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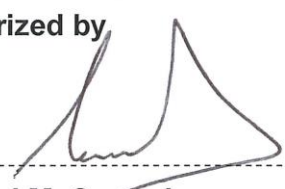
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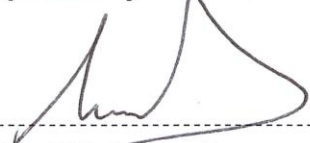
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1. Introduction

The intention of this document is to create an Eskom IEC61850 Interoperability Test Standard to minimise the risk of accepting IEC61850 compliant devices which are not interoperable with existing or future systems in the Substation Automation environment. A large portion of the report published by the Utilities Communications Architecture (UCA) users group on the extensive interoperability tests done in France in 2011 detailing the tests and findings is adopted in this standard. The thinking around this strategy was since UCA had already gathered substantial information on IEC61850 interoperability issues and thus utilised this to generate suitable interoperability tests then it would be useful for Eskom to specify the same tests in testing IEC61850 interoperability across vendors tendering for equipment contracts in the Substation and Automation environment. Furthermore some of the interoperability tests included in this document is from interoperability challenges experienced during pilot projects and laboratory experiments in the Eskom business.

2. Supporting clauses

2.1 Scope

This document presents Eskom Transmission and Distribution's IEC61850 Interoperability tests that shall be used to evaluate Suppliers/Vendors tendering for equipment contracts in Eskom Transmission and Distribution substation and automation environment.

2.1.1 Purpose

This document presents Eskom Transmission and Distribution's IEC61850 Interoperability tests that shall be used to evaluate Suppliers/Vendors tendering for equipment contracts in the substation and automation environment.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Transmission and Distribution Divisions.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] ISO 9001, Quality Management Systems.
- [2] Report on UCAlug 2011 Interoperability Test.

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

None

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
CID	Configured IED Description
CO	Control Object
DPS	Double Point Status
FCD	Functional Constrained Data
FCDA	Functional Constrained Data Attribute
GI	General Interrogation

2.5 Roles and responsibilities

This document forms a standard for the adoption of IEC61850 standard.

2.6 Process for monitoring

PTM&C shall be responsible for revising the document as required.

2.7 Related/supporting documents

Not applicable.

3. IEC61850 Interoperability Tests

3.1 SCL System Testing

3.1.1 SCL Nameplace Restrictions

Supplier shall provide evidence to support all feedback provided

- a) Is the *Supplier* aware of any SCL namespace restrictions on the devices offered in this tender?
- b) Has the Supplier experienced or aware of any interoperability issues with SCL namespace restrictions between their IEC61850 devices and software offered and other vendors IEC61850 devices and software.
- c) As per Ed1, the IdName max length shall be 32 characters. Does the Supplier comply or exceed this requirement. Supplier shall provide evidence of this.
- d) Does DO Names include names of the Data Attribute? If the Suppliers device/s offered had to receive an SCL file from another vendor with DA names in the DO Names, how would the configuration tool / device/s react? Demonstrate this with the vendors SCL files provided.
- e) Are there any restrictions with the GOOSE/Report Control Block name lengths?
- f) Are all DATATYPE Initial Values as per the IEC61850 Standard (e.g. OCTECTString shall be values from 0-9 or A-F and not things like "DummyString")
- g) What are the initial values specified on BOOLEAN VALUES. Eskom preference is {true,false, 1, 0}
- h) What are the initial values of floating point values? Do your devices SCL include this "f" in the floating point values? If yes, can this be changed to exclude it?

Note: Some vendors include the letter "f" in the floating point values which are known to cause interoperability challenges.

- i) Does the Supplier's devices' SCL files define multiple initial values (specify when this is done) and if so, does this comply with the IEC61850-6, Ed1 standard.

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- j) Does the products offered support INT64 as per IEC61850-6?
- k) Are Double Point Statuses supported by the SCL as well as IEC61850 configuration tools (especially Logic Tools)?
- l) LNPrefix Default Value: What is the devices SCL default value when there is no LNPrefix specified?

Note: This is known to cause some interoperability issues as Ed1 does not concretely define what the default value should be if there is no LNPrefix specified. Ed 2 specifies default should be "".

- m) Communication Services Section of the SCL file shall be present for publishers of GOOSE and SV. Is this support for all devices offered?
- n) What is the maximum SCL file size restriction of the Supplier's IEC61850 Config Tool i.e what is the maximum SCL file that can be imported into the IEC61850 Config Tool. Demonstrate that a large SCD file can be processed by the IEC61850 devices and Tools.
- o) Demonstrate that the IEC61850 Server ensures synchronisation between its configuration and the SCL configuration.
- p) Demonstrate the operation of the AddCause functionality as per the standard.
- q) Are the device SCL files based on fixed templates? If so, how will this affect import into other vendors' tools?

3.1.2 ICD and CID Export or Creation

The *Supplier* shall perform/demonstrate the following IEC61850 related tests.

- a) Test: The ICD and CID files of each IEC61850 servers offered shall be validated using <http://scl-validator.erlm.siemens.de/validator/upload.html>.

Expected Result: The file is a **conform** file including GOOSE and Reports configuration.

3.1.3 Individual ICD/CID (or SCD) Import

- a) Test: Import the ICD/CIDs of all relays provided for the Demo Test System
- b) Expected Result: The individual SCL CID files shall import into the Vendor's IEC61850 tool without errors or warnings. Upon the import of each ICD/CID file, the system configurator shall be instructed to configure the system and export a SCD file. This SCD file shall be carefully inspected for each IED type to ensure that all required information exists.

3.1.4 SCD Editor Testing

In order to test the SCD Editor/Tool, the following test cases can be performed. The aim of these tests is to make use of SCL file exchange for the basis of system engineering, modification, and exchange.

3.1.5 Individual CID Import

- a) Test: CID Imports of individual Vendors CID files, needed for other testing. The test shall import all CID files that are needed to create an SCD of the Demo Test System
- b) Expected Result: The individual SCL CID imports shall import into the tooling without errors or warnings and all information from the CID is maintained.

Note: This should result in merged information (e.g. from previously imported CID files) being present in the SCD file. The *Supplier* shall demonstrate that the SCL Editor information reflects an accurate representation of:

- 1) GOOSE information
- 2) Communication information (Verify IP, OSI, MAC and VLAN information)
- 3) Verify LN prefix, dataset names comply with the standard.
- 4) Report Control Block information

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- 5) Information pertaining to private tags is maintained.

3.1.6 SCD Export

- a) Test: Export the SCD file with vendor tool. Then validate the file with an SCL validator.

Expected result: Export is possible and file validates. CID attributes including private tags are kept. Test importing this SCD into another vendors IEC61850 system configuration tool.

3.1.7 SCD Import

- a) Test: Import another vendor's validated SCD file. Then validate the file with an SCL validator.

Expected result: Export is possible and file validates. The imported information shall be the same as provided in the file, however private information is not required to be maintained.

3.1.8 Other SCL Related Tests

- a) Test: Verify that the value of Confrev is incremented when any change is made to the contents of an SCL file that has already been exchanged.
- b) Test: Verify that the IEC 61850 Client offered verifies that the SCL configuration matches with the configuration of the IED before information exchange.
- c) Test: Show on the SCL files of the devices offered that the ctrlModel value is "Status Only" for Data Objects that are not controllable.
- d) Test: Demonstrate that Client offered validates the actual value of ctrlModel on the IEDS.

Note: The reason for this test is due to the fact that local action (on the IED) can change the value and such a change could cause a Client's control action to fail at an inopportune time.

- e) Test: Demonstrate that CIDs generated by the system tools can be exported in other vendors IEC61850 System Configuration Tool (Siemens DIGSI and ABB IET600/CCT600)
- f) Test: Demonstrate that other vendors CID can be imported into your IEC61850 System Integration tool such that a complete SCD can therefore be generated by the tool.

3.2 Client/Server Testing

3.2.1 CID Export or Creation

- a) Test: CID Export/file of each IEC61850 server (from IED tool, IED itself, vendor) is provided. Validate the file with <http://scl-validator.erlm.siemens.de/validator/upload.html>

Expected Result: No errors and warnings shall be generated by the Validator.

3.2.2 Individual CID Import

- a) Test: Import the Server CIDs into the Client's IEC61850 Tools.

Expected Result: The individual SCL CID imports shall import into the tools without errors or warnings.

3.2.3 Read of Data

Clients shall be able to obtain information (e.g data) from servers. This is considered to be one of the several GetDataxxx services specified in IEC 61850-7-2. At the most basic level, the client/server combination must be capable of exchanging FCD and FCDA information.

3.2.4 Polling of Data from the Servers

Servers shall be able to tolerate Clients using the GetAllDataValues or GetDataValues (services S7 and S8 respectively) to poll it for data. If for some reason, the server cannot support the polling rate of the client, it shall not enter into a locked-up state/unable state. *Supplier* shall demonstrate this functionality.

3.2.5 Reading of a FCD

Some clients may not be capable of reading a FCD (e.g. they deal only with FCDAs), however servers shall support the reading of FCDs. The following test cases are valid only for clients that claim to support FCD acquisition.

- a) Test Case: There is one FCD that every Server shall support and that is the Beh attribute of LN0. The client shall issue a read for the Beh attribute of at least one LN0.

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

- b) Test Case: The client shall issue a read for a FCD of FC=MX that contains an Integer value.

Expected Results: The client value of the server's Integer value shall match.

- c) Test Case: The client will issue a read for a FCD of FC=MX that contains a Float32 value.

Expected Results: The client value of the server's FloatingPoint value shall match within possible rounding errors.

- d) Test Case: The client will issue a read for a FCD of FC=ST that contains an SPS value.

Expected Results: The client value of the server's stVal value shall match.

- e) Test Case: Explain and demonstrate how the IEC61850 client handles/processes a timestamp whose timestamp accuracy is unspecified.

- f) Test Case: The client will issue a read for a FCD of FC=ST that contains a DPS value.

Expected Results: The client value stVal shall be the same as the server's stVal.

- g) Test Case: The client shall issue a read for a FCD of FC=CF value.

Expected Results: The client value shall be the same as the server's value.

- h) Test Case: The client shall issue a read for a FCD of FC=DC value.

Expected Results: The client value shall be the same as the server's value.

3.2.6 Reading of a FCDA

Some clients may not be capable of reading a FCDA (e.g. they deal only with FCDs) however according to the IEC61850 standard, all servers shall support the reading of FCDAs. The following test cases are valid only for clients that claim to support FCDA acquisition.

- a) Test Case: There is one FCDA that every Server shall support and that is the Beh attribute of LN0. The client shall issue a read for the Beh attribute of at least one LN0.

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

- b) Test Case: The client shall issue a read for a FCDA of FC=MX that contains an Integer value.

Expected Results: The client value of the server's Integer value shall match.

- c) Test Case: The client will issue a read for a FCDA of FC=MX that is of type Float32.

Expected Results: The client value of the server's Floating Point value shall match within possible rounding errors.

- d) Test: Demonstrate that the IEC61850 Client shall support Floating Point Not-a-Number (NAN).

- e) Test Case: The client will issue a read for a FCDA of FC=ST that contains an SPS value.

Expected Results: The client value of the server's stVal value shall match.

- f) Test Case: The client will issue a read for a FCDA of FC=ST that contains a DPS value.

Expected Results: The client value stVal shall be the same as the server's stVal.

- g) Test Case: The client shall issue a read for a FCDA of FC=CF value.

Expected Results: The client value shall be the same as the server's value.

- h) Test Case: The client shall issue a read for a FCDA of FC=DC value.

Expected Results: The client value shall be the same as the server's value.

- i) Test Case: Assign quality bits to a dataset which will be reported to the Client. Degrade the quality of the data to test if the quality of the device reports to the Client correctly.

3.2.7 Read of a CO FCDA

- a) Test Case: Demonstrate reading of CO FCDA.

Expected Result: The client value shall be the same as the server's value.

3.3 Controls Testing

3.3.1 Direct Controls

- a) Test Case: Configure the server to allow for remote controls. Ensure the Server is configured for "Direct Operate" controls. Client shall then issue a direct control to the server.

Expected Result: The server shall indicate that a direct control action has taken place and the client shall indicate no error.

- b) Test Case: Configure the server to disable remote controls. Ensure the Server is configured for "Direct Operate" controls. Client shall then issue a direct control to the server.

Expected Result: The server shall indicate that no direct control action has taken place and the client shall indicate a control error.

3.3.2 Select Before Operate (SBO) with Normal Security Controls

- a) Test Case: Configure the server to allow for remote controls. Ensure the Server is configured for "Select Before Operate" controls. Client shall then issue a select before operate control to the server.

Expected Result: The server shall indicate that a control action has taken place and the client shall indicate no error.

- b) Test Case: Configure the server to disable remote controls. Ensure the Server is configured for SBO controls. Client shall then issue a SBO control to the server.

Expected Result: The server shall indicate that no control action has taken place and the client shall indicate a control error. The "Select" shall fail.

3.3.3 Select Before Operate (SBO) with Enhanced Security Controls

- a) Test Case: Configure the server to allow for remote controls. Ensure the Server is configured for "Select Before Operate with Enhanced Security" controls. Client shall then issue a select before operate control with Enhanced Security to the server.

Expected Result: The server shall indicate that a control action has taken place and the client shall indicate no error.

- b) Test Case: Configure the server to disable remote controls. Ensure the Server is configured for SBO with Enhanced Security controls. Client shall then issue a SBO with Enhanced Security control to the server.

Expected Result: The server shall indicate that no control action has taken place and the client shall indicate a control error. The "Select" shall fail.

3.4 Reporting Testing

Vendor shall create datasets to be assigned to buffered and unbuffered report control blocks on their server devices offered.

3.4.1 Buffered Reporting Tests

Pre-conditions: The following trigger options shall be demonstrated by the IEC61850 client and the servers: This test shall also be done with the other Eskom approved IEDs provided to demonstrate interoperability of the IEC61850 Client offered by the Vendor.

- General Interrogation (GI)
 - Data Change (dchng)
 - Quality Change (qchng)
 - Data Update (dupd)
- a) Initial Enabling of Report Control Block Test Case: The client shall write and enable a buffered report control block.

Expected Result: The client shall begin receiving reports and shall give some indication that reports are being received.

- b) Resynchronisation of Report Control Block Test Case: After test case 3.4.1.1 was executed and the connection between the client and server is brought down demonstrate that the client shall write and enable a buffered report control block with a resynchronization value.

Expected Result: The client shall begin receiving reports and shall give some indication that reports are being received.

- c) Purging of Buffer Test Case: After test case 3.4.1.1 was executed and the connection between the client and server is brought down demonstrate that the client purges the buffer and shall write and enable a buffered report control block with a resynchronization value.

Expected Result: The client shall begin receiving reports and shall give some indication that reports are being received. No old values shall be received.

- d) Test Case: Can multiple clients be assigned to the same report control blocks? If yes demonstrate this functionality on the Demo Test System.
- e) Test Case: With the buffered report blocks provided by the servers, is it possible to assign all the data required by all Eskom Master Stations to these buffered report blocks without running out? These Eskom datasets shall be provided as part of the Demo Test System.
- f) Test Case: Demonstrate that the Client offered supports servers with indexed and non indexed report control blocks.
- g) *Supplier* shall state any IEC61850 reporting model interoperability challenges of the products offered that are known or have been encountered.

3.4.2 Unbuffered Reporting Tests

Pre-conditions: The following trigger options shall be demonstrated by the IEC61850 client and the servers: This test shall also be done with the other Eskom approved IEDs provided to demonstrate interoperability of the IEC61850 Client offered by the Vendor.

- General Interrogation (GI)
- Data Change (dchng)
- Quality Change (qchng)
- Data Update (dupd)
- a) Initial Enabling of Report Control Block Test Case: The client shall write and enable an unbuffered report control block.

Expected Result: The client shall begin receiving reports and shall give some indication that reports are being received.

3.5 File Transfer (Comtrade only)

As per IEC 61850-8-1 Edition 1, the *Supplier* shall demonstrate the ffg:

- a) "IEEE C37.111(1999) (COMTRADE) files shall be contained within a file directory whose name is "COMTRADE".
- b) The file specifications shall be consistent with the naming conventions and suffixes specified in IEEE C37.111(1999).
- c) The IEEE COMTRADE specification IEEE C37.111(1999) specifies the use of three different suffixes (e.g. hdr, cfg, and dat).
- d) If the directory contains a file with a suffix of "zip", that file shall convey the compressed contents of the COMTRADE hdr, cfg, and dat files of the files of the same name.
- e) The COMTRADE directories shall be located in the appropriate directory path (e.g. within the LD directory or at the root level). This would imply that COMTRADE files shall be in a directory of the Logical Device name and at the root level, in order to claim conformance.
- f) It is known, from past experience, that some implementations do not store the files in this location. Therefore, in order to achieve interoperability, the client shall be able to be configured with the directory and file names to retrieve.

3.5.1 Comtrade File Transfer Tests

- a) Test Case: The server shall generate a set of appropriate COMTRADE files for transfer by the IEC 61850-8-1 File Transfer services. The file set shall include at least the COMTRADE *.cfg and *.dat files.
- b) Test Case: The server shall generate a set of appropriate COMTRADE files for transfer by the IEC 61850-8-1 File Transfer services.
- c) Test Case: The Client shall utilise the 8-1 file transfer services to transfer the individual files, or a *.zip that contains all of the files, and stores the files locally. An analysis tool shall be used to display the contents of the COMTRADE file set.
- d) Test Case: What are the interoperability restrictions with other vendors in terms of the file names?

3.6 MMS File Transfer

- a) **Test Case:** Verify file time stamp of MMS File Transfer

3.7 Client/Server Run Time Behaviour

Verify the runtime Client/Server behaviour with the following tests:

- a) **Test Case:** Client shall change the deadband setting on IEC61850 servers provided for the test.
- b) **Test Case:** Client shall change a ctlModel setting/value on IEC61850 servers provided for the test.
- c) **Test Case:** Client shall properly allow for scaling that is done on the server. Non-unity scaling shall be tested between Client and all Server devices provided for the test.

3.8 GOOSE Test Cases

The aim of the following routines is to test the interoperability of GOOSE messages. Correct reception and interpretation of the GOOSE message by the subscriber shall be demonstrated. For these tests, each publishing IED shall provide a CID or SCD file that contains its configuration information. The CID configuration shall provide a minimum of 2 GOOSE control blocks. One dataset for a GOCB shall contain FCDAs while the other contains dataset members that are FCDs.

The following types of dataset members shall be defined for the FCDA dataset:

- single point status: stVal and q
- double point status: stVal and q
- double point: stSeld and q
- measurement value: mag.f and q

Should a publisher be capable the following types of dataset members shall be defined for the FCD dataset:

- A dataset member that has a functional constraint of ST
- A dataset member that has a functional constraint of MX

3.8.1 Support of VLAN

- a) Test: Demonstrate that GOOSE message published utilises the VLAN functionality as per the standard.

3.8.2 Exchange a GOOSE with FCDAs

- a) Test: A publisher shall publish a dataset whose members are FCDA. Dataset shall contain as many information types as possible.

Expected Results: Subscriber provides confirmation that the GOOSE was received and that the information was properly interpreted.

- b) Test: Demonstrate that the dataset can be made up of data attributes from any of the Logical Nodes and not be constrained to data from GGIOs only.
- c) What is the maximum number of attributes possible per dataset?

3.9 Exchange a GOOSE with FCDs

- a) Test: A publisher shall publish a dataset whose members are FCDs. Dataset shall contain as many information types as possible.

Expected Results: Subscriber provides confirmation that the GOOSE was received and that the information was properly interpreted.

3.10 Test bit

- a) Test: The publisher sends either the FCD or FCDA GOOSE with the test bit set.

Expected Result: The subscriber indicates that it has received and understood the GOOSE Test bit.

3.11 Detection of Time Allowed to Live (TAL) Expiration

- a) Test: The transmission of the published GOOSE is interrupted (pulling the publisher's cable or setting the Enable to false)

Expected Result: The subscribing IED detects a TAL expiration and gives some local indication.

3.12 GOOSE Control Blocks

- a) Enable GOOSE Transmission Test: A client changes the enable of a GOOSE control block from FALSE to TRUE.

Expected Result: The subscribing IED detects the delivery of the GOOSE and gives some local indication.

- b) Disable GOOSE Transmission Test: A 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.

3.13 Time Synchronisation

- a) **Test:** Test Time Performance Class (T1/T2/T3/T4)
- b) **Test:** Demonstrate that all devices offered support more than 1 time master to support Eskom's Time Synchronisation redundancy architecture.
- c) **Test:** Demonstrate that all devices offered can synchronise via SNTP

4. Authorization

This document has been seen and accepted by:

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5. Revisions

Date	Rev	Compiler	Remarks
Feb 2019	2	M Sukhnandan	Only the template was changed. Technical content was not revised.
Nov 2013	1	M Sukhnandan	First Issue

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6. Development team

The following people were involved in the development of this document:

- Marlini Sukhnandan – PTM&C Control and Automation

7. Acknowledgements

Not applicable.