台灣電力公司 TPRI 綜合研究所

IEC 61850 互通性測試與應用

台灣電力公司
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智慧電業
新趨勢

簡報大綱

壹 IEC 61850測試

貳 UCAIug互通性測試

參 IEC 61850互通性實驗室介紹

肆 結語

IEC 61850測試

IEC 61850測試

一、符合性測試(Conformance Test)。
二、效能測試(Performance Test)。
三、功能測試(Function Test)。
四、互通性測試(Interoperability Test)。

一、符合性測試

1. IEC 61850-10: Conformance testing
2. PICS(Protocol Implementation Conformance Statement)
   TICS(Technical Issues Conformance Statement)
   MICS(Model Implementation Conformance Statement)
3. UCAIug Accredited Level A Labs: DNV GL, TÜ V SÜ D, ETC.

UCAIug 認證實驗室

Tester	Level	Ed1 Server	Ed1 Sampled Values	Ed1/Ed2 GOOSE Performance	Ed2 Server	Ed2 Sampled Values	Ed1 Client	Ed2 Client	Ed2 SCL Tool
ABB Switzerland Ltd.	B	Y	Y	Y	Y	-			
AMA-CERT-Lab GmbH	A	Y			Y				
Central Power Research Institute India	A	Y			Y	-			
DNVGL Nederland (formerly KEMA, DNV-KEMA)	A	Y	Y	Y	Y	-	Y	Y	Y
Electronics Testing Center, Taiwan	A				Y			Y	
UK Grid Solutions Ltd. (formerly Alstom/Areva)	B	Y			Y	-			
Korea Electrotechnology Research Institute	A	Y	Y		Y	-	Y	Y	
Xuchang KETOP Testing Technology Co. Ltd.	A	Y	Y			-			
Korea Testing Laboratory	A	Y			Y	-	Y	Y	
NARI-RELAYS Electric Co. Ltd	B	Y				-			
Schneider-Electric China	B	Y			Y	-			
State Grid Electric Power Research Institute	A				Y				
Tecnalia	A				Y	-			
TÜV Rheinland GmbH	A	Y				-			
TÜV SÜD GmbH	A	Y	Y	Y	Y	-	Y	Y	Y
TÜV SÜD China Ltd	A	Y			Y	-		Y	

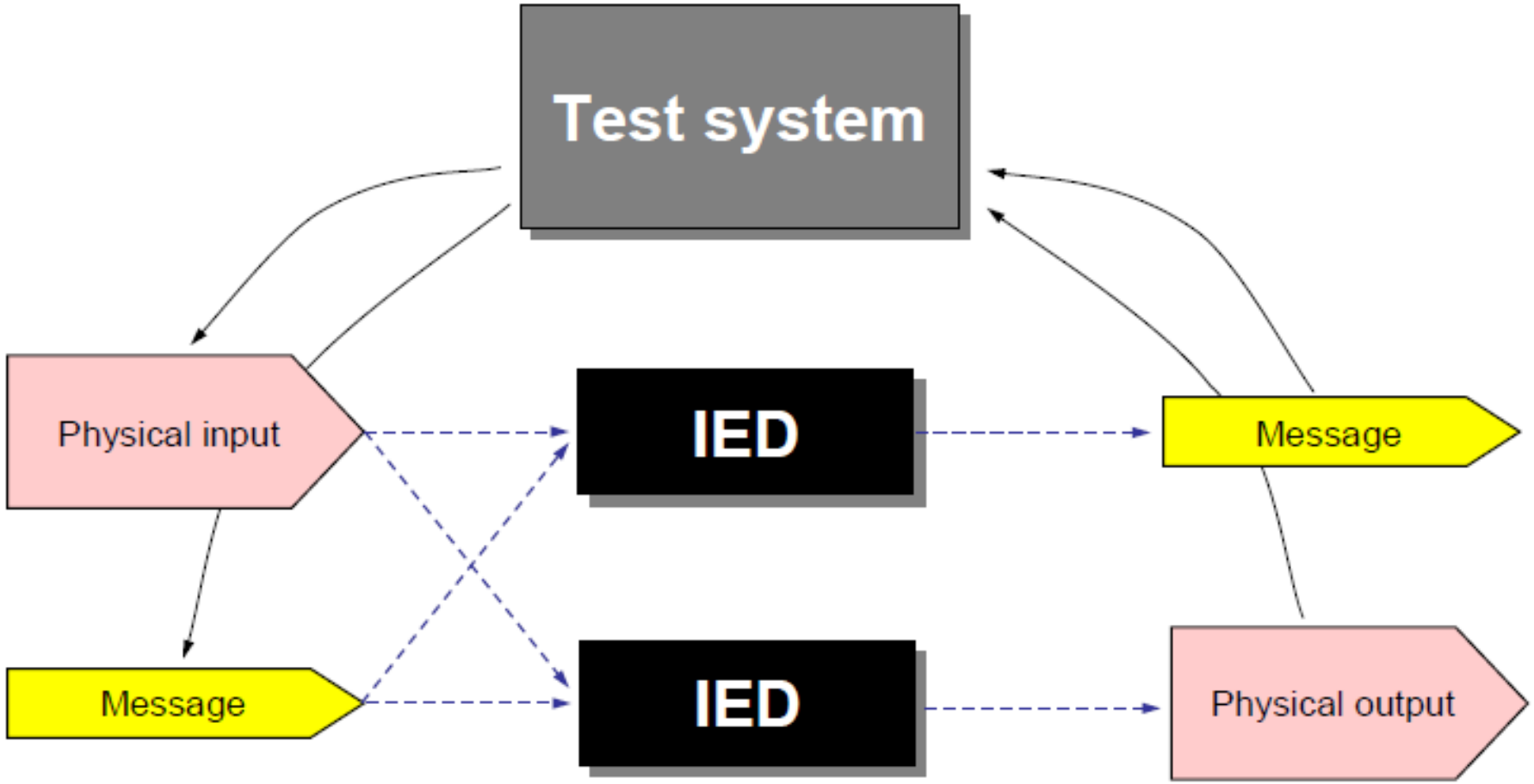
二、效能測試

1. IEC 61850-5: Communication requirements for functions and device models

(1) 通訊延遲 (Communication latency)

(2) 時間同步與精確度 (Time synchronization and accuracy)

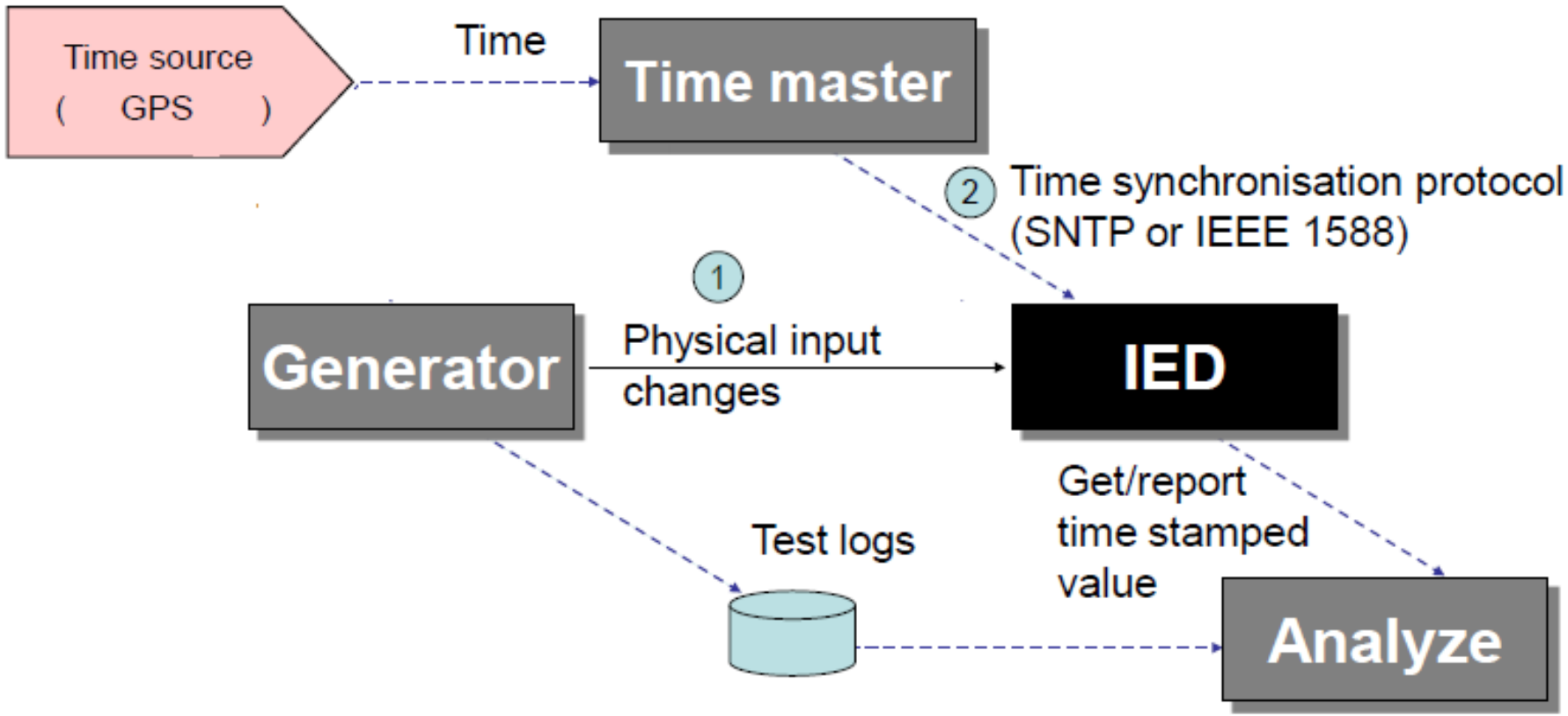
通訊延遲


Test system
Physical input
IED
Message
Message
IED
Physical output

通訊延遲

Latency class	Latency	Application example
TT0	> 1000 ms	File, events, log contents
TT1	≤ 1000 ms	Alarms and Events
TT2	≤ 500 ms	Operator commands
TT3	≤ 50 ms	Slow automatic interaction
TT4	≤ 20 ms	Fast automatic interaction
TT5	≤ 10 ms	Releases, status changes
TT6	≤ 3 ms	Trip, blockings
SOURCE: IEC 61850-5:2013, Table 1.		

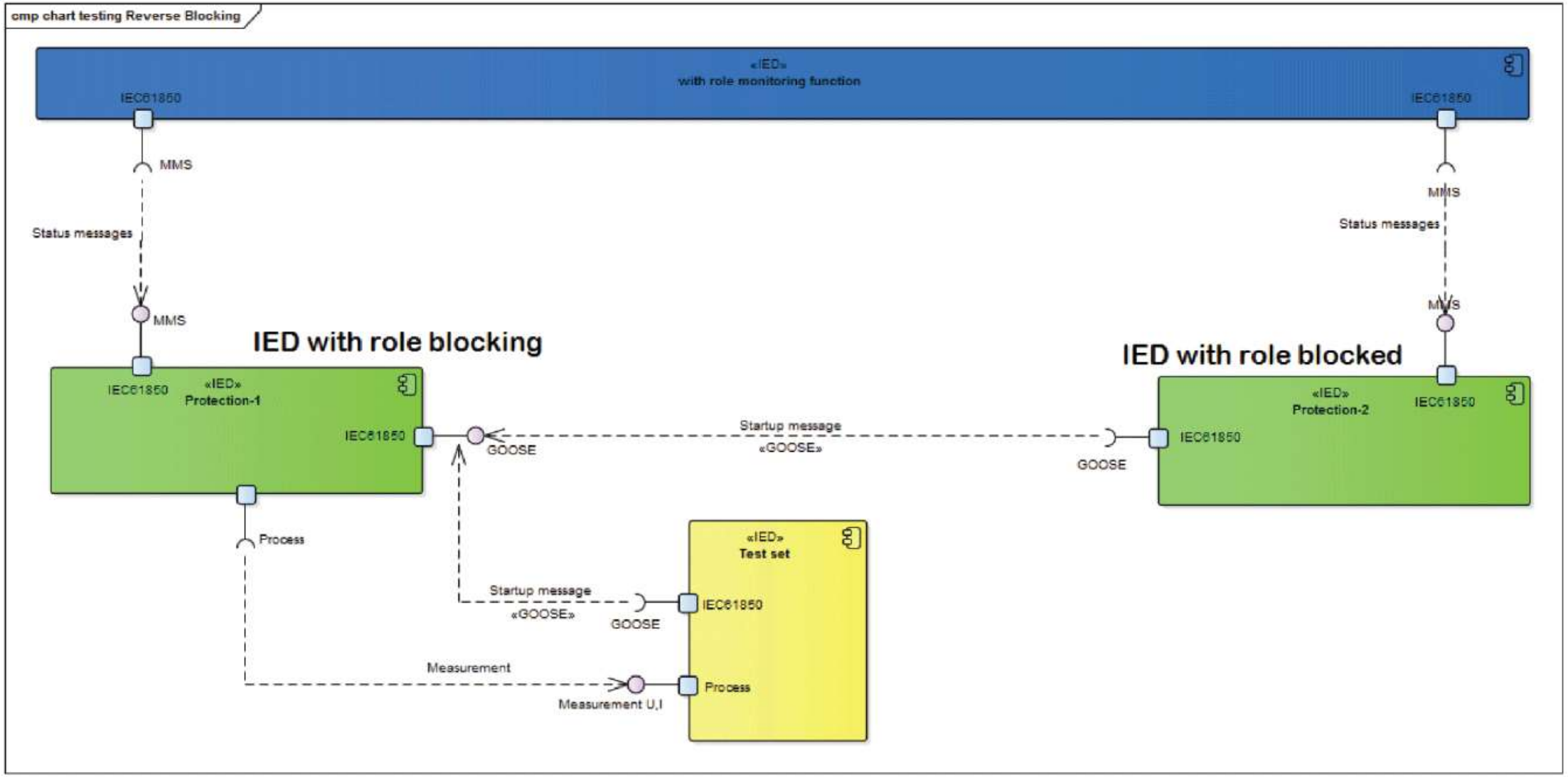
時間同步與精確度


Time source
(GPS)
Time
Time master
2
Time synchronisation protocol
(SNTP or IEEE 1588)
1
Generator
Physical input
changes
IED
Get/report
time stamped
value
Test logs
Analyze

三、功能測試

1. 功能測試需要不同的測試案例和測試序列。
2. 功能測試應著重於測試案例，以基於資訊模型之邏輯節點、資料物件、資料屬性及資訊交換服務與通訊協定來進行驗證。

測試案例: Reverse Blocking



四、互通性測試

1. 不同廠牌設備(例如: IED)可以達到互相溝通之目的。
2. UCAIug互通性測試(2011~2019)。

UCAIug 互通性測試

一、2011 IOP

- 2011: CIM-XML Interoperability Test:

  The Power of the Common Information Model (CIM) to Exchange Power System Data

Vendor and Product

Vendor	Product Name
Alstom	e-terraSource 2.0.1
EDF	PRAO (MV planning Tool), Matlab-PSAT CIM API (MV DMS loadflow), GEDEON (EDF R&D CIM Database)
GE Energy	Electric Office 4.2 and Smallworld GIS Adapter
EPRI	OpenDSS
Open Grid Systems	CIMPHONY
Oracle	
Siemens	Spectrum Power IMM 2.20 / Spectrum Power DNA 1.10
SISCO	Utility Integration Bus for OSIsoft PI System
SUPELEC	CIMCLIPSE 1.0 [BETA VERSION]
TIBCO	IntelliEDGE for CIM

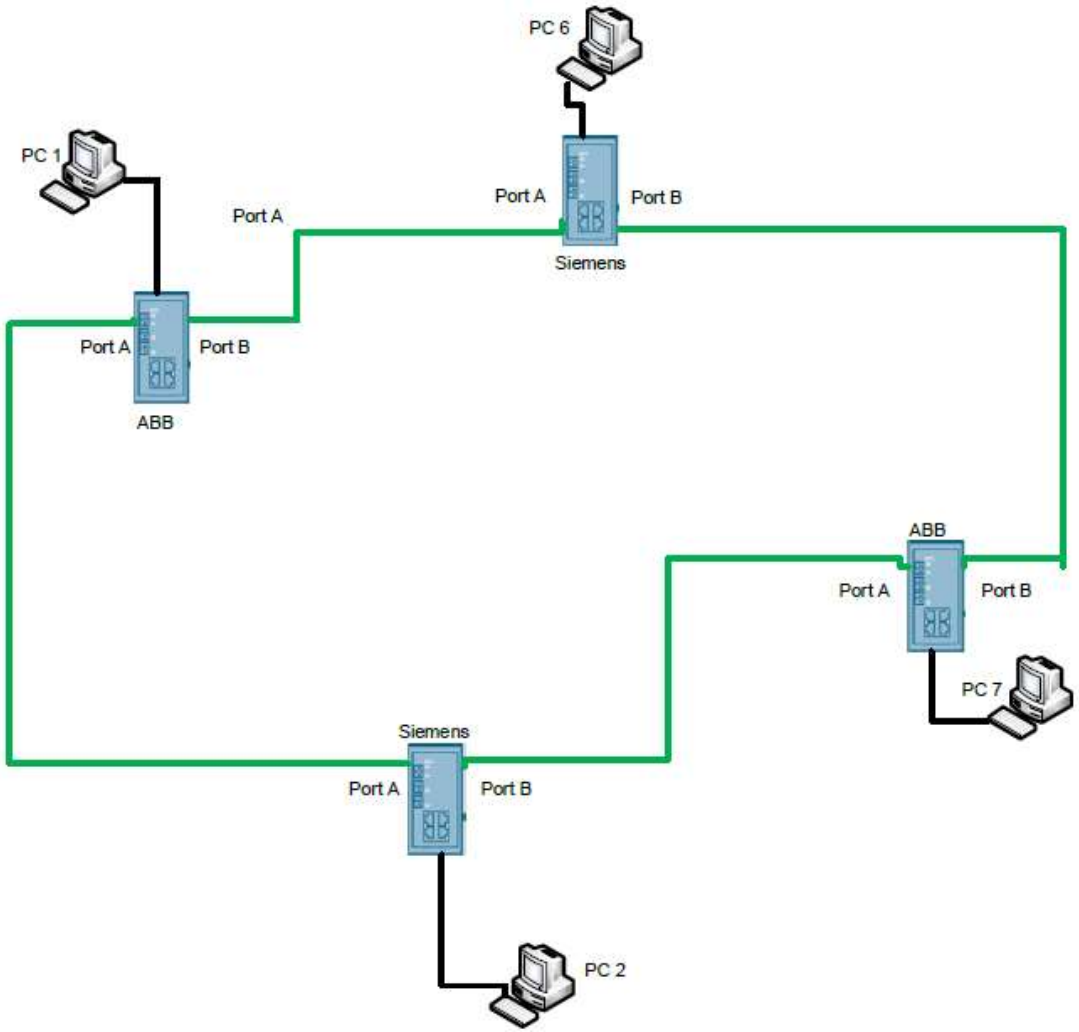
2011 IOP Summary

1. Ten initial models were provided for the tests.
2. Eight vendors performed the basic import test successfully.
3. Six vendors performed the basic export test successfully.
4. Eight vendors successfully imported GIS Models.

二、2013 IOP

1. Network Redundancy:
   (1) HSR (High-availability Seamless Redundancy)
   (2) PRP (Parallel Redundancy Protocol)

2013 IOP: HSR



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2013 IOP: HSR

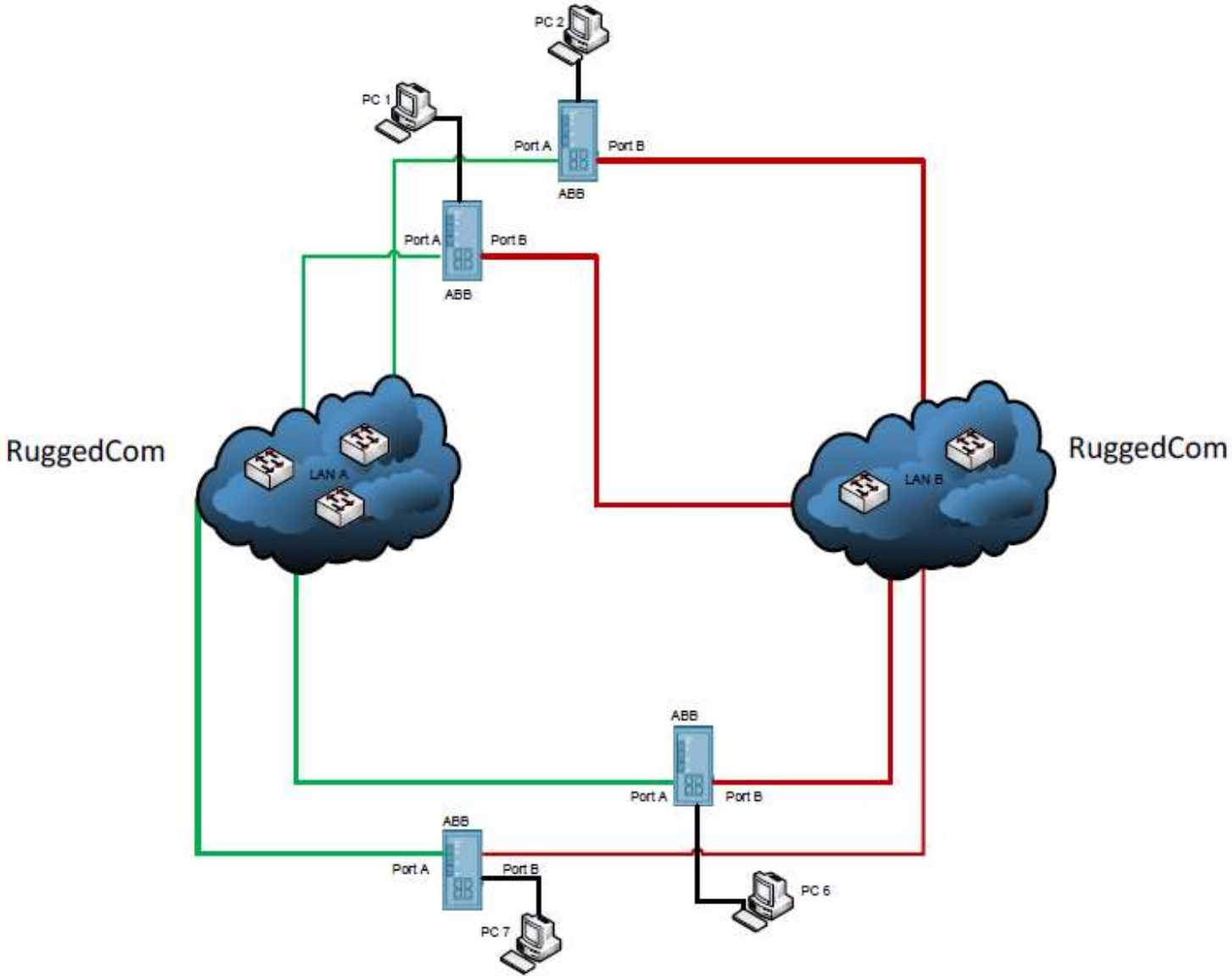
6.3.1 Test Setup

- 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.

2013 IOP: HSR

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

2013 IOP: PRP



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2013 IOP: PRP

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.

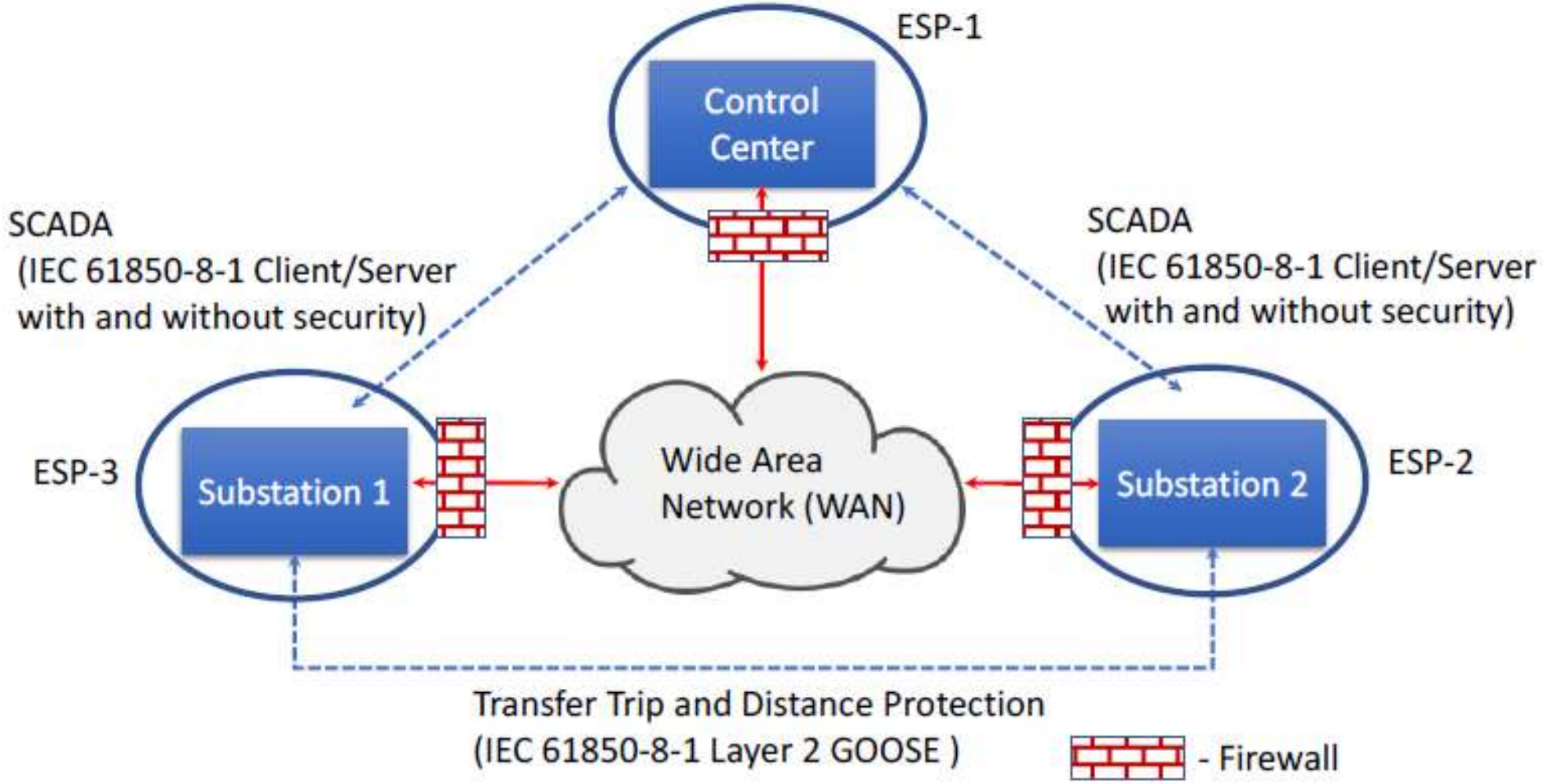
2013 IOP: PRP

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

三、2015 IOP

Participant	SCL	Client/ Server	GOOSE	SV	Time Sync	Networking
ABB	x				x	x
Alstom	x	x	x	x	x	x
ARC Informatique		x				
CopaData		x	x			
Doble			x	x	x	
Efacec	x	x	x			x
General Electric	x	x	x		x	x
Helinks	x					
Kalkitech	x	x				x
Koncar		x				
Moxa						x
OMICRON		x	x	x	x	x
NovaTech		x	x			
NR Electric	x	x	x	x	x	x
R.C. Bresler		x	x	x		
RTDS			x	x		
Schneider Electric	x	x	x			x

四、2017 IOP


ESP-1
Control Center
SCADA
(IEC 61850-8-1 Client/Server with and without security)
SCADA
(IEC 61850-8-1 Client/Server with and without security)
ESP-3
Substation 1
Wide Area Network (WAN)
Substation 2
ESP-2
Transfer Trip and Distance Protection
(IEC 61850-8-1 Layer 2 GOOSE)
- Firewall

2017 IOP

R-GOOSE and R-SV IED Participation Declaration						
Company	Equipment	Support Capabilities Declared				Type of Device
		R-GOOSE Publisher	R-GOOSE Subscriber	R-SV Publisher	R-SV Subscriber	
CISCO	CGR 2010					Router
CISCO	ISA 3000					Firewall
CISCO	IE 4010					Ethernet Switch
GE	Multilin D60	x	x			IED
NREC	PCS-9611	x	x			IED
Palo Alto Networks	PA-3050					Firewall
SISCO	UAP	x	x			IED
Vizimax	PMU 010000			x	x	IED

UCAIug IOP 2013~2017 Summary

1. 2013: IEC 61850 IOP

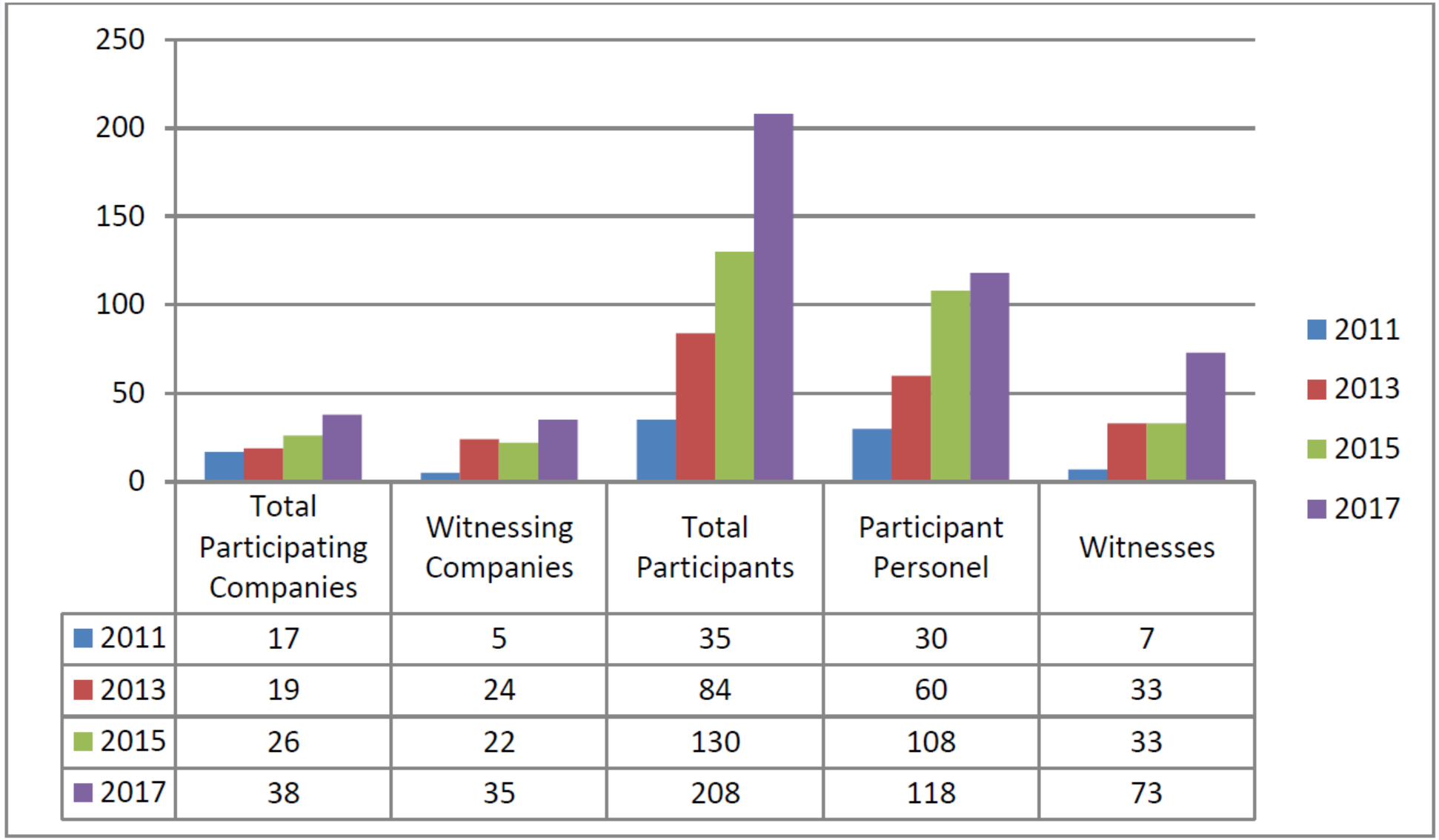
   GOOSE, Sampled Value, Client/Server…
2. 2015: IEC 61850 IOP

   HSR/PRP, PTP-Time Sync…
3. 2017: IEC 61850 IOP

   Routable GOOSE, Routable Sampled Value,

   Security…

2011~2017歷屆參加者比較



	Total Participating Companies	Witnessing Companies	Total Participants	Participant Personel	Witnesses
2011	17	5	35	30	7
2013	19	24	84	60	33
2015	26	22	130	108	33
2017	38	35	208	118	73

五、2019 IOP

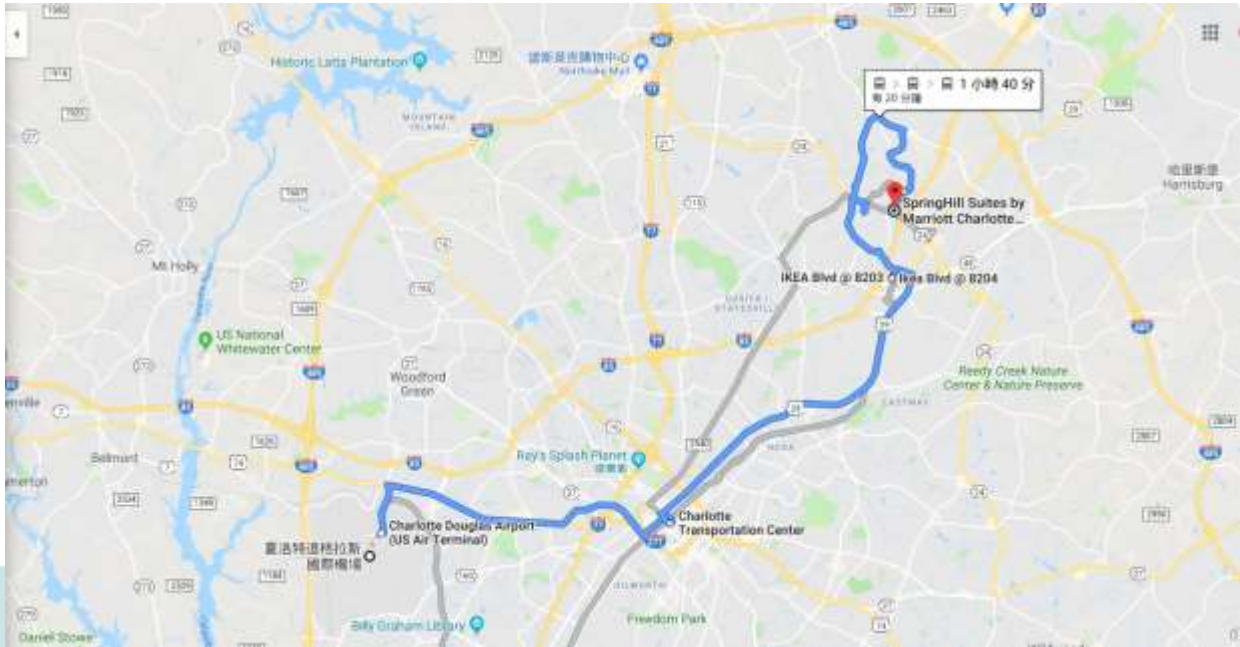
1. 時間: 9/21– 9/27
   (1) 2天 Boot Camp
   (2) 5天 IOP

2. 地點: 美國夏洛特EPRI


舊金山國際機場
11 小時 15 分
$16,333 元起
臺灣桃園國際機場
臺北松山機場
North Pacific Ocean


Carson City
薩克拉門托
Sacramento
聖羅莎
Santa Rosa
舊金山
San Francisco
舊金山國際機場
優勝美地國家公園
Yosemite National Park
Fresno
加利福尼亞
Visalia
Bakersfield
1 小時 25 分
$3,931 元起
拉斯維加斯
Las Vegas
亨德森
Henderson
Grand Canyon-Parashant National Monument
洛杉磯
Los Angeles
洛杉磯國際機場
約書亞樹國家公園
Joshua Tree National Park

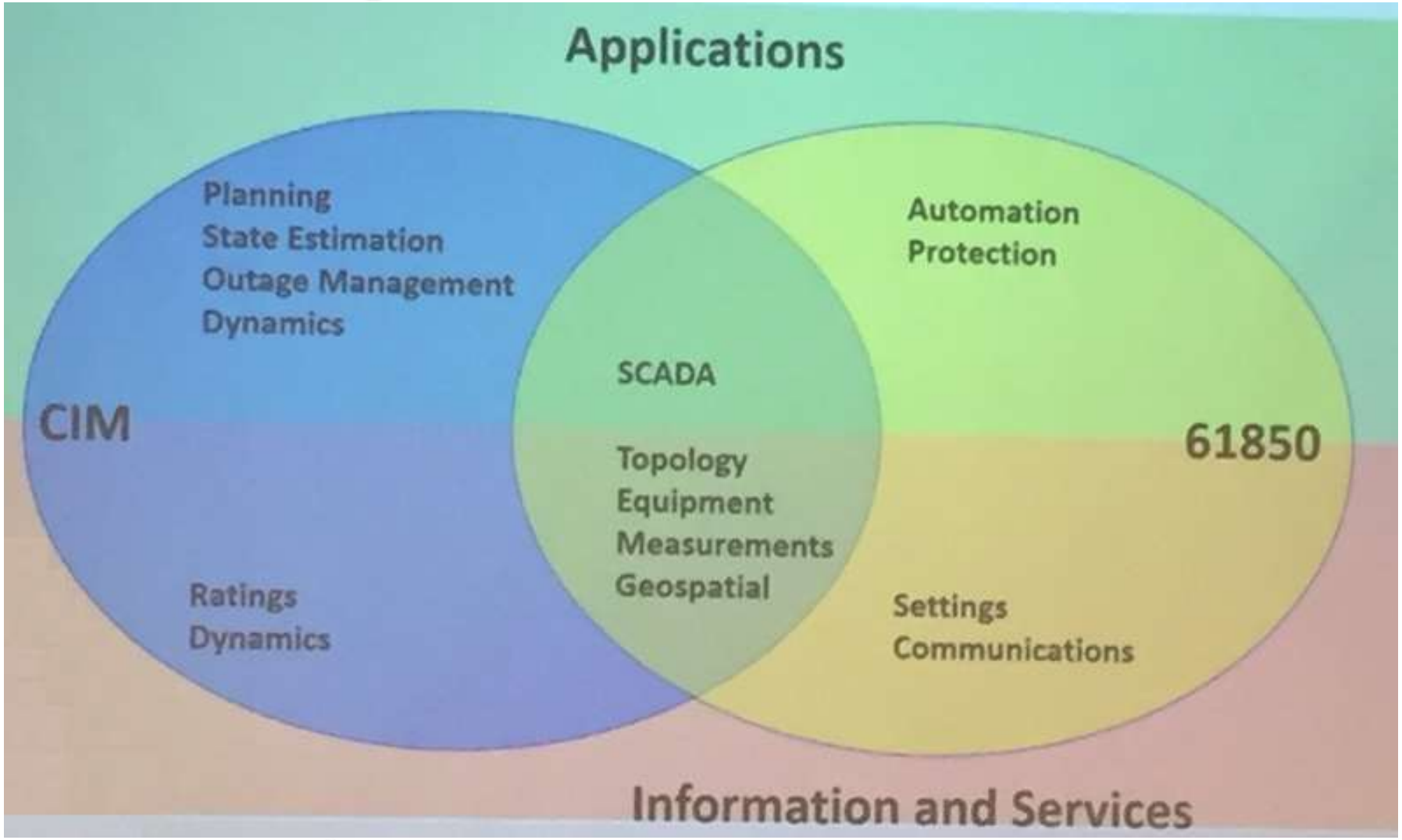

Vancouver
西雅圖
Seattle
蒙特利爾
Montreal
多倫多
Toronto
芝加哥
Chicago
丹佛
Denver
美國
堪薩斯城
Kansas City
印第安納波利斯
Indianapolis
納什維爾
Nashville
4 小時 40 分
$8,212 元起
亞特蘭大
Atlanta
舊金山
San Francisco
聖荷西
San Jose
拉斯維加斯
Las Vegas
洛杉磯國際機場
鳳凰城
Phoenix
達拉斯
Dallas
傑克遜維爾
Jacksonville
奧蘭多
Orlando
El Paso
圖森
Tucson
休斯敦
Houston
坦帕
Tampa
奧斯丁
Austin
聖安東尼奧
San Antonio
拉荷亞
La Habana


Historic Latta Plantation
1 小時 40 分
SpringHill Suites by Marriott Charlotte...
IKEA Blvd @ 8203
Ikea Blvd @ 8204
Mt Holly
US National Whitewater Center
Woodford Green
Belmont
Reedy Creek Nature Center & Nature Preserve
Roy's Splash Planet
Charlotte Douglas Airport (US Air Terminal)
Charlotte Transportation Center
Billy Graham Library
Freedom Park
Harrisburg

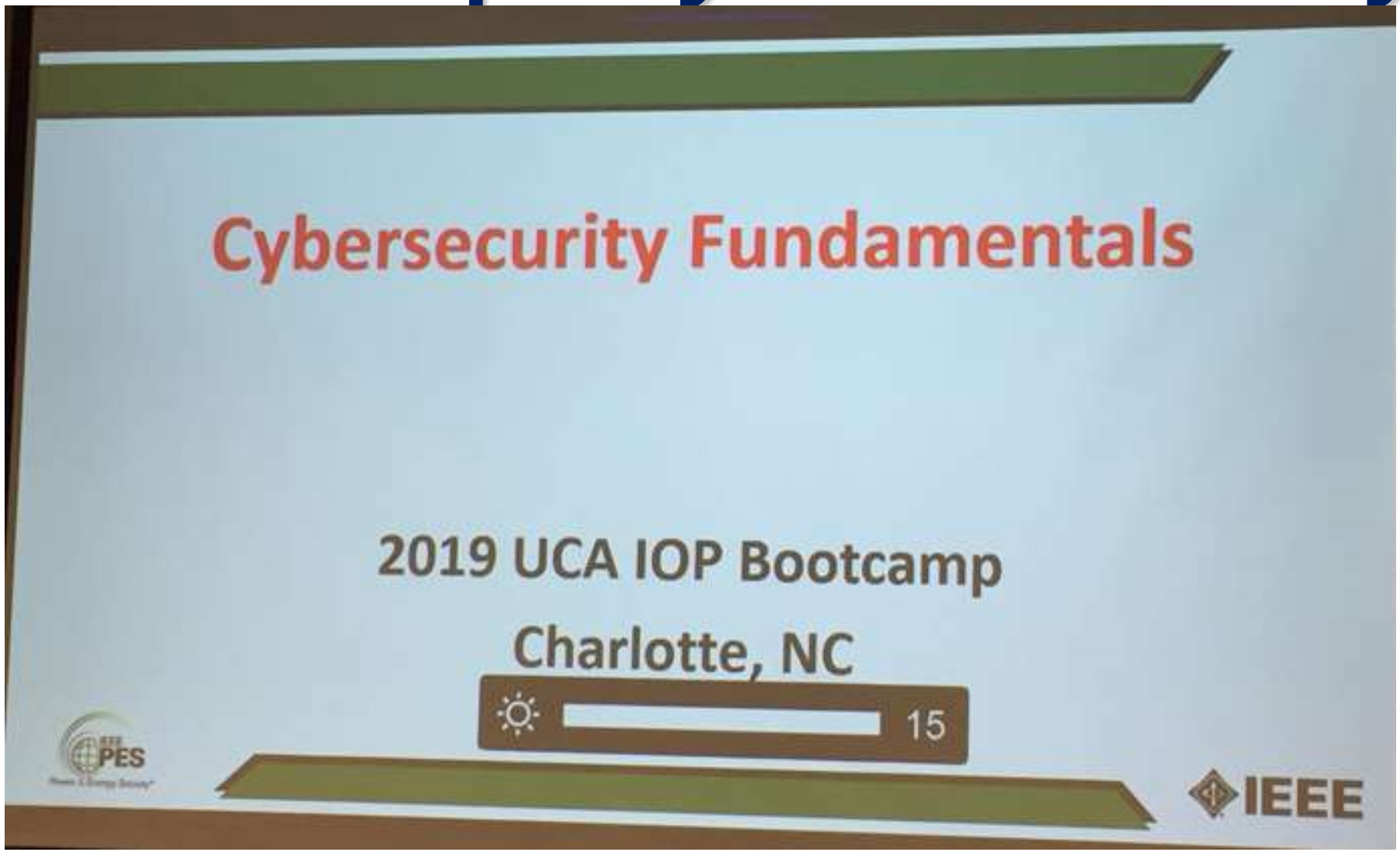
2019 IOP參加者

Participating Companies	Witnessing Companies
ABB	American Electric Power
Arc Informatique	Central Research Institute of Electric Power
CISCO	Commonwealth Edison
Copadata	DNV GL Netherlands B.V.
Doble Engineering	EDF
GE	Electric Power Research Institute
Gridclone	Electrics Testing Center, Taiwan
Helinks	Hydro-Quebec
Kalkitech / ASE	It4Power
KEPCO	KEPCO
KERI (Korea Electrotechnology Research Institute)	Korea Electrotechnology Research Institute
Novatech	National Grid
NR Electric	Pacific Northwest National Lab
OMICRON Electronics GmbH	Power Grid Corporation of India
PCItek	RTE
JPEmbedded SP. J.	Southern California Edison
RTDS Technologies Inc.	Taiwan Power
Schweitzer Engineering Laboratories, Inc.	Zamiren
Siemens	
Beijing Sifang Automation Company	
SISCO, Inc	
Toshiba Energy Systems & Solutions Corp	
Triangle Microworks	
Vizimax, Inc	

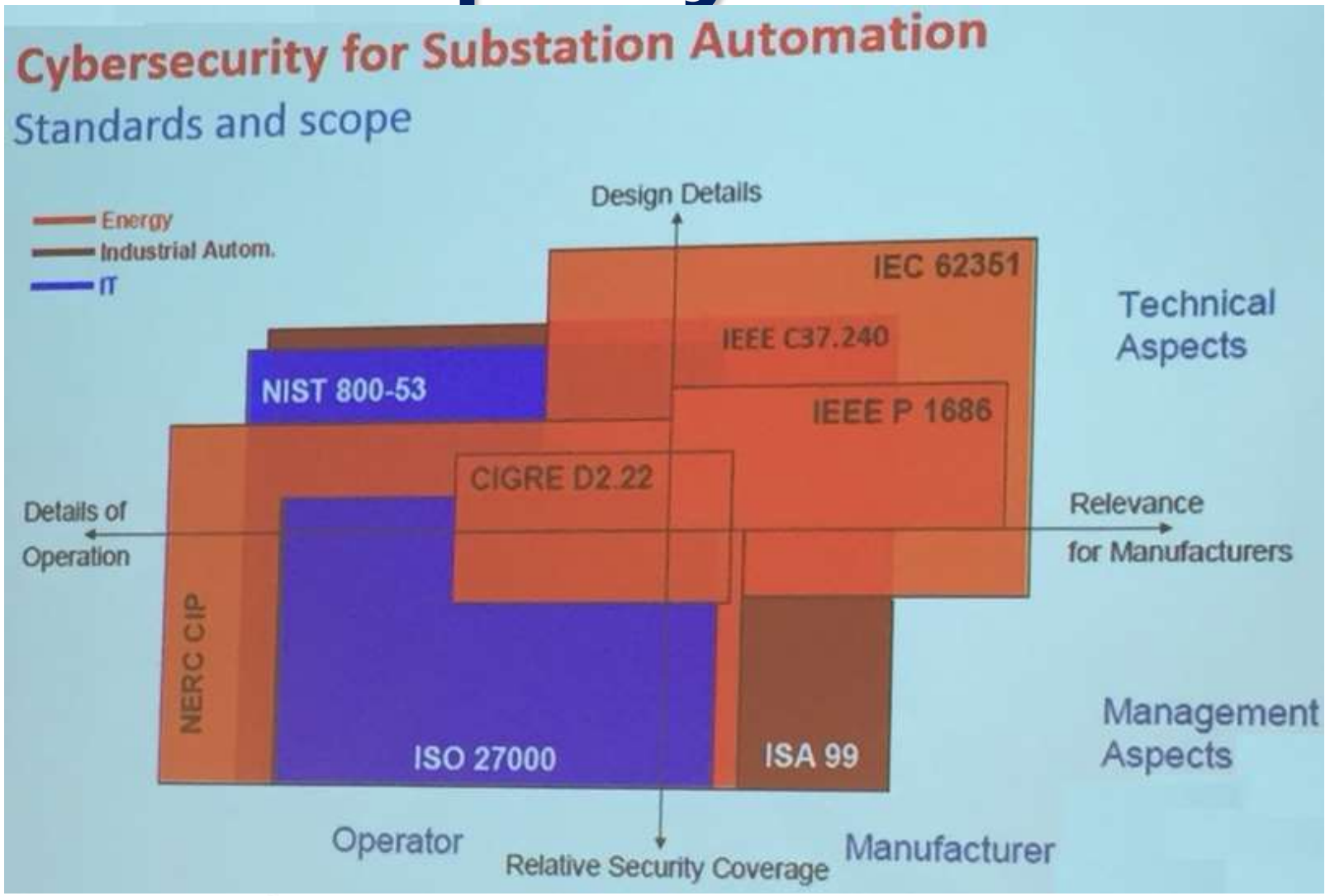
Boot Camp: IEC 61850與CIM調和



Boot Camp: Cyber Security



Boot Camp: Cyber Security

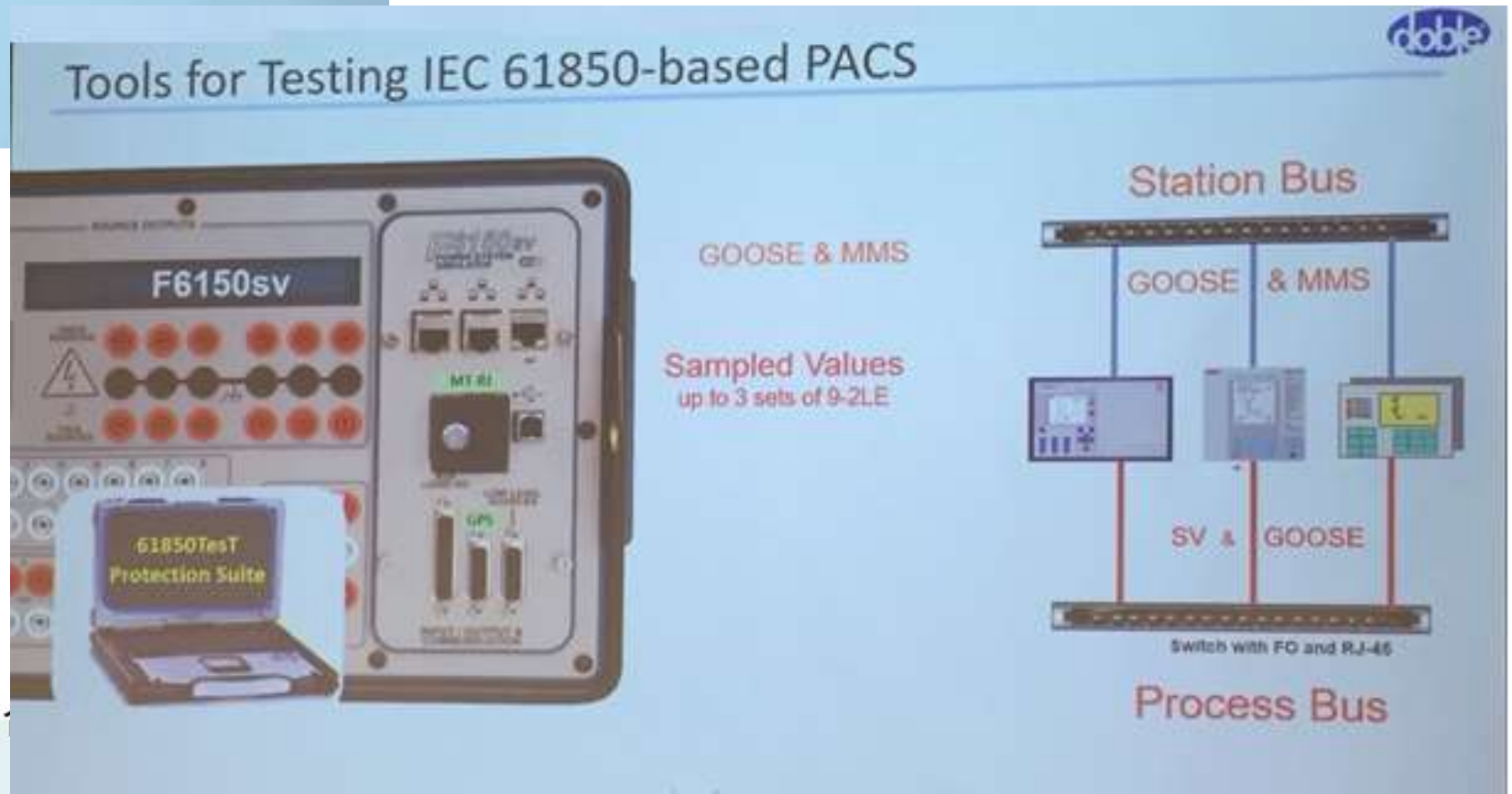


Boot Camp: IEC 61850測試

Testing in IEC 61850 Systems

Focus on Maintenance Testing of Protection Automation and Control Systems in a Live Power System

Doble Engineering
Omicron
RTDS Technologies
Schweitzer Engineering Laboratories



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Boot Camp: IEC 61850優點

1. 互通性
2. 標準化設計
3. 增加彈性
4. 控制系統數位化
5. 改善維護
6. 提升安全性

IEC 61850優點: 減少接線

A New Way of Wiring

Conventional

Excessive, confusing, and expensive wiring and installation

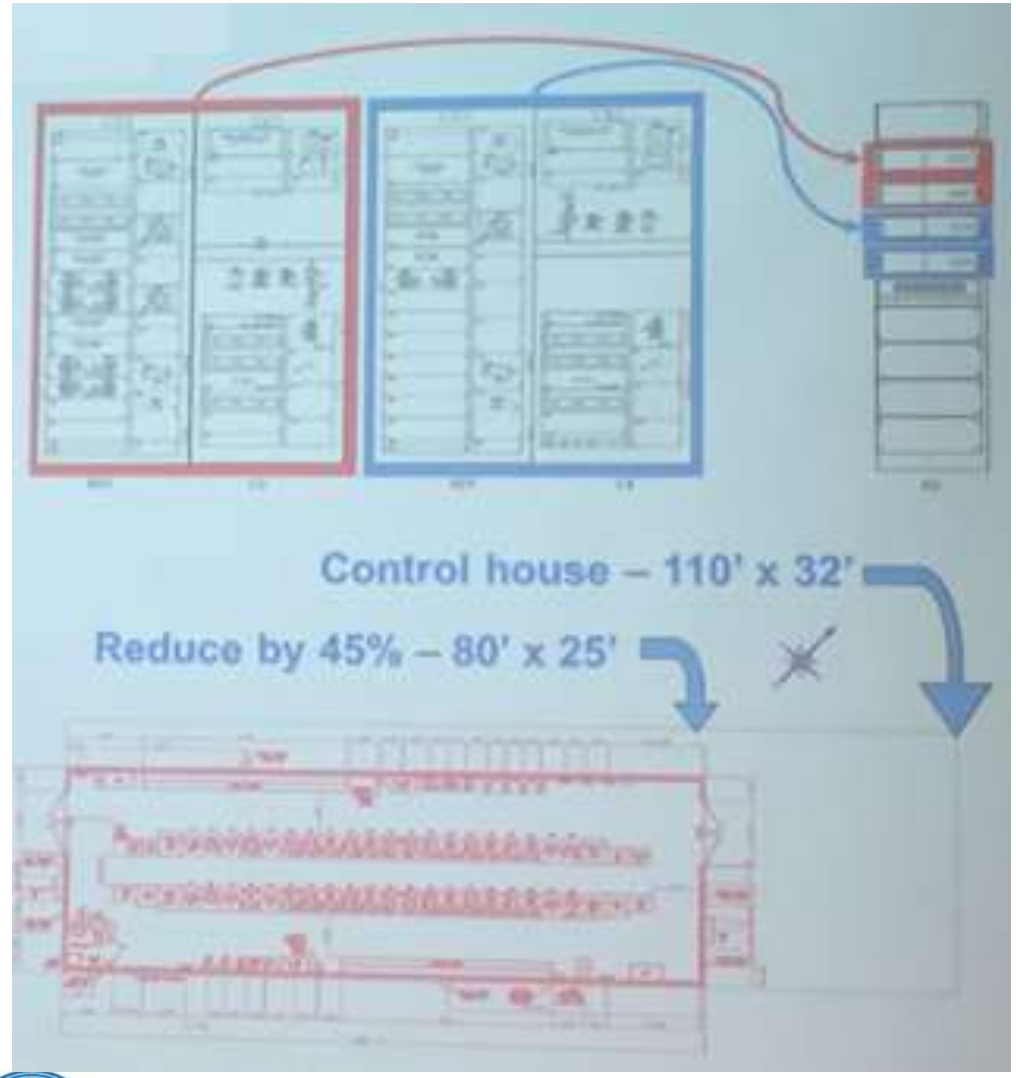
Limited performance and data transmission capabilities

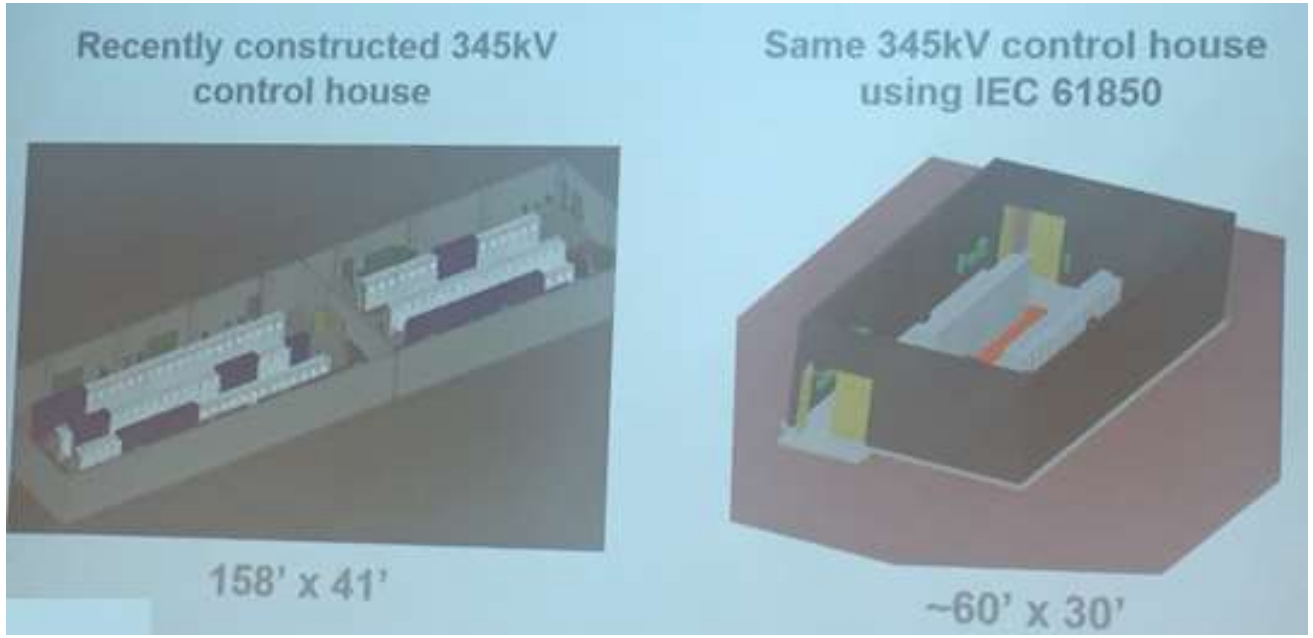
IEC 61850

Simplified, cost-effective, and easy to install and maintain

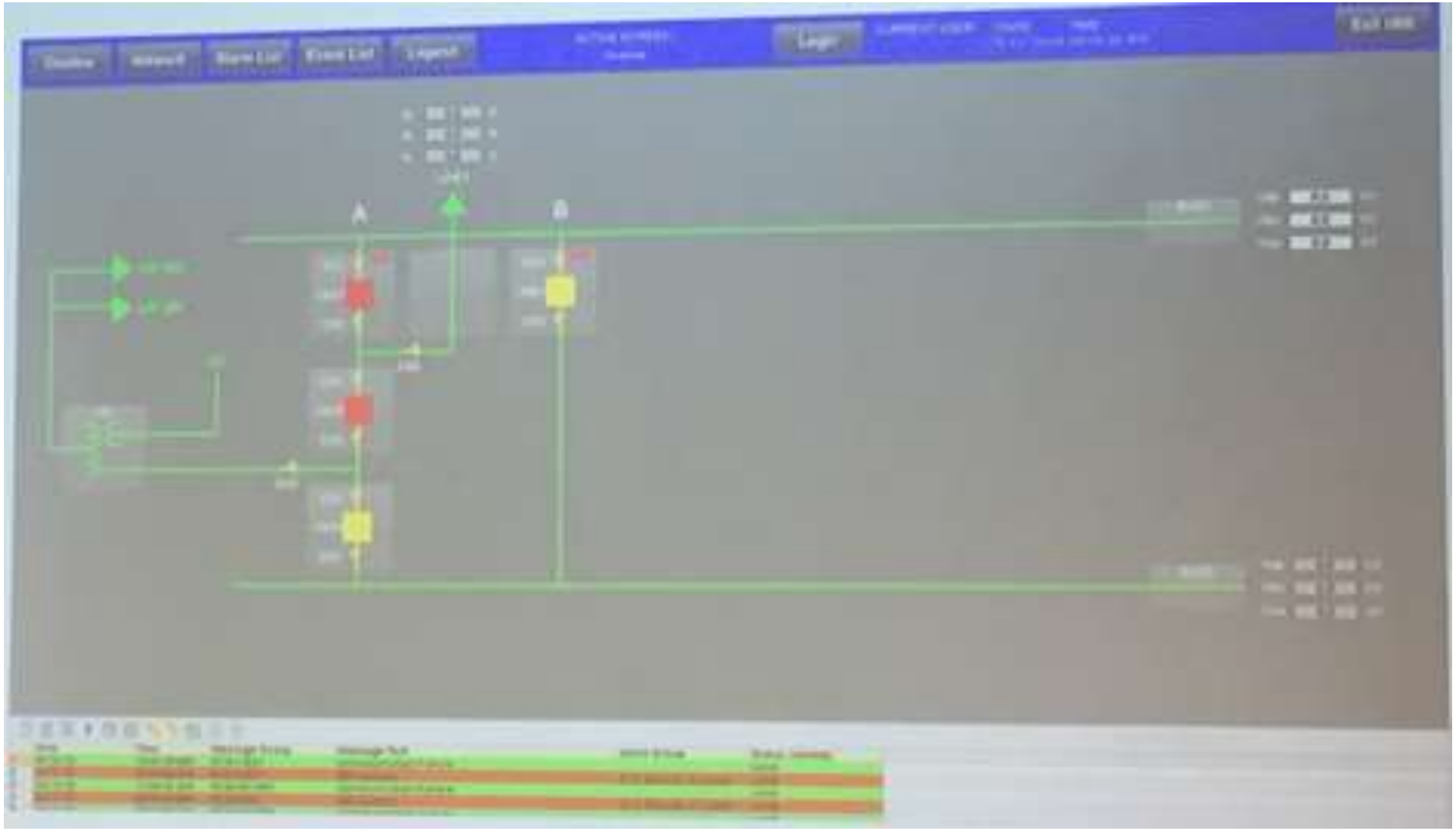
Enhanced performance and data transmission capabilities

IEC 61850優點: 節省空間

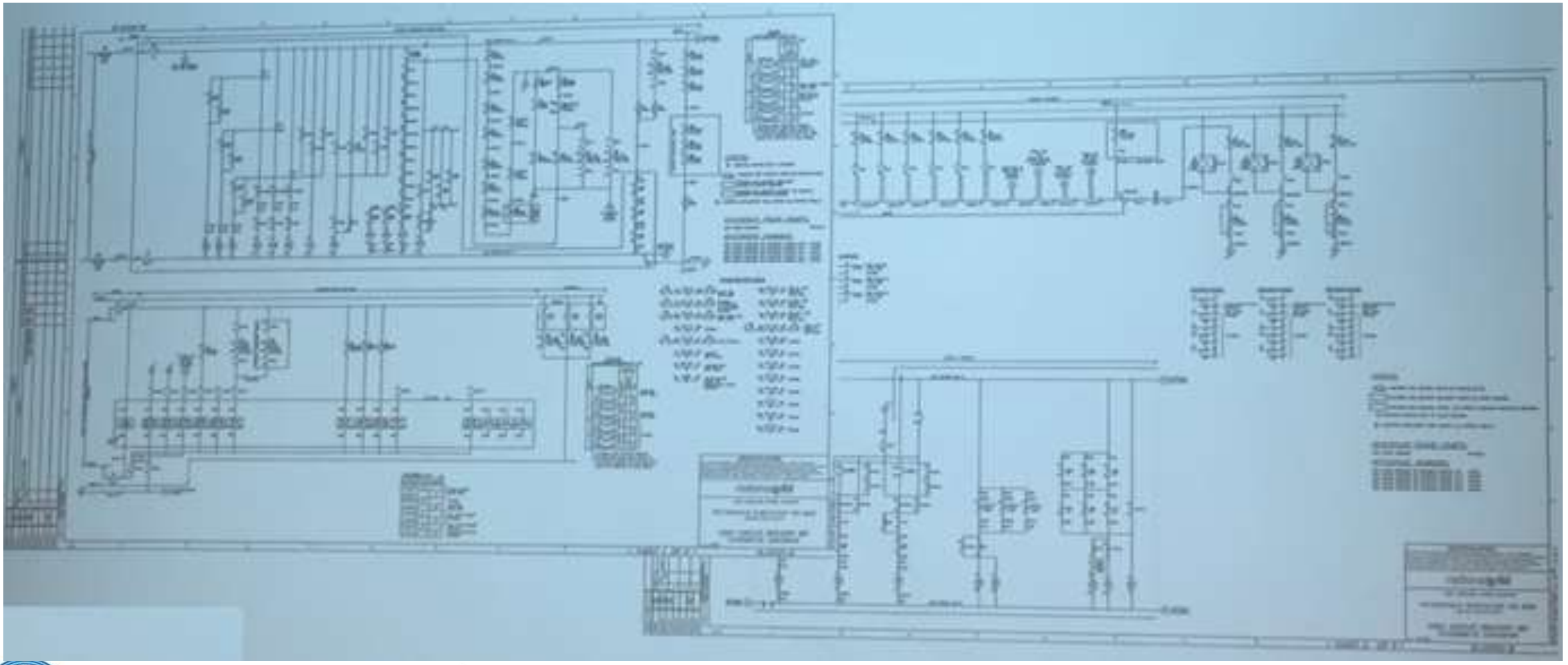




IEC 61850優點: 控制系統數位化



IEC 61850優點:圖面簡化

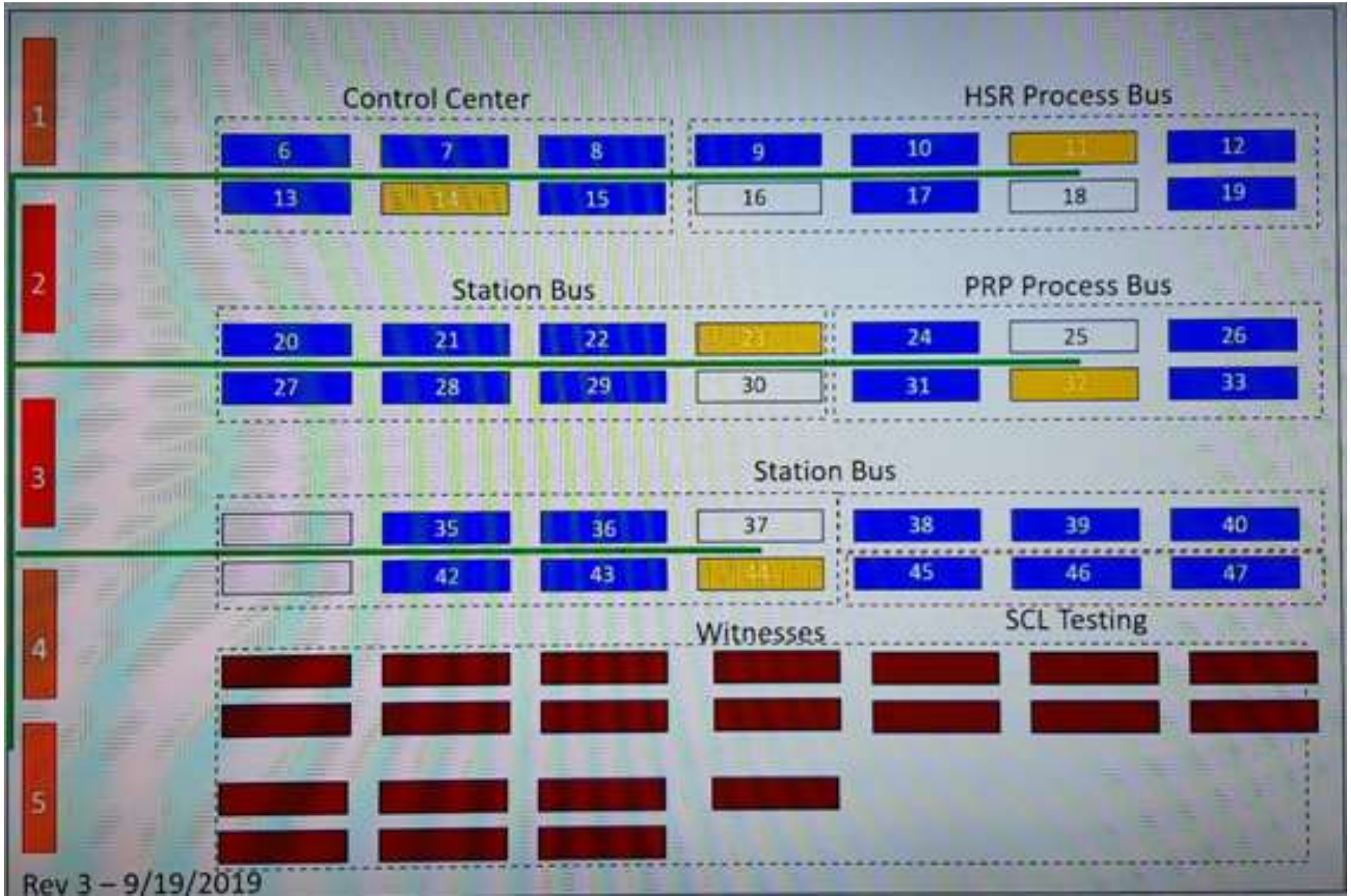


2019 IOP: 測試場地

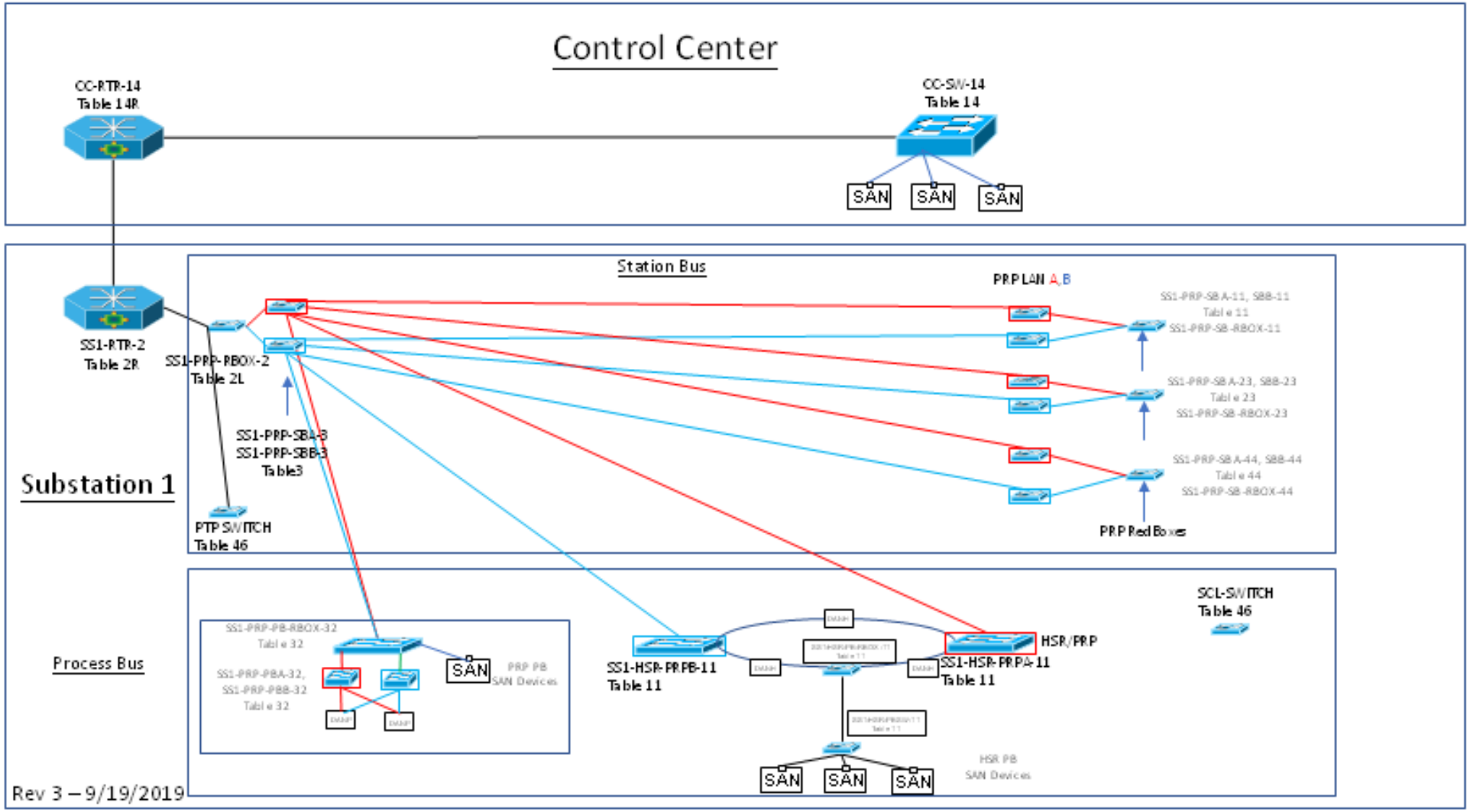
長24公尺

寬17公尺

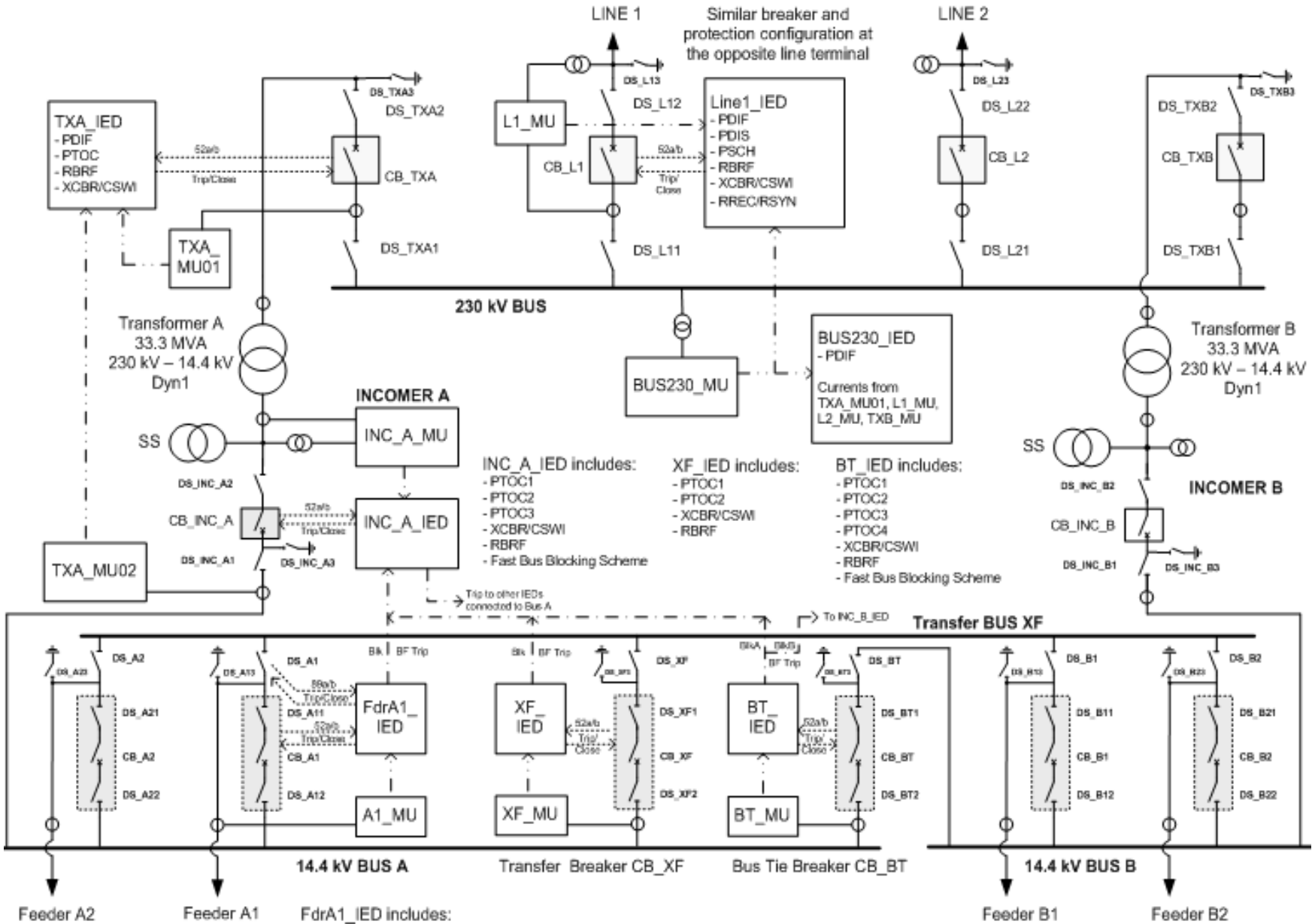
2019 IOP: 空間配置



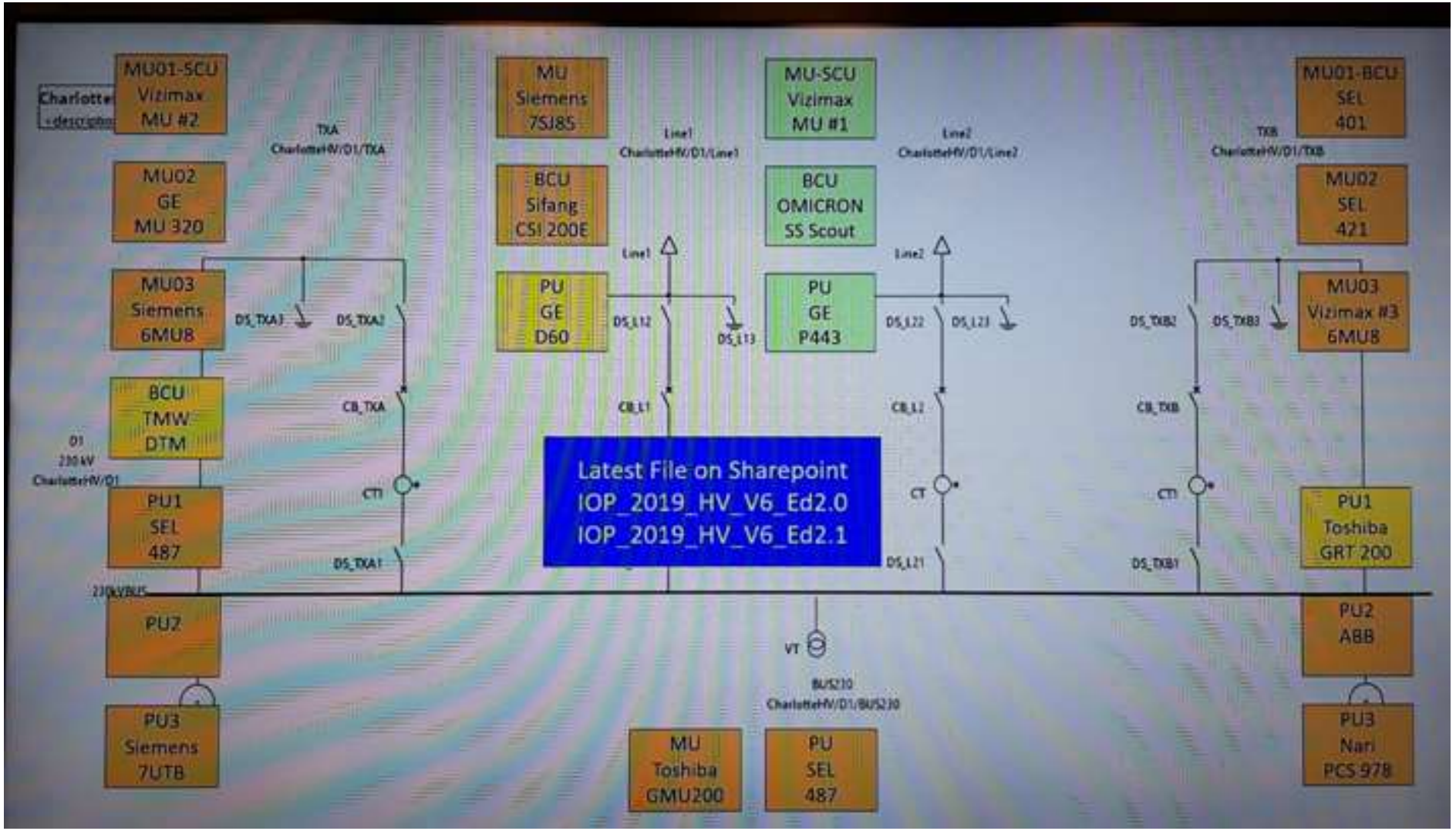
2019 IOP: 網路架構圖



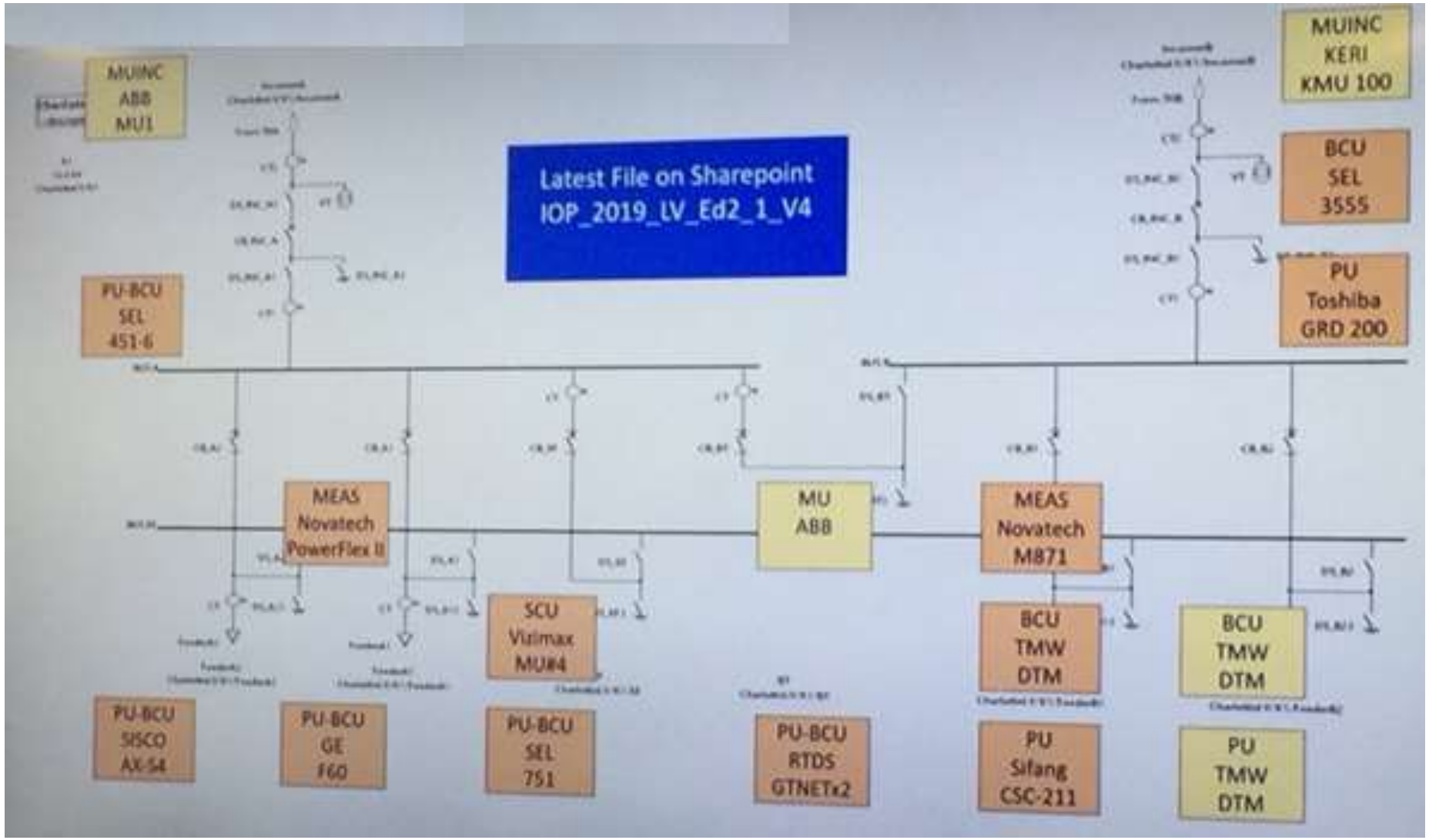
2019 IOP: 單線圖


LINE 1
Similar breaker and protection configuration at the opposite line terminal
LINE 2
TXA_IED
- PDIF
- PTOC
- RBRF
- XCBR/CSWI
DS_TXA3
DS_TXA2
CB_TXA
DS_TXA1
TXA_ MU01
L1_MU
DS_L13
DS_L12
CB_L1
DS_L11
Line1_IED
- PDIF
- PDIS
- PSCH
- RBRF
- XCBR/CSWI
- RREC/RSYN
DS_L23
DS_L22
CB_L2
DS_L21
DS_TXB3
DS_TXB2
CB_TXB
DS_TXB1
230 kV BUS
Transformer A
33.3 MVA
230 kV – 14.4 kV
Dyn1
BUS230_MU
BUS230_IED
- PDIF
Currents from TXA_MU01, L1_MU, L2_MU, TXB_MU
Transformer B
33.3 MVA
230 kV – 14.4 kV
Dyn1
INCOMER A
SS
INC_A_MU
INC_A_IED
DS_INC_A2
CB_INC_A
DS_INC_A1
DS_INC_A3
TXA_MU02
INC_A_IED includes:
- PTOC1
- PTOC2
- PTOC3
- XCBR/CSWI
- RBRF
- Fast Bus Blocking Scheme
XF_IED includes:
- PTOC1
- PTOC2
- XCBR/CSWI
- RBRF
BT_IED includes:
- PTOC1
- PTOC2
- PTOC3
- PTOC4
- XCBR/CSWI
- RBRF
- Fast Bus Blocking Scheme
SS
INCOMER B
DS_INC_B2
CB_INC_B
DS_INC_B1
DS_INC_B3
Trip to other IEDs connected to Bus A
To INC_B_IED
Transfer BUS XF
DS_A2
DS_A21
CB_A2
DS_A22
DS_A1
DS_A11
CB_A1
DS_A12
FdrA1_ IED
A1_MU
XF_ IED
XF_MU
DS_XF
DS_XF1
CB_XF
DS_XF2
BT_ IED
BT_MU
DS_BT
DS_BT1
CB_BT
DS_BT2
DS_B1
DS_B11
CB_B1
DS_B12
DS_B2
DS_B21
CB_B2
DS_B22
14.4 kV BUS A
Transfer Breaker CB_XF
Bus Tie Breaker CB_BT
14.4 kV BUS B
Feeder A2
Feeder A1
FdrA1_IED includes:
Feeder B1
Feeder B2

2019 IOP: HV狀態



2019 IOP: LV狀態



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智慧電業

新趨勢

- Good_for Report_20190924-1530._SCL_NiekDeBruijn_General
- Good_for Report_20190924-1429_SCL_EDF-HQ_TestReport
- 20190925-0730_SCL_StephanGerspach
- 20190924-1857_SCL_BenDay_Standard
- 20190924-1810-Implementation-RTE-03
- 20190924-1800-SCL-RTE-02
- 20190924-1748_SCL_StephanGerspach
- 20190924-1700_SCL_Anderson_SCT
- 20190924-1648_SCL_StephanGerspach
- 20190924-1630_SCL_Anderson(1)
- 20190924-1630_SCL_Anderson
- 20190924-1600._Security_brian.degner_TestCase
- 20190924-1548_SCL_StephanGerspach
- 201909241525_Infrastructure_Anderson_General
- 20190924-1404_SCL_EDF-HQ_TestReport
- 20190924-1340_SCL_RTE_001
- 20190924-1058.Security_Niels_heijker_NORM-03
- 20190924-1020_SCL_EDF-HQ_TestReport
- 20190924-0937.SCL_Niels_Heijker_NORM-SCL-01
- 20190924_1514_SCL_Mackiewicz.IndexedFalse
- 20190924_1455_SCL_BrunnerMACAdress
- 20190924 -1407.security_Niels_Heijker_REV03
- 20190923-1541._SCL_brian.degner_General
- 201909231500_Isolation_Riccardo_ISO05
- 20190923-1500._SCL_karen.leggett_General
- 20190923-1337._SCL_brian.degner_Standard
- 201909231249._PRP_Degner_General
- 20190922-1122_Security_HerbertFalk_GDOI-PULL-01
- 20190922-1122_SCL_EDF_HQ_Standard-01
- 20190922-1035_Security_HerbertFalk_GDOI-PULL-01
- 20190922-1031_Security_HerbertFalk_GDOI-PULL-01
- 20190922-0931_Security_HerbertFalk_GDOI-PULL-01
- 20190922-0907_Security_HerbertFalk_GDOI-PULL-01

ICD file

GE_20190924_D60_UB5_HLH_H87.xml

SCL Validation tool

EDF-HQ RiseClipse

Issue Description:

In the LNodeType definition, there are 2 InRefs with names : **InRef1** and **InRef01**,
They are detected by RiseClipse validation as two DO InRefs with the same instance number.

```
<DO name="InRef1" type="ORG_0"/>
<DO name="InRef01" type="ORG_0"/>
```

RiseClipse error :

ERROR: [NSD validation] DO InRef01 in LNodeType (line 158609) already present with same instance number in LNClass IHMI

Standard reference :

NSD-DOC description of Omulti constraint in 61850-7-2 says :
« Zero or more elements may be present; all instances have an **instance number** within range [min, max] (see IEC 61850-7-1). »

Client\Server

	Pair 1			Pair 2			Pair 3		
	Peer Vendor:			Peer Vendor:			Peer Vendor:		
	Peer Device:			Peer Device:			Peer Device:		
	Role:			Role:			Role:		
	Result	Witness Na	Comment	Result	Witness Na	Comment	Result	Witness Na	Comment
ISO-01									
ISO-02									
ISO-03									
ISO-04									
ISO-05									
ISO-06									
ISO-07									
ISO-08									

GOOSE

	IUT Publisher			IUT Subscriber			IUT Subscriber		
	Peer Vendor:			Peer Vendor:			Peer Vendor:		
	Peer Device:			Peer Device:			Peer Device:		
	Role:			Role:			Role:		
	Result	Witness Na	Comment	Result	Witness Na	Comment	Result	Witness Na	Comment
ISO-08									
ISO-09									
ISO-10									
ISO-11									

SV

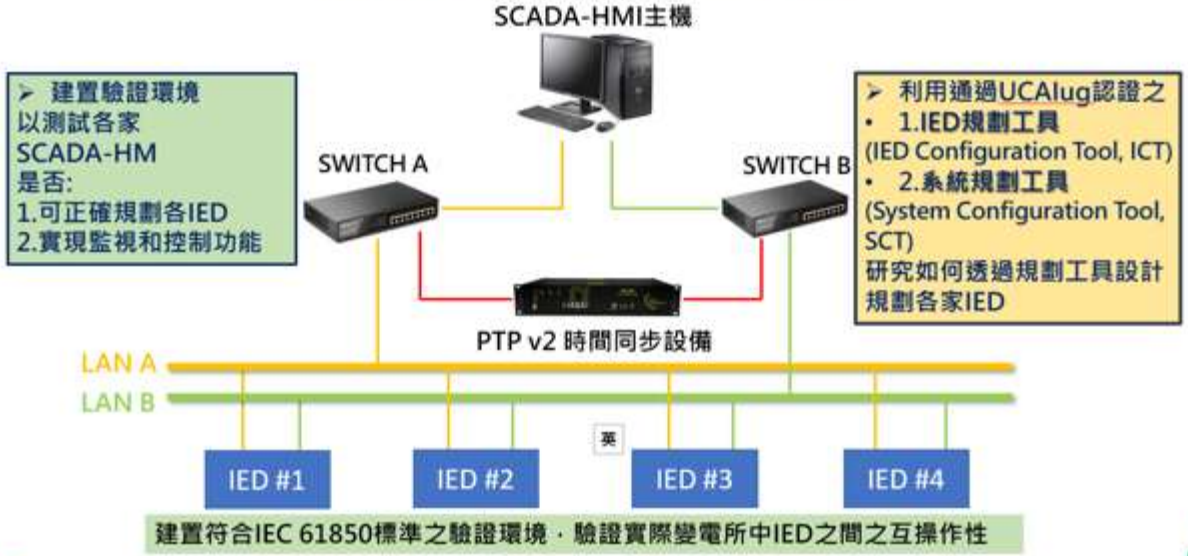
	IUT Publisher			IUT Subscriber			IUT Subscriber		
	Peer Vendor:			Peer Vendor:			Peer Vendor:		
	Peer Device:			Peer Device:			Peer Device:		
	Role:			Role:			Role:		
	Result	Witness Na	Comment	Result	Witness Na	Comment	Result	Witness Na	Comment

IEC 61850
互通性實驗室介紹

IEC 61850 先進實驗室

IEC 61850 XMPP 雲端監控中心

IEC 61850 互操作性試驗中心



結語

結語

1. 參酌 UCAIug IOP 經驗，建置符合公司需求之互通性實驗室。
2. 與相關單位一起協作，制定符合公司 IEC 61850 資訊模型之規範。
3. 建立應用案例，與現場實務做結合，進行相關測試。

感謝聆聽
敬請指導