IEC 61850 at Stedin
Today and Tomorrow

Bas Mulder – Technical Advisor Grid Automation

OUR **OPERATING AREA**

PROVINCES OF ZUID-HOLLAND AND UTRECHT
Stedin is the grid operator of most of the Randstad area, which includes the cities The Hague, Utrecht and Rotterdam, the Rijnmond port area and the Botlek industrial area. High-density urban areas with a complex infrastructure and a high dependency on energy that require continuous availability of energy. Now and in the future.

Stedin also manages energy infrastructure in the regions Kennemerland, Amstelland and north-east Friesland.

Stedin operating area electricity

Stedin operating area gas

STEDIN KEY FIGURES
2018

Electricity

2,068,600
Elektricity connections

19,637 GWh
Of electricity transmitted

19 MIN
Average interruption duricity electricity

44,788 KM
Of electricity cable (planets circumference is appr. 40,000 km)

Gas

1,921,309
Gas connections

1,246,080
customers have had the offer end of 2017 for a smart meter. Appr. 2.5 million meters (E and G) in a period of five years

4,377 MLN M^3
Of gas transmitted

74 SEC
Average interruption duration gas

23.364 KM
Of pipes (planets circumference is appr. 40,000 km)

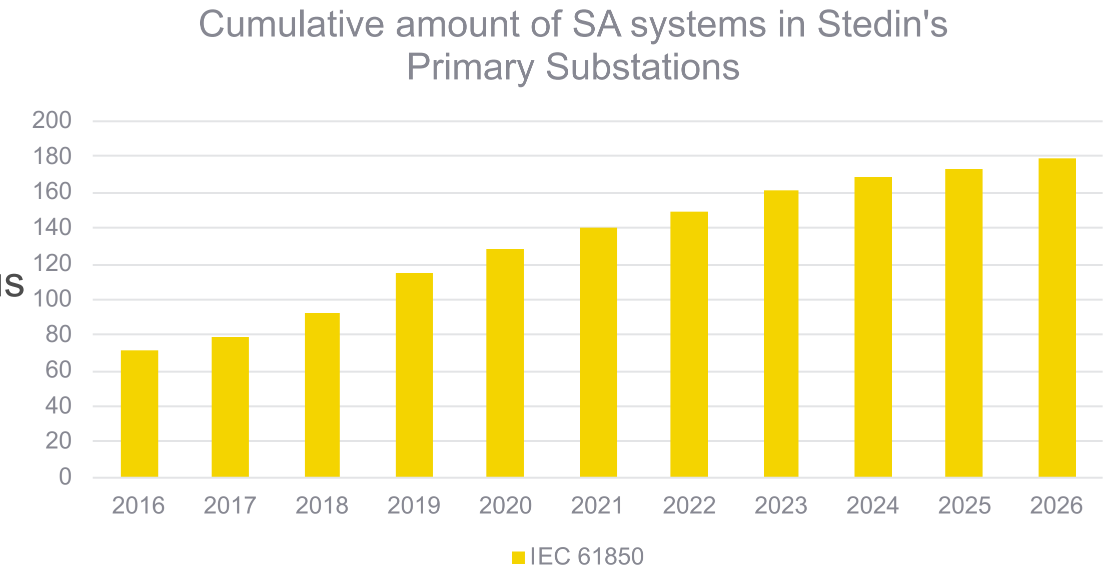
69%
OF OUR CUSTOMERS AWARDED STEDIN A 8 OF HIGHER FOR SERVICES PROVIDED

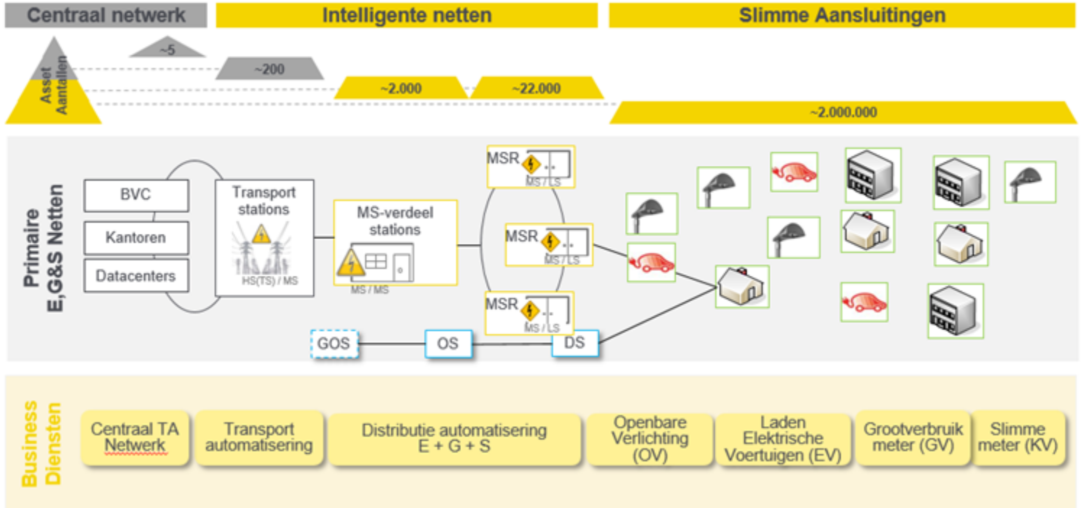

.NET

IEC 61850 at Stedin

FACTS AND FIGURES

- Since 2007 substation automation with IEC 61850 edition 1
- 90 out of 200 substations are equipped with IEC 61850 station bus
- All newly built primary substations are IEC 61850 based
- Refurbishing 10-15 primary substations per year
- Biggest substation consists of 100 IEDs
- Ambition to have vast majority on IEC 61850 in 2030
- Also in distribution: 100 substations (sort of light version)





IEC 61850 at Stedin

WHY?

- Unified data-modelling
- Standardized engineering workflow
- Proven (open) communication protocols
- Application decoupled from communication protocols
- Descriptive data objects and functions
- Vendor independent
- Industry proven and validated

```
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    <!-- O -->
    <DO name="EEName" type="DPL_EEName" />
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</LNodeType>
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```
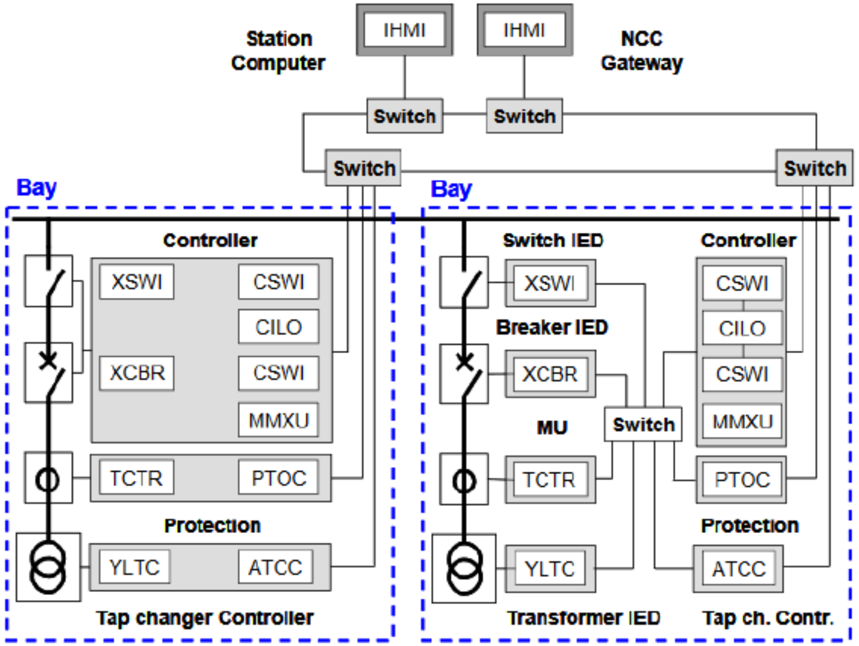

Group indicator	Logical node groups
A	Automatic control
B	Reserved
C	Supervisory control
D	Distributed energy resources
E	Reserved
F	Functional blocks
G	Generic function references
H	Hydro power
I	Interfacing and archiving
J	Reserved
K[a]	Mechanical and non-electrical primary equipment
L	System logical nodes
M	Metering and measurement
N	Reserved
O	Reserved
P	Protection functions
Q	Power quality events detection related
R	Protection related functions
S[a]	Supervision and monitoring
T[a]	Instrument transformer and sensors
U	Reserved
V	Reserved
W	Wind power
X[a]	Switchgear
Y[a]	Power transformer and related functions
Z[a]	Further (power system) equipment



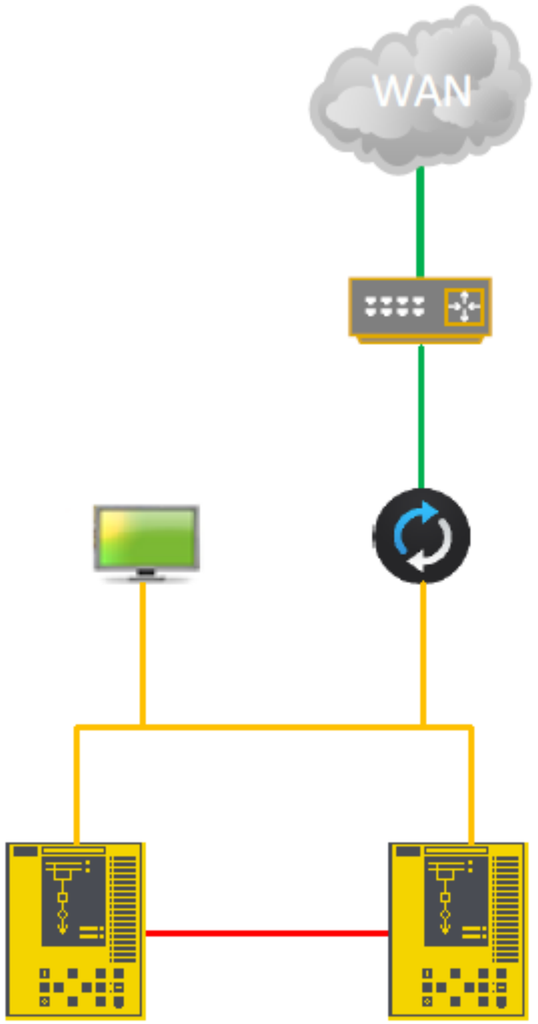
IEC 61850 at Stedin
Today

IEC 61850 at Stedin

3RD GENERATION SAS

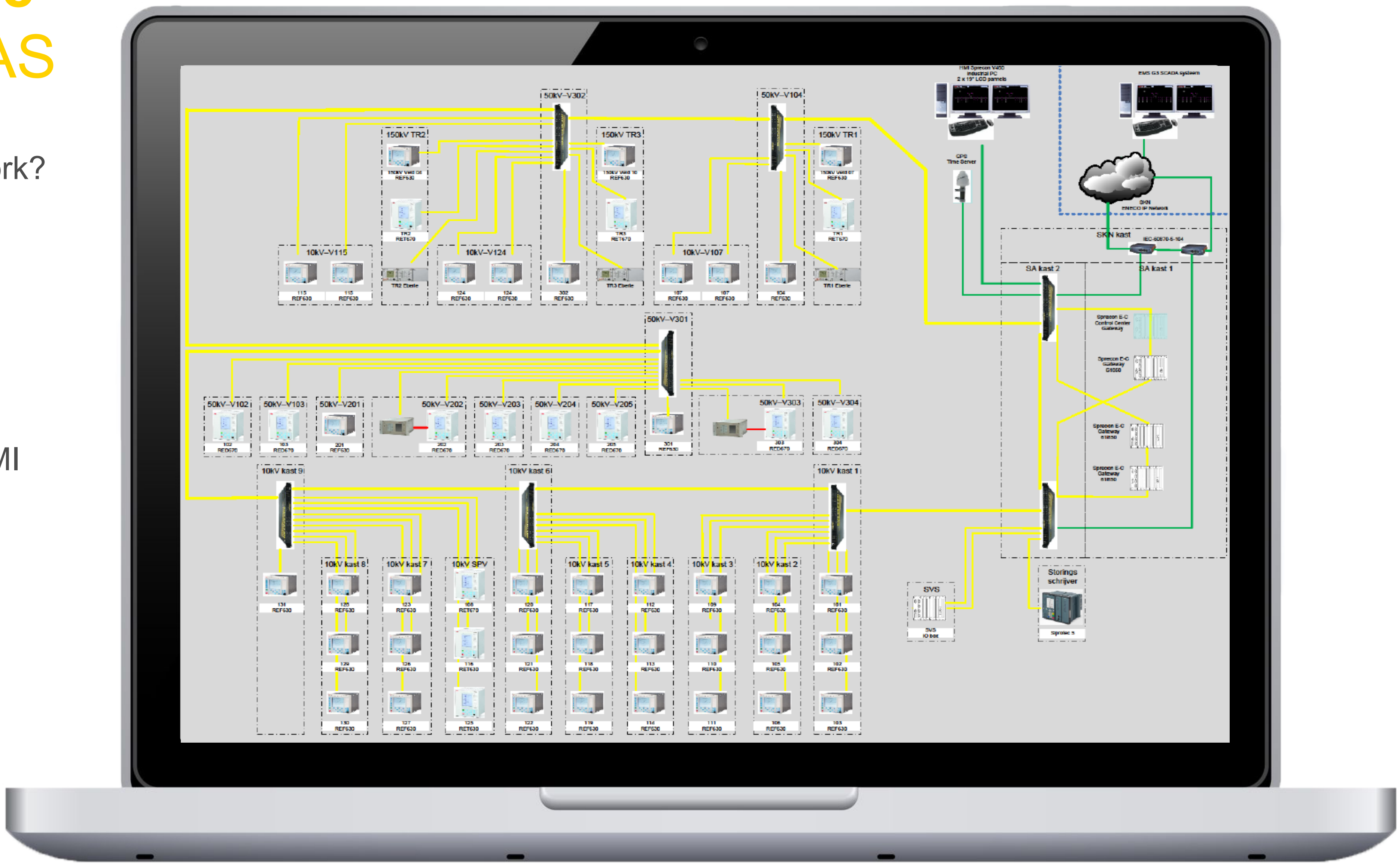
- Communication protocols in IEC 61850 are mapped on Ethernet (Xerox – 1970)
- IEC 61850-8-x and -9-x describe to date 4 communication protocols
  - MMS (e.g. IED to gateway);
  - GOOSE (e.g. IED to IED to exchange breaker positions);
  - Sampled Values (exchange of currents/voltages between primary apparatus & IED);
  - XMMP/MMS (e.g. communication from/to DER devices).

- To date only MMS and GOOSE are used by 3rd generation SA systems
- 4th generation will introduce SMV and digital instrument transformers (Middelharnis!)
- More and detailed data acquisition and processing upstream
- Pilot ongoing to replace IEC 104 for SCADA communication with IEC 61850-90-2



Architecture
3RD GEN SAS

- Standardized network?
- Mix of start and ring
- 100M RSTP links
- FO to IEDs
- UTP to STN
- UTP to NTP and HMI



IEC 61850 at Stedin
Tomorrow

IEC 61850 at Stedin

1990
IEC 61870-5-101 release

1995
IEC 61850 development started

2000
IEC 61870-5-104 release

2007
Stedin **started** with IEC 61850

2008
Release of IEC 61850-80-1

2016
Release of IEC 61850-90-2

2019
Stedin **still using** IEC 60870-5-104

2019
Stedin **started** development of IEC 61850 Edition 2 substations

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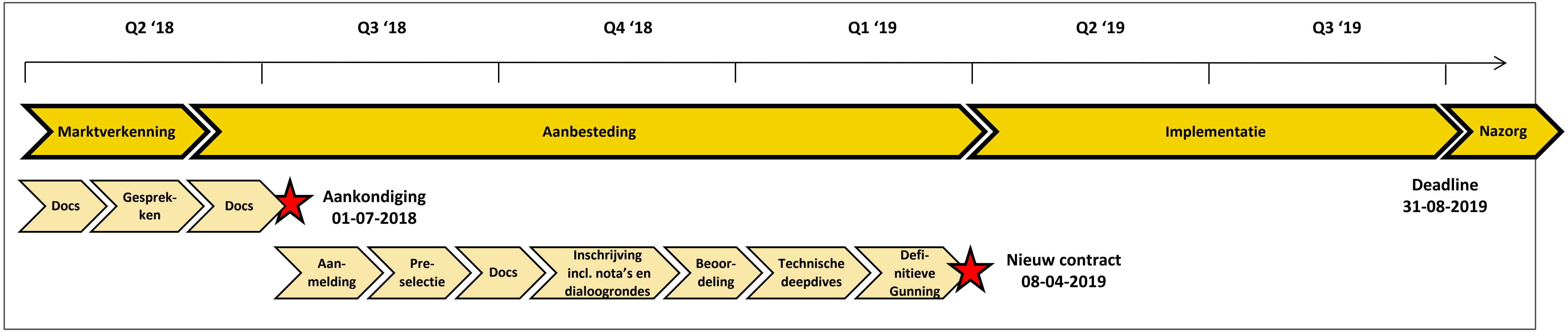
PUBLIC TENDER PROCESS



- 3 months for the market exploration
- Actual tendering done in 9 months

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CLEAR REQUIREMENTS SPEED UP COMPARISON

The intermittent ground fault protection processes the r.m.s. value of the measured earth fault current and compares it to a settable threshold.

Requirement SSRQ-27540 [Weight: 1]

It shall be possible to block the protection functions. This has to be done by the IEC61850 system, a digital input or via the front of the IED

Requirement SSRQ-20222 [KO]

The protection function and measurement functions of the PAC system shall support both clockwise and anticlockwise phase rotation order of the grid.

Sub Requirement(s): SSRQ-23676,

Requirement SSRQ-23676 [Weight: 1]

In case of a deviation between the set phase rotation and the phase rotation of the connected voltage or current an alarm shall be generated

Parent Requirement: SSRQ-20222,

Requirement SSRQ-19769 [KO]

The protection function shall measure the voltage correctly in three phase systems using the following primary equipment:

- Three phase to ground voltage transformers
- Two phase to phase voltage transformers
- Open-delta voltage transformer

Requirement SSRQ-19771 [KO]

The trip pulse output signal duration shall be adjustable.

	Description (not complete)	ID	KO	Weight	Compliant (yes or no
		PKG-19405			
		PKG-19415			
		SSRQ-23394	True		yes
		PKG-19692			
software		SSRQ-19759	True		yes
ded or	The intermittent ground fault	SSRQ-15124	True		yes
0		SSRQ-27540	False	1	yes
h		SSRQ-20222	True		yes
onnected		SSRQ-23676	False	1	yes
the	* Three phase to ground voltage	SSRQ-19769	True		yes
		SSRQ-19771	True		yes
essages		SSRQ-27424	True		yes
ation		SSRQ-18375	True		yes
ed with		SSRQ-19857	True		yes
ne		SSRQ-23589	True		yes
an		SSRQ-19868	True		yes
		SSRQ-23588	True		yes

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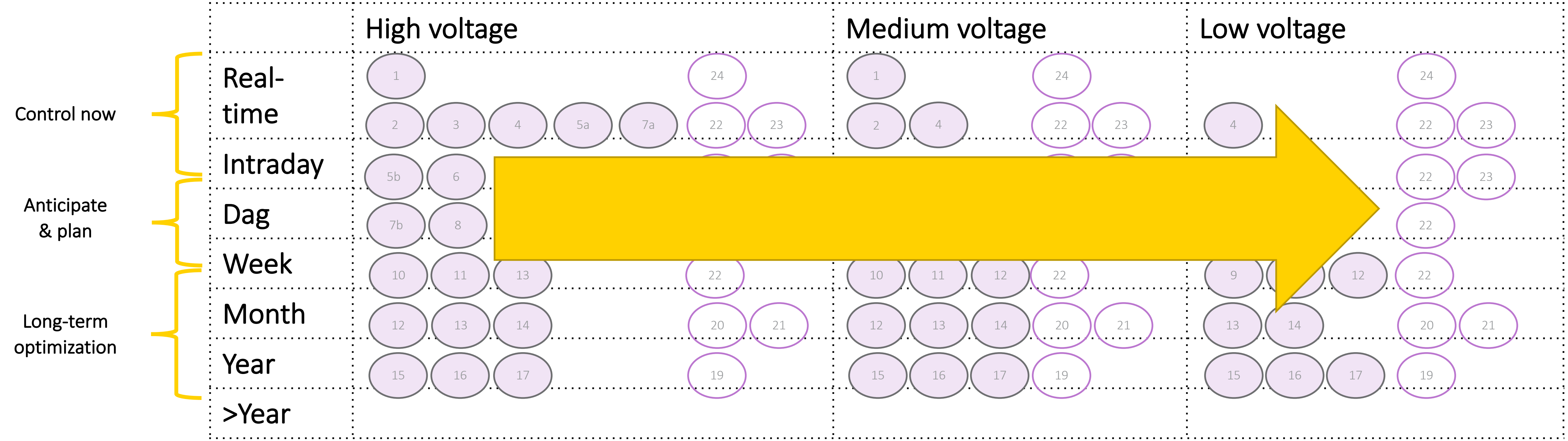
AWARD CRITERIA, PRACTICAL EVALUATION PHASE

Practical Evaluation phase		
I. Score of the Awarding phase	70,0%	
II. Practical Evaluation	30,0%	Process audit (7.5%) Technical audit (22.5%)
Total score:	**100%**	

Digital grid

Digital grid: a common base for real-time to long-term insight and control of the grids.



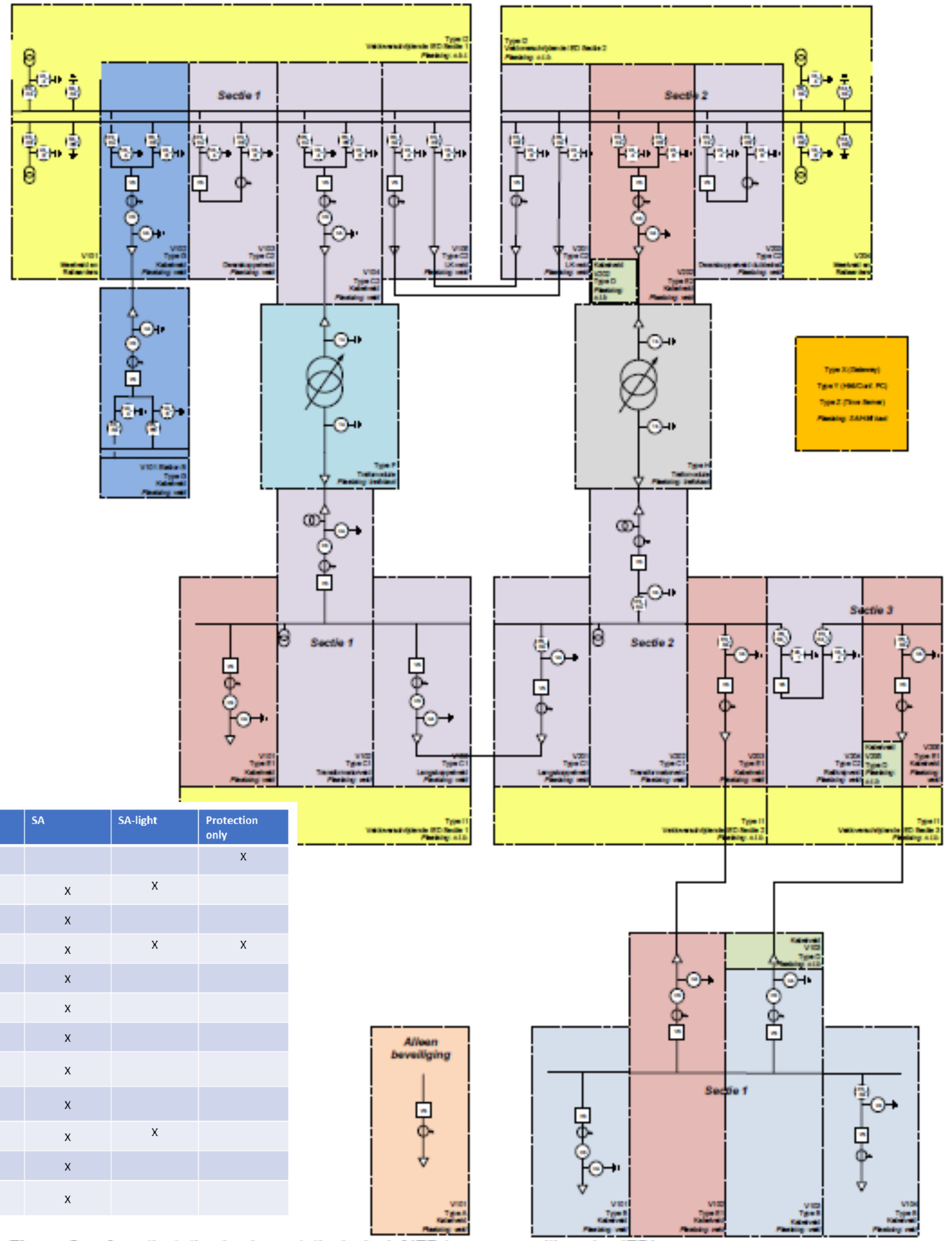
1 – Control, outage detection
2 – Contingency analyses/ planned outage study
3 – Optimization primary equipment
4 - Outage management infra outages
5 – Transport Prognoses (a: intraday, b: day-ahead)
6 –(Operational) capacity constraint
7 – Control plans (a: unplanned, b: planned)
8 – Capacity analyses transport
9 – Fraud detection
10 – Post mortem analysis
11 – Planning energizing
12 – Grid feasibility check
13 – Quality analysis (CAIDI, SAIDI)
14 – Capacity analysis / yearly aggregated capacity
15 – (strategic) Investement plans
16 – Strategic maintenance analysis
17 – Regional (master) plans
18 – Scenario analysis for investement plans
19 – Flex alternatives
20 – Transport constraint (infra)
21 – Temporarily flex
22 – Congestion Management
23 – Transport constraint (transport)
24 – DSM

IEC 61850 at Stedin
4^{TH} GENERATION SAS

- One box solution based upon IEC 61850 Edition 2+
- Stedin IEC 61850 implementation profile (PID) for:
  - Data model (Stedin reference model)
  - Communication services (both inside and outside the SAS)
  - Network architecture
  - Cyber security (RBAC, authentication, virtualization, backups)

- Tendering and evaluation in 2018/2019
- Single vendor (Sprecher)
- Modular / building blocks
- First project : MOTA

Components	Functionalities	SA	SA-light	Protection only
IED Type A: OC	Overcurrent			X
IED Type B: OC + AC	Overcurrent + Automation & Control	X	X	
IED Type C: OC + freq. + AC	Overcurrent + Frequency + Automation & Control	X		
IED Type D: OC + LD	Overcurrent + Line Differential	X	X	X
IED Type E: OC+ LD + AC	Overcurrent + Line Differential + Automation & Control	X		
IED Type F: OC + TD + AC	Overcurrent + Transformer Differential + Automation & Control	X		
IED Type G: OC + LD + Dist + AC	Overcurrent + Line Differential + Distance + Automation & Control	X		
IED Type H: OC+ LD + TD + AC	Overcurrent + Line Differential + Transformer Differential + Automation & Control	X		
IED Type I: Freq + AC (Logic Unit)	Frequency + Automation & Control (Logic Unit)	X		
Type X: Gateway units	For the interfacing central OT systems with PAC system	X	X	
Type Y: Substation HMI	Substation single line overview and control panel	X		
Type Z: GPS receiver with (S)NTP-server	Time server in substation	X		



Figuur 2: *referentiestation implementatie, inclusief IED types en positionering IED's*

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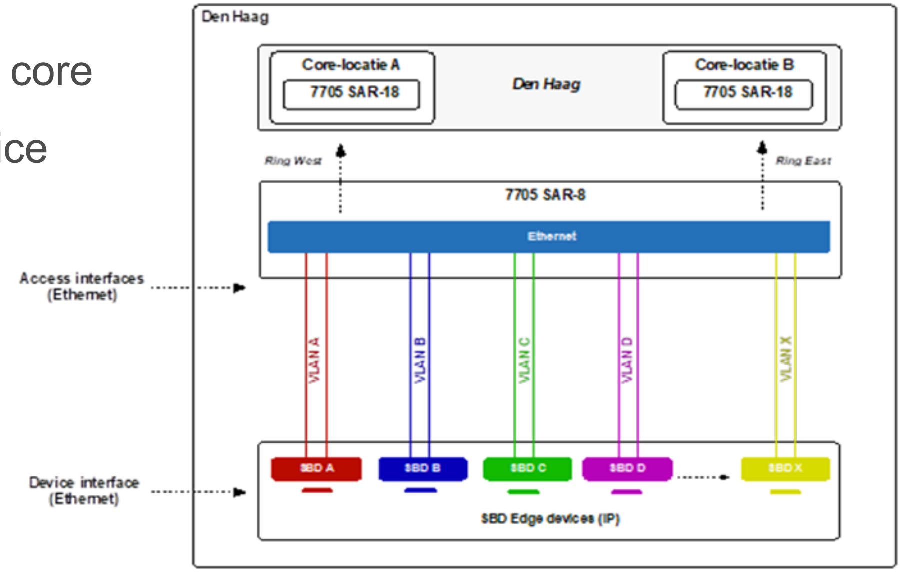
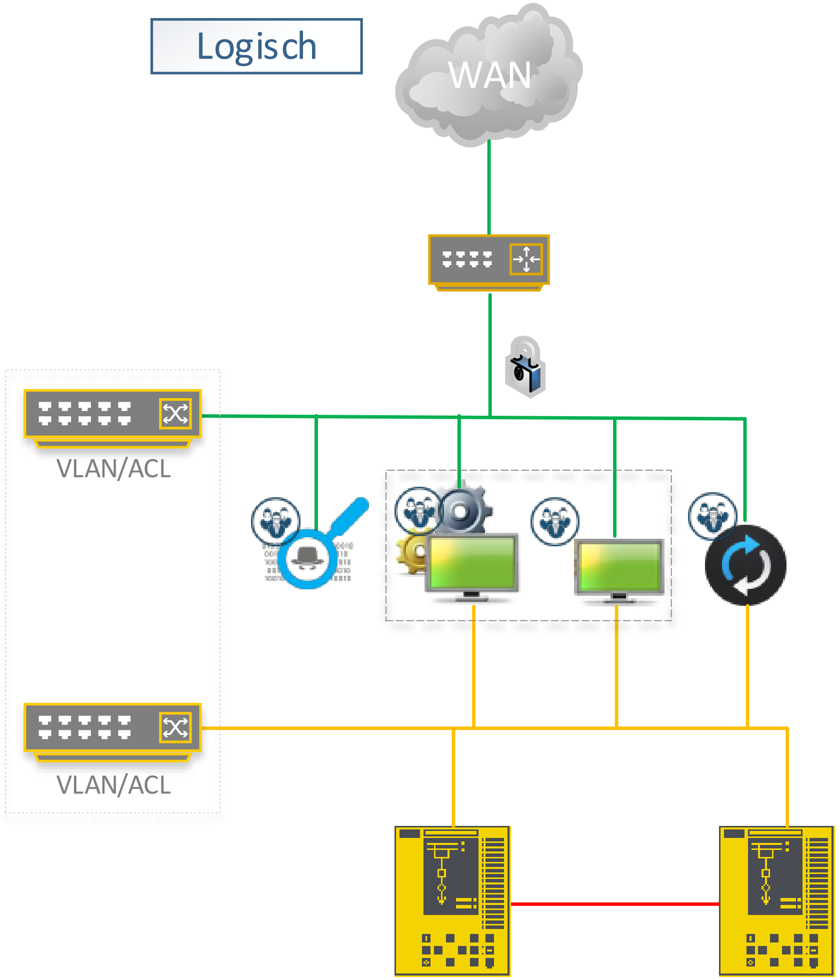
4TH GENERATION SAS

- Redundant 10G links to STN core
- IP/MPLS L3 VLANs per service
- SAR-8 is access to SA LAN

- SA-LAN 1G uplink
- Routing/ACL in the SA LAN
- VLAN tagging in the SA LAN
- RSTP recovery <= 100 ms
- Ring topology to reduce costs

- Jump-server/VMware host in substations (not for SA-Light)





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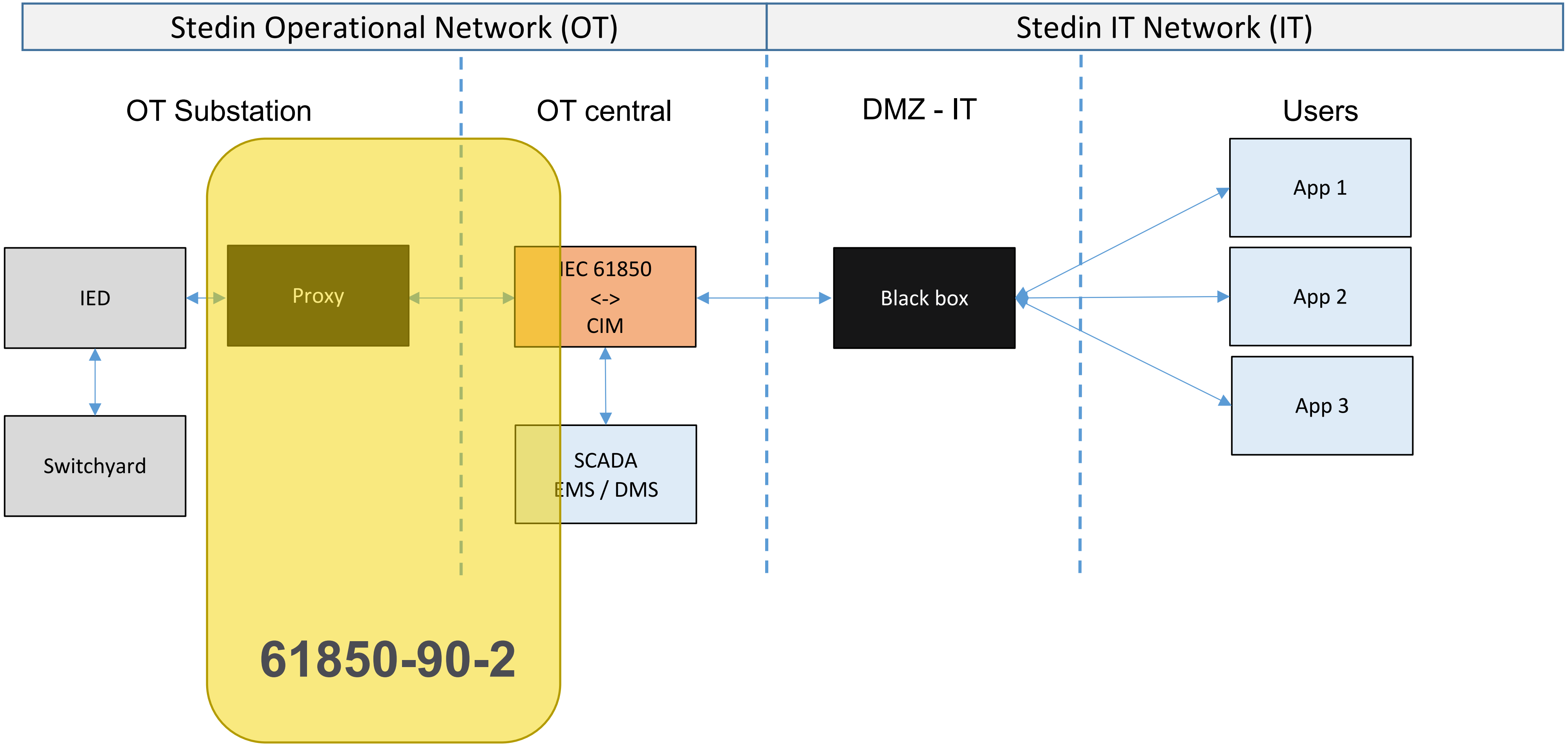
OT AND IT NICELY PLAYING TOGETHER



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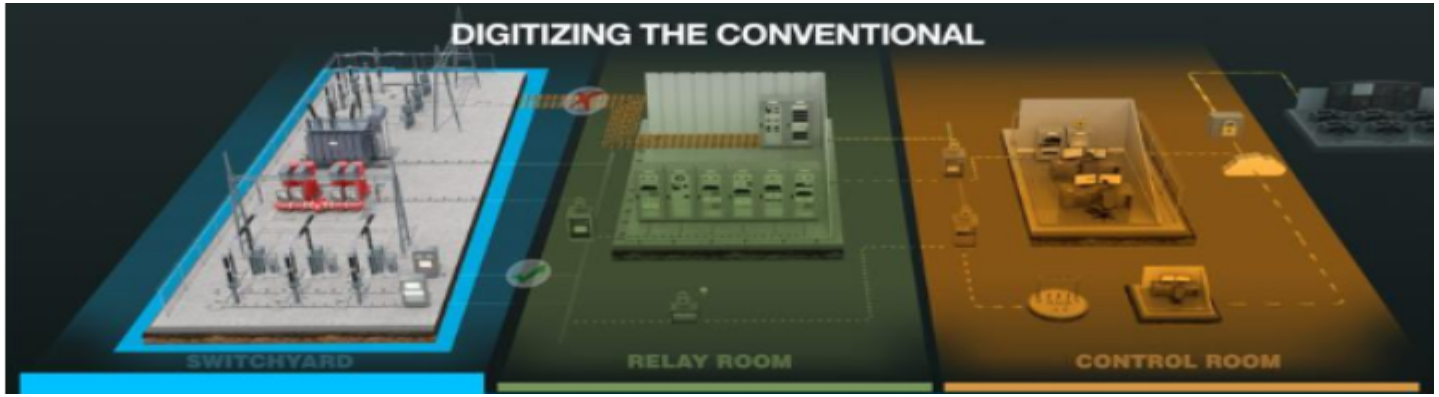
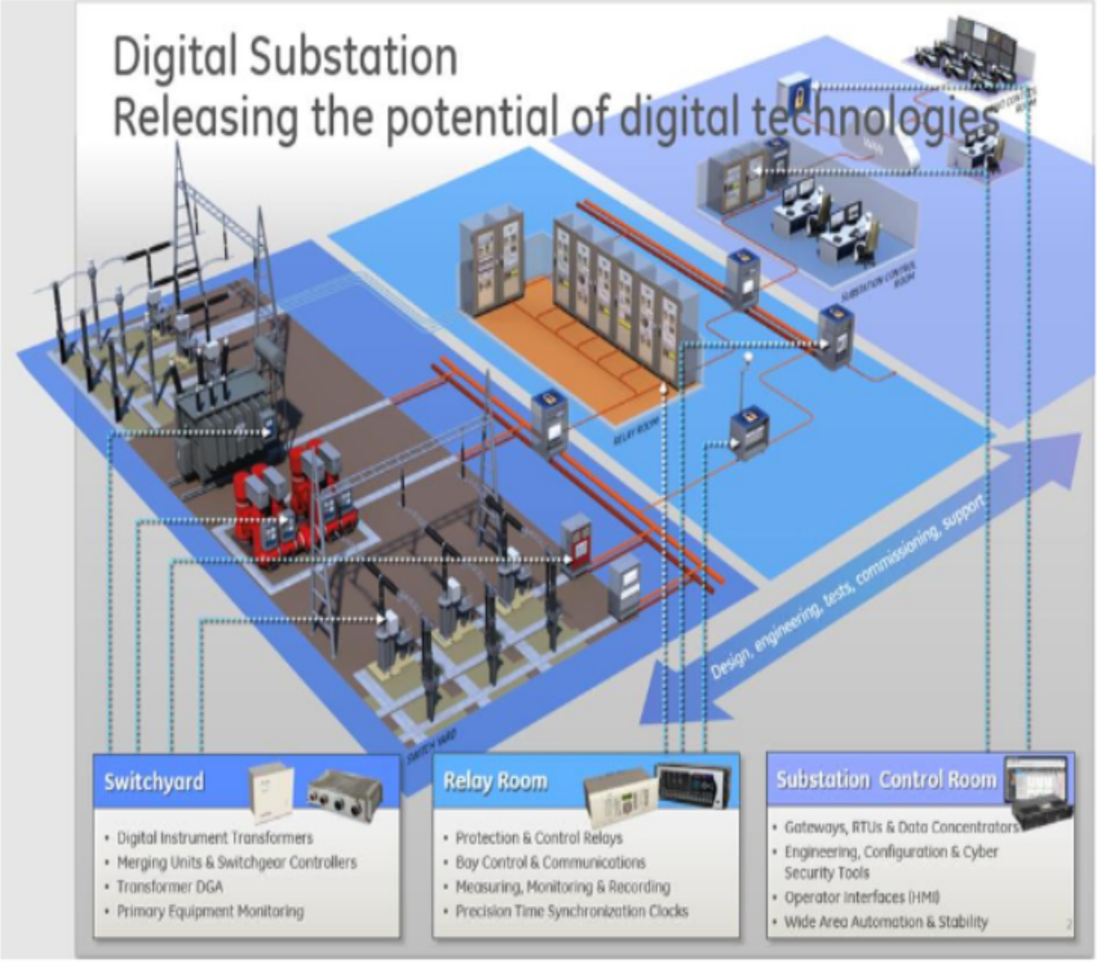
Innovation & near future

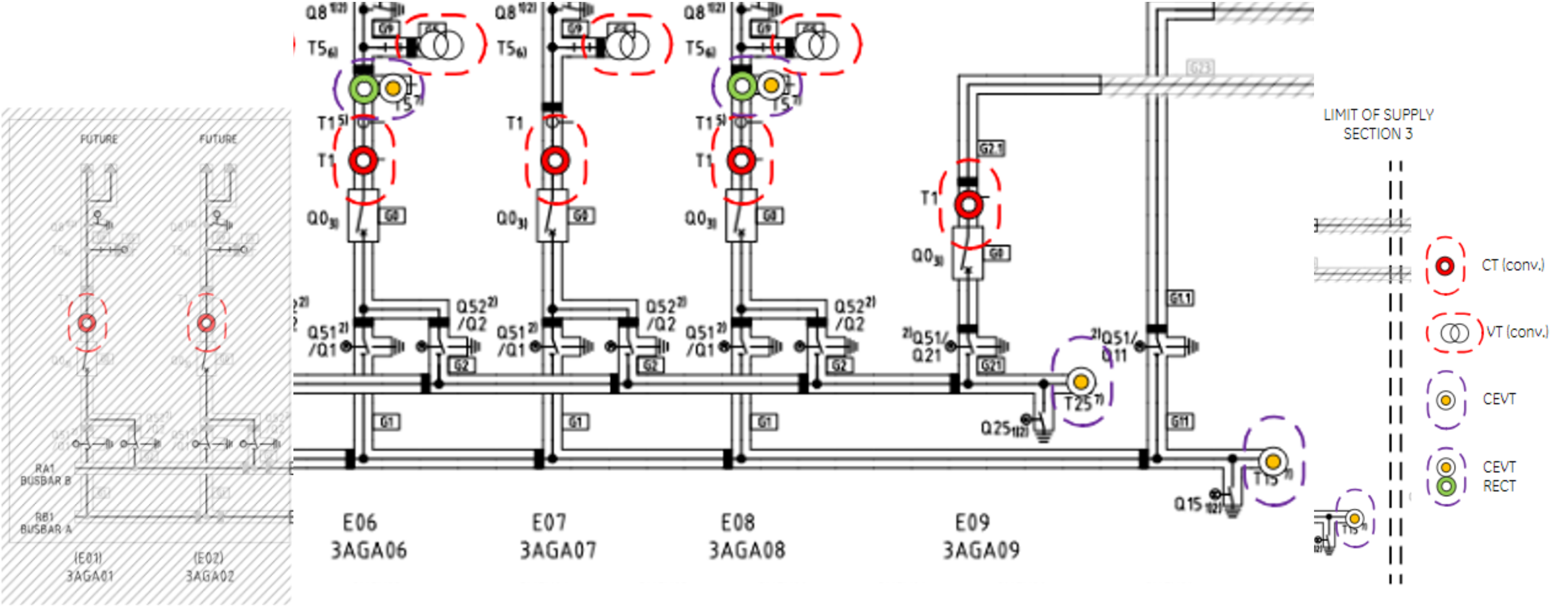
IEC 61850 at Stedin
PROCESS BUS PILOT MIDDELHARNIS

- Advantages of a process bus
  - Improved safety and reliability (no open current circuits)
  - Reduced CT saturation
  - Simple plug-in of extensions on the bus
  - Easy replacement of components
  - Single source of very accurate data
  - Multi vendor and it is awesome!





IEC 61850 at Stedin
PROCESS BUS PILOT MIDDELHARNIS



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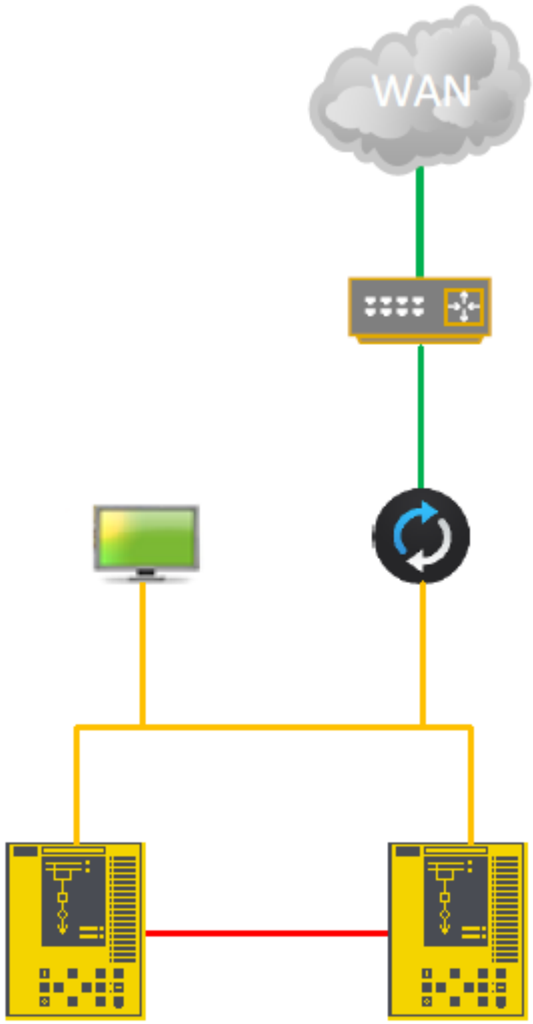
COMPONENTS OF A DIGITAL SUBSTATION

- Communication protocols in IEC 61850 are mapped on Ethernet (Xerox – 1970)
- IEC 61850-8-x and -9-x describe to date 4 communication protocols
  - GOOSE (e.g. IED to IED to exchange breaker positions);

- GOOSE is mapped on multicast Ethernet (publishers and subscribers)
- Often faster compared to (mechanical) support relays and wires
- Fault tolerant and reliable due to continuous transmission
- Real-time behavior but non-routable
- Used for exchange of process information:
  - Interlocking positions
  - Protection functions and trips
  - Automation functions



IEC 61850 at Stedin
COMPONENTS OF A DIGITAL SUBSTATION

- Communication protocols in IEC 61850 are mapped on Ethernet (Xerox – 1970)
- IEC 61850-8-x and -9-x describe to date 4 communication protocols
    - Sampled Values (exchange of currents/voltages between primary apparatus & IED);

- SMV is mapped on multicast Ethernet (publishers and subscribers)
- Fault tolerant and reliable due to continuous transmission
- Real-time behavior
- Used for exchange of current and voltages (e.g. measurements and protections)

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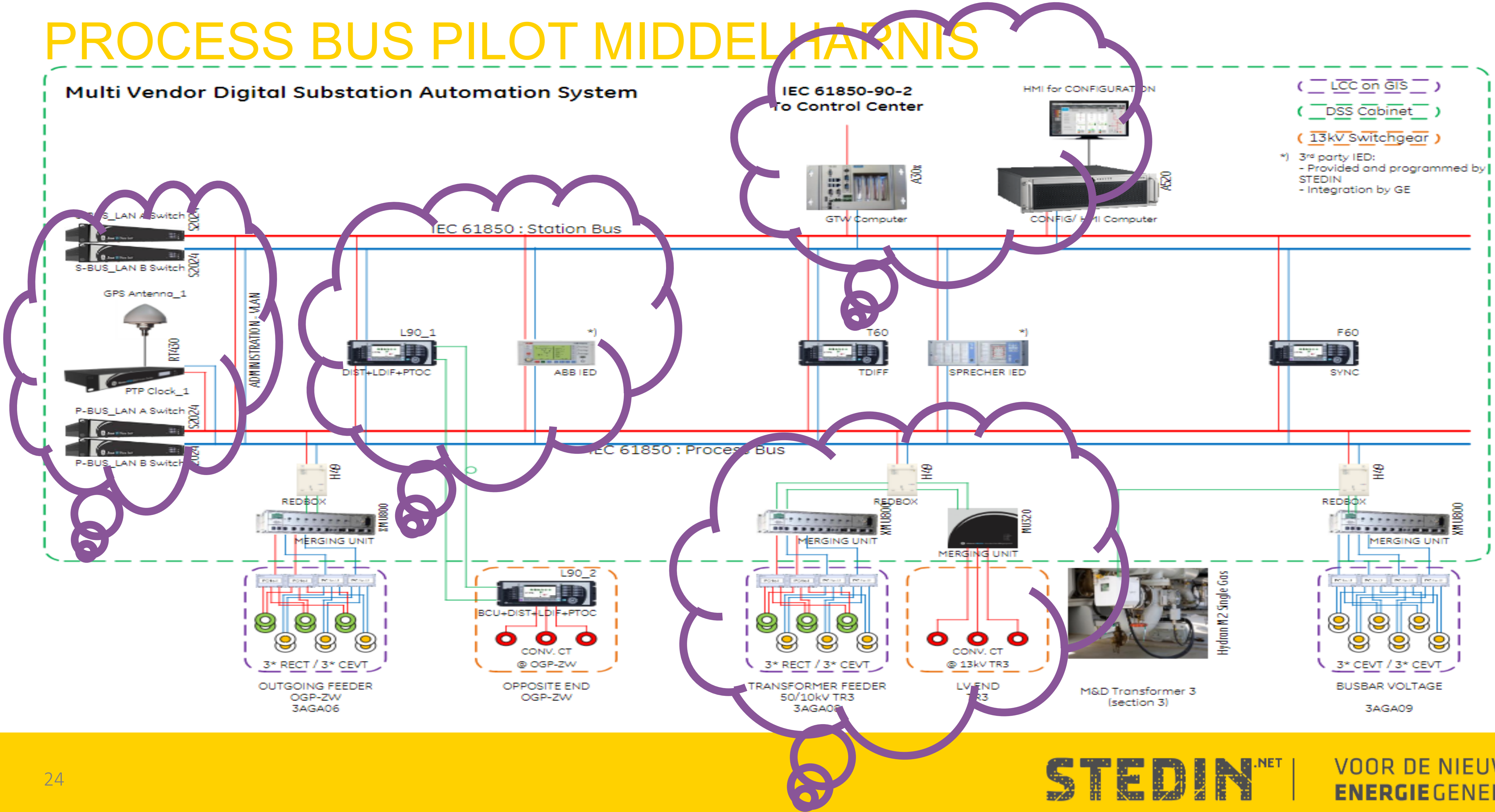
PROCESS BUS PILOT MIDDELHARNIS



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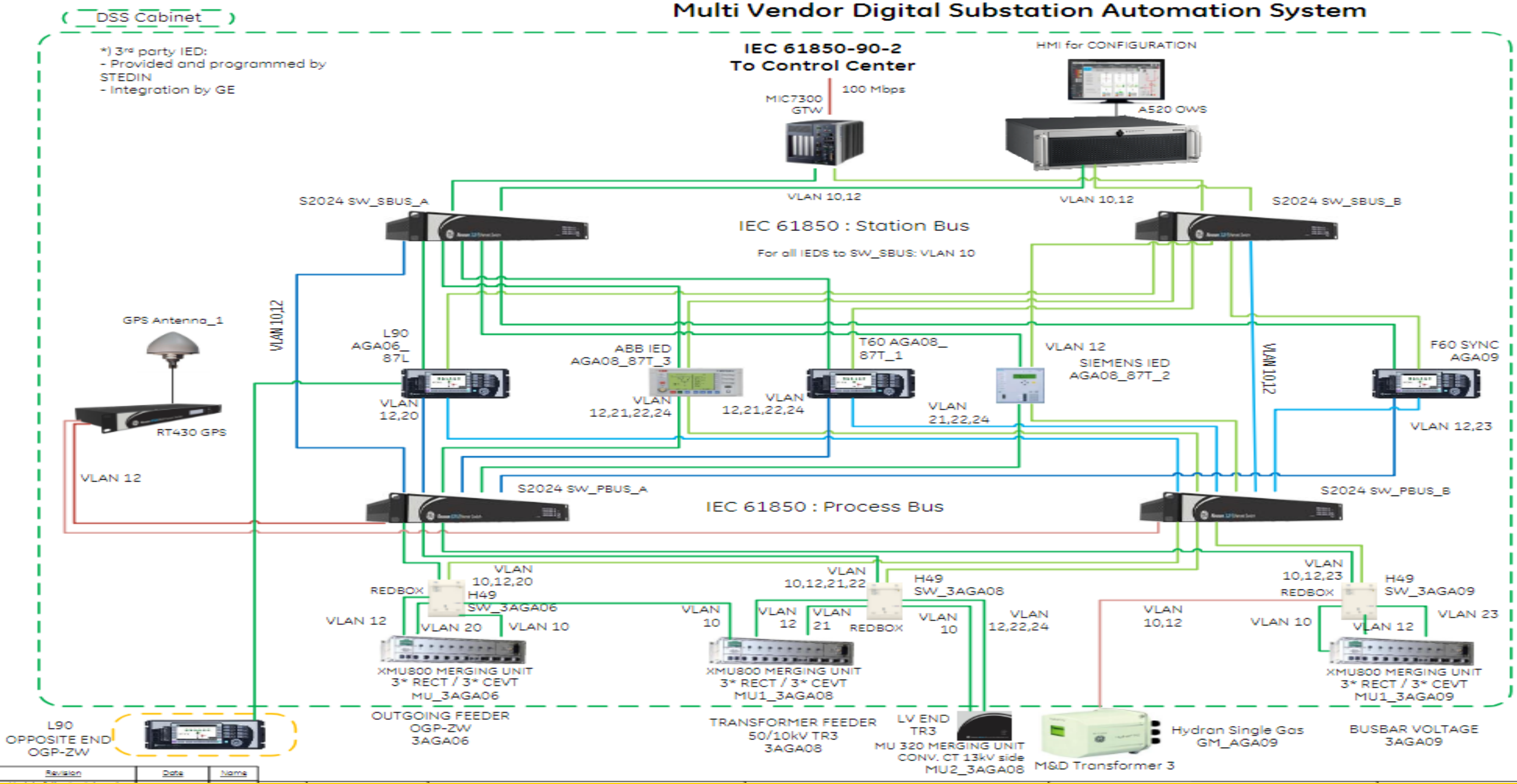

SYMBOL	NAME/DESCRIPTION
	Advantech A520Q DS Agile Operating Workstation
	Advantech MIC7300 DS Agile Gateway
	GE RT430 – GPS Clock PTP and NTP
	GE S2024 – Switch
	GE H49 switch RedBox
	GE UR protection relays
	ABB protection relay
	SIEMENS protection relay
	GE MU320 – Merging Unit for measurement and digital acquisition
	GE XMU800 – Merging Unit for measurement acquisition
	GE HYDRAN – Single Gas Monitoring

LEGEND :

- Copper cable 100 Mbps
- LC/LC Optical fiber 1Gbps
- LC/LC Optical fiber 100 Mbps

VLAN	DESCRIPTION
VLAN10	Administration VLAN
VLAN12	Synchronisation VLAN
VLAN20,21,22,23	PBUS VLANs: oneVLAN dedicated per Sample Values
VLAN24	Pbus GOOSE VLAN

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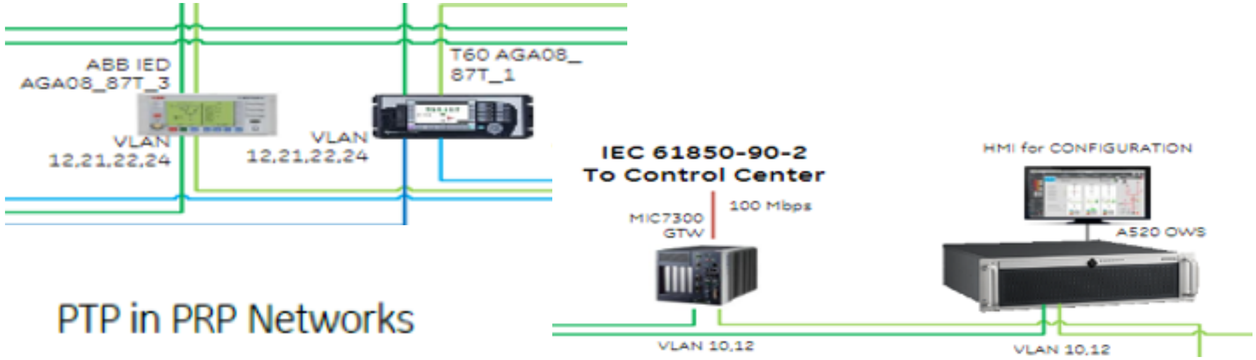
DSS FAT

- Introduction to all components
- Network design review
- Network connection validation
- SCL validation
- GOOSE/SMV checks
- Network performance
- Validation of use-cases
    - Measurements
    - Trips signals
    - Protection functions

IEC 61850 at Stedin
PROJECT EXPERIENCES

- Challenges in station-bus and process-bus design
  - Virtual LANs
  - Priorities
  - Network Speed
  - Interoperability between IEDs and RedBoxes
- Capacity/performance of gateway system
  - Slow cycle time of disturbance file copy
- Time-synchronization PTP (IEEE 1588v2)
  - MU320 without time-sync due to network load
  - No clock-sync SMV -> false trips of ABB IED
  - Variations on network load (70-90% vv) -> false trips
  - Change of time -> reboot of T60 IED



PTP in PRP Networks

RT430 offers the accurate Precise Time Protocol (IEEE 1588 PTP v2) combined with the Paralell Redundancy Protocol (IEC 62439-3 PRP), ensuring 100 ns accuracy and high-availability in time synchronization over Ethernet networks. In case of failure in one of the redundant networks, the recovery-time is zero.

Station Bus Switch	GE S2024G 3XPIHHCXX06B	Modular Managed Ethernet Switch with 4 RJ45 copper 10/100 ports, 8 100 Mbps LC multi-mode fiber and 4	2	
PRP Redbox	GE H49 AABBBB00000A	H49 - PRP Redbox - Quad box switch: 2 Gbps LC multimode ports 4 100 Mbps LC multimode ports	2	
Gateway computer	Advantech MIC-7300 with 24V dc power supply	Rack mount Industrial computers used for: Gateway	1	
GPS clock	RT430 3XPRA2C08B241	GPS Satellite SNTP Server to synchronize the Network.	1	
GPS antenna	RT430 Antenna	GPS antenna	1	

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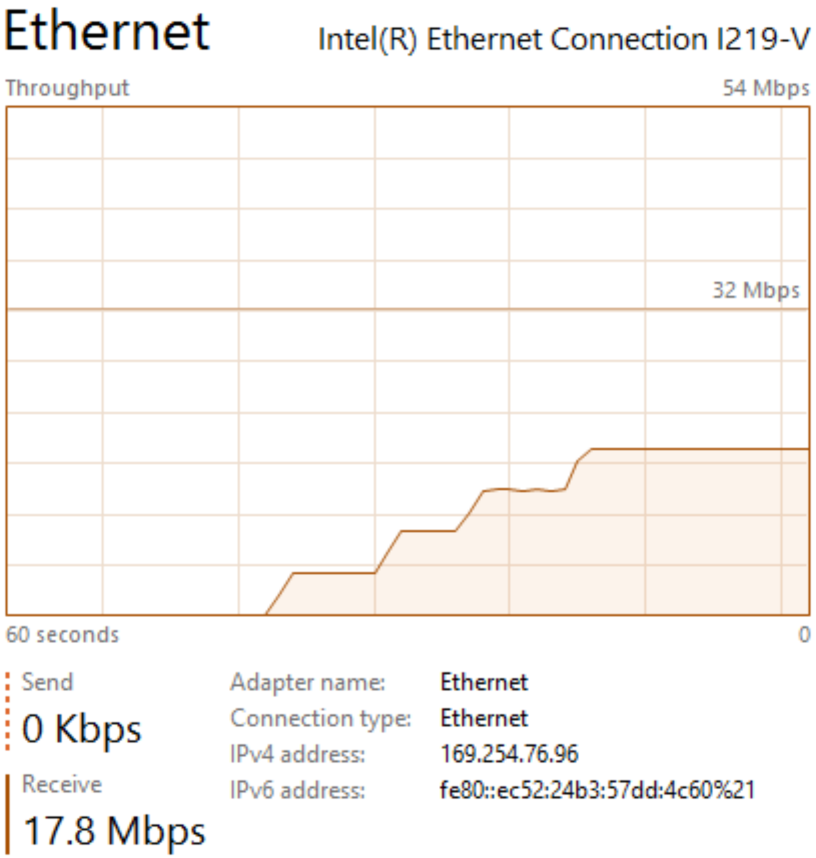
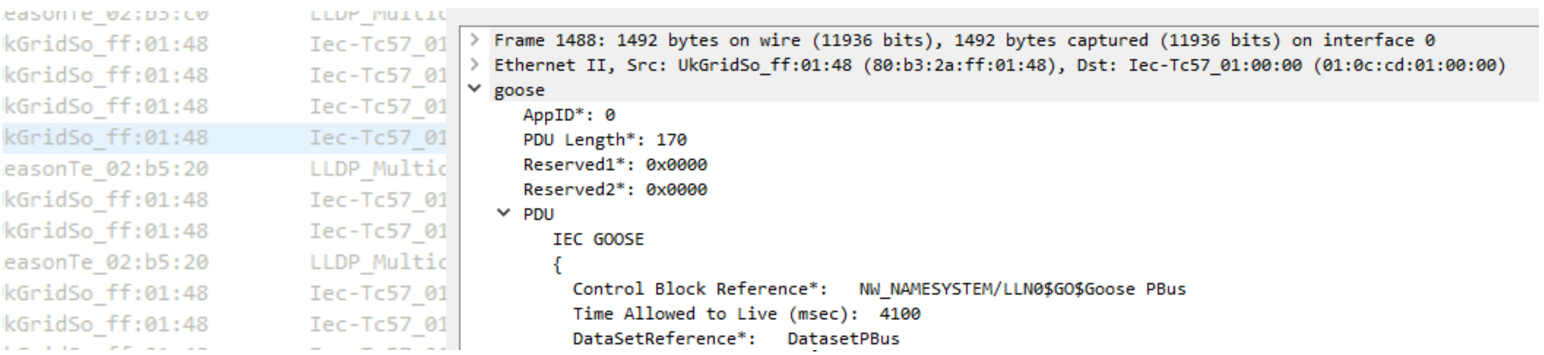
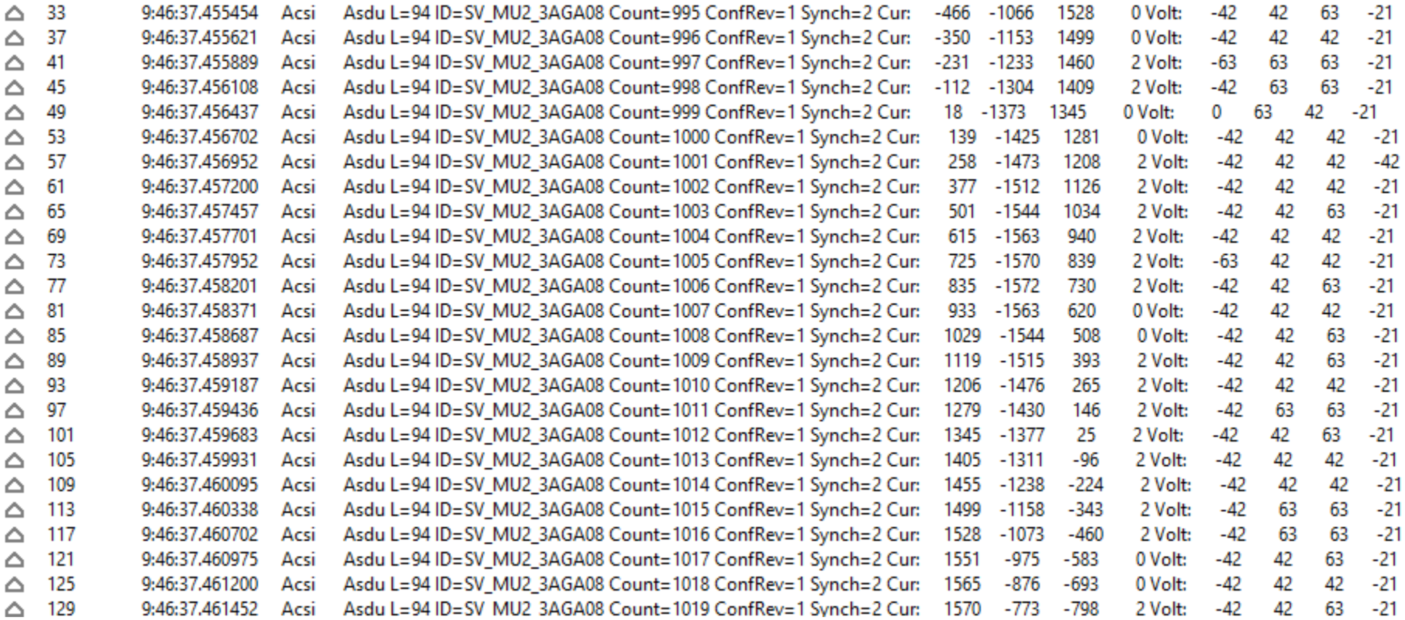
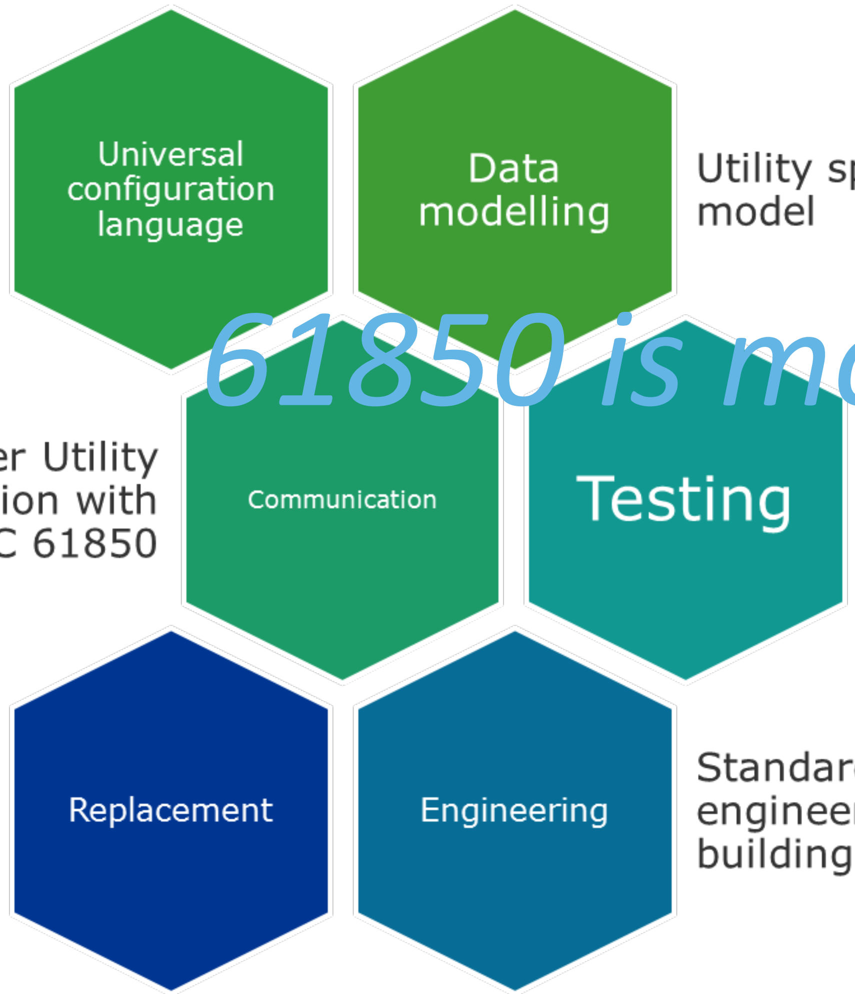
MEASUREMENT MESSAGES?







IEC 61850 at Stedin
PROJECT EXPERIENCES

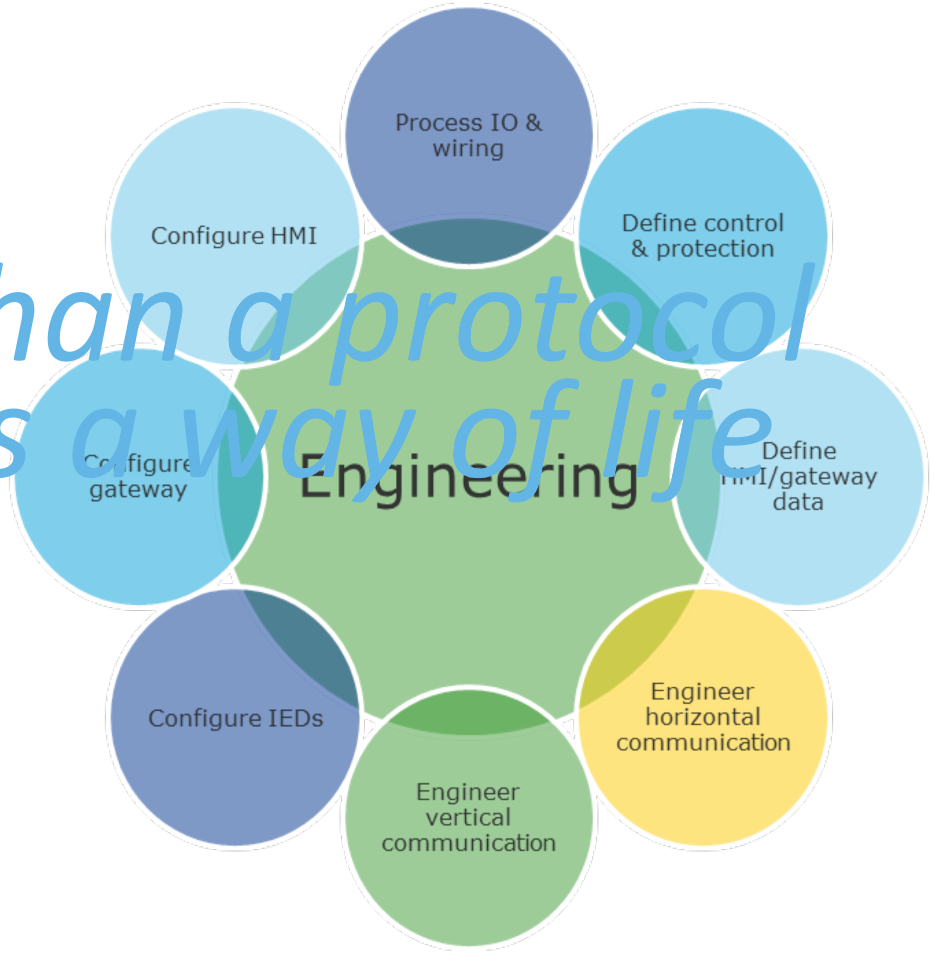


Utility specific data model

Power Utility automation with IEC 61850

Standardized engineering building blocks

61850 is more than a protocol
it is a way of life



THANK YOU
Questions and Answers

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