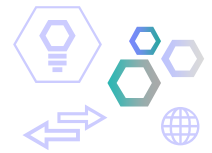


it4power

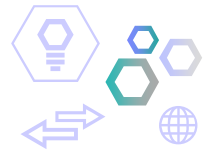


# Development and Testing of Phasor Protocol Standards

Christoph Brunner, it4power  
Ritchie Carroll, GPA  
Herb Falk, SISCO

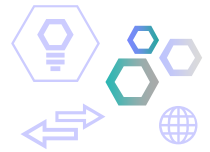


# **FROM IEEE C37.118 TO IEC 61850-90-5**



## Standardization – C37.118 and IEC 61850

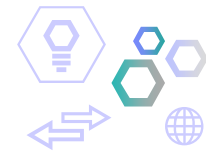
- Measurement part needs to be harmonized with IEC TC95
- For communication part - do a joint development IEEE – IEC
- First step will be a IEC technical report IEC 61850-90-5 describing how to transmit synchrophasor data according to C37.118 using IEC 61850
- The results of that report will then be used to update the concerned parts of IEC 61850



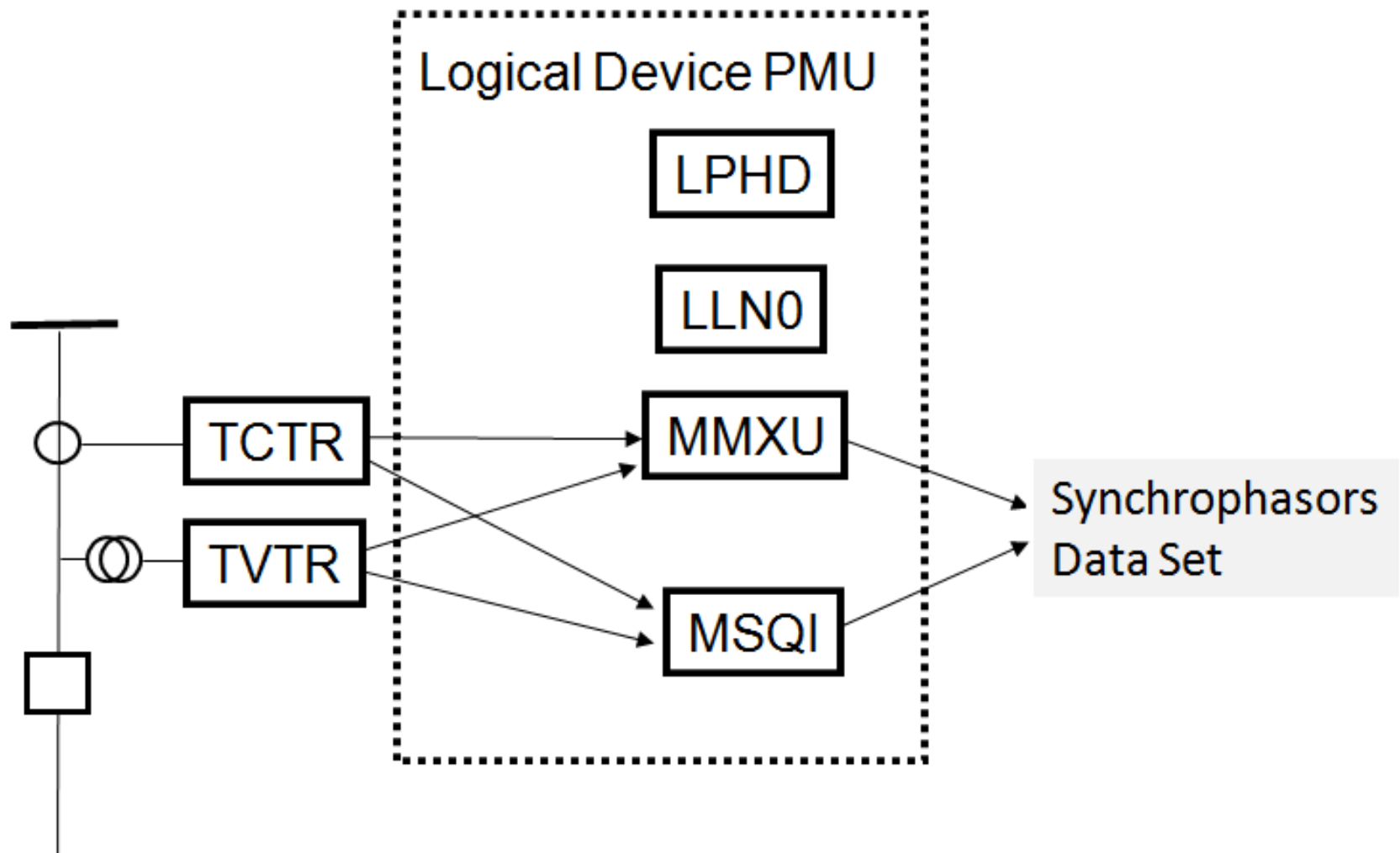
# Modeling aspects

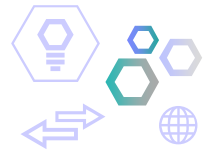
Relation between the data defined in IEEE C37.118 and IEC 61850-7-4 and others

- IEC 61850 logical nodes to be used
  - MMXU
  - MSQI
- Settings of a PMU
  - May be a new logical node to be defined in IEC 61850-7-4



# PMU object model

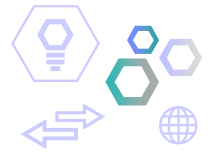




# Communication aspects

## Impact of synchrophasor communication on IEC 61850-7-2

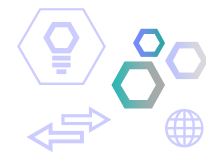
- Communication services from 7-2 to be used
  - Multicast or unicast sampled value transmission for streaming of phasors
  - GOOSE for event driven phasor transmission
- No new abstract communication service needed
- Management of the communication through the control blocks



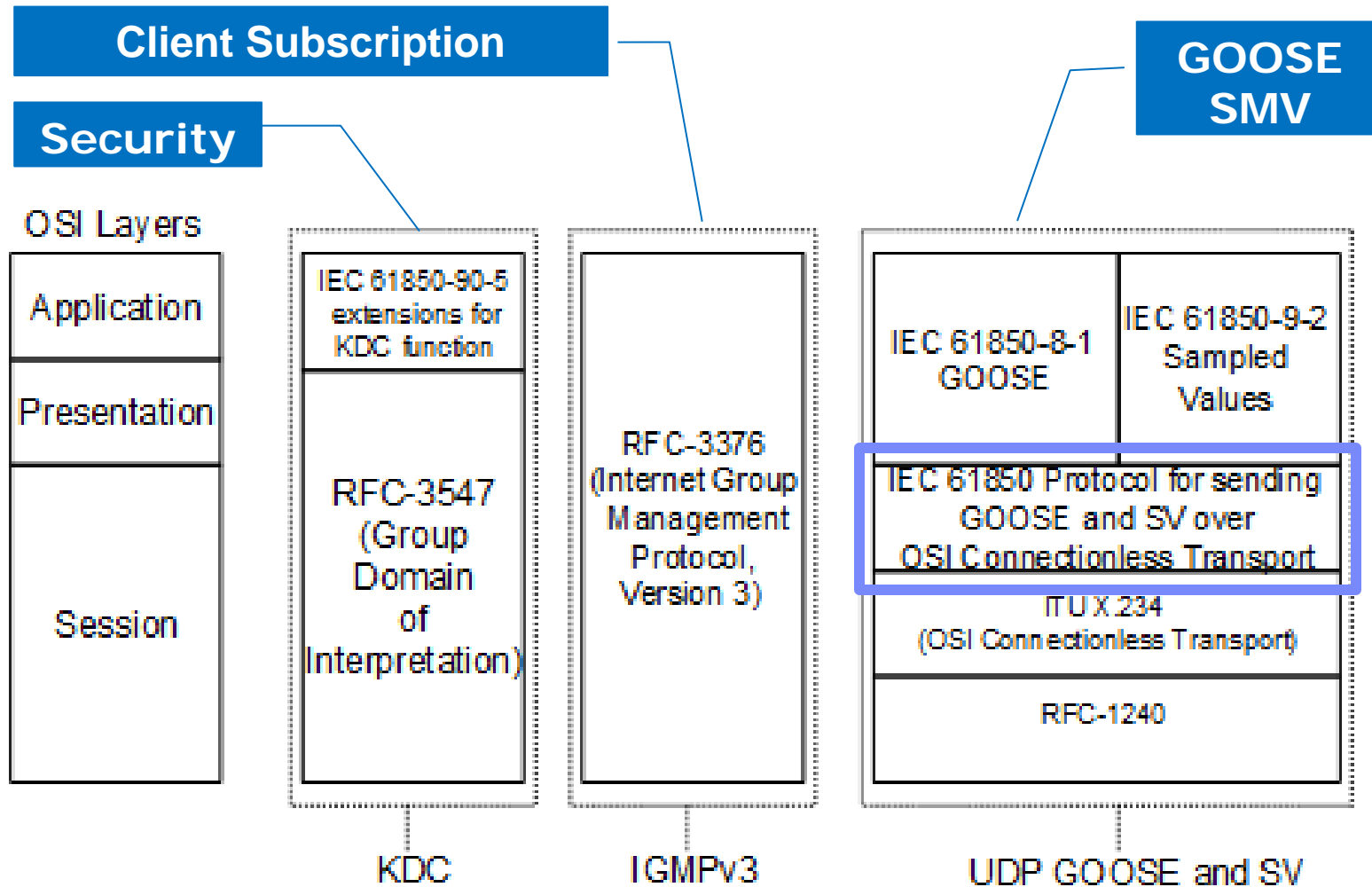
# Communication aspects

## Impact of synchrophasor communication on IEC 61850-8-1 / -9-2 (mappings)

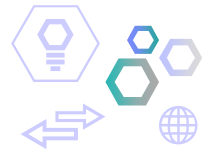
- Dedicated communication links between two end nodes
  - “tunneling” of GOOSE messages or sampled value messages is possible
- Communication network in between two end nodes
  - Routable mapping for sampled value and GOOSE required



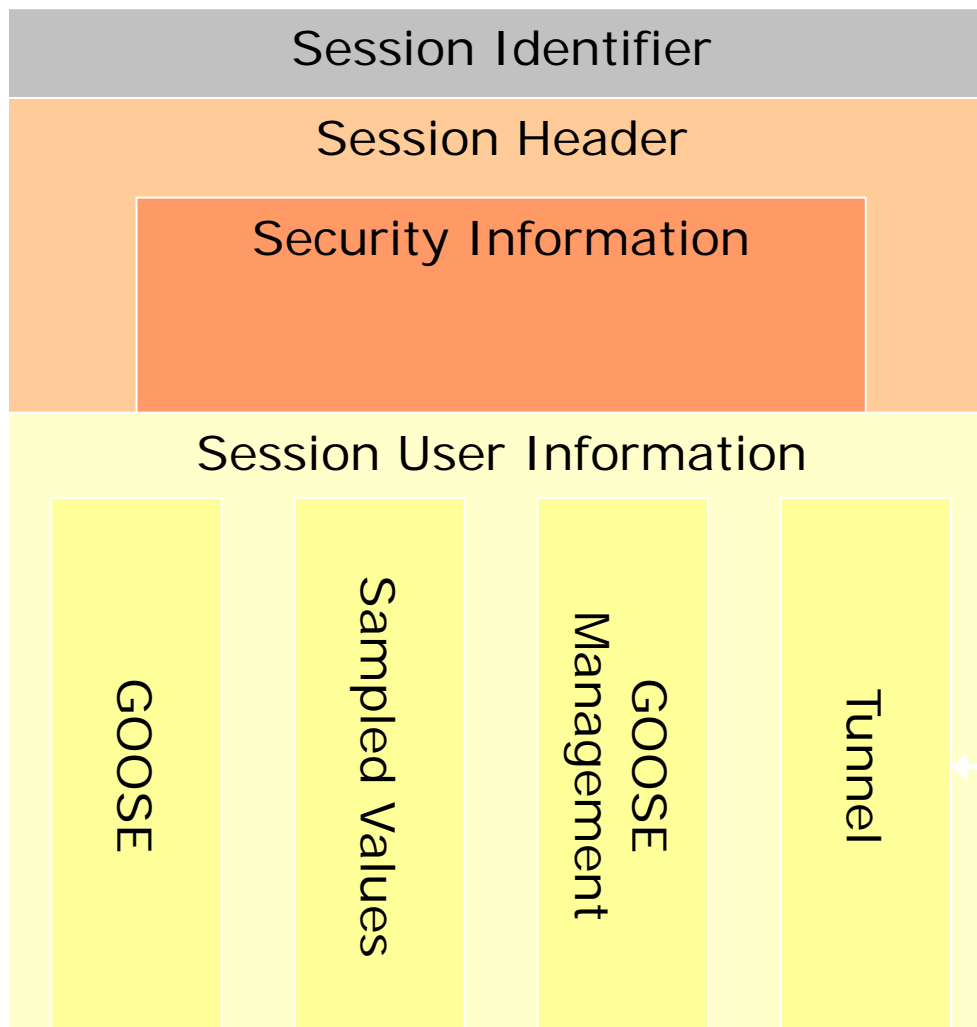
# A-Profiles

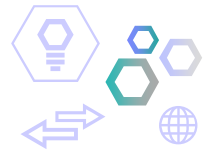






# Session Layer Protocol



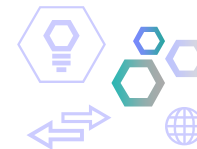


## Summary - what is in 90-5?

- Introduction
- Use cases
- Security Model
- Data Object definitions and enumerations
- SCL enhancements
- Key Management (GDOI)
- New A and T profiles for GOOSE and SV

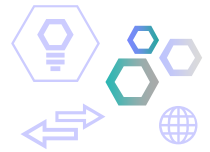
### What is next?

- Integrating IEC 61850-90-5 in the core IEC 61850 parts

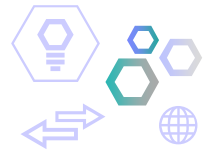


## Where is the information going

90-5 Information	Target Document
Introduction	Revised TR of 90-5
Use cases, Modeling considerations, communication requirements	Revised TR of 90-5
Security Model	IEC 62351-9
New Data Objects and Changes ROCOF, LTIM, LTMS ClcMth (P/M-Class) additions	IEC 61850-7-4 ROCOF goes into MMXU
SCL Enhancements	IEC 61850-6
Key Management GDOI	IEC 62351-9 Update to RFC 6047
A and T Profiles for GOOSE and SV	IEC 61850-8-1 (GOOSE) IEC 61850-9-2 (SV)



# **LESSONS LEARNED FROM IMPLEMENTATION AND TESTING**



## 90-5 Implementation Notes

Two phase implementation:

Phase 1: support for 61850-90-5 input streams

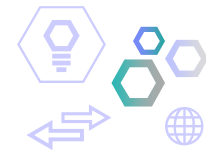
Phase 2: Support for 61850-90-5 output streams

Acceptance testing done at PG&E POC facility

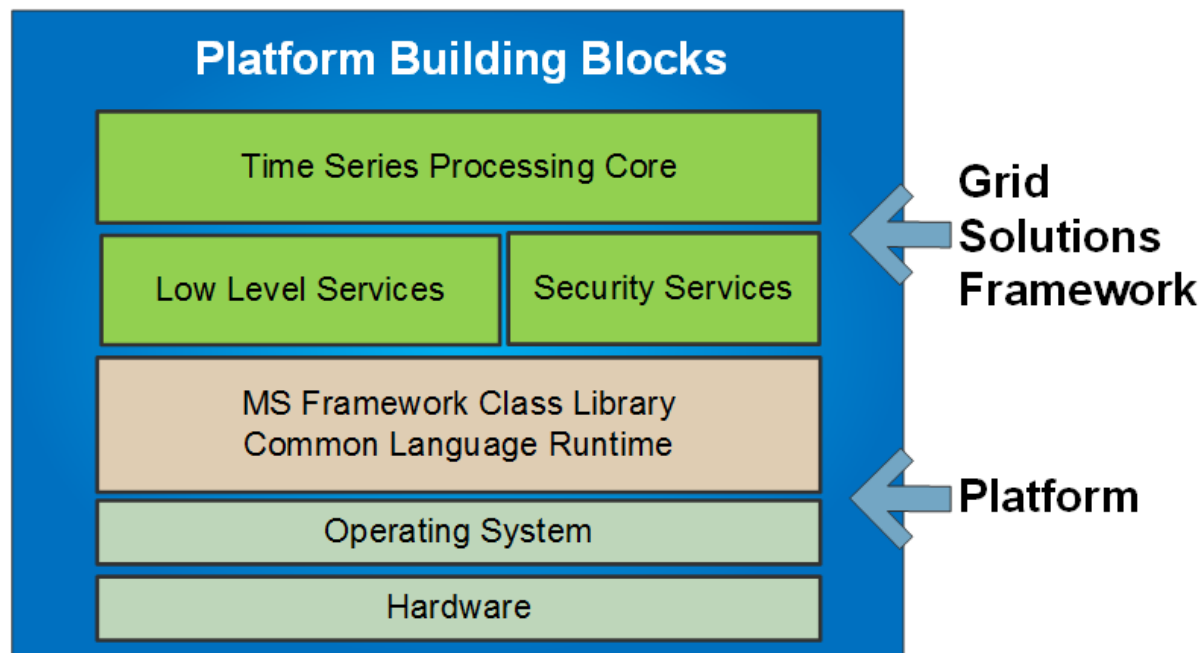
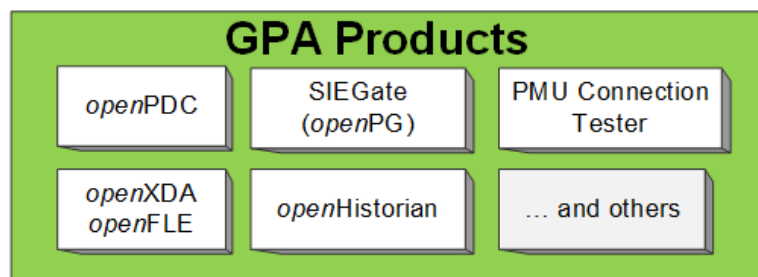
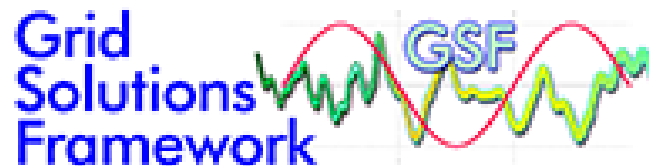
Input from GE P60 and P30 devices

Output to P30 device and to other openPDC

Data exchange using UDP (unicast or multicast).



# IEC 61850-90-5 open source in GSF



- All GPA products implement 90-5 through GSF
- All internal utility projects that use GSF also have access to 90-5

### PMU Connection Tester

File Help

Connection Parameters

Tcp Udp Serial File

Default System IP Stack: IPv6

Protocol: IEC 61850-90-5

Extra Parameters

Local Port: 8800

Enable Multicast / Remote Udp

Device ID Code: 235

Disconnect

Network Interface

Host IP: ::1

Version 4.4.0

Receive From

Remote Port: 5000

Multicast Source

Command:

Configure Alternate Command Channel

Disable Realtime Data

Send

Defined

PMU: ID Code: 2

SHELBY

Phasor: (Selected is reference angle)

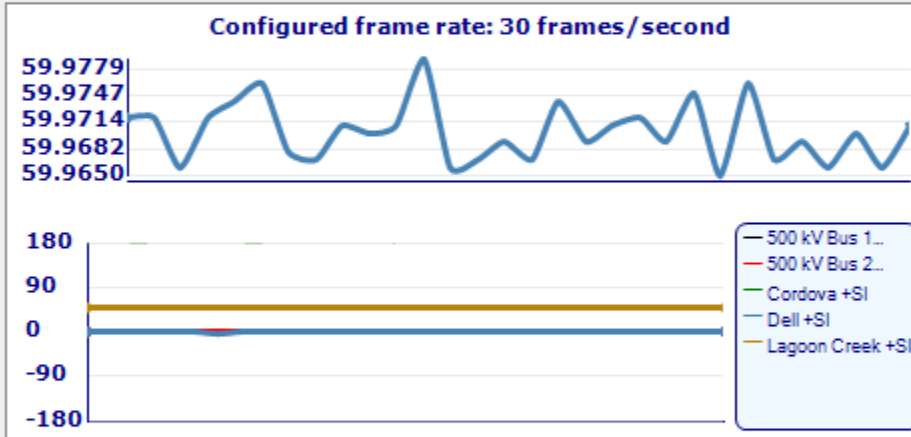
V: 500 kV Bus 1 +SV

Phasors: 5  
Analog: 0  
Digitals: 1  
Nominal Frequency: 60 Hz

Power: -211.6792 MW

Vars: -31.5132 MVars

Configuration Frame



Graph Settings Messages Protocol Specific

Real-time Frame Detail

Frame Type: DataFrame	01 40 A2 18 80 16 00 00 00 8A 00 00 4C D1 00 01 53 34 5C
Time: 2014-03-27 17:12:39.033	07 00 64 00 00 00 00 00 00 00 00 00 74 82 00 00 00 00 6E
Frequency: 59.9660 Hz	60 82 00 72 80 01 01 A2 82 00 63 30 82 00 5F 80 0E 32 33
Angle: 128.146896362305°	35 5F 54 45 53 54 53 54 52 45 41 4D 82 02 4C D1 83 04 00
Magnitude: 299.5459 (518.8287) kV	00 00 01 84 08 53 34 5C 07 08 88 88 00 85 01 01 87 82 00
Display: Hexadecimal	34 10 00 48 92 43 3D 43 00 25 9B 48 91 C3 F0 43 00 2C 8A
	43 6E 26 D5 C2 71 48 62 44 01 32 9F 43 00 ...

Total frames: 141 Frames/sec: 0.0000 Total bytes: 21430 Bit rate (mbps): 0.0000 Queued buffers: 0

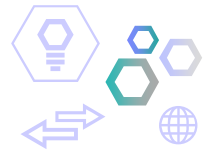
Acronym

TESTSTREAM

Id New Save



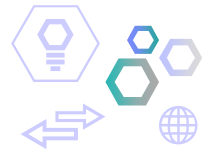
> >>



# Summary of Lessons Learned

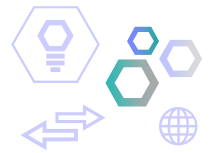
- Standards
  - Having standard(s) is required but not sufficient for interoperability.
  - Standard compliance doesn't guarantee interoperability
- Implementation Agreements
  - Clear Implementation Agreement(s) among various device developers and manufacturers are usually required to achieve interoperability
- Testing
  - Both standards and implementation agreements are subject to interpretation and may include options, choices, or configurations.
  - Only actual testing can verify interoperability between various devices/systems.
  - Testing often identifies the need (or desire) for improvements and enhancements, as well as feedback for improving standards and implementation agreements.
- Life-cycle management
  - Life-cycle management, asset utilization, and revision control are all considerations affected by interoperability
  - Device interoperability needs to support system life-cycle management and asset utilization (long-term system deployment roadmap to be supported)





Testing for:

**INTEROPERABILITY,  
RELIABILITY, AND SECURITY**



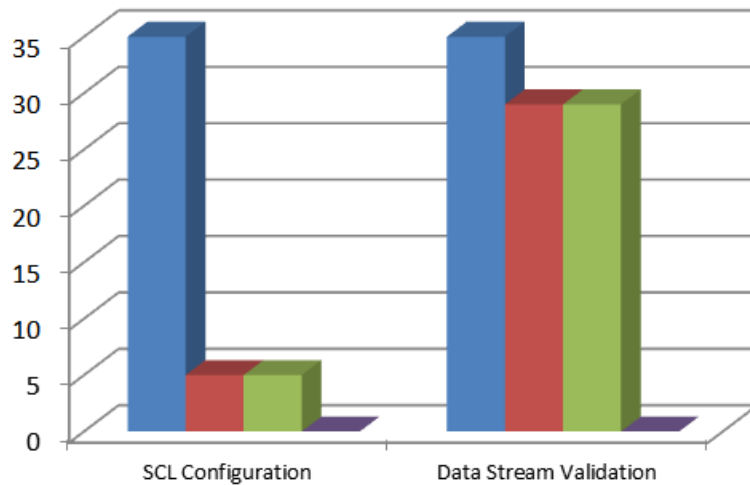
## Several initiatives have occurred regarding IEC 61850-90-5

- IEC 61850-9-2 interoperability testing
- Conformance testing
- Security analysis
- Security testing (future)
- Munich October, 2013
- UCA Testing Committee
- PNL and others
- PNL and **conformance labs.**

# IOP Results for SV

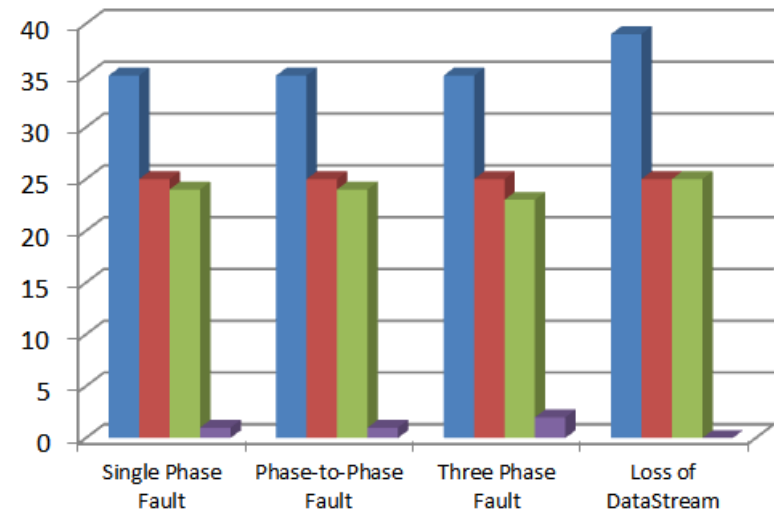
Company	Product	ED.1	ED.2
ABB	SAM/FOCS-MU	X	X
ABB	REL670		X
Alstom	P645	X	X
Alstom	AMU	X	X
Arteche	SDO SAMU	X	
INGETEAM	EF	X	X
Omicron	CMC	X	X
Omicron	SvScout	X	X
RTDS	GE-NET	X	
Schweitzer Electric	SEL 421	X	
ZIV	IRV	X	

**SV Summary Results (SCL Configuration and DataStream Validation)**

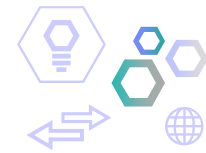


■ Possible ■ Attempted ■ Passed ■ With Issues

**SV Summary Results (Protection Functions)**

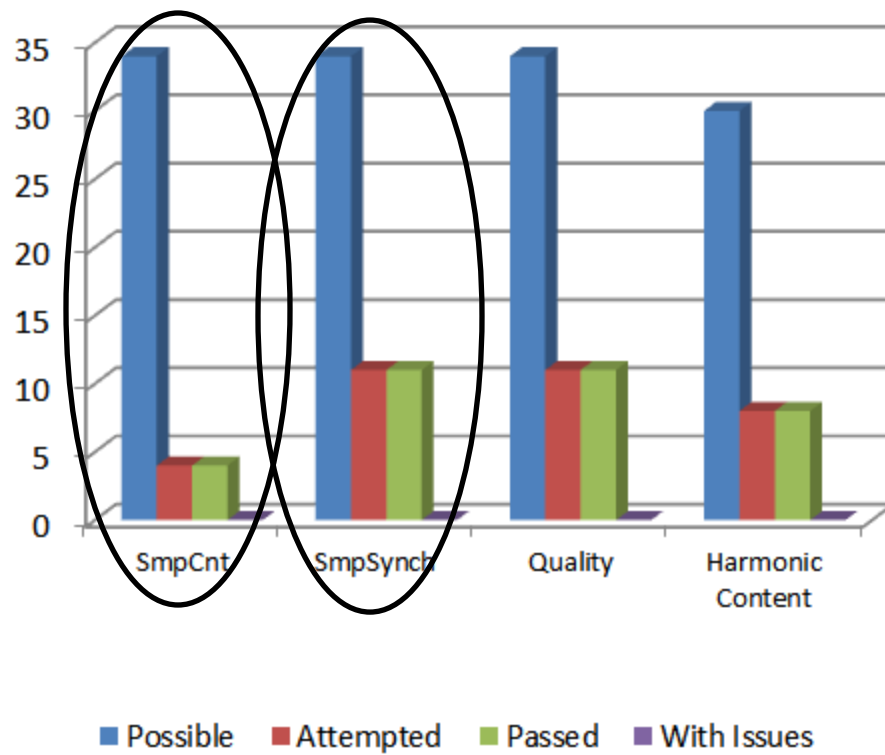


■ Possible ■ Attempted ■ Passed ■ With Issues



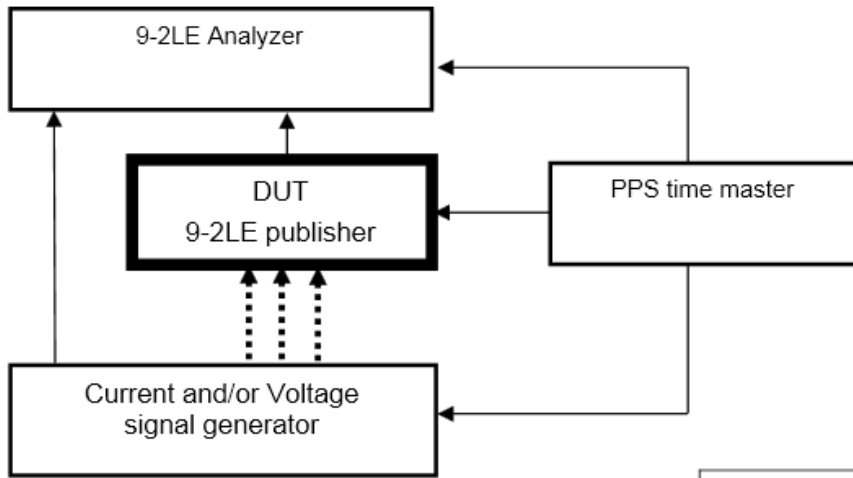
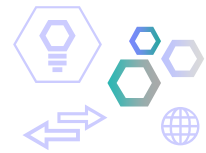
# IOP Results for SV

**SV Summary Results (Optional Tests)**



No issues found in implementations

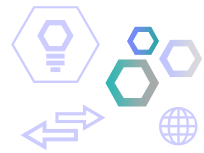
# Conformance Testing (UCA Testing Committee)



Test Rig

Test Group	Mandatory	Conditional	Verdict
Documentation	Doc1, Doc2		
Configuration	Cnf1, Cnf2, Cnf3, Cnf4, Cnf5, Cnf6, Cnf7, Cnf8	Cnf9	
11a Sampled Value Publishing 50 Hz, 80 samples/cycle	Svp1, Svp2, Svp3, Svp6, Svp10, Svp11, Svp14, Svp15	Svp4, Svp7, Svp8, Svp12, Svp13, Svp16, Svp17	
11a Sampled Value Publishing 60Hz, 80 samples/cycle	Svp1, Svp2, Svp3, Svp6, Svp10, Svp11, Svp14, Svp15	Svp4, Svp7, Svp8, Svp12, Svp13, Svp16, Svp17	
11a Sampled Value Publishing 50 Hz, 256 samples/cycle	Svp1, Svp2, Svp3, Svp6, Svp10, Svp11, Svp14, Svp15	Svp5, Svp7, Svp9, Svp12, Svp13, Svp16, Svp17	
11a Sampled Value Publishing 60Hz, 256 samples/cycle	Svp1, Svp2, Svp3, Svp6, Svp10, Svp11, Svp14, Svp15	Svp5, Svp7, Svp9, Svp12, Svp13, Svp16, Svp17	

# Conformance test will need to be changed for synchrophasor (90-5) testing

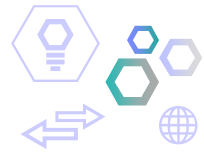


Svp9	Verify that the MSVCB02 samples are transmitted with 32 (256/8) messages per cycle	<input type="checkbox"/> Passed <input type="checkbox"/> Failed <input type="checkbox"/> Inconclusive
9-2LE clause 7.1.4		
<u>Expected result</u> 2. DUT samples the signals as configured 3. In one minute DUT sends $96000 \pm 1$ sampled value messages for 50 Hz and $115200 \pm 1$ for 60 Hz.		
<u>Test description</u> 1. Configure the DUT with the correct parameters 2. Generate 50 Hz current and/or voltage signals 3. Capture the sampled values messages for 1 minute 4. Repeat step 1 to 3 five times 5. Repeat step 1 to 4 for 60 Hz		
<u>Comment</u>		

# Security

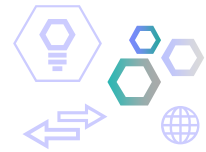


# preventin g



- 90-5 Code/protocol has been analyzed
  - “no” feedback from the national labs in over 2 years
  - Thorough analysis by other entities
- No known penetration tests successful on 90-5
- IEC 62351 series (security standards) conformance test discussions underway.

# Security Testing



- Fuzzing software commercially available for non-90-5 GOOSE and SV
- Cyber security labs (61850 capable) being set up at:
  - PNL
  - Tuv
  - KEMA
  - Others...
- IEC 62351 series (security standards) conformance test discussions underway.
- Red hat teams are available