Development of Tool Interoperability Matrix based on Top Down SCL Engineering Process: An ASEAN Case Study

Mohd Iqbal Ridwan

TNBX Sdn. Bhd.

iqbalri@tnb.com.my

Presentation for IEC 61850 Global 2020 Conference

Contents

Tenaga Nasional Berhad (TNB) and IEC 61850

Overview of IEC 61850 SCL and Engineering Process

Case Study: Top-down Engineering Process with ASEAN Utility

Electric Utility Companies in Malaysia

Company and Speaker Background

Company (Tenaga Nasional Berhad-TNB):

- Vertically integrated utility company (Generation market liberalized)
- Generation, Transmission, Distribution, Retail divisions

Speaker:

- Previously served as Principal Researcher in TNB Research Sdn. Bhd., wholly owned subsidiary of TNB.
- Led IEC 61850 related research, design, engineering, testing and training works
- Currently serving as Senior Manager in TNBX Sdn. Bhd., a subsidiary of Retail Division.
- Main responsibilities are business development and project management for behind-the-meter solutions

TNB and IEC 61850

TNB IEC 61850 Journey

2007

First R&D Project – feasibility studies and lab development

2010

Commissioning of IEC 61850 System Verification and Simulation Laboratory (Station Bus)

2012

1) Initiation of Product Acceptance Process

2) R&D Project on Process Bus

3) Pilot Multi-vendor Station Bus 132/33 kV GIS Substation – project start

2015

1) Process Bus Field Trial Installation with OCT – 1 bay

2) Commissioning of Pilot Multi-vendor Station Bus 132/33 kV GIS Substation

3) Initiated migration projects of legacy Substation Control Systems to IEC 61850

2018 and beyond

1) Edition 2 Product Acceptance Process

2) Digital Substation R&D Project - in-progress

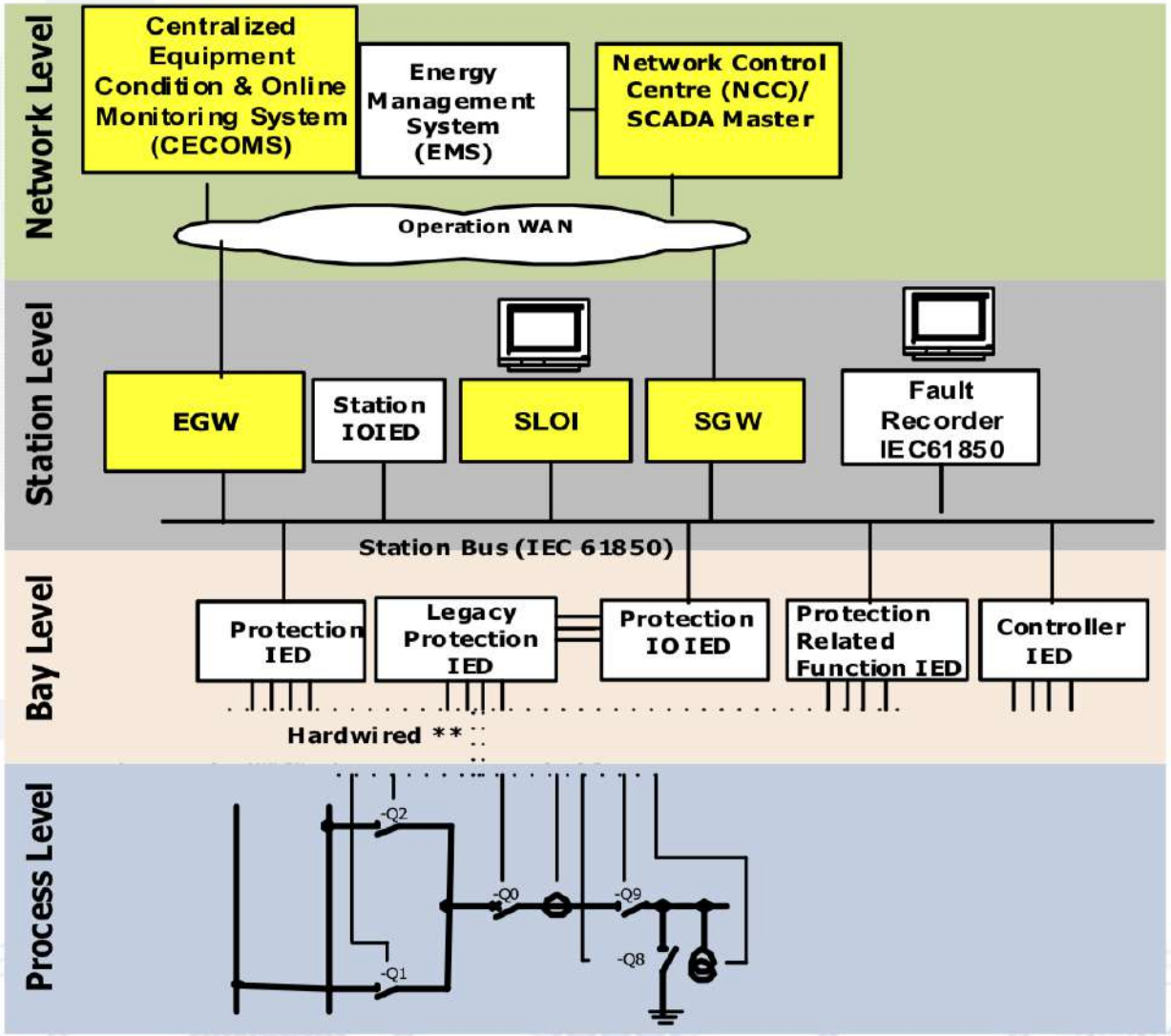
3) IEC 61850 Learning Journey for Grid Division

4) IEC 61850 Project Implementation Process Enhancement

IEC 61850 R&D Projects (2007 to 2019)

No.	Research Projects	Duration
1.	Research and Development on Substation Automation System based on IEC 61850 for Optimal Substation Design in TNB	2007 - 2010
2.	Study and Development of Integrated and Standardized Engineering Workstation (EWS) Applications for TNB Transmission IEC 61850 Based Substation Automation System	2010 -2012
3.	Modelling, Simulation & Performance Assessment of Power System Protection Functions in the IEC 61850 Based Substation Automation System in TNB	2010-2012
4.	Research on the Development of IEC 61850 Process Bus System and Guidelines for TRM Smart Substation Implementation in TNB Transmission	2012 – 2015
5.	Development of Substation Information Management Platform and Advanced IEC 61850 Substation Intelligent Management System (61850 SIMS) in Transmission Division	2013 -2015
6.	Research on Maintenance Strategies, Task and Implementations using Reliability Maintenance (RCM) and Standardized Testing Procedure for IEC 61850 based Substation Protection, Automation and Control Systems in TNB Transmission	2016 - 2017
7.	Development of IEC 61850 Specifications and Guidelines for the Implementation of Substation Protection, Automation and Control System (SPACS) in TNB Distribution	2016-2017
8.	Development of IEC 61850 Substation Protection, Automation and Control System Pilot Project for TNB Distribution Division	2017-2018
9.	Research and Development of IEC 61850 based Digital Substation 2.0 for TNB Grid Division	2019-present

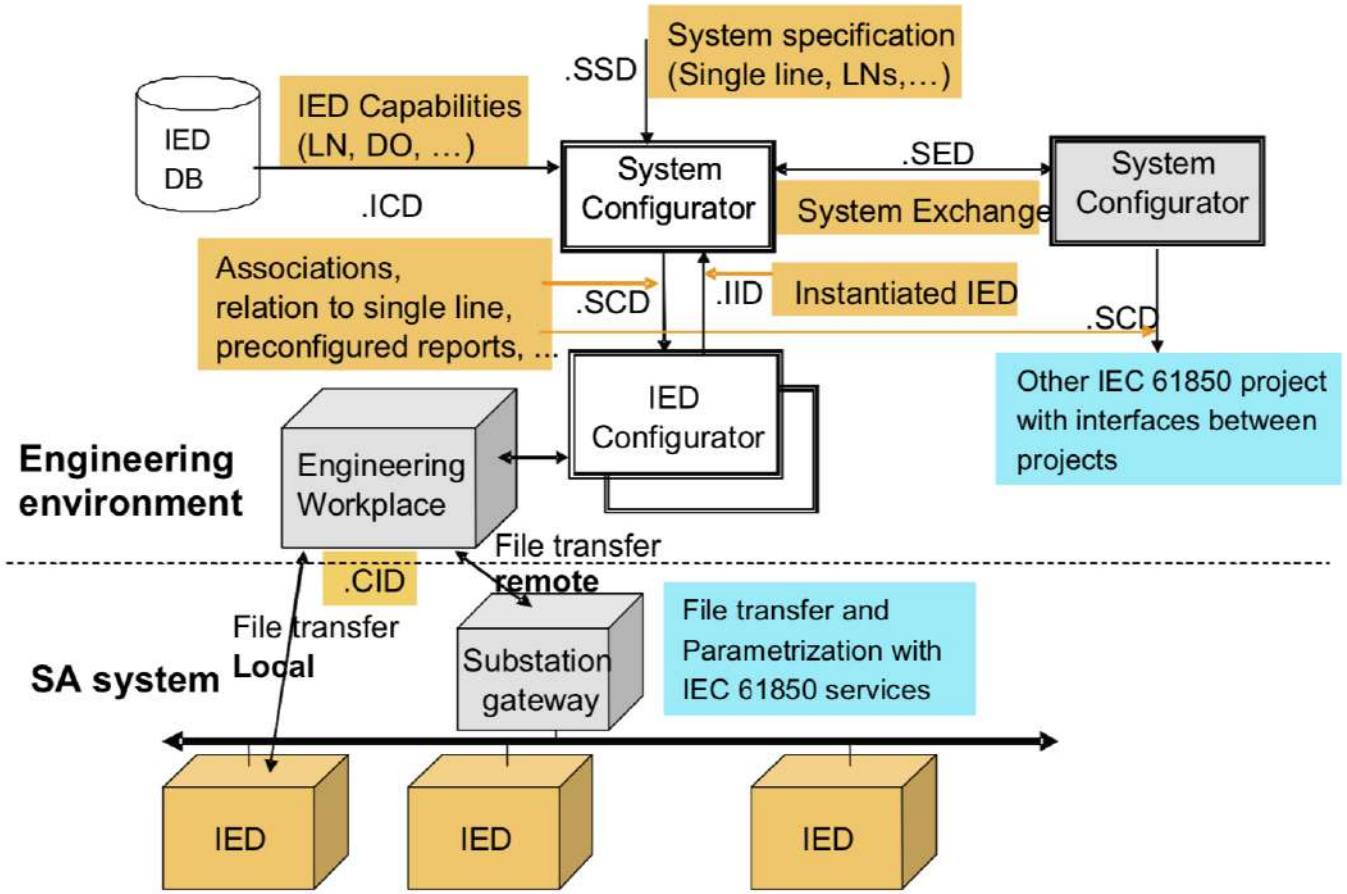
General Architecture for Legacy to IEC 61850 Migration Projects

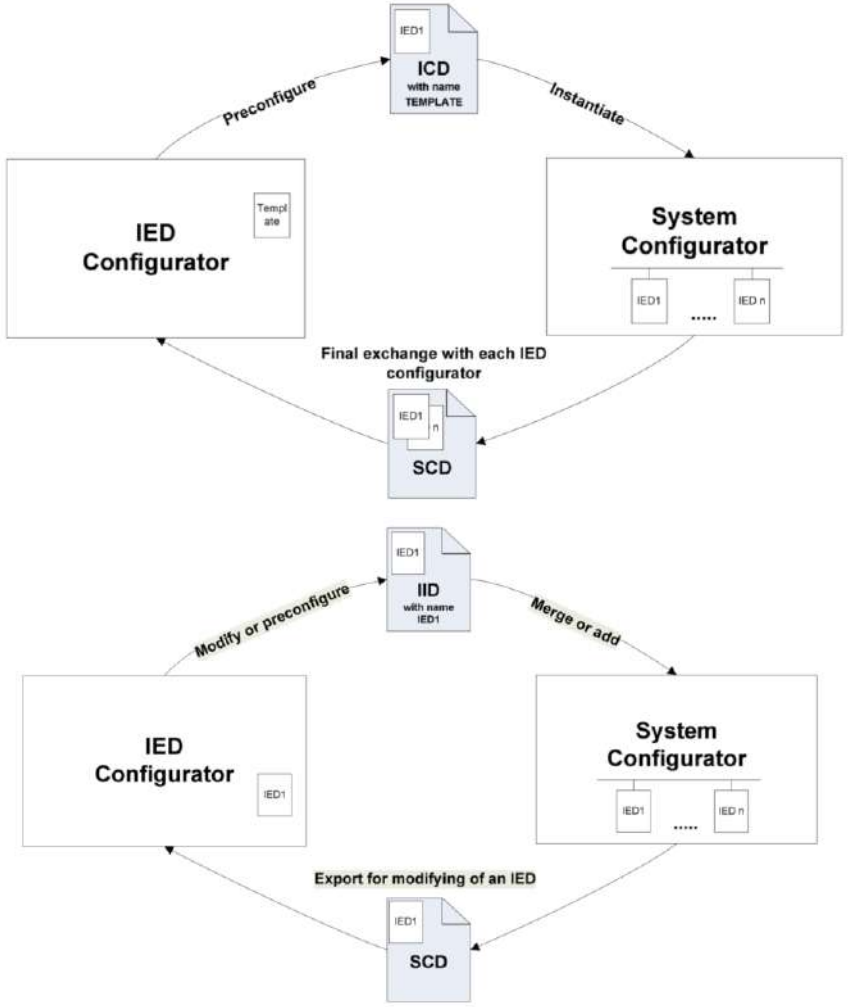


- 1 Gbps optical fibre Ethernet LAN **Station Bus** backbone with distributed architecture
  - Ring network topology
  - Redundancy formed by ESM for each bay, clients and station
  - Time Synchronizing (SNTP)
- Clients – MMS application:
  - HMI
  - SGW
  - EGW to support CECOMS
- IEDs (Servers):
  - Integrated Line Protection
  - *New Circuit Breaker Management (CBM) – CBF, ARSYN, OC, Pole Discordance*
  - Bay Controller (per CB)
  - IOIED for Station alarm and Txmr bay
  - Low Impedance Busbar protection
  - AVR
- Tripping Scheme – hardwire:
  - direct to Trip coil and Master trip
  - CBF tripping bus-wire
  - Live Protection Maintenance
- Control – GOOSE application
  - Interlock (Order Running, CB Trip Block under Live Transfer etc)
  - Autoreclose & DFR initiation

Overview of IEC 61850 System Configuration description Language (SCL) and Engineering Process

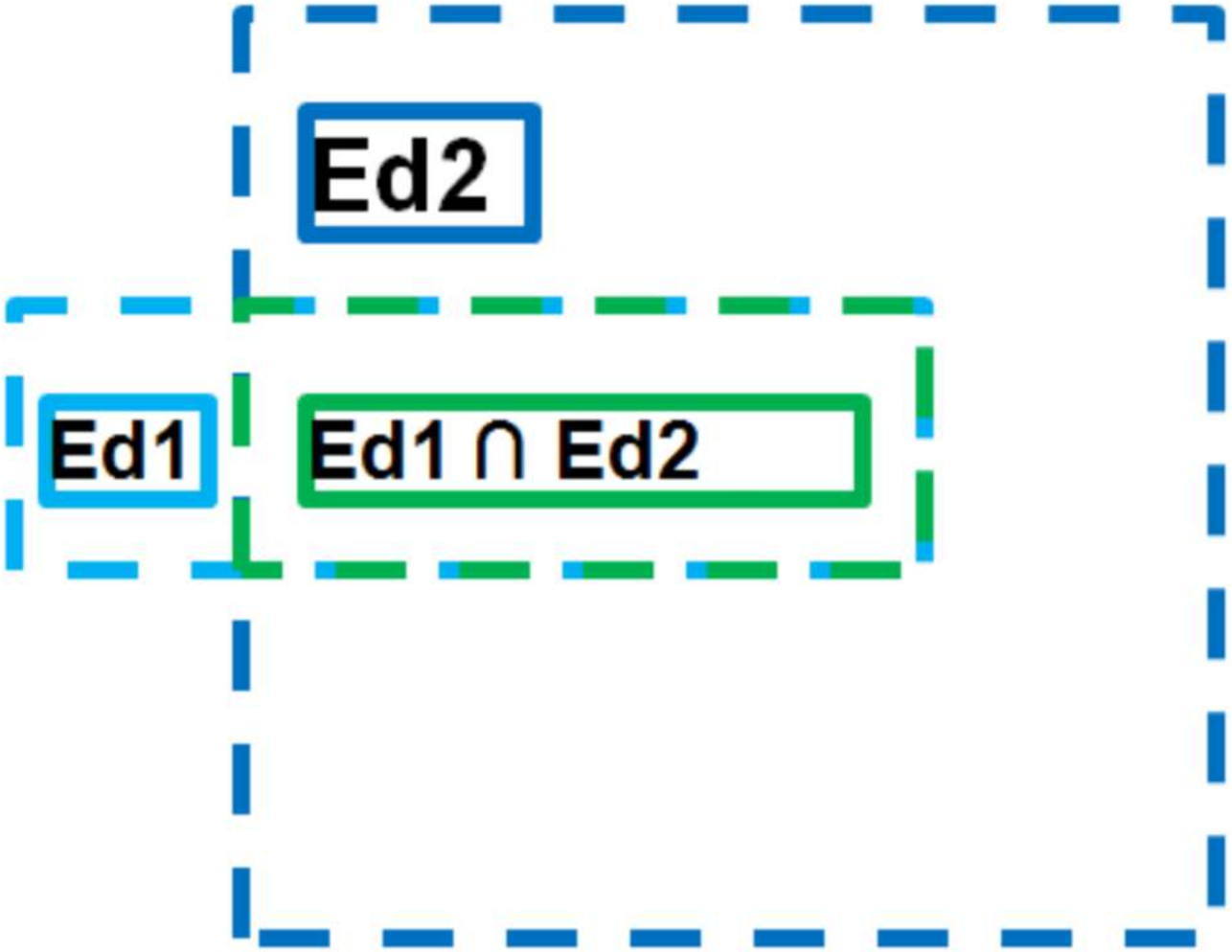
Basic Engineering Flow





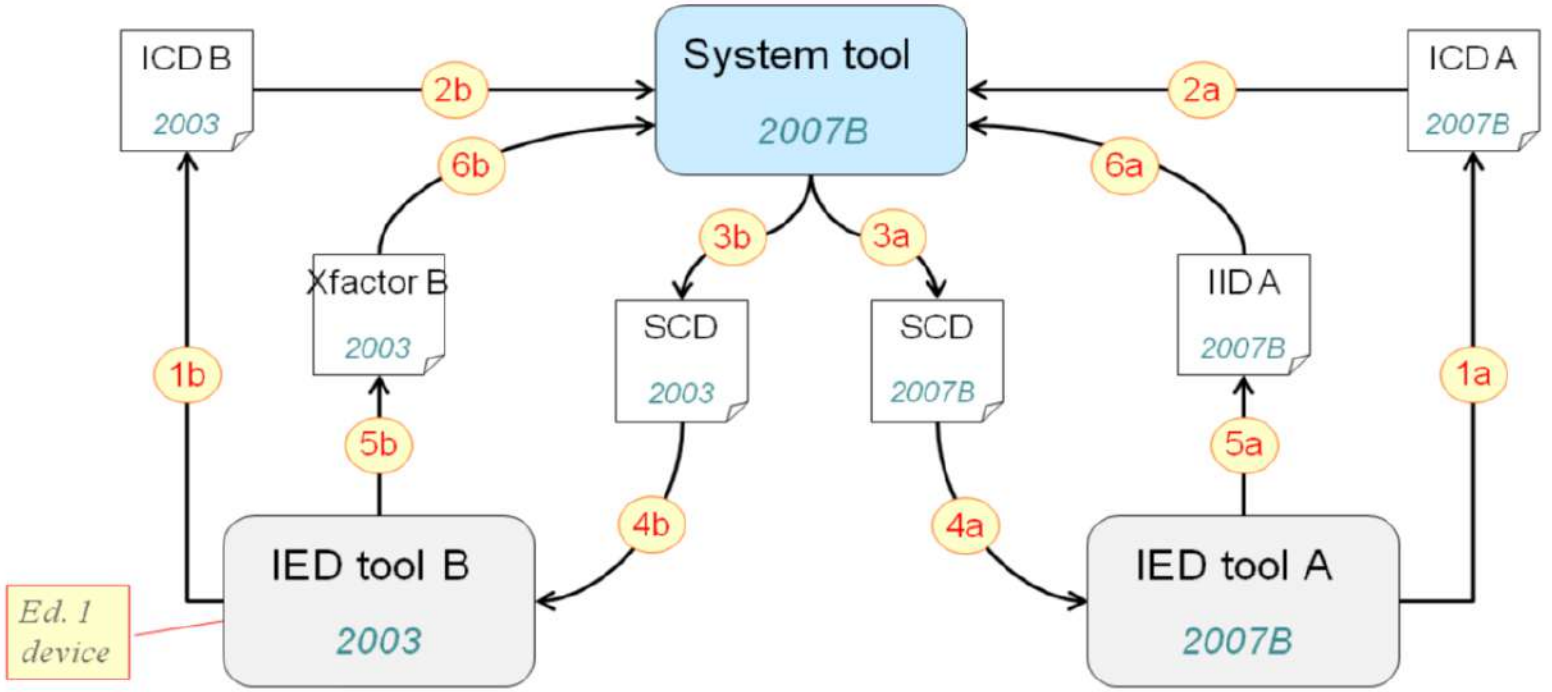
Source: IEC 61850-6:2009

Edition 1 and Edition 2 Area of Compatibility



Source: IEC 61850-6:2009+AMD1:2018

#1: Edition 1 and Edition 2 Mixed Engineering Process – Single System Configuration Tool (SCT) with Different SCL Versions

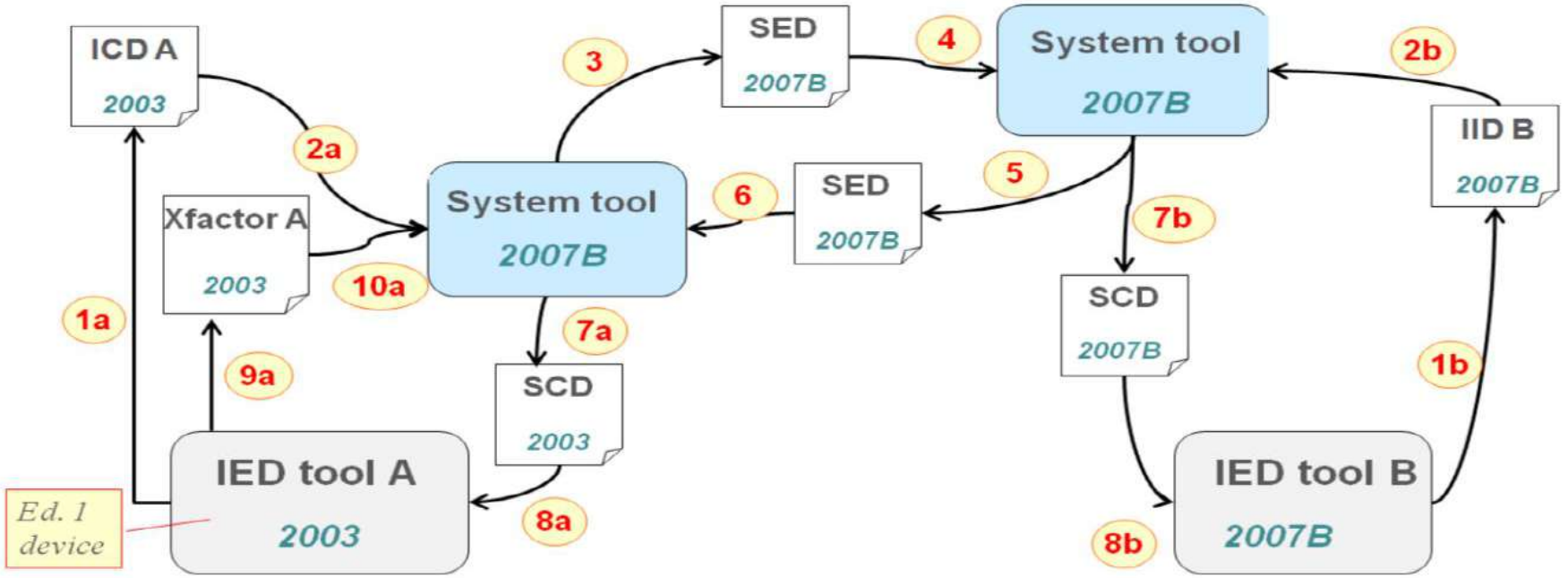


1. Generate ICD
   a. by IED tool A (2007B)
   b. by IED tool B (2003 – Ed.1)
2. System tool imports
   a. ICD A
   b. ICD B (upgrade to SCL 2007B)
3. Generate
   a. SCD 2007B
   b. SCD 2003 (downgrade to Ed.1)
4. SCD import
   a. IED tool A imports SCD 2007B
   b. IED tool B imports SCD 2003
5. Generate
   a. IID by IED tool A (2007B)
   b. "Xfactor" by IED tool B (2003)
6. System tool imports
   a. IID A
   b. "Xfactor" B (upgrade to 2007B)

IEC

Source: IEC 61850-6:2009+AMD1:2018

#2: Edition 1 and Edition 2 Mixed Engineering Process – Multiple System Configuration Tool (SCT) with Different SCL Versions

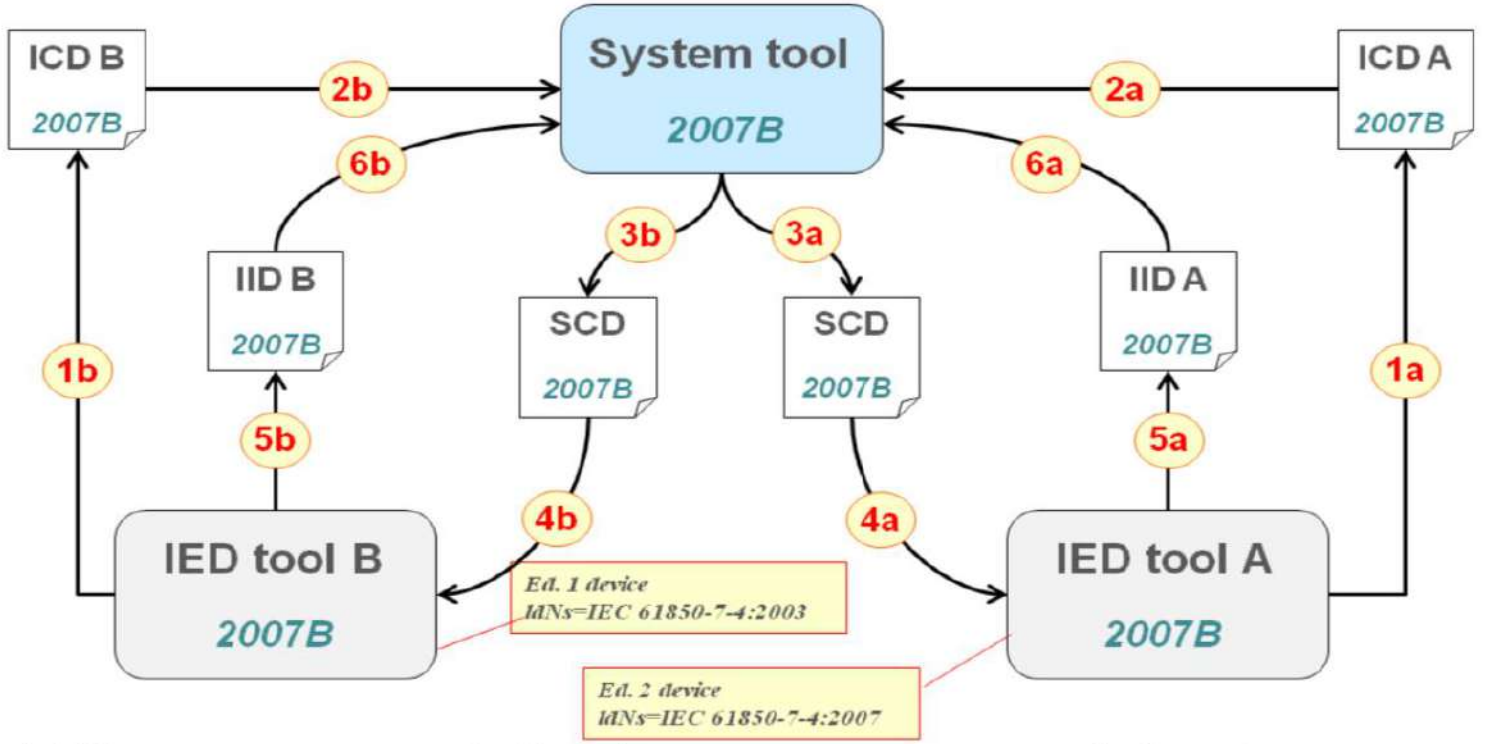


1. Generate ICD/IID
   a. by IED tool A (2003 – Ed.1)
   b. by IED tool B (2007B)
2. System tools import
   a. ICD A
   b. ICD B
3. Generate SED 2007B (upgrading rules of IED A)
4. Import SED 2007B
5. Generate SED 2007B
6. Import SED 2007B (downgrading rules for IED B)
7. Generate
   a. SCD 2003
   b. SCD 2007B
8. SCD import
   a. IED tool A imports SCD 2003
   b. IED tool B imports SCD 2007B
9. Generate
   a. "Xfactor" by IED tool A (2003)
10. System tools import
    a. "Xfactor" A

IEC

Source: IEC 61850-6:2009+AMD1:2018

#3: Hybrid Edition 1 and Edition 2 IEDs Engineering Process

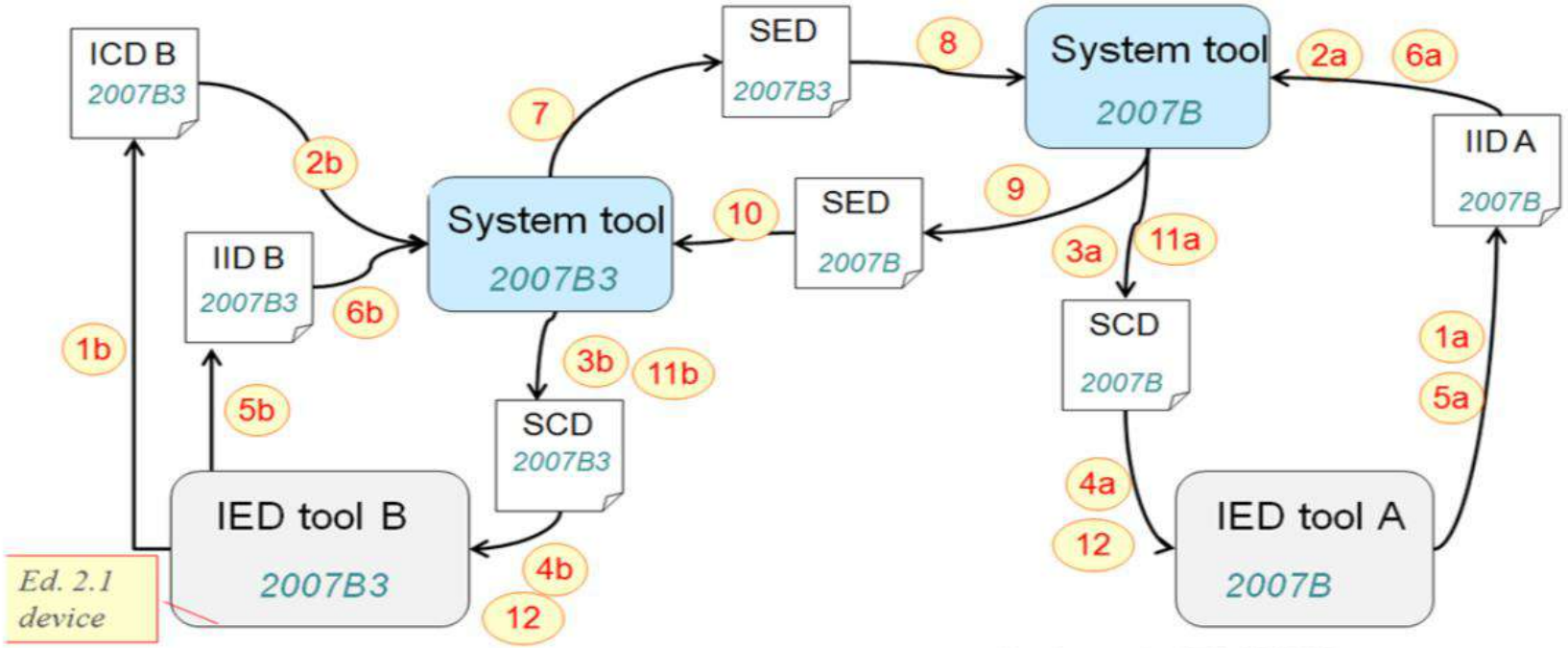


1. Generate ICD
   a. by IED tool A (2007B)
   b. by IED tool B (2007B)
2. System tool imports
   a. ICD A
   b. ICD B (upgrade to SCL 2007B)
3. Generate
   a. SCD 2007B
   b. SCD 2007B
4. SCD import
   a. IED tool A imports SCD 2007B
   b. IED tool B imports SCD 2007B
5. Generate
   a. IID by IED tool A (2007B)
   b. IID by IED tool B (2007B)
6. System tool imports
   a. IID A
   b. IIDB

IEC

Source: IEC 61850-6:2009+AMD1:2018

#4: Edition 2.1 and Edition 2 Mixed Engineering Process – Multiple SCTs with Different SCL versions

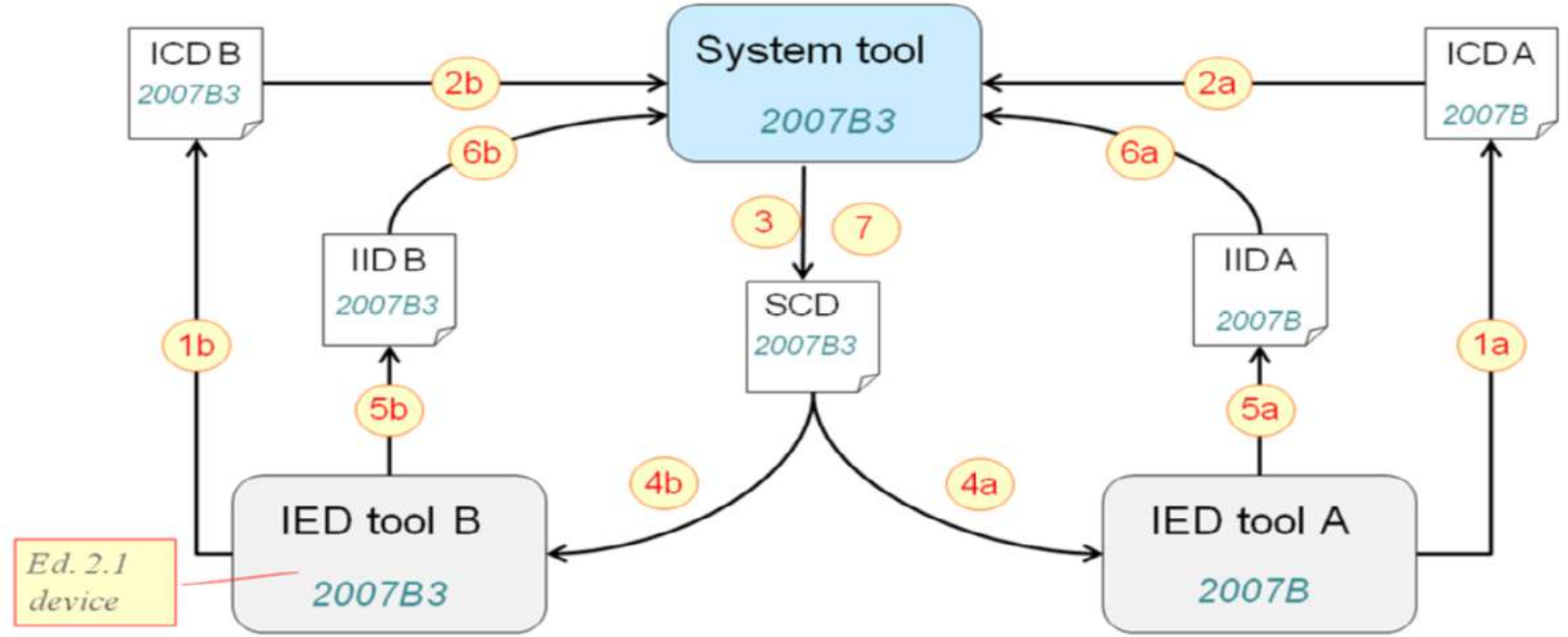


1. Generate ICD/IID
   a. by IED tool A (2007B)
   b. by IED tool B (2007B3)
2. System tools import
   a. ICD A
   b. ICD B
3. Generate
   a. SCD 2007B
   b. SCD 2007B3
4. SCD import
   a. IED tool A imports SCD 2007B3
   b. IED tool B imports SCD 2007B
5. Generate
   a. IID by IED tool A (2007B)
   b. IID by IED tool B (2007B3)
6. System tools import
   a. IID A
   b. IID B
7. Generate SED 2007B3
8. Import SED 2007B3 (mustUnderstand/mayIgnore /validate)
9. Generate SED 2007B
10. Import SED 2007B (upgrading rules for IED A)
11. Generate
    a. SCD 2007B
    b. SCD 2007B3
12. Import SCD

IEC

Source: IEC 61850-6:2009+AMD1:2018

#5: Edition 2.1 and Edition 2 Mixed Engineering Process – Single Edition 2.1 SCT

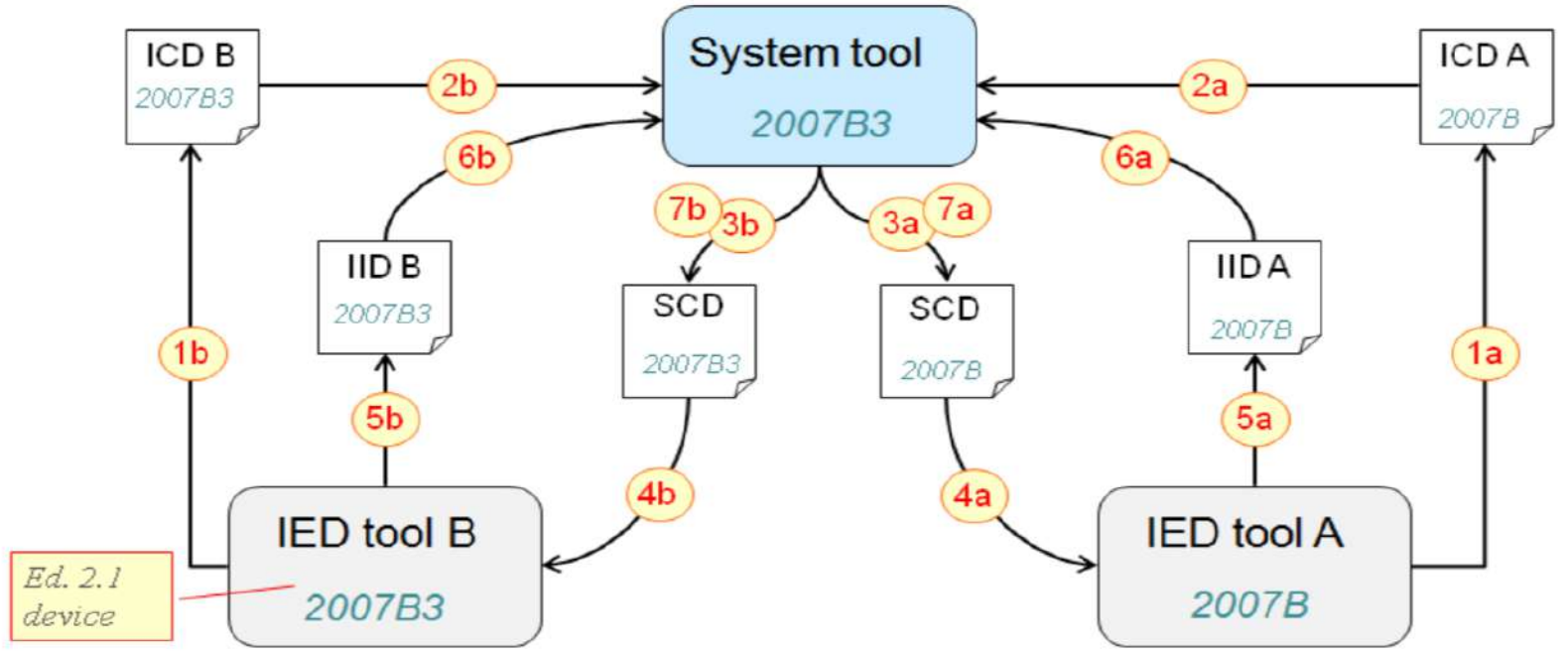


1. Generate ICD
   a. by IED tool A (2007B)
   b. by IED tool B (2007B3)
2. System tool imports
   a. ICD A (upgrade to SCL 2007B3)
   b. ICD B
3. Generate SCD 2007B3
4. SCD import
   a. IED tool A imports SCD 2007B3 (mustUnderstand/mayIgnore)
   a. IED tool B imports SCD 2007B3
5. Generate
   a. IID by IED tool A (2007B)
   b. IID by IED tool B (2007B3)
6. System tool imports
   a. IID A (upgrade to 2007B3)
   b. IID B
7. Export SCD...

IEC

Source: IEC 61850-6:2009+AMD1:2018

#6: Edition 2.1 and Edition 2 Mixed Engineering Process – Edition 2.1 SCT Downgrade Output to Edition 2



1. Generate ICD
   a. by IED tool A (2007B)
   b. by IED tool B (2007B3)
2. System tool imports
   a. ICD A (upgrade to SCL 2007B3)
   b. ICD B
3. Generate
   a. SCD 2007B3
   b. SCD 2007B (downgrade to SCL 2007)
4. SCD import
   a. IED tool A imports SCD 2007B
   b. IED tool B imports SCD 2007B3
5. Generate
   a. IID by IED tool A (2007B)
   b. IID by IED tool B (2007B3)
6. System tool imports
   a. IID A (upgrade to 2007B3)
   b. IID B
7. Export SCD...

IEC

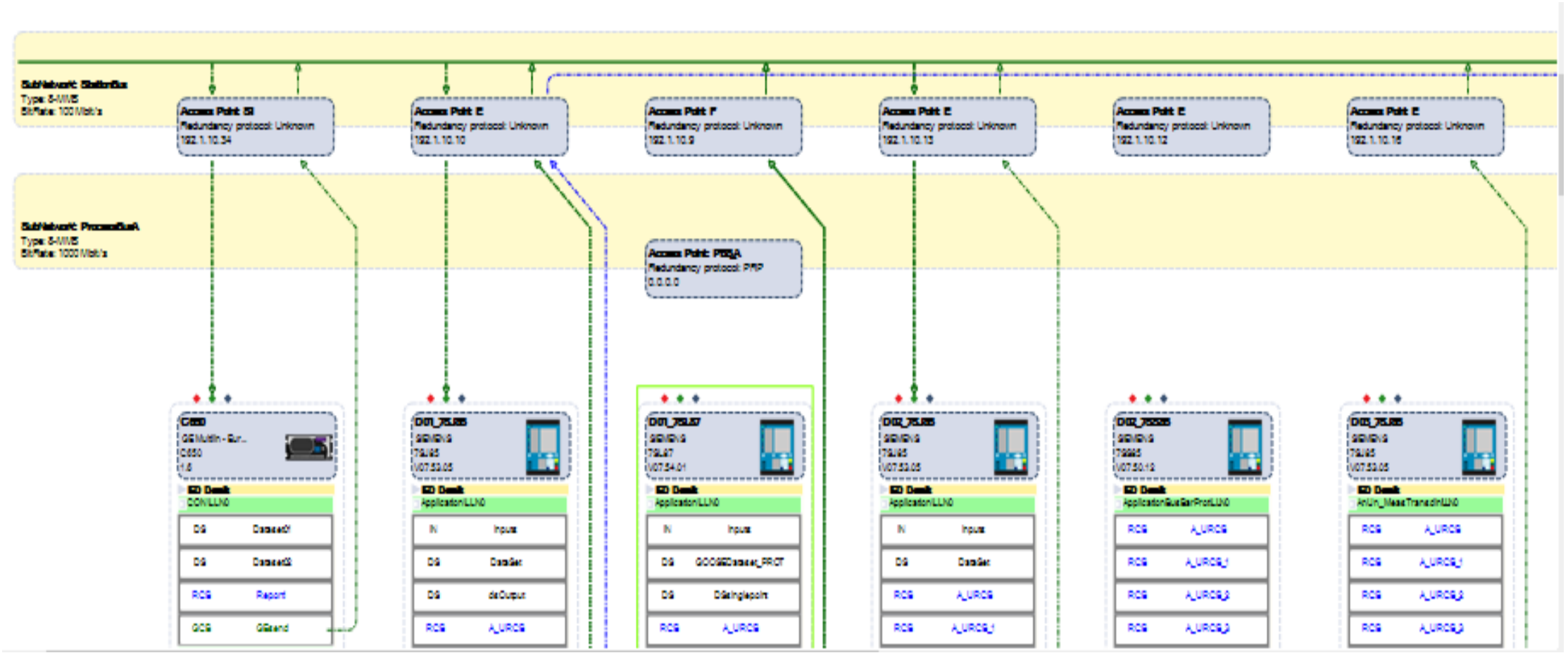
Source: IEC 61850-6:2009+AMD1:2018

Case Study: Top-down Engineering Process with ASEAN Utility

Case Study Background

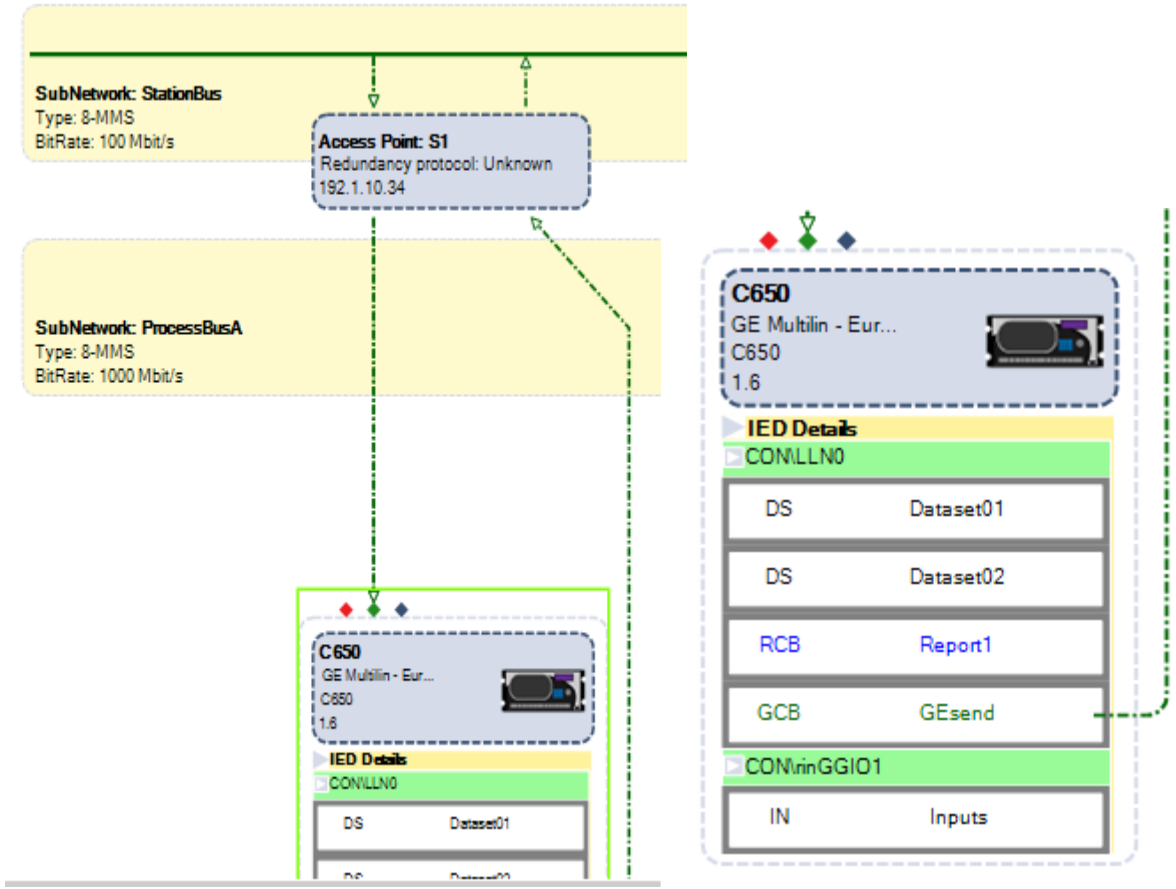
- Speaker was appointed as consultant by an ASEAN utility company in September 2019
- Project objective: To prove a working IEC 61850 top-down engineering process in multi-vendor laboratory environment
- IEDs involved:
  - SIEMENS (2 units Edition 2 IEDs)
  - Schneider Electric (1 unit Edition 2 IED)
  - GE Multilin (1 unit Edition 2 IED)
  - ABB (1 unit Edition 2 IED)
  - Toshiba (1 unit Edition 1 IED)
- Success criterions:
  - Successful import of .scd file from SCT by IED Configuration Tool
  - Successful initiation of signals among IEDs
- Tools used:
  - SCT – SCL Matrix from GridSoftware
  - Client Simulator – IED Scout from Omicron Gmbh
  - IED Configuration Tools (ICT)

Dataflow Diagram in SCL Matrix - General

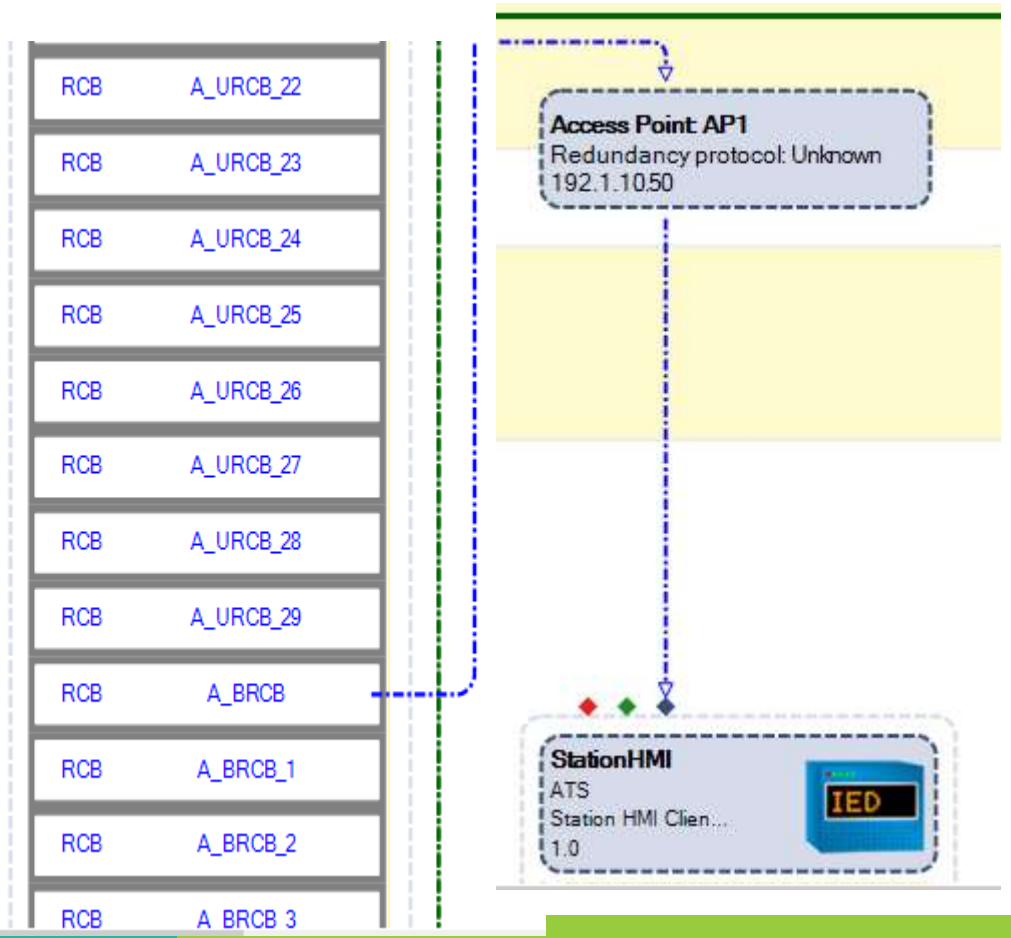


Dataflow Diagram in SCL Matrix – GOOSE and Client-Server Flows

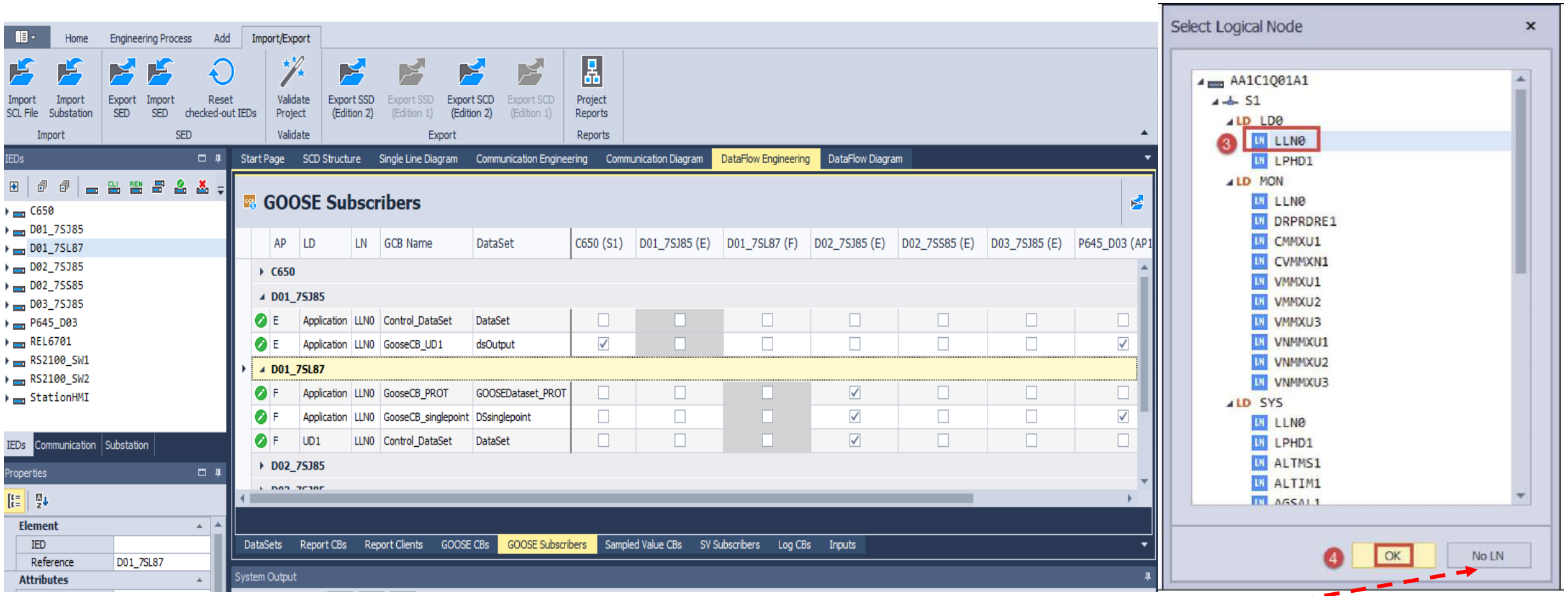
GOOSE Publish and Subscribe



Client-Server: IED to HMI



GOOSE Subscription Input Configuration



- **Need to choose predefined GOOSE input in IEDs or utilize the 'No LN' feature for input binding in ICT after export of .scd file**

Edition 2 to Edition 1 Downgrade Process Implemented in the Project

1) Export .cid file (Ed. 2) from .scd file (Ed. 2) created in SCL Matrix

2) Launch OMICRON IED Scout. Import the .cid file (Ed. 2) to IED Scout.

3) Save the .cid file (Ed. 2) as Ed. 1 .cid (options SCL Schema version 1.4, 1.5 and 1.7)

4) Import the .cid file (Ed. 1) to Ed. 1 ICT

Result: Tool Interoperability Matrix

Publisher	Subscriber					Subscriber (Ed. 1)
	IED (IEC 61850 Ed. 2)	**Vendor A**	**Vendor B**	**Vendor C**	**Vendor D**	**Vendor E**
	Vendor A	Model 1 to Model 2 Top down (.iid) Input: NO LN	Top down (.iid) Input: System.GosGGIO1	Top down (.iid) Input: CON.rinGGIO1	Top down (.iid) Input: LD0.LLN0	**Unsuccessful configuration**
	Vendor B	Top down (.iid) Input: NO LN		Top down (.iid) Input: CON.rinGGIO1	Top down (.iid) Input: LD0.LLN0	SCL Ed. 2 to Ed. 1 Downgrade
	Vendor C	Top down (.iid) Input: NO LN	Top down (.iid) Input: System.GosGGIO1		Top down (.iid) Input: LD0.LLN0	SCL Ed. 2 to Ed. 1 Downgrade
	Vendor D	Top down (.iid) Input: NO LN	Top down (.iid) Input: System.GosGGIO1	Top down (.iid) Input: CON.rinGGIO1		**Unsuccessful configuration**

Summary and Conclusion

- Generally, the project has proven successful information exchange achieved from top-down engineering approach
- Edition 2 ICTs did not exhibit any major issues when importing .scd file generated from third-party SCT
- For Edition 2 to Edition 1 IED engineering, non-standard downgrade process was the only way for successful SCL file import in Edition 1 ICT. Methods suggested in IEC 61850-6:2009+AMD1:2018 did not properly work as Edition 1 ICT could not parse the downgraded .scd file from SCT
- The utilization of 'No LN' method in SCT was because certain ICT did not allow insertion of new external input in SCTs. Some IEDs have fixed LNs designated for GOOSE input signals
- Some issues observed in the project were similar to the findings in UCA IOP 2019 where mostly related to implementation issues in ICT and IED vendors
- The latest version of SCT fully supports ExtRef attributes as outlined in IEC 61850-6:2009+AMD1:2018. To be tested in TNB Research IEC 61850 laboratory and on-going Digital Substation research project

Ir. Ts. Mohd Iqbal Ridwan
Senior Manager
TNBX Sdn. Bhd.
Level 13, Wisma TNB,
No. 19, Jalan Timur,
46200 Petaling Jaya,
Selangor, Malaysia
Tel (O) :03–7967 9000 (HP): 016–521 6590
Email: iqbalri@tnb.com.my

Senri no michi mo, ippo kara hajimaru