2013 IEC 61850 INTEROPERABILITY TEST
Munich, Germany
October 27 – November 1, 2013

FINAL REPORT
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UCAIUG 2013 IEC61850 IOP

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1 Summary

This document provides information regarding the UCA sponsored IEC 61850 Interoperability test that occurred in Munich, Germany during the dates of October 27th - November 1st 2013.

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 19 total participating companies in the interoperability testing.

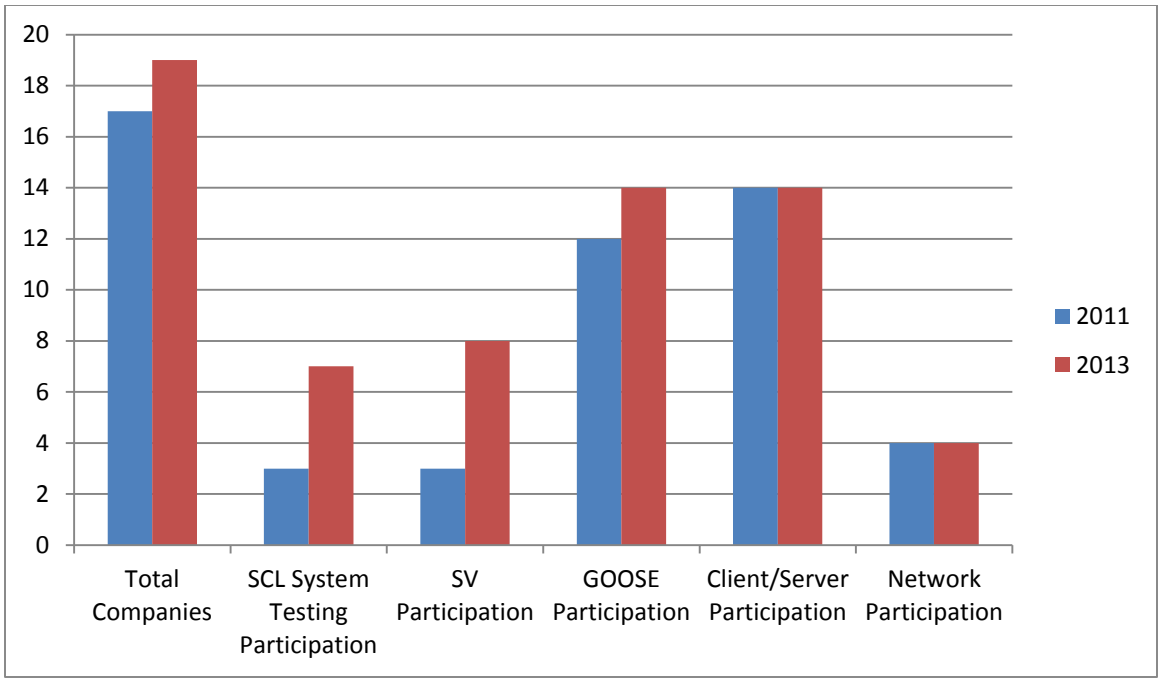


Figure 1: Comparison of Testing Participation 2013 versus 2011

Not only did participation increase, but test coverage also increased.

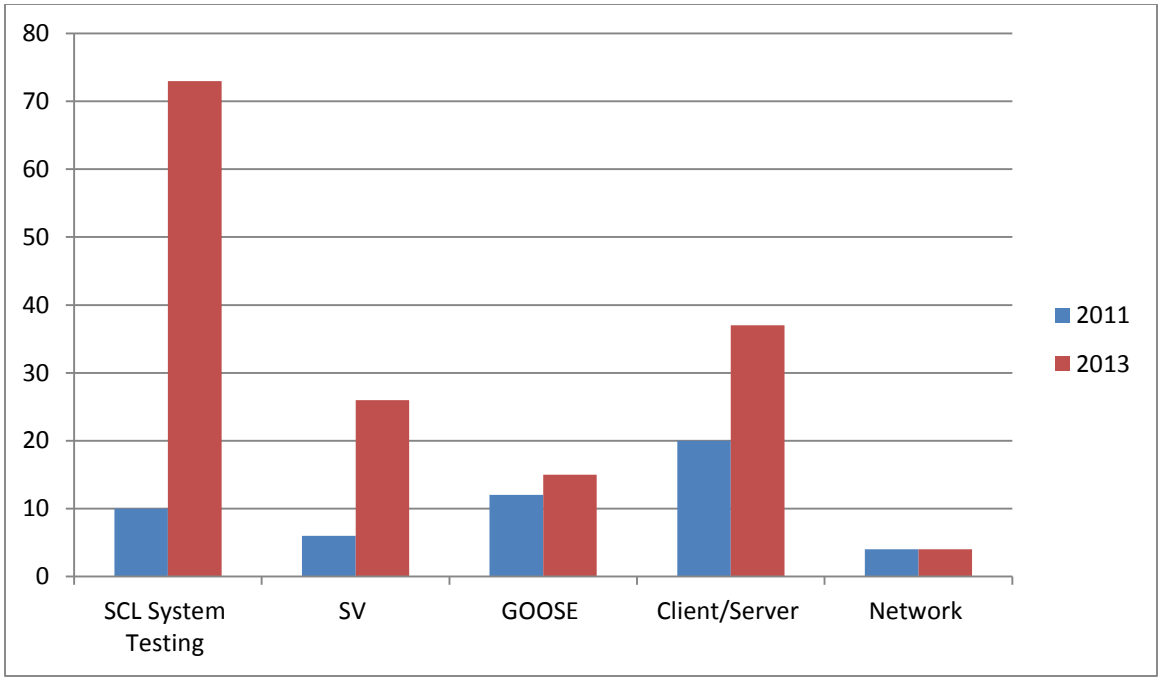


Figure 2: Number of Test Cases available for testing

Figure 2 shows that the number of test cases increased substantially in 2013. This meant that more people (e.g. participants and observers) would be necessary in order to provide adequate test capability and that more time would be required for each category of test to be completed.

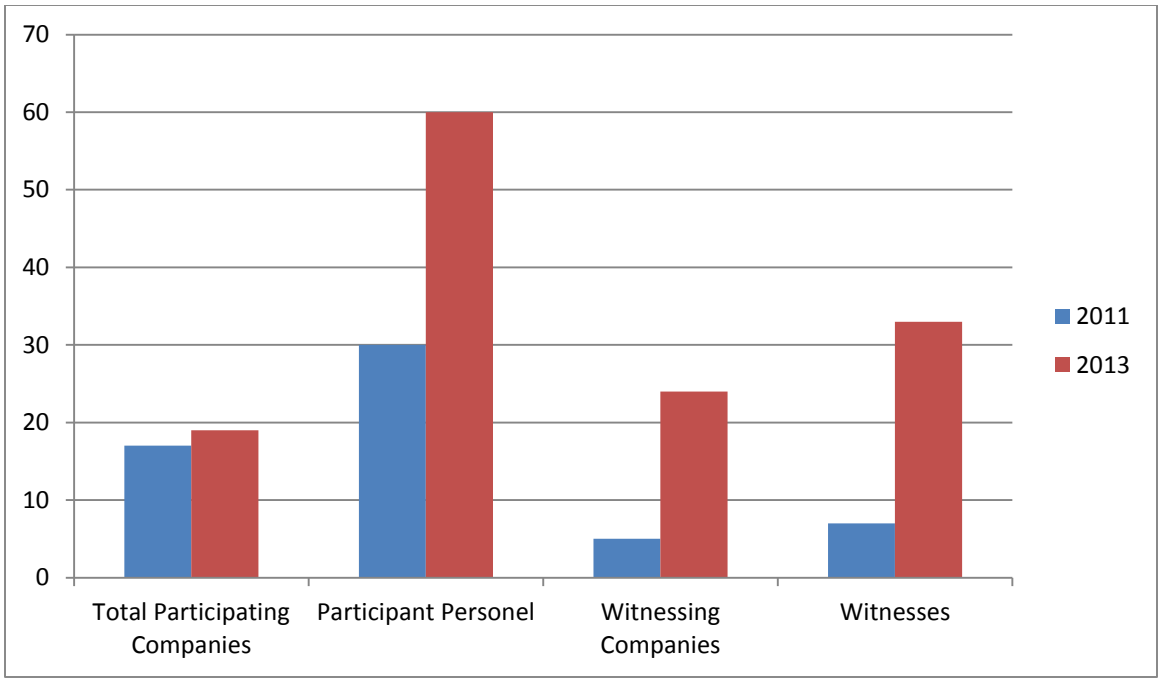


Figure 3: Participation increase 2013 versus 2011

Even though the number of people available to support and witness testing increased dramatically, this increase did not significantly offset the increase in test coverage or the increase of the number of implementations that were to be tested. Therefore, full test coverage was not achieved, nor was it expected.

There were several 2013 participants that also participated in the 2011 tests. These companies tended to be more prepared for the 2013 IOP as they had experienced the 2011 event. Repeating companies are shown in:

Participant	Witness/Observers
Alstom	EDF
ARC Informatique	Enernex
EFACEC	RED Electrica de Espana
General Electric	
RTDS	
RuggedCom (now Siemens)	
Schneider Electric	
Schweitzer Engineering Laboratories	
Siemens	
SISCO	
Toshiba	
Triangle Microworks	
ZIV	

Table 1: Repeat Participants and Witnesses from 2011

As more IOPs occur, the ability to have the same companies/personnel participate allows building the 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.

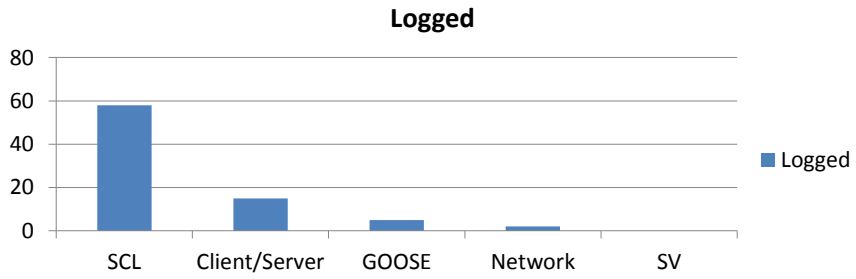


Figure 4: Categorization of Issues encountered

Figure 4 shows the number of logged issues versus testing area (e.g. SCL, Client/Server, etc.). Since 2013 represented the first time where SCL engineering process was tested structurally, and field experience, it was expected many issues would be encountered regarding SCL.

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.

  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. For future interops, the staging of the network will need to occur in advance of the IOP so that the network can be unpacked, plugged together, and be functional in a short period of time.

- Significant interoperability improvements were found since IOP 2011, not only with Ed1 tests, but also with Ed2 and SCL. However, there is an identified need for continued and improved interoperability tests in the future.

- 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

Figure 5: Picture of some of the participants and witnesses

The following tables show the participating and witnessing companies.

Table 2: List of Participating Companies

Participating Companies		
Company	Logo	Contact Information
ABB	Power and productivity for a better world™ ABB	Roman Graf roman.graf@ch.abb.com www.abb.com
Alstom-Grid	ALSTOM	Dylan Jenkins dylan.jenkins@alstom.com
AMA-Systems	AMA SYSTEMS	Irmhild Maska maschka@ama-systems.com
ARC Informatique	PcVue Solutions by ARC Informatique	Fabien RIGAUD f.rigaud@arcinfo.com www.pcvuesolutions.com
Arteche	arteche	Aritz Sanchez azs@arteche.es
CISCO	CISCO	Maik Seewald maseewal@cisco.com
EFACEC	efacec	Claudio Silva claudio.silva@efacec.com

Participating Companies		
Company	Logo	Contact Information
GE		Alberto Huidobro Alberto.Huidobro@ge.com
Infoteam		Trong Nam Hynh Denis Muller denis.muller@infoteam.ch
Ingeteam		Erik San Telmo erik.santelmo@ingeteam.com
Omicron		Fred Steinhauser fred.steinhauser@omicron.at
RTDS		Dean Quellette dean@rtds.com
Siemens-RuggedCom		Richard Harada richard.harada@siemens.com
Schneider Electric		Mario Jardim mario.jardim@schneider-electric.com
Schweitzer		Tim Tibbals tim_tibbals@selinc.com

Participating Companies		
Company	Logo	Contact Information
Siemens	SIEMENS	Cedric Harispuru cedric.harispuru@siemens.com
SISCO	SISCO SYSTEMS INTEGRATION SPECIALISTS	Ralph Mackiewicz ralph@sisconet.com
Toshiba	TOSHIBA	Koichi Hamamatsu koichi.hamamatsu@toshiba.co.jp
Triangle Microworks	TRIANGLE MICROWORKS, INC. SOLUTIONS FOR COMMUNICATION PROTOCOL DEVELOPMENT	Jim Coats jcoats@TriangleMicroWorks.com
ZIV	a Group Company	Javier López j.lopez.s@ziv.es

Witnessing Companies		
Company	Logo	Contact Information
Amprion		Berthold Wuehrmann berthold.wuehrmann@amprion.net
CPRI		Dr. Amit Jain, amitjain@cpri.in
EDF		Thierry Coste thierry.coste@edf.fr
Elia		Grégory Huon Gregory.Huon@elia-engineering.com
EMS/EMC		Vladan Cvejić vladan.cvejic@ems.rs
Enernex		Bruce Muschlitz bruce@enernex.com
Entsoe		Grégory Huon Gregory.Huon@elia-engineering.com

Witnessing Companies		
Company	Logo	Contact Information
EPRI		Paul Myrda pmyrda@epri.com
FGH		Martin Zanner Martin.Zanner@fgh-ma.de
GridClone		Edwin Melenhorst edwin.melenhorst@gridclone.com
Hydro Quebec		**Pierre L. Martin, ing.** martin.pierre.l@hydro.qc.ca
It4Power		Christoph Brunner christoph.brunner@it4power.com
Itaipu Binacional		Marcos Mendes mmendes@itaipu.gov.br
Kema		Richard Schimmel richard.schimmel@dnvkema.com
KERI		Woohyun Seo whseo@keri.re.kr

Witnessing Companies		
Company	Logo	Contact Information
KTL		JINYONG KIM jinyong4213@gmail.com
Myong Ji University		Hyuk-Soo Jang hyuks.jang@gmail.com
Red Electria		Carlos Rodrigues calrodriguez@ree.es
RTE		Patrick Hullier patrick.lhuillier@RTE-FRANCE.COM
Svenska Kräfnet		Nicholas Etherden nicholas.etherden@stri.se
Tennet		Hans-juergen Gruber hans-juergen.gruber@tennet.eu
Tuv Rheinland		Jens Hempel jens.hempel.de.tuv.com
Tuv Sud		Peter Pfisterer Peter.Pfisterer@tuev-sued.de

Witnessing Companies		
Company	Logo	Contact Information
UCAIug		Kay Clinard kay@ucaiug.org
Zamerin		Andre Maizener anjen.maizener@wanadoo.fr

Table 3: List of Witnessing Companies

1.2 SCL

The 2013 structured testing of SCL was a different strategy than the one used during the 2011 IOP. The philosophy in 2013 was to not only validate the SCL file exchanges, but to do so within the context of two (2) prevalent system engineering strategies.

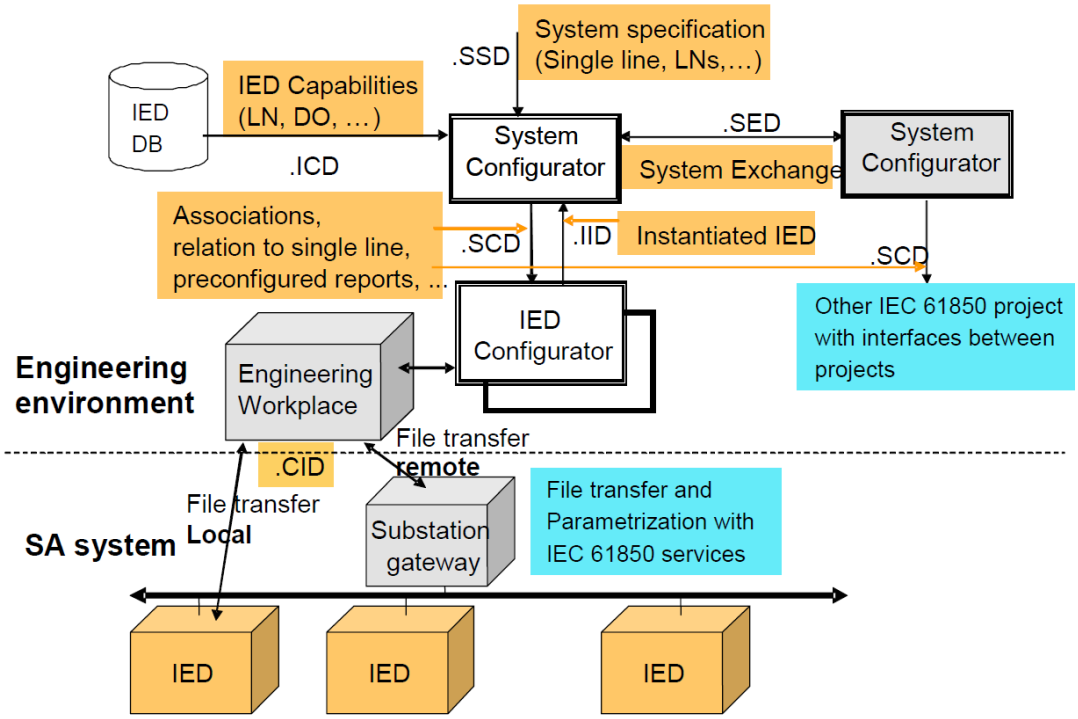


Figure 6: Reference model for information flow in the configuration process (from IEC 61850-6)

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 do not 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. The IOP group deemed the use of CIDs to configure the System Configurator as the use of Xfactor files.

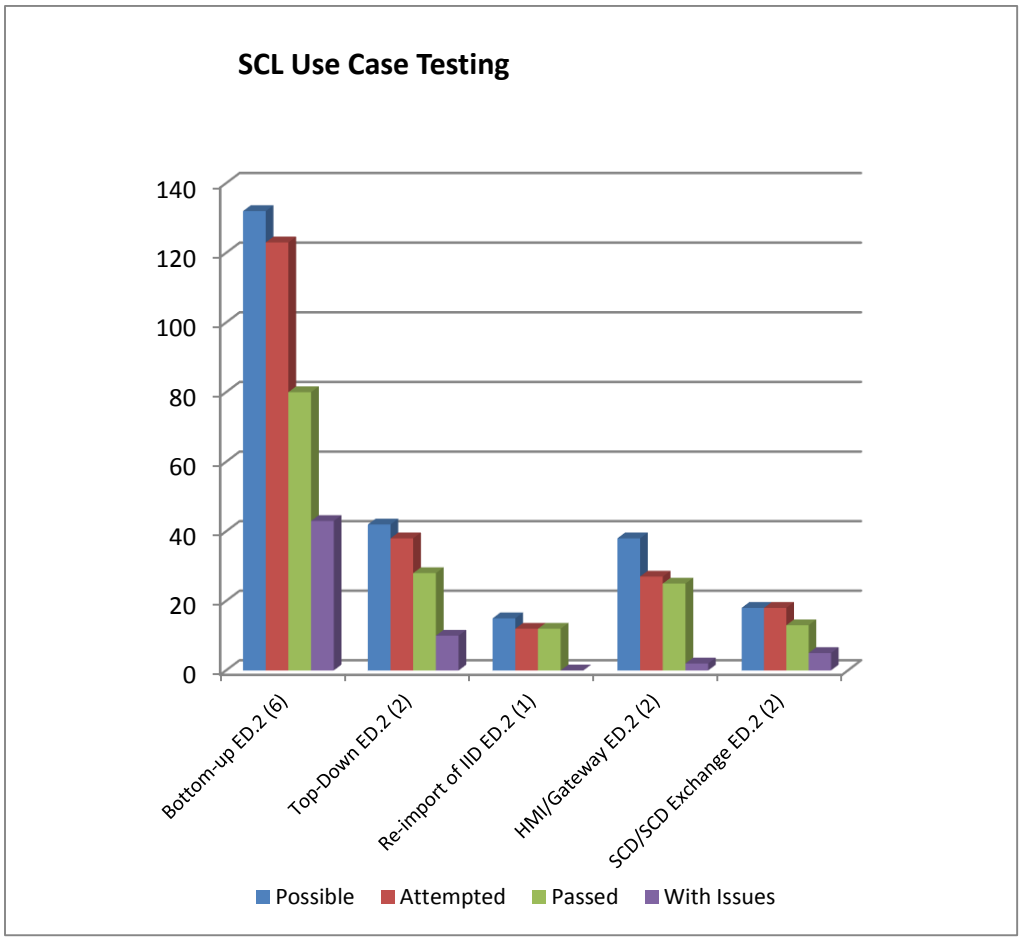


Figure 7: Summary of SCL Test Results

Figure 7 shows the summary of the major test campaigns that were executed. The numbers in parentheses indicates the number of companies/tools that participated in a particular test campaign.

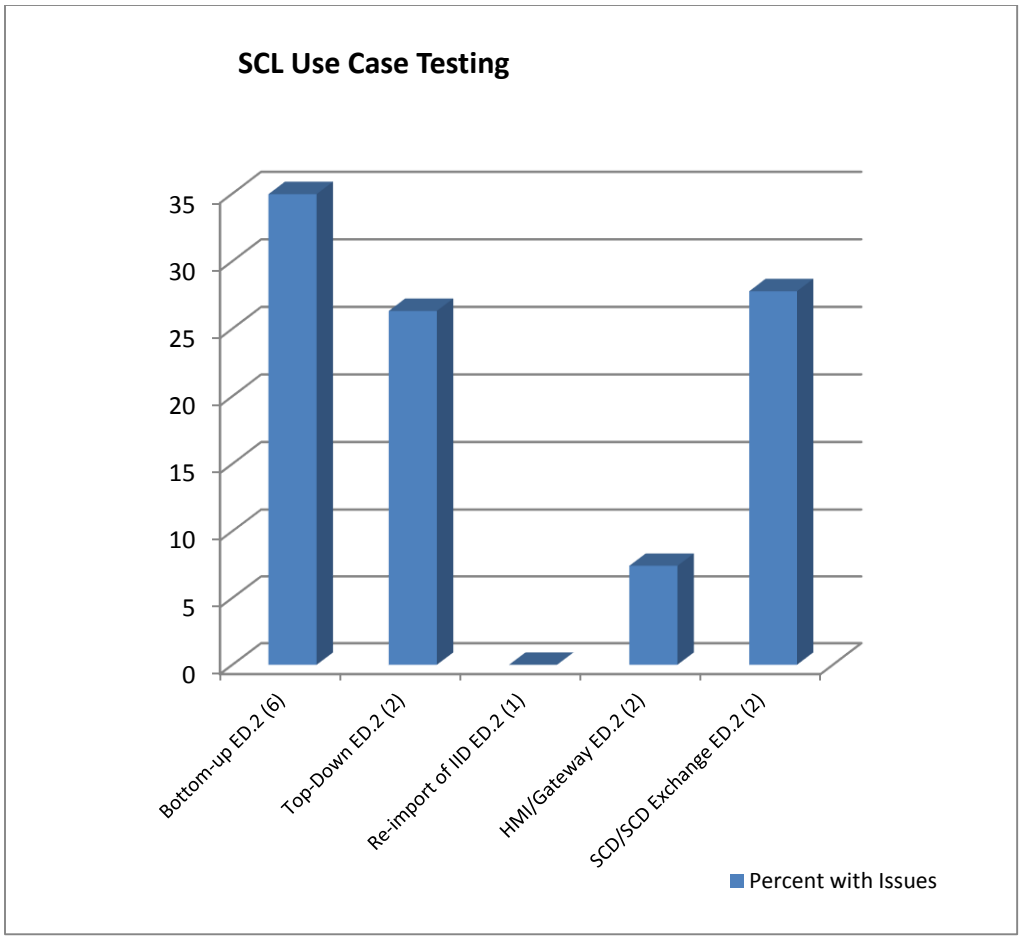


Figure 8: Analysis of SCL Summary as Percentage of Test that exhibited issues

Figure 8 shows the analysis of percentage of test executed that had issues. It shows that Bottom-up had a higher percentage of issues than Top-Down. The values for SCD/SCD and HMI campaign did not have enough participation/coverage to represent a major concern.

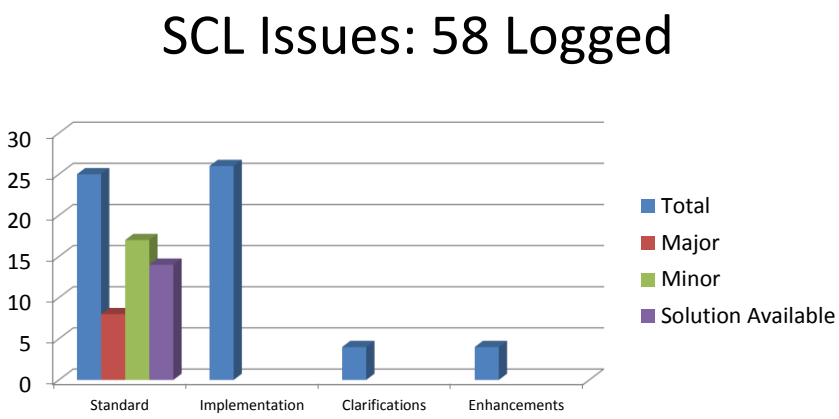


Figure 9: Summary of types of SCL issues

Figure 9 shows the breakdown of the of the identified SCL issues based upon designations of ambiguities/standard related, implementation issues, the need of clarification, or proposed enhancements. These are categorized as part of the issue log for SCL on page 7-3. Although 58 issues were logged, many of these did not come from the structured testing, but rather the unstructured use of SCL for Client/Server, GOOSE, and SV testing. Many of the captured standard issues already have technical proposals generated by the IOP group. These proposals have been provided, along with the issue, to IEC TC57 WG10 and the UCA User Feedback Taskforce.

The specific results, and tests, can be found starting on page 2-1.

1.3 Sampled Values

There were 8 of 19 participating companies that participated in the Sampled Value testing. This represents a 42% participation rate. These 8 companies provided 11 implementations to be tested. This results in a maximum of 35 SV test combinations being available per test case. In 2011, there were only four (4) potential combinations for each test SV case. 2013 represents a 775% increase in the number of test combinations when compared with 2011.

Additionally, the 2013 SV testing involved four (4) implementations that claimed both 61850 Edition 1 and Edition 2 implementations. The 2011 IOP only had Edition 1.

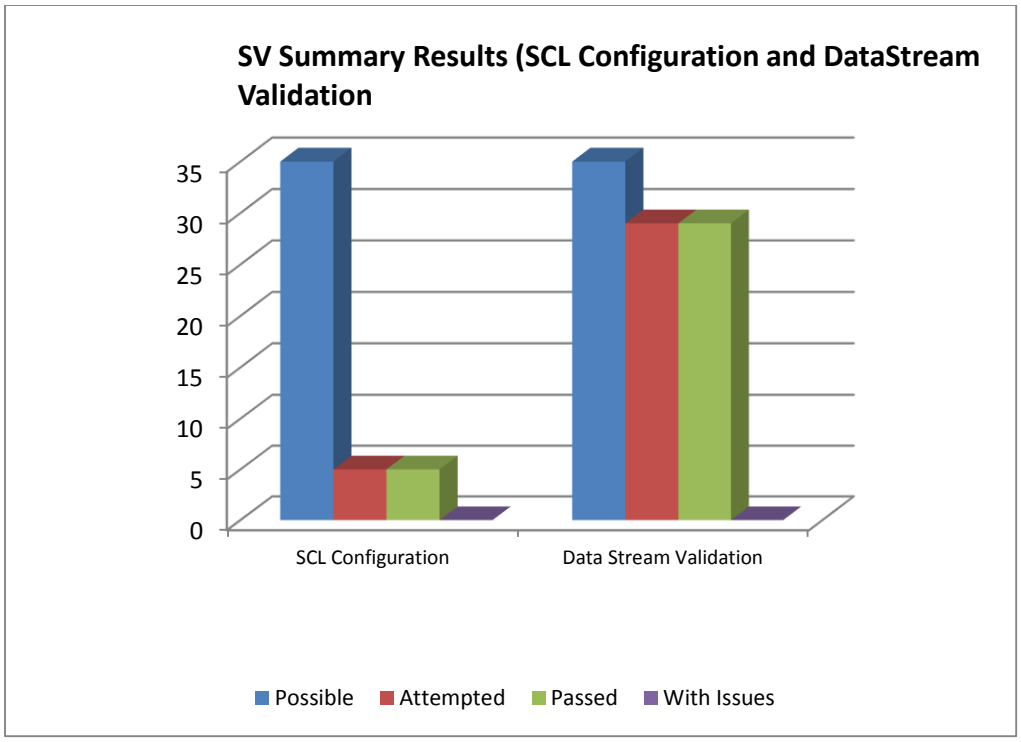


Figure 10: SV SCL and DataStream Validation Summary

Figure 10 shows that of the thirty-five (35) potential opportunities to use SCL to configure the subscribers, only five (5) of the potential tests used SCL exchanges. The SCL exchanges did not involve SCD files, rather CID or Xfactor files were utilized. One of the reasons that this was not a concern is that the major focus of SV testing was that of the UCA 9-2 LE specification. This specification constrains the dataset contents that are published and thus SCL for content definitions was not required. However, SCL's utilization would have avoided manual communication configuration.

Data validation is defined as the ability of a subscriber to receive and process a publisher's data. The figure shows that 82% of the potential test combinations, for data validation, were attempted and passed.

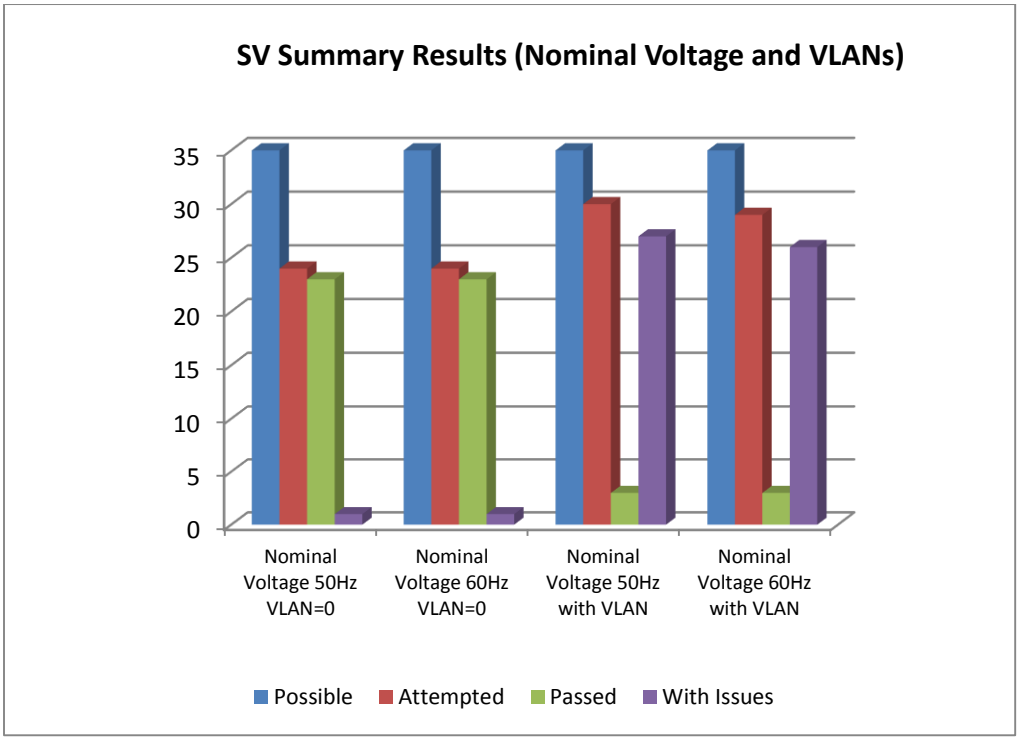


Figure 11: SV Nominal Voltage Test Result Summary

Figure 11 shows the results of nominal voltage test results. The major issues encountered was network configuration that prohibited VLANs , other than a VLAN ID of 0, being able to be utilized. Only in a very small amount of test combinations were the Ethernet switch ports configured in a manner to allow the non-zero VID to be tested. Due to the network configuration issue, only VLAN 0 was utilized for the other tests. Additionally, in order to segment SV traffic, typically provided by VLANs, a separate physical SV Ethernet network was needed.

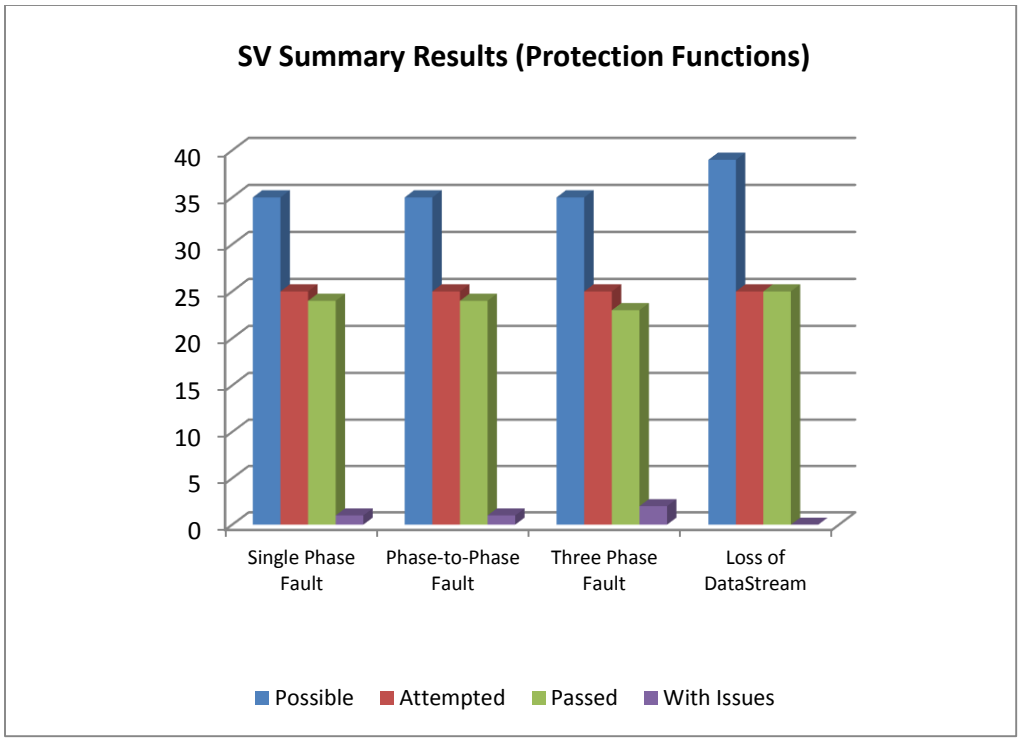


Figure 12: SV Fault testing result summary

Figure 12 shows that there were only minor issues encountered during the testing of the exchange of fault information via SV. It also shows that there were no problems encountered in the detection of a disconnected/offline publisher (e.g. Loss of DataStream).

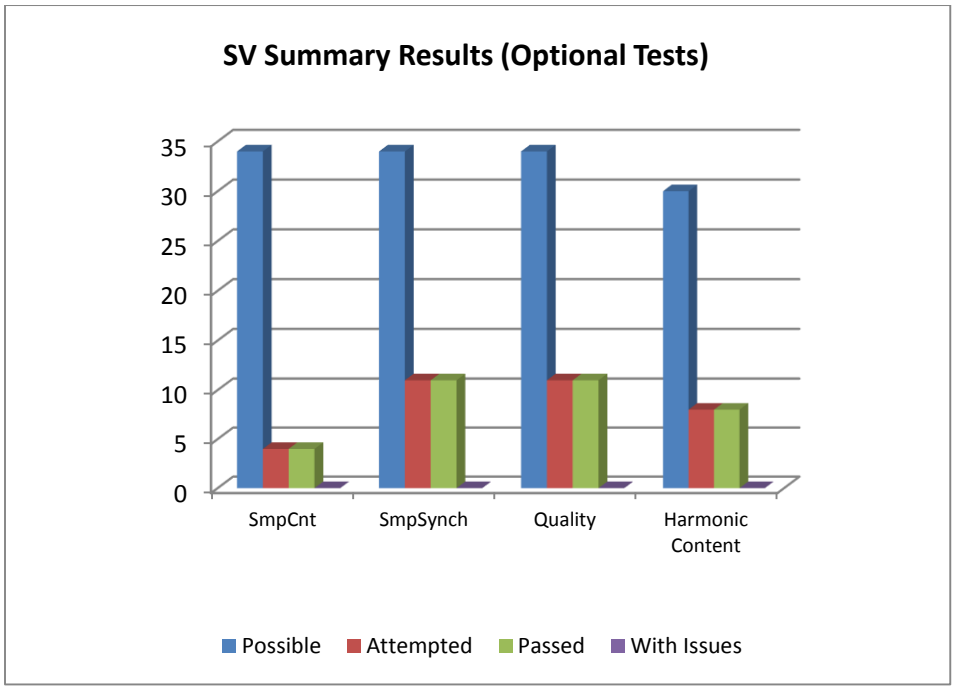


Figure 13: SV Optional test result summary

Figure 13 shows the results for the optional test cases. Many of the possible test cases were not executed due to time constraints but no errors or issues were encountered.

The specific results, and tests, can be found starting on page 3-1.

1.4 GOOSE

There were 14 of 19 participating companies that participated in the GOOSE testing. This represents a 74% participation rate. These 14 companies provided 15 implementations to be tested. This results in a maximum of 236 GOOSE test combinations being available per test case. This represents a 30% increase in the number of test combinations when compared with 2011.

Additionally, the 2013 GOOSE testing involved 61850 Edition 1 and Edition 2 implementations. The 2011 IOP only had Edition 1. Figure 14 shows the distribution of the implementations with their declared edition support.

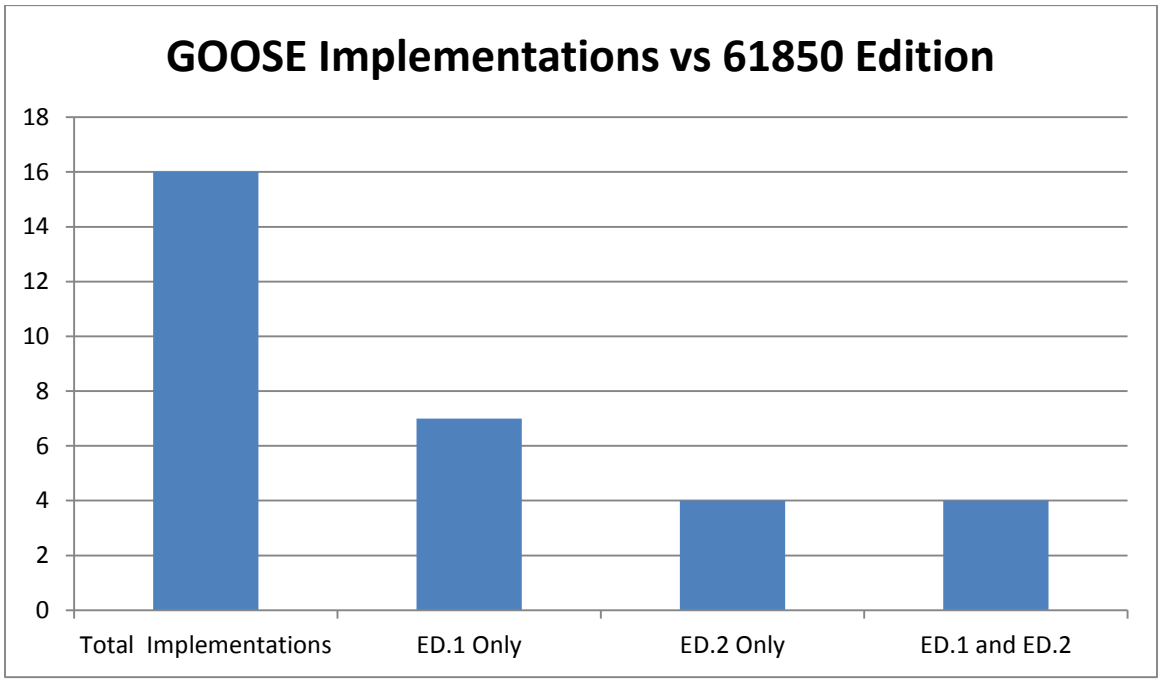


Figure 14: GOOSE participation by 61850 edition support

A primary focus of the 2013 IOP was to test for potential interoperability between Edition 1 and Edition 2 implementations. From a protocol perspective, interoperability should be possible between the editions with the exception of SCL and the testing of the simulation bit. There are known issues captured with the interoperability of Edition 1 and Edition 2 SCL. These have been captured as part of the issues list to be addressed by the UCA User Feedback Task Force and IEC.

In regards to SCL utilization, SCL was utilized for subscription configuration. However, an SCD was not created. Therefore, CIDs and Xfactor files were utilized. During these exchanges, several other SCL issues were discovered. These have also been captured as part of the issue list on page 7-3.

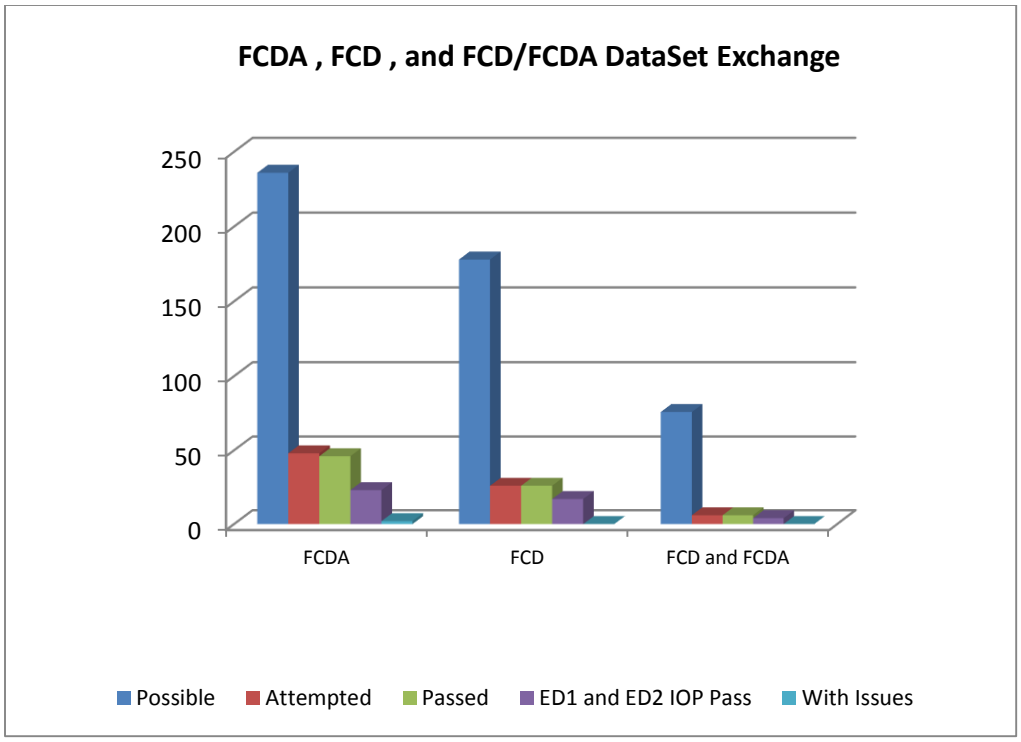


Figure 15: GOOSE Test Result Summary for DataSet Exchanges

Figure 15 shows the summary results for publish and subscription to various types of DataSets. There were three (3) different DataSet types that were to be tested. The difference between the DataSets was the types of the DataSet members. The three types were: members being all FCDAs, an FCD, and members that were FCD and FCDA.

The figure shows that the number of possible test combinations varies drastically. These differences can be accounted for by the fact that original 61850 Edition 1 conformant implementations were not required to be able to subscribe to DataSets with FCDs. This has since been clarified that they must be able to subscribe to DataSets that contain FCDs. However, there is still no requirement that publishers must be able to publish FCDs. Many of the configured systems were not configured with a DataSet that combined members that were FCDs and FCDAs.

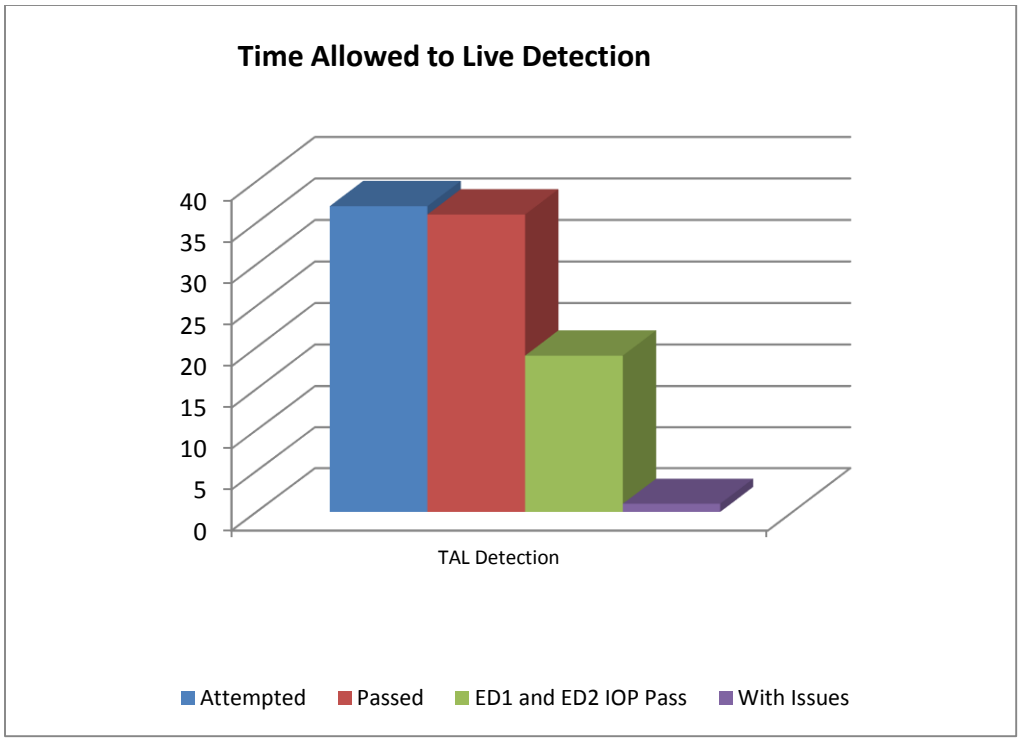


Figure 16: GOOSE Time Allowed to Live Summary Results

Figure 16 shows that there were no significant interoperability issues with time allowed to live detection.

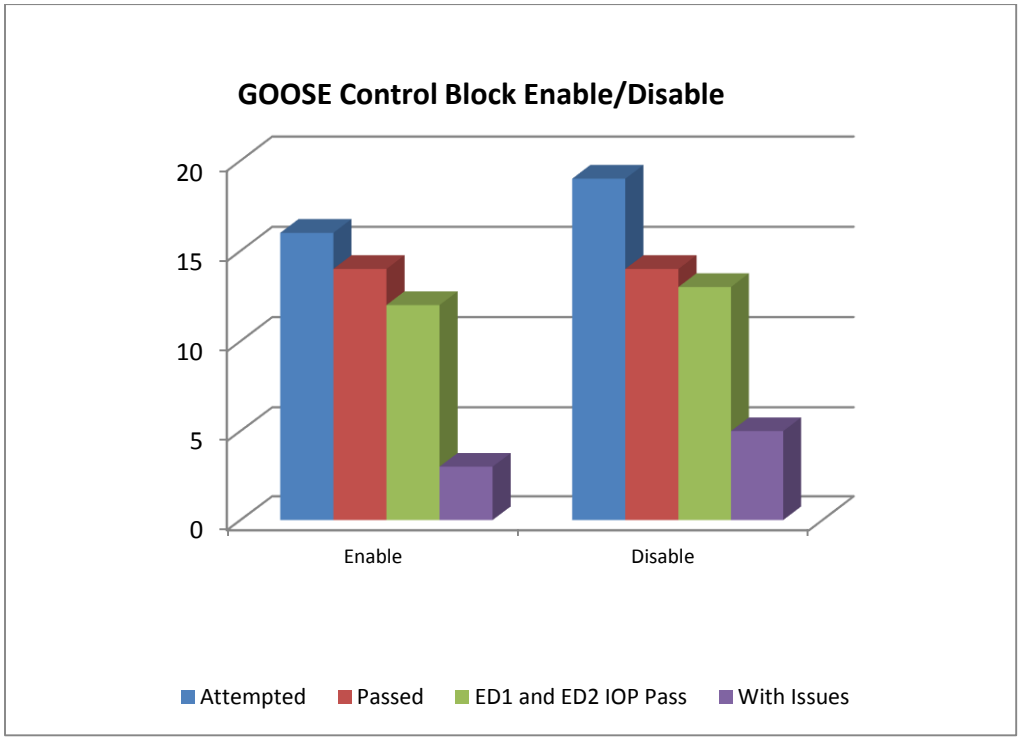


Figure 17: Summary Results for GOOSE Control Block Enable/Disable

Due to the test report forms, the maximum number of possible test combinations for GOOSE Control Block Enable/Disable was not possible. Originally, this testing was supposed to be part of the Client/Server testing, but it was moved to the GOOSE testing campaign. This was probably a mistake and the control block testing should all be done as part of Client/Server testing for future interops.

The figures also show that significant percentages of the passed tests were between implementations that supported different editions of 61850 (e.g. ED.1 and ED.2). In some cases the tests passed using implementations that claimed support for both editions. This is possible since the protocol for data exchange with GOOSE did not change except for the simulation bit.

The simulation bit is a re-definition of the Edition 1 Test bit. The specific behavior is prescribed in Edition clarifies the ambiguities of Test Bit in Edition 1. Since there are behavioral aspects specified in Edition 2, Edition 1 devices are not necessarily capable of behaving per Edition 2. As the test matrixes show, none of the Edition 1 only implementations attempted to participate in the simulation bit testing.

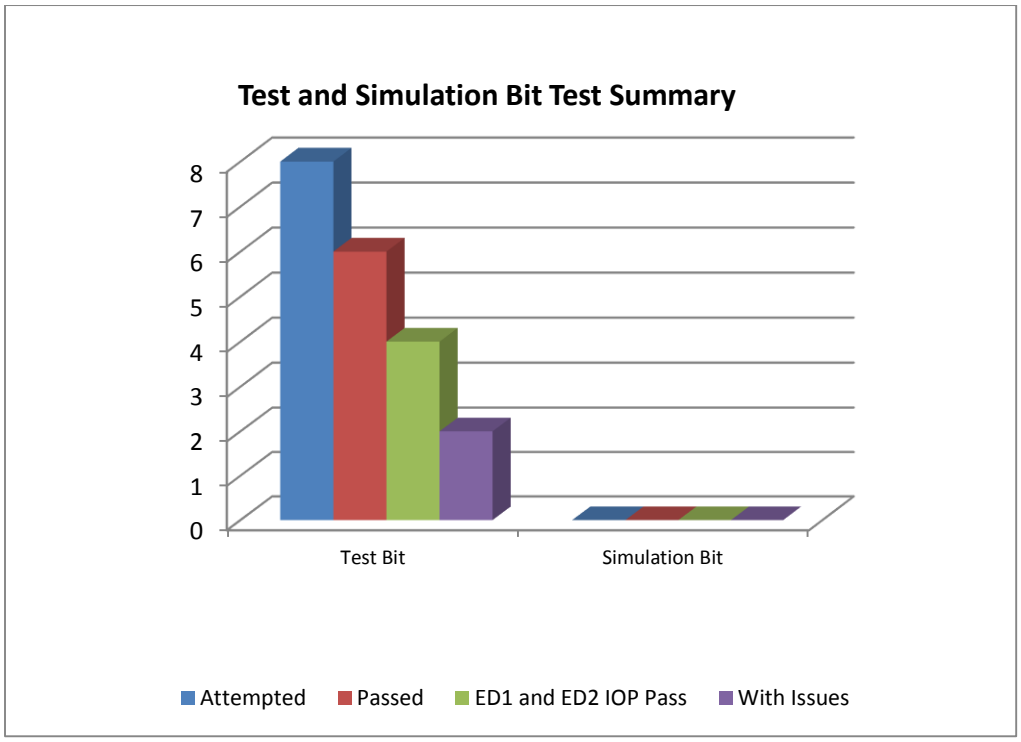


Figure 18: GOOSE Test Summary for Test and Simulation Bit Testing

Figure 18 shows that no Simulation Bit testing was attempted. This is due in large part to the test case being written incorrectly. A different test case needs to be written for future interops that utilize a test set, as opposed to IED peers, to test the simulation bit.

The specific results, and tests, can be found starting on page 2-1.

1.5 Client/Server

There were 15 of 19 participating companies that participated in the Client/Server testing. This represents a 78% participation rate. 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.

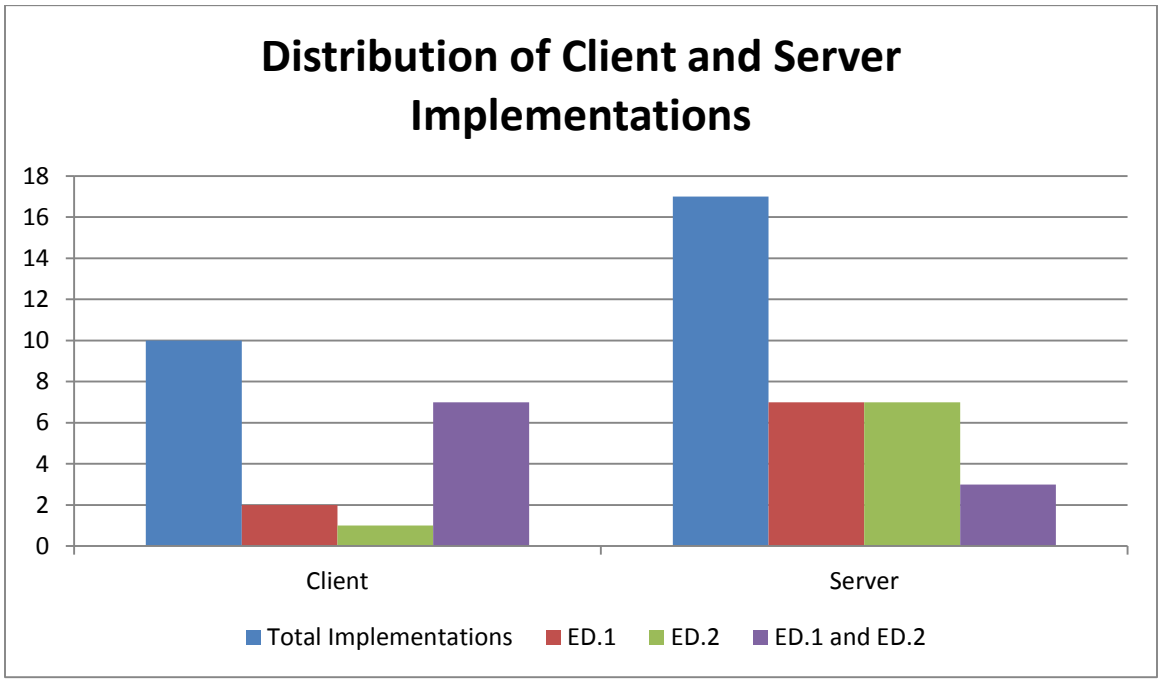


Figure 19: Distribution of Client/Server implementation versus Edition

Figure 19 shows that 70% (e.g. 7 of the 10 implementations tested) claim support for communication to 61850 Edition 1 and Edition 2 servers. The ability to support both editions will prove critical to migration of existing 61850 substations and allowing integration of Edition 2 devices within previously installed Edition 1 substations and the test results give strong indications that such migrations should be possible with the user selection of the appropriate clients.

Another key component to migration is the engineering process and the use of the substation configuration language. The engineering tools are lagging the protocol implementations in their ability to support Edition 1 and Edition 2 simultaneously and there have been issues identified that need resolution by IEC prior to being able to fully support a substation that is both Edition 1 and Edition 2. These issues have been captured as SCL issues.

There was a maximum of 155 Client/Server test combinations possible based upon the number of participating clients and servers. However, only in a couple of instances was the maximum actually

possible for testing due to differing capabilities of the clients and servers. As an example there was a theoretical 155 combinations of client/servers, but only 24 were actually possible due to logging support declarations.

1.5.1 SCL

Additional SCL testing was done as part of the Client/Server testing. This testing was in addition to the structured testing of SCL discussed on page 1-13.

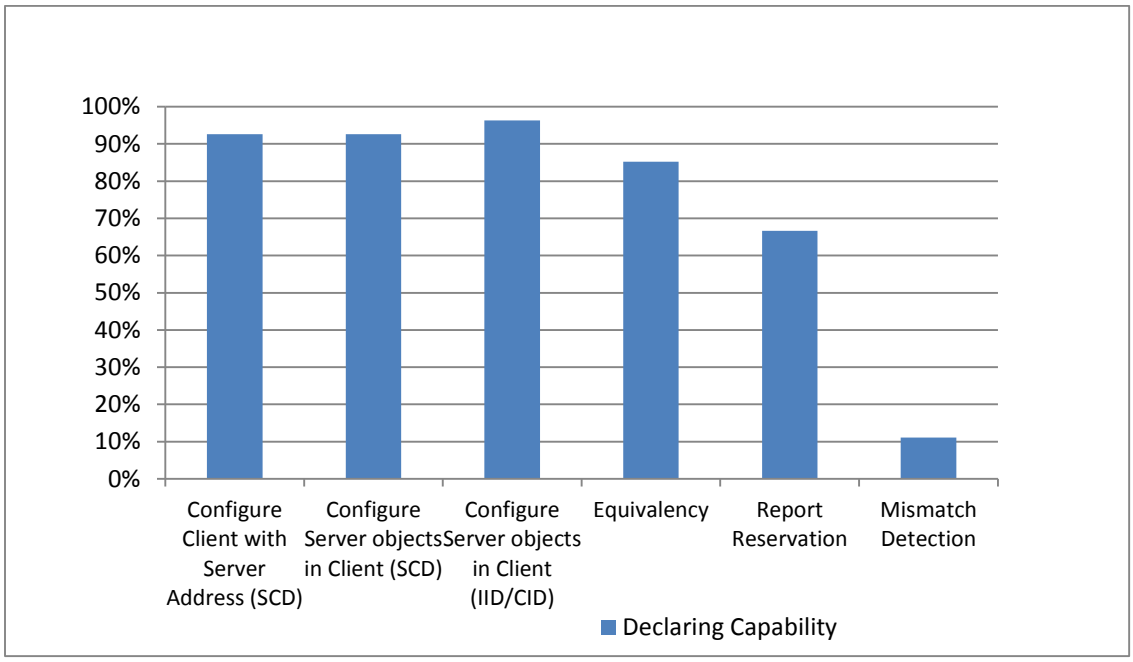


Figure 20: Possible Client/Server SCL testing percentages

Figure 20 shows the percentage of possible tests that occurred for certain tests. This reflects the fact that certain implementations could not support features that were being tested.

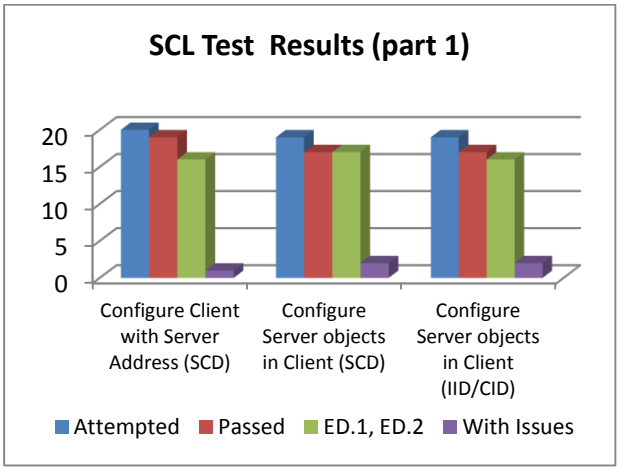


Figure 21: Summary of Client/Server configuration results using SCL

Figure 21 shows the number of actual tests attempted, the number that passed, and the number attempted that were combined testing of Edition 1 and Edition 2 implementations, and the number of attempted tests that had issues. There were few issues encountered during the use of SCL for configuration of Client/Server testing. Those issues, that were encountered, were mainly implementation issues.

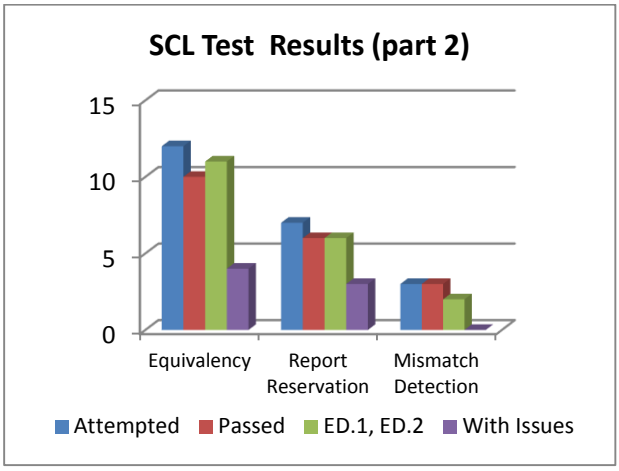


Figure 22: Summary of Client/Server extended SCL results

The results of the extended testing are shown in Figure 22. None of the issues found were major issues, and all were implementation issues.

1.5.2 Reads and DataSets

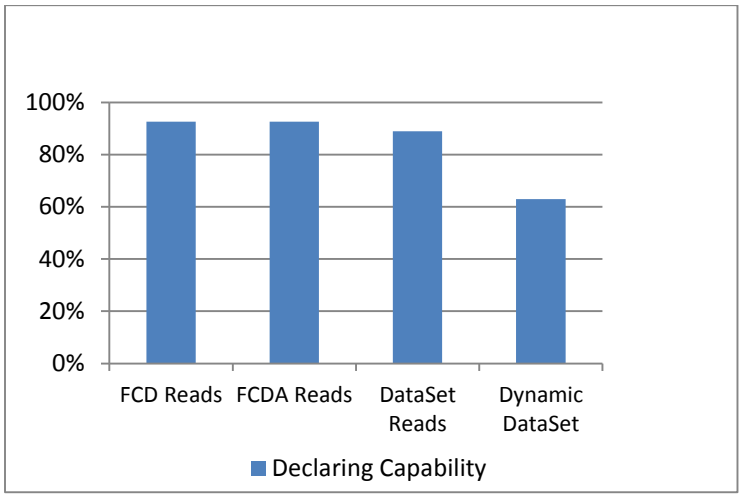


Figure 23: Possible Client/Server Read and DataSet testing percentages

Figure 23 shows the percentage of participating implementations that declared the capability to participate for certain Read and DataSet tests. There was wide support for Reads of FCDs, FCDAs, and DataSets. Client implementations were more limited in their support of the ability to create Dynamic DataSets.

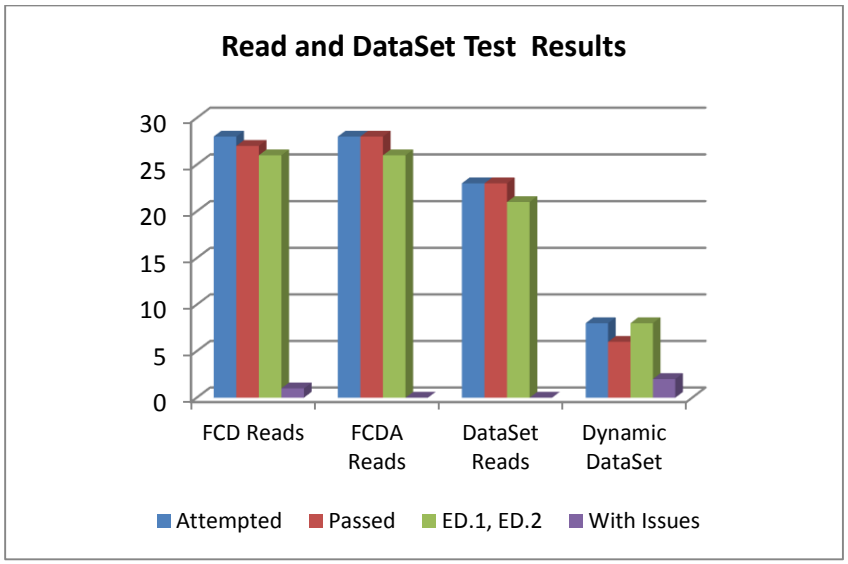


Figure 24: Summary of Client/Server test results for Reads and DataSet tests

Figure 21 shows that there were few issues encountered during the use of Reads and DataSets. There were implementation issues detected for FCD reads and dynamic DataSets. Specific issues and the categorizations can be found on page 7-21.

1.5.3 Reporting

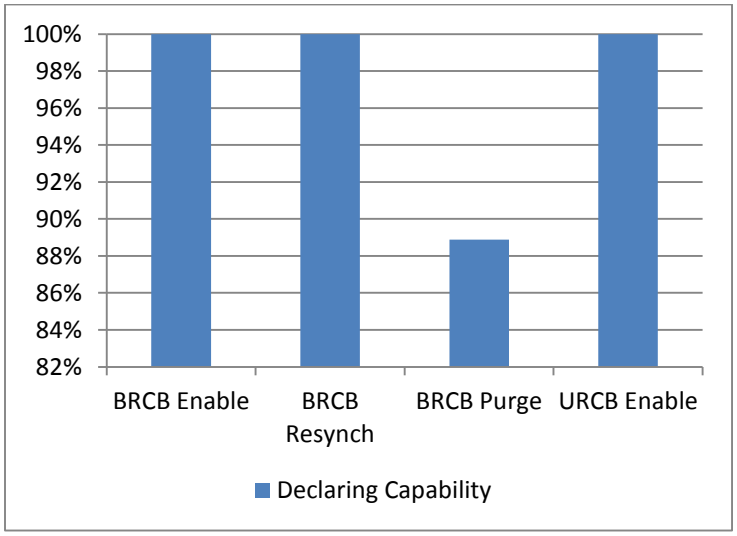


Figure 25: Possible Client/Server Report testing percentages

Figure 25 shows 100% testability for all Report Control block tests except for the ability to command a purge of a buffer. The lower percentage of testability is accounted for by the fact that not all clients have an application need to purge a buffer. All of the servers tested supported the purge capability.

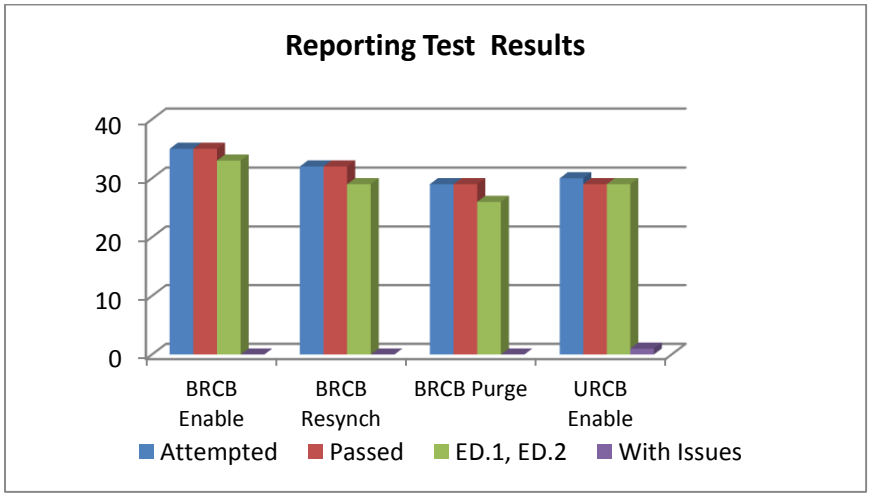


Figure 26: Summary of Client/Server test results for Reporting tests

There were no major issues detected during the execution of the Reporting tests.

1.5.4 Control

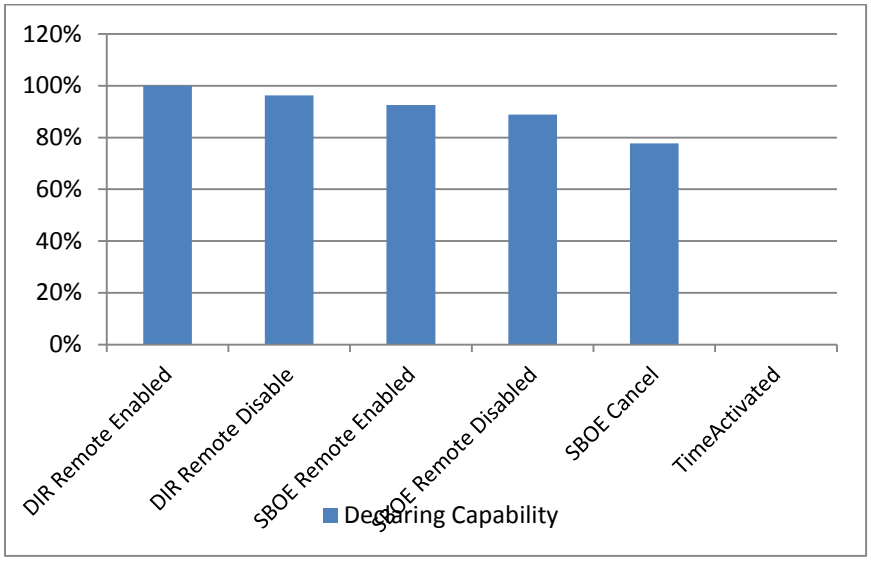


Figure 27: Possible Client/Server Control testing percentages

The most significant conclusion that can be drawn from Figure 27 is that the support for Time Activated Control was not declared by any Clients or Server at the interop. This means users who need this feature should carefully review the capabilities of the Clients and Servers that are selected for a system.

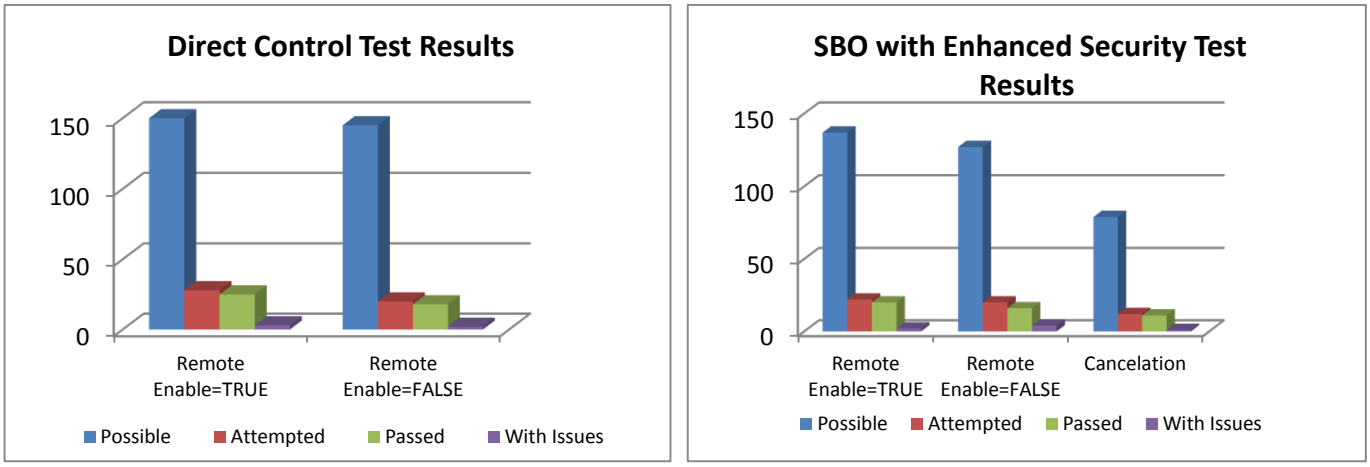


Figure 28: Summary of Client/Server test results for Control tests

Of all of the attempted Control tests, no significant issues were found.

1.5.5 Files

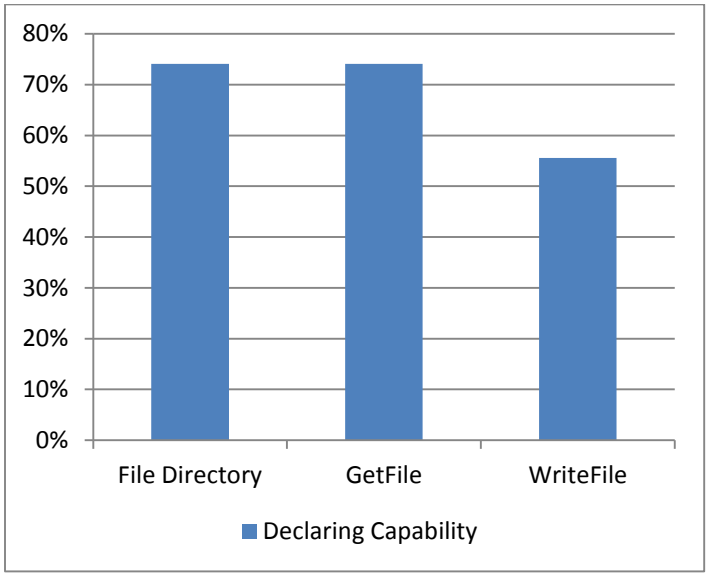


Figure 29: Possible Client/Server File testing percentages

Figure 29 shows that not all clients/servers supported IEC 61850-8-1 file services. The figure does not reflect file transfer ability provided through other means besides IEC 61850 (e.g. FTP, SFTP, or other mechanisms).

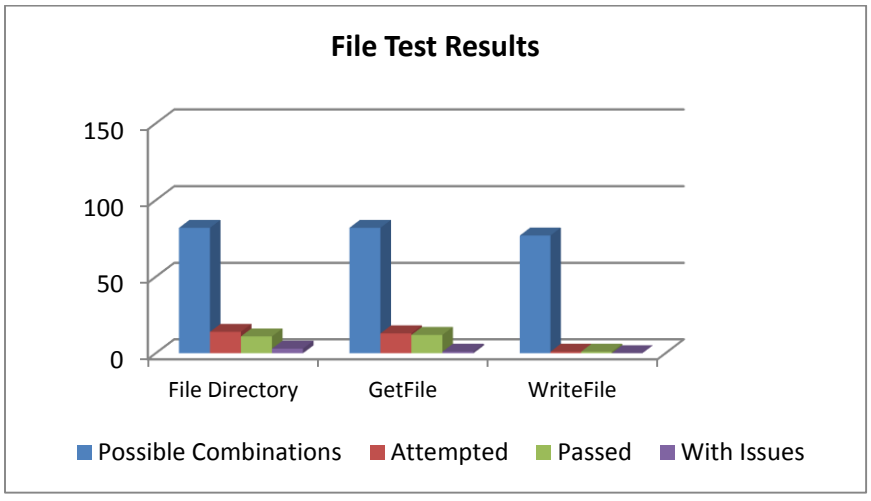


Figure 30: Summary of Client/Server test results for File service tests

Of all of the attempted File tests, no significant issues were found.

1.5.6 Authentication

There were no combinations of client/server implementations that allowed the testing of either weak (e.g. username/password) or strong (e.g. certificate based) authentication.

1.5.7 Miscellaneous

This report section documents the summary results for other suites of test results. These include the use of GOOSE, SV, and Log control blocks. Additionally, it shows the summary results for Settings Group, Substitution, and Tracking.

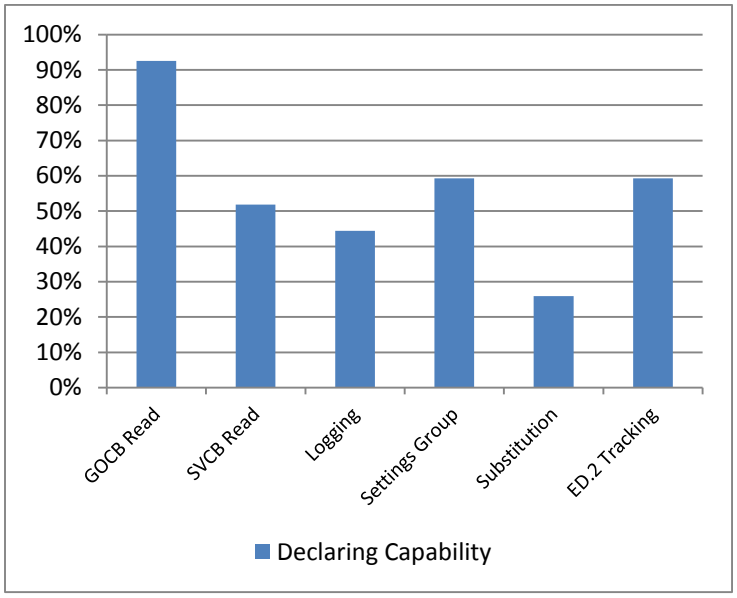
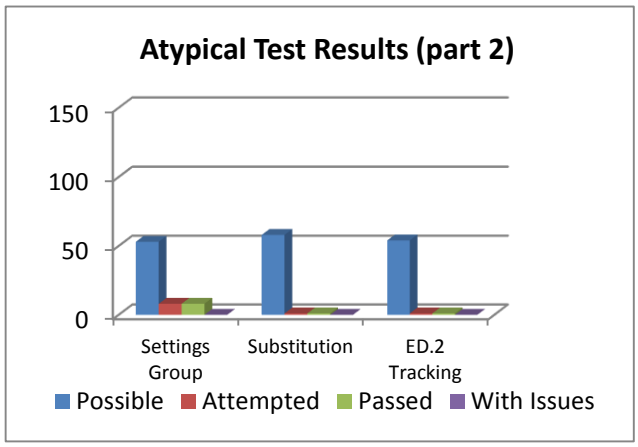


Figure 31: Summary of declared capabilities for various Client/Server test (Logging, Settings Groups, Substitution, etc.)

Figure 31 may be a little misleading in that the amount of capability to test SV control blocks is dis-proportionately supported. This lack of support can be explained by the fact that many of the servers, for client/server testing, were not SV publishers. The figure shows that the support for substitution and logging capabilities is not as wide-spread as other IEC 61850 capabilities. Therefore, users needing these features need to choose the components of their system carefully.



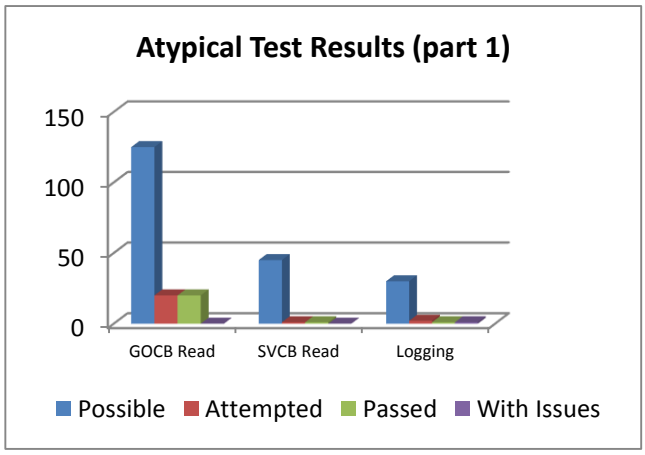


Figure 32: Results of miscellaneous IEC 61850 services

The results show that there were no issues encountered for the tests that were executed.

The specific results, and tests, can be found starting on page 5-1.

1.6 Network

There were 5 of 19 companies that participated in the official network testing. The participating companies were:

- ABB
- Cisco
- Schweitzer
- Siemens
- Siemens RuggedCom

In 2011 there was a concentration on only Rapid Spanning Tree Protocol (RSTP) testing. In 2013, RSTP testing continued as well as Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR). Several different topologies and combinations were scheduled to be tested:

- RSTP with a single Ethernet Ring (see page 6-3)
- RSTP with two (2) Ethernet Sub-Rings (see page 6-7). Due to time constraints test plans/topologies were developed, but no test results were generated.
- RSTP with an Ethernet mesh (see page 6-11). Due to time constraints test plans/topologies were developed, but no test results were generated.
- HSR (see page 6-13).
- PRP (see page 6-15).

- Combined PRP and HSR testing. Due to time constraints test topologies were developed, but no test results or test plans were generated.

During the RSTP testing, additional time was taken to investigate some unexpected results (e.g. recovery and failover times were large). The results of these tests start on page 6-1.

During the staging of the IOP, there were questions raised in regards to how to know/document an Ethernet switches capabilities in a standard and comparable format. To address this issue, a proposed Protocol Implementation Conformance Statement (PICS) has been created (see page 6-19**Error! Bookmark not defined.**). This proposal is intended to be submitted to IEC TC57 WG10 and the UCA Testing subcommittee for standardization.

2 SCL Specific Results

The test results, found in this section, are primarily based upon either a top-down or bottom-up engineering process:

- 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 do not 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.

Unlike, the 2011 IOP, a Single Line Diagram (SLD) was prepared to be used in all of the SCL formal tests. The SLD was used to generate an SSD which SCDs could then use to populate the required Logical Nodes.

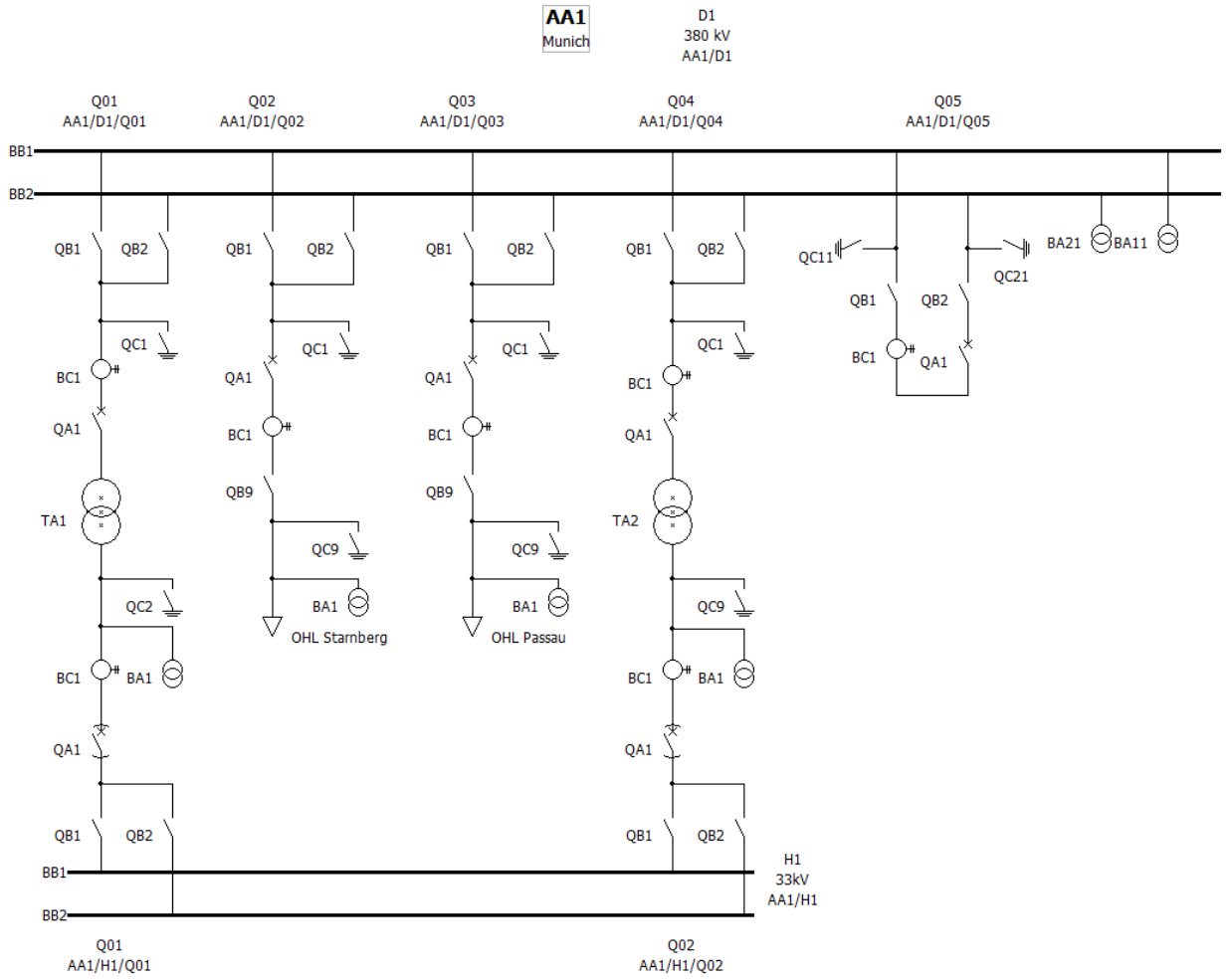


Figure 33: SCL Single Line Diagram used for formal SCL testing

The SLD, and test procedures, allowed for the following types of IEDs to be supported:

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

Additionally, IP addresses were assigned to the IEDs.

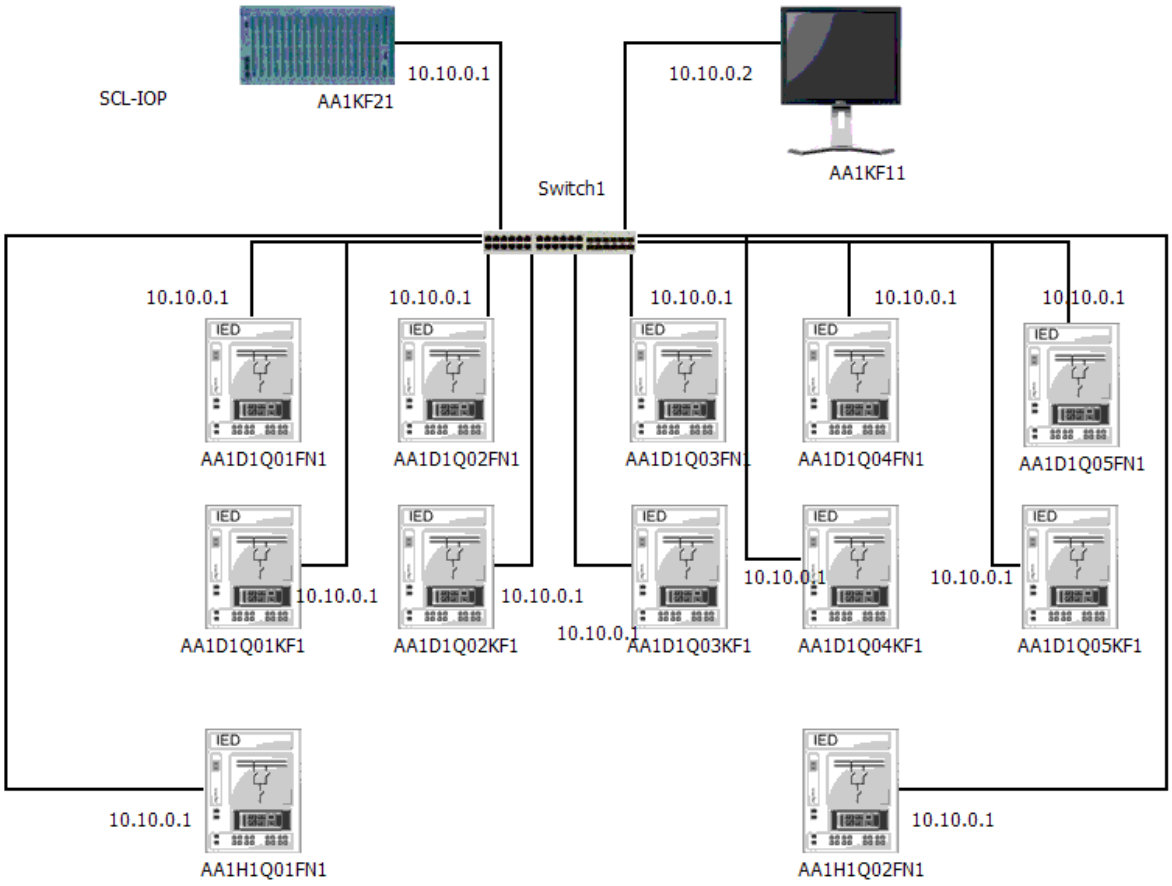


Figure 34: IP Address assignments for formal SCL testing

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)

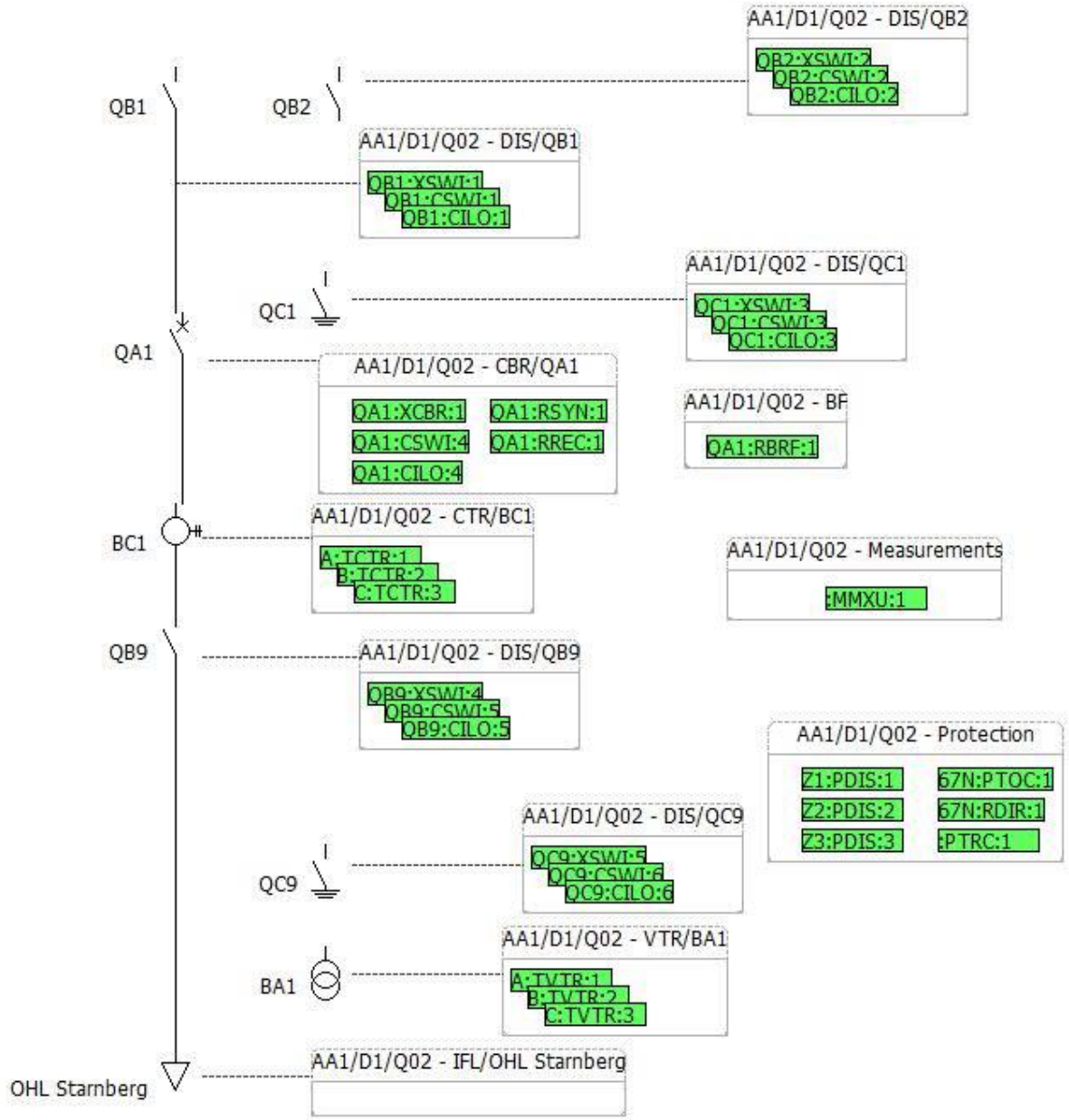


Figure 35 – OHL Bay

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 (including reclosing and synchrocheck) and the breaker failure function will be allocated to the bay controller (AA1D1QnnKF1)

For the transformer HV bays

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

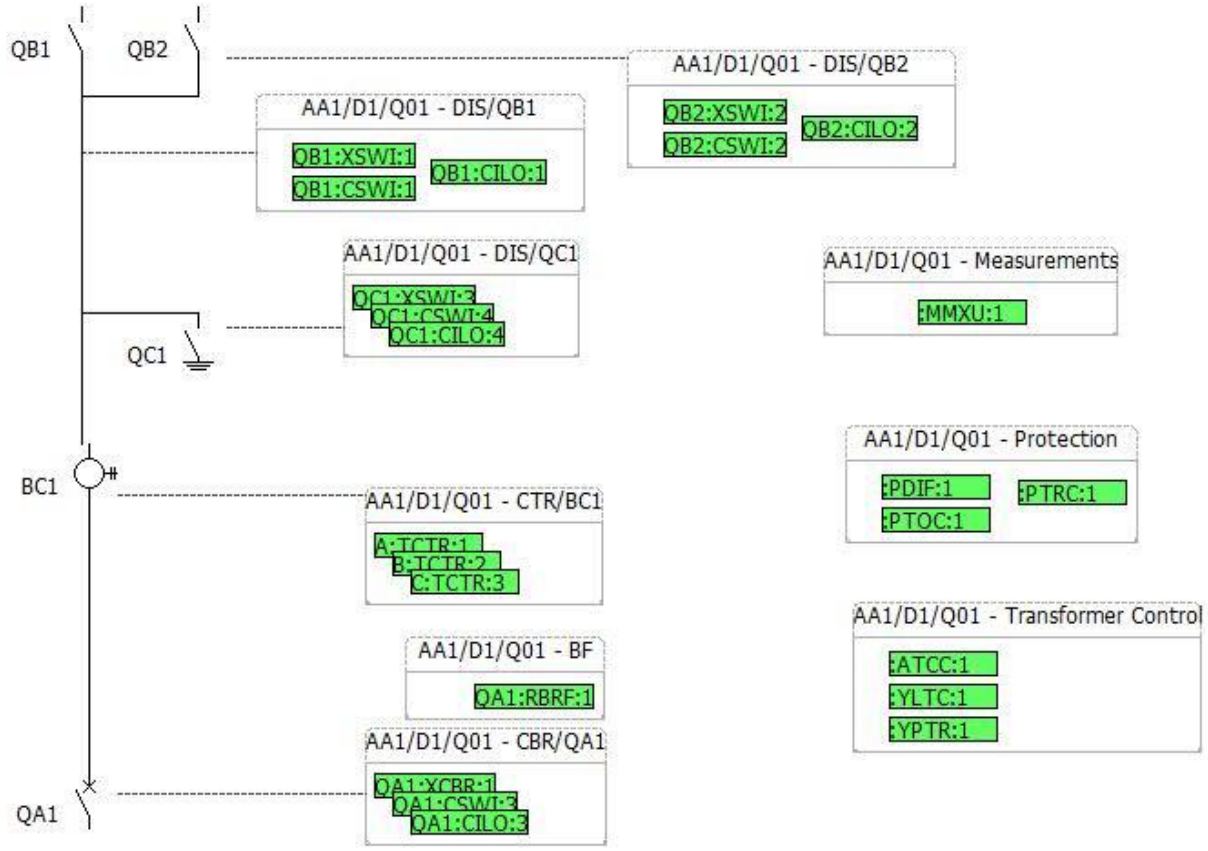


Figure 36 – Transformer HV Bay

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).

For the transformer LV bays

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

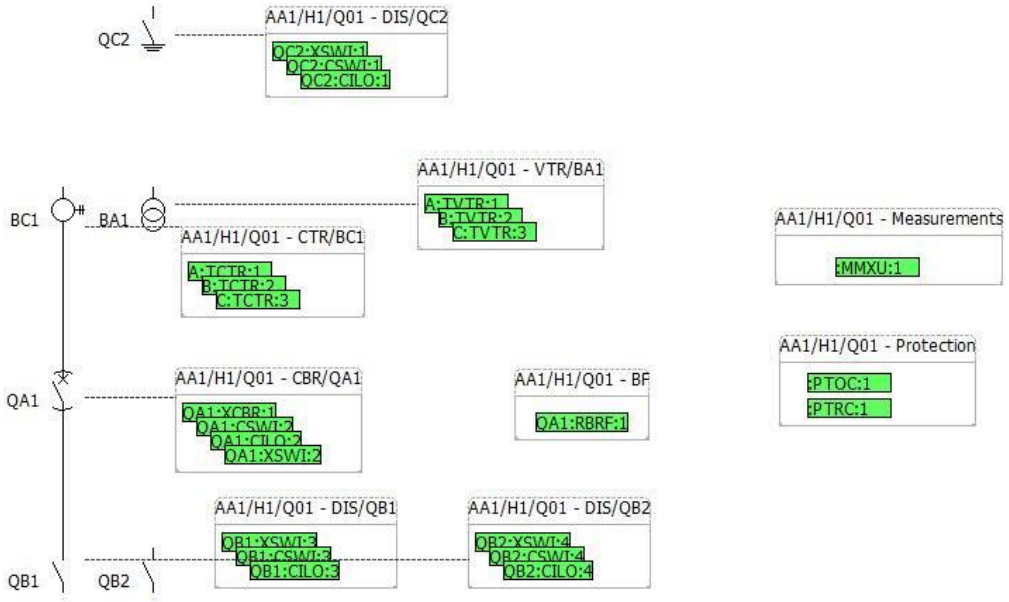


Figure 37 – Transformer LV Bay

For the bus coupler bay

- Measurements (voltage, current)
- Synchrocheck
- Time overcurrent protection (51)

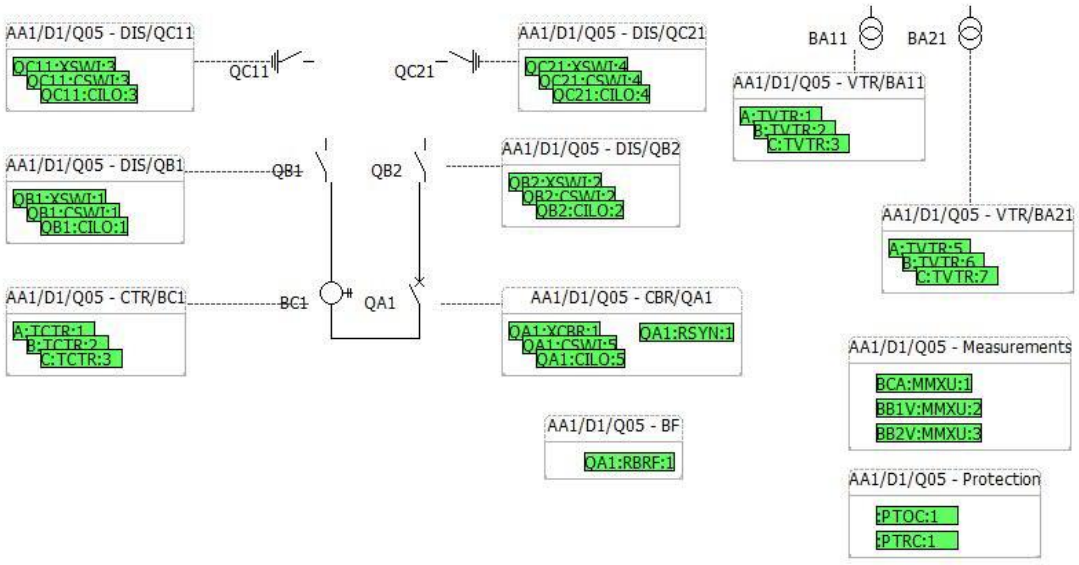


Figure 38 – Bus coupler Bay

In all test cases, the following basic interoperability issues are verified:

- The ability of a SCT to use SSD, IID, ICD and Ed1 XFactor files to create an SCD file that can then be imported by ICTs.
- 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.

Participating companies were:

Company	SCT		ICT	
	ED.1	ED.2	ED.1	ED.2
ABB		X		X
Alstom			X	
Efacec	X	X		
GE				X
InfoTeam	X			
Schneider Electric		X		
Schweitzer Electric			X	
Siemens		X		X
Triangle Microworks				X

Table 4: List of SCL structured testing participants

Table 4 shows the participating companies for the structured SCL testing. The table also shows if the company provided a SCT, ICT, and which version of SCL is supported. The XSD versions used for the IOP were not the official versions for either ED.1 or ED.2. They were the following namespaces:

- ED.1: http://www.iec.ch/61850/2003/SCL version 1.6
- ED.2: http://www.iec.ch/61850/2007/SCL version 3.1

The formal SCL testing was based upon well-defined use cases. Thus, the result sections are organized based upon the defined use cases.

2.1 Bottom Up – Interoperability between SCT and ICT of Bay Level IED

This test case is intended to test the following interoperability:

- 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.
- 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.

- The ability of an ICT to accept GOOSE subscriptions and use the GOOSE subscription for the IED engineering.
- 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 and or PIXITS – example FailMod of LN RBRF.

2.1.1 SCL use case

The following is a formal description of the use case used for this test campaign.

		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

2.1.2 Purpose of the test

The following is the stated purpose of the test campaign.

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.

2.1.3 Test step description

A	Engineering with SCT	
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
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)	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED
A5	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
A6	SCT configures values for parameters of the breaker failure function (if supported by IED)	verify that tool does not offer to change parameter if not allowed
A7	SCT exports SCD file	SCT is able to produce SCD file
B	SCD File inspection	
B0	verify step A7	
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
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
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured
B5	verify step A5	In the SCD file, verify that the data subscription is configured
B6	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured
B7	verify step A6	In the SCD file, verify that the parameters are initialized
C	Engineering with ICT	
C1	ICT imports SCD file	ICT is able to import SCD file
C2	Final IED engineering as required	ICT uses the subscription information from SCD
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured
D	Verify IED behaviour	
D1	verify step A2	Connect with a test client to the IED
D2	verify step A4	Verify that reports are sent to the test client

D3	verify step A6	Read the parameters with the test client; verify the values
D4	verify step A5	Simulate GOOSE message to initiate BF; simulate breaker to remain closed; analyse GOOSE message sent by IED to trip adjacent breakers

2.1.4 Test Results for ED.1

	Testing Companies					
SCT	**InfoTeam/Helinks**		**Efacec**			
ICT	**Schweitzer Electric**		**Alstom**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**		
A1	P	Ed1 in both parts. - SEL gives a CID file - Infoteam import it	☑ S11 – S15 S111	The service part is not present in the IID that were given, (valid because optional) but then impossible to know the capabilities in term of services of the IED. Efacec SCT cannot create any services if not present : has been added manually Confdataset maxAttribute not present in the Alstom IID, the SCT understand 0 and cannot create new dataset -> has been manually modified Ed1 in both parts. - Alstom gives a IID file - Efacec imports it - Rename Alstom IED		

	Testing Companies					
SCT	**InfoTeam/Helinks**		**Efacec**			
ICT	**Schweitzer Electric**		**Alstom**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**		
A2	P	- Change the IP address	P	- Connection - Change the IP address		
A3	P		NS	Not possible in Efacec SCT		
A4	P	- Suppress the dataset of the existing RCB, and suppress the dataset, keep the existing RCB (because cnName="fix") - Create dataset ds_brcb1 and reuse RCBBRep01 - report control block name "fix" -> is it possible to create a new report control block with our own name? To suppress the existing RCB? - The client LN is defined in the Report control block - "Clients only" are not supported because no LD - Does some IED impose that the RCB are in a given LD, and do not accept RCB in any other LD? - Subscription to a report in RptEnabled of the RCB, should it also be in the client part as Inputs? Like the GOOSE?	P	- keep the existing RCB (because cbName="fix") - Create dataset "Dataset1" and reuse brcbH		

	Testing Companies					
SCT	**InfoTeam/Helinks**		**Efacec**			
ICT	**Schweitzer Electric**		**Alstom**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**		
A5	P	- 1 GOOSE CB created, named “gcb1” - 1 dataset created, named “ds_gcb1”	P	- 1 GOOSE CB created, named “GSE1” - VLAN ID : FA0 - 1 dataset created, named “Dataset1” - Reuse the dataset1, reuse gcb08		
A6	NS	- Not supported by SEL IED	NS	- Not supported by Alstom IED		
A7	P		P	Done		
B1	P		P	Done		
B2	P		P	Done		
B3	P		NS	Not supported in Efacec SCT		
B4	P		P	Done		
B5	P		P	Done Subscription found in ClienLn and in the client inputs		
B6	NS	Not relevant (Not permitted by SEL ied)	P	Done		
B7	NS	Not supported	NS	Not relevant (Not permitted by Alstom IED)		

	Testing Companies					
SCT	**InfoTeam/Helinks**		**Efacec**			
ICT	**Schweitzer Electric**		**Alstom**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**		
C1		ICT could not import the SCD, because in the substation section iedname associated to LN were set to “none” which is interpreted by ICT as a real IED name (standard ed1 defines “none” as a null quantity) Datatype templates - SetMag and SetVal are both ST and SP (either of the 2 – Conditional) cause a schema validation error In RCB, GI is declared in the simulated IED (ed2) and SEL is ed1 and raise an error dataTypeTemplates contains iedType that do not exist in the file but LNodeType used in the file (but only recommended) if assigned, ICT may use for validation	P	Name of the IED had been changed -> OK		

	Testing Companies					
SCT	**InfoTeam/Helinks**		**Efacec**			
ICT	**Schweitzer Electric**		**Alstom**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**		
C2			I	Problem in the GOOSE subscription configuration in the ICT : Alstom IED does not support “ACT” type in GOOSE, We reconfigured the AA1D1Q01FN1 to send a GOOSE containing a SPS type (“Protection/PTRC1/Loc”) Should not it be described somewhere in the file, in the capabilities?		
C3			P	Done		
D1			P	Done		
D2			P	Done		
D3			NS	Not relevant		
D4			P	Done		

2.1.5 Test Results for ED.2

	Testing Companies					
SCT	**ABB**		**Efacec**		**Schneider Electric**	
ICT	**Siemens**		**ABB**		**ABB**	
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
A1	P		P	SCT identifies that the communication was absent in client IID files.	P	Required Second try with a new file
A2	P		Note	Subnet type must be filled in for AA1D1Q01KF1	P	modifying possibly predefined addressing information as required: to be verified later
A3	P		NS	Not supported	P	
A4	P		P		P	
A5	P		P		P	
A6	NS	Not supported	NS	Not supported	NS	Not supported
A7	P		P		P	
B1	P		P		P	
B2	P		P		P	
B3	P		NS	Not supported	Note	Note: IEDName contains Q02 while being in the Q01 bay
B4	P		Note		P	
B5	Note	ExtRef : source CB and serviceType are not set	P		Note	
B6	P		P		NS	Source CB is set
B7	NS	Not supported	NS	Not supported	NS	Not supported

	Testing Companies					
SCT	**ABB**		**Efacec**		**Schneider Electric**	
ICT	**Siemens**		**ABB**		**ABB**	
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
C1	Note	File edited by hand as not validating Issues found with: ICT: SchemaLocation not supported with unknown XSD SCT: Had removed mandatory attributes of service section (Subscription) virtual files: wrong prefix (starting with a number: 67N	P		P	
C2	P	Subscription was to XCBR. Changed for GGIO as this is the device implementation	Note	ICT was not able to identify the GOOSE signals to subscribe to, e.g. OpEx.general and OpEx.q. Cause: the SCT was providing only high level information in ExtRef, e.g. ACT SCD file was changed by hand to provide the two input reference: OpEx.general and OpEx.q.	P	

	Testing Companies					
SCT	**ABB**		**Efacec**		**Schneider Electric**	
ICT	**Siemens**		**ABB**		**ABB**	
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
C3	Note	Reporting not working at first in IED as default value for ReportEnabled.max =1 was removed by SCT IED expected the value. File edited by hand	P		Note	Simulated IED had not MinTime and MaxTime that were not supplied by the SCT. Also MAC address had a value of all zeros (0s) which is not a valid multicast address. ExtRef are in LD0 and LN0 to respect ABB constraints IP address must be manually configured on the IED CID file used
D1	P		P		P	
D2	P		P		P	
D3	NS	Not supported	NS	Not supported	NS	Not supported
D4	P		Note	Device not able to subscribe to GOOSE. May be related to the issue identified in C2	P	

	Testing Companies					
SCT	**Schneider Electric**		**Schneider Electric**		**Siemens**	
ICT	**GE**		**Siemens**		**ABB**	
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
A1	P		P		P	The real device from the IID is named AA1D1Q02KF1. Decided to keep it as is.
A2	P	modifying possibly predefined addressing information as required: to be verified later	P	modifying possibly predefined addressing information as required: to be verified later	P	IP address has been changed by SCT for AA1D1Q01KF1
A3	P		P		Note	Supported only for Siprotec5 IEDs not for others
A4	P		P		Note	A new RCB was created For client, SCT expected Client services section in order to decide if it can add buffered reports.
A5	P		P		Note	SCT used an existing GCB ICT needs the subscription within LD0.LN0
A6	NS	Not supported on SCT and ICT	NS	Not supported on SCT and ICT	NS	Not supported
A7	NT	Not Tested	NT	Not Tested	NT	Not Tested
B1	P		P		P	
B2	P		P		P	
B3	P		P		Note	Supported only for Siprotec5 IEDs not for others
B4	P		P		P	

	Testing Companies					
SCT	**Schneider Electric**		**Schneider Electric**		**Siemens**	
ICT	**GE**		**Siemens**		**ABB**	
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
B5	Note	SCT created a new GCB with OpEX.general and q attributes. As these attributes were already in an existing GCB, the new created one didn't have the quality (automatic configuration from SCT).	P		Note	ExtRef : source CB and serviceType IEDName not set
B6	Note	ExtRef: Source CB is set serviceType not set	Note	ExtRef: Source CB is set serviceType not set	Note	Source CB is set serviceType not set
B7	NS	Not supported	NS	Not supported	NS	Not supported
C1	F	ICT is not able to import SCD. It only uses CID. Test aborted here.	Note	As SCT has changed the IED name in the SCD, ICT must change the IED name before importing SCT (ICT is expecting the name that has been configured by itself)	P	
C2	NT	Not Tested due to C1	P		P	Connected to GOOSE receiver function
C3	NT	Not Tested due to C1	Note	ICT expects unit and multiplier for MinTime and MaxTime. It is optional in SCD and has default values fixed to ms. The info was added manually in the SCD file. Issue with reports: ICT is expecting RptEnabled. Max to be present and not removed by SCT (default value is 1)	P	

	Testing Companies					
SCT	**Schneider Electric**		**Schneider Electric**		**Siemens**	
ICT	**GE**		**Siemens**		**ABB**	
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
D1	NT	Not Tested due to C1	Note	Test client required originalSclVersion to be present in the SCD file in order to detect the version of the IED.	P	
D2	NT	Not Tested due to C1	P		P	
D3	NT	Not Tested due to C1	NS	Not supported	NS	Not supported
D4	NT	Not Tested due to C1	P	GOOSE received	P	The breaker failure function tested needed the breaker current information. Everything was simulated up to the OpEx output but no OpEx could be issued because of this requirement

2.1.6 Test Results for mixture of ED.1 and ED.2 SCL Files

No tests were executed for this use case using a mixture of ED.1 and ED.2 SCL files.

2.2 Top Down – Interoperability between SCT and ICT of Bay Level IED

This test case is intended to test the following interoperability:

- 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.
- 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.
- The ability of an ICT to accept GOOSE subscriptions and use the GOOSE subscription for the IED engineering.
- 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 and or PIXITS – example FailMod of LN RBRF.
- The ability of an ICT to accept instantiations of IEDs based on ICD files through an SCD file.

2.2.1 SCL use case

The following is a formal description of the use case used for this test campaign

		System Design – Bottom Up 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

2.2.2 Purpose of the test

The following is the stated purpose of the test campaign.

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.

2.2.3 Test step description

A	Engineering with SCT	
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
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)	verify that tool does not provide capability to configure / change dataset and report control block if not allowed by IED
A5	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
A6	SCT configures values for parameters of the breaker failure function (if supported by IED)	verify that tool does not offer to change parameter if not allowed
A7	SCT exports SCD file	SCT is able to produce SCD file
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
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
B4	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured
B5	verify step A5	In the SCD file, verify that the data subscription is configured
B6	verify step A5	In the SCD file, verify that GOOSE control block and data sets are configured
B7	verify step A6	In the SCD file, verify that the parameters are initialized
C	Engineering with ICT	
C1	ICT imports SCD file	ICT is able to import SCD file and create the instances of the concerned IEDs in the ICT
C2	Final IED engineering as required	ICT uses the subscription information from SCD
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured
D	Verify IED behaviour	
D1	verify step A2	Connect with a test client to the IED
D2	verify step A4	Verify that reports are sent to the test client

D3	verify step A6	Read the parameters with the test client; verify the values
D4	verify step A5	Simulate GOOSE message to initiate BF; simulate breaker to remain closed; analyse GOOSE message sent by IED to trip adjacent breakers

2.2.4 Test Results for ED.1

No tests were executed for this use case using only ED.1 SCL files.

2.2.5 Test Results for ED.2

	Testing Companies					
SCT	**Siemens**		**Schneider Electric**			
ICT	**ABB**		**ABB**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
A1	P		P			
A2	P		P			
A3	Note	Supported only for Siprotec5 IEDs not for others	P			
A4	P		P			
A5	P		P			
A6	NS	Not supported	NS	Not supported		
A7	P		P			
B1	P		P			
B2	P		P			
B3	Note	Supported only for Siprotec5 IEDs not for others	P			
B4	P		P			
B5	P		P			
B6	P		P			
B7	NS	Not supported	NS	Not supported		
C1	P		P			
C2	P		P			

	Testing Companies					
SCT	**Siemens**		**Schneider Electric**			
ICT	**ABB**		**ABB**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
C3	Note	Device is not rebooting: Simulated IED had not MinTime and MaxTime that were not supplied by the SCT. Also MAC address was all 0s ExtRef are in LD0 and LN0 to respect ABB constraints	Note	Device is not rebooting: Simulated IED had not MinTime and MaxTime that were not supplied by the SCT. Also MAC address was all 0s ExtRef are in LD0 and LN0 to respect ABB constraints		
D1	NT	Not Tested	NT	Not Tested		
D2	NT	Not Tested	NT	Not Tested		
D3	NS	Not supported	NS	Not supported		
D4	P	The breaker failure function tested needed the breaker current information. Everything was simulated up to the OpEx output but no OpEx could be issued because of this requirement	P	The breaker failure function tested needed the breaker current information. Everything was simulated up to the OpEx output but no OpEx could be issued because of this requirement		

2.2.6 Test Results for mixture of ED.1 and ED.2 SCL Files

No tests were executed for this use case using a mixture of ED.1 and ED.2 SCL files.

2.3 Reimport of IID file for modification during system engineering – IOP between ICT and SCT

This test case is intended to test the following interoperability:

- 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.
- 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

2.3.1 SCL use case

The following is a formal description of the use case used for this test campaign

		System Design – Bottom Up approach
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

2.3.2 Purpose of the test

The following is the stated purpose of the test campaign.

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

2.3.3 Test step description

A	Engineering with SCT	
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
B	SCD File inspection	
B1	verify that the SCD file corresponds to test case 1 with steps A1 to A4 done	verify that the SCD file corresponds to test case 1 with steps A1 to A4 done
C	Engineering with ICT	
C1	ICT imports SCD file	ICT is able to import SCD file
C2	Missing data object is added with ICT. Already used data objects and control blocks are not allowed to be modified	
C3	ICT exports the IID	
D	Verify IED behaviour	
D1	Verify step C2	Verify that already engineered information like datasets and report control blocks or IP addresses have not been changed.
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
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
E3	SCT exports SCD file	SCT is able to produce SCD file
F	SCD File inspection	
F1	verify step E2	In the SCD file, verify that the data subscription is configured
F2	verify step E2	In the SCD file, verify that GOOSE control block and data sets are configured
G	Engineering with ICT	
G1	ICT imports SCD file	ICT is able to import SCD file
G2	Final IED engineering as required	ICT uses the subscription information from SCD
G3	ICT configures the IED AA1D1Q01KF1	IED can be configured
H	Verify IED behaviour	
H1	verify step E2	Simulate GOOSE message to initiate BF; simulate breaker to remain closed; analyse GOOSE message sent by IED to trip adjacent breakers

2.3.4 Test Results for ED.1

Not tests were executed for this use case using only ED.1 SCL files.

2.3.5 Test Results for ED.2

	Testing Companies					
SCT	**Schneider Electric**					
ICT	**ABB**					
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
A1	P					
B1	NT	Not Tested				
C1	P					
C2	P	The ICT used had not the possibility to change any GOOSE subscription or client reservation, only their SCT could have done the changes. That is exactly the concept of ICT vs SCT				
C3	P					
D1	P					
E1	P					
E2	P					
E3	P					
F1	P					
F2	P					
G1	P					
G2	P					
G3	NT	Not tested				
H1	NT	Not tested				

2.3.6 Test Results for mixture of ED.1 and ED.2 SCL Files

No tests were executed for this use case using a mixture of ED.1 and ED.2 SCL files.

2.4 Interoperability between ICT of station level device (gateway and HMI) and SCT

This test case is intended to test the following interoperability:

- 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.
- 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
- The ability of an ICT for a client device, to accept subscriptions from reporting configured by the SCT.
- The ability to manage preconfigured clients for buffered reporting

2.4.1 SCL use case

The following is a formal description of the use case used for this test campaign

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.

2.4.2 Purpose of the test

The following is the stated purpose of the test campaign.

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

2.4.3 Test step description

A	Engineering with SCT	
A1	make sure that steps A1 to A3 according to test case 1 (chapter 2.1.3) are done	
A2	SCT imports IID/XFactor files for gateway and HMI and adds these to the design	
A3	SCT adds the gateway and HMI to the already existing subnetwork modifying possibly predefined addressing information as required	
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
A5	SCT configures clientLN for report control block and creates subscriptions for client	
A6	SCT exports SCD file	SCT is able to produce SCD file
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
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
B3	verify step A4	In the SCD file, verify that the report control blocks and data sets are configured
B4	verify step A5	In the SCD file, verify that the ClientLN and data subscription are configured
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 concerned IEDs in the ICT
C2	Final IED engineering as required	ICT uses the subscription information from SCD
C3	ICT configures the IED AA1D1Q01KF1	IED can be configured
D	Engineering with ICT for the client / gateway	
D1	ICT imports SCD file	ICT is able to import SCD file
D2	Final HMI / Gateway engineering as required	ICT uses information from SCD
D3	ICT configures the gateway / HMI	Gateway / HMI can be configured
E	Verify system behaviour	
E1	Gateway or HMI connects to the IED	Verify that the connection is established automatically by the client based on the configuration
E2	verify step A4 / A5	Verify that gateway can enable its reserved report control blocks
E3	Initiate breaker operation from the client	Verify that the breaker operates

2.4.4 Test Results for ED.1

No tests were executed for this use case using only ED.1 SCL files.

2.4.5 Test Results for ED.2

	Testing Companies					
SCT	**ABB**		**Schneider Electric**			
ICT	**Triangle**		**GE**			
Clnt	**SISCO**		**Arc Info PcVue**			
Serv	**Triangle**		**GE**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
A1	NT	Not done. The test is based only on the addition of a client and a server within an SCD file. Some reports were created and DO command was sent. Client and server were simulated instead of real device	NT	Not Tested		
A2	NT	Not Tested	P	No gateway, only pure client, A1KF11 used		
A3	NT	Not Tested	P			
A4	NT	Not Tested	P			
A5	NT	Not Tested	P			
A6	NT	Not Tested	Note	ARC communication section is missing OSI selectors		
B1	P	Tested with only one client	P	Only the ARC IED was added		
B2	P		NT	Not Tested		
B3	P		P			

	Testing Companies					
SCT	**ABB**		**Schneider Electric**			
ICT	**Triangle**		**GE**			
Clnt	**SISCO**		**Arc Info PcVue**			
Serv	**Triangle**		**GE**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
B4	P	ClientLN is set No ExtRef created at the ClientLN	P			
C1	P	IED was simulated	Note	GE has problems importing SCD with change types		
C2	P	IED was simulated	P			
C3	P	IED was simulated	NT	Not Tested		
D1	P		P			
D2	P		P			
D3	P		P			
E1	P		NT	Not Tested		
E2	P		NT	Not Tested		
E3	P	Direct operate only	NT	Not Tested		

2.4.6 Test Results for mixture of ED.1 and ED.2 SCL Files

No tests were executed for this use case using a mixture of ED.1 and ED.2 SCL files.

2.5 Interoperability between SCTs – Use of existing SCD file

This test case is intended to test the following interoperability:

- The ability of SCTa to export SCD file which can be imported by SCTb. Example, SCTa exports SCD file, SCTb imports that file, makes a change, exports to SCTa and SCTa understands the change and it can be verified that no other changes have been made
- The portability of single line diagrams between SCTs

2.5.1 SCL use case

The following is a formal description of the use case used for this test campaign

1	SCTa	Exports the SCD file
2	SCTb	Imports the SCD file
3	SCTb	Modifies the project configuration
4	SCTb	Exports SCD file

2.5.2 Purpose of the test

The following is the stated purpose of the test campaign.

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

2.5.3 Test step description

A	Engineering with SCTb	
A1	SCTb imports SCD file	SCT is able to import SCD file without any manual editing
A2	SCTb imports IID/XFactor file of modified IED	SCT is able to import IID/XFactor file
A3	SCTb associates new LN to single line diagram / substation section	
A4	SCTb exports SCD file	
B	SCD File inspection	
B1	verify A2	In the SCD file, verify that the data model of IED AA1D1Q01FK1 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 RBRF1.
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 AA1D1Q01FK1) are identical

2.5.4 Test Results for ED.1

No tests were executed for this use case using only ED.1 SCL files.

2.5.5 Test Results for ED.2

	Testing Companies					
SCTA	**Schneider Electric**		**Schneider Electric**			
SCTB	**ABB**		**Siemens**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
A1	P		P			
A2	P		Note	See remark in A4 for partial failure.		
A3	P		P			
A4	P		Note	Problem on export. Problem was really on import of modified IID file. File had GSE removed but database did not erase corresponding GSE information prior to import.		
B1	P		P			
B2	P		Note	See A3 above, no associations possible		
C1	NT	Not Tested	NT	Not Tested		

	Testing Companies					
SCTA	**Schneider Electric**		**Schneider Electric**			
SCTB	**ABB**		**Siemens**			
Step	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**	**Pass/ Fail**	**Comment**
C2	Note	SCTb had removed the subscription associated with the GCB_a in AA1D1Q01FN1 it SCTb had replaced some private sections owned by SCTa by its own private sections The ClientLN section has been removed from rcb_d Participant knowledge of the SCTb tool was not comprehensive enough to end this step	P	Files are different size by factor of 2: a) LLN0 and LPHD LNTypes collapsed b) Smaller file has less data objects in LLN0 and other LNs		
C3	Note	See C2	P			

2.5.6 Test Results for mixture of ED.1 and ED.2 SCL Files

No tests were executed for this use case using a mixture of ED.1 and ED.2 SCL files.

3 Sampled Values Specific Results

The following company products were tested as part of the Sample Value testing.

Company	Product	ED.1	ED.2
ABB	SAM/FOCS-MU	X	X
ABB	REL670		X
Alstom	P645	X	X
Alstom	AMU	X	X
Arteche	SDO SAMU	X	
INGETEAM	EF	X	X
Omicron	CMC	X	X
Omicron	SvScout	X	X
RTDS	GE-NET	X	
Schweitzer Electric	SEL 421	X	
ZIV	IRV	X	

Table 5: Participating companies and products for SV testing

Table 5 shows the products and IEC 61850-9-2 versions that were declared to be supported. However, the focus of the testing was the UCA specification: 'IMPLEMENTATION GUIDELINE FOR DIGITAL INTERFACE TO INSTRUMENT TRANSFORMERS USING IEC 61850-9-2', Revision 2.1 (R2-1 / 2004-07-07)".

This specification details the contents/data types of the SV publication. As such, the use of SCL exchange only truly aids in verification and subscription addressing information. Many of the publishers did not produce SCL files nor did many subscribers have an import capability. This will need to be tested in upcoming IOPs so that SCDs can be used to configure SV subscriptions and publications.

The IEC 61850-9-2 standard has a set of recommended multicast addresses for SV publications. Some implementations, in the past, have assumed that this is the only allowed range for SV. In order to verify more flexible configuration capability, the assignments of destination MAC addresses divided into recommended and outside the recommended range.

Company	Recommended 01-0C-CD-04-00-zz zz range	Non-Recommended 81-FF-FF-05-xx-yy xx	yy range
ABB	0-9	1	2-254
Alstom Grid	10-19	2	2-254
Arteche	40-49	5	2-254
INGETEAM	90-99	10	2-254
Omicron	110-119	12	2-254

Company	Recommended 01-0C-CD-04-00-zz zz range	Non-Recommended 81-FF-FF-05-xx-yy xx	yy range
RTDS	130-139	14	2-254
Schweitzer Electric	160-169	17	2-254
ZIV	210-209	22	2-254

Table 6: SV assigned destination MAC Addresses

All SV 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 61850-9-2, the default VLAN for SV is VLAN ID 0. The VLAN ID that was supposed to be tested with was 4018 (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
	Test combination was not attempted
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.

Table 7: Legend for SV test results

3.1 SCL Configuration Validation

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

Test Case Description:	The Subscriber may be able to be configured with a SCD file that includes the publisher's information from the IID file or ED1 XFactor file.
Expected Result:	The subscriber should use the SCD file for configuration.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**N1**	**P**	**N1**	**N1**
	Alstom	P645	**N1**		**N1**	**N1**	**N1**
	INGETEAM	ED (ED.1, ED.2)	**N1**	**N1**	**N1**	**N1**	**N1**
	Omicron	SVScout	**N1**				**N1**
	RTDS	GTnet-GSE ED.1	**N1**	**N1**	**N1**	**N1**	
	Schweitzer	421-5 ED.1	**N1**	**N1**	**N1**	**N1**	**N1**
	ZIV	7IRVA3N406B ED.1	**P**	**P**	**P**	**P**	

N1- SCL was not used for configuration

Table 8: SV SCL Testing Results

3.2 92LE Data Stream Validation

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

Test Case Description:	The subscriber should listen to the published datastream.
Expected Result:	The subscriber should process the datastream and be able to show data is being received properly. I.e. metering values, no data loss alarms, etc…

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**P**	**P**	**P**	**P**
	Alstom	P645	**P**		**P**	**P**	**P**
	INGETEAM	ED (ED.1, ED.2)	**P**	**P**	**P**	**P**	**P**
	Omicron	SVScout	**P**				**P**
	RTDS	GTnet-GSE ED.1	**P**	**P**	**P**	**P**	
	Schweitzer	421-5 ED.1	**P**	**P**	**P**	**P**	**P**
	ZIV	7IRVA3N406B ED.1	**P**	**P**	**P**	**P**	

Table 9: SV Data Stream Validation Results

3.3 VLAN Capability

This suite of tests is supposed to test the capability of subscribers to process SVs that are delivered with or without VLAN IDs. Both deliveries must be supported by a subscriber since VLAN IDs may be stripped at egress ports of switches.

3.3.1 Nominal Voltage and Current at 50Hz with VLAN Tag

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

Test Case Description:	The Subscriber should accept 9.2LE packets with VLAN tags. It is ideal to perform the test with all participants and then leave the network in a state where data packets are tagged.
Expected Result:	The subscriber shall decode the packets with and without VLAN tags.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**NS**	**NO**	**NO**	**NO**
	Alstom	P645	**NS**		**NS**	**NO**	**NO**
	INGETEAM	ED (ED.1, ED.2)	**NS**	**NS**	**NS**	**NO**	**NO**
	Omicron	SVScout	**NO**				**NO**
	RTDS	GTnet-GSE ED.1	**NS**	**P**	**P**	**NO**	
	Schweitzer	421-5 ED.1	**NS**	**NO**	**NO**	**NO**	**P**
	ZIV	7IRVA3N406B ED.1	**NS**	**I**	**NO**	**NO**	

NO – VLAN tags not Observed

NS – VLAN Tagging Not Supported by Publisher

Table 10: SV 50 Hz Nominal Voltage with VLAN Test Results

The NO notation could be explained due to Ethernet VLAN ID stripping on the observing test equipment.

3.3.2 Nominal Voltage and Current at 50Hz with VLAN Tag 0

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

Test Case Description:	The Subscriber should accept 9.2LE packets without VLAN tags. It is ideal to perform the test with all participants and then leave the network in a state where data packets are tagged.
Expected Result:	The subscriber shall decode the packets with and without VLAN tags.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**P**	**P**	**P**	**P**
	Alstom	P645	**P**		**P**	**P**	**P**
	INGETEAM	ED (ED.1, ED.2)	**P**	**P**	**P**	**P**	**P**
	Omicron	SVScout					**P**
	RTDS	GTnet-GSE ED.1	**P**		**P**	**P**	
	Schweitzer	421-5 ED.1	**P**	**I**			**P**
	ZIV	7IRVA3N406B ED.1	**P**	**P**	**P**	**P**	

Table 11: SV 50 Hz Nominal Voltage with Priority Only (VLAN ID=0) Test Results

3.3.3 Nominal Voltage and Current at 60Hz with VLAN Tag

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

Test Case Description:	The Subscriber should accept 9.2LE packets with VLAN tags. It is ideal to perform the test with all participants and then leave the network in a state where data packets are tagged.
Expected Result:	The subscriber shall decode the packets with and without VLAN tags.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**NS**	**NO**	**NO**	**NO**
	Alstom	P645	**NS**		**NS**	**NO**	**NO**
	INGETEAM	ED (ED.1, ED.2)	**NS**	**NS**	**NS**	**NO**	**NO**
	Omicron	SVScout	**NO**				**NO**
	RTDS	GTnet-GSE ED.1	**NS**	**P**	**P**	**NO**	
	Schweitzer	421-5 ED.1	**NS**	**NO**	**NO**	**NO**	**P**
	ZIV	7IRVA3N406B ED.1	**NS**	**I**	**NO**	**NO**	

NO – VLAN tags not Observed

NS – VLAN Tagging Not Supported by Publisher

Table 12: SV 60 Hz Nominal Voltage with VLAN Test Results

The NO notation could be explained due to Ethernet VLAN ID stripping on the observing test equipment.

3.3.4 Nominal Voltage and Current at 60Hz with VLAN Tag 0

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

Test Case Description:	The Subscriber should accept 9.2LE packets without VLAN tags. It is ideal to perform the test with all participants and then leave the network in a state where data packets are tagged.
Expected Result:	The subscriber shall decode the packets with and without VLAN tags.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**P**	**P**	**P**	**P**
	Alstom	P645	**P**		**P**	**P**	**P**
	INGETEAM	ED (ED.1, ED.2)	**P**	**P**	**P**	**P**	**P**
	Omicron	SVScout					**P**
	RTDS	GTnet-GSE ED.1	**P**		**P**	**P**	
	Schweitzer	421-5 ED.1	**P**	**I**			**P**
	ZIV	7IRVA3N406B ED.1	**P**	**P**	**P**	**P**	

Table 13: SV 50 Hz Nominal Voltage with Priority Only (VLAN ID=0) Results

3.4 Application Testing

Subscribers obtaining 9-2 data must be able to properly use the data for the intended purpose i.e. protection and control. The following test cases shall be used to verify that the Subscriber is capable of using a 9-2LE data stream for their intended purpose.

The subscriber should be able to properly protect the intended part of the network that is affected by system faults i.e. real-time simulation or recorded waveforms.

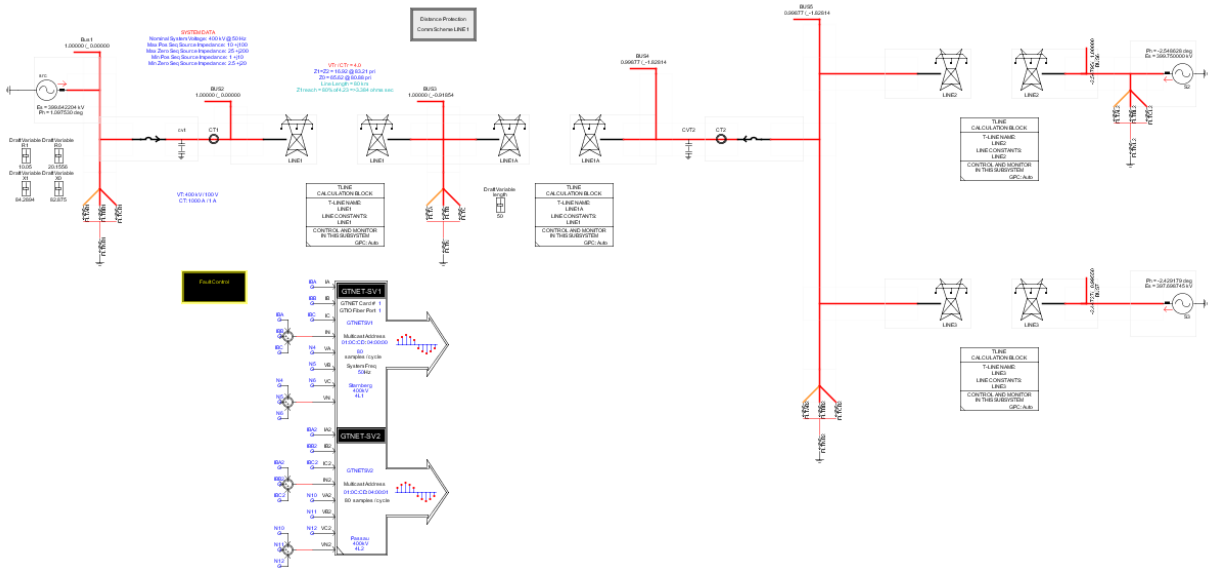


Figure 39: Protection zones and fault diagram for SV testing

3.4.1 Single Phase Fault

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

Test Case Description:	Apply single phase fault at 10%, 50%, and 90% of the line length.
Expected Result:	The IED should identify the proper fault type and clear the fault and reclose or block reclose. Fault identification is mandatory but fault clearing and reclose testing is optional.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**P**	**P**	**P**	**P**
	Alstom	P645	**P**		**P**	**P**	**P**
	INGETEAM	ED (ED.1, ED.2)	**P**	**P**	**P**	**P**	
	Omicron	SVScout					
	RTDS	GTnet-GSE ED.1	**P**	**P**	**I**	**P**	
	Schweitzer	421-5 ED.1	**P**	**P**	**P**	**P**	**P**
	ZIV	7IRVA3N406B ED.1	**P**	**P**	**P**	**P**	

Table 14: SV Single Phase Fault Test Results

3.4.2 Phase to Phase Fault

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

Test Case Description:	Apply phase to phase fault at 10%, 50%, and 90% of the line length.
Expected Result:	The IED should identify the proper fault type and clear the fault and reclose or block reclose. Fault identification is mandatory but fault clearing and reclose testing is optional.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**P**	**P**	**P**	**P**
	Alstom	P645	**P**		**P**	**P**	**P**
	INGETEAM	ED (ED.1, ED.2)		**P**	**P**	**P**	
	Omicron	SVScout					
	RTDS	GTnet-GSE ED.1	**P**	**P**	**I**	**P**	
	Schweitzer	421-5 ED.1	**P**	**P**	**P**	**P**	**P**
	ZIV	7IRVA3N406B ED.1	**P**	**P**	**P**	**P**	

Table 15: SV Phase-to-Phase Fault Test Results

3.4.3 Three Phase Fault

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

Test Case Description:	Apply three phase fault at 10%, 50%, and 90% of the line length.
Expected Result:	The IED should identify the proper fault type and clear the fault and reclose or block reclose. Fault identification is mandatory but fault clearing and reclose testing is optional.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**P**	**P**	**P**	**P**
	Alstom	P645	**P**		**P**	**P**	**P**
	INGETEAM	ED (ED.1, ED.2)		**P**	**P**	**P**	
	Omicron	SVScout					
	RTDS	GTnet-GSE ED.1	**P**	**P**	**I**	**P**	
	Schweitzer	421-5 ED.1	**NI**	**P**	**I**	**P**	**P**
	ZIV	7IRVA3N406B ED.1	**P**	**P**	**P**		

NI – Test Interrupted and Incomplete

Table 16: SV Three Phase Fault Test Results

3.4.4 Loss of DataStream

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

Test Case Description:	Analogue values lost (physically disconnected connection or publisher operating mode configured to Off) shall not cause IED to mal-operate protection.
Expected Result:	Protection does not mal-operate.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**P**	**P**		**P**
	Alstom	P645	**P**			**P**	**P**
	INGETEAM	ED (ED.1, ED.2)	**P**	**P**		**P**	**P**
	Omicron	SVScout	**P**				**P**
	RTDS	GTnet-GSE ED.1	**P**	**P**	**P**	**P**	
	Schweitzer	421-5 ED.1		**P**	**P**	**P**	**P**
	ZIV	7IRVA3N406B ED.1	**P**	**P**		**P**	

Table 17: SV Loss of Data Stream Test Results

3.5 Optional Tests

The previous SV sections were mandatory tests. The following sections represent optional tests.

3.5.1 SmpCnt

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

Test Case Description:	The Publisher should produce a datastream with a smpCnt from 0-4799 @ 60Hz and 0-3999 @ 50Hz.
Expected Result:	The captured packets file should contain correct smpCnts.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670			**P**		
	Alstom	P645				**P**	**P**
	INGETEAM	ED (ED.1, ED.2)					
	Omicron	SVScout					
	RTDS	GTnet-GSE ED.1		**P**			
	Schweitzer	421-5 ED.1					
	ZIV	7IRVA3N406B ED.1					

Table 18: SV SmpCnt Test Results

3.5.2 SmpSynch

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

Test Case Description:	The Publisher may be able to set the smpSynch flag
Expected Result:	The captured packets file should contain correct smpSynch if settable.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		P	P		
	Alstom	P645				P	P
	INGETEAM	ED (ED.1, ED.2)					
	Omicron	SVScout					
	RTDS	GTnet-GSE ED.1	P	P		P	
	Schweitzer	421-5 ED.1	P	P	P	P	
	ZIV	7IRVA3N406B ED.1	P			P	

Table 19: SV SmpSynch Test Results

3.5.3 Quality

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

Test Case Description:	The Publisher may be able to set the detail quality bits.
Expected Result:	The captured packets file should contain correct quality bits if settable.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		P	P	P	P
	Alstom	P645				P	P
	INGETEAM	ED (ED.1, ED.2)					
	Omicron	SVScout			P		P
	RTDS	GTnet-GSE ED.1	P			P	
	Schweitzer	421-5 ED.1	P	P			
	ZIV	7IRVA3N406B ED.1	P			P	

Table 20: SV Quality Value Test Results

3.5.4 Harmonic Content

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

Test Case Description:	The Publisher should be able to produce an accurate waveform containing harmonic content.
Expected Result:	The captured packets file should contain correct amount of fundamental and harmonic content.

Actual results:

		Publishers					
Subscribers		Company	ABB	Alstom	Arteche	Omicron	RTDS
	Company	Product	MU	AMU	SDO SAMU	CMC	GSE
	ABB	REL670		**P**	**P**	**P**	
	Alstom	P645				**P**	
	INGETEAM	ED (ED.1, ED.2)					
	Omicron	SVScout					
	RTDS	GTnet-GSE ED.1				**P**	
	Schweitzer	421-5 ED.1		**P**	**P**		
	ZIV	7IRVA3N406B ED.1					

Table 21: SV Harmonic Content Test Results

4 GOOSE Specific Results

The following company products were tested as part of the GOOSE testing.

Company	Product	ED.1	ED.2
ABB	REL670		X
Alstom	P14DZ	X	
AMA	AMA-61850-ServerSim-G	X	
EFACEC	S220-S	X	
GE	850		X
INGETEAM	INGESYS IT EF	X	X
Omicron	IEDScout	X	X
Omicron	ISIO 200	X	
RTDS	GTnet-GSE	X	
Schweitzer Electric	421	X	
SIEMENS	SIPROTEC4		X
SISCO	AXS4-61850	X	X
Toshiba	GRL200	X	X
Triangle	Anvil	X	X
Triangle	Hammer		X
ZIV	7IRVA3N406B	X	

Table 22: Participating companies and products for GOOSE testing

Table 22 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 01-0C-CD-01-00-zz zz range	Non-Recommended 81-FF-FF-01-xx-yy xx	yy range
ABB	0-9	1	2-254
Alstom Grid	10-19	2	2-254
AMA-Systems	20-29	3	2-254
Efacec	60-69	7	2-254
GE	70-79	8	2-254
INGETEAM	90-99	10	2-254
Omicron	110-119	12	2-254
RTDS	130-139	14	2-254
Schweitzer Electric	160-169	17	2-254
Siemens	170-179	18	2-254
SISCO	180-189	19	2-254
Triangle Microworks	190-199	20	2-254
Toshiba	200-209	21	2-254
ZIV	210-209	22	2-254

Table 23: 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
	Test combination was not attempted
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.
	Indicates that an ED.2/ED.1 test combination was tested.

Table 24: 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 4-7).

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 7.1.3.

4.2 FCDA Exchange

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

Test Case Description:	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.

Actual results:

		Publishers																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2												I,N1				
	Alstom	P14DZ ED.1			P							P		P				P
	AMA	61850-ServerSim ED.1																
	EFACEC	TPUS220 ED.1						P						P				P
	GE	850 ED.2										P		P				P
	INGETEAM	INGEPAC EF ED.1., ED.2										P		P	P			
	Omicron	IEDScout ED.1, ED.2																
	Omicron	ISIO 200 ED.1			P							P		P	P			P
	RTDS	GTnet-GSE ED.1										P		P				P
	Schweitzer	421-5 ED.1	P	P			P	P		P	P		P	P	P	P		P
	Siemens	SIPROTEC4 Compact ED.2	P											I,N1				

		Publishers															
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
	SISCO	AXS4-61850 ED.1, ED.2	P	P														
	Toshiba	GRL200 ED.1, ED.2						P		P		P						P
	Triangle Microworks	Anvil ED.1, ED.2										P						
		Hammer ED.1	P															
	ZIV	7IRVA3N406B ED.1		P		P	P				P	P		P	P			

N1 – Problem encountered with SCL import.

Table 25: Results for FCDA exchange via GOOSE

4.3 FCD Exchange

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

Test Case Description:	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.

Actual results:

		Publishers																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2																
	Alstom	P14DZ ED.1			P							P		P				P, N1
	AMA	61850-ServerSim ED.1																
	EFACEC	TPUS220 ED.1												P				P
	GE	850 ED.2										P						P
	INGETEAM	INGEPAC EF ED.1., ED.2									P	P		P	P			
	Omicron	IEDScout ED.1, ED.2			P													
	Omicron	ISIO 200 ED.1													P			P
	RTDS	GTnet-GSE ED.1						P				P						P
	Schweitzer	421-5 ED.1		P			P							P	P	P		P
	Siemens	SIPROTEC4 Compact ED.2																
	SISCO	AXS4-61850 ED.1, ED.2		P						P								
	Toshiba	GRL200 ED.1, ED.2								P								
	Triangle Microworks	Anvil ED.1, ED.2										P						
		Hammer ED.1	P															
	ZIV	7IRVA3N406B ED.1																

N1 – Subscriber SCL Import issue Encountered

Table 26: Results for FCD exchange via GOOSE

4.4 FCD and FCDA Exchange

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

Test Case Description:	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.

Actual results:

		Publishers																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2																
	Alstom	P14DZ ED.1																
	AMA	61850-ServerSim ED.1																
	EFACEC	TPUS220 ED.1																
	GE	850 ED.2																
	INGETEAM	INGEPAC EF ED.1., ED.2																
	Omicron	IEDScout ED.1, ED.2																
	Omicron	ISIO 200 ED.1																P
	RTDS	GTnet-GSE ED.1												P				
	Schweitzer	421-5 ED.1														P		P
	Siemens	SIPROTEC4 Compact ED.2																
	SISCO	AXS4-61850 ED.1, ED.2									P							
	Toshiba	GRL200 ED.1, ED.2																
	Triangle Microworks	Anvil ED.1, ED.2																
		Hammer ED.1	P															
	ZIV	7IRVA3N406B ED.1																

Table 27: Results for FCDA and FCD DataSet exchange via GOOSE

4.5 Test Bit Exchange

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

Test Case Description:	The publisher sends either the FCD or FCDA GOOSE with the IECGoosePdu.test bit set to a value of TRUE.
Expected Result:	The subscriber indicates that it has received and understood the GOOSE Test bit.

Actual results:

		Publishers																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2																
	Alstom	P14DZ ED.1																
	AMA	61850-ServerSim ED.1																
	EFACEC	TPUS220 ED.1																
	GE	850 ED.2																
	INGETEAM	INGEPAC EF ED.1., ED.2									P							
	Omicron	IEDScout ED.1, ED.2																
	Omicron	ISIO 200 ED.1													P			
	RTDS	GTnet-GSE ED.1												P				
	Schweitzer	421-5 ED.1		P												P		
	Siemens	SIPROTEC4 Compact ED.2																
	SISCO	AXS4-61850 ED.1, ED.2		I							P							
	Toshiba	GRL200 ED.1, ED.2								P								
	Triangle Microworks	Anvil ED.1, ED.2																
		Hammer ED.1																
	ZIV	7IRVA3N406B ED.1		P														

Table 28: Results for Test Bit exchange via GOOSE

4.6 Simulation Bit Exchange (Simulation transition to true)

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

Test Case Description:	The subscriber is placed into simulation (LPHD.sim = TRUE) mode. The publisher sends either the FCD or FCDA GOOSE with the simulation bit set.
Expected Result:	The subscriber indicates that it has received and understood the GOOSE simulation bit and has processed the data in the dataset.

Actual results:

		Publishers																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2																
	Alstom	P14DZ ED.1																
	AMA	61850-ServerSim ED.1																
	EFACEC	TPUS220 ED.1																
	GE	850 ED.2																
	INGETEAM	INGEPAC EF ED.1., ED.2																
	Omicron	IEDScout ED.1, ED.2																
	Omicron	ISIO 200 ED.1																
	RTDS	GTnet-GSE ED.1																
	Schweitzer	421-5 ED.1																
	Siemens	SIPROTEC4 Compact ED.2																
	SISCO	AXS4-61850 ED.1, ED.2																
	Toshiba	GRL200 ED.1, ED.2																
	Triangle Microworks	Anvil ED.1, ED.2																
		Hammer ED.1																
	ZIV	7IRVA3N406B ED.1																

Table 29: Results for Simulation Bit= TURE exchange via GOOSE

4.7 Simulation Bit Exchange (Simulation transition to true, ignore due to Mode)

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

Test Case Description:	The subscriber is placed into (LPHD.sim = FALSE) operational mode. The publisher sends either the FCD or FCDA GOOSE with the simulation bit set.
Expected Result:	The subscriber ignores/does not process the incoming DataSet information for information that is included in a GOOSE that has the simulation bit set.

Actual results:

		Publishers																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2	■															
	Alstom	P14DZ ED.1		■														
	AMA	61850-ServerSim ED.1			■													
	EFACEC	TPUS220 ED.1				■												
	GE	850 ED.2					■											
	INGETEAM	INGEPAC EF ED.1., ED.2						■										
	Omicron	IEDScout ED.1, ED.2							■	■								
	Omicron	ISIO 200 ED.1							■	■								
	RTDS	GTnet-GSE ED.1									■							
	Schweitzer	421-5 ED.1										■						
	Siemens	SIPROTEC4 Compact ED.2											■					
	SISCO	AXS4-61850 ED.1, ED.2												■				
	Toshiba	GRL200 ED.1, ED.2													■			
	Triangle Microworks	Anvil ED.1, ED.2														■	■	
		Hammer ED.1														■	■	
	ZIV	7IRVA3N406B ED.1																■

Table 30: Results for Simulation Bit exchange where IED is not in the correct Mode

4.8 Time Allowed to Live Detection

4.8.1 Normal TAL Detection

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

Test Case Description:	The transmission of the published GOOSE is interrupted.
Expected Result:	The subscribing IED detects a TAL expiration and gives some local indication.

Actual results:

		Publishers																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2																
	Alstom	P14DZ ED.1			**P**							**P**		**P**				**P**
	AMA	61850-ServerSim ED.1																
	EFACEC	TPUS220 ED.1						**P**						**P**				**P**
	GE	850 ED.2										**P**						
	INGETEAM	INGEPAC EF ED.1., ED.2									**P**	**P**			**P**			
	Omicron	IEDScout ED.1, ED.2																
	Omicron	ISIO 200 ED.1																
	RTDS	GTnet-GSE ED.1						**P**				**P**		**P**				**P**
	Schweitzer	421-5 ED.1	**P**	**P**			**P**	**P**		**P**			**P**		**P**	**P**		**P**
	Siemens	SIPROTEC4 Compact ED.2																
	SISCO	AXS4-61850 ED.1, ED.2	**P**	**P**							**P**							
	Toshiba	GRL200 ED.1, ED.2						**P**				**P**						**P**
	Triangle Microworks	Anvil ED.1, ED.2																
		Hammer ED.1	**I, N1**															
	ZIV	7IRVA3N406B ED.1		**P**		**P**					**P**	**P**		**P**	**P**			

N1- Test execution inconclusive.

Table 31: Results for Time Allowed to live expiration detection

4.8.2 TAL Detection with Simulation Bit set True

This section contains a brief description of the test case, expected result, and the actual results. This test case is intended to verify the proper implementation of Technical Issue (Tissue) 1151.

Test Case Description:	The subscriber is placed into (LPHD.sim = True) operational mode. Observer should be able to observe/verify that published GOOSE information with simulation bit=TRUE is being received and used.
Expected Result:	The subscriber provides an indication that TAL expiration has been detected.

No test results were recorded for this test case.

4.9 Control Block Enable

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

Test Case Description:	A 61850 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.

Actual results:

		Client																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2															P	
	Alstom	P14DZ ED.1										P						P
	AMA	61850-ServerSim ED.1		P														
	EFACEC	TPUS220 ED.1						P						P				
	GE	850 ED.2																
	INGETEAM	INGEPAC EF ED.1., ED.2													P			
	Omicron	IEDScout ED.1, ED.2																
	Omicron	ISIO 200 ED.1																
	RTDS	GTnet-GSE ED.1												P				
	Schweitzer	421-5 ED.1	P													N1		
	Siemens	SIPROTEC4 Compact ED.2																
	SISCO	AXS4-61850 ED.1, ED.2	P								P							
	Toshiba	GRL200 ED.1, ED.2						P	P									
	Triangle Microworks	Anvil ED.1, ED.2																
		Hammer ED.1	F															
	ZIV	7IRVA3N406B ED.1		P														

N1 – Server did not allow Enable/Disable

Table 32: Results for GOOSE Control Block enabling

4.10 Control Block Disable

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

Test Case Description:	A 61850 client changes the enable of a GOOSE control block from TRUE to FALSE.
Expected Result:	The subscribing IED detects a TAL expiration and gives some local indication.

Actual results:

		Client																
		Company	ABB	Alstom	AMA	EFACEC	GE	INGE-TEAM	Omicron		RTDS	SEL	Siemens	SISCO	Toshiba	Triangle Microworks		ZIV
	Company	Product	670	P14DZ	SIM-G	TPUS220	850	PAC EF	IEDScout	ISIO	GSE	421	SIP.4	AXS4	GRL200	Anvil	Hammer	7IRVA
Subscribers	ABB	670 ED.2															P	
	Alstom	P14DZ ED.1										P						P
	AMA	61850-ServerSim ED.1		P														
	EFACEC	TPUS220 ED.1						P						P				
	GE	850 ED.2																
	INGETEAM	INGEPAC EF ED.1,ED.2													P			
	Omicron	IEDScout ED.1, ED.2																
	Omicron	ISIO 200 ED.1																
	RTDS	GTnet-GSE ED.1												P				
	Schweitzer	421-5 ED.1	N1													N1		
	Siemens	SIPROTEC4 Compact ED.2																
	SISCO	AXS4-61850 ED.1, ED.2	P								P							
	Toshiba	GRL200 ED.1, ED.2						P	P									
	Triangle Microworks	Anvil ED.1, ED.2																
		Hammer ED.1	F															
	ZIV	7IRVA3N406B ED.1		P			N2			N2				P				

N1 – Server did not allow Enable/Disable

N2 –Unexpected Behavior Observed

Table 33: Results for GOOSE Control Block disabling

5 Client Server Specific Results

Company	Product	Client	Server	ED.1	ED.2
ABB	ARF 677		X		X
ABB	Rex670		X		X
Alstom	P60		X	X	
AMA	61850 ServerSim		X	X	
ARC Informatique	PcVue	X		X	X
Efacec	TPUS220		X	X	
GE	850		X		X
INGETEAM	INGEPAC™ EF		X	X	X
Schweitzer Electric	421		X	X	
Siemens	SIPROTEC 4 Compact		X		X
Siemens	SIPROTEC 5		X		X
Toshiba	GRL200		X	X	X
Triangle Microworks	Anvil		X	X	X
Triangle Microworks	SDG		X	X	X
ZIV	7IRV		X	X	
Omicron	IEDScout	X		X	X
ABB	SYS 600	X		X	X
Efacec	AS	X		X	X
Infoteam	StreamX	X		X	
INGETEAM	INGESYS® IT	X		X	X
Siemens	SICAM PAS	X		X	X
SISCO	AXS4-61850	X	X	X	X
Triangle Microworks	Gateway Client	X		X	X
Triangle Microworks	Hammer	X		X	

Table 34: Participating companies and products for client/server testing

Table 34 shows the companies and products that participated in the client/server testing. The table also show if the product supported client-only, server-only, or client-server functionality. The edition of 61850 to which the product claimed support is also shown.

Of the products that were tested as clients, 78% of the clients supported IEC 61850-8-1 Edition 1 and Edition 2. This support gives a strong indication that utilities should be able to protect their investment in Edition 1 systems while migrating to Edition 2. This migration/protection would be accomplished through the deployment of clients that support both editions. However, SCL support for mixed edition SASs is still an issue and is in the SCL issues list that has been forwarded to the User Feedback Taskforce to have IEC TC57 WG10 resolve the issue.

Of the fourteen (14) servers, 64% were Edition 2 implementations with the remaining 36% being Edition 1 only. There were 28% (4 of 14) servers that claimed support for both Edition 1 and Edition 2. These percentages give a strong indication that the support for Edition 2 is increasing.

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.
	Indicates that an ED.2/ED.1 test combination was tested.

Table 35: Legend for Client/Server test results

5.1 SCL

5.1.1 Client imports Server addressing information from SCL Import

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. Testing begins without any client configuration of a server.** **2. Client selects the server (IED) with which the test is being conducted from the SCD file using local means.** **3. 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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										P
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1			P							
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P	P	
	Schweitzer	421-5 ED.1	P					P		P		
	Siemens	SIPROTEC4 Compact ED.2	P	P								
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.1, ED.2		P								
	Toshiba	GRL200 ED.1, ED.2					P					P
	Triangle Microworks	Anvil ED.1					P					
		Anvil ED.2	P	P					P			
		SDG ED.1										
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	P	P						I		

Table 36: Client/Server results for SCL configuration of network addressing

5.1.2 Configure Server Object Models in Client using SCD

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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										P
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2									P	
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P		
	Schweitzer	421-5 ED.1	P					P		P	P	
	Siemens	SIPROTEC4 Compact ED.2	P	P		P						
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2										P
	Triangle Microworks	Anvil ED.1						P				
		Anvil ED.2	P	P					P			
		SDG ED.1										
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	P	P						I		

Table 37: Client/Server results for Client configuration of Server objects via SCD

5.1.3 Client knowledge of Server Object Model through SCL Import containing a Single IED

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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 (ED.1, ED.2)	PcVue (ED.1, ED.2)	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										P
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1			P							
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P	P	
	Schweitzer	421-5 ED.1	P					P		P		
	Siemens	SIPROTEC4 Compact ED.2	N1	P								
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2					P					
	Triangle Microworks	Anvil ED.1	P									
		Anvil ED.2		P					P			
		SDG ED.1				P						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	P	P						I		

N1- IID file was missing IP Address of Server.

Table 38: Client/Server results for Client configuration of Server objects via SCL IID/CID files

5.1.4 Equivalency of Server Object Models from SCL vs ACSI 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 5.1.3 and that configured via ACSI services are equivalent.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 (ED.1, ED.2)	PcVue (ED.1, ED.2)	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										P
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1			P							
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P		
	Schweitzer	421-5 ED.1						P		P N2		
	Siemens	SIPROTEC4 Compact ED.2			P							
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2		P								
		SDG ED.1				P,N1						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1		P, N1						I		

N1- Client did not support alternate access for arrays. Server contained an array.

N2 – Attempted to compare ED.2 imported SCD vs ED.1 ACSI discovery. Indicates issues in expressing ED.1 object definitions in ED.2 SCL.

Table 39: Client/Server results for Client configuration of Server Equivalency

5.1.5 Configure Report Control Block Subscriptions for SCD file

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

Test Case Description:	**1. IEDs provide an ICD/IID file** **a. IEC61850 Client with its IP address** **b. IEC61850 Server** **2. SCT is configuring reports** **a. Based on server service capabilities:** **i. New DataSets can be added, or existing can be changed** **ii. New RCB can be added, or existing attributes can be changed** **b. Available ClientLN can be mapped to configured RCBs** **i. Information about ClientLN added to the RCB, e.g. similar to <ClientLN iedName="Client" apRef=" desc=""/>** **ii. Input section with ExtRef can be added to the LN of the Client** **3. SCT is providing SCD file to SCT of Client tool** **4. SCT of Client tool is configured with the IP address provided.** **5. SCT 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** **6. ICT is loading the server** **7. 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** **b. If Resv attribute not set, a Client with another IP address can connect**
Expected Result:	The Client is connecting to the server, enabling the reports with the configured attributes and retrieving he reports according to the RCB settings.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P,N1		
	Schweitzer	421-5 ED.1						P				
	Siemens	SIPROTEC4 Compact ED.2										
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	Anvil ED.1					P					
		Anvil ED.2	P						P			
		SDG ED.1										
		SDG ED.2								I,N2		
	ZIV	7IRVA3N406B ED.1								I		

N1- Some private information needed to be removed from SCL file prior to import. N2 – Selection of incorrect RCB occurred.

Table 40: Client/Server test results for Report Control Block Subscriptions for SCD file

5.1.6 Client detection of mismatch between SCL Model and actual Server

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, DataSet, TrgOps and OptFields** **3. Modify the SCD file and configure mismatches for the data attributes listed above. Additionally disallow ACSI writing of RCB attributes by setting "ReportSettings" to "conf".** **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.** **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

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED1, ED.2	PcVue (ED.1, ED.2)	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										P
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2										
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2		P								
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2										
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1	P									

Table 41: SCL test results for Client/Server model mismatch

5.2 Reads

5.2.1 FCD

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

Test Case Description:	This test case summarizes three (3) tests: A. There is one FCD that every Server must support and that is the Beh attribute of LN0. The client shall issue a read for the Beh attribute of at least one LN0. B. The client will issue a read for a FCD of FC=MX that contains an Integer value. C. The client will issue a read for a FCD of FC=MX that contains a Float32.
Expected Result:	A. The client value of the server's LN0.Beh.stval (FC=ST) shall match. B. The client value of the server's Integer value shall match. C. The client value of the server's FloatingPoint value shall match within possible rounding errors.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P,N1						P
	Alstom	P60 Agile ED.1	P	P								
	AMA	61850-ServerSim ED.1			P,N1	P, N1		p				
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P, N2		
	Schweitzer	421-5 ED.1	P			P,N1		P		P		
	Siemens	SIPROTEC4 Compact ED.2	P, N1	P		P,N1						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2		P, N1								
	Toshiba	GRL200 ED.1, ED.2				P, N1,N2				P		P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2	P,N1	P,N1								
		SDG ED.1				P, N1						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	P,N1	P,N1						P, N1		

N1 – Client did not support alternate access capability. N2 – Server did not support alternate access

Table 42: Client/Server test results for reads of FCDs

5.2.2 FCDA

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

Test Case Description:	This test case summarizes two(2) tests: A. The client will issue a read for a FCDA of FC=ST that contains an SPS value. B. The client will issue a read for a FCDA of FC=ST that contains a DPS value.
Expected Result:	A. The client value of the server's stVal value shall match. B. The client value of the server's stVal value shall match.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P						P
	Alstom	P60 Agile ED.1	P	P								
	AMA	61850-ServerSim ED.1			P	P		P				
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P		
	Schweitzer	421-5 ED.1	P			P		P		P		
	Siemens	SIPROTEC4 Compact ED.2	P	P		P						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2				P				P		P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2	P	P								
		SDG ED.1				P						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	P	P						P		

Table 43: Client/Server test results for reads of FCDAs

5.3 DataSets

5.3.1 Reading DataSet Values

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

Test Case Description:	Perform GetDataSetValues on any predefined dataset. For Edition 2 implementations add: Perform GetDataSetValues on a dataset that defines an FCDA using the indexing feature.
Expected Result:	The client values for the members of the data set should match those of the server.

Actual results:

			Clients										
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P						P
	Alstom	P60 Agile ED.1		P								
	AMA	61850-ServerSim ED.1				P		P				
	Efacec	TPU S220 ED.1									P	
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P	P	
	Schweitzer	421-5 ED.1				P		P		P	P	
	Siemens	SIPROTEC4 Compact ED.2		P		P						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850		P								
	Toshiba	GRL200 ED.1, ED.2				P				P		P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2		P								
		SDG ED.1				P, N1						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1		P						P		

N1 – Client did not support alternate access capability could not read individual array elements.

Table 44: Client/Server test results for reads of predefined DataSets

5.3.2 Dynamic DataSets

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

Test Case Description:	**This test case consist of two(2) tests:** A. Create a Dynamic DataSet with at least 4 members. With at least one member being an FCD Expected Result: DataSet on server is defined correctly. **B.** DeleteDataSet just created.
Expected Result:	A. DataSet on server is defined correctly. B. Server removes data**set**

Actual results:

			Clients										
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										
	Alstom	P60 Agile ED.1	P,N3									
	AMA	61850-ServerSim ED.1				P		P				
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2										
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2	P			P						
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2	I, N2									
		SDG ED.1				P, N1						
		SDG ED.2								I,N4		
	ZIV	7IRVA3N406B ED.1										

N1 – Client did not support alternate access capability could not read individual array elements. N2 – Creation was a success, deletion failed.
N3 – Issued found with Client. N4 – constraint in client for when dynamic dataset creation is available.

Table 45: Client/Server test results for reads of Dynamic DataSets

5.4 Buffered Reporting

5.4.1 Enabling Control Blocks

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

Test Case Description:	**The client will write 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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P						P
	Alstom	P60 Agile ED.1	P	P								
	AMA	61850-ServerSim ED.1			P	P		P				
	Efacec	TPU S220 ED.1									P	
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P	P	
	Schweitzer	421-5 ED.1	P			P		P		P	P	
	Siemens	SIPROTEC4 Compact ED.2	P	P		P						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2				P	P, N1			P		P
	Triangle Microworks	Anvil ED.1					P			P		
		Anvil ED.2	P	P								
		SDG ED.1				P						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	P	P								

N1 – Comment indicated enable every report available in the server when starting do not use RCB/RptEnabled/ClientLN

Table 46: Client/Server results of enabling BRCB tests

5.4.2 Resynchronization

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. The client will write and enable a buffered report control block with a resynchronization value (entryID).
Expected Result:	The client should begin receiving reports and shall give some indication that reports are being received.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P						P
	Alstom	P60 Agile ED.1	P	P								
	AMA	61850-ServerSim ED.1			P	P		P				
	Efacec	TPU S220 ED.1									P	
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P	P	
	Schweitzer	421-5 ED.1	P			P		P		P	P	
	Siemens	SIPROTEC4 Compact ED.2	P	P		P						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2				P				P		P
	Triangle Microworks	Anvil ED.1					P					
		Anvil ED.2	P	P								
		SDG ED.1				P						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	P	P						I		

Table 47: Client/Server test results for BRCB resynchronization

5.4.3 Purging

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. The client will purge the buffer write and enable a buffered report control block with a resynchronization value.
Expected Result:	The client should begin receiving reports and shall give some indication that reports are being received. No old values should be received.

Actual results:

			Clients										
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P						P
	Alstom	P60 Agile ED.1	P	P								
	AMA	61850-ServerSim ED.1			P	P		P				
	Efacec	TPU S220 ED.1									P	
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P	I	
	Schweitzer	421-5 ED.1	P			P		P		P	P	
	Siemens	SIPROTEC4 Compact ED.2	P	P		P						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2				P				P		P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2										
		SDG ED.1				P						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	I	P						P		

Table 48: Client/Server test results for BRCB purging

5.5 UnBuffered Reporting

5.5.1 Enabling Control Blocks

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

Test Case Description:	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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P						
	Alstom	P60 Agile ED.1	P	P								
	AMA	61850-ServerSim ED.1			P	P		P				
	Efacec	TPU S220 ED.1									P	
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P	P	
	Schweitzer	421-5 ED.1	P			P		P		P	P	
	Siemens	SIPROTEC4 Compact ED.2	P			P						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2				P				N1		P
	Triangle Microworks	Anvil ED.1					P					
		Anvil ED.2	P	P								
		SDG ED.1				P						
		SDG ED.2								P		
	ZIV	7IRVA3N406B ED.1	P	P						P		

N1 – Partial Success

Table 49: Client/Server test results for URCB purging

5.6 Controls

5.6.1 Direct Control with normal security

5.6.1.1 With 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 direct control action indication on the server is reset. The FCD configuration is for Direct Operate.** **Client issues a direct control to the server that is enabled for remote control to the same state that the control is currently in.**
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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1, ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P, N4		P						P
	Alstom	P60 Agile ED.1	P	P, N4								
	AMA	61850-ServerSim ED.1			N3	P		P				
	Efacec	TPU S220 ED.1									P	
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								I, N2	P	
	Schweitzer	421-5 ED.1	P			P		P		P	P	
	Siemens	SIPROTEC4 Compact ED.2	P	I		P						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2				P				P		
	Triangle Microworks	Anvil ED.1				P	P					
		Anvil ED.2	P	P		P						
		SDG ED.1					P					
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1	P, N1	P						P		

N1- issue with test case encountered regarding the use of addCause N2 – No remote enable was possible, only with direct change in the server.
N3 – Server did not refuse control that had the same state value. N4 – Add Cause not displayed

Table 50: Client/Server test results for Direct Control with Server enabled for remote control

5.6.1.2 With 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 FCD configuration is for Direct Operate. Client issues a direct control to the server that is enabled for 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 if addCause is supported by client. Witness to note whether addCause is indicated.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P,N2		P						P
	Alstom	P60 Agile ED.1		P,N2								
	AMA	61850-ServerSim ED.1			P	P		P				
	Efacec	TPU S220 ED.1									P	
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2									P	
	Schweitzer	421-5 ED.1				P				I		
	Siemens	SIPROTEC4 Compact ED.2	P			P						
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2				P				P,N1		P
	Triangle Microworks	Anvil ED.1					P					
		Anvil ED.2	P	P								
		SDG ED.1				P						
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1	P, N1	P						P		

N1- issue with test case encountered regarding the use of addCause N2 – Did not display AddCause

Table 51: Client/Server test results for Direct Control with Server disabled for remote control

5.6.2 Select Before Operate (SBO) with enhanced security

5.6.2.1 With 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 direct control action indication on the server is reset. The FCD configuration is for Select Before Operate with Enhanced Security. Client issues a SBOE control to the server that is enabled for remote control to the same state that the control is currently in.
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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED., ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P						P
	Alstom	P60 Agile ED.1	P	P				P				
	AMA	61850-ServerSim ED.1			N2	P						
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								N1	P	
	Schweitzer	421-5 ED.1	P					P				
	Siemens	SIPROTEC4 Compact ED.2	P	P		P						
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2				P						P
	Triangle Microworks	Anvil ED.1				P	P					
		Anvil ED.2	P	P								
		SDG ED.2										
		SDG ED.1										
	ZIV	7IRVA3N406B ED.1	P	P						P		

N1– No remote enable was possible, only with direct change in the server. N2 – Server did not reject control with same value.

Table 52: Client/Server test results for SBOE with Server enabled for remote control

5.6.2.2 With 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 FCD configuration is for Select Before Operate with Enhanced Security.** **Test Case: Client issues a SBOE control to the server that is enabled for 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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED., ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1, ED.2	Gateway Client ED.1,ED.2 Client	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P		P						P
	Alstom	P60 Agile ED.1	P	P								
	AMA	61850-ServerSim ED.1			I,N3	P		P				
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P, N1	P	
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2	P			P						
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2				P				P		P
	Triangle Microworks	Anvil ED.1					P					
		Anvil ED.2	P	P								
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1	P	P								

N1 – unable to display addCause. Client received, processed, but did not display. N3 – Server issue incorrect addCause.

Table 53: Client/Server test results for SBOE with Server disabled for remote control

5.6.2.3 Cancellation

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. The FCD configuration is for Select Before Operate with Enhanced Security.** **Test Case: Client issues a SelectWithValue request to the server that is enabled for remote control 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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2		P								P
	Alstom	P60 Agile ED.1	P									
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2										
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2	P			P						
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2				P						P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2	P	P								
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1	P	P						I		

Table 54: Client/Server test results for SBOE cancellation

5.7 File Services

5.7.1 Directory

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

Test Case Description:	**Client performs a GetServerDirectory[File] {i.e. it needs no information other than server name}** **Server returns (at least) all files in root directory** **Client performs "whatever it takes" to retrieve the directory of other files** • **Server returns list of names suitable for requesting a file read (open/read/read/close)** • **Verifications:** o **All file "visible through 61850" are included in the list** o **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")**
Expected Result:	The directory entries will be correctly displayed by the client.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2				N1						P
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1				P						
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P		
	Schweitzer	421-5 ED.1	N1			P						
	Siemens	SIPROTEC4 Compact ED.2	P									
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2				P				P		P
	Triangle Microworks	Anvil ED.1					P					
		Anvil ED.2	P									
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1	P							I		

N1- Problem detected in client

Table 55: Client/Server test results for FileDirectory

5.7.2 GetFile

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

Test Case Description:	This test case shall verify that a client can transfer a file from the server using ACSI GetFile services. Procedure: 1. The file(s) to be read from the server will be determined using one or both of the following means: a. The server will provide written specification of the FileName(s) (as defined in IEC 61850-7-2) to be transferred during the test; and/or b. Upon successful completion of the File Directory test above (10.2) the FileName(s) retrieved shall be used as the FileName(s) for the File Read test. 2. The client will then execute the GetFile service for the specified file(s) via some local means and store that file on a filestore local to the client.
Expected Result:	The file(s) will be successfully transferred without error.

Actual results:

			Clients										
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2				N1						P
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1				P						
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P		
	Schweitzer	421-5 ED.1	N1			P						
	Siemens	SIPROTEC4 Compact ED.2	P									
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2				P				P		P
	Triangle Microworks	Anvil ED.1					P					
		Anvil ED.2	P									
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1	P							P		

N1 – Problem detected in Client

Table 56: Client/Server test results for GetFile

5.7.3 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. Client will send the file and then compare the file and use directory service to verify the file size.**
Expected Result:	The file names and sizes should match.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P		
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2										
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2										
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1										

Table 57: Client/Server test results for FileWrite

5.8 GOOSE

5.8.1 Read Control Blocks

The Client/Server testing of GOOSE control blocks is restricted to the reading of the GOCB. The test results for enabling GOOSE control blocks was performed as part of the GOOSE testing. Specific results regarding control of a GOCB can be found on page 4-17.

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

Test Case Description:	**The client shall be able to read the GOOSE control block structure.**
Expected Result:	The information read by the client should match that of the server.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2				P						P
	Alstom	P60 Agile ED.1	P									
	AMA	61850-ServerSim ED.1			P	P		P				
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P		
	Schweitzer	421-5 ED.1	P			P		P		P		
	Siemens	SIPROTEC4 Compact ED.2				P						
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2		P								
	Toshiba	GRL200 ED.1, ED.2				P						P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2	P									
		SDG ED.1				P						
		SDGED.2										
	ZIV	7IRVA3N406B ED.1	P							P		

Table 58: Client/Server test results of reading GOOSE Control Blocks

5.9 Sampled Values

5.9.1 Read MSVCB Control Blocks

The Client/Server testing of MSVCB control blocks is restricted to the reading of the MSVCB. There was no testing, as part of SV testing, of enabling of a MSVCB.

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

Test Case Description:	**The client shall be able to read the Multicast Sampled Value Control block structure.**
Expected Result:	The information read by the client should match that of the server.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue (ED.1, ED.2)	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2										
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2										
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2	P									
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1										

Table 59: Client/Server test results of reading MSVCB

5.10 Logging

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

Test Case Description:	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.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2										
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2										
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850										
	Toshiba	GRL200 ED.1, ED.2				I						P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2										
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1										

Table 60: Client/Server test results for LCB

5.11 Settings Group

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

Test Case Description:	Available SGCB are imported via SCL The used setting-group "ActSG"is read. If the number of SettingGroup is higher than 1, the user can select another group and request to switch it.
Expected Result:	New settings are now active in the server. The Client can verify the new activated SG.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600 ED.1, ED.2	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1,ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2				P						
	Alstom	P60 Agile ED.1	P									
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2								P		
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2										
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850										
	Toshiba	GRL200 ED.1, ED.2				P				P		P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2										
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1	P							P		

Table 61: Client/Server test results for Settings Groups

5.12 Substitution (Adhoc Testing)

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

Test Case Description:	The client uses the substitution service.
Expected Result:	Server uses the substituted value as part of its processing.

Actual results:

			Clients										
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600	PcVue (ED.1, ED.2)	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850 ED.1, ED.2	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2										
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2										
		SIPROTEC5 ED.2								P		
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2										
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2										
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1										

Table 62: Client/Server test results for Substitution

5.13 Tracking Control (ED.2 Servers Only)

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

Test Case Description:	**Enable a control referencing a DataSet containing tracking (SR) nodes. Perform a valid control write and an invalid control write. Expected Results: Expected Results: Receive a report of the valid control access, receive a report showing error on the invalid access.** **Test Case: Write a SBO, Oper then write and Oper without SBO**
Expected Result:	Receive a report of the valid access, receive a report showing error.

Actual results:

			Clients									
		Company	ABB	ARC Informatique	EFACEC	INGETEAM	Infoteam	OMICRON	Siemens	SISCO	Triangle Microworks	
Servers	Company	Product	SYS 600	PcVue ED.1, ED.2	AS ED1, ED2	INGESYS® IT ED.1, ED.2	StreamX ED.1	IEDScout ED.1,ED.2	SICAM PAS ED.1,ED.2	AXS4-61850	Gateway Client ED.1,ED.2	Hammer ED.1
	ABB	ARF 677 ED.2										
	ABB	REx670 ED.2										
	Alstom	P60 Agile ED.1										
	AMA	61850-ServerSim ED.1										
	Efacec	TPU S220 ED.1										
	GE	850 ED.2										
	INGETEAM	INGEPAC™ EF ED.1,ED.2										
	Schweitzer	421-5 ED.1										
	Siemens	SIPROTEC4 Compact ED.2										
		SIPROTEC5 ED.2										
	SISCO	AXS4-61850 ED.2										
	Toshiba	GRL200 ED.1, ED.2										P
	Triangle Microworks	Anvil ED.1										
		Anvil ED.2	P									
		SDG ED.1										
		SDG ED.2										
	ZIV	7IRVA3N406B ED.1										

Table 63: Client/Server test results for Edition 2 tracking service

6 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 2011 in Paris. The purpose of testing networking devices is to show interoperability between vendors of networking devices compliant to IEC 61850-3. The scope of the interoperability testing is a set of features of layer 2 Ethernet switches that are relevant to IEC 61850 based communication networks typical for electrical substations.

Other advanced features such as IGMP, NAT, cyber security, etc., are out of scope of this test.

The participants for network testing were: ABB, Cisco; RuggedCom; Schweitzer; and Siemens. Not all companies participated in all tests. Participants for the individual test campaigns can be found within each testing section.

6.1 RSTP

There are three basic network topologies that apply to the testing of Rapid Spanning Tree Protocol (RSTP). These are:

- Single Ring
- A main ring with sub-rings
- A main ring with a mesh

Figures depicting the basic topologies follow.

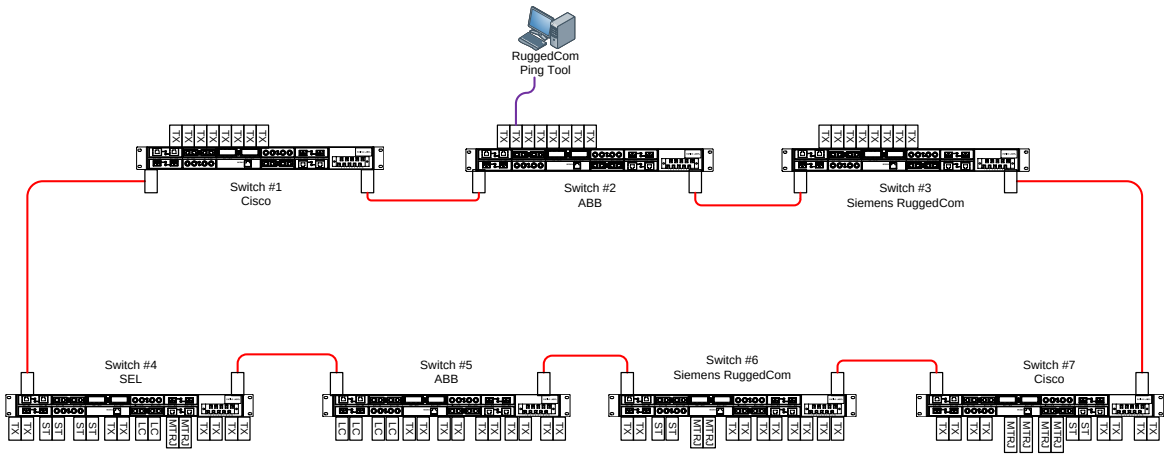


Figure 40: Network testing topology 1 - Single Ring

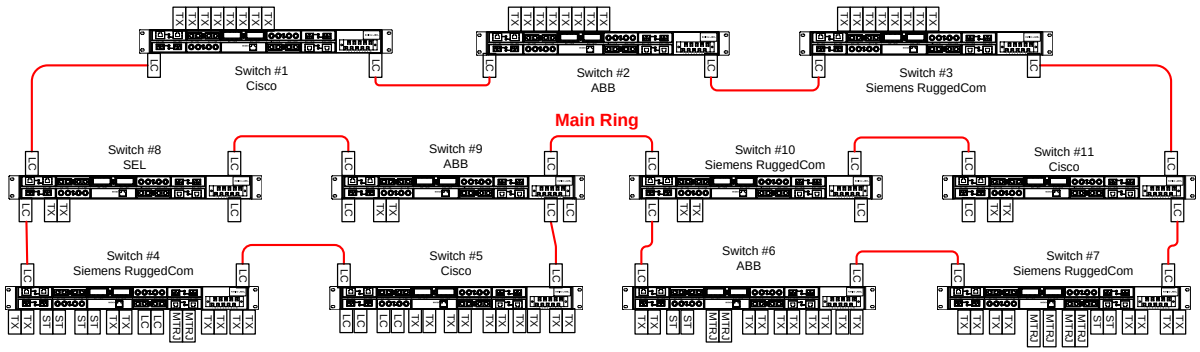


Figure 41: Network testing topology 2 - Main ring with two sub-rings

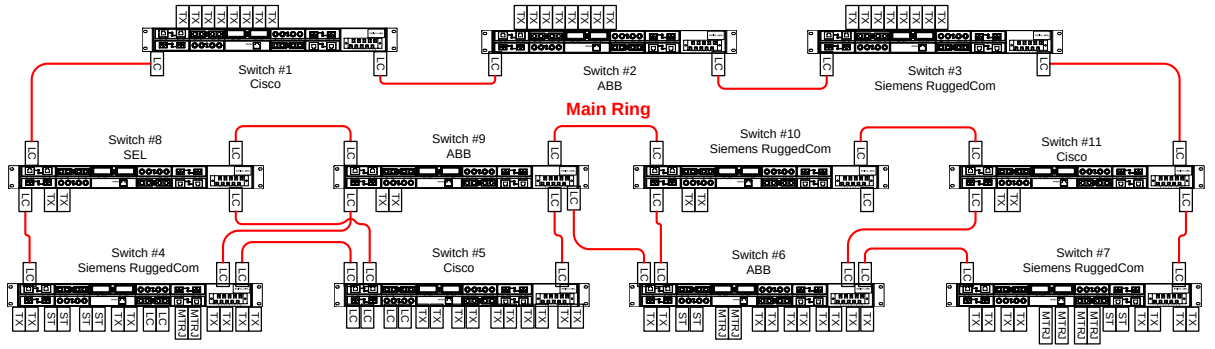


Figure 42: Network testing topology 3 - Main ring with Mesh

The test setup and results can be found in the following sections. The focus of the tests is to measure the latencies and recovery time (called convergence time) should the rings be disrupted.

The following were the participants for RSTP testing: ABB, Cisco; RuggedCom; and Schweitzer.

6.1.1 Interoperability Test Plan for Topology 1- Single Ring

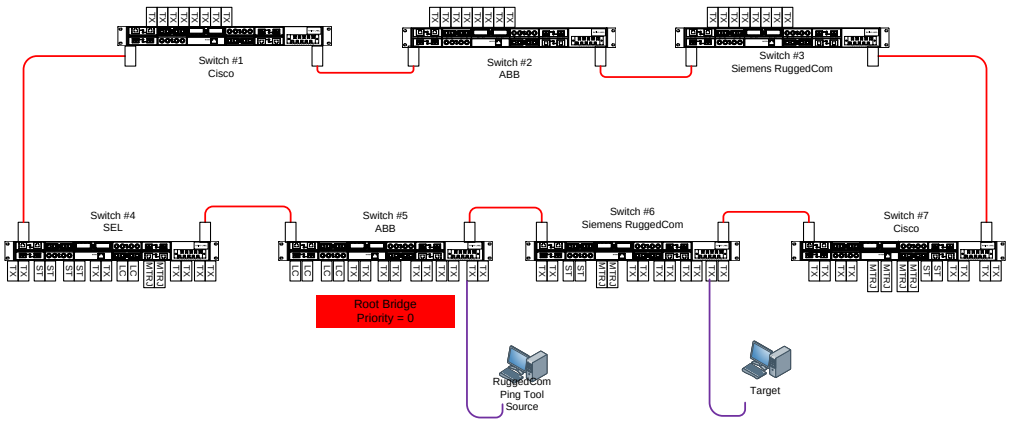


Figure 43: Network testing topology- Single ring topology with monitoring PCs and RSTP Root Bridge as switch #5

The setup configuration of the switches/ring is:

- All switches shall have the standard RSTP protocol enabled and other proprietary or non-standard enhancements to RSTP shall be disabled.
- Enable at least 1 Mirror port on every switch on copper 100BaseTX port

The test methodology consists of measuring the recovery time as measured by two monitoring PCs running specialized ping applications:

- Consists on having two monitoring PCs connected to the same switches as the IEDs in Method a)
- The source PC is connected to switch #5 and is running a free tool called RuggedPing. RuggedPing is a high accuracy graphical ping tool capable of processing incoming ping responses with a granularity of 1ms.
- The source PC is configured to Ping the destination PC connected to switch #6 with 4ms interval

6.1.1.1 RSTP Convergence Time upon Link Failure

Purpose of the test:

- Test the network reconfiguration behavior in case of single link failure
- Test the network reconfiguration behavior in case of link reconnection

Test actions:

- Disconnect link between the root bridge and the neighboring bridge on the right
- Disconnect link between the root bridge and the neighboring bridge on the left

- Repeat the each test three times to see variations
- Then change the position of the root bridge to test all switches in the topology configured as root bridge

Note: Failure of links directly connected to the root bridge are expected to result in the worst network recovery time.

Example of the procedure with Root bridge at Switch#5:

- Configure Switch#5 as the Root Bridge in the network by setting the Bridge Priority = 0
- Start Communication between IEDs
- Connect one PC to Switch#5 and another PC to Switch#6 in the network
- Install RuggedPing in the Source PC connected to Switch#5
- IP Address Assignment for the source and Destination PCs
  Source PC: 192.168.33.250 /24

  Destination PC: 192.168.33.251

- Use RuggedPing to Ping the Destination PC connected to Switch#6 with 4 ms interval

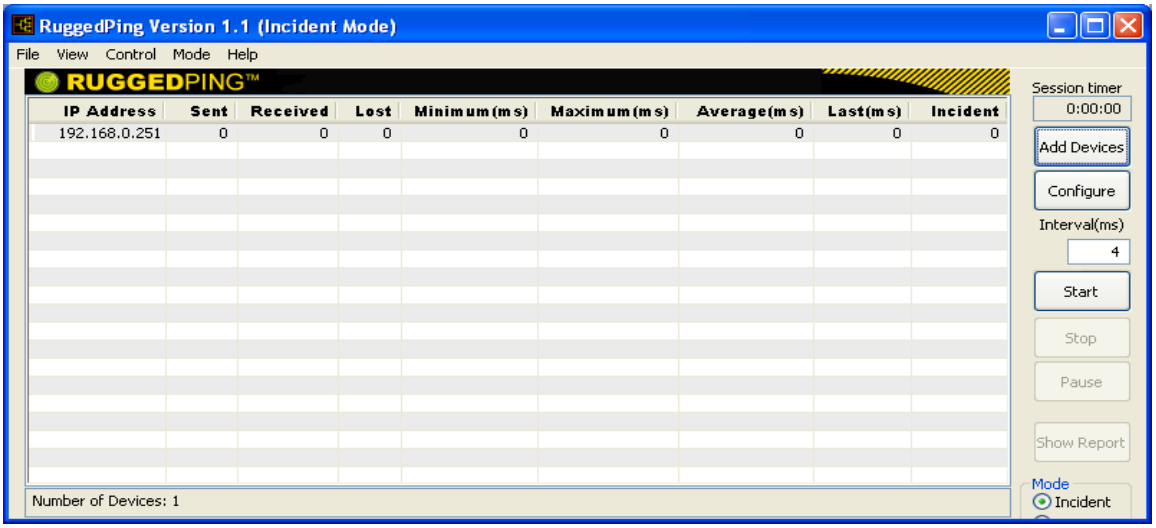


Figure 44: Screenshot of RuggedPing graphical ping tool

- Disconnect the link between Switch#5 and Switch#6 during the traffic flow

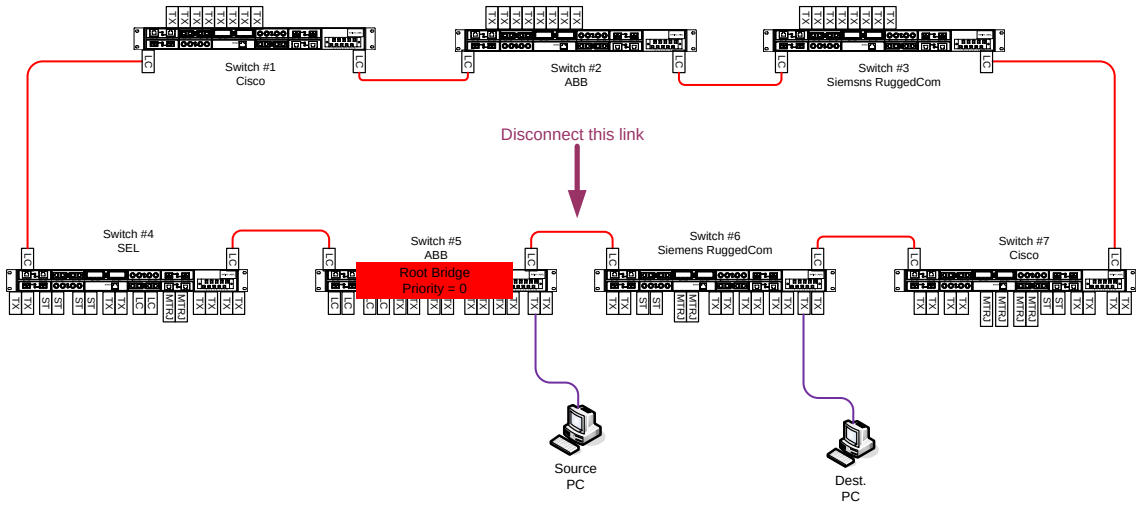
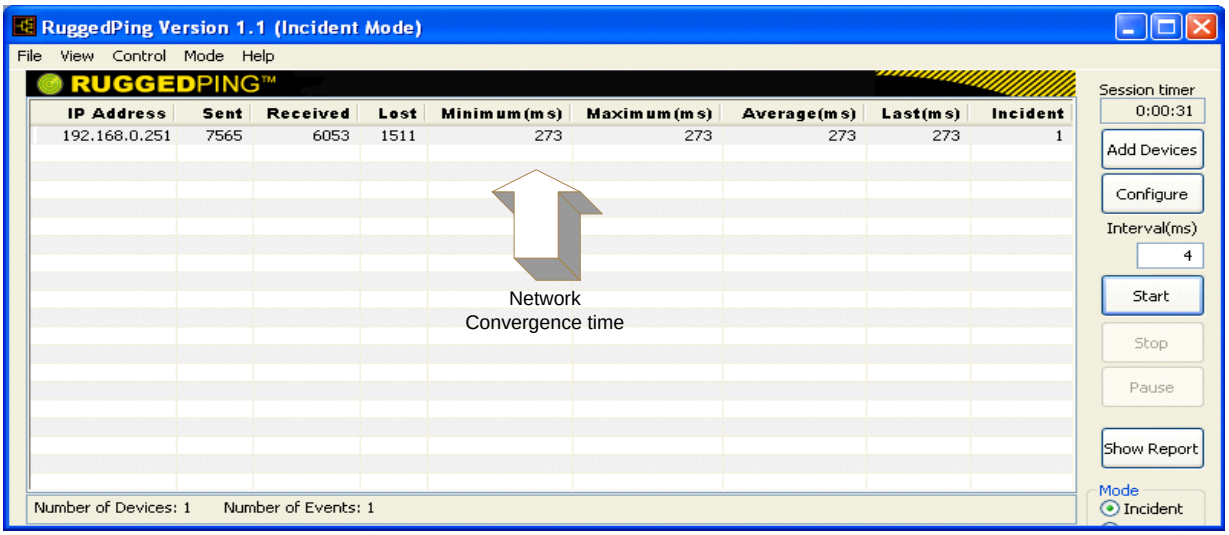


Figure 45: Network testing topology- Single ring topology with link disconnected between Switch#5 and Switch#6

- Stop RuggedPing and record the network failover time.



- Check the communication between IEDs
- Stop and Start RuggedPing and reconnect the link between Switch#5 and Switch#6 and measure the network recovery time.
- Verify the communication between IEDs
- Change the location of the Destination PC from Switch#6 to Switch#4
- Continue the test by disconnecting the link between Switch#4 and Switch#5

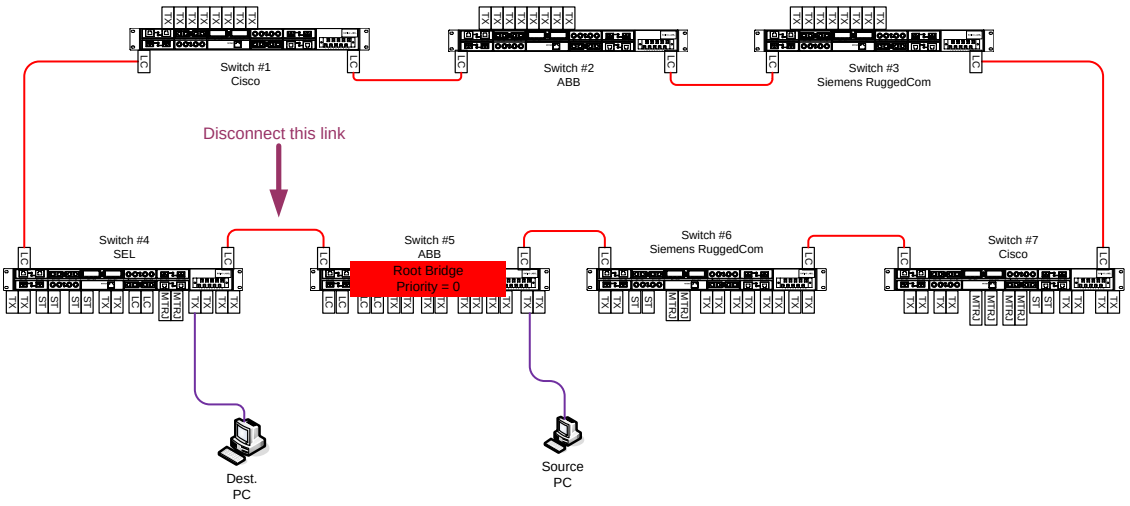


Figure 46: Network testing topology- Single ring topology with link disconnected between Switch#4 and Switch#5

- Measure the network failover time using RuggedPing and verify the communication between IEDs
- Restart RuggedPing and reconnect the link between Switch#4 and Switch#5
- Measure the network recovery time and verify the communication between IEDs
- Finally do a test disconnecting a link that is not on the shortest path e.g. by disconnecting the link between Switch#1 and Switch#2

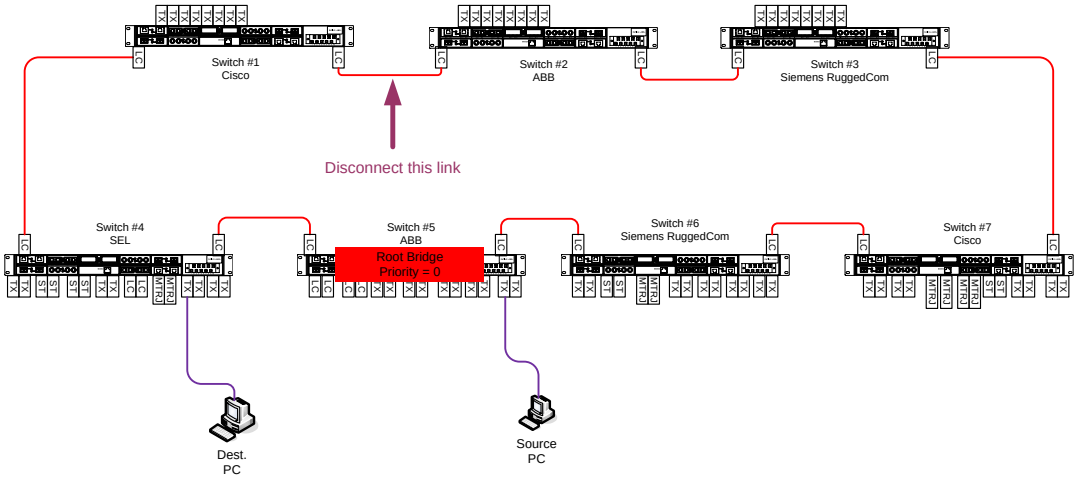


Figure 47: Network testing topology- Single ring topology with link disconnected between Switch#1 and Switch#2

- Verify that there is no frame loss in RuggedPing

Table 64 details the test configuration and results for the testing of Switch #1/Cisco as the Root Bridge.

Test Setup				
Switch ID	Function	Priority	Ping	**Comments**
SW1	Root	0	Source PC	
SW2	-	4096	Dest PC	
SW3	-	8192		
SW4	-	12288	**Dest PC**	**Changed from SW7 to match physical set-up**
SW5	-	12288		
SW6	-	8192		
SW7	**-**	**4096**		

Test Results					
		Failover/Recovery Time [ms]			**Comments**
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.4.1.1	Disconnect link between SW1 and SW2	4349	5540		**436 + 555 lost packages**
3.4.1.2	Reconnect link between SW1 and SW2	90	10		**10 + 2 lost packages**
3.4.1.3	Change Dest PC to SW**4**. Disconnect link between SW1 and SW**4**	4330	5030		**434 + 504 lost packages**
3.4.1.4	**Reconnect link between SW1 and SW4**	**60**	**60**		**7 + 7 lost packages**

Table 64: Test results for RSTP testing on Single Ring with Switch#1/Cisco as Root Bridge

Table 65 details the test configuration and results for the testing of Switch #2/ABB as the Root Bridge.

Test Setup				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW2	Root	0	Source PC	
SW3	-	4096	Dest PC	
SW4	-	8192		
SW5	-	12288		
SW6	-	12288		
SW7	-	8192		
SW1	**-**	**4096**	**Dest PC**	

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.4.2.1	Disconnect link between SW2 and SW3	4900	4650		**491 + 476 lost packages**
3.4.2.2	Reconnect link between SW2 and SW3	10	10		**2 + 2 lost packages**
3.4.2.3	Change Dest PC to SW1. Disconnect link between SW2 and SW1	170	110		**18 + 12 lost packages**
3.4.2.4	**Reconnect link between SW2 and SW1**	**40**	**40**		**5 + 5 lost packages**

Table 65: Test results for RSTP testing on Single Ring with Switch#2/ABB as Root Bridge

Table 66 details the test configuration and results for the testing of Switch #3/RuggedCom as the Root Bridge.

Test Setup				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW3	Root	0	Source PC	
SW4	-	4096		
SW5	-	8192		
SW6	-	12288		
SW7	-	12288	**Dest PC**	Changed to match physical set-up
SW1	-	8192		
SW2	**-**	**4096**	**Dest PC**	

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.4.3.1	Disconnect link between SW3 and SW**7**	1250	100		**126 + 11 lost packages**
3.4.3.2	Reconnect link between SW3 and SW**7**	20	20		**3 + 3 lost packages**
3.4.3.3	Change Dest PC to SW2. Disconnect link between SW3 and SW2	60	40		**7 + 5 lost packages**
3.4.3.4	**Reconnect link between SW3 and SW2**	**10**	**10**		**2 + 2 lost packages**

Table 66: Test results for RSTP testing on Single Ring with Switch#3/RuggedCom as Root Bridge

Table 67 details the test configuration and results for the testing of Switch #4/Schweitzer as the Root Bridge.

Test Configuration				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW4	Root	0	Source PC	
SW5	-	4096	Dest PC	
SW6	-	8192		
SW7	-	12288		
SW1	-	12288	Dest pc	Changed to SW1 instead of SW3 to match physical set-up
SW2	-	8192		
SW3	**-**	**4096**		

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.4.4.1	Disconnect link between SW4 and SW5	5910	5889		**592 + 590 lost packages**
3.4.4.2	Reconnect link between SW4 and SW5	2269	1320		**228 + 133 lost packages**
3.4.4.3	Change Dest PC to SW**1**. Disconnect link between SW4 and SW**1**	100	70		**11 + 8 lost packages**
3.4.4.4	**Reconnect link between SW4 and SW**1	**1469**	**1630**		**148 + 164 lost packages**

Table 67: Test results for RSTP testing on Single Ring with Switch#4/Schweitzer as Root Bridge

Table 68 details the test configuration and results for the testing of Switch #5/ABB as the Root Bridge.

Test Configuration				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW5	Root	0	Source PC	
SW6	-	4096	Dest PC	
SW7	-	8192		
SW1	-	12288		
SW2	-	12288		
SW3	-	8192		
SW4	**-**	**4096**	**Dest PC**	

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.4.5.1	Disconnect link between SW5 and SW6	3265	5270		**Lost packages 655 + 528**
3.4.5.2	Reconnect link between SW5 and SW6	2180	2640		**Reconnection time took 10 ms + 2 more lost packages**
3.4.5.3	Change Dest PC to SW4. Disconnect link between SW5 and SW4	190	479	750	**Lost packages 20 + 49 + 76**
3.4.5.4	**Reconnect link between SW5 and SW4**	**<10**	**10**	**7450**	**Reconnection time was < 10 ms without package lost Reconnection caused 2 lost packages Reconnection caused 746 lost packages**

Table 68: Test results for RSTP testing on Single Ring with Switch#5/ABB as Root Bridge

Table 69 details the test configuration and results for the testing of Switch #6/RuggedCom as the Root Bridge.

Test Configuration				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW6	Root	0	Source PC	
SW7	-	4096	Dest PC	
SW1	-	8192		
SW2	-	12288		
SW3	-	12288		
SW4	-	8192		
SW5	**-**	**4096**	**Dest PC**	

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.4.6.1	Disconnect link between SW6 and SW7	130	120		**14 + 13 lost packages**
3.4.6.2	Reconnect link between SW6 and SW7	15	10		**5 + 2 lost packages**
3.4.6.3	Change Dest PC to SW5. Disconnect link between SW6 and SW5	70	70		**8 + 8 lost packages**
3.4.6.4	**Reconnect link between SW6 and SW5**	**10**	**10**		**2 + 2 lost packages**

Table 69: Test results for RSTP testing on Single Ring with Switch#6/RuggedCom as Root Bridge

Table 70 details the test configuration and results for the testing of Switch #7/Cisco as the Root Bridge.

Test Configuration				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW7	Root	0	Source PC	
SW1	-	4096		
SW2	-	8192		
SW3	-	12288	Dest pc	was originally Sw1, changed to match physical set-up
SW4	-	12288		
SW5	-	8192		
SW6	**-**	**4096**	**Dest PC**	

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.4.7.1	Disconnect link between SW7 and SW**3**	1930	1690		**194 + 170 lost packages**
3.4.7.2	Reconnect link between SW7 and SW**3**	30	30		**4 + 4 lost packages**
3.4.7.3	Change Dest PC to SW6. Disconnect link between SW7 and SW6	1740	1780		**175 + 179 lost packages**
3.4.7.4	**Reconnect link between SW7 and SW6**	**20**	**20**		**3 + 3 lost packages**

Table 70: Test results for RSTP testing on Single Ring with Switch#7/Cisco as Root Bridge

6.1.1.2 RSTP Convergence Time upon Root Bridge Failure

Purpose of the test:

- Test the network reconfiguration behavior in case of root bridge failure
- Test the network reconfiguration behavior when root bridge recovers and reconnects to the topology

Test actions:

- Power off the root bridge and measure the failover time
- Power on the root bridge and measure the recovery time
- Repeat the test three times to see variations

Note: The measuring PCs are located at switches that are neighbors of the root bridge, this represents the worst case scenario**.**

Procedure:

- Configure Switch#2 as the Root Bridge in the network by setting the Bridge Priority = 0, and Switch#1 to be the Backup Root Bridge with Bridge Priority = 4096

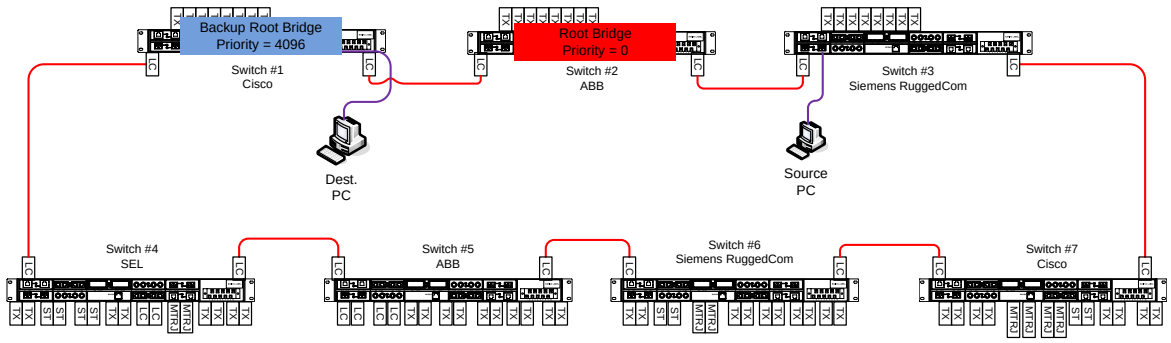


Figure 48: Network testing topology- Root Bridge Failure

- Start communication between IEDs
- Connect one PC to Switch#3 and another PC to Switch#1 in the network
- **Change the priority of the switches according to table 3.5.1 (below)**
- Use RuggedPing to Ping the Destination PC connected to Switch#1 with 4 ms interval
- Power Off the Root Bridge (Switch#2) during the traffic flow and record the failover time from RuggedPing

- Verify the communication between IEDs
- Stop and Start RuggedPing and Power on the Root Bridge
- Record the network recovery time from RuggedPing
- Verify the communication between IEDs

Test Configuration and results with SW2/ABB as main and SW1/Cisco follow:

Test Configuration				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW1	Backup Root	4096	Dest PC	
SW2	Root	0		
SW3	-	32768	Source PC	
SW4	-	32768		
SW5	-	32768		
SW6	-	32768		
SW7	**-**	**32768**		

Test Configuration					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.5.1.1	Power off the root bridge	72722	4860	5220	
3.5.1.2	**Power on the root bridge**		**130**	**50**	**Two outages when powering on the root bridge during test2**

Table 71: Test results for RSTP testing on Single Ring – ABB Root Bridge, Cisco backup Root Bridge

Test results and configuration with SW1/Cisco as main and SW4/Schweitzer as backup follow:

Test Configuration				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW1	Root	0		
SW2	-	32768	Source PC	
SW3	-	32768		
SW4	Backup Root	4096	Dest PC	
SW5	-	32768		
SW6	-	32768		
SW7	**-**	**32768**		

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.5.1.1	Power off the root bridge	5959	5480		
3.5.1.2	**Power on the root bridge**	**50**	**80**		

Table 72: Test results for RSTP testing on Single Ring – Cisco Root Bridge, Schweitzer backup Root Bridge

Test Configuration with SW4/Schweitzer as main and SW5/ABB as backup:

Test Configuration				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW1	-	32768		**Dest PC**
SW2	-	32768		
SW3	-	32768		
SW4	Root	0		
SW5	Backup Root	4096		**Source PC**
SW6	-	32768		
SW7	**-**	**32768**		

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.5.1.1	Power off the root bridge	4700	5529		
3.5.1.2	**Power on the root bridge**	**<100**	**50**		

Table 73: Test results for RSTP testing on Single Ring – Schweitzer Root Bridge, ABB backup Root Bridge

Test Configuration with SW7/Cisco as main and SW6/RuggedCom as backup:

Test Configuration				
Switch ID	**Function**	**Priority**	**Ping**	Comments
SW1	-	32768		
SW2	-	32768		
SW3	-	32768		**Source PC**
SW4	-	32768		
SW5	-	32768		
SW6	Backup Root	4096		**Dest PC**
SW7	**Root**	**0**		

Test Results					
		Failover/Recovery Time [ms]			Comments
Test ID	**Action**	**Test 1**	**Test 2**	**Test 3**	
3.5.1.1	Power off the root bridge	80	80		
3.5.1.2	**Power on the root bridge**	**40**	**80**		

Table 74: Test results for RSTP testing on Single Ring – Cisco Root Bridge, RuggedCom backup Root Bridge

6.1.1.3 Adhoc Tests

Additional adhoc RSTP Tests were performed to investigate long failover times. The following figures depict the test topologies for the additional tests.

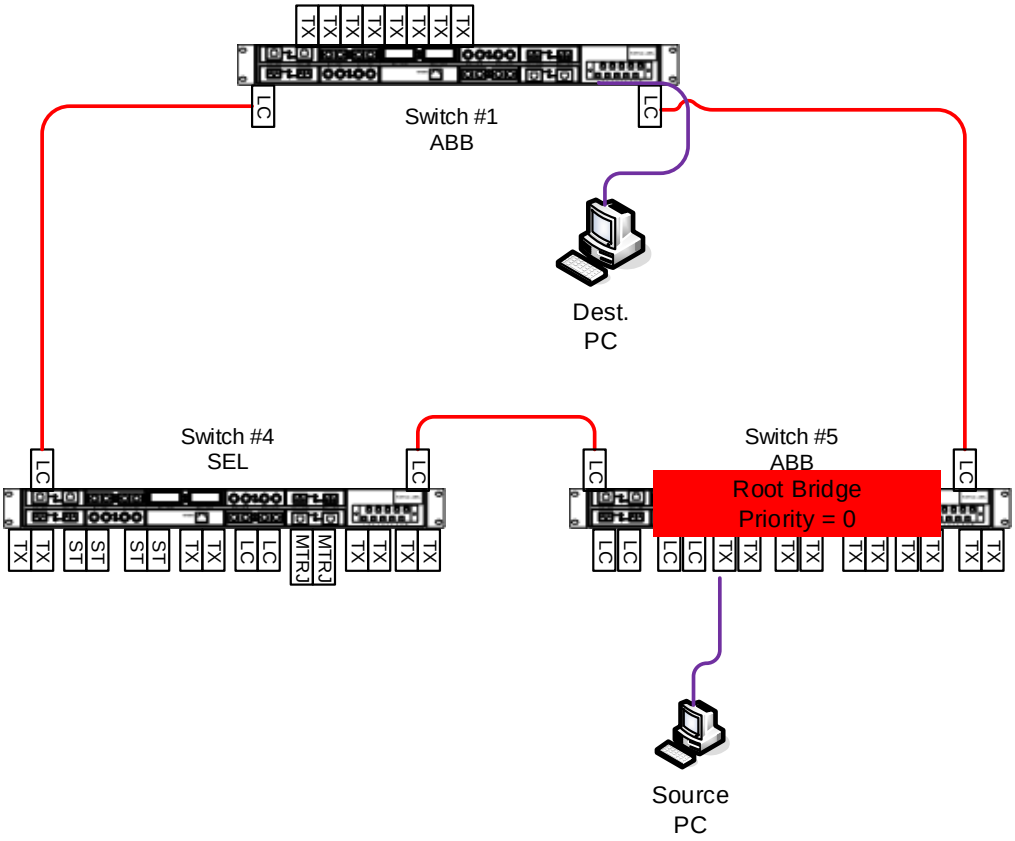
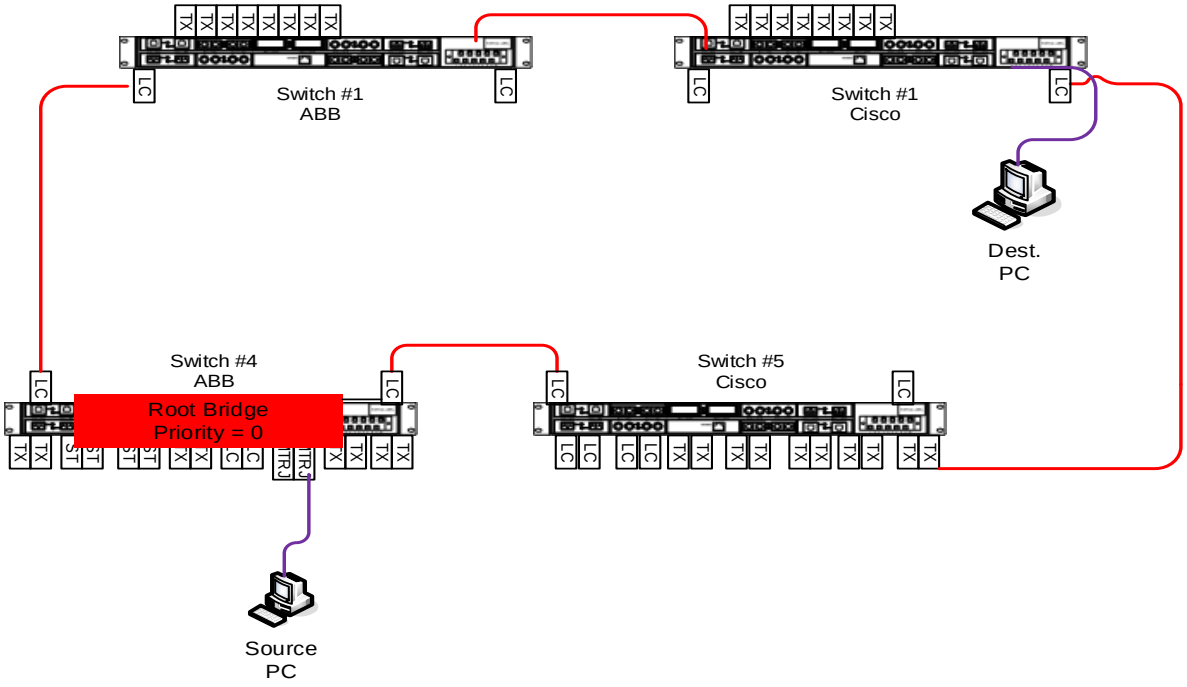
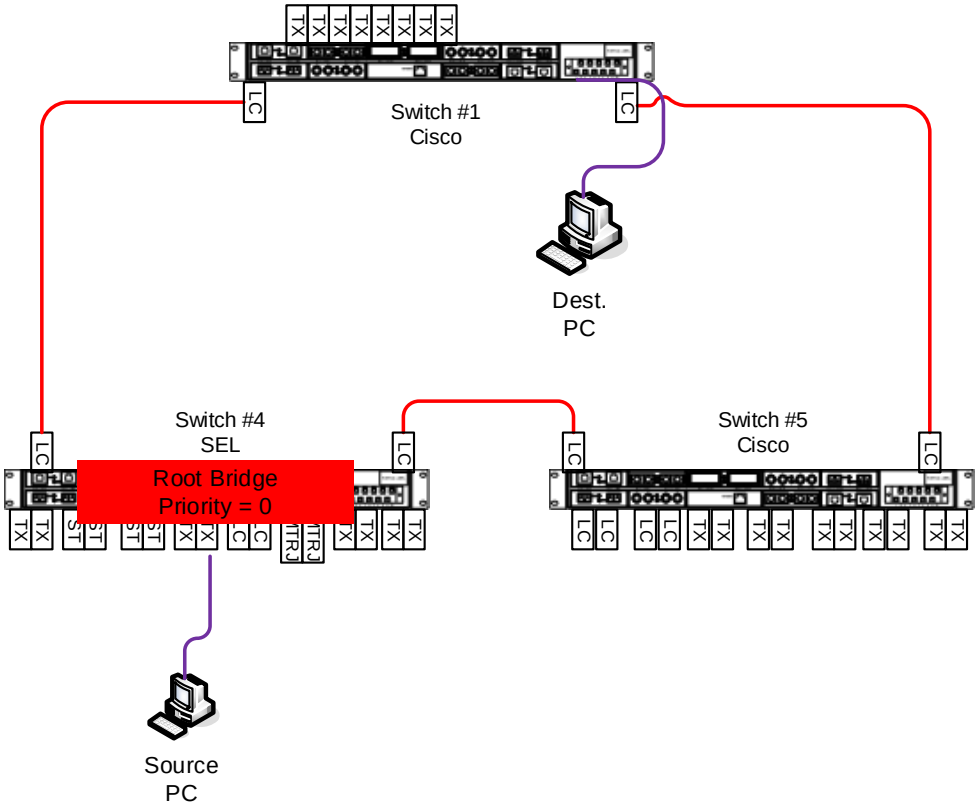


Figure 49: Network RSTP Additional Tests - Topologies for tests 1 and 2


Switch #1
ABB
Switch #1
Cisco
Dest.
PC
Switch #4
ABB
Root Bridge
Priority = 0
Switch #5
Cisco
Source
PC


Switch #1
Cisco
Dest.
PC
Switch #4
SEL
Root Bridge
Priority = 0
Switch #5
Cisco
Source
PC

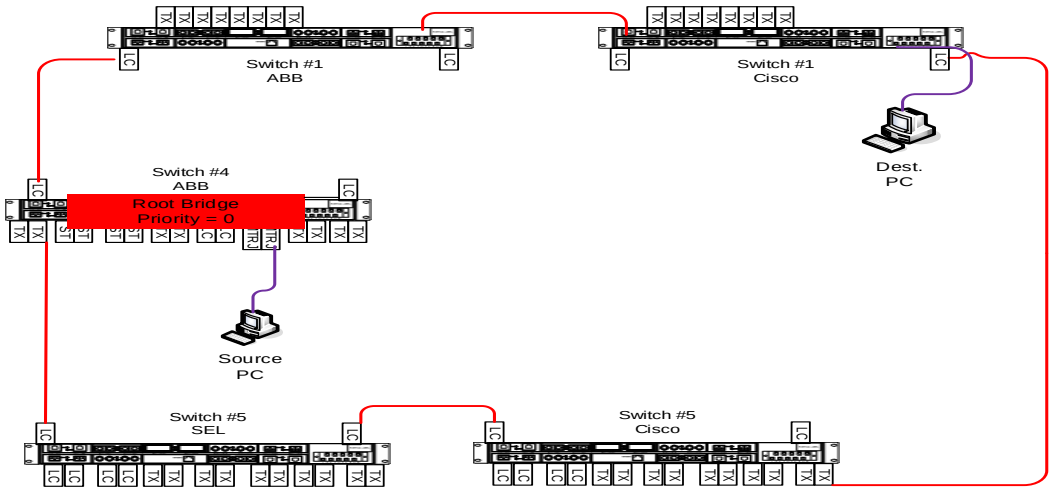


Figure 50: Network RSTP Additional Tests - Topologies for tests 3 and 4

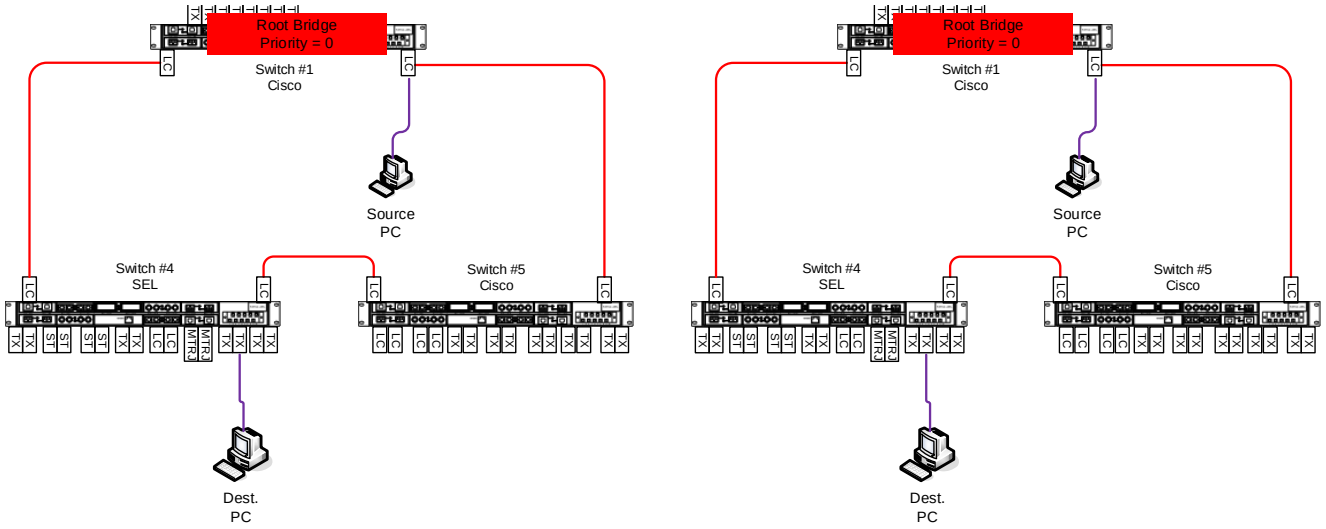


Figure 51: Network RSTP Additional Tests - Topologies for tests 5 and 6

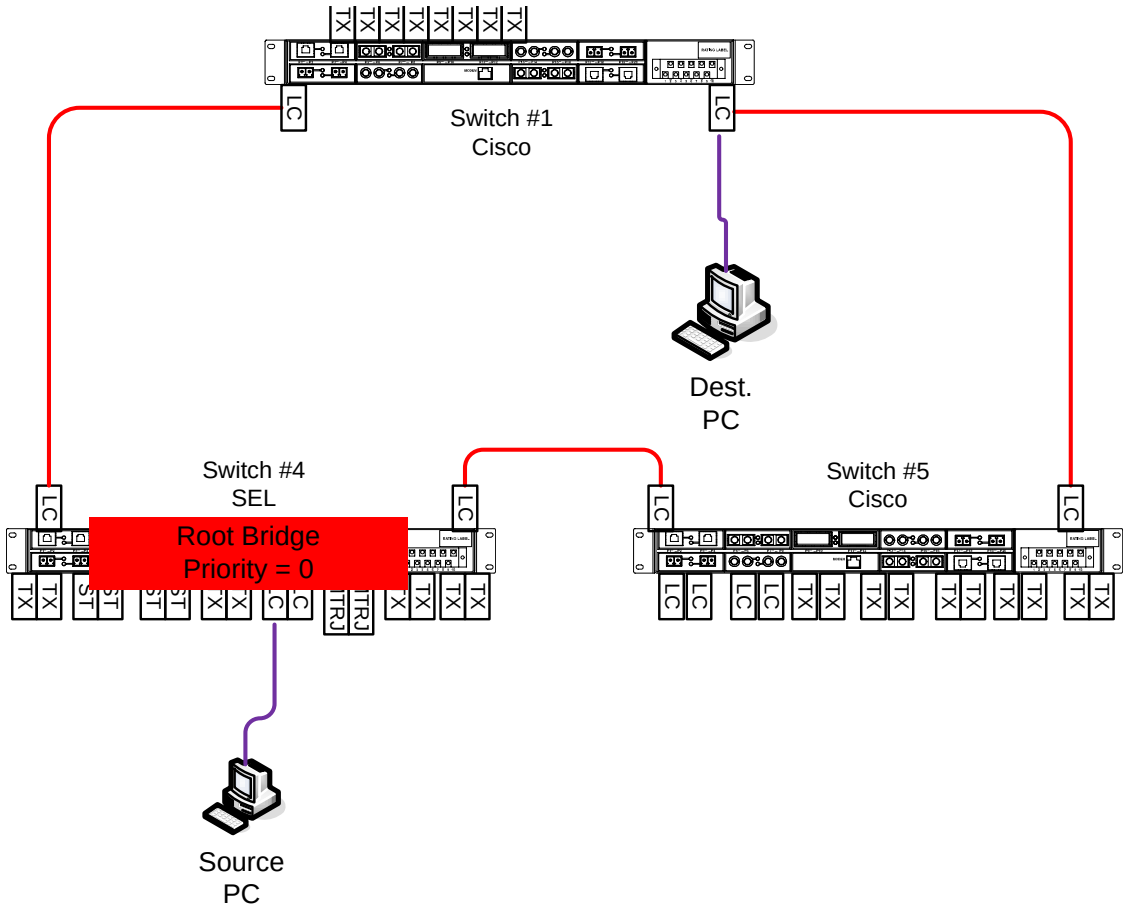


Figure 52: Network RSTP Additional Tests - Topologies for tests 7

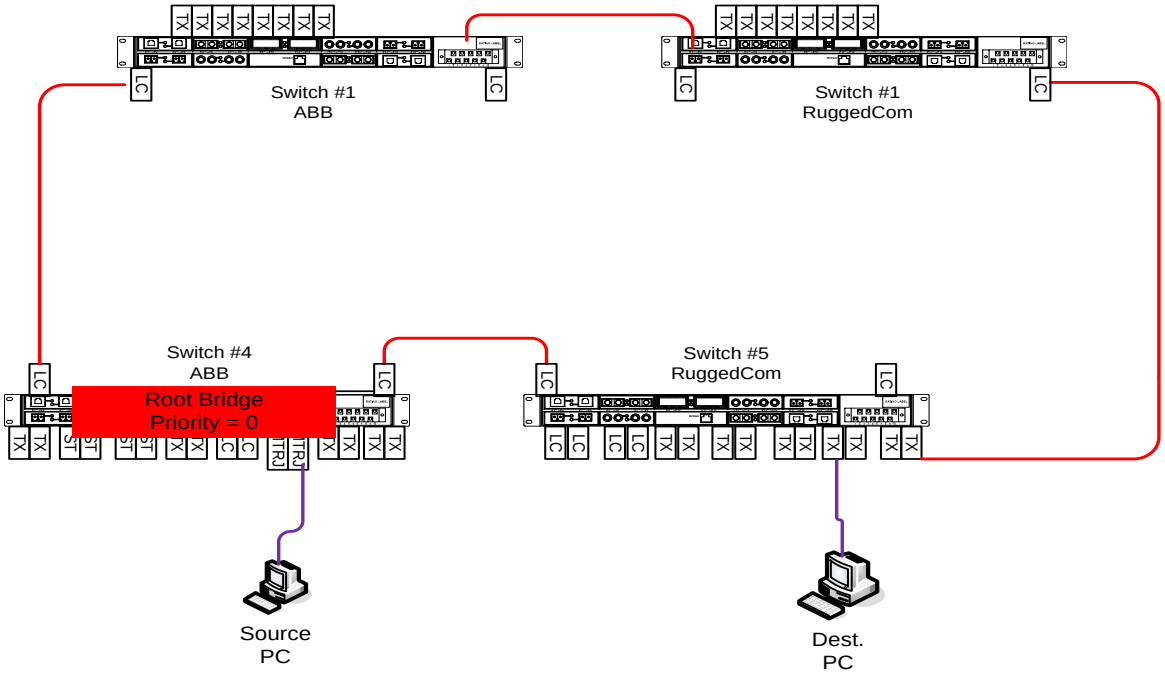


Figure 53: Network RSTP Additional Tests - Topologies for tests 8 and 8a

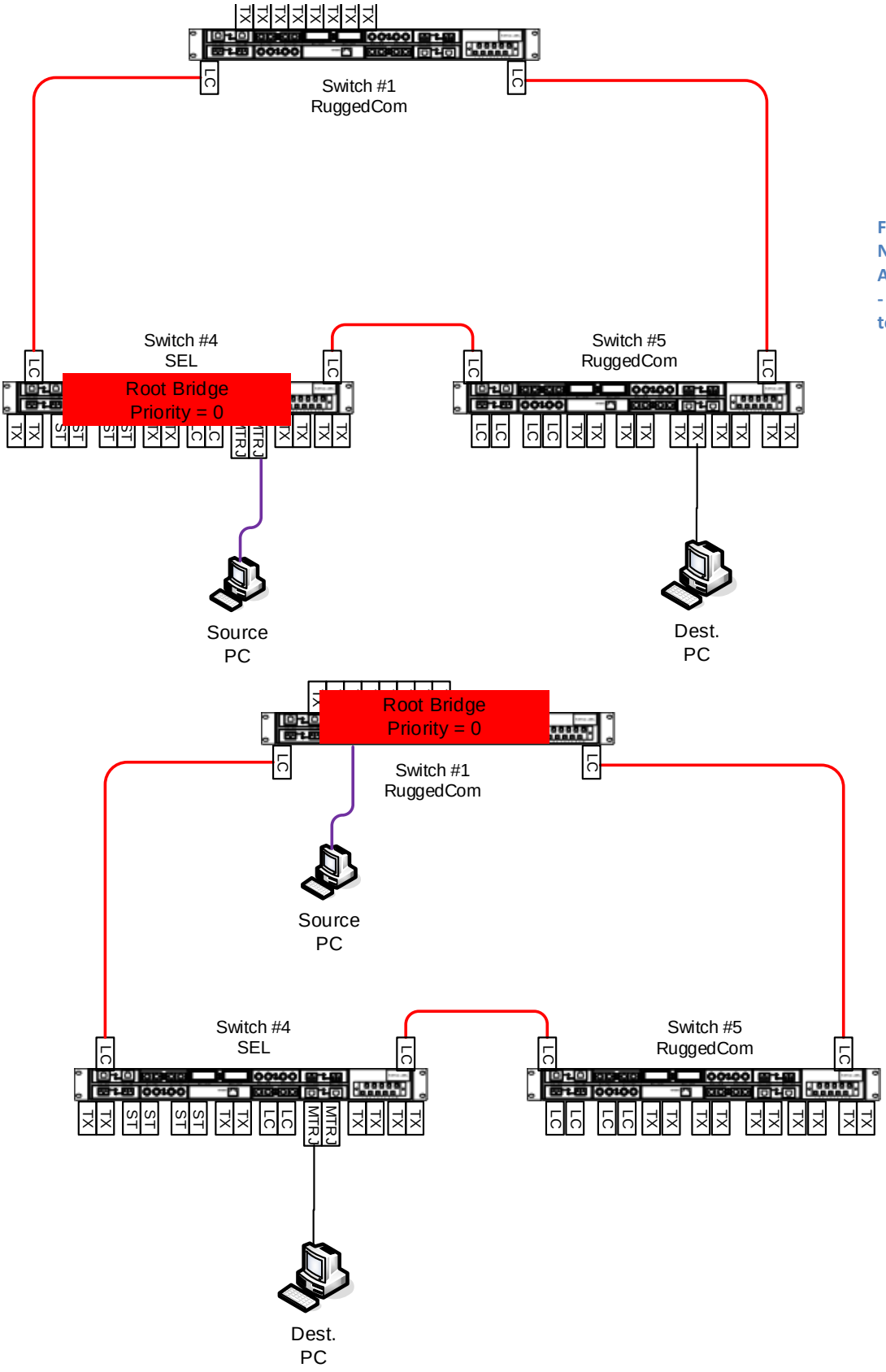


Figure 54: Network RSTP Additional Tests - Topologies for tests 9 and 10

The results of the various diagnostic tests are shown in the following table.

Additional Test Number	Root Bridge	Other Switches	Failover Time (msec)	Recovery Time (msec)
1	ABB	ABB, Schweitzer	20	20
2	ABB	ABB, Cisco, Cisco	30	10
3	ABB	ABB, Cisco, Cisco, Schweitzer	5810, 5470	10
4	Schweitzer	Cisco, Cisco	110, 130	1460, 1399
5	Cisco	Cisco, Schweitzer	460, 660	30, 10
6*	Cisco	Cisco, Schweitzer	20, 90	20, 10
7	Schweitzer	Cisco, Cisco	110, 120, 140	1530, 50, 310
8	ABB	ABB, RuggedCom, RuggedCom	600,20,20	10,10,10
8a (Reboot of switches)	ABB	ABB, RuggedCom, RuggedCom	1860,20,15	10,10,5
9	Schweitzer	RuggedCom, RuggedCom	3310, 3600	>4000, >4000
10	RuggedCom	Schweitzer, RuggedCom	20,10,15,12	10, <10, <10, 3

Table 75: Network RSTP Additional Test Results

Based upon the test results, additional investigation of the RSTP performance of the ABB and Schweitzer switches need to be performed.

6.1.2 Interoperability Test Plan for Topology 2 - with Two Sub-rings

This topology is typical in high voltage substations with the main ring connecting station level devices such as gateways, substation computers running local SCADA or IEC 61850 clients applications. The two subrings are divided per voltage level.

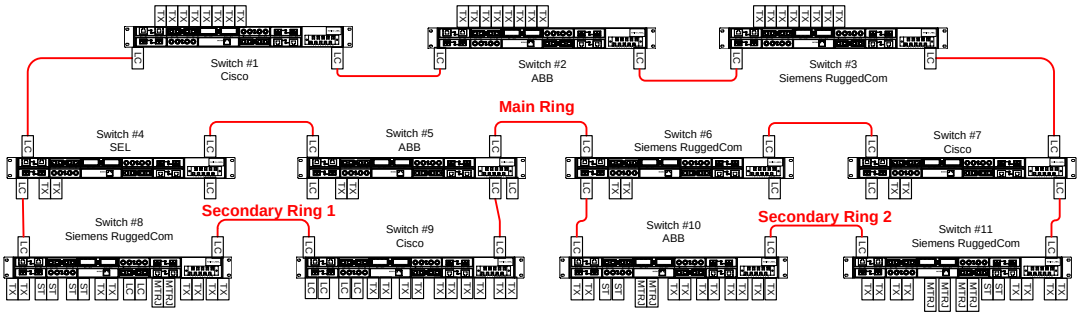


Figure 55: Network testing topology- Single ring topology with two sub-rings

6.1.2.1 RSTP Convergence Time upon Link Failure (procedure only)

Purpose of the test:

- Test the network reconfiguration behavior in case of single link failure
- Test the network reconfiguration behavior in case of link reconnection

Test actions:

- Disconnect selected link
- Repeat the each test three times to see variations
- Then change the position of the root bridge to test different locations of the root bridge and backup root bridge

There were no tests executed for this particular test campaign, therefore the following documents the procedure for testing a Root Bridge at Switch 5 with the backup root bridge being Switch 6.

Sample test process

Procedure:

- From the previous test change the RSTP Bridge Priority of the Root Bridge and the Backup Root Bridge to be the default (Priority = 32768)
- Configure Switch#9 as the Root Bridge in the network by setting the Bridge Priority = 0 and Switch#10 as the backup Root Bridge with Priority = 4096

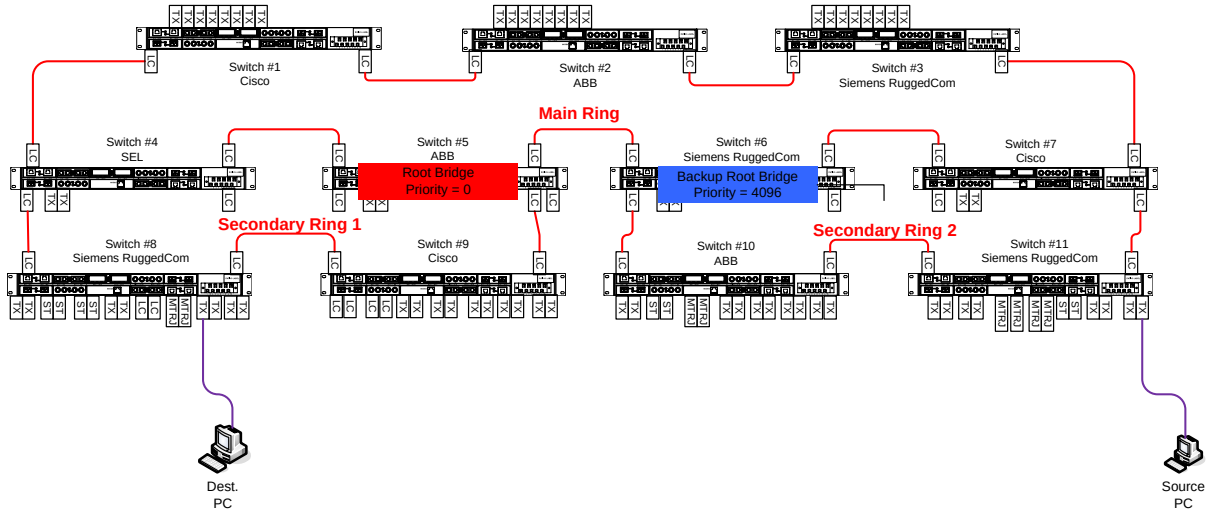


Figure 56: Network testing topology- Single ring topology with two sub-rings with two Root Bridges

- Start communication between IEDs
- Connect one PC to Switch#8 and another PC to Switch#11 in the network
- Use RuggedPing in the Source PC connected to Switch#11
- Use RuggedPing to Ping the Destination PC connected to Switch#8 with 4 ms interval
- Disconnect the cable between Switch#5 and Switch#6 during the traffic flow

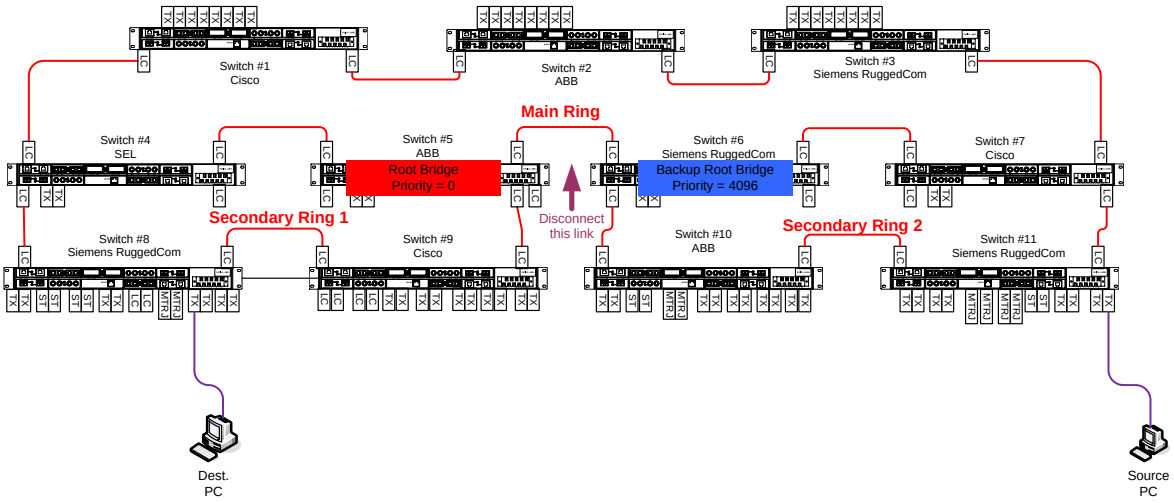


Figure 57: Network testing topology- Single ring topology with two sub-rings with two Root Bridges - Main ring disconnect

- Verify the communication between IEDs
- Stop RuggedPing and record the network failover time
- Restart RuggedPing and reconnect the cable between Switch#5 and Switch#6 and measure the network recovery time.
- Verify the communication between IEDs

6.1.2.2 RSTP Convergence Time upon Root Bridge Failure (procedure only)

Purpose of the test:

- Test the network reconfiguration behavior in case of root bridge failure
- Test the network reconfiguration behavior when root bridge recovers and reconnects to the topology

Test actions:

- Power off the root bridge and measure the failover time
- Power on the root bridge and measure the recovery time
- Repeat the test three times to see variations

Procedure:

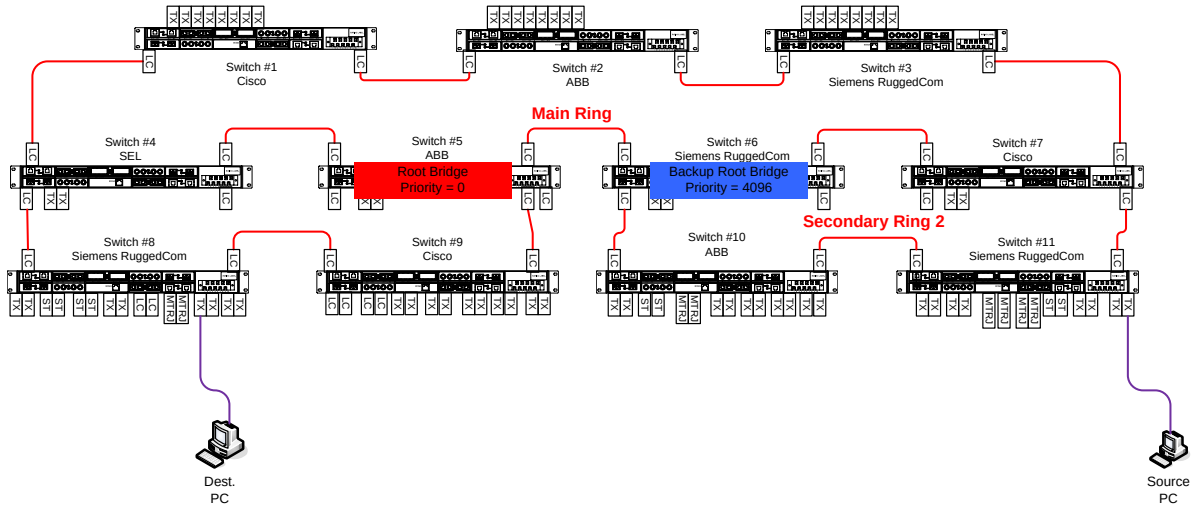


Figure 58: Network testing topology- Single ring topology with two sub-rings with two Root Bridges - Root Bridge Failure

- Configure Root bridge as switch #5, Backup Root bridge as switch #6, Source PC at switch #11 and Destination PCs at switch #5.
- Start communication between IEDs
- Use RuggedPing to Ping the Destination PC connected to Switch#8 with 4 ms interval
- Power Off the Root Bridge (Switch#9) during the traffic flow and record the failover time from RuggedPing.
- Verify the communication between IEDs
- Stop and Start RuggedPing and Power on the Root Bridge
- Record the network recovery time from RuggedPing
- Verify the communication between IEDs

No tests were executed for this configuration.

6.2 Interoperability Test Plan for Topology 3 - Main Ring with Mesh

This section details the test procedures and results for the Main Ring with Mesh.

Use topology 2 as a base and add additional links between the switches in the network as shown on Figure 3.

6.2.1 RSTP Convergence Time upon Root Bridge Failure (procedure only)

Root bridge failure in meshed topology is characterized by a non-deterministic failover and recovery time. In some situations in highly meshed networks the failover or recovery time can be in the range of several hundreds of milliseconds.

Purpose of the test:

- Test the network reconfiguration behavior in case of root bridge failure in the meshed topology
- Test the network reconfiguration behavior when root bridge recovers and reconnects to the topology

Test actions:

- Power off the root bridge and measure the failover time
- Power on the root bridge and measure the recovery time
- Repeat the test three times to see variations

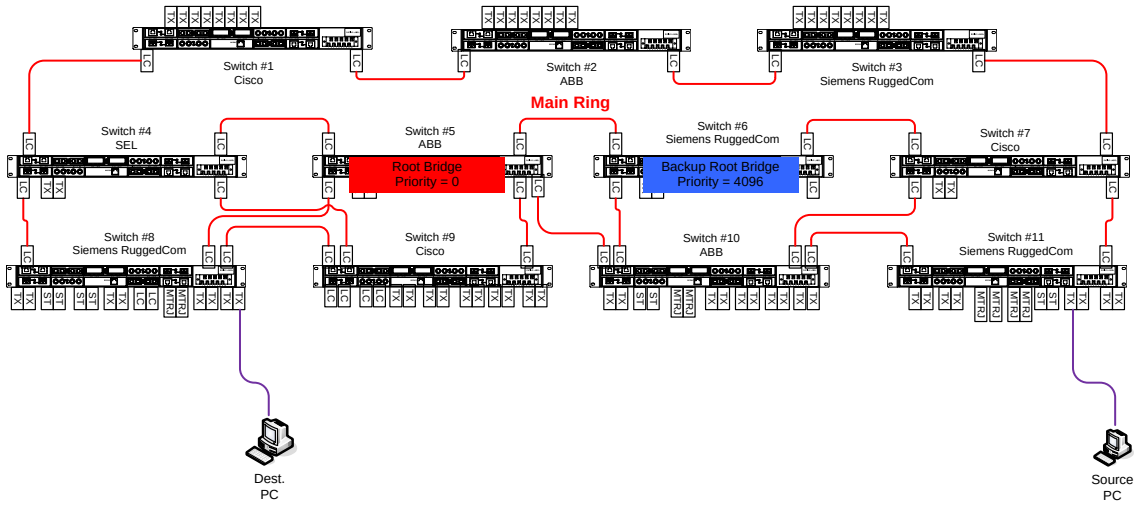


Figure 59: Network testing topology- Single ring topology with mesh and two Root Bridges - Disconnect

- Configure Root bridge as switch #9, Backup Root bridge as switch #5, Source PC at switch #11 and Destination PCs at switch #8.
- Start communication between IEDs
- Use RuggedPing to Ping the Destination PC connected to Switch#8 with 4 ms interval

- Power Off the Root Bridge (Switch#9) during the traffic flow and record the failover time from RuggedPing.
- Verify the communication between IEDs
- Stop and Start RuggedPing and Power on the Root Bridge
- Record the network recovery time from RuggedPing
- Verify the communication between IEDs

Repeat the above test several times annotating the recovery time.

Changing the location of destination PC to switch #4. Repeat the above test several times annotating the recovery time

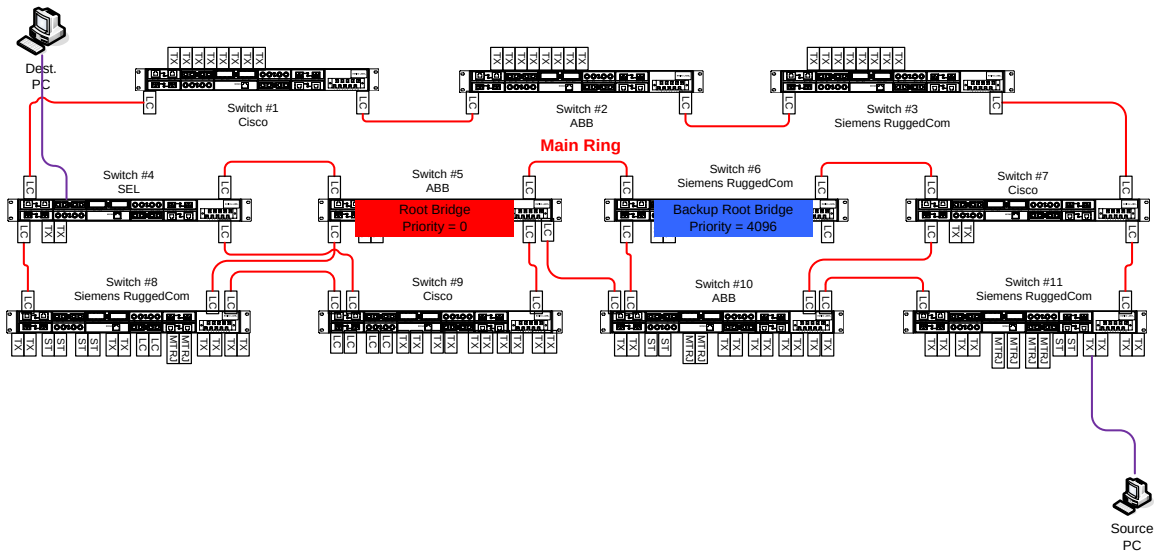


Figure 60: Network testing topology- Single ring topology with mesh and two Root Bridges – Disconnect Position #2

There were no tests executed for this test campaign.

6.3 HSR Interoperability Testing

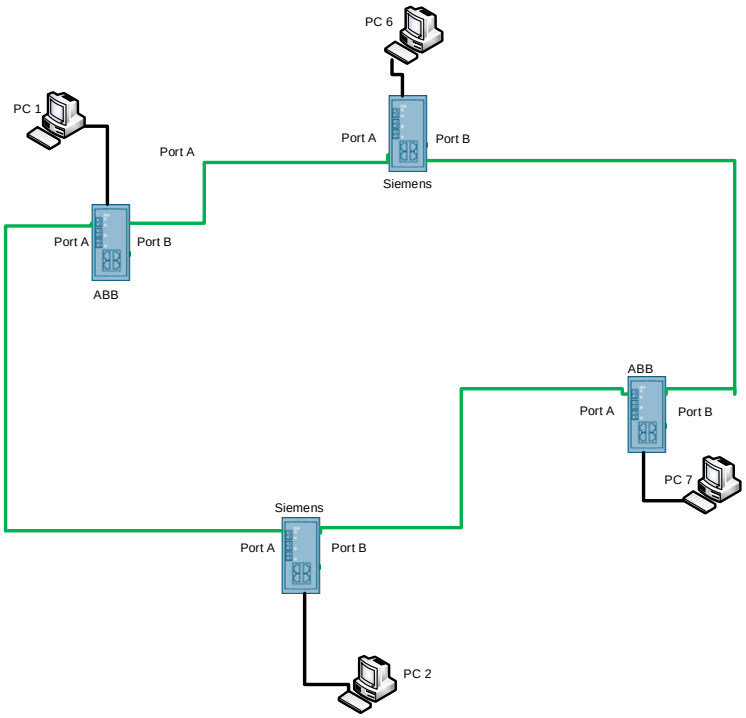


Figure 61: Testing topology for HSR

The participants for HSR testing were “red boxes” supplied by ABB and Siemens.

6.3.1 Test Setup

- HSR switches are connected in a ring topology using port A and B as shown.
- PC1, PC2, PC3 and PC4 are connected to the local port.
- PCs are representing network analyzer
- Ping PC2, PC3 and PC4 from PC1.Ping should be successful.
- Data Rate was 20Mbps bidirectionally.
- Packet sizes were 128 to 1330 bytes.

6.3.2 Breaking Connections

- Connection will be broken directly on the Redbox connections and within LAN A and LAN B as per the table below
- Network analyzer tool shall be connected at the Source and Destination as per the table below
- Packet loss shall be recorded in the table below.

Breaking Connections		Packet Loss
Source PC 1	Destination PC 6	
Disconnect	Source A	0
	Source B	0
	Destination A	0
	Destination B	0
Source PC 1	Destination PC 7	
Disconnect	Source A	0
	Source B	0
	Destination A	0
	Destination B	0
Source PC 6	Destination PC 7	
Disconnect	Source A	0
	Source B	0
	Destination A	0
	Destination B	0
Source PC 6	Destination PC 2	
Disconnect	Source A	0
	Source B	0
	Destination A	0
	Destination B	0

6.4 PRP Interoperability Testing

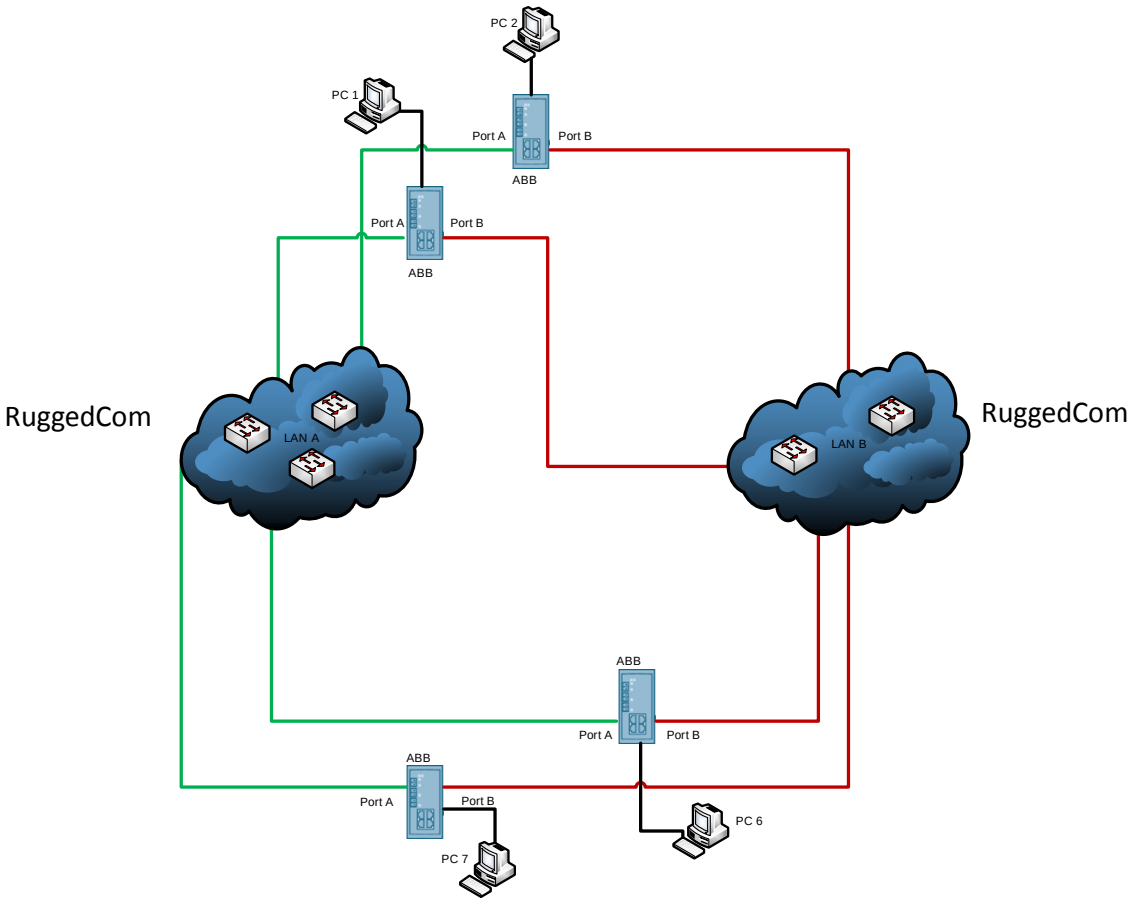


Figure 62: PRP testing topology

In order to test PRP, two independent PRP switch networks were setup. Both LANs utilized RuggedCom switches. Red boxes from ABB were used to provide HSR connectivity to the LANs.

6.4.1 Test Setup

- PRP switches are connected as shown in the above setup
- LAN A has three ethernet switches connected in a ring topology.
- Spanning tree is enabled on all the three switches.
- ROOT switch has priority 0.
- SW2 has priority 4096.
- The traffic should always go through ROOT->SW2->SW1 in LAN A.
- LAN B has two ethernet switches connected to each other. Spanning tree is also enabled on both the switches.
- Spanning tree can be disabled on the ports connected to PRP switches.
- PC1, PC2, PC3 and PC4 should be in the same subnet.
- PCs are representing network analyzer
- Data rate was 20 Mbps.
- Packet size was 128 bytes.

6.4.2 Breaking Connections

- Connection will be broken directly on the Redbox connections and within LAN A and LAN B as per the table below
- Network analyzer tool shall be connected at the Source and Destination as per the table below
- BER shall be measured for each connection break
- Ping PC2, PC3 and PC4 from PC1 and verify that ping is successful.
- Tests are executed, with 20 mbits and 80 mbits port utilization

Breaking LAN A		Packet Loss
Source PC 1	Destination PC 6	
Disconnect	Source A	0
	Source B	0
	LAN A	0
	Destination A	0
	Destination B	0
	LAN B	0
Source PC 1	Destination PC 7	
Disconnect	Source A	0
	Source B	0
	LAN A	0
	Destination A	0
	Destination B	0
	LAN B	0
Source PC 2	Destination PC 6	
Disconnect	Source A	0
	Source B	0
	LAN A	0
	Destination A	0
	Destination B	0
	LAN B	0
Source PC 2	Destination PC 7	
Disconnect	Source A	0
	Source B	0
	LAN A	0
	Destination A	0
	Destination B	0
	LAN B	0

6.5 PRP and HSR Interoperability

There were several topologies that were developed to be tested that mixed PRP and HSR technologies. The proposed topologies are shown in Figure 63.

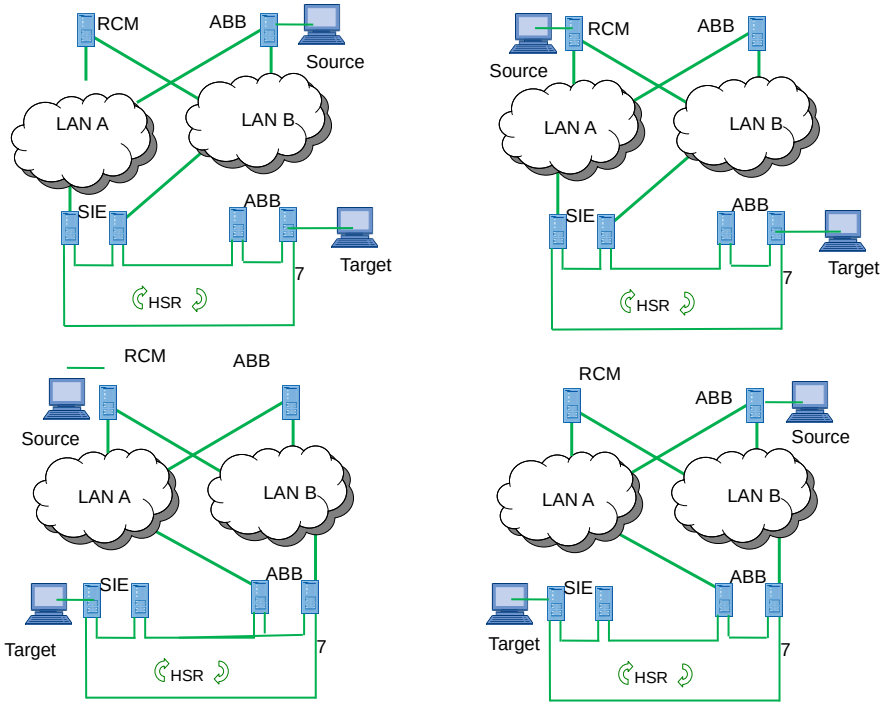


Figure 63: Test topologies for mixed PRP and HSR networks

Due to time constraints, no test campaigns were developed or executed.

6.6 Ethernet Switch Protocol Implementation Conformance Statement (PICS)

During the two(2) years since the 2011 IOP, several questions have arisen regarding how to verify Ethernet switch data sheets and the impact misconceptions on the datasheets can have on system configuration.

As an example, there are 8 levels (0-7) of IEEE 802.1P. However, many switches do not have queues for each priority. In some cases, there are only three priorities supported. Thus if a SAS designer inadvertently chooses two priorities that map into the same queue, the priority differentiation of those messages will probably be loss.

In order to assist in the selection of Ethernet switches, the following section propose a PICs that is proposed for standardization to IEC TC57 WG10.

6.6.1 General

To evaluate conformance of a particular implementation, it is necessary to have a statement of which capabilities and options have been implemented for a given Ethernet Local Area Network (LAN). Such a statement is called a Protocol Implementation Conformance Statement (PICS)

6.6.2 Basic Ethernet Switch conformance statement

The basic conformance statement is defined in Table A.76.

Table A.76 – Basic conformance statement

			Value/ Comments
Non-blocking, store and forward			Number of ports
S1	Port speed 100 Mbps	Y/N	
S2	Port speed 1 Gbps	Y/N	
S3	Port speed 10 Gbps	Y/N	
S4	Typical Latency		Specify in usec
S5	Auto negotiating	Y/N	

Supported physical interfaces			
	Type	Number	Speed/Wavelength/Distance
I1	RJ45 UTP/STP	#	
I2	ST FO	#	
I3	SC FO	#	
I4	LC FO	#	
I5	MTRJ FO	#	
I6	SFP(note 1)	#	
I7	**Critical Alarm Relay**	Y/N	
I8	**Modular Port Configuration**	Y/N	
I9	Local Management Port	Y/N	
I10	Accessible memory	Y/N	
note 1	**There are known interoperability issues between different vendors SFP transceivers.**		

Management			
M1	IEC 61850	Y/N	
M2	SNMP	Y/N	Versions supported?
M3	Is remote access supported?	Y/N	If (Y), specify the method(s) of remote access: HTTP, HTTPS, telnet, SSH, other (specify).
M4	Is there a mechanism to disable remote access?	Y/N	
M4	Proprietary configuration tool	Y/N	
M5	RMON support	Y/N	
M6	Syslog support	Y/N	
M7	Configuration backup and restore	Y/N	
M8	Firmware backup and restore	Y/N	If (Y), specify which methods are used: HTTP, HTTPS, TFTP, FTP, Other (specify).
M9	Does the upgrade process failsafe (e.g. the upgrade fails but no changes are applied)	Y/N	
M10	Port Mirroring	Y/N	
M11	Does the device support 802.1AR	Y/N	

6.6.3 Substation Ethernet Switch conformance statement

For the use of the Ethernet switch in a substation environment the following aspects need to be considered.

Table A.2 – Substation Ethernet Switch conformance statement

			Value/ Comments
Redundancy protocols			Convergence Time
RR1	(R)STP	Y/N	ms
RR2	PRP	Y/N	
RR3	HSR	Y/N	
RR4	What is the largest MTU supported		Specify in number of bytes
RR5	Type of port mirroring supported		None, SPAN, RSPAN, ERSPAN, Ethernet frame over UDP, Ethernet frame over GRE

Virtual LAN			
V1	Is the full range of IEEE 802.1Q VLAN IDs supported?	Y/N	How many?
V2	Specify the range of VLAN IDs that can be supported by the switch simultaneously:		
	a). All (0-4095)	Y/N	
	b). A range of values:	Y/N	Specify how the range is constrained.
	c). A specific number:	Y/N	How many?
V3	Specify the maximum number of VLAN IDs supported per port:		Number of VIDs?
	a). A range of values:	Y/N	Specify how the range is constrained.
	b). A specific number:	Y/N	How many?
V4	Support for priority levels	Y/N	How many levels?
V5	How many priority levels per queue		Amount
V6	Specify which priorities map into the same queue		Specify priorities vs queue mapping.
V7	Do the trunk port(s) discard packets with VLAN ID = 0	Y/N	
V8	Do the egress trunk port(s) remove VLAN ID = 0	Y/N	
V9	Do ingress trunk port(s) remove VLAN ID = 0	Y/N	
V10	VLANs per trunk port		Amount
	a). A range of values:	Y/N	Specify how the range is constrained.
	b). A specific number:	Y/N	How many?
V11	VLANs per edge port		Amount
	a). A range of values:	Y/N	Specify how the range is constrained.
	b). A specific number:	Y/N	How many?
V12	Methods available for VLAN registration		VTP, legacy GVRP, 802.1AK, MVRP, manual?

RSTP			
R1	Root bridge?	Y/N	
R2	User configurable priority?	Y/N	
R3	Version of (R)STP		802.1?
R4	Mac filters per port		amount
R5	Matching algorithm (Exact or hash)		Exact/hash
R6	Worst case fault recovery time per hop		<5ms
R7	Bridge Diameter		160 switches

Time synchronization			
T1	SNTP	Y/N	
T2	IEEE 1588 with hardware time-stamping	Y/N	
T3	What profile of 1588 is supported		None, or specify version/profile
T4	Transparent Clock 1 Step	Y/N	Accuracy
T5	Transparent Clock 2 Step	Y/N	Accuracy
T6	Grandmaster Clock	Y/N	Accuracy / Time Source
T7	Boundary Clock	Y/N	Accuracy
T8	Ordinary Clock	Y/N	
T9	Synchronization Source		GPS/IRIG-B/1588
T10	Timing Output		IRIG-B TTL/AM/PPS

Management Security			
S1	RADIUS support for login authentication	Y/N	
S2	Authentication mechanisms are supported		
	RADIUS	Y/N	
	TACACS	Y/N	
	Other		List other mechanisms
S3	Roles supported	Y/N	Specify number of roles
	Specify the different authorization/roles (limited, operator, manager, and other).		Limited, Operator, Manager, other (specify).
S4	Passwords supported	Y/N	
S5	Minimum allowed length of passwords		Enter length
S6	Maximum allowed length of passwords		Enter length
S7	Password expiration supported	Y/N	Enter default expiration period.
Switch Properties			
SP1	Port enable/disable	Y/N	
SP2	Port based IEEE 803.AR authentication	Y/N	
SP3	Port Mac authentication	Y/N	Specify number of roles
SP4	Port rate limiting	Y/N	
SP5	Switching Bandwidth		Specify Gbps
SP6	MAC Addresses filtering supported	Y/N	
	If (Y)es, how many MACs can be supported prior to forwarding all MACs		Specify number of MACs
SP7	802.1p Class of Service	Y/N	
SP8	GMRP Multicast Filtering	Y/N	
SP9	What is the largest MTU supported		Specify in number of bytes
SP10	Type of port mirroring supported		None, SPAN, RSPAN, ERSPAN, Ethernet frame over UDP, Ethernet frame over GRE
SP11	Is OpenFlow supported	Y/N	

EMI and Environmental			
E1	Meets EMI and environmental requirements as per IEC61850-3	Y/N	
E2	Meets IEEE 1613 Class 2 (electric utility substations)	Y/N	
E3	Operational between -40C +85C (no fans)	Y/N	

Prioritization			
P1	Number of classes of service support		Specify number
P2	Prioritize by ingress port	Y/N	
P3	Prioritize by 802.1Q priority field	Y/N	
P4	Prioritize by source or destination MAC address	Y/N	
P5	Prioritize by TOS DSCP in IP header	Y/N	

Power Supplies			
PS1	Dual Redundant, Load Sharing Power Supplies	Y/N	
PS2	24VDC	Y/N	
PS3	48VDC	Y/N	
PS4	High Voltage 88-300VDC or 85-264VAC	Y/N	
PS5	Is Power-Over-Ethernet supported	Y/N	
	If (Y)es what is the maximum aggregate wattage		Specify watts

7 Issues

During the IOP testing, several issues were found. The following sections detail the issues and the recommendations to resolve those issues.

7.1 Issues Found

The following sections provide a list of issues that have been encountered during the IOP. The sub-sections indicate the technology for which the issue was raised, not the testing in which the issue was found. As an example, several SCL issues were found during Client/Server testing. These issues are listed under the SCL section.

The tables provide a summary of the:

- Category: What is the root cause of the problem (e.g. standard, implementation, non-issue, not identified).
- Issue: What was the problem/issue that was encountered.
- Diagnosis: What is the impact of the issue.
- Action: This indicates the action(s) that are intended to be taken to resolve the issue.

7.1.1 Substation Configuration Language (SCL)

Issue Number	Category	Issue Description	Diagnosis	Action
1.	61850-6 Standard ED.1/ED.2 Interoperability	There is currently no mechanism available to mix ED.1 and ED.2 DataModels in an Ed.2 SCL file.	The use of a static set of CDCs in the ED.2 schema prevents ED.1 data models from being used in an ED.2 SCL file. Additionally, there is no mandatory mechanism provided to allows an indication if an IED is ED.1 or ED.2 in behavior after import into an SCT/SCT.	Address this issue within WG10. Submit through User Feedback Task Force.
2.	Implementation Interoperability	In the communication section of an ICD, there was an GOOSE Control Block that referenced a non-existent/not-configured GOOSE Control Block in LLN0.	It is allowed to have more GCBs in the communication section than are actually configured in LLN0. However, an ICD should be self-consistent (e.g. a communication section configuration should not be configured with something that does not exist). However, it is also suggested that the SCT be tolerant and correct such integrity issues if possible.	No action required by standards or UCA IUG.
3.	61850-6 Standard Interoperability	The actual format required for an ExtRef is not specified fully or in an understandable way.	Tools configured different combinations of values to create ExtRef. A single unique mechanism, that is unambiguous, needs to be documented.	Address this issue within WG10. Submit through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
4.	61850-6 Standard Interoperability	The actual format required for an ClientLN (used for ReportControl Block reservation) is not specified fully or in an understandable way.	LDInst is required, but for Client only IEDs, there is no LD. The standard indicates to select a random LDInst and provides some guidance. However, in order to insure that there is interoperability and that importers understand that there is NO LDInst, the value to indicate this needs to be standardized. Recommend the use of "none".	Address this issue within WG10. Submit through User Feedback Task Force.
5.	61850-6 Standard Implementation Interoperability	SCTs imported multiple ICD files and if there was a duplicate named DataTypeTemplate object, the last file imported defined the object. This caused changes in the IED object namespaces, and that is not allowed.	The standard is clear about the need to rename duplicate DataTypeTemplates. However, the IEDType attribute is optional for the IED and DataTemplateTypes. Making this mandatory may help with efficient management of the DataTypeTemplate section. The implementation needs to be fixed. However, in fixing the SCT problem, there were problems discovered with some ICTs. See Issue 6.	Discuss the making of IEDType mandatory within WG10. Submit through User Feedback Task Force. The implementation needs to be fixed.

Issue Number	Category	Issue Description	Diagnosis	Action
6.	Implementation Interoperability	Some ICTs expect the information in the DataTypeTemplate section to be exactly what they provided in there ICDs. Renaming of these types by the SCT is mandatory if there are duplicates imported by the SCD. If the renamed DataTypeTemplates were supplied back to the ICT for device configuration, the SCD was not imported and therefore configuration could not occur.	The ICT must be capable of resolving renamed objects in the DataTypeTemplate section. See discussion on Issue 5.	The implementation needs to be fixed.
7.	61850-6 Standard Interoperability Implementation	An ICT provided a file that had a destination MAC address of 00:00:00:00:00. The schema validated this address.	The address of 00:00:00:00:00 is not a multicast address which means it can't be used officially for GOOSE or SV. The question is should the schema validate that the MAC addresses are multicast addresses. The IOP group felt that validation could help prevent unintended errors.	Discuss the validation of MAC addresses as being multicast within WG10. Submit through User Feedback Task Force

Issue Number	Category	Issue Description	Diagnosis	Action
8.	Implementation Interoperability	An SCL file had an initial value (e.g. <VAL>) for a timestamp. The file imported, but the initial value was of the incorrect format. Initial value was not set.	The format of the <Val> was: 2001-01-01t00:00:00.000 it should have been 2001-01-01T00:00:00.000Z There is no mechanism to validate a <VAL> through schema validation. Therefore, the importer needs to not only validate schema, but more than schema.	Need to have a discussion regarding the semantics of the different layers of validation. This should probably be done in WG10 in a whitepaper. It does not belong in 61850-6. Implementation that provided the <Val> needs to provide the appropriate format.
9.	Implementation Interoperability	There was an attempt to import an SCL file where a LN was defined in the Server section with an Object (SDI in this case) that was not defined in the DataTypeTemplate section. The result was that the file did not import.	It is clear in 61850-6, that LNs in the Server section must be fully defined in the DataTypeTemplate section.	Fix the exporting implementation.

Issue Number	Category	Issue Description	Diagnosis	Action
10.	61850-6 Standard Interoperability	An SCL file was attempted to be imported that had TMAX and TMIN missing. The expected behavior for this case is not specified. And the file import was rejected.	61850-6 defines TMAX and TMIN as optional in order to provide backward compatibility with ED.1 schema. However, in ED.2 the fact that these are needed to control the expected behavior creates a need to define the default behavior or to develop a ED.2 profile that can be applied in addition to the XSD for validation.	Submit the concept of profiling to WG10 through User Feedback Task Force
11.	61850-6 Standard Implementation Interoperability	There was an SCL file that had a Logical Device namespace (LDNs) specified as “2007”. This file did not import due to the expectation by the importer that the value would be “2007A”.	61850-6 ED.2 implies that the namespace should be “2007A”. The text reads: “starting with A for the first released version revision”. For clarity, the text could read: “starting with A for the first released version”. The group agreed that “2007A” was correct.	Submit to WG10 through User Feedback Task Force
12.	Implementation Interoperability	An SCL file was provided where the <DAI>, in the IED section, declaration was not in the correct order per the standard or the information in the DataTypeTemplate section. The result was that the importer refused the file.	The data hierarchy in the IED section must reflect the hierarchy as specified in the standard and DataTypeTemplate section. The actual occurrence of this was a ctVal.	Exporting implementation needs to be fixed.

Issue Number	Category	Issue Description	Diagnosis	Action
13.	Implementation Workflow	An IID file was provided to an SCT with fully configured IP Addresses, IP Subnet, and Gateway Client ED.1,ED.2 information. Upon import, the SCT automatically re-assigned the addresses to addresses that were not in the IID. This caused a workflow issue in that the user of the SCT then had to re-edit the IP addressing information that had been correct originally.	It is clear that the standard specifies that an SCT can change the addressing/communication information provided.	The implementation of the SCT needs to be more tolerant of a bottom-up engineering process.
14.	61850-6 Standard Interoperability	A ICD was generated for a Client Only IED. It had an LN defined (e.g. IHMI). The ICD had no definition for IHMI in the DataTypeTemplate section. Upon import, the file did not validate.	61850-6 has text that specifies that a Client Only IED may define a LN and not have any entry (could not find the text) defining the LN in the DataTypeTemplate section. However, the XSDs do not allow this.	Submit to WG10 through User Feedback Task Force to fix XSD.
15.	Implementation Interoperability	An SCD file had a <RptEna> with no max attribute and assumed that this meant that no ClientLNs could be used to reserve the control block. This behavior prevented the export from an SCD with the appropriate reservation information.	61850-6 specifies in the XSD that the default value for max is 1. Therefore, a single ClientLN should have been allowed. A missing *RptEnabled* element within an ICD file indicates that this value shall be set by the system configurator within the limits defined by the *ConfReportControl* and *DynAssociation* element's *max* attributes.	Implementation needs to be fixed.

Issue Number	Category	Issue Description	Diagnosis	Action
16.	61850-6 Standard	During the discussion of issue 15, a question was raised about what is the meaning of max=0.	It was the discussion of the group that 0 should not be allowed if interpreted as having no instances of the RCB. In that case, the entire RCB should be missing from the SCL file.	Submit to WG10 through User Feedback Task Force for clarification in the standard.
17.	61850-6 Enhancement		Although 61850-6 allows the standardized expression of an ExtRef, the IntAddr typically associated with it is a proprietary vendor format. Therefore, there is no easy mechanism to express, in a standard way, the semantics expectation of what the ExtRef is to provide or the IntAddr.	Submit to WG10 through User Feedback Task Force for enhancement of the standard.
18.	Question 61850-6 61850-7-1 Standard	An SCL file was produced that instantiated a new DO within a LN. The DO was from the same 61850-7-4 Namespace. The question that arose was what should be the Logical Node Namespace or Data Namespace.	After discussion, the group tended to lean towards the use of DataNS to indicate this type of LN. However, clarification is needed within the standards.	Submit to WG10 through User Feedback Task Force for enhancement of the standard.
19.	Question 61850-6 Standard	During the SCL testing, a question was raised in regards to how does a SCT know the maximum number of instantiated RCBs allowed in an IED and what the allowed distribution per RCB. Without this information, it is possible for an SCT to configure more resources than the IED can support.	The ability to specify either constraint appears to be missing in ED.2. An analysis of GOOSE and SV control blocks show that the maximum allowed is specified. A possible solution might be that each RCB is described in the ICD might be required to use RptEnabled max.	Submit to WG10 through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
20.	Interoperability 61850-6 Standard	A client only ICD did not have a ClientServices section. An SCT imported the file and assigned used the IED to reserve a RCB without validation.	In ED.1, there was no ClientServices. Ed.2 added this to the SCL. Therefore, this could be an issue to resolve in ED.1 and ED.2 co-residence in a single SCD (see SCL issue 1). Within the context of ED.2, the ClientServices should be present ,although marked as not being required for backward compatibility. In this case an interoperability profile needs to be developed.	Submit to WG10 through User Feedback Task Force.
21.	Interoperability Implementation	A SCL file was produced that contained LNs, in a Server section, that were not defined in the DataTypeTemplate section. There was another instance where a <DAI> was added for a DA that did not exist in the DataTypeTemplate Section. The import attempt rejected the file.	In the case of an LN defined in a Server section of an IED, it must be defined in the DataTypeTemplate section. Similar to SCL issue 37.	Exporter implementation needs to be fixed.
22.	61850-6 Standard Interoperability	A SCL file was created that did not have the maxAttributes attribute defined. What does it mean semantically if the attribute is missing.	61850-6 should define the semantic meaning of maxAttributes not being present. It is optional in both ED.1 and ED.2.	Submit to WG10 through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
23.	Implementation Interoperability	ICT did not use the IEDName\LDInst as part of the GOCB name. This meant that the SCL file could not be properly interpreted/validate by the importer.	The alternate naming of "functional naming" was being used and the ICT did not recognize the alternate naming convention. Functional naming is allowed in 61850-6.	Implementation needs to be fixed.
24.	Question 61850-6 Standard	During discussions, a question arose in regards to if there is a RCB with cBName="fix" and the maximum number of RCBs has not been reached, is it legal to create new RCBs.	61850-6 does not answer this question.	Submit to WG10 through User Feedback Task Force.
25.	Implementation Interoperability 61850-6 Standard	There was an ICT/IED combination that only allowed RCBs and ExtRefs to be defined in a certain LD/LN. It did not allow any RCBs/ExtRefs to be defined for any other LD/LN combination. The SCT attempted to define RCBs/ExtRefs in other logical nodes through and SCD. The import of the SCD was refused.	61850 allows ExtRefs/RCBs to be defined in any logical node. However, there is no mechanism in SCL for an ICT to declare where it is legal to do so or what the semantics required for ExtRef are. This relates to SCL Issues 17 and 19.	Submit to WG10 through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
26.	Question Interoperability 61850-6 Standard	The usage of ClientLN in RptEna is optional. What does this mean.	61850-6 made this option for backward compatibility with ED.1. However, in order to standardize reservation mechanisms, it needs to be made mandatory. This means some type of a profile for turning optional into mandatory for ED.2. Additionally, this impacts SCL Issue 1. From an IOP perspective there is agreement that ClientLN should be the only mechanism for reserving a RCB. Proprietary mechanisms should not be allowed.	Submit to WG10 through User Feedback Task Force to potentially define a mandatory profile for ED.2.
27.	Question Interoperability 61850-6 Standard	The use of ExtRef to subscribe to a GOOSE was questioned.	There are several different mechanisms that could be used in 61850-6 to subscribe to a GOOSE. However, the IOP group decided to use ExtRef. The standard should be revised to make this the only mechanism.	Submit to WG10 through User Feedback Task Force.
28.	Question Interoperability 61850-6 Standard	The use of ExtRef to subscribe to a SV was questioned.	There are several different mechanisms that could be used in 61850-6 to subscribe to a SV. However, the IOP group decided to use ExtRef. The standard should be revised to make this the only mechanism.	Submit to WG10 through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
29.	Implementation Interoperability	There was an SCL that had multiple GOOSE Control Blocks that were configured to send the same DataSet. The importing ICT refused to import the file.	There are use cases for having multiple GOCBs with the same DataSet configured and it is allowed in 61850.	Importer needs to be fixed.
30.	Implementation Interoperability	An ICT, declared to be an ED.2 capable ICT, failed to import a SCL file with the extended length of sAddr per ED.2	The ICT needs to be fully compliant with ED.2.	Importer needs to be fixed.
31.	Implementation Interoperability	An SCL file was provided that expressed VLAN IDs as decimal values. The importer accepted these values since they validate against the schema. This has the potential to cause non-communication (e.g. IEDs sending on the incorrect VLAN).	VLAN IDs are specified to be hexadecimal numbers in 61850-6.	Exporter needs to be fixed.
32.	61850-6 Standard Interoperability	During GOOSE testing, an SCL GOCB was properly configured. However, the importer refused the file since some of the dataTypes of the DataSet members were not natively processed by the IED.	There is no mechanism to declare what data types are supported within SCL. A subset of mandatory supported data types needs to be defined or all data types need to be supported. See GOOSE issue 1. See SCL issue 45.	Submit to WG10 through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
33.	Implementation Interoperability	A SCT did not allow the configuration of a subscription to a DataSet that contained a controllable FCD. The DataSet member of the FCD was FC=ST.	This is allowed by 61850-7-3.	Fix Implementation.
34.	Implementation Interoperability	An SCL file was provided that contained a DataSet that had the same FCDA duplicated as multiple DS members. The ICT refused to import the file.	The standard allows the same Data to be repeated as multiple DataSet members. The problem with the ICT may be deeper. Consider a DataSet with a FCD and an FCDA from the FCD. Although not tested, such a file would probably also be refused. In general, there needs to be guidance given to users about the construction of DataSets.	Fix Implementation. Submit through User Feedback Task Force. Target would be for a system design document within UCA IUG.
35.	Implementation Interoperability	An SCL file was provided that did not specify a ProtNs <Val> for SCSM specific Data Attributes (e.g. Oper).	This is required by the standard.	Fix implementation.
36.	61850-6 Standard	There is an issue about differentiation between “fixed” /preconfigured DataSets and those that can be changed in a SCT. Some ICTs expect specific DataSets to be returned to them. If the SCT changes these, the file will not import.	The issue is that there is currently no mechanism standardized to allow an ICT to declare that a specific DataSet must not be changed or deleted. The group believes that the valimport syntax should be added to DataSet definitions.	Submit to WG10 through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
37.	Interoperability Implementation	A SCL file was produced that contained a <DAI> was added for a DA that did not exist in the DataTypeTemplate Section. The import attempt rejected the file.	In the case of an DAI defined in a Server section of an IED, the DA must be defined in the DataTypeTemplate section. Similar to SCL issue 21.	Exporter implementation needs to be fixed.
38.	Implementation Interoperability	An ICT provided an SCL file that had <RptEnabled max=1>. The SCT returned an SCD with <RptEnabled>. The ICT did not import the file since max=1 was missing.	The semantics of <RptEnabled max=1> and <RptEnabled> are the same since the default value for "max" is 1. The ICT should import based upon the required semantic.	Fix Implementation.
39.	Implementation Interoperability	There were at least two cases of illegal AP Titles (e.g. Object IDs) found in SCL files. One value was 4.x.y.z, the other was 1.1.999.xx.yy. The SCL files with these values did not PAS ED.1,ED.2s higher level validation (e.g. beyond schema import) or import in some cases.	The registration of OIDs is tightly controlled. The first integer value can go from 0-3. The values are standard(0), registration-authority(1), member-body (2), identified organization (3). Therefore, starting with a "4" is clearly not allowed. In the case of the 1.1.999.x.y, it is clear that this was an attempt to specify a private OID. The appropriate values for this are 1.3.9999.xx.yy .	Fix Implementations.
40.	Observation 61850-6 Standard	The fact that xsi:type is missing from the SCL files makes validation more difficult.	It would be suggested that a recommendation be made that xsi:types should be included. However, there are other levels of validation that could cover this as well.	Submit to WG10 through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
41.	Question Implementation Interoperability	In a SCD there were LNodes in the substation section that were not associated to a specific IED/LN instance. The question was if this was allowed. In particular, an SCD file contained an IEDName whose value was "null". This file did not import into certain tooling.	According to 61850-6, this is allowed and for such LNodes, the IEDName shall be "None". Thus the exporting implementation needs to be changed.	Fix Implementation
42.	61850-6 Standard Interoperability	In a SCD there were LNodes in the substation section that were not associated to a specific IED/LN instance. The question was if this was allowed. In particular, an SCD file contained an IEDName whose value was "null". This file did not import into certain tooling.	The 61850-6 standard is not explicit that LNodes imported from a SSD should be maintained. The IOP group believes that LNodes should be maintained and that the standard should be updated to reflect this.	Submit to WG10 through User Feedback Task Force.
43.	61850-6 Standard	There are normative ENUM definitions for 7-4. (e.g. Mod) but there is no guidance in regards to naming rules (e.g. Modkind).		Submit to WG10 through User Feedback Task Force.
44.	Implementation	SCT can't export substation section in an SCD.	It is unclear if an SCT is required to export a Substation section as part of a SCD. What if it is empty? Needs to be addressed by the testing subcommittee.	Submit to UCA IUG testing group through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
45.	Implementation Interoperability 61850-6 Standard	An IED would not subscribe to a GOOSE that had an FCD of a type ACT.	This is a similar to SCL Issue 32.	Submit to WG10 through User Feedback Task Force.
46.	Implementation	A SCD was provided that had setMag and setVal at the same level within an instantiated CDC. The file did not validate.	The schema and 61850-6 disallow both of these being present.	Fix Implementation
47.	61850-6 Standard ED.1/ED.2 Interoperability	The mechanism for defining a GI attribute in a ED.2 RCB does not validate and import into an ED.1 ICT.		Address this issue within WG10. Submit through User Feedback Task Force.
48.	Interoperability Implementation 61850-6 Standard	The iedType attribute is optional within SCL. However, some SCL tools use this as part of validation. Lack of the attribute/value prevented import of the file.	It is suggested to make this attribute mandatory with a standardized value for “unknown”.	Address this issue within WG10. Submit through User Feedback Task Force.
49.	Interoperability Implementation	An ICT provides an IID/ICD file that defines 4 GOCBs. The SCT imports this file, creates an SCD which has only 1 GOCB. The ICT refuses to import the SCD as it is expecting 4 GOCBs.	At first analysis, the SCT should not remove the configured GOCBs. However, this is an issue that needs further clarification.	Address this issue within WG10. Submit through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
50.	Question 61850-6 Standard	How should an SCL file express the initial value of GOCB.Ena and SVCB.Ena.	It would appear that the Control Block schema definitions (in the IED section) need to be expanded to allow this capability.	Address this issue within WG10. Submit through User Feedback Task Force.
51.	Interoperability 61850-6 Standard ED.1/ED.2	An ED.2 SCT would not import an ED.1 SCL file.	This needs to be addressed with rules of transformation and the definition of a schema that can be used.	Address this issue within WG10. Submit through User Feedback Task Force.
52.	Implementation	A server would not subscribe to a GOOSE since there were no MMS services available.	There is no requirement that MMS services be supported for GOOSE. Such a requirement prohibits the use of GOOSE only devices.	Fix Implementation.
53.	Interoperability 61850-6 Standard	An SCL file was provided that had a <Val> for an OctetString value. A question was raised as to the correct format for the value.	61850-6 has 2 references that could be interpreted as providing the format specification for the value. One is RFC 2045, the other is the W3C XML Schema Part 2 specification. The W3C specification does not have an explicit definition for Octetstring. It is suggest that this is the format specified as: "([0-9A-Fa-f][0-9A-Fa-f])(*[0-9A-Fa-f][0-9A-Fa-f])*"	Address this issue within WG10. Submit through User Feedback Task Force.
54.	Interoperability 61850-6 Standard	The use/specification of ExtRef is not 100% defined. One SCL tool expects it to be initialized as part of a DOI, others require it to be a DAI.	This needs to be resolved in conjunction with SCL issue 17.	Address this issue within WG10. Submit through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
55.	Question Interoperability	Should all SCTs support a substation section and the ability to associate LNodes into that section.	This should be a SICs issue and part of a guideline.	Address this issue within UCA IUG testing committee and System Design. Submit through User Feedback Task Force.
56.	61850-6 Standard		With the renaming of LNTypes, DOTypes, etc., there should be a specification as to the maximum size for these names. The XSD should reflect the chosen size.	Address this issue within WG10. Submit through User Feedback Task Force.
57.	61850-6 Standard		Currently, in SCL, the size of an array is numeric. This could lead to issues of consistency (e.g. one having 32 array elements and the other 33). This is not allowed in CDCs such as HDEL. It is suggested that some mechanism be developed to use a single value instead of multiple integers.	Submit to WG10 through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
58.	61850-6 Standard	Throughout the IOP, there was discussion about validation. However, validation has several different levels to it. There is no vocabulary defined regarding this.	A model/set of definitions should be created to allow discussion about validation. The different levels already identified are: 1). XML – is the file well-formed per the XML standard. 2). SCL Schema – is the file well-formed per the SCL schema. 3). SCL – is the file well formed in regards to mandatory/options expressed in 61850-6 that are not included in the schema. 4). Profile – is the file well formed in regards to optional attributes that have been turned mandatory should a profile be created. 5). ObjectModel – does the object model conform to the mandatory model components specified in 61850-7-3 and 61850-7-4. 6). Data Initialization – do the <Vals> have the appropriate value (e.g. no String values for floating point values) and have the correct format. Others…	Address this issue within UCA IUG testing committee. Submit through User Feedback Task Force.

7.1.2 Client/Server

Issue Number	Category	Issue Description	Diagnosis	Action
1.	61850-8-1	There is currently no mechanism to allow an array member to be added as a DataSet member.	In the conformance tables of 8-1, alternate access for arrays is marked out-of-scope. This prevents an element of an array to be used as a member of a DataSet.	Tissue 1174 has been entered. Address this issue within WG10. Submit through User Feedback Task Force.
2.	Interoperability Implementation	An SCL file was produced that had a GOOSE DataSet that contained members that had FC=CO and FC=CF. The SCT performing the import refused to import the file.	61850-7-3 ED.2 Specifies the allowed FCs for DataSets that are used for particular purposes (see clause 7.5.1). For GOOSE, only FCs of MX and ST are allowed. DataSets that are standalone, or used for reporting, may have any FC. In edition 2, the FC of CO no longer exists and therefore can't be utilized. Additionally, 61850-7-3 ED.1 is mute on the allowed contents of a GOOSE DataSet (see Table 42), and therefore any FC is allowed. This issue raises the issue of how and ED.1 device can co-exist in an ED.2 SCD (See SCL issue 1).	Address this issue within WG10. Submit through User Feedback Task Force as part of SCL issue 1.

Issue Number	Category	Issue Description	Diagnosis	Action
3.	Interoperability	A different client made use of a URCB that had been reserved in SCL for use by a different client via ClientLN.	Currently, there is no way to enforce reservation on the server without utilizing Authentication which was not part of the IOP. Therefore, it is up to the clients to behave in accordance with the ClientLN reservation. Since the URCB does not have an indication that the RCB is reserved (e.g. no resvTms), this may happen in the real world. An option could be to add a reservation indicator into the control block as part of IEC 61850-8-1.	Address this issue within WG10. Submit through User Feedback Task Force.
4.	Implementation	A Client wrote a GOOSE Control Block enable to false. The IED communication was lost due to a reboot.		Server implementation needs to be fixed.
5.	Implementation	During Client/Server testing a Client could not ping/connect to the IED. However, other Clients/computers could ping and connect.	After an analysis, the ARP table of the IED was found to have been corrupted due to cables being pulled. Same as Network Issue 2.	Fix implementation.
6.	Question	A question was raised about the consistency of 61850-7-2 (clause 20.2) and 61850-8-1 (clause 20.4) in regards to the use of Last Application Error.	Upon a cursory analysis, there does not seem to be an inconsistency between the two. However, it would be best for WG10 to do a thorough review.	Address this issue within WG10. Submit through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
7.	Question	A question was raised in regards to how a client should resynchronize to receive the last report (Buffered Reporting).	The standard is clear that resynchronization gives the next report, not the last report. However, it was suggested that guidance be given on how clients should generally perform this (e.g. GI for synchronization of data and the use of EntryID.). Guidance also needs to be given on the use of PurgeBuf and EntryID=00000000.	Submit through User Feedback Task Force. Target would be for a system design document within UCA IUG.
8.	Test Case Issue	There was an issue in regards to what addCause values should be returned in step 7.7.2.	Upon review, the test case was very explicit.	No action needed.
9.	Implementation Interoperability	A Server returned file names that were not the fully qualified path. Failure to return the full path would mean clients might not be able to retrieve files.	The requirement for a fully qualified path/filename was clarified via an approved technical issue for ED.1 and is explicitly specified in ED.2.	Implementation needs to be fixed.
10.	Question 61850-7-2 Standard	When should buffering start for a reserved and fully configured BRCB.	The discussion was that buffering should probably begin upon power-up. Richard Schimmel will investigate.	Address this issue within WG10. Submit through User Feedback Task Force.
11.	61850-7-2 61850-8-1 Standard	A question was raised in regards to the expected behavior of a server/BRCB that has been purged (e.g. no events buffered) and the client resynchronizes with EntryID=00000000 indicating return the first set of events. This results in a client not knowing if the resync was successful or not.	61850-7-2 ED.2 Figure 24 indicates that in such a situation, the Resynch should fail and give an indication of the failure. In 61850-8-1, that would translate into the V-Put failing. 61850-8-1 should specify a specific failure code to represent this situation.	Address this issue within WG10. Submit through User Feedback Task Force.

Issue Number	Category	Issue Description	Diagnosis	Action
12.	Interoperability	A question was raised in regards can Report EntryIDs be reused after IED restart. If so, guidance needs to be given for system design on how to recover/resync.	The standards do not mandate any particular behavior. In general, this should not represent an issue since the events previously buffered are no longer present. The issue is if a client reads the RCB and sees the same EntryID, what should the client do. This is part of the resync process that needs to be described. See Client/Server Issue 7.	Submit through User Feedback Task Force. Target would be for a system design document within UCA IUG.
13.	Test Case Issue	Test case 7.1.1 appears to be a negative only test case.		For next IOP, try to define an additional positive test case.
14.	Question Test Case Issue	Test case 7.1.1 requires failure for a direct-control-with-normal-security if the stVal is already at the desired state.	The test case appears to be incorrect. The AddCause of “Position-reached” should be returned.	Address this issue within UCA IUG Testing Committee. Submit through User Feedback Task Force.
15.	Question	Given that there are 2 RCBs that are configured with the same dataset, how does a client differentiate between the reports.	In general, the appropriate optFlds need to be included in the report. At a minimum, the ControlBlockReference could be a differentiator. Additionally, if the client sets different RptIDs this could also be used.	Submit through User Feedback Task Force. Target would be for a system design document within UCA IUG.
16.				

7.1.3 GOOSE

Issue Number	Category	Issue Description	Diagnosis	Action
1.	61850-8-1 Standard Interoperability	During GOOSE testing, GOOSE messages were being transmitted and received. However, some of the DataSet member data could not be processed or displayed.	There is no mechanism to declare what data types are supported within SCL. A subset of mandatory supported data types needs to be defined or all data types need to be supported. See SCL issue 32.	Submit to WG10 through User Feedback Task Force.
2.	Interoperability Implementation	An ICT could load and process an appropriately configured IID. However, the IED that the ICT configured could not subscribe to a GOOSE.	There were a couple of instances of this problem during the IOP. One instance was the failure of a general laptop Ethernet port that caused a need for the computer to be restarted. The other instance was investigated, but no final diagnosis was determined.	Further diagnosis is required.
3.	Implementation	A subscriber could not subscribe to a FCD that had more than one floating point value in it.	There are many FCDs where this is going to occur (vector, WYE measurements, etc..). It is expected that FCD support is provided by subscribers in ED.2 and any ED.1 subscriber claiming FCD support should also behave appropriately.	Fix Implementation.

Issue Number	Category	Issue Description	Diagnosis	Action
4.	Question	A question arose about if a GOOSE stNum should update if a value is "updated" but the value does not change.	GOOSE is a state changed based protocol. Therefore, if a value in the DataSet does not change, there is no requirement for stNum to increment. However, if the Timestamp is part of the DataSet, an "update" would typically change the value of the Timestamp and the GOOSE must be sent with a different stNum. Is it allowed to send a GOOSE and increment stNum on a value "update"? The standard does not prohibit this and subscribers should be capable of receiving such information.	Submit through User Feedback Task Force. Target would be for a system design document within UCA IUG.
5.	Interoperability	A GOOSE publisher sent a DataSet member value that was a 2-bit bitstring. However, the unused bits were set to values of True. The bitstring was received by a subscriber and discarded since the unused bits were True.	ASN.1 implies that the unused bits should be set to False. The publisher should be sending False. It is suggested that the subscriber be more tolerant and ignore the values of unused bits.	Fix Implementation.

7.1.4 SV

Issue Number	Category	Issue Description	Diagnosis	Action
1.	Implementation Interoperability	There are still different interpretations, between implementations, of some quality attributes. In particular, issues were seen with the interpretation of test, source, and substitution.	The standard(s) (e.g. 61850-7-2 and 61850-7-3) for ED.2 appear to be specific.	WG10 should review the definition of the quality bits.
2.	Implementation	Many implementations did not provide ICD/CID files, nor ICTs. This will become an issue for SCD based integration.		This is an implementation specific issue that needs to be addressed.

7.1.5 Networking

Issue Number	Category	Issue Description	Diagnosis	Action
1.	61850 Standard Implementation Interoperability	Some switches discard the IEEE 802.1Q tag known as VLAN 0 on packets sent/received on the trunk ports. Others discard the packet entirely.	The IEEE 802.1Q specification does not give guidance to switch manufacturers in regards to what to do with VLAN 0. However, IEC 61850-8-1 mandates the use of VLAN 0 as the default value to use since it represents a priority only tag and should not require the configuration of VLANs. The impact to users is that GOOSE and SV traffic will either lose their priority or be dropped entirely. It will make diagnosing network delivery problems difficult at best since there is no documentation provided regarding this behavior. Switches claiming conformance/support for IEC 61850 should neither strip VLAN 0 nor discard those packets.	Add switch action pertaining to VLAN 0 to switch PICS statement. Address the use of VLAN 0 within WG10. Submit through User Feedback Task Force.
2.	Implementation	During Client/Server testing a Client could not ping/connect to the IED. However, other Clients/computers could ping and connect.	After an analysis, the ARP table of the IED was found to have been corrupted due to cables being pulled. Same as Client/Server Issue 5.	Fix implementation.