset

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: This test will verify a dataset can be created on a server and deleted on the server by the client.

Procedure:

1 Create a Dynamic DataSet with at least 4 members. With at least one member being an FCDA.
2. Read the DataSet.
3. Delete the DataSet

Expected Result:

1. DataSet on server is defined correctly.
2. The client values for .the members of the data set should match those of the server.
3. DataSet is deleted from server.

5.5.2.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										
	RC Bresler	TOP 300 ED. 2						P			I	
	OMICRON	ISIO 200 2.0 Both							P		P	
		IEDscout 4.10 ED. 1, ED. 2						P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2						P	P		P	
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2						P	P	P		
		Anvil ED.2									P	

Table 133: Client/Server test results for creating/deleting server datasets by client (FCDA) – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 134: Client/Server test results for creating/deleting server datasets by client (FCDA) – Set 2

5.5.3 Datasets Using Array Indexing

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: This test will verify a dataset can be created on a server and deleted on the server by the client.

Procedure:

1 CreateDataSet that defines an FCDA that uses the indexing feature. For example, (taken from the spec):
<FCDA ldInst="C1" lnInst="1" lnClass="PVOC" doName=" TmASt " fc="SP" daName="curvPts(2).xVal" ix="2"/>
<FCDA ldInst="C1" lnInst="1" lnClass="MHAI" doName="HPhV.phsAHar(3)" fc="MX" daName="mag" ix="3"/>

2 Read the DataSet

3 Delete the DataSet

Expected Result:

1. DataSet on server is defined correctly.
2. The client values for .the members of the data set should match those of the server.
3. DataSet is deleted from server.

5.5.3.1 *Test Results*

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2								P		
		Anvil ED.2									I	

Table 135: Client/Server test results for create/delete server datasets using array indexing – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2					
		Anvil ED.2					

Table 136: Client/Server test results for create/delete server datasets using array indexing – Set 2

5.6 Buffered Reporting

5.6.1 Initial Enabling of Report Control Block

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This test will verify that a client can receive reports and indicate reception of same. Note that for Ed. 1 only, the client and server must mutually agree upon the GI trigger options that are to be supported. The agreed upon attributes of the control block shall be recorded as part of the test results. Procedure: The client will enable a buffered report control block.
Expected Result:	The client should begin receiving reports and shall give some indication that reports are being received.

5.6.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2	P	P				P	P			P
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P		F	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	F			P		P	P	I	P	
	SISCO	AXS64-61850 ED. 1, ED.2		P				P	P		P	
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2		P			P	P	P	P		
		Anvil ED.2									P	

Table 137: Client/Server results of enabling BRCB tests –Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		F
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 138: Client/Server results of enabling BRCB tests –Set 2

Test Case Description: The Initial Enabling test case was executed and the connection between the client and server is brought down.
Procedure:

1. Disable the BRCB.
2. The client will write a resynchronization value (entryID) and enable a buffered report control block.

Expected Result: The client should begin receiving reports and shall give some indication that reports are being received, starting with the entry following the entryID written.

5.6.2.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2	P	P				P	P			P
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1						P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		I				I			F	
	OMICRON	ISIO 200 2.0 Both		I					P		P	
		IEDscout 4.10 ED. 1, ED. 2		I				F	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P			
	Schweitzer	421-5 ED.1										
		RTACH	F			P		P	P	I	P	

Servers			ED.1, ED.2	ED. 1, ED. 2	ED1, ED2	ED. 1, ED. 2	ED. 1	ED. 1, ED. 2	ED. 1, ED. 2	ED.1, ED.2	Voyageur ED. 1	Both
	Triangle Microworks	DTM ED. 2		I				P	P	P		
		Anvil ED.2									P	

Table 139: Client/Server test results for BRCB resynchronization – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	F		P		
		M871 ED. 2	F				
		PPX2 ED. 2	F				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			F		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 140: Client/Server test results for BRCB resynchronization – Set 2

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	The Initial Enabling test case was executed and the connection between the client and server is brought down. Procedure: The client will purge the buffer and enable the buffered report control.
Expected Result:	The client should begin receiving reports and shall give some indication that reports are being received. No old values should be received. BufOvfl will be set in the first report.

5.6.3.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2	P	P				P	P			
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2								I		
	Kalki	SYNC3000 ED. 1						P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P			
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	F			P		P	P	P	P	

Servers			ED.1, ED.2	ED. 1, ED. 2	ED1, ED2	ED. 1, ED. 2	ED. 1	ED. 1, ED. 2	ED. 1, ED. 2	ED.1, ED.2	Voyageur ED. 1	Both
		Anvil ED.2									P	

Table 141: Client/Server test results for BRCB purging – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 142: Client/Server test results for BRCB purging – Set 2

5.7.1 Enabling Control Blocks

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This test will verify that a client can receive unbuffered reports. Note that for Ed. 1 only, the client and server must mutually agree upon the trigger options that are to be supported. The mutually agreed upon attributes of the control block shall be recorded as part of the test matrix. Procedure: The client will write and enable an unbuffered report control block.
Expected Result:	The client should begin receiving reports and shall give some indication that reports are being received.

5.7.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2	P	P				P	P			P
	GE	F650 ED.2									P	
		850 ED. 2		P					P		P	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1						P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2						P				
		M871 ED. 2										
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P		F	
	Schweitzer	421-5 ED.1										

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	SISCO	AXS64-61850 ED. 1, ED.2		P				P	P		P	
	Toshiba	GRL200 ED.1, ED.2	F					P				
	Triangle Microworks	DTM ED. 2		P				P	P	P		
		Anvil ED.2									P	

Table 143: Client/Server test results for enabling URCB tests – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P		P		
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		P
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 144: Client/Server test results for enabling URCB tests – Set 2

5.8.1 QueryLog

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	This test will verify that a client can poll for logs and indicate that logs are being received. Procedure: The client will write and enable a log report control block if needed...
Expected Result:	The client should poll for logs and shall give some indication that logs are being received.

5.8.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2									P	
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										

Serv ers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Triangle Microworks	DTM ED. 2							P			
		Anvil ED.2										

Table 145: Client/Server test results for logging test – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2			F		
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2					
		Anvil ED.2					

Table 146: Client/Server test results for logging test – Set 2

5.9.1 Direct Control with normal security

5.9.1.1 Remote Control Enabled

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	The server is enabled for remote control and the Pos.stVal on the server is “on”. The control model is Direct Operate. Procedure: Client issues a direct control to the server that is enabled for remote control with a ctlVal of “on”...
Expected Result:	Server will indicate that no control action has taken place and the client shall indicate a control error and display the correct additional cause diagnoses (Position-reached) if addCause is supported by client. Witness to note whether addCause is indicated.

5.9.1.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P					P	P	P		
	EFACEC	TPU S220 ED.2	P	P				P	F			P
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		F							F	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider	MiCom P145	P	P				P	P		P	

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2		P					P		I	
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2		P			P	P	P	P		
		Anvil ED.2									P	

Table 147: Client/Server test results for Direct Control with Server enabled for remote control – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2	P				
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both	F				
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2		P			
		Anvil ED.2					

5.9.1.2 Remote Control Disabled

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	The server is disabled for remote. The control model is Direct Operate. Procedure: Client issues a direct control to the server with orCat of remote-control.
Expected Result:	Server will indicate that no control action has taken place and the client shall indicate a control error and display the correct additional cause diagnoses (Blocked-by-switching-hierarchy) if addCause is supported by client.

5.9.1.2.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2	P	P				P	P			P
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1				P						
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		I		P		P			P	P
	RC Bresler	TOP 300 ED. 2									F	
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P		P	

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2		P					F			
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2		P			P	P	P	P		
		Anvil ED.2									P	

Table 149: Client/Server test results for Direct Control with Server disabled for remote control – Set 1

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			I		
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 150: Client/Server test results for Direct Control with Server disabled for remote control – Set 2

5.9.1.3 Remote Control Enabled and Time Activated Operate

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	The server is enabled for remote control. The control model is Direct Operate. Procedure: Client issues a direct control to the server that is enabled for remote control and provides a “future” timestamp (e.g., 10s from current time) for control operation.
Expected Result:	After the time period given, server will indicate that a control action has taken place and the client shall indicate no error…

5.9.1.3.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2						P				
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED. 2										

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Triangle Microworks	DTM ED. 2										
		Anvil ED.2										

Table 151: Client/Server test results for Direct Control with Server enabled for remote control and time-activated operate – Set 2

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2					
		Anvil ED.2					

Table 152: Client/Server test results for Direct Control with Server enabled for remote control and time-activated operate – Set 2

5.9.2 Select Before Operate (SBO) with enhanced security

5.9.2.1 *Remote Control Enabled*

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:	The server is enabled for remote control and the Pos.stVal is "on". The control model is Select Before Operate with Enhanced Security. Procedure: Client issues a SBOE control to the server that is enabled for remote control with a ctlVal of "on".
Expected Result:	Server will indicate that no control action has taken place and the client shall indicate a control error and display the correct additional cause diagnoses (Position-reached). Witness to note whether addCause is indicated...

5.9.2.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2							F			
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1				P		P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2		F							F	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider	MiCom P145	P	P				P	P		P	

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2	P					P				
	Triangle Microworks	DTM ED. 2					P	P	P	P		
		Anvil ED.2									P	

Table 153: Client/Server test results for SBOE with Server enabled for remote control – Set 1

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2			P		
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	F			
		Anvil ED.2					

Table 154: Client/Server test results for SBOE with Server enabled for remote control – Set 2

Test Case Description: The server is disabled for remote. The FCD configuration is for Select Before Operate with Enhanced Security.
Procedure:
Client issues a SBOE control to the server with orCat of remote-control

Expected Result: Server will indicate that no control action has taken place and the client shall indicate a control error and display the correct additional cause diagnoses (Blocked-by-switching-hierarchy) if addCause is supported by client. Witness to note whether addCause is indicated

5.9.2.2.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2							F			
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1				P						
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	P
	RC Bresler	TOP 300 ED. 2									F	
	OMICRON	ISIO 200 2.0 Both							P			
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P			P		P	P	P	P	
	SISCO	AXS64-61850										

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		ED.1, ED.2										
	Triangle Microworks	DTM ED. 2					P	P	P	P		
		Anvil ED.2									P	

Table 155: Client/Server test results for SBOE with Server disabled for remote control – Set 1

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			I		
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P	P			
		Anvil ED.2					

Table 156: Client/Server test results for SBOE with Server disabled for remote control – Set 2

Test Case Description:	The server is enabled for remote control. The control model is Select Before Operate with Enhanced Security. Procedure: Client issues a SBOE control to the server that is enabled for remote control and provides a “future” timestamp (10s from current time) for control operation.
Expected Result:	After the time sent, server will indicate that a control action has taken place and the client shall indicate no error.

5.9.2.3.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both							P			
		IEDscout 4.10 ED. 1, ED. 2						P				
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850										

Serv ers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		ED.1, ED.2										
	Triangle Microworks	DTM ED. 2										
		Anvil ED.2										

Table 157: Client/Server test results for SBOE with Server enabled for remote control and time-activated operate – Set 1

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2					
		Anvil ED.2					

Table 158: Client/Server test results for SBOE with Server enabled for remote control and time-activated operate – Set 2

Test Case Description: The server is enabled for remote. The FCD configuration is for Select Before Operate with Enhanced Security.
Procedure:
Client issues a valid SelectWithValue request to the server followed by a Cancel Request.

Expected Result:	Server will indicate that a control has been selected and that the cancel operation was successful without executing any control action.

5.9.2.4.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P					P	P	P		
	EFACEC	TPU S220 ED.2							P			
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1						P				
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P				P			P	
	RC Bresler	TOP 300 ED. 2						P			F	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2		P				P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2	P	P				P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P					F	P	F	P	
	SISCO	AXS64-61850 ED. 1, ED.2										

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Triangle Microworks	DTM ED. 2						P	P	P		
		Anvil ED.2									P	

Table 159: Client/Server test results for SBOE cancellation- Set 1

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 160: Client/Server test results for SBOE cancellation- Set 2

5.10 Settings Group

5.10.1 Settings Groups

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: Available SGCBs are imported via SCL

.Procedure:

1. If the number of SettingGroup is higher than 1, the user can select another group and request to switch it.
2. The used setting-group "ActSG" is read.

Expected Result: New settings are now active in the server
The Client can verify the new activated SG

5.10.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2						P	P	P		
	EFACEC	TPU S220 ED.2		P				P	P			
	GE	F650 ED.2						P			P	
		850 ED. 2										
		C60 ED. 2								I		
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P				P			P	
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider	MiCom P145		P				F	P		P	

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2						P				
	Triangle Microworks	DTM ED. 2		P				P	P			
		Anvil ED.2									P	

Table 161: Client/Server test results for switching settings groups – Set 1

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					F
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			I		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	I				
		Anvil ED.2					

Table 162: Client/Server test results for switching settings groups – Set 2

5.11.1 Tracking Control Block Accesses

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1. Enable a control block referencing a dataSet containing tracking (SR) nodes.
2. Perform a valid RCB write.
3. Preform an invalid RCB write

Expected Result:	Receive a report of the valid RCB access. Receive a report showing error on the invalid access.

5.11.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2						P				
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										

Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2		P				P	P	P		
		Anvil ED.2										

Table 163: Client/Server test results for tracking Control Block accesses – Set 1

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 164: Client/Server test results for tracking Control Block accesses – Set 2

5.12 File Services

Preconditions: Servers providing file services shall provide the information in the SCL service section. This test includes MMS file services only – not ftp or other means

5.12.1 File Directory

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:
Client performs a GetServerDirectory[File] {i.e. it needs no information other than server name}

Expected Result:	1. Server returns (at least) all files in root directory 2. Server returns list of names suitable for requesting a file read (open/read/read/close). All files are contained within folders either at root level (example "\COMTRADE" or "COMTRADE") or within the named Logical Device (example: "\MyLD\COMTRADE" or "myLD\COMTRADE") 3. The directory entries will be correctly displayed by the client

5.12.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2				P		P	P			
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2						P			P	
		850 ED. 2		P					P		P	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0										

Serv ers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2		P				P	P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2		P					P		P	
	Toshiba	GRL200 ED.1, ED.2						P				
	Triangle Microworks	DTM ED. 2		P				P	P			
		Anvil ED.2									P	

Table 165: Client/Server test results for FileDirectory – Set 1

		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2	P				
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1			F		
	NovaTech/ Bitronics	M660 ED. 1, ED. 2			P		
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					P
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both			I		
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1	P				
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 166: Client/Server test results for FileDirectory – Set 2

5.12.2 Get File

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: The client retrieves the file from the server and saves the file to a path specified locally on the client.
Procedure:
Client will retrieve the file from the server and store the file locally.

Expected Result: File can be retrieved completely from the server. File name, size and file contents will match on client and server.

5.12.2.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2				P		P	P			
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2						P			F	
		850 ED. 2		P					P		P	
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			I	
	RC Bresler	TOP 300 ED. 2		P				P			P	
	OMICRON	ISIO 200 2.0 Both										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2		P					P		P	
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2		P					P		P	
	Toshiba	GRL200 ED.1, ED.2						P				
	Triangle Microworks	DTM ED. 2		P				P	P			
		Anvil ED.2									P	

Table 167: Client/Server test results for GetFile – Set 2

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2			P		
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2	P				
		PPX2 ED. 2					

			Clients					
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			P		
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					F
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			I		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 168: Client/Server test results for GetFile – Set 2

5.12.3 File Write

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: The server vendor will provide path to write a file to.
Procedure:
Client will send the file and then compare the file and use directory service to verify the file size.

Expected Result: File name and size will match on client and server.

5.12.3.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2							P		P	
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2							P			
		Anvil ED.2									P	

Table 169: Client/Server test results for FileWrite – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			I		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 170: Client/Server test results for FileWrite – Set 2

5.13 Substitution

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description: The participants shall agree upon a server DO that supports substitution. Client reads DO and verifies subEna=FALSE and stVal represents the process value.
Procedure:
Client writes a value to subVal that is different from stVal, and writes subEna to TRUE. Client reads the DO

Expected Result: stVal is equal to subVal, and that q indicates a substituted value.

5.13.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2						F	P			
	GE	F650 ED.2										
		850 ED. 2							P			
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P				P			P	

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2		P					P	P		
		Anvil ED.2									P	

Table 171: Client/Server test results for Substitution – Set 2

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2			P		
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660					

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
		ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2			P		
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2					
		Anvil ED.2					

Table 172: Client/Server test results for Substitution – Set 2

5.14 Mod/Beh

5.14.1 Change Mod/Beh (Client)

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1. Check that client receives data with q.test=FALSE and q.operatorBlocked=FALSE.
2. Client sets LLN0.Mod to Test via a control operation.
3. Check that LLN0.Mod.stVal is set to Test on the server. The server now sends data with q.test=TRUE and q.operatorBlocked=FALSE.
4. Check that client receives data with q.test=TRUE and q.operatorBlocked=FALSE

Expected Result:	Client is able to change LLN0.Mod via a control operation. Client recognizes q=test on received data

5.14.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2							P			
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2								P		

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Kalki	SYNC3000 ED. 1				P						
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2				P		P			P	
	RC Bresler	TOP 300 ED. 2									F	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2						P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2									I	
	Toshiba	GRL200 ED.1, ED.2						F				
	Triangle Microworks	DTM ED. 2										
		Anvil ED.2										

Table 173: Client/Server test results for changing Mod/Beh – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			I		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 174: Client/Server test results for changing Mod/Beh – Set 2

5.14.2 Mod/Beh: On (Server)

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1 Client sets LLN0.Mod to On via a control operation.

2 Apply a stimulus that triggers a process output change on the server. This can either be a control operation by the Client, or an external stimulus.

3 Check that output to the process (switchgear) was performed.

4 Check that server sent data changes with q.test=FALSE and q.operatorBlocked=FALSE.

Expected Result:	1. Server can be set to mode On. 2. Server sends data with q.test=FALSE. 3. Output to process was performed

5.14.2.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2							P			P
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		PPX2 ED. 2							P			
	NR Electric	PCS 902 ED. 1, ED. 2				P		P			P	
	RC Bresler	TOP 300 ED. 2									P	
	OMICRON	ISIO 200 2.0 Both		P					P		P	
		IEDscout 4.10 ED. 1, ED. 2						P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P						P			
	SISCO	AXS64-61850 ED. 1, ED.2						I				
	Toshiba	GRL200 ED.1, ED.2						F				
	Triangle Microworks	DTM ED. 2										
		Anvil ED.2										

Table 175: Client/Server test results for setting Mod/Beh on – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2	P				
		M871 ED. 2	P				
		PPX2 ED. 2	P				
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			I		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 176: Client/Server test results for setting Mod/Beh on – Set 2

5.14.3 Mod/Beh: On-Blocked (Server)

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1. Client sets LLN0.Mod to On-Blocked via a control operation.
2. Apply a stimulus that would trigger a process output change on the server. This can either be a control operation by the Client, or an external stimulus.
3. Check that output to the process (switchgear) was not performed.
   Check that server sent data changes with q.test=FALSE and q.operatorBlocked=FALSE

Expected Result:

1. Server can be set to mode On-Blocked.
2. Server sends data with q.test=FALSE and q.operatorBlocked=FALSE.
3. Output to process was not performed.

5.14.3.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2							P			
	GE	F650 ED.2										
		850										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		ED. 2										
		C60 ED. 2								F		
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2				P		P			P	
	RC Bresler	TOP 300 ED. 2									P	
	OMICRON	ISIO 200 2.0 Both		I					P			
		IEDscout 4.10 ED. 1, ED. 2						P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2										
		Anvil ED.2										

Table 177: Client/Server test results for setting Mod/Beh on-blocked – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			I		
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 178: Client/Server test results for setting Mod/Beh on-blocked – Set 2

5.14.4 Mod/Beh: Test (Server)

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1 Client sets LLN0.Mod to Test via a control operation.
2 Apply a stimulus that triggers a process output change on the server. This can either be a control operation by the Client, or an external stimulus.
3 Check that output to the process (switchgear) was performed.
4 Check that server sent data changes with q.test=TRUE and q.operatorBlocked=FALSE.

Expected Result:

1. Server can be set to mode Test.
2. Server sends data with q.test=TRUE and q.operatorBlocked=FALSE.
3. Output to process was performed.

5.14.4.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2							F			
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2				P		P			P	
	RC Bresler	TOP 300 ED. 2									P	
	OMICRON	ISIO 200 2.0 Both		P					I		P	
		IEDscout 4.10 ED. 1, ED. 2						P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2	F					F				
	Triangle Microworks	DTM ED. 2										
		Anvil ED.2										

Table 179: Client/Server test results for setting Mod/Beh to Test – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
gmtServers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			I		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 180: Client/Server test results for setting Mod/Beh to Test – Set 2

5.14.5 Mod/Beh: Test-Blocked (Server)

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1 Client sets LLN0.Mod to Test-Blocked via a control operation.
2 Apply a stimulus that would trigger a process output change on the server. This can either be a control operation by the Client, or an external stimulus.
3 Check that output to the process (switchgear) was not performed.
4 Check that server sent data changes with q.test=TRUE and q.operatorBlocked=FALSE

Expected Result:	1. Server can be set to mode Test-Blocked. 2. Server sends data with q.test=TRUE and q.operatorBlocked=FALSE. 3. Output to process was not performed..

5.14.5.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2	P			P		P	P	P		
	EFACEC	TPU S220 ED.2							F			
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2								P		

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2				P		P			P	
	RC Bresler	TOP 300 ED. 2									P	
	OMICRON	ISIO 200 2.0 Both		I					I			
		IEDscout 4.10 ED. 1, ED. 2						P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2										
		Anvil ED.2										

Table 181: Client/Server test results for setting Mod/Beh to Test-Blocked – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			I		
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 182: Client/Server test results for setting Mod/Beh to Test-Blocked – Set 2

5.14.6 Mod/Beh: Off (Server)

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1 Client sets LLN0.Mod to Off via a control operation

2 Apply a stimulus that would trigger a process output change on the server. This can either be a control operation by the Client, or an external stimulus.

3 Check that output to the process (switchgear) was not performed.

4 Check that server sent no data changes.

Expected Result:

1. Server can be set to mode Off.
2. Server sends no data changes.
3. Output to process was not performed..

5.14.6.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2							P			
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2								P		
	Kalki	SYNC3000 ED. 1										
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2		P		P		P			P	
	RC Bresler	TOP 300 ED. 2									F	
	OMICRON	ISIO 200 2.0 Both		P					P			
		IEDscout 4.10 ED. 1, ED. 2						P	P			
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2										
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2										
		Anvil ED.2										

Table 183: Client/Server test results for setting Mod/Beh Off – Set 2

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2			I		
	OMICRON	ISIO 200 2.0 Both			P		
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2			P		
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2	P				
		Anvil ED.2					

Table 184: Client/Server test results for setting Mod/Beh Off – Set 2

5.15 Authentication

5.15.1 ACSE Password

This section contains a brief description of the test case, expected result, and the actual results.

Test Case Description:

Procedure:

1. Client and server configured to use username "IOP" and password "2015"
2. Client initiates TPAA
3. Disconnect
4. Client changes password to "2014"
5. Client initiates TPAA

Expected Result:	TPAA is established. Connection is refused.

5.15.1.1 Test Results

For legibility, test results have been separated into two result sets. The servers are listed in all sets, but the clients vary per set. See Table 104 for details.

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	Alstom	P645 ED. 2										
	EFACEC	TPU S220 ED.2										
	GE	F650 ED.2										
		850 ED. 2										
		C60 ED. 2										
	Kalki	SYNC3000 ED. 1										

			Clients									
		Company	ARC Informatique	CopaData	EFACEC	GE	Kalki	Koncar	NR Electric	OMICRON	RTDS	SEL
Servers	Company	Product	PcVue 11.2 ED.1, ED.2	Zenon 7.50 ED. 1, ED. 2	AS ED1, ED2	D400 ED. 1, ED. 2	SYNC3000 ED. 1	PROZA-NET ED. 1, ED. 2	PCS-9799 ED. 1, ED. 2	IEDScout 4.10 ED.1, ED.2	MMS Voyageur ED. 1	RTACH Both
	NovaTech/ Bitronics	M660 ED. 1, ED. 2										
		M871 ED. 2										
		PPX2 ED. 2										
	NR Electric	PCS 902 ED. 1, ED. 2										
	RC Bresler	TOP 300 ED. 2										
	OMICRON	ISIO 200 2.0 Both										
		IEDscout 4.10 ED. 1, ED. 2										
	RTDS	GTNETx2_GSE Both										
	Schneider Electric	MiCom P145 ED. 1, ED.2										
	Schweitzer	421-5 ED.1										
		RTACH ED. 1, ED. 2	P							P	P	
	SISCO	AXS64-61850 ED. 1, ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	DTM ED. 2		P						P		
		Anvil ED.2										

Table 185: Client/Server test results for Authentication – Set 1

			Clients				
		Company	SISCO	SUBNET	Triangle Microworks		XELAS Energy
Servers	Company	Product	AX-S4 61850 ED.1, ED. 2	SubStation Server Ed. 2	DTM ED.1,ED.2	Hammer ED.1 , ED. 2	61850 Energy Mgmt. ED. 1, ED. 2
	Alstom	P645 ED. 2					
	EFACEC	TPU S220 ED.2					
	GE	F650 ED.2					
		850 ED. 2					
		C60 ED. 2					
	Kalki	SYNC3000 ED. 1					
	NovaTech/ Bitronics	M660 ED. 1, ED. 2					
		M871 ED. 2					
		PPX2 ED. 2					
	NR Electric	PCS 902 ED. 1, ED. 2					
	RC Bresler	TOP 300 ED. 2					
	OMICRON	ISIO 200 2.0 Both					
		IEDscout 4.10 ED. 1, ED. 2					
	RTDS	GTNETx2_GSE Both					
	Schneider Electric	MiCom P145 ED. 1, ED.2					
	Schweitzer	421-5 ED.1					
		RTACH ED. 1, ED. 2					
	SISCO	AXS64-61850 ED. 1, ED.2					
	Toshiba	GRL200 ED.1, ED.2					
	Triangle Microworks	DTM ED. 2					
		Anvil ED.2					

Table 186: Client/Server test results for Authentication – Set 2

6 HSR/PRP - Network Testing

This test plan is prepared based on the requirements specified by the group of experts forming part of the IOP initiative to be held in March 2015. The purpose of the testing was to:

- Test interoperability of High Speed Redundancy (HSR) implementations (see
- Test interoperability of Parallel Redundancy Protocol (PRP) implementations
- Test hybrid network exchanges when:
    - PRP is connected to HSR
    - PRP connected to Rapid Spanning Tree Protocol (RSTP)
    - HSR connected to RSTP
- Performance testing of HSR (see
- Performance testing of network bridges (e.g. coupling)

Participants for the various tests were:

Company	HSR	PRP	HSR/PRP	HSR/RSTP	Performance of HSR	Network Bridge
ABB	x	x	x	x		
Alstom	x	x	x	x	x	
Efacec	x	x	x		x	x
GE	x	x	x	x		x
Moxa	x	x	x	x	x	x
NR Electric	x	x	x			
OMICRON DANEO 400				x	x	x
Schneider	x	x	x	x	x	x
Siemens /RuggedCom	x	x	x	x	x	x
Toshiba	x	x	x			
Vizimax	x	x	x		x	

Table 187: HSR/PRP participants versus test areas

6.1 High Speed Redundancy (HSR) Testing

The purpose of testing HSR was to verify that IEC 61850 communication protocols worked properly amongst different vendor's implementations of HSR. The implementations included Intelligent Electronic Devices (IEDs) as well as Intermediate Systems (ISs).

During the preparation for testing, it was discussed how to diagnose issues with HSR interoperability. Few HSR implementations had human accessible diagnostic information that would allow diagnostics of issues, therefore HSR unit testing was required as part of building the initial HSR network.

Thus the sequence of testing was:

- Unit testing as part of building the initial HSR network.

- IEC 61850 service testing over HSR:
  - Client/Server
  - GOOSE Publisher/Subscriber
  - Sampled Value Publisher/Subscriber

- Bandwidth/Performance testing using Sampled Values to load the HSR network

6.1.1 Unit Testing

Unit testing was performed in order to validate that there were no issues, regarding redundancy, introduced by HSR implementations as the HSR ring was expanded through the addition of more implementations.

In order to accomplish this, two reference implementations were chosen to create a GOOSE publisher/subscriber relationship. Both references published a GOOSE that the other reference subscribed to. The references provided visual indications (e.g. front panel LEDs) if the subscribed GOOSE message was being received. The reference IEDs were provided by Schneider and Efacec.

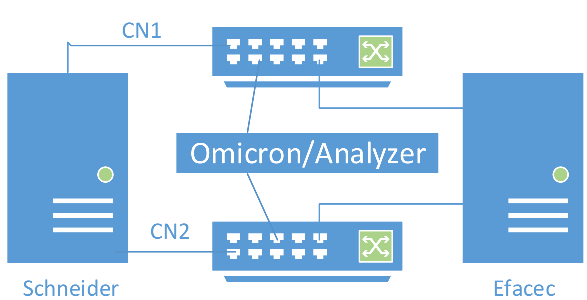


Figure 24: Initial HSR Reference Testing Network Topology

In order to be able to diagnose HSR issues two non-HSR Ethernet switches were inserted into the ring as shown in Figure 24. These switches allowed network analyzers (e.g. OMICRON and Wireshark) to be used to observed and diagnose network related issues. The switches also allowed injection of non-HSR tagged packets that were required for other test steps.

Once the references were validated, other Dual Attached Nodes (DANs) were added to the network a single device at a time. Each device, including the references, was tested for:

- The ability to pass HSR tagged frames appropriately and to not disrupt the delivery of GOOSE (see page 369).
- The ability to not disrupt the HSR network during power-down/power-up cycling.
- The ability to pass non-configured VLAN tagged frames.
- The ability to not be disrupted by non-HSR tagged frames being on the HSR network.

6.1.1.1 Normal HSR Redundancy Testing

The testing of HSR redundancy for the Device Under Test (DUT) required that the DUT be an HSR Dual Attached Node (DAN). The DUT is then inserted between the reference implementations (see Figure 25). The purpose was to ensure that the DUT passes normal HSR traffic and allows HSR redundancy.

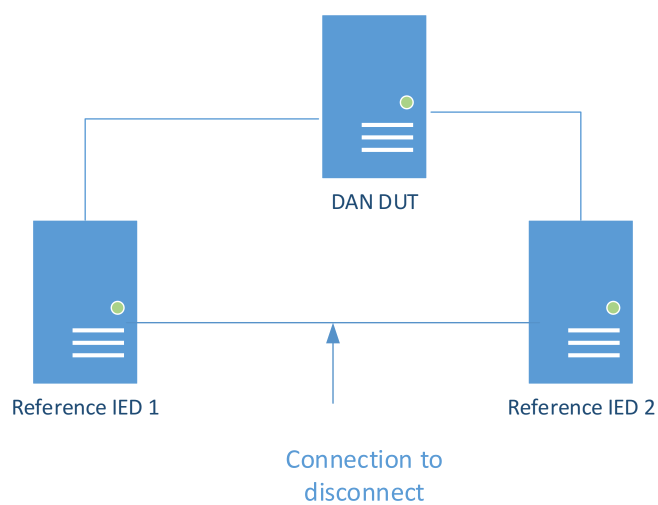


Figure 25: Unit Testing Network Topology for DAN DUT

In order to perform diagnostics (e.g. network sniffers) two non-HSR switches were added into the ring so that non-HSR sniffers could receive the traffic. The switches did not impact the HSR traffic except for a minor latency.

The test procedure was:

- Insert the DUT and observe that the references still indicated reception of GOOSE traffic from the references.
- Disconnect the connection that directly connected the two references and ensure that the references still received the other references GOOSE traffic.

As additional DUTs were tested, the HSR ring was increased to include the previously tested DUTs.

6.1.1.2 Power Cycle Testing

The purpose of this test was to verify that during power-down, or power-up, of a DAN DUT that no unexpected disruption to the HSR network occurred. The network topology used, for this test, is the same as shown in Figure 25 except no cables were disconnected. The normal HSR testing was a prerequisite to be completed prior to executing this test. Thus the DAN DUT was already connected into the HSR network and its ability to pass HSR frames had already been verified..

The test procedure was:

- Ensure that both references are still receiving the other reference's GOOSE message.
- Disconnect the power from the DAN DUT and ensure that there was not a disruption in the ability of the references to receive the other's GOOSE message.
- Reconnect the power on the DAN DUT and ensure that there was not a disruption in the ability of the references to receive the other's GOOSE message.
- Disconnect the cable that directly attaches the references.
- Disconnect the power from the DAN DUT and ensure neither reference is receiving the other reference's GOOSE message.
- Reconnect the power on the DAN DUT and ensure that references are receiving the other reference's GOOSE message.

6.1.1.3 Non-configured VLAN testing

This test was constructed to see how DUTs behaved upon reception of a HSR tagged packet, with a non-configured VLAN. The expectation is that the HSR implementation must pass all VLAN tagged packets and not just the VLAN(s) for which the DUT is configured. The final network topology used for the testing was as shown in Figure 26.

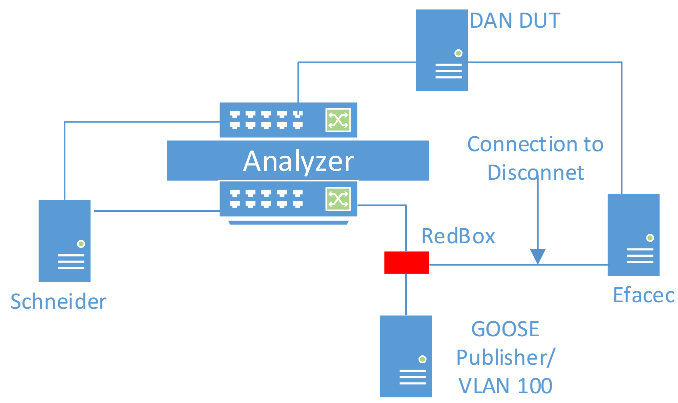


Figure 26: Network Topology for non-configured VLAN HSR frames testing

The GOOSE publisher simulated the Schneider GOOSE publication except it was published with a VLAN tag of 100. A RedBox (e.g. a converter from non-HSR Ethernet to HSR Ethernet) was utilized to inject the VLAN 100 tagged GOOSE into the HSR network. A network analyzer was used to verify that the VLAN 100 tagged packets were actually transmitted onto the HSR network appropriately.

The test procedure was:

- Ensure that VLAN 100 tag GOOSE was on the network.
- Disconnect the connection that directly connected the two references and ensure that the references still received the other references GOOSE traffic.
- Reconnect the connection that directly connected the two references and ensure that the references still received the other references GOOSE traffic.
- For DUTs that subscribed to the Schneider GOOSE, the Schneider reference was powered-down. The expected result was that the DUT would not receive/process the VLAN 100 tagged GOOSE as being that of the Schneider device.

  The theory behind the last test procedure step is to check the VLAN filtering of the DUT itself since the HSR “switch” must pass all HSR tagged traffic. Therefore, other filtering techniques, besides configured switch VLAN filtering would need to be implemented to prevent the VLAN 100 tagged frame from being interpreted as the Schneider’s GOOSE message.

This test was not executed since there was a question/issue raised about the HSR standard in regards to the VLAN filtering required by the HSR switch. This question was resolved after testing was completed. The standard states that the HSR switch should not filter out any VLAN tags.

6.1.1.4 Injection of Non-HSR packets on the HSR network

The HSR specification allows for non-HSR tagged packets to be transmitted on a HSR network. This is not a recommended network topology. However, it could happen in a substation by mistake.

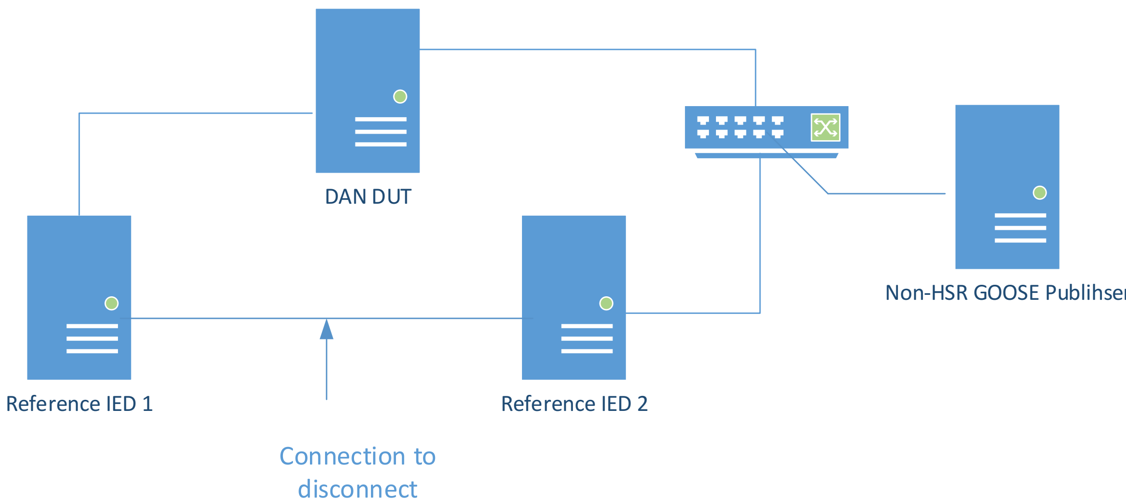


Figure 27: Network Topology for Injecting non-HSR frames onto a HSR network

A standard Ethernet switch is used to allow a GOOSE publisher to be connected into the HSR network. Without the use of a RedBox, no HSR frame header will be added to the GOOSE of the Non-HSR GOOSE Publisher. The purpose of the test is to ensure that none of the devices crash.

The test procedure was:

- Connect the DUT to the network.
- Make sure that the non-HSR GOOSE publisher is publishing.
- Make sure that the references are still receiving the other reference's GOOSE message.
- Disconnect the cable between the reference IEDs. The references should still be receiving the other reference's GOOSE message.
- No implementations should crash during any step of the test.

6.1.1.5 Results

The results of the testing are shown in Table 188.

	Test Executed		
Implementation Tested	Normal Redundancy	Power-up/ Power-Down	Non-HSR tagged frames
ABB SAM600	P	P	P
Alstom Grid P546	P	P	P
Efacec TPU L450	P	P	P
GE F650	P	P	P
Moxa PT-G503	P	P	P
Moxa PT-7728	P	P	P
NR Electric PCS 9705	P	P	P
Schneider MiCOM P145	P	P	P
Siemens RS950G	P	P	P
Siemens RSG2100	P	P	P
Toshiba GRL 200	P	P	P
Vizimax PC Software DAP	P	P	P

Table 188: Results for HSR Base Functional Testing

6.1.2 Building the HSR Network

After the unit testing was completed, the HSR ring was already built since the previous testing was performed by adding DAN DUTs between the two references without removing previously tested DAN DUTs that passed the unit testing.

The original HSR ring consisted of:

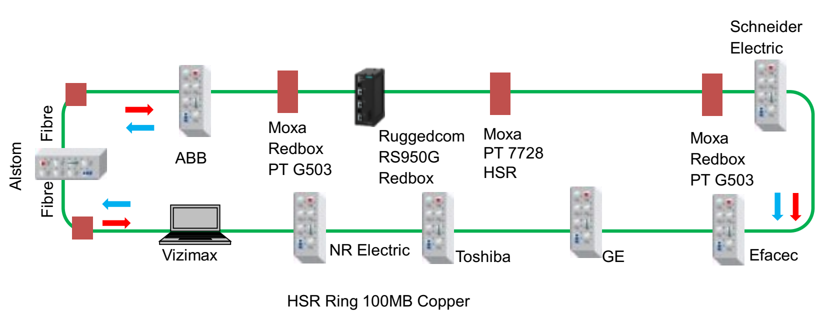


Figure 28: Initial HSR Network Staged

However, the HSR ring was not stable. After diagnostics, it was found that the NR Electric device was causing packets to be dropped. Therefore, NR Electric was put on its own HSR ring which was connected to the main HSR ring through Moxa RedBoxes as shown in Figure 29.

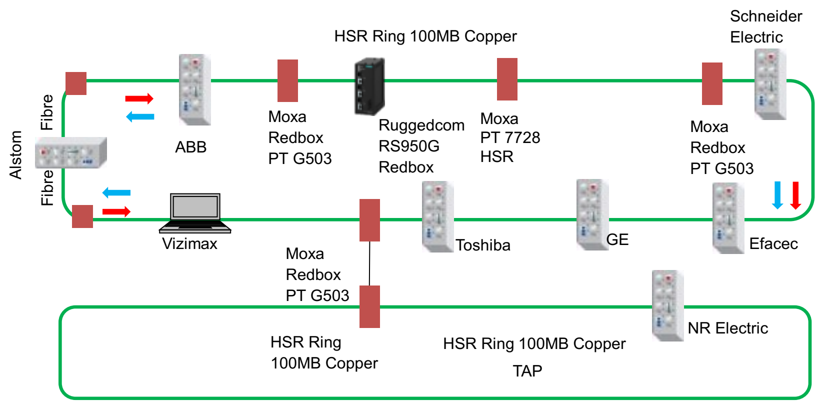


Figure 29: Final HSR Network used for testing

6.1.3 Client/Server Testing

In order to test Client/Server communications over HSR, a reference IEC 61850 Client was added to the HSR ring through a RedBox. The client was used to establish a 61850 association to a DUT and then the reference client performed a 61850 GetDataValues (e.g. MMS Read) to ensure that data was actually able to be transmitted. The purpose was to ensure that none of the HSR implementations created issues in regards to Client/Server messaging.

The procedure was:

- Establish a connection from the reference client to the DUT server.
- One of the connections to the RedBox to which the DUT server was disconnected.
- The reference client performed a GetDataValue with the expectation that data would be returned.
- The pulled cable was reconnected and the other cable was disconnected from the DUT Server.
- The reference client performed a GetDataValue with the expectation that data would be returned.
- The disconnected cable was reconnected.

6.1.3.1 Results

All DUTs that passed unit testing, and declared capability as a DUT Server, passed the test. The DUT Servers were:

Implementation Tested	Client/Server Test Result
ABB SAM600	
Alstom Grid P546	P
Efacec TPU L450	P
GE F650	P
Moxa PT-G503	P
Moxa PT-7728	P
NR Electric PCS 9705	

Schneider MiCOM P145	P
Schneider Saitel DP	P [N1]
Siemens Ruggedcom RS950G	P
Toshiba GRL 200	P
Vizimax PC Software DAP	
N1- Saitel DP was not a native HSR implementation it was connected to the HSR ring through a tested RedBox.	

Table 189: Results for HSR Client/Server Testing

No problems were detected with any of the HSR implementations on the ring.

6.1.4 GOOSE Testing

In order to test GOOSE Publisher/Subscriber communications over HSR, subscribers were configured to receive the GOOSE of the peer publisher. The purpose was to ensure that none of the HSR implementations created issues in regards to publication and delivery of GOOSE messages.

The procedure was:

- Establish that the subscriber is receiving the GOOSE from the publisher.
- One of the connections to the subscriber was disconnected.
- The subscriber should still be receiving the publisher's GOOSE message.
- The disconnected cable was reconnected and the other cable was disconnected from the subscriber.
- The subscriber should still be receiving the publisher's GOOSE message.
- The disconnected cable was reconnected.

6.1.4.1 Results

All DUTs that were tested passed.

GOOSE Subscriber	Efacec TPU L450	GE F650	Schneider MiCOM P145	Wireshark
GOOSE Publisher				
Alstom Grid P546				P
Efacec TPU L450			P	P
GE F650	P		P	P
NR Electric				P
Schneider MiCOM P145	P		P	P
Schneider Saitel DP				P [N1]
Toshiba GRL 200				P
N1- Saitel DP was not a native HSR implementation it was connected to the HSR ring through a tested RedBox.				

Table 190: Test Results for HSR GOOSE Publisher/Subscriber Testing

In order to minimize configuration time, Wireshark was also used to verify GOOSE publishers were working properly. Additionally, all HSR implementations properly passed GOOSE traffic.

No problems were detected with any of the HSR implementations on the ring.

6.1.5 Sampled Value Testing

In order to test Sampled Value Publisher/Subscriber communications over HSR, subscribers were configured to receive the Sampled Value of the peer publisher. The ABB SAM600 was the only Sampled Value publisher on the HSR ring. There were no Sampled Value subscribers. Therefore, Wireshark (a network analyzer) was used to ensure that the HSR ring, and the SAM 600, properly transmitted Sampled Values of HSR and that none of the SV traffic was blocked by any of the other HSR implementations on the ring.

The procedure was:

- Establish that the subscriber is receiving the Sampled Values from the publisher.
- One of the connections to the subscriber was disconnected.
- The subscriber should still be receiving the publisher's Sampled Values message.
- The disconnected cable was reconnected and the other cable was disconnected from the subscriber.
- The subscriber should still be receiving the publisher's Sampled Values message.
- The disconnected cable was reconnected.

6.1.5.1 Results

The ABB SAM600 behaved as expected and none of the other HSR implementations on the ring caused any issue with the transmission/reception of Sampled Value messages.

6.2 Parallel Redundancy Protocol (PRP) Testing

The purpose of testing PRP was to verify that IEC 61850 communication protocols worked properly amongst different vendor's implementations of PRP. The implementations included Intelligent Electronic Devices (IEDs) as well as Intermediate Systems (ISs).

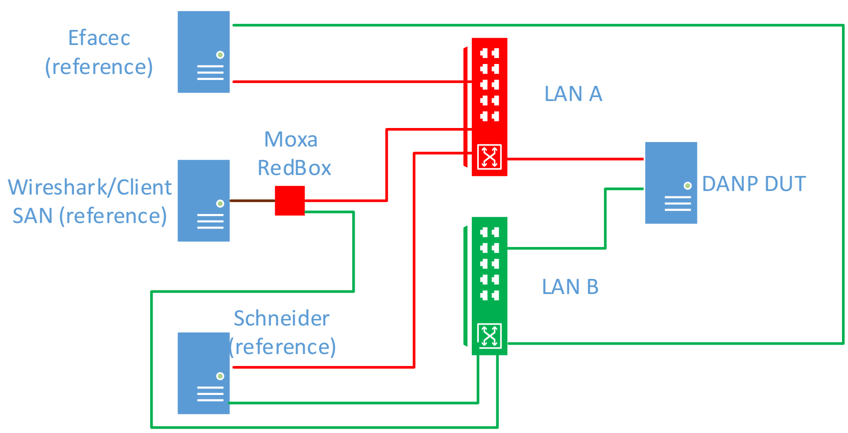


Figure 30: General PRP Testing Network Architecture

Figure 30 depicts the general PRP test architecture. It consists of two (2) LANs (A & B) to which Dual Attached Nodes (DANs) are connected. The DANs are responsible for implementation of PRP. The GOOSE reference publisher/subscriber (e.g. Efacec and Schneider) were moved and reconfigured to provide PRP DANP functionality so that the GOOSE references could be used during power-down/power-up testing of Devices Under Test. Additionally, a Single Attached Node (SAN) PC was connected to a Moxa RedBox. The RedBox allowed the Wireshark network analyzer to analyze traffic and the reference MMS Client. The SAN reference is detached from the RedBox in order to test PRP DAN and SAN interoperability.

Thus the sequence of testing was:

- DANP DUT Power cycling testing
- IEC 61850 service testing over HSR:
  - Client/Server
  - GOOSE Publisher/Subscriber
  - Sampled Value Publisher/Subscriber

- Single Attached Node (SAN) and DANP DUT interoperability.

  One of the benefits of PRP is that a non-PRP implementation should be able to exchange and understand IEC 61850 packets with an implementation that supports PRP.

- Maximum Transmission Unit (MTU) sizing testing.
  Due to the way PRP is embedded in an Ethernet frame (e.g. appended and not included in the Ethernet Frame length), there is an impact on MTU sizes. IEC 62439 does not mandate that the maximum MTU size shall be supported.

6.2.1 Power Cycle Testing

The purpose of this test was to verify that during power-down, or power-up, of a DAN DUT that no unexpected disruption to the PRP network occurred. The network topology used, for this test, is the same as shown in Figure 30 except no cables were disconnected.

The test procedure was:

- Ensure that both references are still receiving the other reference's GOOSE message.
- Disconnect the power from the DANP DUT and ensure that there was not a disruption in the ability of the references to receive the other's GOOSE message.
- Reconnect the power on the DANP DUT and ensure that there was not a disruption in the ability of the references to receive the other's GOOSE message.
- Disconnect the power from the DANP DUT and ensure neither reference is receiving the other reference's GOOSE message.
- Reconnect the power on the DANP DUT and ensure that references are receiving the other reference's GOOSE message.

The results of the testing are shown in Table 188.

Implementation Tested	Power-up/ Power-Down
Alstom Grid P546	P
Alstom Grid MU320	P
Efacec TPU L450	P
GE F650	P
GE D400	P
Kalkitech SYNC 3000S12R6	P
NR Electric PCS 9705	P
Schneider MiCOM P145	P
Schneider Saitel DP	P
Toshiba GRL 200	P
Vizimax PC Software DAP	P

Table 191: Results for PRP Power Cycling Testing

6.2.2 Client/Server Testing

In order to test Client/Server communications using PRP, a reference IEC 61850 Client was used. As shown in Figure 30, the reference was attached through a RedBox. The client was used to establish a 61850 association to a DANP DUT and then the reference client performed a 61850 GetDataValues (e.g. MMS Read) to ensure that data was actually able to be transmitted. The purpose was to ensure that none of the PRP implementations created issues in regards to Client/Server messaging.

The procedure was:

- Establish a connection from the reference client to the DUT server.
- One of the connections to theDANP DUT server was disconnected.
- The reference client then performed a GetDataValue with the expectation that data would be returned.
- The pulled cable was reconnected and the other cable was disconnected from the DANP DUT Server.
- The reference client then performed a GetDataValue with the expectation that data would be returned.
- The disconnected cable was reconnected.

Implementation Tested	Client/Server Test Result
Alstom Grid P546	P

Efacec TPU L450	P
GE F650	P
Moxa PT-G503	P
Moxa PT-7728	P
NR Electric PCS 9705	P
Schneider MiCOM P145	P
Schneider Saitel DP	P [N1]
Toshiba GRL 200	P
Siemens Ruggedcom RS950G	P
Vizimax PC Software DAP	
N1- Saitel DP was not a native HSR implementation it was connected to the HSR ring through a tested RedBox.	

Table 192: Results of Client/Server Testing using a DANP Reference

The second part of the test was to verify that the reference client, acting as a SAN, could still communicate with a DANP DUT.

The procedure was:

- Disconnect the Client reference from the RedBox.
- Connect the reference directly to the LAN A switch.

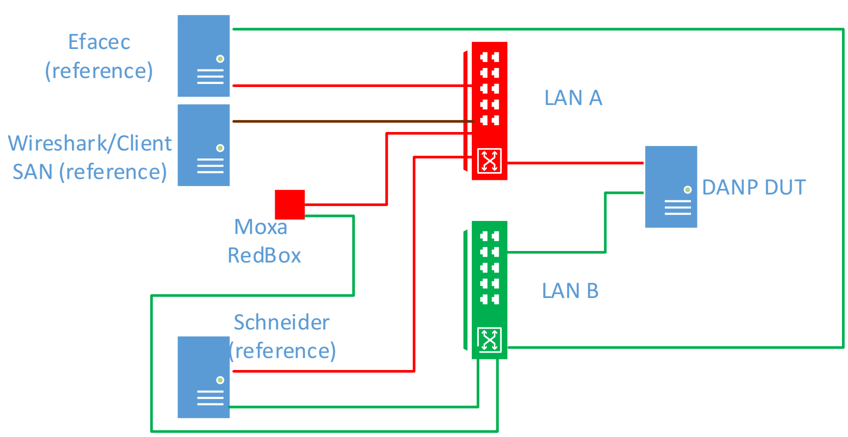


Figure 31: Reference as a SAN testing a DANP DUT

- Establish a connection from the reference client to the DUT server.

- The reference client the performed a GetDataValue with the expectation that data would be returned.

Implementation Tested	Client/Server Test Result
Alstom Grid P546	P
Efacec TPU L450	P
GE F650	P
Moxa PT-G503	P
Moxa PT-7728	P
NR Electric PCS 9705	P
Schneider MiCOM P145	P
Schneider Saitel DP	P [N1]
Toshiba GRL 200	P
Vizimax PC Software DAP	
N1- Saitel DP was not a native HSR implementation it was connected to the HSR ring through a tested RedBox.	

Table 193: Results of Client/Server Testing using a SAN Reference

6.2.3 GOOSE Testing

In order to test GOOSE Publisher/Subscriber communications over PRP, subscribers were configured to receive the GOOSE of the peer publisher. The purpose was to ensure that none of the PRP implementations created issues in regards to publication and delivery of GOOSE messages. In some cases, publishers were verified using a Wireshark network analyzer (referred to as reference).

The procedure was:

- Establish that the subscriber is receiving the GOOSE from the publisher.
- One of the connections to the subscriber was disconnected.
- The subscriber should still be receiving the publisher's GOOSE message.
- The disconnected cable was reconnected and the other cable was disconnected from the subscriber.
- The subscriber should still be receiving the publisher's GOOSE message.
- The disconnected cable was reconnected.

All DUTs that were tested passed.

GOOSE Subscriber	Alstom Grid P143	Efacec TPU L450	Schneider MiCOM P145	Schneider Satiel DP	Vizimax AMU	Vizimax Laptop	Wireshark (reference)
GOOSE Publisher							

Alstom Grid MU320						P	P
Alstom Grid P143					P		P
Efacec TPU L450			P				P
Kalkitech SYNC 3000S12R6							P
NR Electric							P
Schneider MiCOM P145		P		P[N1]			P
Schneider Saitel DP			P[N1]				P
Toshiba GRL 200							P
Vizimax AMU	P						P
N1: Connected through RedBox							

Table 194: Test Results for HSR GOOSE Publisher/Subscriber Testing

In order to minimize configuration time, Wireshark was also used to verify GOOSE publishers were working properly.

6.2.4 Sampled Value Testing

In order to test Sampled Value Publisher/Subscriber communications over PRP, Wireshark was used as the reference subscriber. There was only a single PRP DANP Sampled Value publisher, the Vizimax AMU.

The procedure was:

- Establish that the subscriber is receiving the Sampled Values from the publisher.
- One of the connections to the subscriber was disconnected.
- The subscriber should still be receiving the publisher's Sampled Values message.
- The disconnected cable was reconnected and the other cable was disconnected from the subscriber.
- The subscriber should still be receiving the publisher's Sampled Values message.
- The disconnected cable was reconnected.

Sampled Value Publisher	Sampled Value Subscriber	Wireshark (reference)
Vizimax AMU		P

Figure 32: Results of PRP Sampled Value Testing

6.2.5 MTU Size Testing

Due to the way PRP is embedded in an Ethernet frame (e.g. appended and not included in the Ethernet Frame length), there is an impact on MTU sizes. IEC 62439 does not mandate that the maximum MTU size shall be supported. Therefore, it is important to design a PRP network with the knowledge of implementations supporting extended Ethernet Frame sizes.

Vizimax provided a utility that executed a ICMP Ping using the maximum allowed non-extended Ethernet frame size (e.g. 1518 octets). The implementation then appended the PRP information to the ping frame. The utility indicates if a ping response is received.

Procedure:

- Using the utility, ping the DANP DUT.
- If a ping response is received, the extended MTU is supported.
- Record if the extended MTU is supported or not.

DANP DUT	Extended MTU Size	
	Supported	Not Supported
Alstom Grid MU320		x
Alstom Grid P145		x
Efacec TPU L450	x	
GE 8 Series	x	
Moxa PT-7728		x
Moxa PT-G503		x
Schneider MiCOM P145		x
Schneider Saitel DP[N1]	x	
Siemens Ruggedcom RS950G		x
Toshiba GRL 200		x
Vizimax AMU	x	

Figure 33: MTU Size Testing

If a system is implemented using devices that do not support the extended MTU sizes, care in the design of the system will need to be considered.

6.3 PRP and HSR Coupling

The purpose of this set of tests was to test quad box couplers and to see if there were any issues using the couplers to connect HSR and PRP networks. In order to test coupling, HSR and PRP tested IEDs were distributed across a HSR and PRP network.

Of particular importance was the distribution of the Efacec and Schneider GOOSE publisher/subscriber. The Schneider was places on the HSR network and the Efacec remained on the PRP network. This allowed for immediate verification that the Coupling boxes, under test, could couple GOOSE messages. In general, the test architecture was:

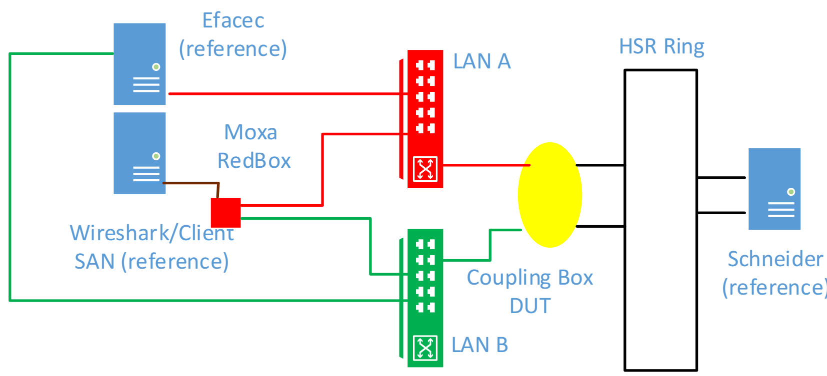


Figure 34: General Network Topology for Coupled PRP/HSR Testing

The tests that were executed were:

- Verification that GOOSE messages were transmitted/received between HSR and PRP.
- Verification the IEC 61850 Client/Server communication was allowed between HSR and PRP.
- Verification that Sampled Value traffic was allowed between HSR and PRP.
- Verification that IEC 61850 Client messages, as a SAN, were allowed between HSR and PRP.
- Verification that NTP messaging was allowed between HSR and PRP.

6.3.1 Test Procedures

6.3.1.1 GOOSE Coupling

The procedure to test a Coupling Box was to:

- Insert the Coupling Box into the network.
- Verify that the GOOSE references (e.g. Efacec and Schneider) were still receiving each other GOOSE messages.
- Disconnect one of the HSR cables from the Coupling box.
- Verify that the GOOSE references (e.g. Efacec and Schneider) were still receiving each other GOOSE messages.
- Reconnect the cable.
- Disconnect the other HSR cable from the Coupling box.
- Verify that the GOOSE references (e.g. Efacec and Schneider) were still receiving each other GOOSE messages.
- Reconnect the cable.

- Disconnect one of the PRP cables from the Coupling box.
- Verify that the GOOSE references (e.g. Efacec and Schneider) were still receiving each other GOOSE messages.
- Reconnect the cable.
- Disconnect the other PRP cable from the Coupling box.
- Verify that the GOOSE references (e.g. Efacec and Schneider) were still receiving each other GOOSE messages.
- Reconnect the cable.

6.3.1.2 IEC 61850 Client/Server Coupling

The procedure to test a Coupling Box was to:

- Insert the Coupling Box into the network.
- Using the IEC 61850 Client reference, establish a 61850 association to the Schneider device and read data.
- Disconnect one of the HSR cables from the Coupling box.
- Verify that the client can still read data.
- Reconnect the cable.
- Disconnect the other HSR cable from the Coupling box.
- Verify that the client can still read data.
- Reconnect the cable.
- Disconnect one of the PRP cables from the Coupling box.
- Verify that the client can still read data.
- Reconnect the cable.
- Disconnect the other PRP cable from the Coupling box.
- Verify that the client can still read data.
- Reconnect the cable.

6.3.1.3 Sampled Value Coupling

There were two Sample Value references utilized: ABB SAM 600 and Alstom MU320. The ABB was located on the PRP network and the Alstom was located on the HSR network. An OMICRON DANEO 400 Network analyzer node was installed on the HSR network in order to verify that the Sampled Value traffic was delivered to the HSR Ring. The general architecture for testing was:

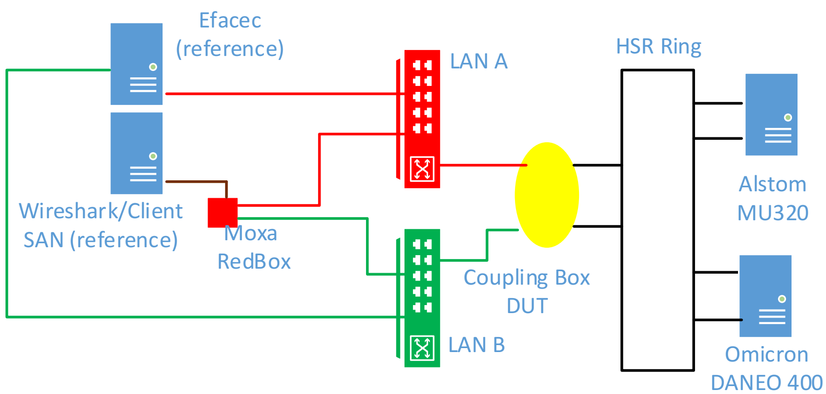


Figure 35: General Network Testing Topology for HSR/PRP Coupling for Sampled Value testing

The procedure to test a Coupling Box was to:

- Insert the Coupling Box into the network.
- Using Wireshark and the OMICRON DANEO, verify that the SV publisher traffic is being seen on the other network.
- Disconnect one of the HSR cables from the Coupling box.
- Using Wireshark and the OMICRON DANEO, verify that the SV publisher traffic is being seen on the other network.
- Reconnect the cable.
- Disconnect the other HSR cables from the Coupling box.
- Using Wireshark and the OMICRON DANEO, verify that the SV publisher traffic is being seen on the other network.
- Reconnect the cable.
- Disconnect one of the PRP cables from the Coupling box.
- Using Wireshark and the OMICRON DANEO, verify that the SV publisher traffic is being seen on the other network.
- Reconnect the cable.
- Disconnect the other PRP cables from the Coupling box.
- Using Wireshark and the OMICRON DANEO, verify that the SV publisher traffic is being seen on the other network.
- Reconnect the cable.

6.3.1.4 SAN Traffic Coupling

In order to test the Coupling box to determine if it would pass SAN traffic on the PRP network to the HSR network, the following network topology was used:

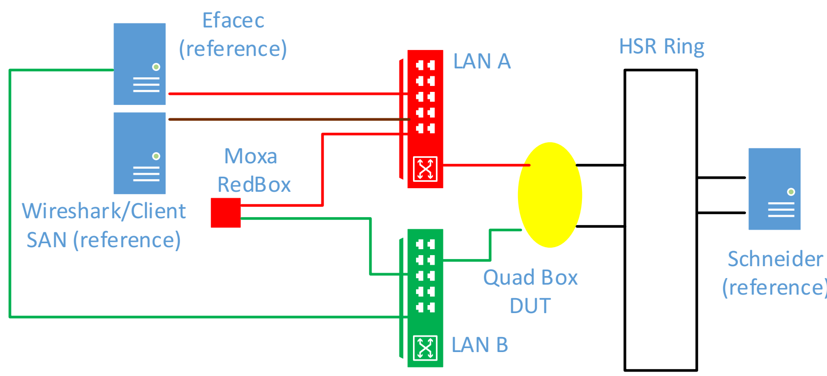


Figure 36: PRP/HSR Network Topology for testing SAN traffic through Coupling box.

The procedure to test a Coupling Box was to:

- Insert the Coupling Box into the network.
- Using the IEC 61850 Client reference, establish a 61850 association to the Schneider device and read data.
- Disconnect one of the HSR cables from the Coupling box.
- Verify that the client can still read data.
- Reconnect the cable.
- Disconnect the other HSR cable from the Coupling box.
- Verify that the client can still read data.
- Reconnect the cable.
- Disconnect one of the PRP cables from the Coupling box.
- Verify that the client can still read data.
- Reconnect the cable.
- Disconnect the other PRP cable from the Coupling box.
- Verify that the client can still read data.
- Reconnect the cable.

6.3.1.5 NTP Traffic Coupling

In order to test NTP, the Alstom RT430 NTP Server was placed on the PRP network. There were NTP clients (e.g. Alstom and Schneider IEDs).

The procedure was to verify that the Schneider IED's clock was adjusted by the NTP server.

6.3.2 Results

The following table shows the results of the various HSR/PRP coupling tests versus the Quad Boxes tested.

Tests	Tested Quad Boxes	
	Moxa PTG-503	PT-7728
GOOSE coupling	P	P
IEC 61850 Client/Server Coupling (DAN)	P	P
Sampled Value Coupling	P	P
IEC 61850 Client/Server coupling (SAN)	N1	N1
NTP Coupling	P	P
N1: The SAN traffic did not couple properly to the HSR network. There was an initial question if SAN traffic should be coupled to the HSR network. This was raised as an issue to be resolved by the standards committee. The resolution was that SAN traffic should be appropriately coupled from PRP to HSR.		

6.4 HSR/PRP Coupled to RSTP

In many situations, instances of HSR or PRP will need to be interconnected to a RSTP network.

This situation is likely to occur in existing substations that currently use RSTP for Ethernet redundancy but are adding HSR or PRP. In other situations, HSR/PRP could be chosen for critical high-speed redundancy and then interconnected to a network that does not have the high-speed redundancy requirements (e.g. for connections from the substation/bay level to control center (e.g. what IEC 61850 refers to as Station Bus),

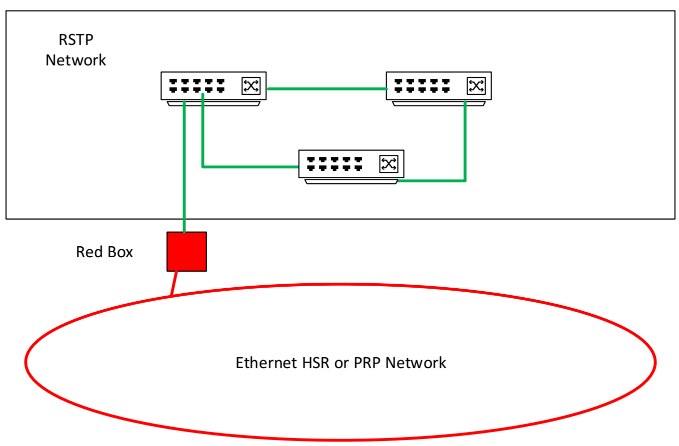


Figure 37: Example of RSTP and HSR/PRP Interconnection

Figure 37 shows the typical interconnection between HSR/PRP networks and a RSTP network. The interconnection requires the use of what is known as a “Red Box”. It is the purpose of the Red Box to take traffic from the RSTP network and add the appropriate information required to transmit it on the HSR/PRP network and to remove the same information when packets are transferred from HSR/PRP to RSTP.

In several situations, network designers consider the Red Box as a single point of failure and require a second Red Box be added (see Figure 37).

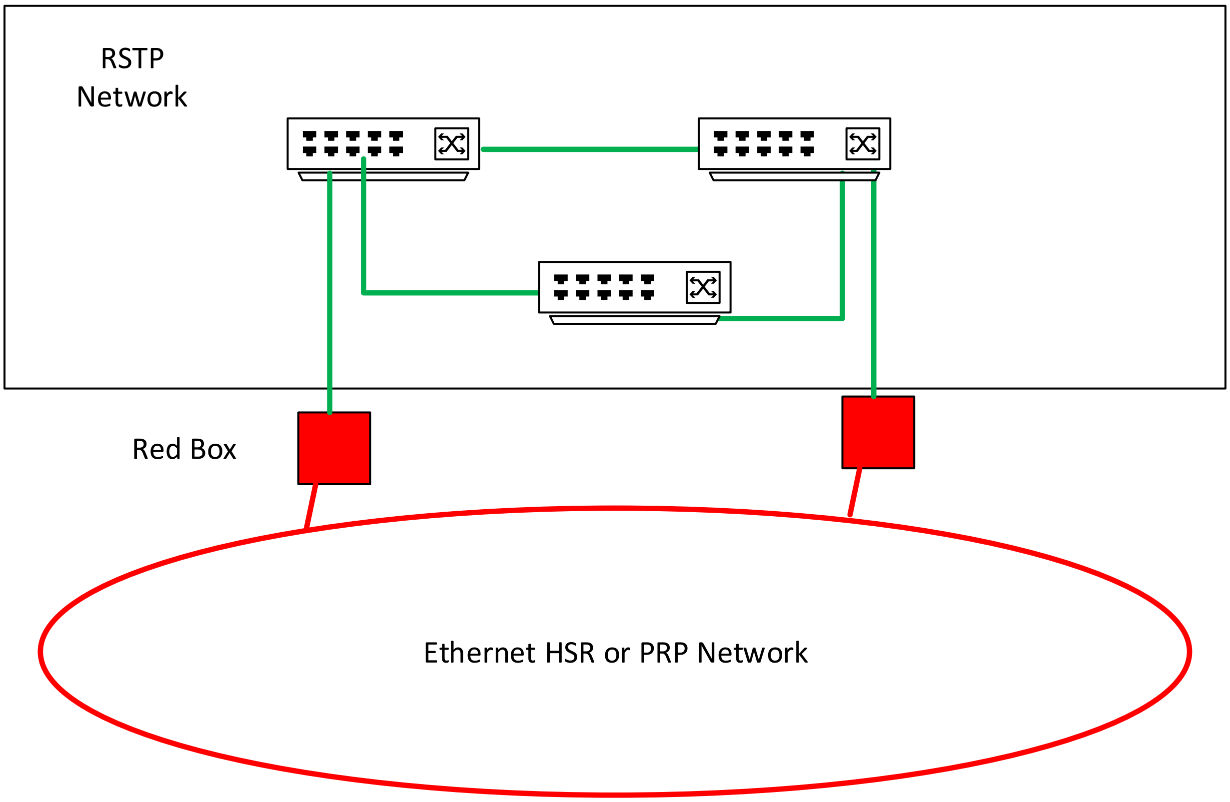


Figure 38: Dual Connection of HSR/PRP with RSTP

In theory, the topology in Figure 38 might create multicast storms and cause both networks to crash. Therefore, the purpose of this test is to prove/disprove the theory.

The actual network tested was initially a single RedBox being used to couple HSR/PRP to RSTP (see Figure 39):

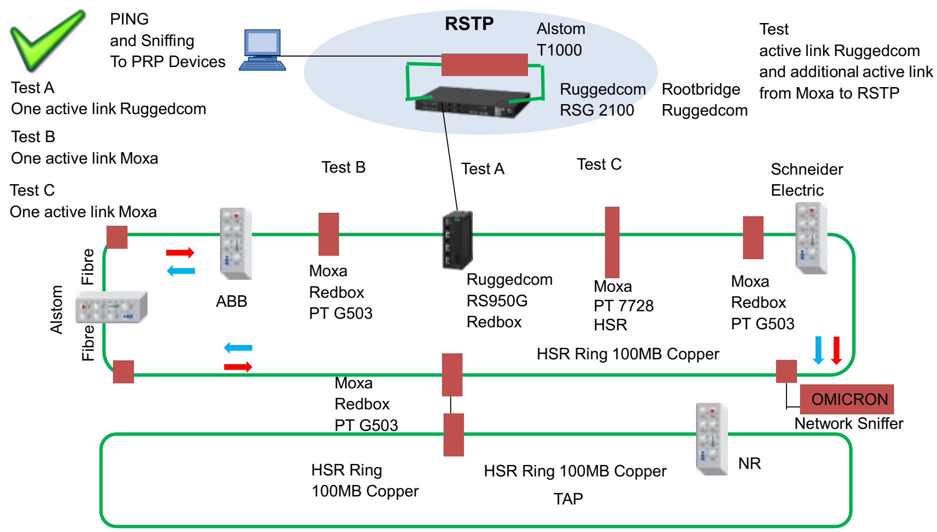


Figure 39: RSTP and HSR singly coupled

The sniffing devices were used to verify that the published GOOSE messages from the Schneider were coupled onto the RSTP network. The OMICRON was used to verify that the HSR network was operating properly.

After proper operation of the single RedBox topology was verified, another Redbox was connected from the HSR network to the RSTP network (as shown in Figure 40).

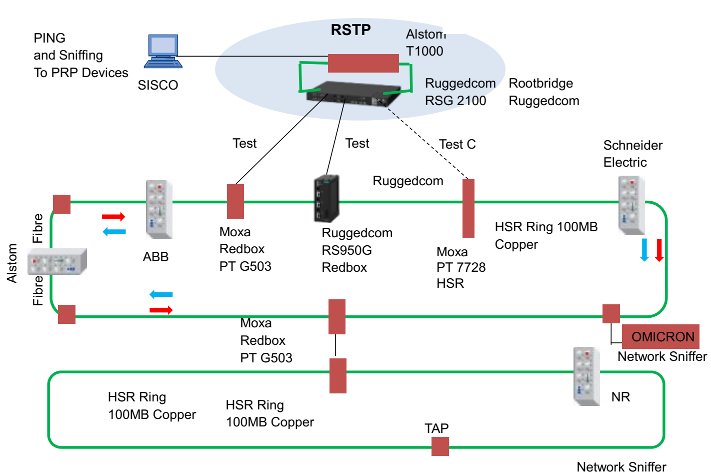


Figure 40: HSR and RSTP dual coupling

Tests were performed with various combinations of Moxa and Siemens/RuggedCom Redboxes. In all tests, the bandwidth of the HSR network became the maximum of 88 Mb/second (detected by the OMICRON DANEO 400). The OMICRON captured the beginning of the multicast storm as shown in Figure 41.

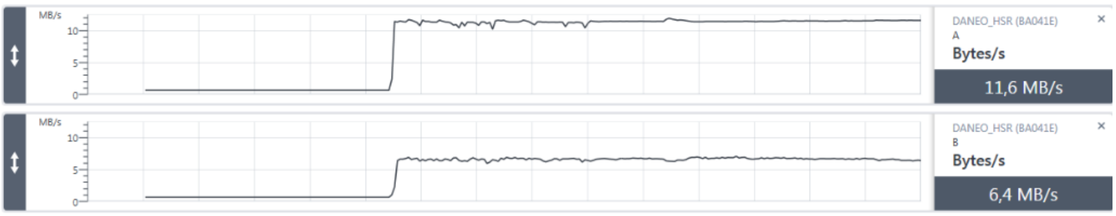


Figure 41: Multicast Storm resulting from dual coupling of HSR and RSTP

Additionally, the DANEO detected:

- Packets circulating on the combined network that were over 5 minutes old based upon GOOSE timestamps.

- Packets being dropped in both directions of the HSR ring.

The topology in Figure 38 causes multicast storms and packets to circulate both networks until network bandwidth capacities are reached. Therefore, this dual interconnection methodology SHOULD NOT BE USED unless the Red Boxes have a proprietary mechanism to prevent the problem.

The problem is caused by two factors:

- The RSTP Bridge Protocol Data Unit (BPDU) is not exchanged/known by the Red Boxes. There is therefore no ability of the Red Boxes to decide which is to transmit information from the HSR/PRP network to the RSTP network (e.g. to act as an extension of the RSTP network).

- The information regarding the origination of the packet on the HSR/PRP network has been removed when the packet is transmitted onto the RSTP network.

The result of these factors is that a packet transmitted onto the RSTP network by Red Box 1 will be re-transmitted on the HSR/PRP network by Red Box 2. Likewise, packets transmitted by Red Box 2 will be retransmitted onto the HSR/PRP network by Red Box 1.

Upon close investigation, this behavior needs to be corrected through the IEEE 802 standard. IEC TC57 WG10 is attempting to forward this problem appropriately for standard resolution. Until such a resolution is reached, there are only two options:

- Use a Red Box that has a proprietary mechanism to stop the problem. However, testing needs to be performed to make sure that such mechanisms actually work appropriately with the other network devices in use.

- Only use a single Red Box between the HSR/PRP network and RSTP network.

There was a retest performed with RedBoxes from Moxa (MOXA PT-7728 HSR and PT-G503) which had a proprietary mechanism enabled. The test was rerun and the multicast storm was prevented.

6.5 HSR Sampled Values Load Testing

There is interest in the number of Sampled Value streams that can be supported by an HSR and PRP network. There are two resources that may impact the amount of SV that can be supported: network bandwidth and duplicate detection buffer size.

The duplicate detection buffer size is an issue if the number of SV packets exceeds the internal duplicate detection ability of an IED or node. If the internal buffer has been exceeded, there is a high probability that duplicate packets will not be discarded. For PRP networks, the failure of the duplicate detection mechanism would mean that an IED/node would process the "same" packet twice. For HSR, the failure of the duplicate packet detection algorithm would mean that the packets would continue to be forwarded on the HSR network.

Based upon HSR being the network technology with the potential largest issue, it was decided to stage testing for SV limits of an HSR network.

From a high level, the network setup is shown in

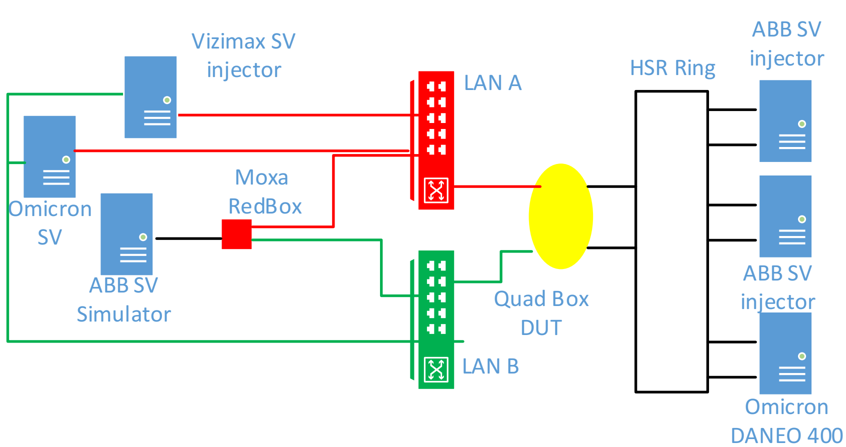


Figure 42: SV Load Test HSR Network Topology

The DANEO 400 is used to measure HSR bandwidth consumption and to detect if packets are being dropped. The other nodes that participated in the testing were used as sources of SV data.

The base SV sampling rate was 4000 Hz (80 samples per cycle at 50 Hz). Table 195 shows the results of adding additional SV streams on the HSR network:

Number of SV stream	SV Injectors	HSR Bandwidth consumed (Megabytes/s)	Packet loss detected
1	Vizimax	0.7	No
2	Vizimax 1 ABB	1.2	No
3	Vizimax 2 ABB	1.8	No
13	Vizimax 2 ABB 10 streams – ABB simulator	6.4	No
16	Vizimax 2 ABB 10 streams – ABB simulator 3 streams OMICRON	8.1	No
18	Vizimax 2 ABB 10 streams – ABB simulator 5 streams OMICRON	9.7	Yes

Table 195: HSR SV Load Test Results

Therefore, the conclusion is that approximately 16 Sampled Value streams can be supported on HSR.

By approximation, the Sampled Value (9-2 LE) payload would be:

Item	Number of Octets
Ethernet octets, including FCS	24
HSR	6
SV information, including Ethertype	127
Total Octet	157

Table 196: Estimate of HSR packet size used during Load Testing

The OMICRON also captured the packets/second of Sampled Value traffic for the 18 Sampled Value stream. The number of packets/second was 72,400. Therefore, the bandwidth consumption (of a 100 Mbs/network) could be calculated to be:

Bandwidth consumed by SV= (72,400 *157*8)*100/100000000 = 90% bandwidth utilization

It is recommended that HSR networks not exceed 88% utilization.

Note: If the sampling frequency is 4800 Hz (80 s/c at 60 Hz), then the bandwidth consumed would be 20% higher, and the number of MUs that can be installed on an HSR ring would be 20% lower (or 14-15 depending).

6.6 Hop latency testing

There is interest in determining the approximate hop latency of HSR networked devices. The network topology used to determine this metric is shown in Figure 43 .

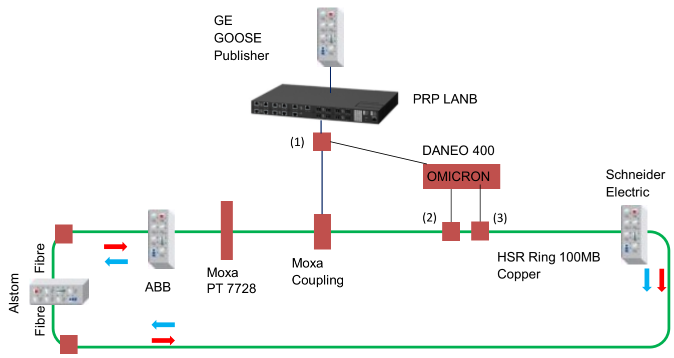


Figure 43: Topology for HSR Hop Latency testing

A GE relay was used to publish GOOSE messages onto LANB of a PRP network. In series with the Coupling box, there was an OMICRON probe (1) so that the DANEO 400 could determine the a relative timestamp of the published packet prior to the packet being transmitted onto the HSR network. The DANEO had two other probes (e.g. (2) and (3)) that were used to timestamp the reception of the GOOSE packets from both directions of the HSR network. The difference in average latency was calculated for: A=(2)-(1) and B=(3)-(1). The difference (B-A) was divided by the number of intervening nodes to calculate the average HSR hop latency which was 10 usec.

The loading on the HSR ring was 52,000 packets/second or approximately 63 Mbs of a 100 Mbs network.

7 PTP – Time Sync Testing

There were 10 participating companies. Some companies participated in both the 61850-9-3 testing and the IEEE C37.238 testing

	Test Participation	
Company	61850-9-3	IEEE C37.238
ABB	X	x
Alstom	X	x
Doble	X	x
\GE	X	x
Moxa	X	
NR Electric	X	
OMICRON	X	x
Sertel	X	x
Siemens	x	
Schweitzer		x
Vizimax	x	

Table 197: List of PTP test participants

Figure 44: Time Synchronization test area

7.1 61850-9-3 Testing

7.1.1 Protocol Implementation Conformance Statement (PICS)

The following are the Protocol Implementation Conformance declaration for the participating clocks/devices. The “Base” column indicates if the capability is mandatory (m) or optional (o). Conditions of support are indication in the “Condition” column and the specific conditions are defined in Table 199.

PICS for IEC 61850-9-3				Company	OMICRON	OMICRON	Belden	ABB	ABB	Vizimax	Sertel	NR Electric
				Device	OTMC 100	TICRO 100	RSP20	SAM600-TS	SAM600-VT	PMU01000	T-GPS-300	PCS-902
PICS proforma reference	Capability	Value Range	Base	Condition	Support	Support	Support	Support	Support	Support	Support	Support
CLOCK_TYPE_OC	clock is OC according to this base	TRUE, FALSE	m	c.1	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
CLOCK_TYPE_TC	clock is TC according to this base	TRUE, FALSE	m	c.1	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE
CLOCK_TYPE_BC	clock is OC according to this base	TRUE, FALSE	m	c.1	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE	FALSE
NR_PORTS	number of clock ports (total)	integer>0	m		1	1	10	2	2	2	1	7
PORTS_STEP	1: all ports support 1-step at egress 2: all ports support 2-step at egress 3: all ports support both 1-step and 2.	1..3	m		3	3	2	3	3	3	3	2
SLAVE_ONLY	all ports of the clock are slave-only	TRUE, FALSE	m	c.2	FALSE	TRUE		FALSE	FALSE	FALSE	TRUE	TRUE
TIME_TRACEABLE	connectable to a time reference outside of PTP (e.g. GPS)	TRUE, FALSE	m	c.3	TRUE		FALSE	FALSE	FALSE	TRUE		FALSE
FREQ_TRACEABLE	connectable to a frequency reference outside of PTP (e.g. GPS)	TRUE, FALSE	m	c.3	TRUE		FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
DAC	doubly attached OC	TRUE, FALSE	o		FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
PORTS_PAIRED	paired clock ports for redundancy (e.g. {3-4})	identifier pair	o	c.4				{1,2}	{1,2}	{1,2}		{1,2}
REDBOX_DATC	Redbox as TC	TRUE, FALSE	o	c.5				FALSE	FALSE	FALSE		FALSE
REDBOX_SLTC	Redbox as Stateless TC	TRUE, FALSE	o	c.5				FALSE	FALSE	FALSE		FALSE
REDBOX_TWBC	Redbox as three-way BC	TRUE, FALSE	o	c.6				FALSE	FALSE	FALSE		FALSE
REDBOX_DABC	Redbox as DAC BC	TRUE, FALSE	o	c.6				FALSE	FALSE	FALSE		FALSE
MIB_SNMP	supports MIB of IEC 62439-3 Annex E	TRUE, FALSE	m	c.7	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
MIB_61850	supports MIB of IEC 61859-90-4 Clock objects	TRUE, FALSE	m	c.7	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
MIB_OTHER	clock supports fixed values or a mechanism defined by the manufacturer (If True, This list is appended to this PICS)	TRUE, FALSE	m	c.7	TRUE void list.	TRUE void list.	TRUE void list.	TRUE void list	TRUE void list	TRUE void list	TRUE void List.	TRUE void List.

Table 198: PICS for IEC 61850-9-3 Test Participants

Condition	Description
c.1	at least one shall be supported (CLOCK_TYPE_OC and CLOCK_TYPE_TC may be both TRUE)
c.2	only if CLOCK_TYPE_OC = TRUE
c.3	only if SLAVE_ONLY = FALSE
c.4	shall be "m" (>1) if DAC = TRUE
c.5	support shall only be declared if CLOCK_TYPE_TC = TRUE and DAC=TRUE
c.6	support shall only be declared if CLOCK_TYPE_BC = TRUE and DAC=TRUE
c.7	at least one shall be supported

Table 199: PICS Condition Definitions for IEC 61850-9-3 Participants

7.1.2 Test Cases

7.1.2.1 Network time synchronization to a single grandmaster

Use case:
The Grandmaster must be capable of time synchronizing all connected TCs, BCs and OCs using the mandatory and default settings defined in **Error! Reference source not found.**
Proposed measurement setup:
A Grandmaster Clock (GM-DUT) is synchronized via a L-Band signal provided by a GPS simulator. The Devices Under Test (DUTs) are connected to a single transparent clock (TC1). GM capable Clocks (GM-DUT2) are synchronized directly via the 1 PPS output of the GPS Simulator. The successful synchronization of all devices is checked by analyzing the network traffic (Wireshark), checking the synchronization status of the DUTs and comparing the accuracy of 1 PPS time reference signals provided by the DUTs or OCs connected to the DUTs. To ensure that only the GM-DUT is Grandmaster all Grandmaster capable OCs must use a priority setting that ensures that they never will be Grandmaster.

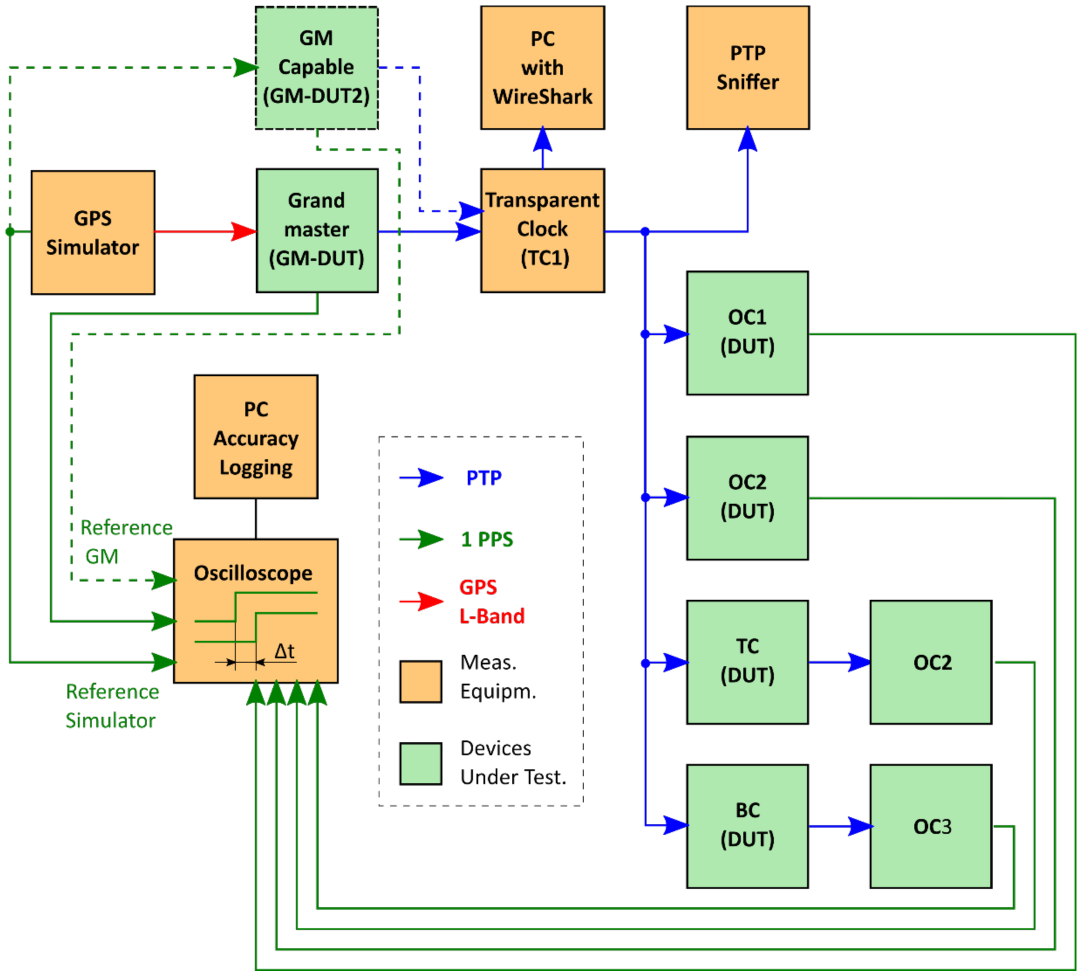


Figure 45 - General Synchronization Test

Alternative Setup to test island operation:
To test island operation a GM-capable Clock (GM-DUT2) locked to the 1 PPS signal of the GPS simulator can be used in the setup as shown in Figure 45.

7.1.2.2 Synchronization Test
TC1 and all DUTs should be setup to properly synchronize to the GM-DUT

7.1.2.2.1 Basic check of synchronization

Test Case:
Time synchronization of DUT's is verified by checking their status and time with the DUT supplier's tools or user interfaces.

Expected Results:

- All DUTs have the same TAI date and time like the GPS Simulator
  (Devices that do not support TAI must show the corresponding UTC or local time zone)
- All DUTs show a locked indication
- All DUTs show the Grandmaster identity of the GM-DUT they are locked to
- All DUTs display further information on the GM-DUT they are locked to e.g.:

Parent

Port identity:	1@20:b7:c0:ff:fe:00:0c:5e
Grandmaster identity:	20:b7:c0:ff:fe:00:0c:5e
Grandmaster clock class:	PRIMARY_REF_PTP (6)
Grandmaster clock accuracy:	WITHIN_100_NS (0x21)
Grandmaster clock variance:	18465
Grandmaster priority 1:	128
Grandmaster priority 2:	128

7.1.2.2.2 Check of general time inaccuracy:

Test Case:
The inaccuracy of DUTs connected to TC1 is assessed by comparing time reference signals provided by the DUTs with the 1 PPS signal provided by the GPS Simulator and the GM-DUT. The measurement is performed according to the measurement conditions defined in 7.1. of Ref A

Maximum introduced inaccuracies:

Device	Added inaccuracy	
GM-DUT	250 ns	Ref A (7.4.1)
GM-DUT 2	250 ns	Ref A (7.4.1)
TC 1	50 ns	Ref A (7.5)
BC	200 ns	Ref A (7.6)
OC	50 ns	Typical (optional)

Expected Results:
The results are assessed after the equipment is in steady state according to Ref 1. Further on delays introduced by long cables can be compensated if supported by the equipment. For equipment that does not offer this possibility a 5 ns/m delay can be subtracted from the measured result.

- Optional: OCs connected to TC1 are not deviating more than ±100 ns to the GM-DUTs 1pps
- Mandatory: TCs connected to TC1 are not deviating more than ±100 ns (for TCs with 1pps output) or more than ±150 ns (for 1 pps provided by OCs connected to TCs without 1pps output) to the GM-DUTs 1pps
- Mandatory: BCs connected to TC1 are not deviating more than ±250 ns (for BCs with 1pps output) or more than ±300 ns (for 1 PPS provided by OCs connected to BCs without 1 PPS output) to the GM-DUTs 1pps
- Mandatory The GM-DUT itself is not allowed to deviate more than ±250 ns from the 1 PPS provided by the GPS simulator

Remark:

It will be difficult to measure the time inaccuracy of SlaveOnly OCs (like protection relays) which do not have a 1 PPS output. One possibility might be that the 1 PPS output of the GPS simulator is connected to the IED and a time stamped event is created by the relay. By analyzing the time stamp at least a rough accuracy might be evaluated.

7.1.2.2.3 One-step / Two-step compatibility at ingress:

Test Case:

a.) TC1 is set to one-step mechanism at egress

b.) TC1 is set to two-step mechanism at egress

Expected Results:

a.) All DUTs connected to TC1 synchronize correctly (locked indication, correct time) – no follow up messages are seen on Wireshark
- inaccuracy of components needs to remain the same like in 2.1.2

b.) All DUTs connected to TC1 synchronize correctly (locked indication, correct time) – follow up messages are seen on Wireshark
- inaccuracy of components needs to remain the same like in 2.1.2

7.1.2.3 Time base related tests

7.1.2.3.1 Check of TAI – UTC – Local time

Use Case:

PTP synchronized devices can be switched to use different time zones as well as UTC and TAI

Test Case:

All DUTs are switched to TAI, UTC and the local time zone CET/CEST

Expected Results:

- TAI (mandatory): All DUTs show the same TAI date and time
- UTC offset (mandatory): All DUTs show the same UTC offset to TAI
  (expected to be still 36 s in September)
- UTC time (optional): all DUTs show the same UTC date/time
- CET/CEST (optional): All DUTs show the correct time zone offset to UTC for the selected time zone

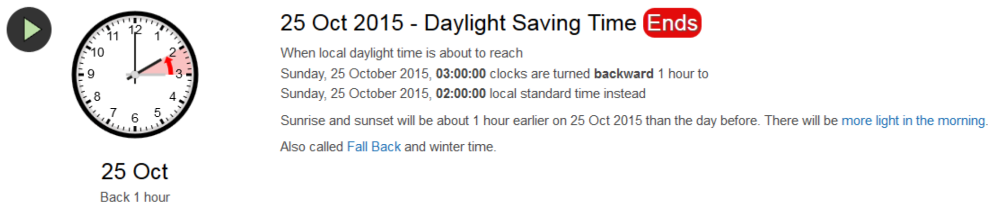
7.1.2.3.2 Check DST Time switching (optional)

Use Case:

DUTs operated in local time need to follow the DST change automatically

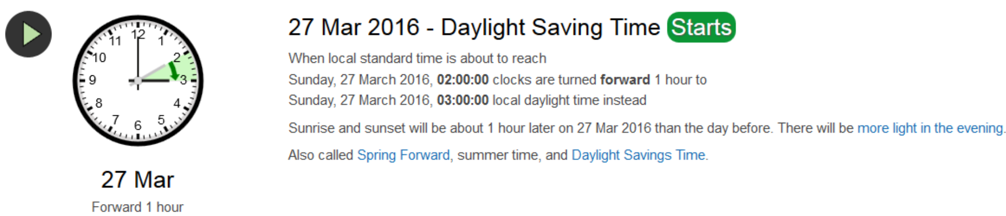
Test Cases:

a.) Negative DST change:



All DUTs are set to CEST (UTC+2hours). The GPS Simulator date/time is set to 25 Oct 2015 00:50:00 (UTC) then the device is kept running until the negative DST time is taking place at 01:00:00 (UTC)

b.) Positive DST change:



All DUTs are set to CET (UTC+1hour). The GPS Simulator date/time is set to 27 Mar 2016 00:50:00 (UTC) then the device is kept running until the positive DST time is taking place at 01:00:00 (UTC)

Expected results:

a.) At 01:00:00 UTC all DUTs operated in CEST change from 03:00:00 to 02:00:00. The new UTC offset is displayed correctly as UTC+1.

b.) At 01:00:00 UTC all DUTs operated in CET change from 02:00:00 to 03:00:00. The new UTC offset is displayed correctly as UTC+2.

7.1.2.3.3 Leap Second Insertion

Use Case:
Equipment operating in UTC or in a local time zone must execute leap second changes if a leap second change is announced via GPS.

Test Cases:
a.) Positive leap second insertion initiated via GPS Simulator with a simulated date either June 30th or Dec 31st

b.) Negative leap second insertion initiated via GPS Simulator either June 30th or Dec 31st

Remark:
The announcement of the leap second will be done via the GPS simulator in accordance to the standard. It will start with a date & time 30 minutes prior the leap second insertion. GMs need to start after start of the GPS simulator.

Expected Results:

Test Case a.)
The GM-DUT should display the Leap Second Insertion as shown in his GUI

Properties	No Leap Second announced	Positive Leap Second announced	After Leap Second Insertion
timePropertiesDS.currentUtcOffset	36	36	37
timePropertiesDS.currentUtcOffsetValid	TRUE	TRUE	TRUE
timePropertiesDS.leap59	FALSE	FALSE	FALSE
timePropertiesDS.leap61	FALSE	TRUE	FALSE

TC's, BC's and OC's need to follow the leap second insertion. And should display the correct UTC offset after the insertion.

Optional:

To check this either the time display of the device or time stamped events are used – UTC Time stamps for events taking place every full second should be: 23:59:58; 23:59:59; 23:59:60; 00:00:00; and 00:00:01.

Optional: If the OCs output IRIG-B or DCF77 output signals the leap second insertion needs to be done according to the respective standards.

Test Case b.)

The GM-DUT should display the Leap Second Insertion as shown in his GUI

Properties	No Leap Second announced	Negative Leap Second announced	After Leap negative Second Insertion
timePropertiesDS.currentUtcOffset	36	36	35
timePropertiesDS.currentUtcOffsetValid	TRUE	TRUE	TRUE
timePropertiesDS.leap59	FALSE	TRUE	FALSE
timePropertiesDS.leap61	FALSE	FALSE	FALSE

TC's, BC's and OC's need to follow a negative leap second insertion.

Optional:

To check this either the time display of the device or time stamped events are used – UTC Time stamps for events taking place every full second should be: 23:59:57; 23:59:58; 00:00:00; and 00:00:01.

Optional:
If they output IRIG-B or DCF77 output signals the leap second insertion needs to be done according to the respective standards.

7.1.2.4 Network time synchronization with multiple attached Grandmasters

UseCase:
In a network with multiple grandmaster-capable clocks the best clock must be chosen as grandmaster in accordance with the BMCA defined in (Ref B). All other grandmaster capable clocks need to be in passive mode. All TCs, BCs and OCs in the network must lock to this Best Grandmaster achieving accuracy as defined in 7.2 of Ref A. In case of a switch over between grandmasters the network needs to remain in synch as defined in 7.1 of Ref A.

Proposed measurement setup:
Several Grandmaster Clocks (GM-DUT) are synchronized via an L-Band signal provided by a GPS simulator. In addition a GM-capable OC (GM-DUT2) is provided with a 1 PPS signal from the GPS Simulator. All GM-DUTs are assigned different priorities. The best GM-DUT (highest priority and accuracy) becomes Grandmaster. Devices Under Test (DUTs) are connected to a single transparent clock (TC1). The successful synchronization of all devices is checked by analyzing the network traffic

(Wireshark), checking the synchronization status of the DUTs and comparing the accuracy of time reference signals provided by the DUTs or OCs connected to the DUTs. To ensure that only one of the GM-DUTs connected to the GPS simulator (via L-Band or 1 PPS) is Grandmaster all Grandmaster capable OCs must use a priority setting that ensures that they never will be Grandmaster.

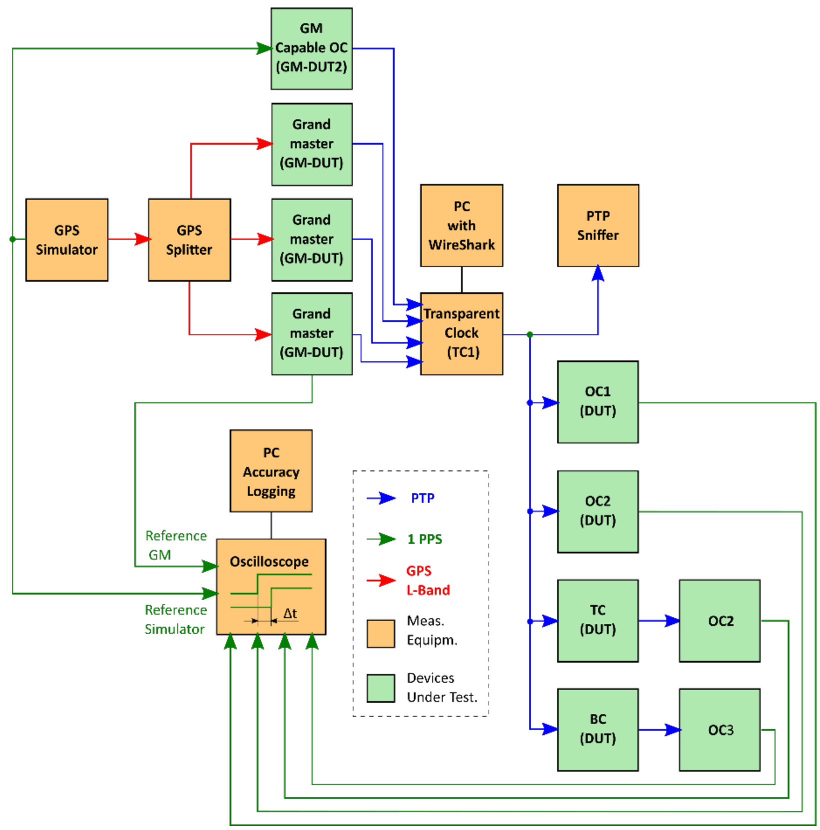


Figure 46 - BMCA test

7.1.2.4.1 Check of BMCA

Test Case:

All GM-DUTs are set to different priorities (parentDS.grandmasterPriority1 & parentDS.grandmasterPriority2).

Expected results:

- The Best GM-DUT becomes grandmaster
- All other GM-DUTs but one are in passive mode
- All DUTs have the same TAI date and time like the GPS Simulator
  (Devices that do not support TAI must show the corresponding UTC or local time zone)

- All DUTs show a locked indication
- All DUTs show the Grandmaster identity of the SAME best GM-DUT.
- All DUTs display further information on the GM-DUT they are locked to e.g.:

Parent

Port identity:	1@20:b7:c0:ff:fe:00:0c:5e
Grandmaster identity:	20:b7:c0:ff:fe:00:0c:5e
Grandmaster clock class:	PRIMARY_REF_PTP (6)
Grandmaster clock accuracy:	WITHIN_100_NS (0x21)
Grandmaster clock variance:	18465
Grandmaster priority 1:	128
Grandmaster priority 2:	128

7.1.2.4.2 Check of BMCA switch over

Test case:
The priority of a GM-DUT that is currently not the GM is changed so that it will become the new best GM. Alternatively the current GM is disconnected to initiate a switch over. To test if a GM-capable clock can take over control finally all GPS locked GM clocks are switched off.

Expected results 16 s after the switchover was initiated:

- The new Best GM-DUT becomes grandmaster
- All other GM-DUTs including the former GM are in passive mode
- All DUTs have the same TAI date and time like the GPS Simulator
  (Devices that do not support TAI must show the corresponding UTC or local time zone)
- All DUTs show a locked indication
- All DUTs show the Grandmaster identity of the SAME NEW best GM-DUT.
- Steady state is achieved within 16s after the switchover

7.1.2.4.3 BMCA Switch over with Boundary clocks

Use Case:

BMCA is also possible for networks with Boundary Clocks that are connected to two GM-capable clocks in different network domains.

Proposed Measurement set-up:

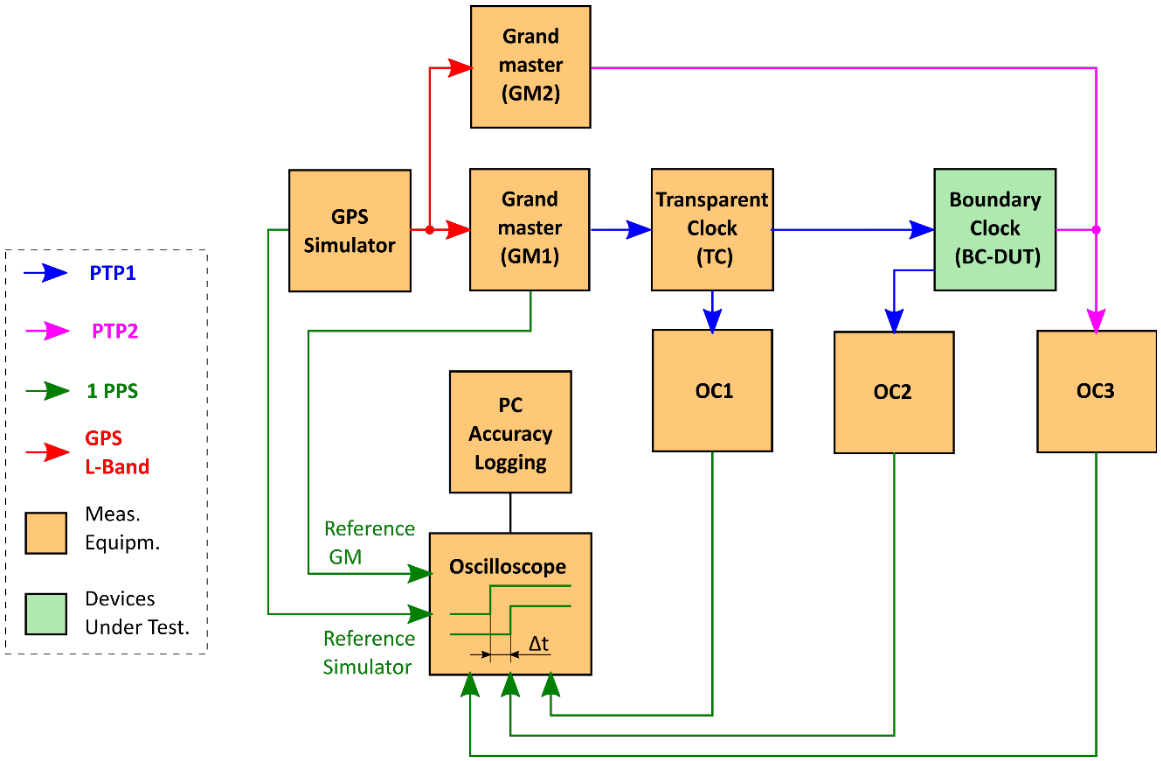


Figure 47 - BMCA with BC

Test case:

a.) Priorities of GM1 and GM2 are chosen in a way that GM1 is the Grandmaster in the system
b.) Priorities are changed so that GM2 becomes the Grandmaster

Expected Results:

a.) TC, OC1, OC2 and BC-DUT are synchronized to GM1. The BC-DUT shows GM1 as its master. OC3 is synchronized to BC-DUT. GM2 is in passive mode.

b.) BC-DUT & OC3 are synchronized to GM2. TC, OC1, OC2 are synchronized to BC-DUT. GM1 is in passive mode.

7.1.2.5 Requirements for GMs

Use case:

Grandmaster Clocks (GMs) are used as station clocks to time synchronize entire IEC 61850 infrastructures. In RefA several requirements are defined which have to be fulfilled.

Proposed Measurement setup:
To assess the accuracy of the GM-DUTs they are all connected to the same GPS Simulator. GM clocks with 1pps Output are connected directly to a scope to measure the deviation of their output signal to the reference 1 PPS provided by the simulator. GM-DUTs without 1 PPS output are connected to the scope via an OC. In addition all GM-DUTs are connected to a switch that allows to analyze PTP traffic via Wireshark and to control the GM-DUTs via Ethernet.

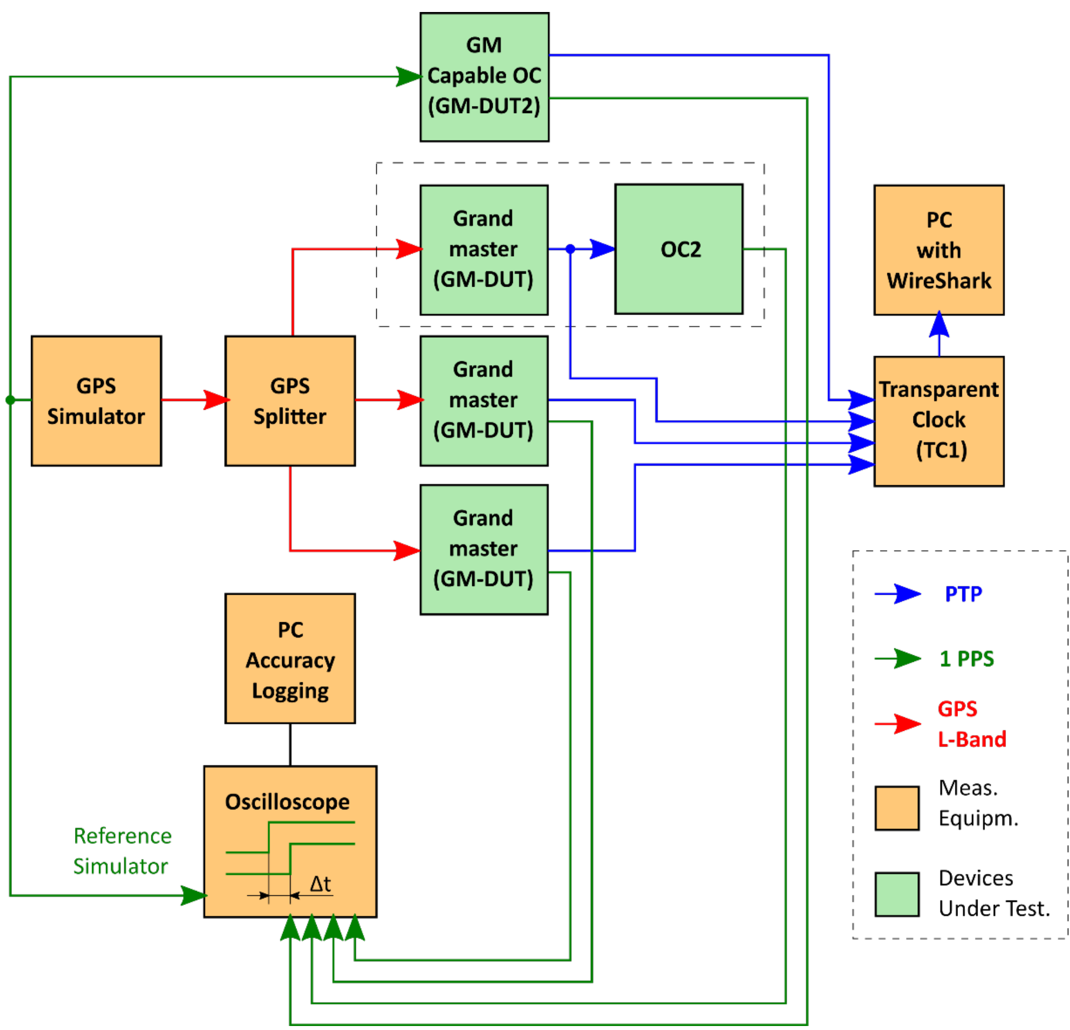


Figure 48 - GM Inaccuracy

7.1.2.5.1 GM Time Inaccuracy

Test case:

The GM Time Inaccuracy is assessed after all GM-DUTs have successfully locked to the primary time source (GPS simulator) and are in steady state according to 7.1 of Ref A. The measurement is done by comparing 1 PPS signals delivered by the GM-DUTs with the 1 PPS reference signal delivered by the GPS Simulator

Expected results:

All GM-DUTs show an inaccuracy of less than 250 ns

7.1.2.5.2 GM hold over and recovery

This section applies to GM clocks locked to GPS and the GM-capable OCs when in GM operation:

Test cases

a.) The time reference signal[2] is muted while all GM-DUTs are in steady state
b.) The time reference signal is unmuted after a period of 5 minutes

Expected results:

For Test case a.)

- The time inaccuracies of all GMs remain below ± 250 ns for 5 s in accordance with 7.4.2 of Ref A.
- The clockClass changes from 6 to 7
- As soon as an inaccuracy exceeds ± 250 ns the clock class changes from 7 to 52
- As soon as the inaccuracy exceeds ± 1µs the clock class changes from 52 to 187

For Test case b.)

- After the time reference signal has been recovered and the clock is in steady state the clock class should change again to 6
- The time inaccuracy of all GMs is below ± 250 ns as soon as they are in steady state

[2] GPS Simulator output for GMs. PTP or 1 PPS for GM-capable clocks

7.1.2.6 Requirements for Transparent Clocks (TCs)

Use case:

TCs are used to distribute PTP synchronization packages throughout a network. TCs are not allowed to introduce additional errors bigger than ± 50ns.

7.1.2.6.1 TC time inaccuracy

General comment:

The measurement at packet level is very difficult and according to the author's opinion out-of-scope for an accurate measurement during the IOP. Therefore a measurement approach is proposed.

Test Case:

Step 1:

A test network is built up as shown below. Optionally artificial network load can be generated with a network traffic generator.

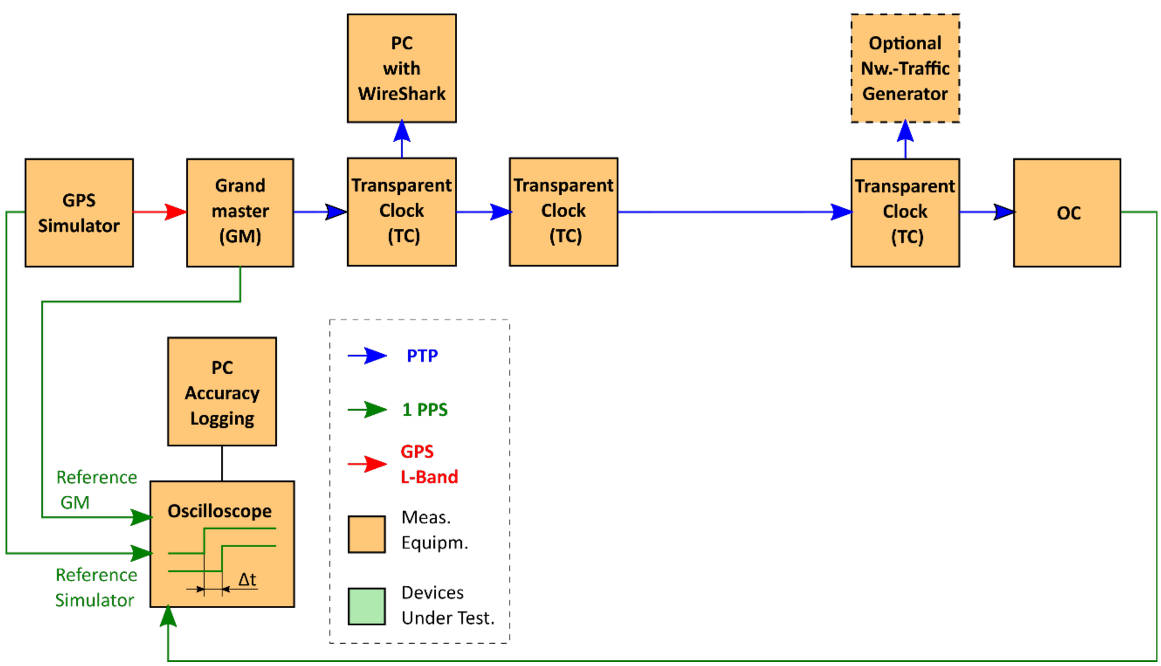


Figure 49 - TC inaccuracy step 1

Step 2:

The TC under test is inserted between two switches. After the system is stabilized the time inaccuracy added by the TC-DUT can be measured. Again network traffic can be added a network traffic generator optionally.

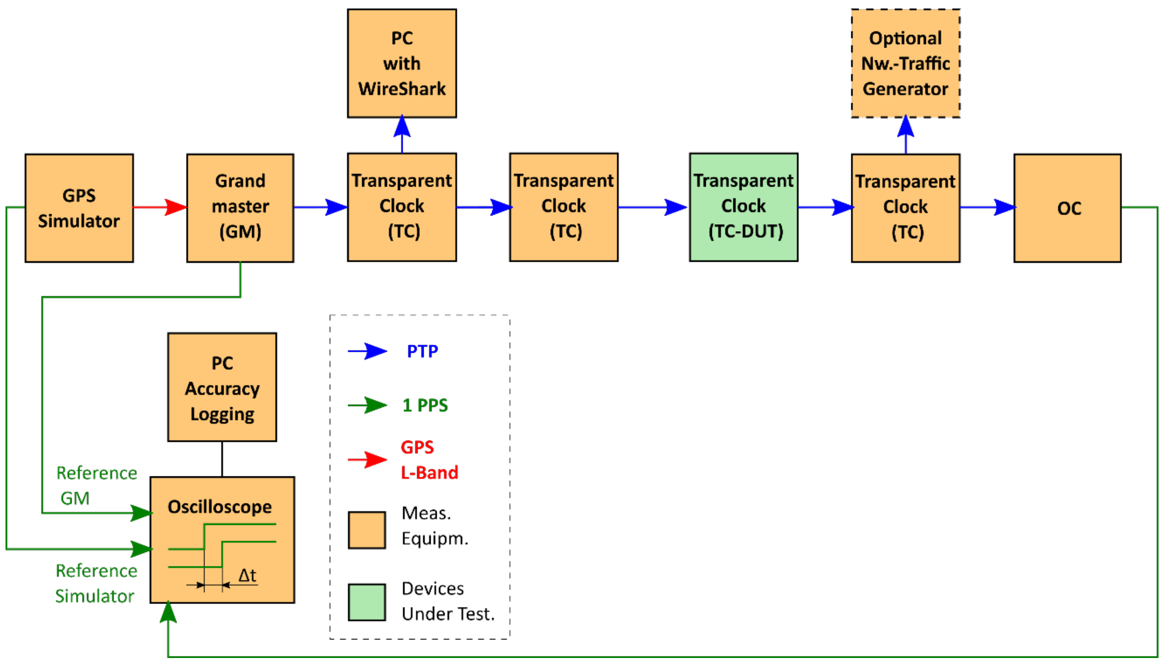


Figure 50 - TC inaccuracy step 2

Expected results:

After Step 1.)
A certain inaccuracy between OC and the GM is measured – this is the reference inaccuracy.

After Step 2.)

Due to the routing via the TC-DUT an additional inaccuracy is introduced. The total inaccuracy in comparison to the reference inaccuracy is not allowed deviate more than
± 50 ns

7.1.2.7 Requirements for Boundary Clocks

Use case:

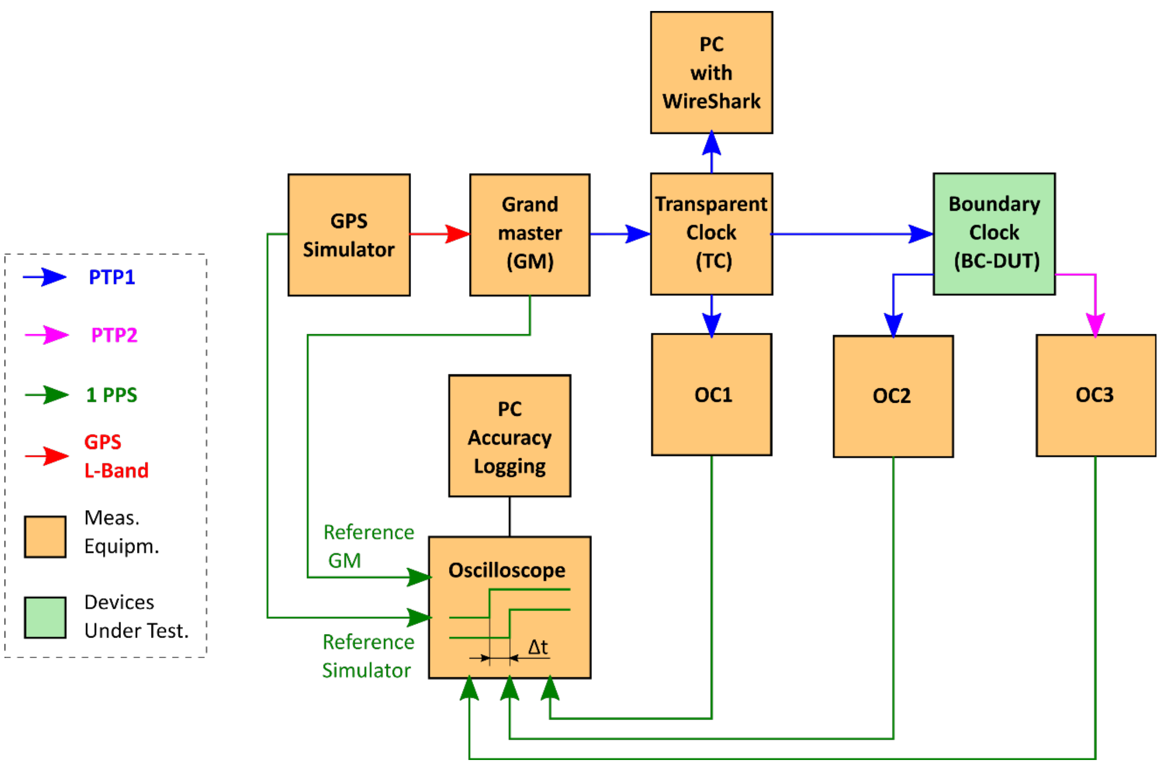
Boundary clocks (BC) are used to synchronize two separate Ethernet networks to the same grandmaster.

7.1.2.7.1 BC Time inaccuracy

Test case:

Two OCs of the same type (OC2 & OC3) are connected on both sides of the boundary clock. The time difference between the clocks is measured. OC1 and OC2 are operated in the same domain.

Measurement setup:



Expected Results:

The maximum time difference between OC2 & OC3 must be less than ± 200 ns (250ns with inaccuracy of OC's)

The maximum time deviation between OC1 & OC2 must be less than ± 50 ns (100ns with inaccuracy of OC's)

7.1.2.7.2 BC as Master in holdover

Test case:

The network is in steady state. The output of the GPS simulator is muted.
The Boundary Clock will go to hold over

Expected results:

For the first 5s of holdover the time inaccuracy of OC2 and OC3 is not allowed to shift more than ±250 ns in comparison to their inaccuracy during steady state.

7.1.2.8 Requirements for Slave Only Clocks (optional)

Use case:

Slave Only clocks can be either IEDs that are synchronized via PTP or Clocks which are used to generate time reference signals and legacy time codes.

7.1.2.8.1 Slave Only Clock Time inaccuracy (optional)

Test cases:

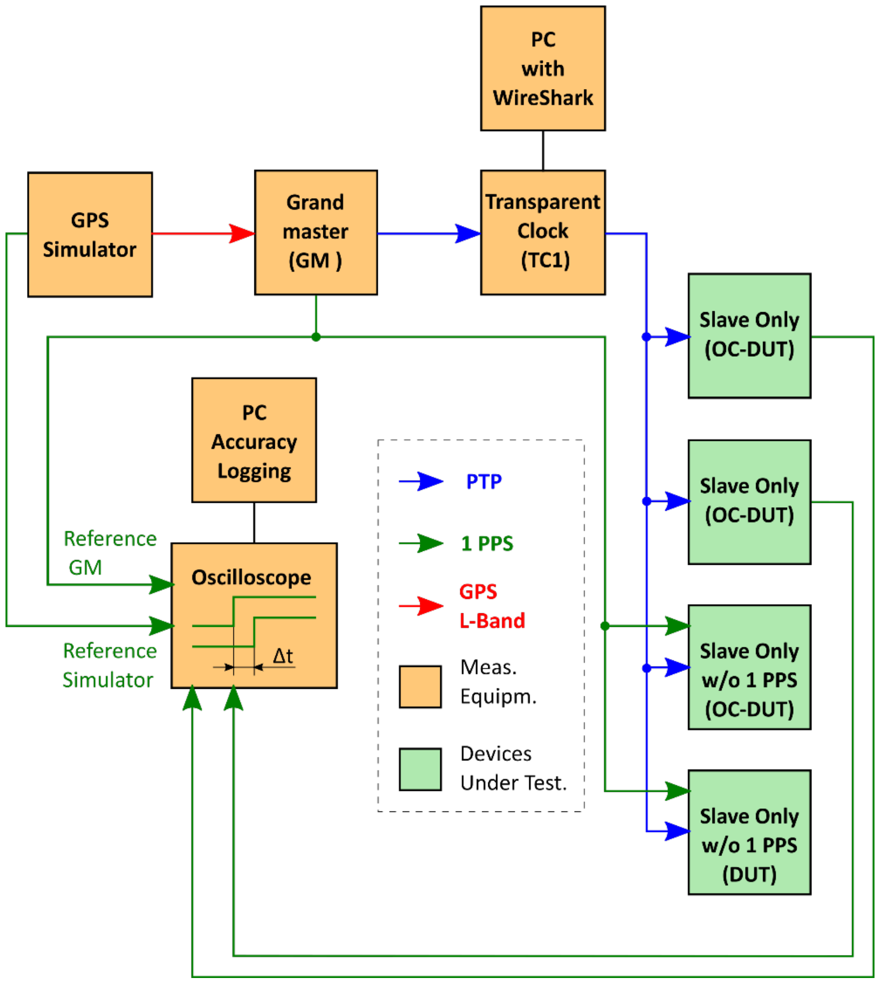
All OC-DUTs are connected to the same TC. The accuracy of the OC-DUTs is assessed by either:

a.) Comparing their 1 PPS output with a 1PPS output provided by the GM of the network

OR

b.) Creating time stamped events based on the 1 PPS Signal provided by the GM

Measurement setup:



Expected Results:

For Test case a.)

- The 1PPS signal provided OC-DUTs connected to TC1 is not deviating more than ±100 ns to the GMs 1 PPS

For Test case b.)

- The time stamp of the event (created from the GMs 1 PPS signal) is at the full second ±100 ns[3]

[3] This depends on the accuracy of the internal resolution for creating the time stamps. For some IEDs the resolution might be in the ms range.

7.1.2.8.2 Slave Only OC in hold over (optional)

Test case:

The network is in steady state. TC 1 is disconnected from the GM.

Expected results:

For the first 5s[4] of holdover the time inaccuracy is not allowed to shift more than (in comparison to the GMs 1 PPS output):± 1 µs[5] for OC-DUTs used for metering or ± 4 µs[4] for OC-DUTs used for protection.

[4] According to IEC 61869-9 chapter 6.904.5
[5] According to IEC 61869-9 chapter 6.904.1

Company	ABB	Alstom	Doble	GE	Moxa	NR Electric	OMICRON	SERTEL	Siemens	Vizimax
Table	Table 200	Table 200	Table 200	Table 200	Table 200	Table 201	Table 201	Table 201	Table 201	Table 201

Table 200: 61850-9-3 Results - Set 1

2.1	**Synchronization Test**	ABB			Alstom						Doble	GE	Moxa		
2.1.1	**Basic Check of Synchronization**	SAM600 as Merge Unit (SO)	SAM600 as PMU (TC)	SAM600 as PMU (GM)	T1000 as PTP Switch (TC)	T1000 as PMU (BC)	RT434 as GPS Clock (SO)	P441 as Prot IED (SO)	MU320 as SAMU (SO)	RT434 as GM Clock (GM)	F6052 as GM Clock (GM)	F650 as Prot IED (SO)	PT7728PTP as SW/Clock (SO)	PT7728PTP as SW/Clock (TC)	PT7728PT[illegible] as PMU (BC)
	Correct TAI (or UTC and TAI offset)	P	P		P		P	P	P		P	P	P		
	Locked to GM-DUT	P	P		P		P	P	P			P	P		
	Locked to GM-DUT SV Disturbance on Network. Overload 90%	P										P			
	Correct GM Identity displayed	P	P		P		P	P	P			P	P		
	Further Information displayed	P	P		P		P	F	P				P		
2.1.2	**Time inaccuracy below limit**														
	For OC < ±100 ns	P					I					P			
	For TCs with 1 PPS output < ± 100 ns		P		P										
	For TCs without 1 PPS output and connected OC < ± 150 ns		P		P										
	For BCs with 1 PPS output < ± 250 ns														
	For BCs without 1 PPS output and														

2.1.1	**Basic Check of Synchronization**	SAM600 as Merge Unit (SO)	SAM600 as PMU (TC)	SAM600 as PMU (GM)	T1000 as PTP Switch (TC)	T1000 as PMU (BC)	RT434 as GPS Clock (SO)	P441 as Prot IED (SO)	MU320 as SAMU (SO)	RT434 as GM Clock (GM)	F6052 as GM Clock (GM)	F650 as Prot IED (SO)	PT7728PTP as SW/Clock (SO)	PT7728PTP as SW/Clock (TC)	PT7728PT as PMU (BC)
	For GMs < ± 250 ns			P							P				
2.1.3	**One-step / Two-step capability**														
	Correct synchronization with one-step at ingress	P	P		P										
	Correct synchronization with two-step at ingress	P	P		P									P	
	Correct generation of 1-step frames as GM at egress			P						P					
	Correct generation of 2-step frames as GM at egress									P					
2.2	**Time Base related tests**														
2.2.1	**Check of TAI-UTC-Local Time**														
	Correct TAL time														
	Correct UTC offset														
	Correct UTC time														
	Correct CET/CEST														
2.2.2	**Test of DST time switching**														
	Correct change from CEST to CET														
	Correct change from CET to CEST														
2.2.3	**Leap second Insertion**														
	Correct positive leap second insertion														
	Correct positive leap														

2.1.1	**Basic Check of Synchronization**	SAM600 as Merge Unit (SO)	SAM600 as PMU (TC)	SAM600 as PMU (GM)	T1000 as PTP Switch (TC)	T1000 as PMU (BC)	RT434 as GPS Clock (SO)	P441 as Prot IED (SO)	MU320 as SAMU (SO)	RT434 as GM Clock (GM)	F6052 as GM Clock (GM)	F650 as Prot IED (SO)	PT7728PTP as SW/Clock (SO)	PT7728PTP as SW/Clock (TC)	PT7728PTP as PMU (BC)
3	**BMCA**															
3.1	**Check of BMCA**															
	Best GM-DUT becomes GM			P						P						
	Other GM-DUTs in passive mode			P						P						
	Correct Time displayed	P		P			P			P						
	Locked to GM-DUT	P					P									
	Correct GM Identity displayed	P					P									
	Further GM Information displayed	P														
3.2	**Check of BMCA switch over**															
	New best GM-DUT becomes GM			P												
	Other GM-DUTs in passive mode			P												
	Correct time of all devices			P			P									
	Locked			P			P									
	Correct GM identity displayed			P			P									
	Further GM Information displayed			P												
3.3	**BMCA with BC**															
	Correct GM chosen (GM1)															
	Correct GM chosen (GM2)															
4	**Requirements for GMs**															

2.1.1	**Basic Check of Synchronization**	SAM600 as Merge Unit (SO)	SAM600 as PMU (TC)	SAM600 as PMU (GM)	T1000 as PTP Switch (TC)	T1000 as PMU (BC)	RT434 as GPS Clock (SO)	P441 as Prot IED (SO)	MU320 as SAMU (SO)	RT434 as GM Clock (GM)	F6052 as GM Clock (GM)	F650 as Prot IED (SO)	PT7728PTP as SW/Clock (SO)	PT7728PTP as SW/Clock (TC)	PT7728PT as PMU (BC)
	Time inaccuracy < 250 ns			P											
4.2	**GM Hold over and Recovery**														
hold over	Time inaccuracy < 250 ns for 5s														
	Correct Clock class changing														
Recovery	Time inaccuracy < 250 ns after steady state is reached														
	Correct Clock class changing														
5	**Requirements for TCs**														
5.1	**Inserted time inaccuracy**														
	inserted time inaccuracy < 50 ns/TC		P		P									P	
	Inserted time inaccuracy < 50 ns/TC Network Overload with TCP-IP Messages. 90% (100 Mb/s)		P												
	Inserted time inaccuracy < 50 ns/TC Network Overload with Multicast SV Messages. 90% of		P		P									P	

2.1.1	**Basic Check of Synchronization**	SAM600 as Merge Unit (SO)	SAM600 as PMU (TC)	SAM600 as PMU (GM)	T1000 as PTP Switch (TC)	T1000 as PMU (BC)	RT434 as GPS Clock (SO)	P441 as Prot IED (SO)	MU320 as SAMU (SO)	RT434 as GM Clock (GM)	F6052 as GM Clock (GM)	F650 as Prot IED (SO)	PT7728PTP as SW/Clock (SO)	PT7728PTP as SW/Clock (TC)	PT7728PTP as PMU (BC)
6	**Requirements for BCs**														
6.1	**Inserted time inaccuracy**														
	Inserted time difference between clocks in different domains < ±250 ns					F									I
	Inserted time difference between clocks in same domain < ±100 ns														
6.2	**BC as master in hold over**														
	Time inaccuracy < 250 ns for 5s														
	Time inaccuracy as slave to the BC < 50 ns compared to BC	P													
7	**Requirements for Slave Only Clocks**														
7.1	**Inserted time inaccuracy**														
	Time Inaccuracy in comparison to GM < ±100 ns for OCs with 1 PPS output														
	Time stamp of event created from GM 1 PPS at full second														
7.2	**Slave Only OC**														

2.1.1	**Basic Check of Synchronization**	SAM600 as Merge Unit (SO)	SAM600 as PMU (TC)	SAM600 as PMU (GM)	T1000 as PTP Switch (TC)	T1000 as PMU (BC)	RT434 as GPS Clock (SO)	P441 as Prot IED (SO)	MU320 as SAMU (SO)	RT434 as GM Clock (GM)	F6052 as GM Clock (GM)	F650 as Prot IED (SO)	PT7728PTP as SW/Clock (SO)	PT7728PTP as SW/Clock (TC)	PT7728PTI as PMU (BC)
	Time inaccuracy < ±1 µs for 5s for Slave Only OCs used for metering	P					P								
	Time inaccuracy < ±4 µs for 5s for Slave Only OCs used for protection											P			

Table 201: 61850-9-3 Results - Set 2

2.1	**Synchronization Test**	NR Electric	OMICRON		SERTEL	Siemens				Vizimax		
2.1.1	**Basic Check of Synchronization**	PCS931 as Prot IED (SO)	OTMC100 as GM Clock (GM)	TICRO100 as Slave only Clock (SO)	TGPS300 as Prot Slave Clock (SO)	RSG2488 as GPS Clock (TC)	RSG2488 as PMU (BC)	RSG2488 as GM Clock/SW (GM)	RMC8388 as GPS Clock (SO)	PMU010000 as PMU (SO)	PMU010000 as PMU (BC)	PMU010000 as PMU (GM)
	Correct TAI (or UTC and TAI offset)	P	P	P	P				P	P		P
	Locked to GM-DUT	P		P	P				P	P		
	Locked to GM-DUT SV Disturbance on Network. Overload 90%			P					P			P
	Correct GM Identity displayed	P		P	P				P	P		
	Further Information displayed			P	P					P		
2.1.2	**Time inaccuracy below limit**											
	For OC < ±100 ns	P		P					P	P		
	For TCs with 1 PPS output < ± 100 ns											

	For BCs with 1 PPS output < ± 250 ns											
	For BCs without 1 PPS output and connected OC < ± 300 ns											
	For GMs < ± 250 ns		P									P
2.1.3	**One-step / Two-step capability**											
	Correct synchronization with one-step at ingress			P	P	P				P		
	Correct synchronization with two-step at ingress			P	P	P				P		
	1-Step / 2-Step translation					P						
	Correct generation of 1-step frames as GM at egress		P					P				P
	Correct generation of 2-step frames as GM at egress		P					P				P
2.2	**Time Base related tests**											
2.2.1	**Check of TAI-UTC-Local Time**											
	Correct TAL time											
	Correct UTC offset											
	Correct UTC time											
	Correct CET/CEST											
2.2.2	**Test of DST time switching**											
	Correct change from CEST to CET											
	Correct change from CET to CEST											
2.2.3	**Leap second**											

	second insertion											
3	**BMCA**											
3.1	**Check of BMCA**											
	Best GM-DUT becomes GM		P					P				P
	Other GM-DUTs in passive mode		P					P				P
	Correct Time displayed		P	P	P			P	P	P		P
	Locked to GM-DUT			P	P				P	P		
	Correct GM Identity displayed			P	P				P	P		
	Further GM Information displayed									P		
3.2	**Check of BMCA switch over**											
	New best GM-DUT becomes GM		P					P				P
	Other GM-DUTs in passive mode		P					P				P
	Correct time of all devices		P					P		P		P
	Locked		P					P		P		P
	Correct GM identity displayed		P					P		P		P
	Further GM Information displayed									P		
3.3	**BMCA with BC**											
	Correct GM chosen (GM1)											
	Correct GM chosen (GM2)											
4	**Requirements for GMs**											
4.1	**GM Time Inaccuracy**											
	Time inaccuracy < 250 ns											
	GM Hold over											

over	Correct Clock class changing											
Recovery	Time inaccuracy < 250 ns after steady state is reached											
	Correct Clock class changing											
5	**Requirements for TCs**											
5.1	**Inserted time inaccuracy**											
	inserted time inaccuracy < 50 ns					P						
	Inserted time inaccuracy < 50 ns Network Overload with TCP-IP Messages. 90% (100 Mb/s)					P						
	Inserted time inaccuracy < 50 ns Network Overload with Multicast SV Messages. 90% of Network Overload					P						
6	**Requirements for BCs**											
6.1	**Inserted time inaccuracy**											
	Inserted time difference between clocks in different domains < ±250 ns						I				P	
	Inserted time difference between clocks in same domain < ±100 ns											

	250 ns for 5s											
	Time inaccuracy as slave to the BC < 50 ns compared to BC											
7	**Requirements for Slave Only Clocks**											
7.1	**Inserted time inaccuracy**											
	Time Inaccuracy in comparison to GM < ±100 ns for OCs with 1 PPS output											
	Time stamp of event created from GM 1 PPS at full second											
7.2	**Slave Only OC in hold over**											
	Time inaccuracy < ±1 µs for 5s for Slave Only OCs used for metering									P		
	Time inaccuracy < ±4 µs for 5s for Slave Only OCs used for protection											

Table 202: PTP IEC 61850-9-3 test results

7.2 IEEE C37.238 Testing

7.2.1 Network time synchronization to a single grandmaster

Use case:

The Grandmaster must be capable of time synchronizing all connected TCs, BCs and OCs using the mandatory and default settings defined in **Error! Reference source not found.**

Proposed measurement setup:

A Grandmaster Clock (GM-DUT) is synchronized via an L-Band signal provided by a GPS simulator. The Devices Under Test (DUTs) are connected to a single transparent clock (TC1). GM capable Clocks (GM-DUT2) are synchronized directly via the 1 PPS output of the GPS Simulator. The successful synchronization of all devices is checked by analyzing the network traffic (Wireshark), checking the synchronization status of the DUTs and comparing the accuracy of 1 PPS time reference signals provided by the DUTs or OCs connected to the DUTs. To ensure that only the GM-DUT is Grandmaster all Grandmaster capable OCs must use a priority setting that ensures that they never will be Grandmaster.

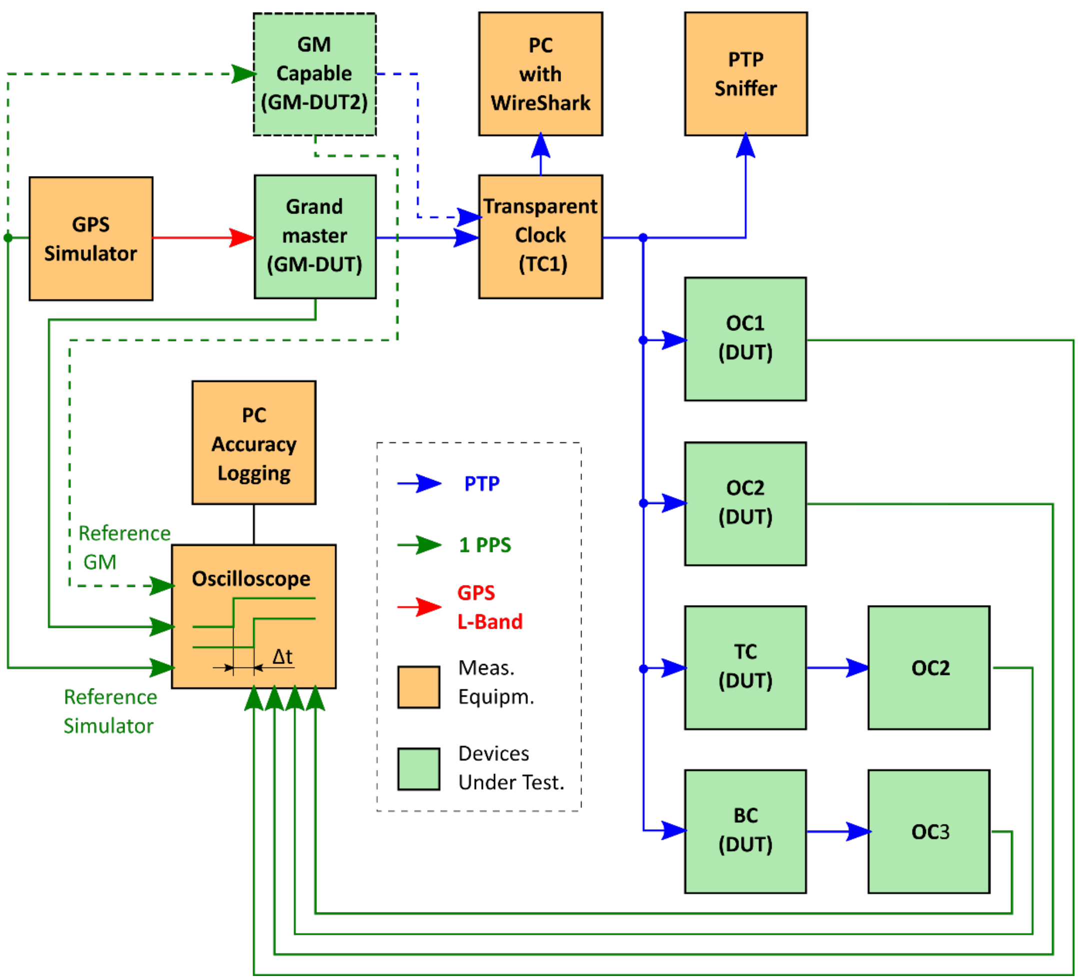


Figure 51 - General Synchronization Test

Alternative Setup to test island operation:

To test island operation a GM-capable Clock (GM-DUT2) locked to the 1 PPS signal of the GPS simulator can be used in the setup as shown in Figure 45.

7.2.2 Synchronization Test

TC1 and all DUTs should be setup to properly synchronize to the GM-DUT

7.2.2.1 Basic check of synchronization

Test Case:

Time synchronization of DUT's is verified by checking their status and time with the DUT supplier's tools or user interfaces.

Expected Results:

- All DUTs have the same TAI date and time like the GPS Simulator
  (Devices that do not support TAI must show the corresponding UTC or local time zone)
- All DUTs show a locked indication
- All DUTs show the Grandmaster identity of the GM-DUT they are locked to
- All DUTs display further information on the GM-DUT they are locked to e.g.:

Parent

Port identity:	1@20:b7:c0:ff:fe:00:0c:5e
Grandmaster identity:	20:b7:c0:ff:fe:00:0c:5e
Grandmaster clock class:	PRIMARY_REF_PTP (6)
Grandmaster clock accuracy:	WITHIN_100_NS (0x21)
Grandmaster clock variance:	18465
Grandmaster priority 1:	128
Grandmaster priority 2:	128

7.2.2.2 Check of general time inaccuracy:

Test Case:

The inaccuracy of DUTs connected to TC1 is assessed by comparing time reference signals provided by the DUTs with the 1 PPS signal provided by the GPS Simulator and the GM-DUT. The measurement is performed according to the measurement conditions defined in Annex B of Ref A

Maximum introduced inaccuracies:

Device	Added inaccuracy	
GM-DUT	200 ns	Ref A Annex B
GM-DUT 2	200 ns	Ref A Annex B
TC 1	50 ns	Ref A Annex B
BC	200 ns	typical
OC	50 ns	typical

Expected Results:

The results are assessed after the equipment is in steady state according to Ref 1. Further on delays introduced by long cables can be compensated if supported by the equipment. For equipment that does not offer this possibility a 5 ns/m delay can be subtracted from the measured result.

- OCs connected to TC1 are not deviating more than ±100 ns to the GM-DUTs 1pps
- TCs connected to TC1 are not deviating more than ±100 ns (for TCs with 1pps output) or more than ±150 ns (for 1 pps provided by OCs connected to TCs without 1pps output) to the GM-DUTs 1pps
- BCs connected to TC1 are not deviating more than ±250 ns (for BCs with 1pps output) or more than ±300 ns (for 1 PPS provided by OCs connected to BCs without 1 PPS output) to the GM-DUTs 1pps
- The GM-DUT itself is not allowed to deviate more than ±200 ns from the 1 PPS provided by the GPS simulator

Remark:

It will be difficult to measure the time inaccuracy of SlaveOnly OCs (like protection relays) which do not have a 1 PPS output. One possibility might be that the 1 PPS output of the GPS simulator is connected to the IED and a time stamped event is created by the relay. By analyzing the time stamp at least a rough accuracy might be evaluated. See Section 7.2.8 for more details.

7.2.2.3 One-step / Two-step compatibility at ingress:

Test Case:
a.) TC1 is set to one-step mechanism at egress

b.) TC1 is set to two-step mechanism at egress

Expected Results:

c.) All DUTs connected to TC1 synchronize correctly (locked indication, correct time) – no follow up messages are seen on Wireshark
- inaccuracy of components needs to remain the same like in 2.1.2

d.) All DUTs connected to TC1 synchronize correctly (locked indication, correct time) – follow up messages are seen on Wireshark
- inaccuracy of components needs to remain the same like in 2.1.2

7.2.2.4 Use of correct Multicast MAC Addresses:

According to Ref A 5.8 all IEEE C37.238 Pdelay Messages shall have the Multicast MAC Address 01:80:C2:00:00:0E

All other IEEE C37.238 Messages shall have the Multicast MAC Address 01:1B:19:00:00:00

Test case:
Check all traffic with Wireshark

Expected Results:

All DUTs connected to TC1 use the correct Multicast MAC Addresses

7.2.2.5 Correct Implementation of TLVs:

IEEE C37.238 TLV and Alternate time offset indicator TLV have to be implemented in accordance with Ref A 5.12

Test case:
a.) Check with Wireshark if all announce messages contain the correct TLVs

b.) Check if all synchronized DUTs use the TLV information correctly by checking if the correct networkTimeInaccuracy and correct grandmasterTimeInaccuracy is diplayed

Expected Results:

a.) Wireshark shows standard compliant TLVs in the announce messages
b.) Synchronized DUTs show the correct networkTimeInaccuracy and correct grandmasterTimeInaccuracy of the current GM

7.2.3 Time base related tests

7.2.3.1 Check of TAI – UTC – Local time

Use Case:
PTP synchronized devices can be switched to use different time zones as well as UTC and TAI

Test Case:

All DUTs are switched to TAI, UTC and the local time zone CET/CEST

Expected Results:

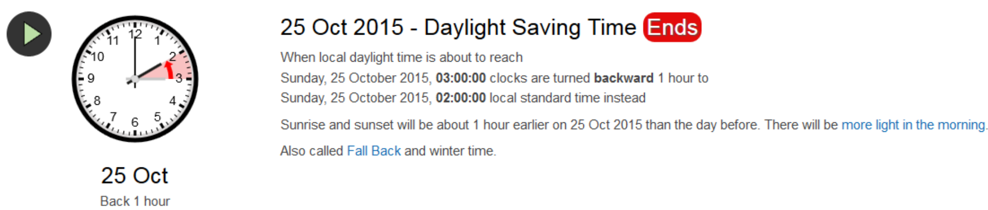
- TAI (mandatory): All DUTs show the same TAI date and time OR a UTC date and time that considers the correct UTC offset.
- UTC offset (mandatory): All DUTs show the same UTC offset to TAI
  (expected to be still 36 s in September)
- UTC time (optional): all DUTs show the same UTC date/time
- CET/CEST (optional): All DUTs show the correct time zone offset to UTC for the selected time zone

7.2.3.2 Check DST Time switching (optional)

Use Case:
DUTs operated in local time need to follow the DST change automatically

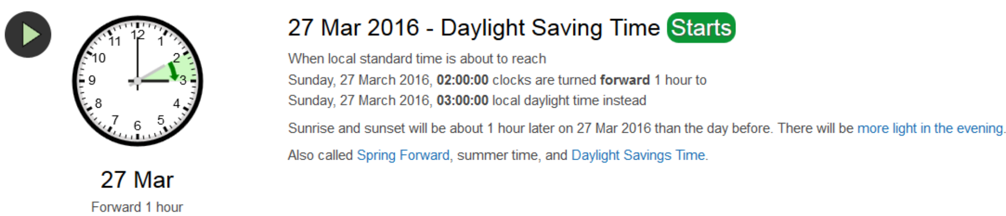
Test Cases:

c.) Negative DST change:



All DUTs are set to CEST (UTC+2hours). The GPS Simulator date/time is set to 25 Oct 2015 00:50:00 (UTC) then the device is kept running until the negative DST time is taking place at 01:00:00 (UTC)

d.) Positive DST change:



All DUTs are set to CET (UTC+1hour). The GPS Simulator date/time is set to
27 Mar 2016 00:50:00 (UTC) then the device is kept running until the positive DST time is taking place at 01:00:00 (UTC)

Expected results:

c.) At 01:00:00 UTC all DUTs operated in CEST change from 03:00:00 to 02:00:00. The new UTC offset is displayed correctly as UTC+1.
d.) At 01:00:00 UTC all DUTs operated in CET change from 02:00:00 to 03:00:00. The new UTC offset is displayed correctly as UTC+2.

7.2.3.3 Leap Second Insertion

Use Case:
Equipment operating in UTC or in a local time zone must execute leap second changes if a leap second change is announced via GPS.

Test Cases:

a.) Positive leap second insertion initiated via GPS Simulator with a simulated date either June 30th or Dec 31st

b.) Negative leap second insertion initiated via GPS Simulator either June 30th or Dec 31st

Remark:

The announcement of the leap second will be done via the GPS simulator in accordance to the standard. It will start with a date & time 30 minutes prior the leap second insertion. GMs need to start after start of the GPS simulator.

Expected Results:

Test Case a.)

The GM-DUT should display the Leap Second Insertion as shown in his GUI

Properties	No Leap Second announced	Positive Leap Second announced	After Leap Second Insertion
timePropertiesDS.currentUtcOffset	36	36	37
timePropertiesDS.currentUtcOffsetValid	TRUE	TRUE	TRUE
timePropertiesDS.leap59	FALSE	FALSE	FALSE
timePropertiesDS.leap61	FALSE	TRUE	FALSE

TC's, BC's and OC's need to follow the leap second insertion. And should display the correct UTC offset after the insertion.

Optional:

To check this either the time display of the device or time stamped events are used – UTC Time stamps for events taking place every full second should be: 23:59:58; 23:59:59 ; 23:59:60; 00:00:00; and 00:00:01.

Optional: If the OCs output IRIG-B or DCF77 output signals the leap second insertion needs to be done according to the respective standards.

Test Case b.)

The GM-DUT should display the Leap Second Insertion as shown in his GUI

Properties	No Leap Second announced	Negative Leap Second announced	After Leap negative Second Insertion
timePropertiesDS.currentUtcOffset	36	36	35

timePropertiesDS.currentUtcOffsetValid	TRUE	TRUE	TRUE
timePropertiesDS.leap59	FALSE	TRUE	FALSE
timePropertiesDS.leap61	FALSE	FALSE	FALSE

TC's, BC's and OC's need to follow a negative leap second insertion.

Optional:

To check this either the time display of the device or time stamped events are used – UTC Time stamps for events taking place every full second should be: 23:59:57; 23:59:58; 00:00:00; and 00:00:01.

Optional:
If they output IRIG-B or DCF77 output signals the leap second insertion needs to be done according to the respective standards.

7.2.4 Network time synchronization with multiple attached Grandmasters

UseCase:
In a network with multiple grandmaster-capable clocks the best clock must be chosen as grandmaster in accordance with the BMCA defined in (Ref B). All other grandmaster capable clocks need to be in passive mode. All TCs, BCs and OCs in the network must lock to this Best Grandmaster achieving accuracy as defined in Annex B of Ref A. In case of a switch over between grandmasters the network needs to remain in synch as defined in Annex B of Ref A.

Proposed measurement setup:
Several Grandmaster Clocks (GM-DUT) are synchronized via an L-Band signal provided by a GPS simulator. In addition a GM-capable OC (GM-DUT2) is provided with a 1 PPS signal from the GPS Simulator. All GM-DUTs are assigned different priorities. The best GM-DUT (highest priority and accuracy) becomes Grandmaster. Devices Under Test (DUTs) are connected to a single transparent clock (TC1). The successful synchronization of all devices is checked by analyzing the network traffic (Wireshark), checking the synchronization status of the DUTs and comparing the accuracy of time reference signals provided by the DUTs or OCs connected to the DUTs. To ensure that only one of the GM-DUTs connected to the GPS simulator (via L-Band or 1 PPS) is Grandmaster all Grandmaster capable OCs must use a priority setting that ensures that they never will be Grandmaster.

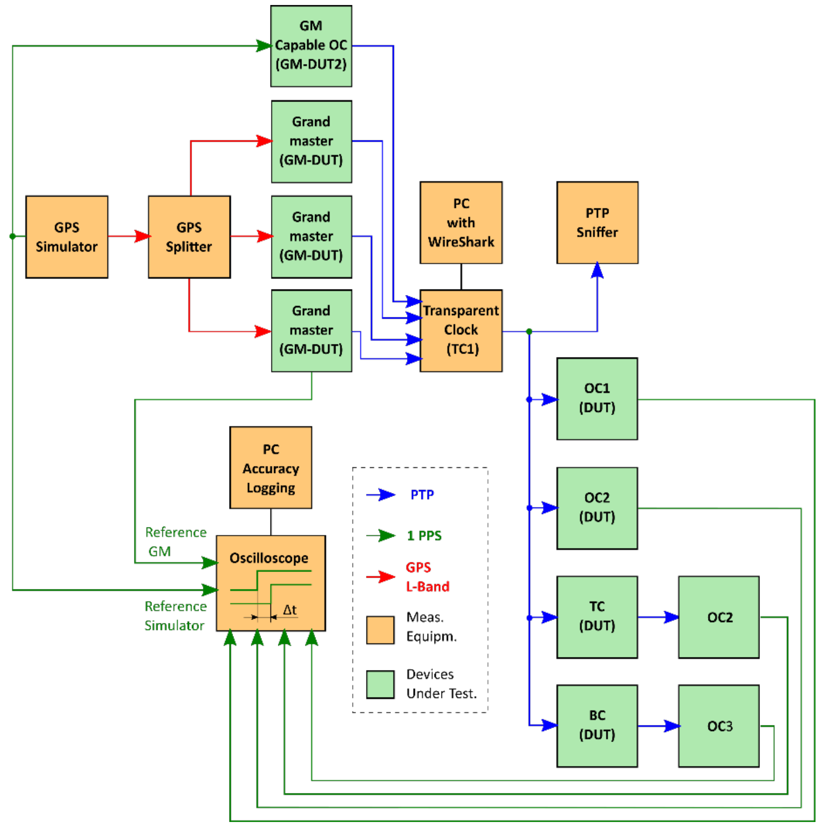


Figure 52 - BMCA test

7.2.4.1 Check of BMCA

Test Case:

All GM-DUTs are set to different priorities (parentDS.grandmasterPriority1 & parentDS.grandmasterPriority2).

Expected results:

- The Best GM-DUT becomes grandmaster
- All other GM-DUTs but one are in passive mode
- All DUTs have the same TAI date and time like the GPS Simulator
  (Devices that do not support TAI must show the corresponding UTC or local time zone)
- All DUTs show a locked indication
- All DUTs show the Grandmaster identity of the SAME best GM-DUT.

- All DUTs display further information on the GM-DUT they are locked to e.g.:

Parent

Port identity:	1@20:b7:c0:ff:fe:00:0c:5e
Grandmaster identity:	20:b7:c0:ff:fe:00:0c:5e
Grandmaster clock class:	PRIMARY_REF_PTP (6)
Grandmaster clock accuracy:	WITHIN_100_NS (0x21)
Grandmaster clock variance:	18465
Grandmaster priority 1:	128
Grandmaster priority 2:	128

7.2.4.2 Check of BMCA switch over

Test case:

The priority of a GM-DUT that is currently not the GM is changed so that it will become the new best GM. Alternatively the current GM is disconnected to initiate a switch over. To test if a GM-capable clock can take over control finally all GPS locked GM clocks are switched off.

Expected results 16 s after the switchover was initiated:

- The new Best GM-DUT becomes grandmaster
- All other GM-DUTs including the former GM are in passive mode
- All DUTs have the same TAI date and time like the GPS Simulator
  (Devices that do not support TAI must show the corresponding UTC or local time zone)
- All DUTs show a locked indication
- All DUTs show the Grandmaster identity of the SAME NEW best GM-DUT.
- Steady state is achieved within 16s after the switchover

7.2.4.3 Check exclusion of GMs without TLV

Test case:

The priority of a GM-DUT (that is currently not the GM and does not send TLVs in it's announce message) is changed so that it would become the new best GM. Alternatively the current GM is disconnected to initiate a switch over.

Expected results 16 s after the switchover was initiated:

- The GM-DUT that is not sending out TLVs is NOT becoming grandmaster. The second best clock which sends out TLVs becomes Grandmaster.
- All other GM-DUTs including the former GM are in passive mode
- All DUTs have the same TAI date and time like the GPS Simulator
  (Devices that do not support TAI must show the corresponding UTC or local time zone)
- All DUTs show a locked indication
- All DUTs show the Grandmaster identity of the SAME NEW best GM-DUT.
- Steady state is achieved within 16s after the switchover (optional since no steady state time is defined in C37.238)

7.2.4.4 BMCA Switch over with Boundary clocks (optional)

Use Case:

BMCA is also possible for networks with Boundary Clocks that are connected to two GM-capable clocks in different network domains.

Proposed Measurement set-up:

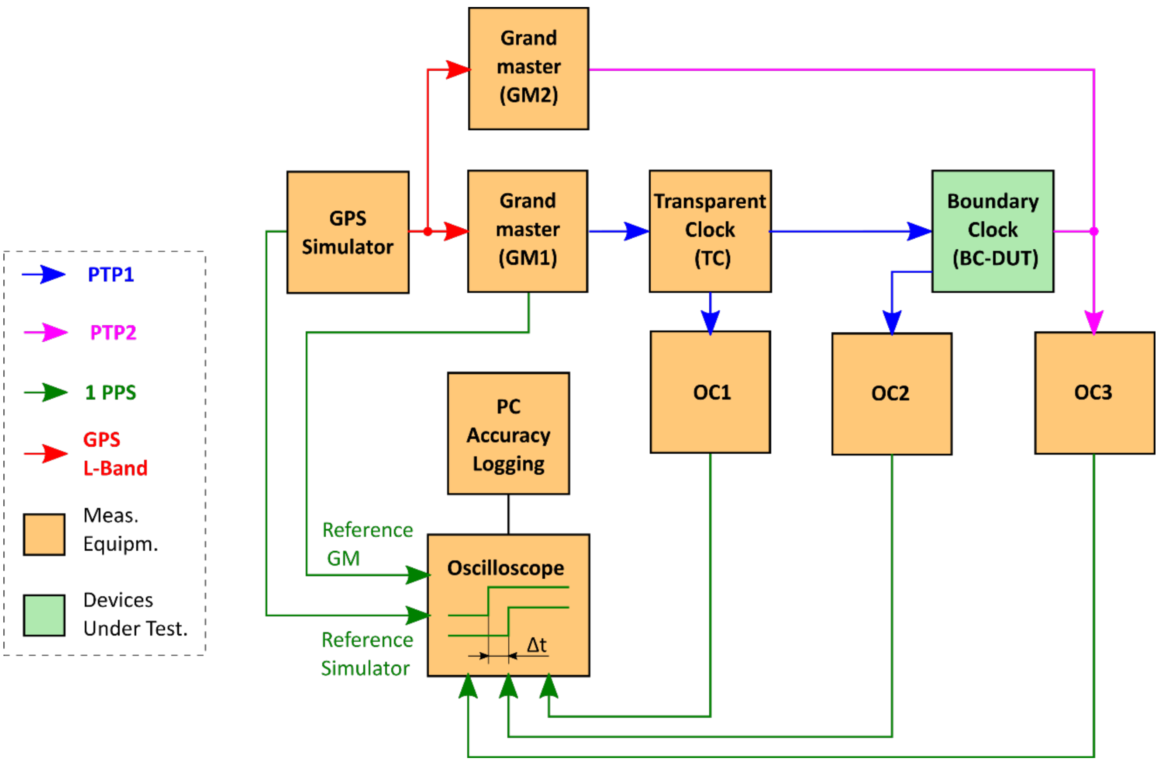


Figure 53 - BMCA with BC

Test case:

c.) Priorities of GM1 and GM2 are chosen in a way that GM1 is the Grandmaster in the system
d.) Priorities are changed so that GM2 becomes the Grandmaster

Expected Results:

c.) TC, OC1, OC2 and BC-DUT are synchronized to GM1. The BC-DUT shows GM1 as its master. OC3 is synchronized to BC-DUT. GM2 is in passive mode.

d.) BC-DUT & OC3 are synchronized to GM2. TC, OC1, OC2 are synchronized to BC-DUT. GM1 is in passive mode.

7.2.5 Requirements for GMs

Use case:

Grandmaster Clocks (GMs) are used as station clocks to time synchronize entire IEC 61850 infrastructures. In RefA several requirements are defined which have to be fulfilled.

Proposed Measurement setup:

To assess the accuracy of the GM-DUTs they are all connected to the same GPS Simulator. GM clocks with 1pps Output are connected directly to a scope to measure the deviation of their output signal to the reference 1 PPS provided by the simulator. GM-DUTs without 1 PPS output are connected to the scope via an OC. In addition all GM-DUTs are connected to a switch that allows to analyze PTP traffic via Wireshark and to control the GM-DUTs via Ethernet.

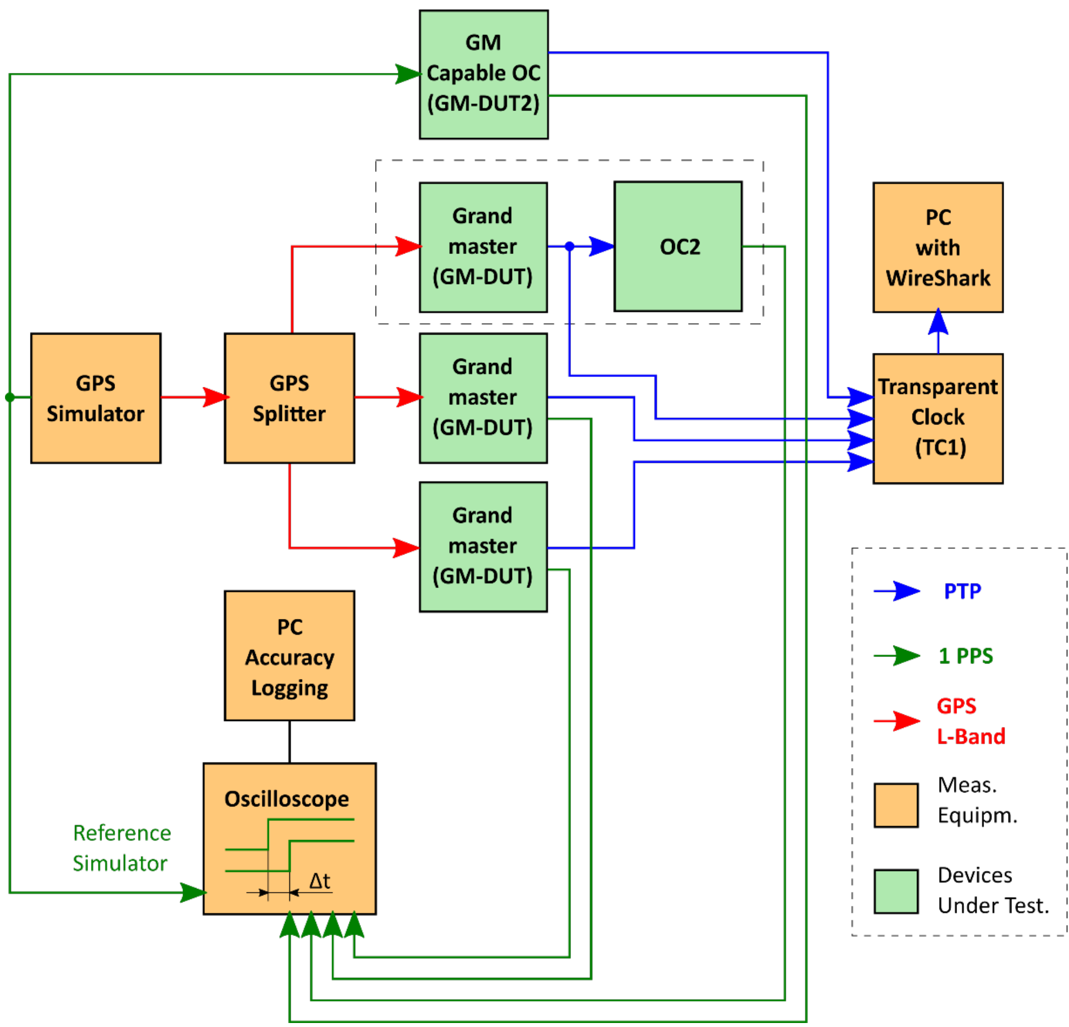


Figure 54 - GM Inaccuracy

7.2.5.1 GM Time Inaccuracy

Test case:

The GM Time Inaccuracy is assessed after all GM-DUTs have successfully locked to the primary time source (GPS simulator) and are in steady state according to Annex B of Ref A. The measurement is done by comparing 1 PPS signals delivered by the GM-DUTs with the 1 PPS reference signal delivered by the GPS Simulator

Expected results:

All GM-DUTs show an inaccuracy of less than 200 ns

7.2.5.2 GM hold over and recovery

This section applies to GM clocks locked to GPS and the GM-capable OCs when in GM operation:

Test cases

c.) The time reference signal[6] is muted while all GM-DUTs are in steady state
d.) The time reference signal is unmuted after a period of 5 minutes

Expected results:

For Test case a.)

- The time inaccuracies of all GMs remain below ± 2µs for 5 s in accordance with Annex B of Ref A.
- The clockClass changes in accordance of Ref B 7.6.2.4 Table 5 (Clock Classes)

For Test case b.)

- After the time reference signal has been recovered and the clock is in steady state the clock class should change again to 6
- The time inaccuracy of all GMs is below ± 200 ns as soon as they are in steady state

7.2.6 Requirements for Transparent Clocks (TCs)

[6] GPS Simulator output for GMs.

Use case:

TCs are used to distribute PTP synchronization packages throughout a network. TCs are not allowed to introduce additional errors bigger than ± 50ns.

7.2.6.1 TC time inaccuracy

General comment:

The measurement at packet level is very difficult and according to the author's opinion out-of-scope for an accurate measurement during the IOP. Therefore a measurement approach is proposed.

Test Case:

Step 1:

A test network is built up as shown below. Optionally artificial network load can be generated with a network traffic generator.

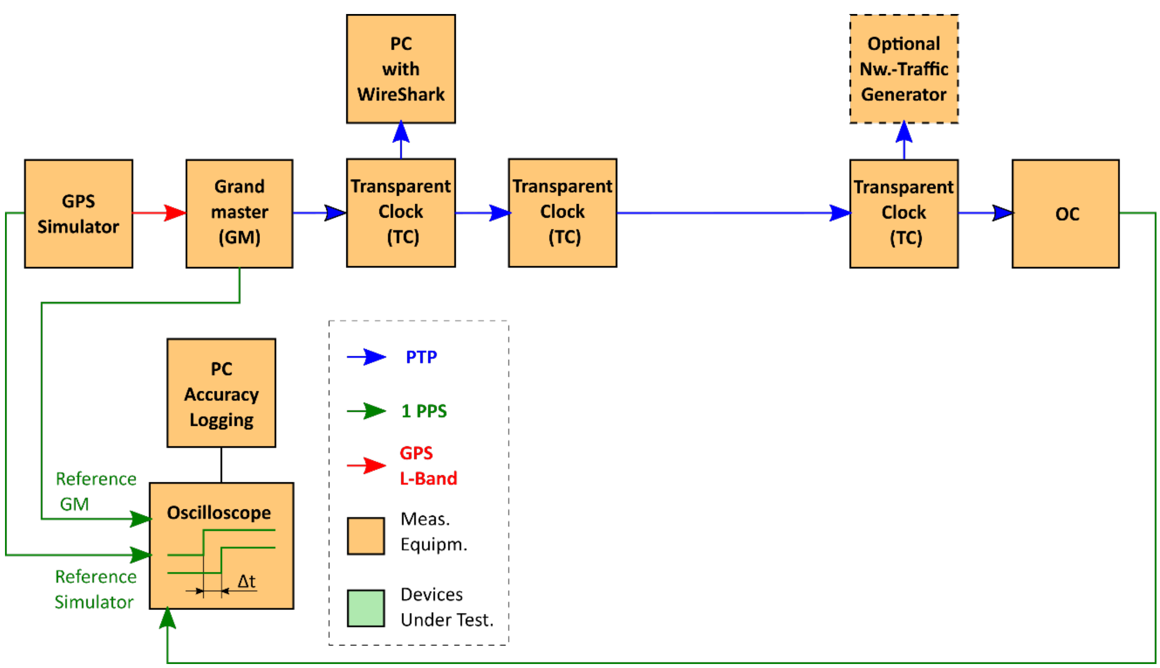


Figure 55 - TC inaccuracy step 1

Step 2:

The TC under test is inserted between two switches. After the system is stabilized the time inaccuracy added by the TC-DUT can be measured. Again network traffic can be added a network traffic generator optionally.

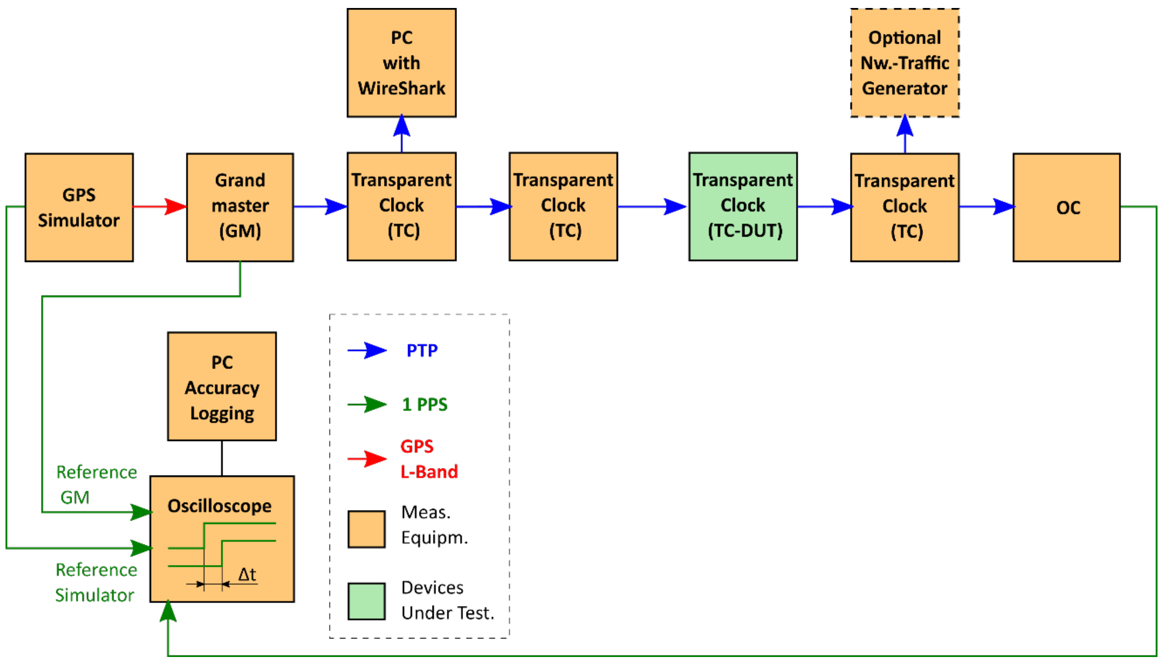


Figure 56 - TC inaccuracy step 2

Expected results:

After Step 1.)
A certain inaccuracy between OC and the GM is measured – this is the reference inaccuracy.

After Step 2.)

Due to the routing via the TC-DUT an additional inaccuracy is introduced. The total inaccuracy in comparison to the reference inaccuracy is not allowed deviate more than
± 50 ns

7.2.7 Requirements for Boundary Clocks (optional)

Use case:

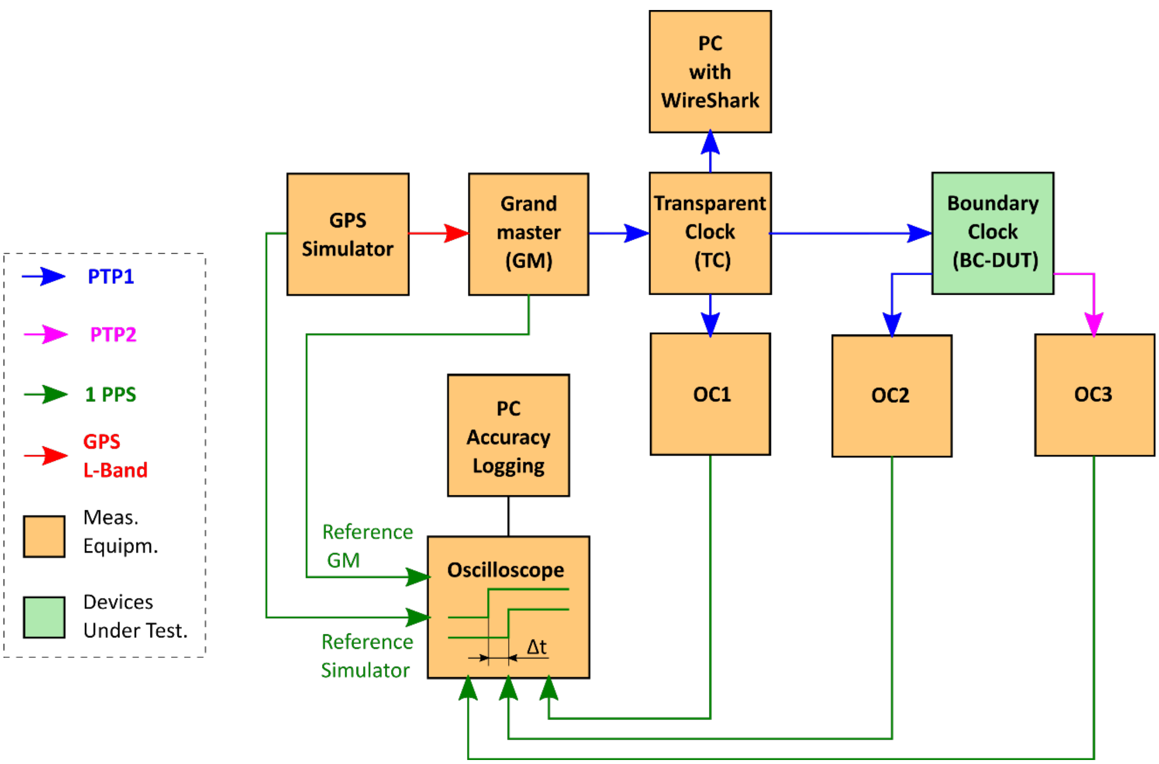
Boundary clocks (BC) are used to synchronize two separate Ethernet networks to the same grandmaster.

7.2.7.1 BC Time inaccuracy

Test case:

Two OCs of the same type (OC2 & OC3) are connected on both sides of the boundary clock. The time difference between the clocks is measured. OC1 and OC2 are operated in the same domain.

Measurement setup:



Expected Results:

The maximum time difference between OC2 & OC3 must be less than ± 200 ns (250ns with inaccuracy of OC's)

The maximum time deviation between OC1 & OC2 must be less than ± 50 ns (100ns with inaccuracy of OC's)

7.2.7.2 BC as Master in holdover (optional)

Test case:

The network is in steady state. The output of the GPS simulator is muted.
The Boundary Clock will go to hold over

Expected results:

For the first 5s of holdover the time inaccuracy of OC2 and OC3 is not allowed to shift more than 2 µs in comparison to their inaccuracy during steady state.

7.2.8 Requirements for Slave Only Clocks (optional)

Use case:

Slave Only clocks can be either IEDs that are synchronized via PTP or Clocks which are used to generate time reference signals and legacy time codes.

7.2.8.1 Slave Only Clock Time inaccuracy (optional)

Test cases:

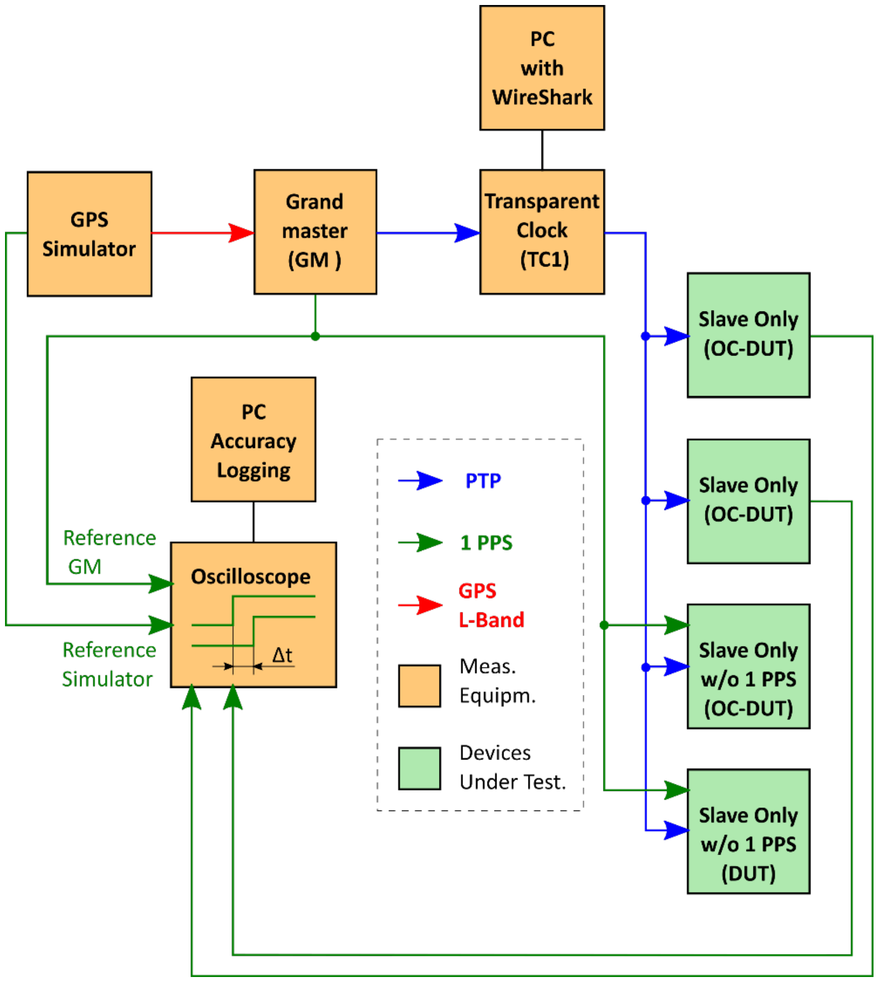
All OC-DUTs are connected to the same TC. The accuracy of the OC-DUTs is assessed by either:

c.) Comparing their 1 PPS output with a 1PPS output provided by the GM of the network

OR

d.) Creating time stamped events based on the 1 PPS Signal provided by the GM

Measurement setup:



Expected Results:

For Test case a.)

- The 1PPS signal provided OC-DUTs connected to TC1 is not deviating more than ±100 ns to the GMs 1 PPS

For Test case b.)

- The time stamp of the event (created from the GMs 1 PPS signal) is at the full second ±100 ns[7]

7.2.8.2 Slave Only OC in hold over (optional)

Test case:

[7] This depends on the accuracy of the internal resolution for creating the time stamps. For some IEDs the resolution might be in the ms range.

The network is in steady state. TC 1 is disconnected from the GM

Expected results:

For the first 5s[8] of holdover the time inaccuracy is not allowed to shift more than:

± 1 µs[9] for OC-DUTs used for metering

± 4 µs[4] for OC-DUTs used for protection

in comparison to the GMs 1 PPS output.

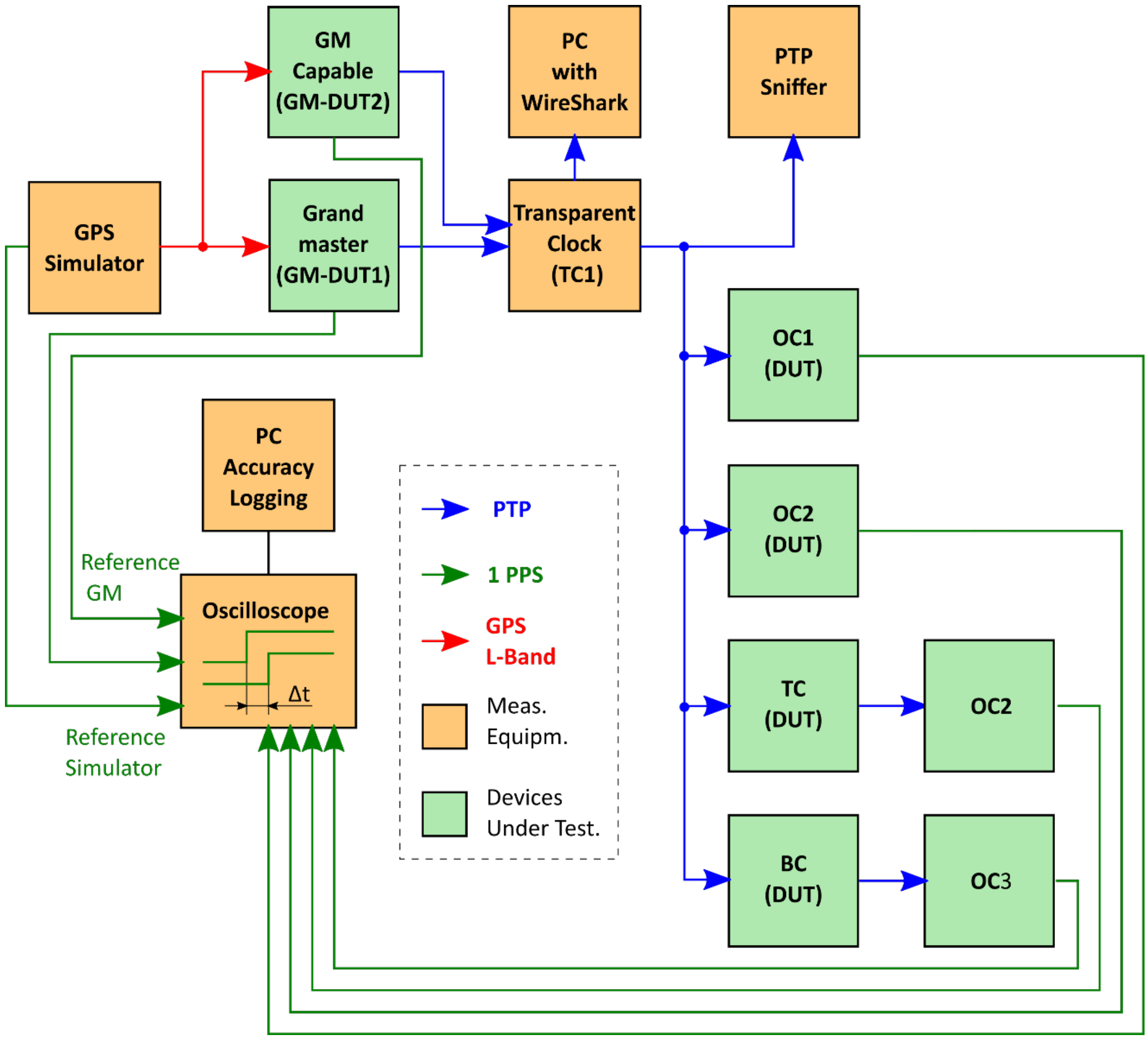
7.2.9 Profile Specific Implementations

7.2.9.1 Use of VLAN IDs

Use Case:
VLAN IDs are used to operate separate time synchronization networks in one network. This allows to synchronize equipment in the same network to different grandmasters and to limit network traffic.

Proposed Setup:

[8] According to IEC 61869-9 chapter 6.904.5
[9] According to IEC 61869-9 chapter 6.904.1


GM
Capable
(GM-DUT2)
PC
with
WireShark
PTP
Sniffer
GPS
Simulator
Grand
master
(GM-DUT1)
Transparent
Clock
(TC1)
OC1
(DUT)
PC
Accuracy
Logging
PTP
1 PPS
GPS
L-Band
Meas.
Equipm.
Devices
Under Test.
OC2
(DUT)
Reference
GM
Oscilloscope
Δt
Reference
Simulator
TC
(DUT)
OC2
BC
(DUT)
OC3

7.2.9.1.1 General VLAN

Test Cases:
A time synchronization network with two grandmasters operated with different VLAN IDs is built up. TCs are set up to pass the VLAN IDs correctly to the connected DUTs.

GM-DUT1 is set to VLAN ID 12 and Priority 5

GM-DUT2 is set to VLAN ID 1588 and Priority 4

a.) All DUTs are set to VLAN ID 12
b.) Step by step all OCs are set to VLAN ID 1588

Expected results:

General:

All PTP Data Packages contain the correct VLAN ID and Priority according to the set values. (Checked with Wireshark)

For Test Case a.)
All Clocks are locked to GM-DUT 1 (correct GM ID shown)

For Test Case b.)

As soon as the VLAN ID is changed to 1588 of respective DUTs are synchronizing to GM-DUT2. All DUT's which VLAN ID have not been changed remain locked to GM-DUT2

7.2.9.1.2 Strip VLAN Tags (Ref A 5.6)

UseCase:
If no GM is available in a specific VLAN a clock is assigned to, it should synchronize to a

GM that is not in a VLAN or which VLAN Tags have been stripped by a switch.

Test Case:

Test Case a.)

GM-DUT1 is set to VLAN ID 12 and Priority 5

GM-DUT2 is disabled

All DUTs are set to VLAN ID 12 and Priority 5. After the system is in steady state the VLAN stripping for TC1 is activated.

Test case b.)

GM-DUT1 is set to VLAN ID 12 and Priority 5

GM-DUT2 is set to VLAN ID 1588 and Priority 4

All DUTs are set to VLAN ID 12 and Priority 5. After the system is in steady state the VLAN stripping for TC1 is activated.

Expected results:

Test case a.)

All DUTs remain either locked to GMDUT1 or re-synchronize on GM-DUT 1

Test case b.)

All DUTs remain either locked to GMDUT1 or re-synchronize on GM-DUT 1 or GM-DUT2

7.2.10 Test Results

For legibility, the results have been divided into multiple tables.

Company	ABB	Alstom	Doble	GE	Schweitzer	OMICRON	Vizimax
Table	Table 200	Table 200	Table 200	Table 200	Table 200	Table 204	Table 204

Table 203: IEEE C37.238 Test Results - Set 1

	C37.238 Test Results – Set 1	ABB	Alstom	DOBLE	GE	SEL
		SAM600 as Merge Unit (SO)	RT434 AS GPS clock (SO)	F6052 as GPS Grand Master Clock (GM)	F650 as Prot IED (SO)	SEL 2488 as GPS Clock (GM)
2.1	**Synchronization Test**					
2.1.1	**Basic Check of Synchronization**					
	Correct TAI (or UTC and TAI offset)	P	P	P	P	P
	Locked to GM-DUT	P	P		P	
	Correct GM Identity displayed	P	P		P	
	Further Information displayed					

2.1.2	**Time inaccuracy below limit**					
	For OC < ±100 ns	P			P	
	For TCs with 1 PPS output < ± 100 ns					
	For TCs without 1 PPS output and connected OC < ± 150 ns					
	For BCs with 1 PPS output < ± 250 ns					
	For BCs without 1 PPS output and connected OC < ± 300 ns					
	For GMs < ± 200 ns			P		P
2.1.3	**One-step / Two-step compatibility at ingress**					
	Correct synchronization with one-step at ingress					
	Correct synchronization with two-step at ingress					
2.1.4	**Use of correct Multicast MAC Addresses:**					
	Announce Messages contain correct TLV			I		P
	DUT shows correct networkTimeInaccuracy and correct grandmasterTimeInaccuracy				I	
2.1.4	**Correct Implementation of TLVs**					
	Announce Messages contain correct TLV					
	DUT shows correct networkTimeInaccuracy and correct grandmasterTimeInaccuracy					
2.2	**Time Base related tests**					

2.2.1	**Check of TAI-UTC-Local Time**					
	Correct TAI time (or UTC and UTC-TAI offset)					
	Correct UTC offset					
	Correct UTC time					
	Correct CET/CEST					
2.2.2	**Test of DST time switching**					
	Correct change from CEST to CET					
	Correct change from CET to CEST					
2.2.3	**Leap Second Insertion**					
	Correct positive leap second insertion					
	Correct positive leap second insertion					
3	**BMCA**					
3.1	**Check of BMCA**					
	Best GM-DUT becomes GM			I		P
	Other GM-DUTs in passive mode			I		P
	Correct Time displayed			P		P
	Locked to GM-DUT	P	P		P	
	Correct GM Identity displayed	P	P		P	
3.2	**Check of BMCA switch over**					

	New best GM-DUT becomes GM					
	Other GM-DUTs in passive mode					
	Correct time of all devices					
	Locked					
	Correct GM identity displayed					
	Steady State has been achieved within 16s after switching					
3.3	**Check exclusion of GMs without TLV**					
	New best GM-DUT not sending out TLV is not becoming GM					
	Other GM-DUTs in passive mode					
	Correct time of all devices					
	Locked					
	Correct GM identity displayed					
	Steady State has been achieved within 16s after switching					
3.3	**BMCA with BC**					
	Correct GM chosen (GM1)					
	Correct GM chosen (GM2)					
4	**Requirements for GMs**					
4.1	**GM Time Inaccuracy**					
	Time inaccuracy < 200 ns					
4.2	**GM Hold over and Recovery**					

hold over	Time inaccuracy ± 2µs for 5s					
	Correct Clock class changing					
Recovery	Time inaccuracy < 200 ns after steady state is reached					
	Correct Clock class changing					
5	**Requirements for TCs**					
5.1	**Inserted time inaccuracy**					
	inserted time inaccuracy < 50 ns					
6	**Requirements for BCs**					
6.1	**Inserted time inaccuracy**					
	Inserted time difference between clocks in different domains < ±250 ns					
	Inserted time difference between clocks in same domain < ±100 ns					
6.2	**BC as master in hold over**					
	Time inaccuracy < 250 ns for 5s					
7	**Requirements for Slave Only Clocks**					
7.1	**Inserted time inaccuracy**					
	Time Inaccuracy in comparison to GM < ±100 ns for OCs with 1 PPS output					

	Time stamp of event created from GM 1 PPS at full second					
7.2	**Slave Only OC in hold over**					
	Time inaccuracy < ±1 µs for 5s for Slave Only OCs used for metering					
	Time inaccuracy < ±4 µs for 5s for Slave Only OCs used for protection					
8	**Profile Specific Implementations**					
8.1	**Use of VLAN IDs**					
	All clocks locked to GM in their VLAN					
	When VLAN ID is changed clocks switch to GM in new VLAN					
8.2	**Stripping of VLAN Tags**					
	All Clocks locked to GM with stripped VLAN					
	BMCA with VLAN Stripping					

Table 204: IEEE C37.238 Test Results - Set 2

		OMICRON	OMICRON	Vizimax
		OTMC 100 as Clock (GM)	TICRO 100 as GPS Clock (SO)	PMU 010000 as PMU (GM)
2.1	**Synchronization Test**			
2.1.1	**Basic Check of Synchronization**			
	Correct TAI (or UTC and TAI offset)	P	P	P
	Locked to GM-DUT		P	
	Correct GM Identity displayed		P	
	Further Information displayed			
2.1.2	**Time inaccuracy below limit**			
	For OC < ±100 ns		P	
	For TCs with 1 PPS output < ± 100 ns			
	For TCs without 1 PPS output and connected OC < ± 150 ns			
	For BCs with 1 PPS output < ± 250 ns			
	For BCs without 1 PPS output and connected OC < ± 300 ns			
	For GMs < ± 200 ns	P		P
2.1.3	**One-step / Two-step compatibility at ingress**			

		OMICRON	OMICRON	Vizimax
		OTMC 100 as Clock (GM)	TICRO 100 as GPS Clock (SO)	PMU 010000 as PMU (GM)
	Correct synchronization with one-step at ingress			
	Correct synchronization with two-step at ingress			
2.1.4	**Use of correct Multicast MAC Addresses:**			
	Announce Messages contain correct TLV	P		P
	DUT shows correct networkTimeInaccuracy and correct grandmasterTimeInaccuracy			
2.1.4	**Correct Implementation of TLVs**			
	Announce Messages contain correct TLV			
	DUT shows correct networkTimeInaccuracy and correct grandmasterTimeInaccuracy			
2.2	**Time Base related tests**			
2.2.1	**Check of TAI-UTC-Local Time**			
	Correct TAI time (or UTC and UTC-TAI offset)			
	Correct UTC offset			
	Correct UTC time			
	Correct CET/CEST			

		OMICRON	OMICRON	Vizimax
		OTMC 100 as Clock (GM)	TICRO 100 as GPS Clock (SO)	PMU 010000 as PMU (GM)
2.2.2	**Test of DST time switching**			
	Correct change from CEST to CET			
	Correct change from CET to CEST			
2.2.3	**Leap Second Insertion**			
	Correct positive leap second insertion			
	Correct positive leap second insertion			
3	**BMCA**			
3.1	**Check of BMCA**			
	Best GM-DUT becomes GM	P		P
	Other GM-DUTs in passive mode	P		P
	Correct Time displayed	P		P
	Locked to GM-DUT		P	
	Correct GM Identity displayed		P	
3.2	**Check of BMCA switch over**			
	New best GM-DUT becomes GM			
	Other GM-DUTs in passive mode			

		OMICRON	OMICRON	Vizimax
		OTMC 100 as Clock (GM)	TICRO 100 as GPS Clock (SO)	PMU 010000 as PMU (GM)
	Correct time of all devices			
	Locked			
	Correct GM identity displayed			
	Steady State has been achieved within 16s after switching			
3.3	**Check exclusion of GMs without TLV**			
	New best GM-DUT not sending out TLV is not becoming GM			
	Other GM-DUTs in passive mode			
	Correct time of all devices			
	Locked			
	Correct GM identity displayed			
	Steady State has been achieved within 16s after switching			
3.3	**BMCA with BC**			
	Correct GM chosen (GM1)			
	Correct GM chosen (GM2)			
4	**Requirements for GMs**			
4.1	**GM Time Inaccuracy**			
	Time inaccuracy < 200 ns			

		OMICRON	OMICRON	Vizimax
		OTMC 100 as Clock (GM)	TICRO 100 as GPS Clock (SO)	PMU 010000 as PMU (GM)
4.2	**GM Hold over and Recovery**			
hold over	Time inaccuracy ± 2µs for 5s			
	Correct Clock class changing			
Recovery	Time inaccuracy < 200 ns after steady state is reached			
	Correct Clock class changing			
5	**Requirements for TCs**			
5.1	**Inserted time inaccuracy**			
	inserted time inaccuracy < 50 ns			
6	**Requirements for BCs**			
6.1	**Inserted time inaccuracy**			
	Inserted time difference between clocks in different domains < ±250 ns			
	Inserted time difference between clocks in same domain < ±100 ns			
6.2	**BC as master in hold over**			
	Time inaccuracy < 250 ns for 5s			

		OMICRON	OMICRON	Vizimax
		OTMC 100 as Clock (GM)	TICRO 100 as GPS Clock (SO)	PMU 010000 as PMU (GM)
7	**Requirements for Slave Only Clocks**			
7.1	**Inserted time inaccuracy**			
	Time Inaccuracy in comparison to GM < ±100 ns for OCs with 1 PPS output			
	Time stamp of event created from GM 1 PPS at full second			
7.2	**Slave Only OC in hold over**			
	Time inaccuracy < ±1 µs for 5s for Slave Only OCs used for metering			
	Time inaccuracy < ±4 µs for 5s for Slave Only OCs used for protection			
8	**Profile Specific Implementations**			
8.1	**Use of VLAN IDs**			
	All clocks locked to GM in their VLAN			
	When VLAN ID is changed clocks switch to GM in new VLAN			
8.2	**Stripping of VLAN Tags**			

		OMICRON	OMICRON	Vizimax
		OTMC 100 as Clock (GM)	TICRO 100 as GPS Clock (SO)	PMU 010000 as PMU (GM)
	All Clocks locked to GM with stripped VLAN			
	BMCA with VLAN Stripping			

8 Problems Reported

The overall issue breakdown, from the IOP, can be divided into implementation issues and issues requiring IEC TC57 WG10 analysis, response, and/or changes within the IEC 61850 standards. There were forty-seven total issues reported. Thirteen of these issues were reviewed and classified as implementation issues. The following sections details non-implementation testing areas/campaigns issues.

The issues in this section have been reported to the User Feedback Task Force of IEC TC57 WG10. They have been resolved or are in the process of being resolved. There were thirty-four (34) IOP issues reported to the User Feedback Task Force which have been represented as thirty-eight individual issues in this document. The distribution of the issues is as shown

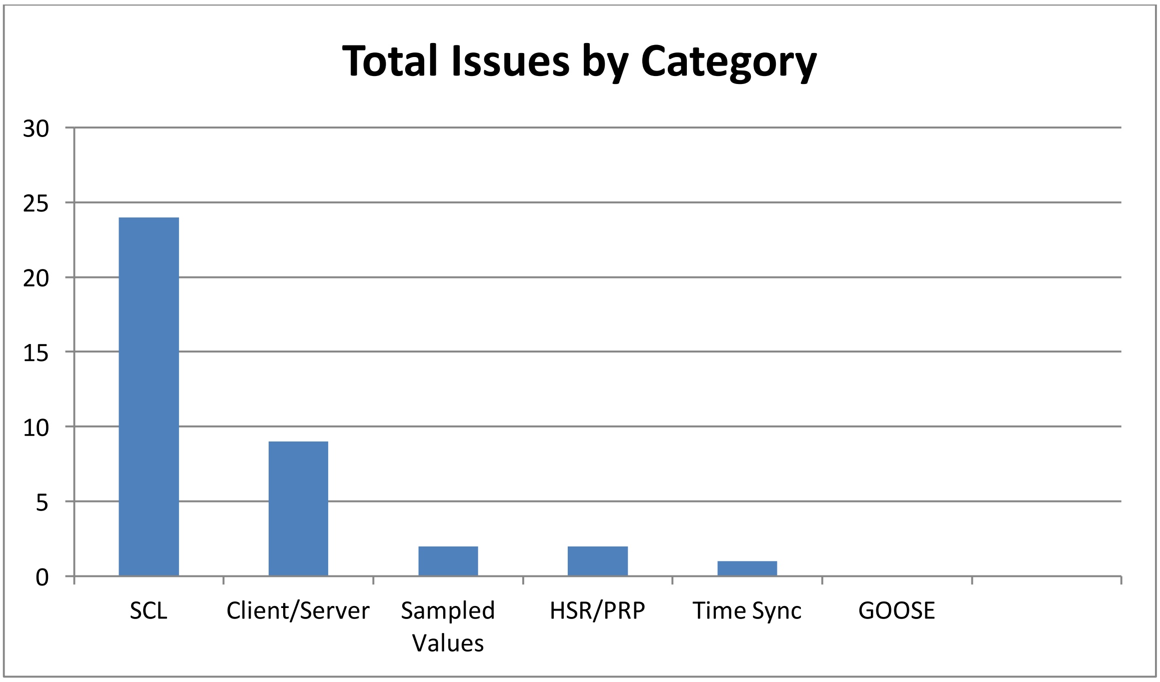


Figure 57: Distribution of 2015 IOP Reported Problems

In comparison, with the 2013 IOP, the numbers of problems encountered are much less.

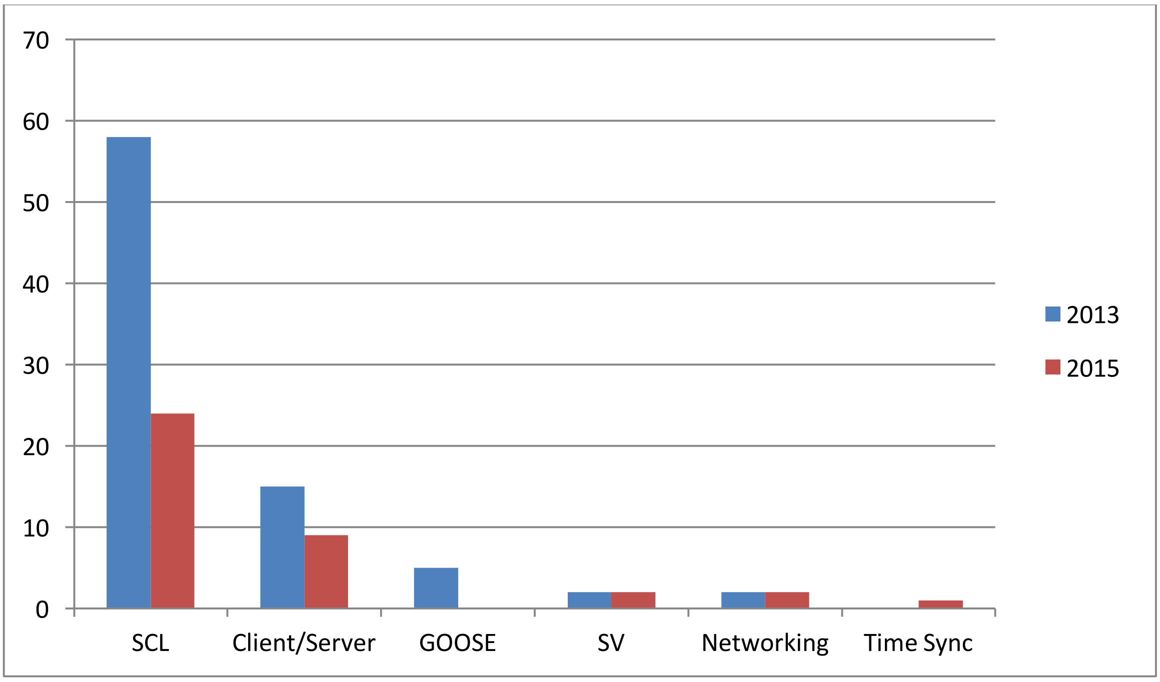


Figure 58: Comparison of 2015 and 2013 number of reported problems

Overall, the type of issues reported changed in nature. In 2013, there were many more misunderstandings and philosophical issues. In 2015, many of the SCL issues were due to agreements made prior to the IOP or were much more detailed in nature.

The following sections have tables that provide a description of the reported problem, a categorization of the resolution, and an explanation of the resolution.

The categorization legend is:

M – misunderstanding

C - Clarification

T – Technical Issue needed (TISSUE)

O – still open/un-resolved

In the case where there have been technical issues documented on http://tissue.iec61850.com/, the tissue number is also documented.

8.1 SCL

This section documents the issues reported regarding SCL.

SCL IOP Issues Reported						
Issue Number	**Description**	**Resolution**				**Comment**
		M	**C**	**T**	**O**	
1	An ICT has required LGOS configuration coming from SCT to be able to subscribe GOOSE. Is it the way it should work?		x			LGOS engineering to be described in Part 7-1. Add note to 7-4 for LGOS/LSVS that 7-1 explains their engineering
2	In the service section, there is the new element “client services”. That element includes GOOSE (default FALSE). Is it required that every ICD/IID file of a server (only), that supports GOOSE subscription, requires that element to be there? If missing, can a system tool assume that it cannot configure GOOSE messages to be sent to that device? Issue centers around fix or conf referring to all CBs & datasets. Is per-CB attribute needed? If cbName = fix is CB deletable ?			x		http://tissue.iec61850.com/tissue/1451

SCL IOP Issues Reported

Issue Number	Description	Resolution				Comment
		M	C	T	O	
3	An ICD file has predefined ReportControlBlock. With the SCT we attached a dataset to one URCB. Afterwards we decide to de-configure this URCB. SCT warning us and says that is not allowed to leave URCB empty so the tool delete the entire URCB. Is it allowed to delete predefined RCB (blank or not RCB in an ICD file) ? There is a way to define a RCB services in the ICD file to clarify this issue? Question: is it allowed to delete predefined RCB (blank or not RCB in an ICD file) ? There is a way to define a RCB services in the ICD file to clarify this issue?	x		x		WG10 Action: No such thing as predefined. It is either all fixed or not depends on service. See Tissue 1298. Will create a tissue that clarifies the interaction service entries allowing delete of Control blocks vs fixed control block name. Tissue regarding report control blocks entered. http://tissue.iec61850.com/tissue/1446

SCL IOP Issues Reported						
Issue Number	**Description**	**Resolution**				**Comment**
		M	**C**	**T**	**O**	
4	Declaration of Clients in an SCL file: The ICD/IID file of a client only device can have a LN at the level of the access point. The LN requires a data type template entry; even that the data model is not used – is there a good reason for that? A client LN reference may include a LD reference – why, if the LN is at the access point? If a client device declares in the ICD/IID file a server with a LD and a LN e.g. IHMI, does this mean that this device has a well a server role? If we have a device that has both a client as well as a server role, is the LN at the access point required, or is it then sufficient to have the LN in the server? Can a clientLN reference point to that LN in the server, even if there is as well a LN at the access point directly? How to model an IED that supports two HMIs but has no server? Do we need to model two LN IHMI at the access point and we then configure to each of them a clientLN, differentiate the client LNs only by the Instance ID? What if the same device has as well a server and implements two logical device – one each per HMI. Can I then configure the clientLN to the LD and LN of the server? How should a client, and client/server SCL be defined and what should subscriptions look like	x				WG10 believes the standard is clear.

SCL IOP Issues Reported

Issue Number	Description	Resolution M	C	T	O	Comment
5	In the service section, an IED can declare “modify dataset” to be FALSE. That means, datasets in the IED cannot be changed by the system tool. Assume, an IED supports 10 datasets (declared in the service section), has preconfigured three datasets and declares modify dataset to be FALSE. Does the modify dataset only apply to the three preconfigured ones, and the SCT can add (and configure) 7 new datasets? Or does this mean, that the SCT cannot add any dataset, since it is no allowed to modify datasets. If the second would be true, how can an IED declare that datasets can be added, but the existing ones cannot be changed?			x		http://tissue.iec61850.com/tissue/1444
6	Declaration of CtlModel for controllable CDCs (a) If a device does not support configuration of the ctlModel for a specific DO – what is the correct way to declare this? • Declare the DA as RO in SCL and configure a value (e.g. direct operate) • Provide in the data model for that DO only the attributes required for the supported model (e.g. oper) • Both of the above? And what if they disagree?	x				If not writable outside of ICT/IED (i.e., valkind= RO and valImport = false), then it is optional. If restricted can deal as documentation only. If writable, then only the supported control models shall be included (i.e., it must be restricted).

SCL IOP Issues Reported

Issue Number	Description	Resolution M	Resolution C	Resolution T	Resolution O	Comment
7	(a) If a device does not support configuration of the ctlModel for a specific DO – what is the correct way to declare this? • Declare the DA as RO in SCL and configure a value (e.g. direct operate) • Provide in the data model for that DO only the attributes required for the supported model (e.g. oper) • Both of the above? And what if they disagree? (b) If a device supports configuration of ctlModel, but does not support all variants • Define the restrictions in a enum type, that is only applicable for all DOs that have the same constraint • Provide in the data model for that DO only the DAs that are required for the supported model. Note that with that, you could not really define that a variant that is a subset (e.g. direct operate if SBO is supported as well), is not supported. • Do a combination of above; e.g. define an enum type status only, sbo. Define the data model for some of the DOs that has oper and sbo DAs (this DO allows status only and sbo); and for some others, a data model that has none of the control attributes (this DO will be status only). Note: again, with that approach it may not be possible to support all variants. • If restrictions are defined through a enum type, does the data model need to match the restriction (e.g., if a DO is defined with a specific enum type to support status only, is it forbidden to have oper in the data model?) ENUMTYPE: Declaration of enum types: If a device does not support all possible values of an enum type (e.g. LN Mode ON-BLOCKED not supported), but it has no private additional values (extensions), it is allowed to define an enum type in the SCL file (data type template section) that is a subset of the standardized type. - is it allowed or is it required to define an enum type that only includes the subset?			x		If not writable outside of ICT/IED, then it is optional to restrict the set of values. If restricted can deal as documentation only. A DA is writable if - it is a control service parameter, OR - configuration DA (FC={SP,SE,CF}), and (valKind!="RO" OR valImport=true) If writable, then only the supported enum values shall be included (i.e., EnumType MUST be restricted). Applies to DA level (of course restricted EnumType can be reused). Are there exceptions, special cases? (Concern: SCL file size may increase.) - Identified exceptions: SIUnitKind, MultiplierKind. Tissue entered: http://tissue.iec61850.com/tissue/1447

SCL IOP Issues Reported

Issue Number	Description	Resolution				Comment
		M	C	T	O	
8	An ICD/IID file is not required to include the “original SCL” element. Is it required to be added to the IED instance in the SCD file by the SCT in any case or is it sufficient to be added only if different from version referred to in namespace of the SCD?			x		TISSUE to be posted by xxx, referring to 1398; make it clear that: - ICD (Ed. 2 or later) shall set originalSclXxx attributes - SCT shall set originalSclXxx attributes on importing an IxD file without originalSclXxx attributes according to the version of the SCL file Add rule that for an IxD file, the originalSclXxx values shall match the SCL version/revision/release. Tissue entered: http://tissue.iec61850.com/tissue/1450
9	X/Y Coordinates Upon exchanging the SCD file between SCT tools, the drawing/visualization of the single line diagram is incorrectly depicted. In general, there is a lack of X, Y coordinates supported to visualize the single line diagram between SCT tools. This is similar to SSD Problem Report (Vladen). Require coordinates for: - Connectivity nodes - Size & Location of All Objects Some users/utilities have already created a standard/schema to model their single line diagram. Suggest using these as a starting point.			x	x	Need to harmonize with CIM. Target solution is Edition 3. Tissue entered for tracking. http://tissue.iec61850.com/tissue/1407
10	During import of SSD file SST/SCT is not able to recognize Busbar connection node. It is connectivity node and there is no rule to recognize it during import.			x	x	Need to harmonize with CIM. Target solution is Edition 3. Tissue entered for tracking. http://tissue.iec61850.com/tissue/1407

SCL IOP Issues Reported

Issue Number	Description	Resolution M	C	T	O	Comment
11	SCT Behavior When Revising/Replacing IED Configuration Between SCT Tools In terms of the data model structure and communication services, the SCT required a one-to-one relationship to be maintained between old IED and new IED, including: - Physical Device Name - Logical Device - Logical Node - Data Object - Data Attribute - Data Sets - RCB’s - Access points - Communication Services		x		x	Seems to be an implementation issue. Tool shall not crash. • Is there a need to clarify Part 6 on what it means for an SCT to import an SCD? (It is a new project, not a merge.) • Clarification of type of file to be used when another person is working on SCD, SED or SCD? For the first person, he may not have any rights on the IEDs anymore until the second person has done its work. Needs a picture in Part 6 to clarify. Complete Figure 1 for SCD import from • Note: SICS S7? have SCD import defined, but for the use case where one SCT is replaced by another (but no round-trip). • Action item: Have a proposal for February WG10 meeting.
12	Issue 3: Symmetrical Bindings of DA In case of late Binding at DO/DA Level. IED expects DO at later binding, but source IED dataset has two DA of that specific DO. In this case the SCT uses later binding to map first DA and also inserts a new ExtRef for 2nd DA. Since SCT is not allowed to insert intAddress. See slide 7 of WG10 ExtRef slides. Situations may occur when late binding is achieved using a combination of DO’s and DA’s.			x		Need to take IOP presentation and convert into the standard. Tissues entered: http://tissue.iec61850.com/tissue/1458 http://tissue.iec61850.com/tissue/1257 http://tissue.iec61850.com/tissue/1402
13	IED support 50% URCB and 50% BRCB Service section only provides a total RCB number			x		Tissue entered: http://tissue.iec61850.com/tissue/1448
14	ICT vendor have a single Ctlmodel for the full IED. This limitation is not specified as allowed in the standard.	x				This is not allowed by the standard.

SCL IOP Issues Reported

Issue Number	Description	Resolution				Comment
		M	C	T	O	
15	GoCB confRev - behavior if ConfRev="0" IED rejected that value. 7-2: If there are inconsistent attribute values in the GoCB (for example the value of DatSet is Null) or if the value of ConfRev equals 0, a SetGoCBValues with the parameter GoEna equals TRUE Standard is clear on the behavior of the IED if RCB ConfRev ="0" 7-2:The initial value for ConfRev is outside the scope of this part of IEC 61850. The value of 0 shall be reserved. The value of ConfRev, upon a restart of the IED, is a local issue.			x		Need to address and probably make consistent with RPT. Text already aligned for GoCB for Ed. 2.1 in Part 7-2. Need to clarify what "The value of 0 shall be reserved" implies: means a tool SHALL never set a confRev to 0 (applies to RCB, GoCB, SVCB, and LCB). Editors of 7-2 to clarify the text. Text in Edition 2.1.
16	Private section – namespace moved from SCL node to Private nodes ICT added the namespace within the privates instead of keeping them within the SCL top node. It leads to issues during IID update in SCT.					Clarification added in Edition 2.1.
17	BufConf is optional for ReportControl. No default value provided by the schema. SCT is interpreting as unbuffered only.				x	

SCL IOP Issues Reported

Issue Number	Description	Resolution M	Resolution C	Resolution T	Resolution O	Comment
18	In SCL it is possible to define unbuffered report control blocks with indexed set to false but with max instances set to higher than 1. This was possible for edition 1 since IEDs where supposed to handle connection specific request, but this was modified in Edition 2. The text in part 6 edition 2 should be reviewed. <ReportControl … indexed="false"> <RptEnabled max="7" /> </ReportControl> Also, what does max=”0” mean? Issue 2: (Implementation issue) Number of RCB : <ConfReportControl max="14" bufMode="both" bufConf="true" /> But when we count all instances of RCB max = 56. Already clarified in TISSUE 1298. Issue 3: When converting SCD file from revision 2007B to 2003 should SCT maintain modification of Data model NS revision (to change everything to 2003) or ICT should bypass this issue?				x	
19	During import of SSD file SST/SCT is not able to recognize Busbar connection node. It is connectivity node and there is no rule to recognize it during import.					Need to coordinate with CIM. To be resolved in Edition 3.

SCL IOP Issues Reported

Issue Number	Description	Resolution M	C	T	O	Comment
20	History section is present in ICD but during import SCT is discarding this history section. Also, maintenance of history section revisions during import of several ICD/IID files has to be addressed.				x	When is this history needed? Not history, but version/revision information from the last IxD. Proposal: add two attributes to IED matching the SCL/Header.version (and revision) of the last imported IxD. => Optional ixdVersion and ixdRevision attributes on IED, shall be set in the SCD/SED by SCT upon import of an IxD. ICT can remove that information from IxD it exports, if present, must be the same as the IxD History.version and revision attributes. Also: in IxD file we need to “remember” the last SCD imported. (Different set of attributes) => Optional attributes scdVersion and scdRevision on IED element, shall be set in the IxD by ICT, and imported by SCT as is. SCT shall indicate in the SCD which IEDs were modified. Proposal will be prepared for February WG10 meeting.

SCL IOP Issues Reported						
Issue Number	**Description**	**Resolution**				**Comment**
		M	**C**	**T**	**O**	
21	When IID file from ICT includes “mustUnderstand” attribute in <GSEcontrol> such as <GSEControl desc="System Logical Device GOOSE Control Block 1" name="gcb01" datSet="ds_gcb1" confRev="10000" appID="AA1D1Q01KF1System/LLN0gcb01"> <Protocol mustUnderstand="true" /> </GSEControl> where is the proper order to add <IEDName> attribute? Prior to it, or the next to it? In general case, bottom or top? If tool checks the appropriate attribute order according to schema, it could be issue.	x	x			The order of elements in SCL is clearly defined in the SCL schema, so no additional clarification is needed. Nonetheless, Part 6 should include an example showing the usage of the mustUnderstand attribute (with GSEControl/Protocol) for clarification.
22	Statement: an SCT A export an SED file with engineering rights “fix” and expectation was SCT B could add Goose clients after importing SED file from SCT A. Result: SCT B IS not allowing goose client cause by the engineering rights “fix” 1- A precision is require in the standard, Is the “Fix” tag means also that is not allowed to add client to a goose from an IED already engineered by the fisrt SCT?? 2- When the engineering rights is “fix”	x				Even if engRight=fix you are allowed to add subscriber/client information.

SCL IOP Issues Reported

Issue Number	Description	Resolution M	C	T	O	Comment
23	Content of CID with GOOSE Subscriptions During testing we noticed some CID files contained a single IED, whereas others contained multiple IEDs. Many are under the perception that CID files are to only contain a single IED, however a CID file is also to contain the required information (e.g. MAC Address from other publishers) to bind the GOOSE publishers/subscribers, which may require multiple IEDs to be declared in a CID file. Some ICT tools are declaring the subscription information in private namespace instead of explicitly declaring it within the IED section using the SCL namespace. It should be clear that all information required for GOOSE binding is to be declared in the SCL namespace. Is it acceptable to have multiple IEDs in the CID file	x				In a CID, it is acceptable to have multiple IEDs. In an IID, it is not acceptable. (2015-10-15): yes, already written in the standard. - Ed. 1: “It is an SCD file, possibly stripped down to what the concerned IED shall know” - Ed. 2: “It is an SCD file, possibly stripped down to what the concerned IED shall know (restricted view of source IEDs).” However CID is used for exchange between ICT and IED and therefore out of scope of any interoperability test.
24	Information required for GOOSE binding should be declared using the SCL namespace This may also apply to Sample Values.	x		x		The agreement on subscriptions has been made (e.g. not in private) but needs to be converted into the standard. CID file is an SCL file and thus shall follow SCL rules => subscription must be in standard SCL at least (additional information may be required by the IED and is thus out of scope of the standard). Tissue entered: http://tissue.iec61850.com/tissue/1400

8.2 GOOSE

There were no issues reported regarding GOOSE testing.

GOOSE IOP Issues Reported

Issue Number	Description	Resolution				Comment
		M	C	T	O	

8.3 Client/Server

This section documents the issues reported regarding Client/Server testing.

Client/Server IOP Issues Reported

Issue Number	Description	Resolution				Comment
		M	C	T	O	
1	If the client reads a SCD file and loads then the data model (or vice versa ???) what data shall a client compare? confRef's, datSet in Control Blocks, ctlModels, everything. There is nothing defined in the standard … or I missed it … but it makes sense that a client displays configuration mismatches, isn't it?		x		x	Assigned to IEEE PSRC H30 working group.

Client/Server IOP Issues Reported						
Issue Number	**Description**	**Resolution**				**Comment**
		M	**C**	**T**	**O**	
2	RptID attribute of a ReportControl section in SCL is optional, as stated in IEC 61850-6. IEC 61850-8-1 states to send RCB object reference as RptID when RptID is set to NULL in the Report service (17.1.2). But IEC 61850-8-1 does not state how to send RptID field when is set to NULL for GetBRCBValues/GetURCBValues (17.2.2 and 17.2.4).*				x	
3	Sequence that generates the question: 1. Report Control Block is disabled and four events (four reports) are generated 2. Client sends MMS Write RptEna=true to the BRCB 3. Server sends the four InformationReport 4. Server sends the MMS Write success to the MMS Write RptEna=true request 5. Client ignores the four InformationReport because they were received before receiving the confirmation of the MMS Write RptEna=true operation Should the standard clarify that this is a valid situation so the client should accept the InformationReport received before the confirmation to the Write operation?				x	

Client/Server IOP Issues Reported

Issue Number	Description	Resolution M	C	T	O	Comment
4	For the latest TISSUE 1361 for Ed2.0 (statement in the attachment), there are two things to be clarified: 1. The statement: Switching between the modes (Mod.stVal) should only happen as a result of an operator command to the data object Mod. Mod and Beh are always accessible by the services. Question: What does the operator command mean? Only communication service or a local switch is also allowed? The statement may influence the implementation.	x		x		Was previously resolved by Tissue 1273. http://tissue.iec61850.com/tissue/1273
5	" Mod will always accept commands with Test=false", what if the client send a command with test=true when the server is in test Mode?			x		Tissue needs to be opened that supersedes Tissue 1331. The new tissue should state that Server behavior for LN and LD Mod, Beh, and Health the test shall be false. In order to facilitate backward compatibility, Clients and Subscribers shall ignore the q.Test bit for LN and LD Mod, Beh, and Health. Should be an Interop tissue. See Tissue 1456.
6	Priority of error checking in controls – i.e. position-reached instead of Blocked-by-switching-hierarchy. The order of checks is not specified, but could lead to serious problems of interpretation.		x			

Client/Server IOP Issues Reported						
Issue Number	Description	Resolution				Comment
		M	C	T	O	
7	These test cases (see 5.9.2) assume that a server will send a negative response to an operate of the same value. Some servers will accept this behavior as described in PIXIT. The goal of the test is to get a negative response, which was possible with other scenarios.	x				
8	Buffered reporting testing – anomaly with resynch (write of entryId failed, but buffered reports still sent). Because of indexed report control block names, client selected different BRCB on second connection, but had entryId's from the first. Check reporting in 7-2 and 8-1 to make sure entryIds are associated with BRCB instance, not dataset.		x			Standard is correct and proper.

8.4 Sample Values

This section documents the issues reported regarding Sampled Value testing.

Issue Number	Description	Resolution				Comment
		M	C	T	O	
1	The Quality bits alignment in 9-2LE seems different from 8-1 quality bits with ASN.1. So it caused confusion that which bit should be sent firstly, especially for Validity. During the IOP test, people don't have the same understanding of the same value "10" of Validity, some take it as reserved, and the others take it as invalid. A clarification of Validity bit sequence is strongly recommended.		x			Standard is being updated to add the appropriate clarifications.
2	Does the SVID character have to be specifically mentioned to be within 10-34 characters? Some of the vendors have implemented the svID field in the configuration tool to have at least 10 characters.	x	x			1) Reference page 15/31 of Implementation guide of 9-2LE Rev2-1 2)Reference Page 27 of IEC 61869-9 working draft may 2015

8.5 Time Synchronization

This section documents the issues reported regarding Time Synchronization testing.

Time Synchronization IOP Issues Reported						
Issue Number	**Description**	**Resolution**				**Comment**
		M	**C**	**T**	**O**	
1	IEC 61850-9-3 slaves can by design lock themselves to IEEE C37.238 (Power Profile) masters. This is intended behavior, since IEC 61850-9-3 was defined that way. If, in a domain, there is a grandmaster with C37.238 profile and another with IEC 61850-9-3 profile, the BMCA of the masters may not work, as both may announce themselves as grandmaster. The reason for this is that according to C37.238 all clocks that do not send the C37.238 Extension TLV are to be excluded from the BMCA. So an IEC C37.238 clock will always announce itself as master regardless of the presence of better 61850-9-3 masters.		x			This is not an interoperability issue within a standard since two standards are involved. Proposal: insert a note on this issue in C37.238 revision to warn network engineers about this fact (since C37.238:2011 altered the default BMCA)

8.6 Networking - HSR/PRP

This section documents the issues reported regarding HSR/PRP testing.

HSR/PRP IOP Issues Reported

Issue Number	Description	Resolution M	C	T	O	Comment
		M	C	T	O	
1	Testing unconfigured VLAN, there is a question of how VLAN tags (e.g. 20) should be handled by the HSR ring. However, what should an application do? As an example, a dataset was GOOSE'd with VLAN 0 and received and processed by an IED. When the publisher changes and publishes on VLAN 20, should the IED still process the packet. Please note this filtering is typically handled in a switch. But with HSR, the switch is internal to the device. Should IEDs enforce VLAN filtering, or should we generate a recommendation/warning that VLAN tag enforcement is not guaranteed with HSR?		x			The general thought pattern is that the application, HSR interface should not check VLANs.
2	HSR and PRP are redundancy protocols. In order to prevent a single point of failure, many people are considering 2 red boxes to connect from HSR/PRP to RSTP. Results in RSTP and HSR/PRP network instability. In the case of HSR, network saturation occurred almost immediately. 11 MB/s = 88 Megabits/sec of a 100 Mb network.					Need to fix 61850-90-12 to enunciate the issue. Also need to enunciate in the HSR standard. Already being addressed.

	The bandwidth restriction of HSR actually saved the RSTP network.

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