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Smart Substations in MEA's Distribution System

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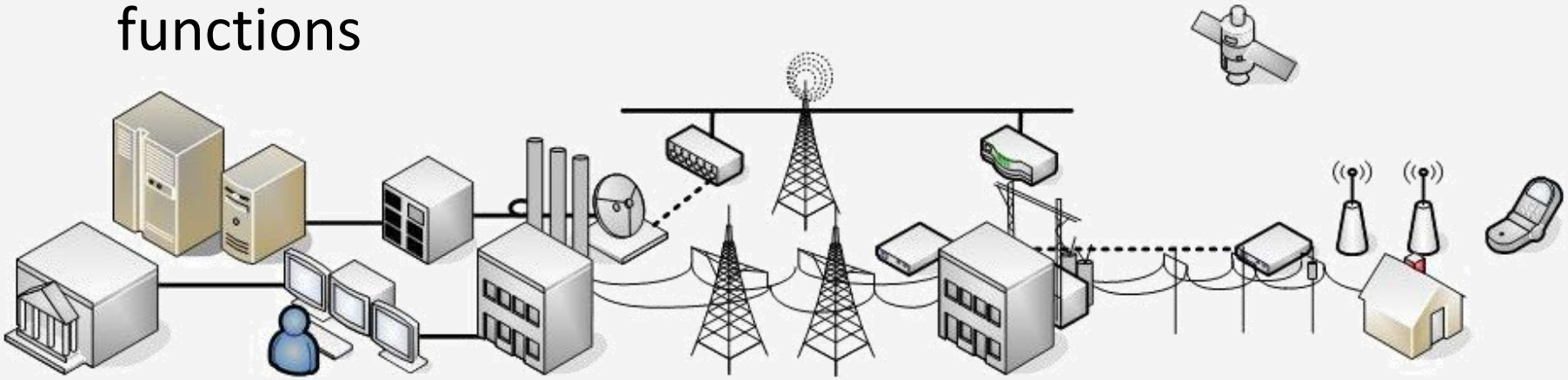
Smart Grid

Electrical Infrastructure + Intelligence Infrastructure

- Uses information technologies to improve how electricity travels from power plants to consumers
- Allows consumers to interact with the grid
- Integrates new and improved technologies into the operation of the grid resulting in new services and functions



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MEA's Smart Grid Objectives

Power System

- Enhance reliability of the existing grid
- Improve efficiency of MEA power system

Services

- Create opportunities for new services
- Enable active participation by consumers

Energy Saving and Renewable Energy

- Promote energy saving and integration of renewable energy resources
- Support new technologies i.e., electric Vehicle-to-Grid (V2G)

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MEA's Smart Grid Roadmap

	Stage 1 2012– 2016 Laying the Foundations	Stage 2 2017 – 2021 Large Scale Implementation	Stage 3 2022 – 2026 Ultimate Stage
Power System	Implement Substation Automation based on IEC61850 for existing substations		
	40 substations	100 substations	100% (approx. 170 substations)
	Implement Distribution Management System		
	30% of service area	60% of service area	100% of service area
	Employ outage monitoring system in HV and MV		Extend outage monitoring system to LV
	Initiate self-healing capability in HV and MV for some areas.		Expand self-healing capability in HV and MV to cover the entire service area
	Implement asset management to reduce operation and maintenance costs		

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Smarter Substation

Substation + The Latest Information Technologies

- Focusing on secondary devices (protective relay, CT/PT) commonly called IEDs (Intelligence Electronic Device).
- Layer-3 Ethernet switches and TCP/IP (instead of serial comm.)
- IEC61850 (Trend of application protocol).
- Substation applications have to utilize real-time information as much as possible.
- The old smart substation ‘s applications normally use only DI/DO and can not utilize AI which maybe required for very fast decision such as 3-bays BTO.

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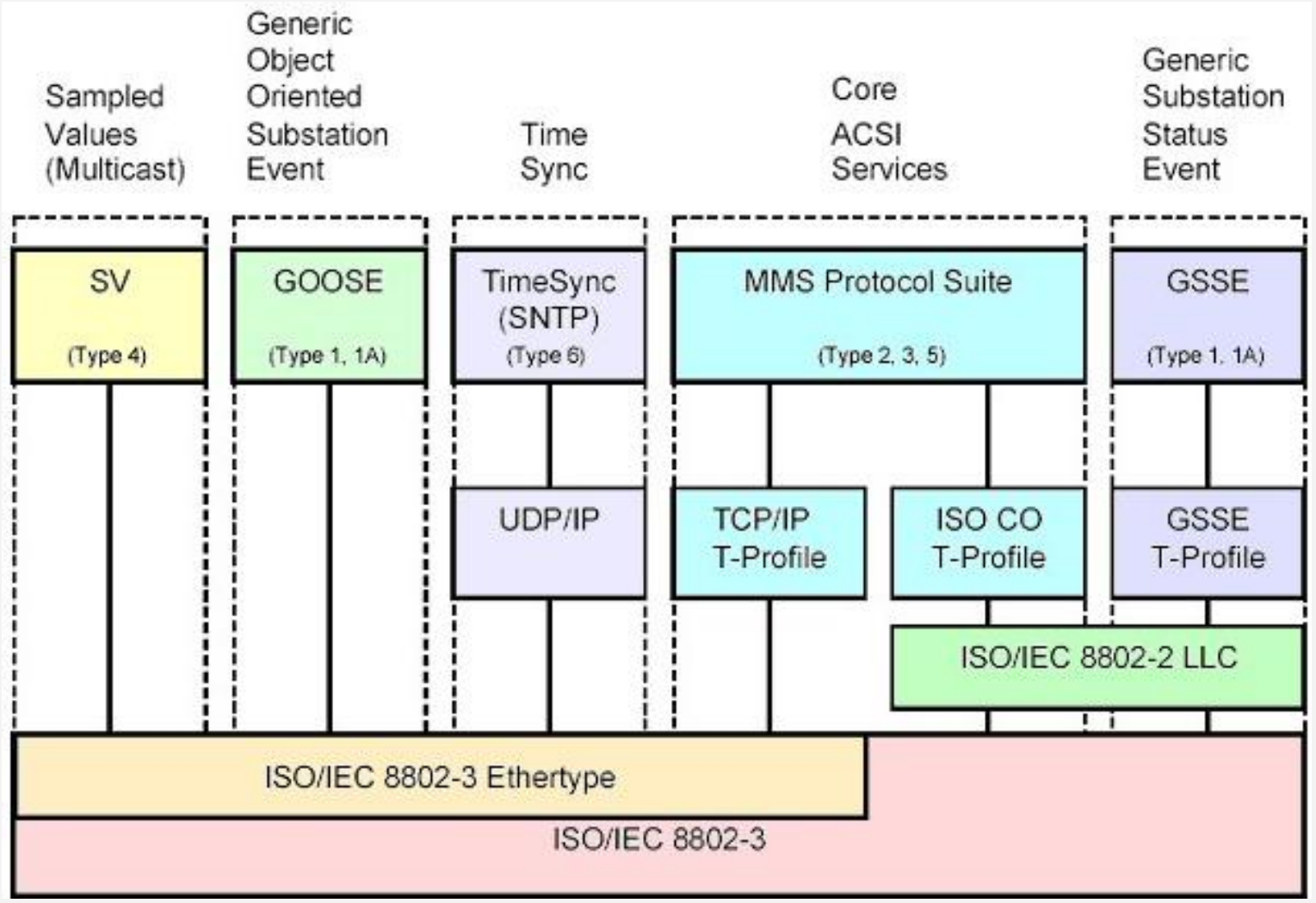
IEC61850 Messaging (1)



IEC61850 Messaging (2)

- **read** a value / attribute
- **write** configuration attributes
- **control** a device (direct operate / **s**elect **b**efore **o**perate)
- **event oriented** communication with reporting
- local storage of time-stamped events in a **log**
- get **directory information**
- **file transfer** for e.g.
  - parameter and software download
  - upload from monitoring information like travel curves or history of gas density values
- **Transfer of generic object oriented system events (GOOSE)**
- **Transfer of sampled (analog) values (SV)**

Non time-critical Services

Time-critical Services

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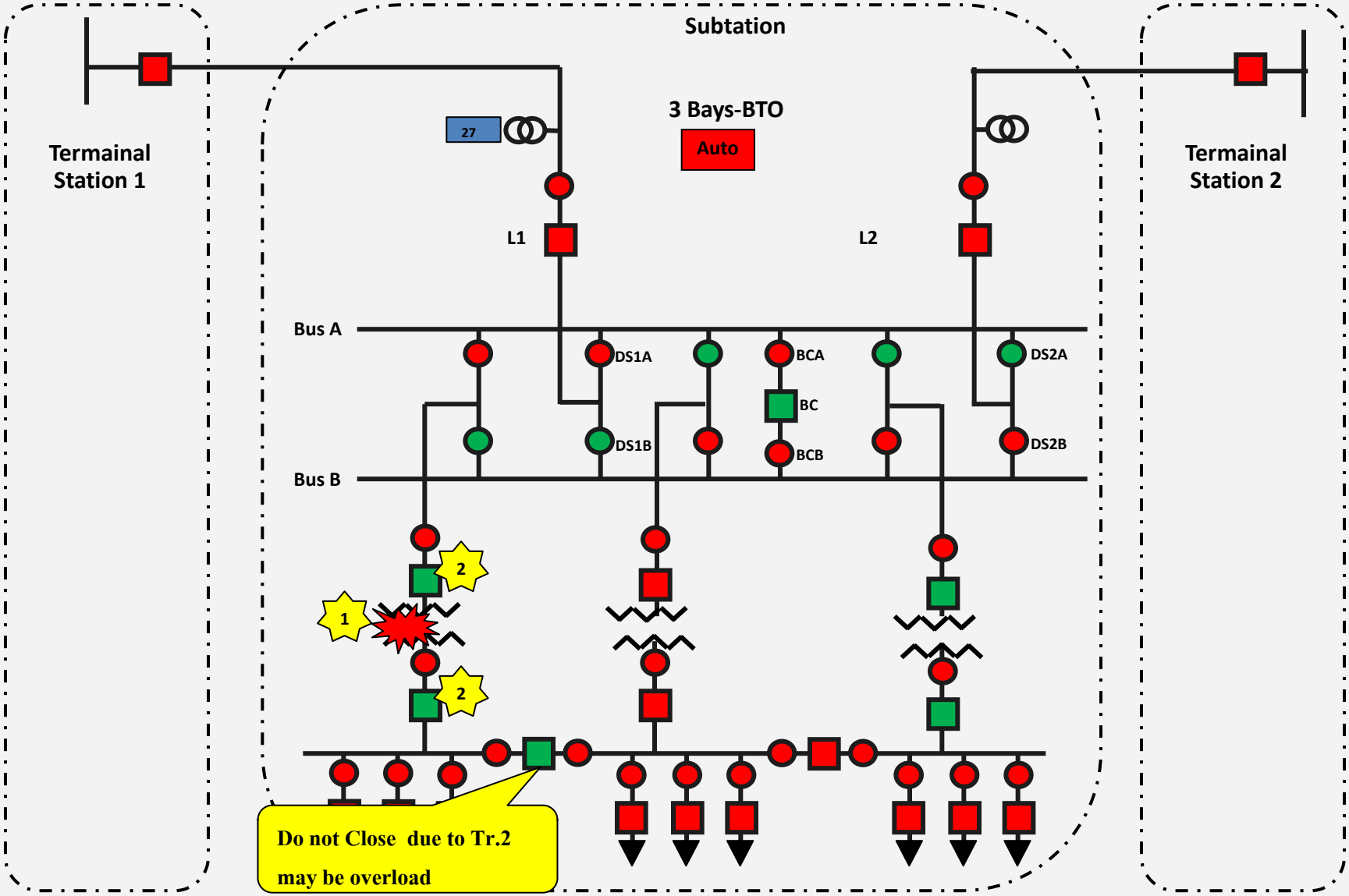
3-Bays BTO Function (1)



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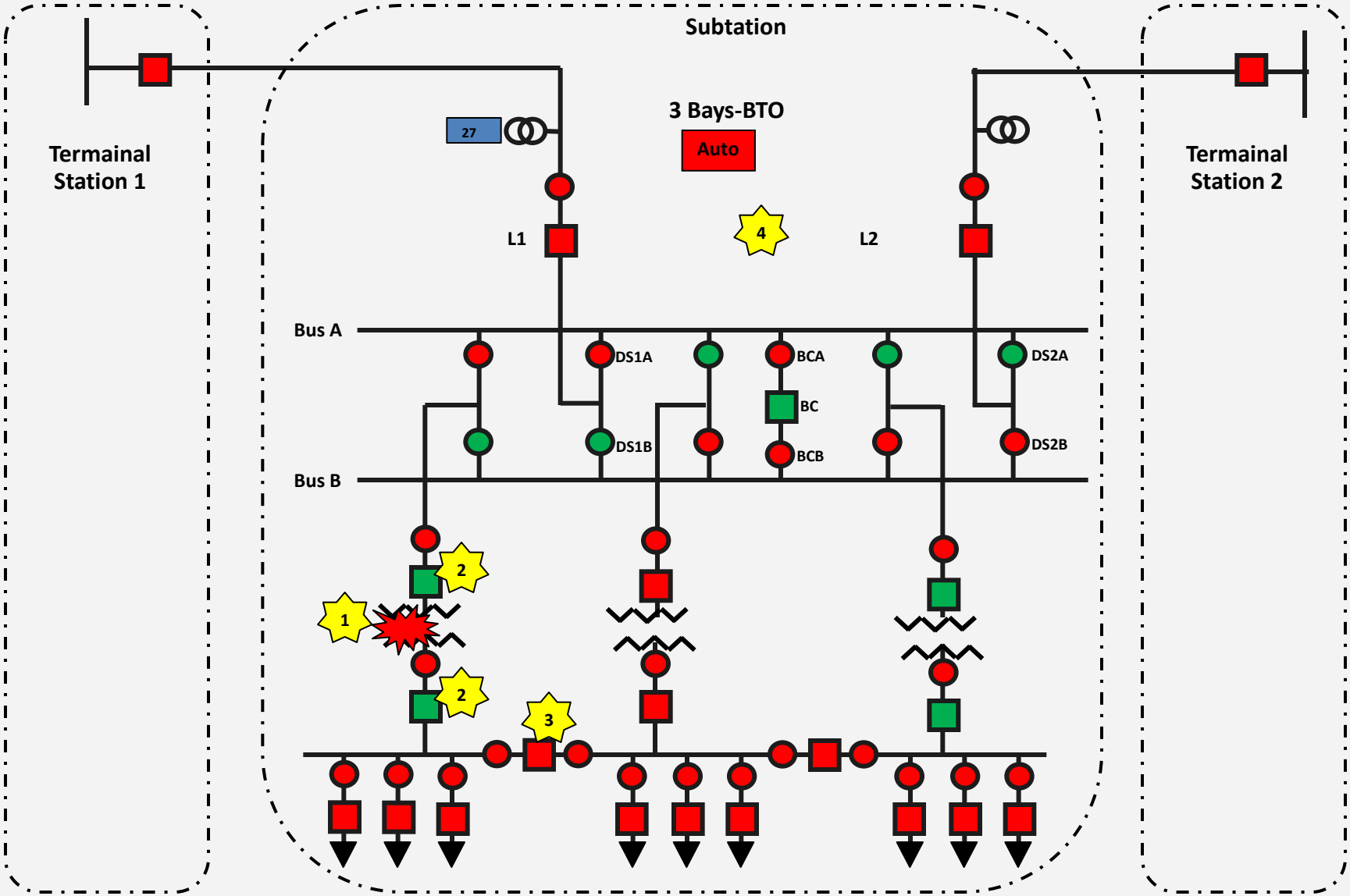
3-Bays BTO Function (2)



Smart Substation for Smart Grid

Because of TCP/IP, Switch, IEC61850 technologies

- Supporting future grid applications in scale of bay-level response time (4ms by native GOOSE, super fast for grid level) by using VLAN across WAN.
- GOOSE/UDP is coming for across network via gateways /firewalls.
- Making us can share communication infrastructure such as fiber-optic cores. For Example ,in the past, we had to use dedicated cores and PLCs for LTF (Line Transfer Function between substations)

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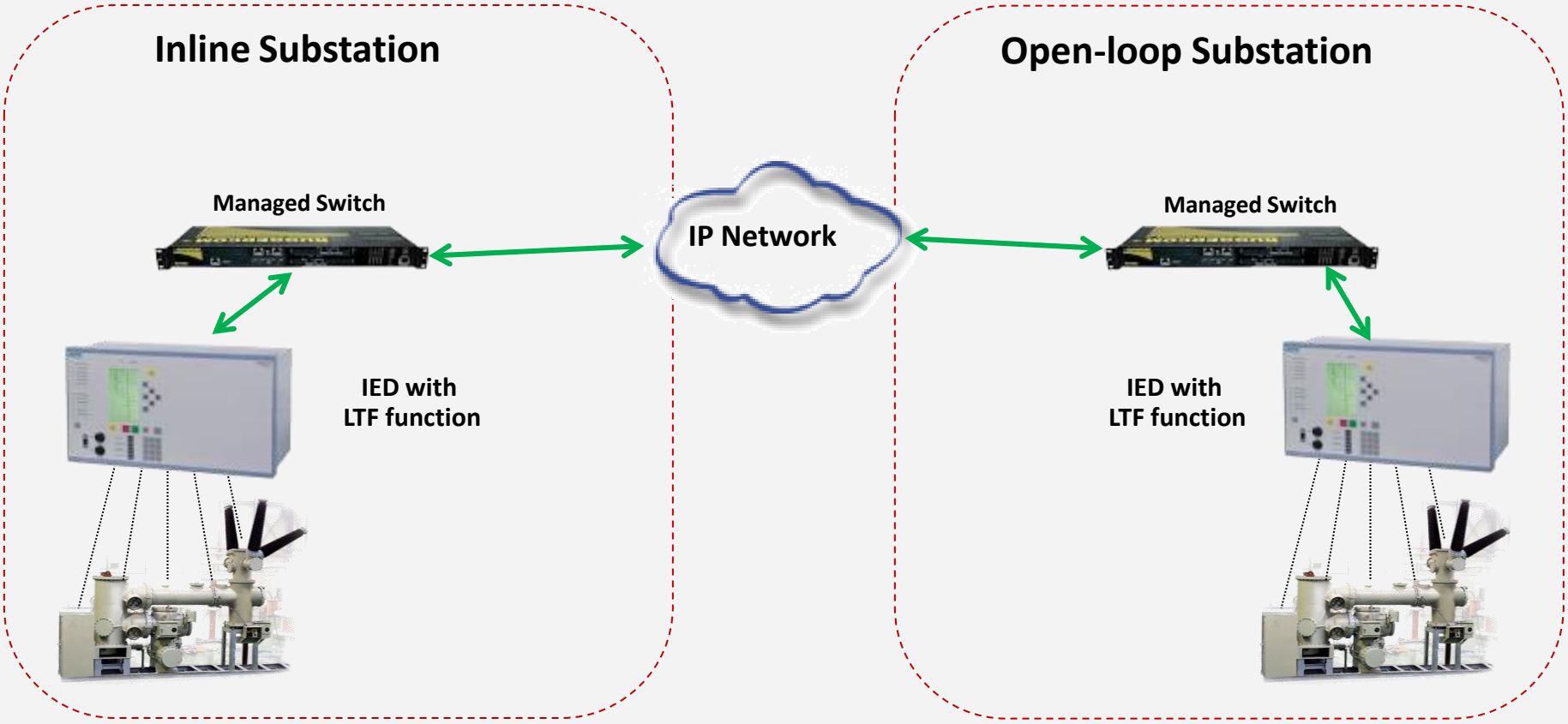
LTF (1)



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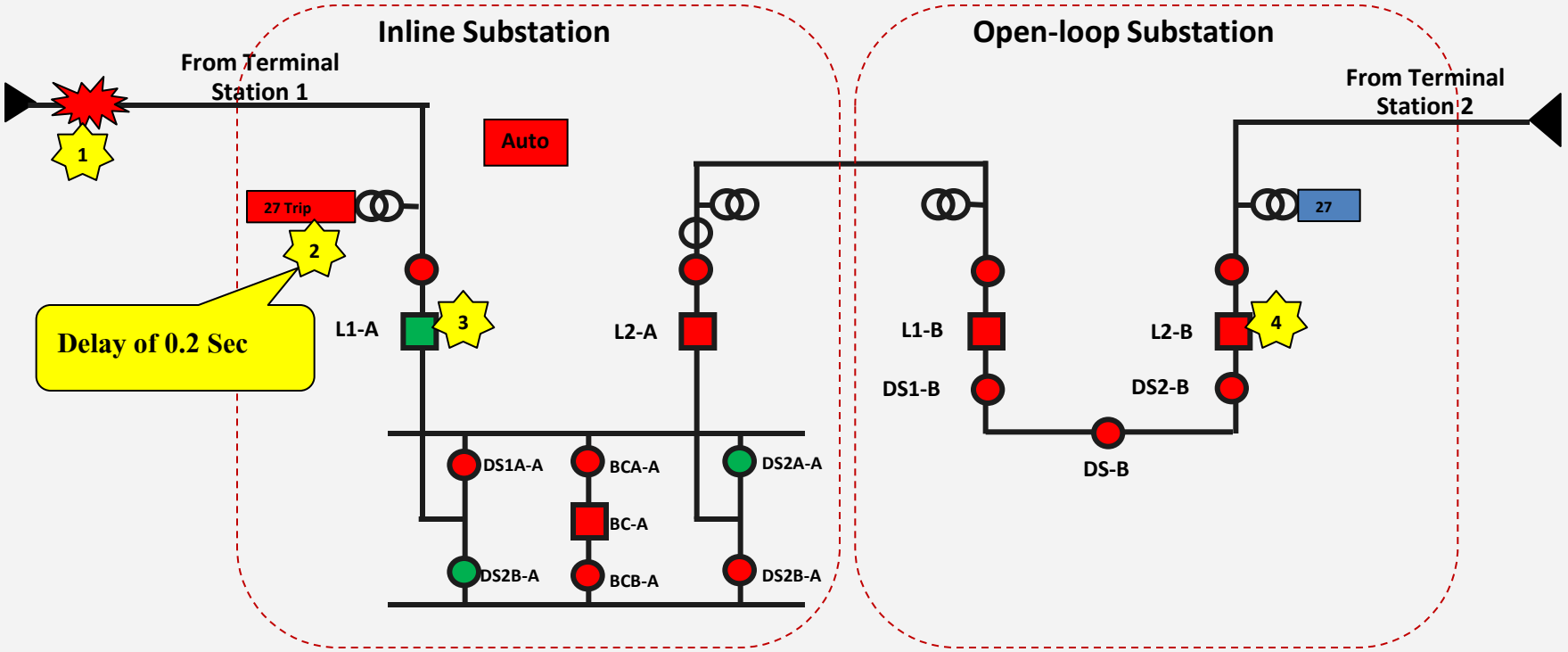
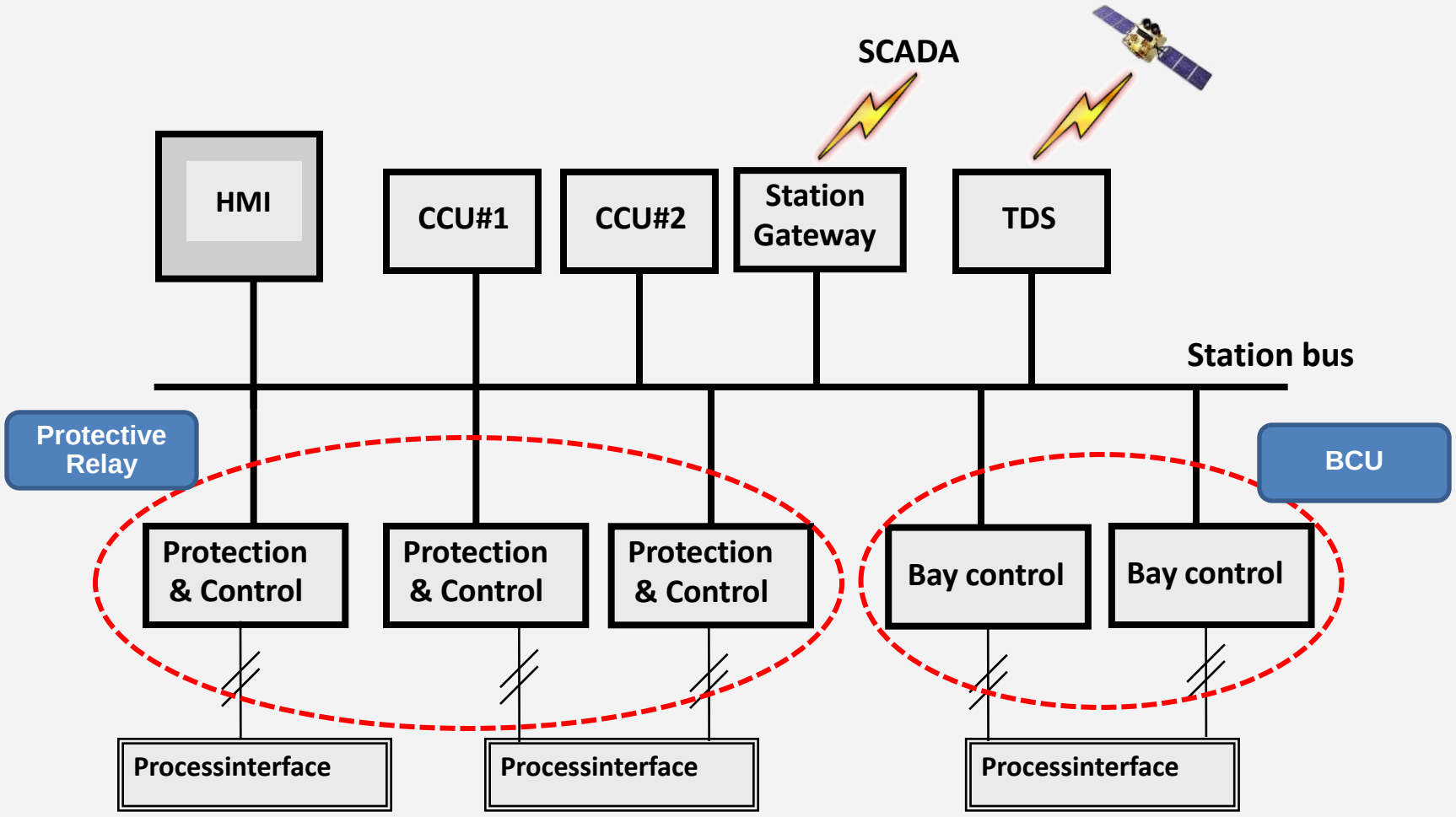
LTF (2)



Consolidation Concept

Smart Substation > Substation Automation



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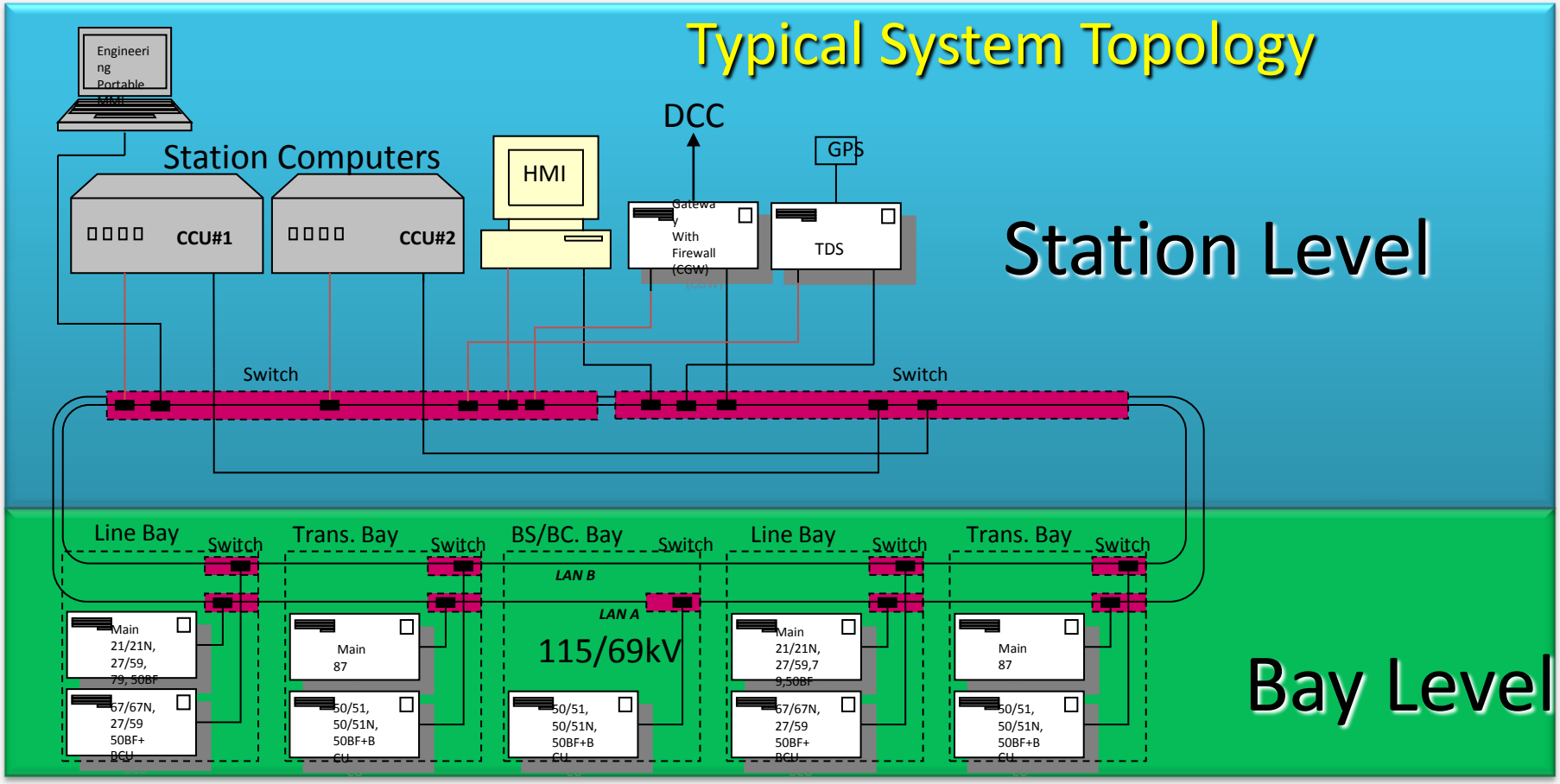
Lasted MEA's SA Specification



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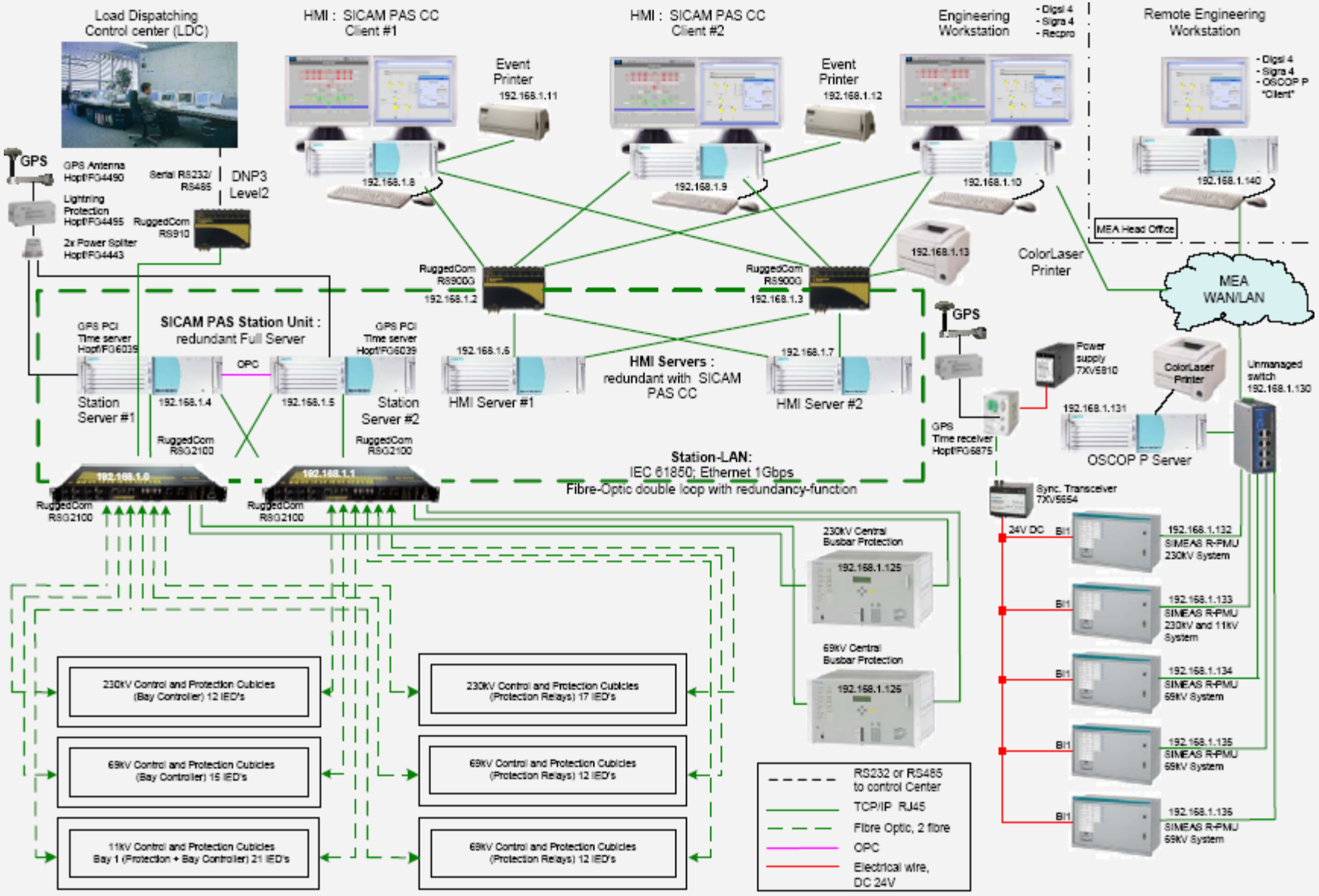
Substation Automation (SA)



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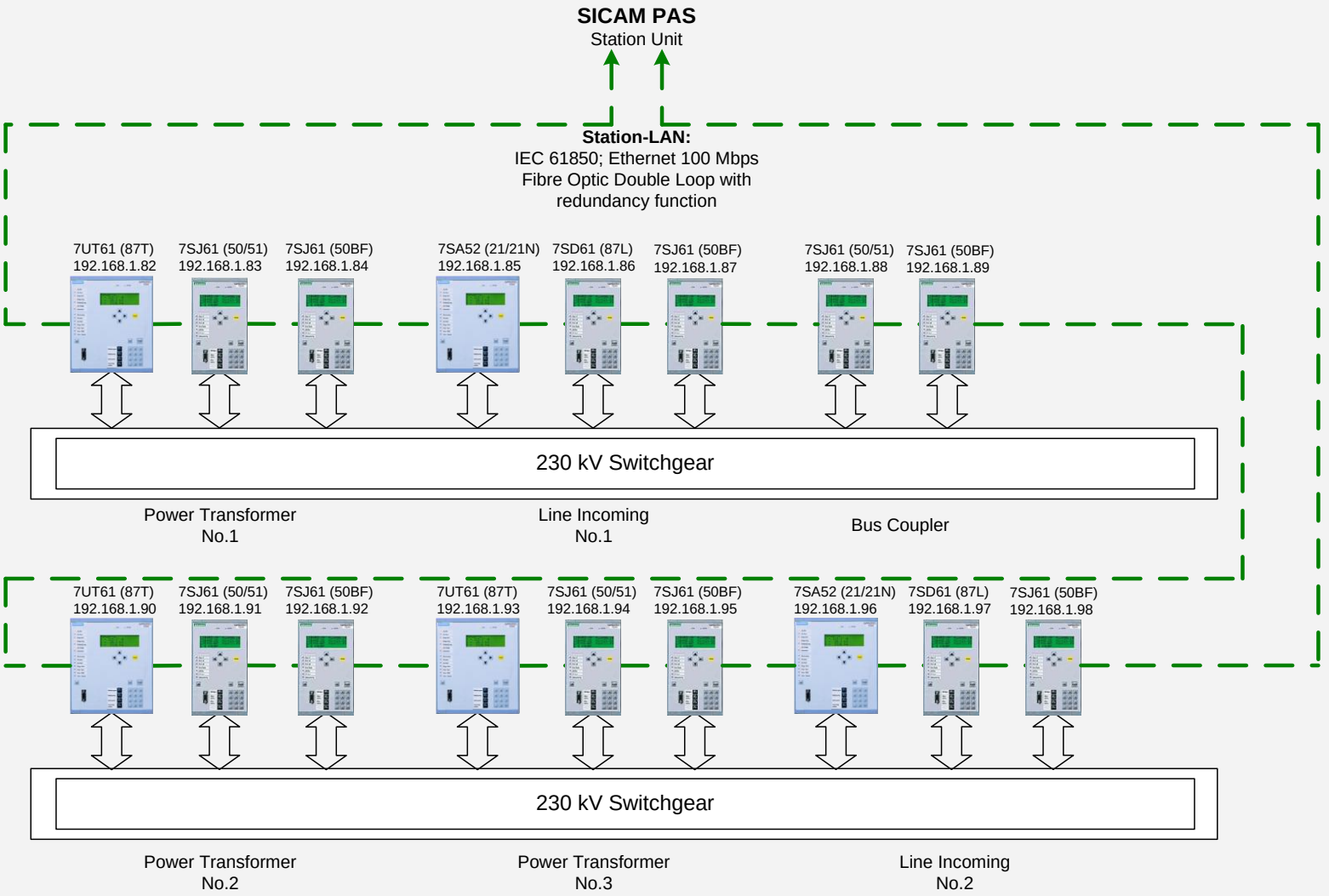
Substation Automation (SA)



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SA Physical Allocation

- **Station Level**
  - 2 Station Computers
  - 2 Man Machine Interface Servers
  - 2 Operator Man Machine Interface (HMI)
  - Engineering Work Station and Fault Evaluation System
  - Communication Gateway (CGW)
  - Time and Date Server (TDS)
  - Station LAN
  - Ethernet Switches
- **Bay Level**
  - Main and Backup Protection Relay (87L, 21, 87B, 87T, 67, 50/51,…)
  - Backup Protection (Breaker Failure Protection : 50BF)
  - Bay Control Unit (BCU)
- **Process Level**
  - Conventional Type CT/VT
  - Conventional Hardwire Connection

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Process Level: Hard Wiring

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SA Functions (1)

- **HMI and Related Station Level**
- **Operator or Control Functions**
- **Monitoring and Measurement**
- **Protection** (Main and Backup)
  - Line : 87L,21,67, 50BF,…
  - Busbar : 87B (Low impedance)
  - Transformer : 87, 50/51, 50/51N, 50BF
  - Feeder : 50/51, 50/51N, 50BF

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SA Functions (2)

- **Automatic Functions**
  - High Speed Automatic Transfer Scheme
  - Voltage Selection
  - Automatic Load Shedding
  - Automatic Load Restoration
  - Interlocking
  - Breaker Failure Protection
  - Rate-of-Change Calculations and Alarming for Selected Analog Input Variables
  - Heartbeat Function
  - Maintenance of TRIP Counters for Breakers
  - Breaker Operating Time Checks

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SA Functions (3)

- Local/Remote Control and Monitor
- Voltage and Var Control
- Trend Records
- Events, Alarm and Disturbance Records
- Fault Location

Implementation of SA Chidlom Terminal Station

Substation Automation Systems

Base on IEC 61850

Energized on May 09, 2009

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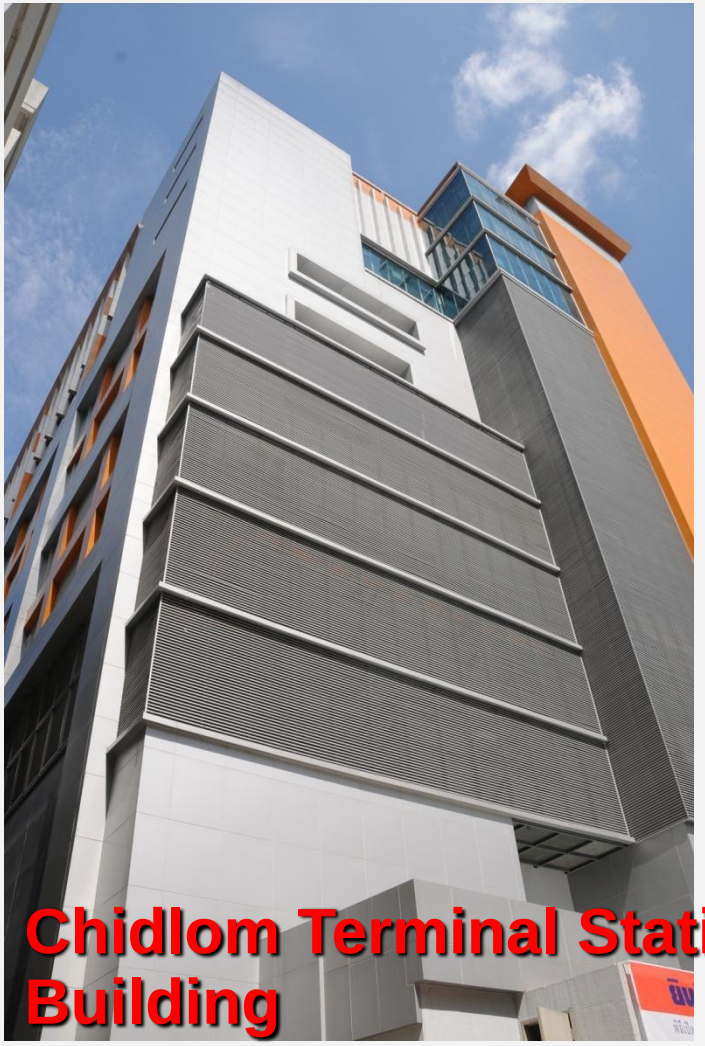
Indoor Type Substation



Chidlom Terminal Station Building

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Primary Equipment : 230kV GIS

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Transformer : 300 MVA

Primary Equipment : 69kV GIS

Primary Equipment : 24kV GIS

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Mimic Board and HMI

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Station Computers

Station Computers

- 2 Station Computers
- 2 Man Machine Interface Servers
- 2 Operator Man Machine Interface (MMI)
- Engineering Work Station
- Communication Gateway (CGW)
- Time and Date Server (TDS)
- Station LAN
- Ethernet Switches

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Bay Level : Relay & BCU Panel

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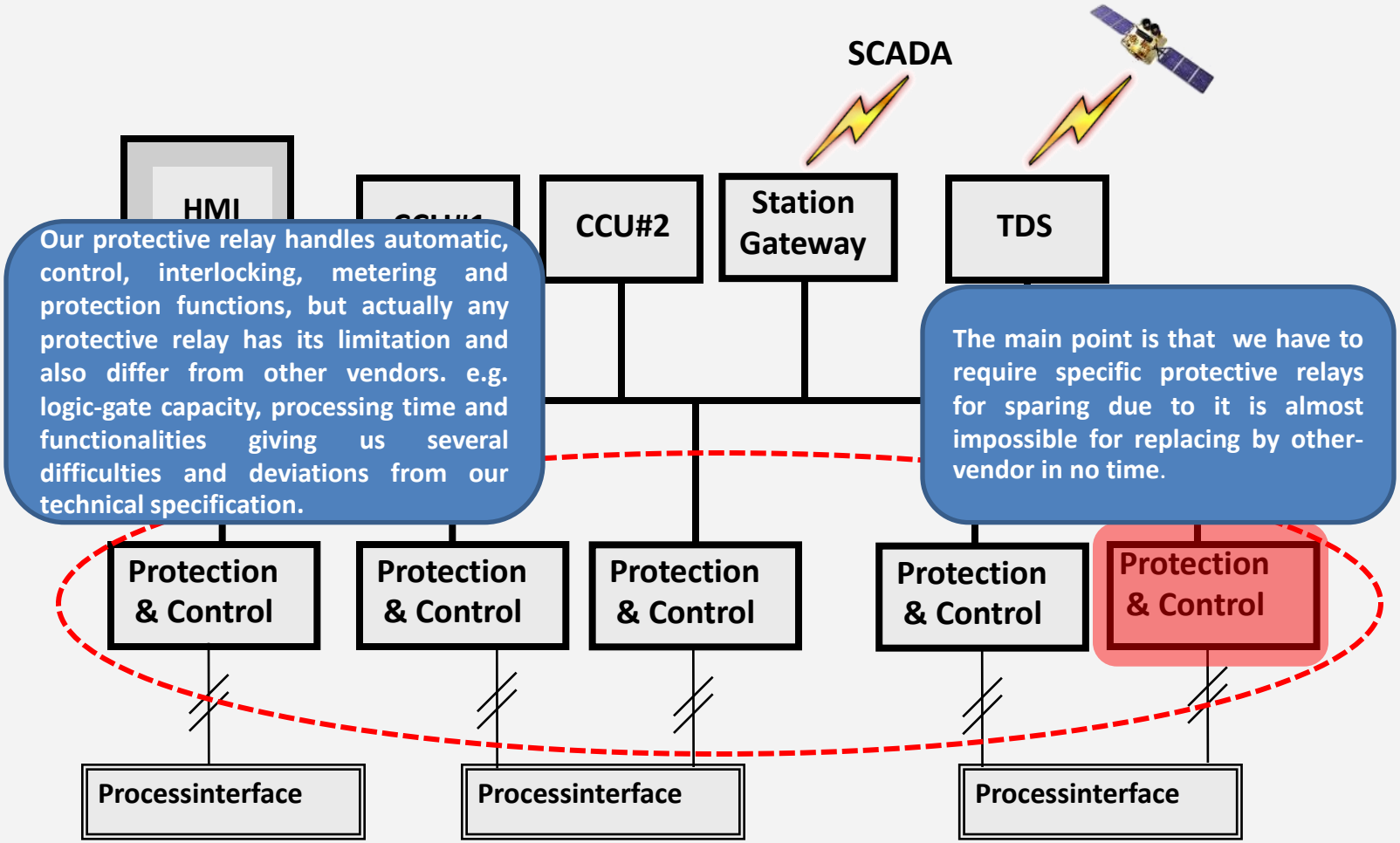
IEC61850 Experiences



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IEC61850 Experiences

- To maintain SA as easy as possible
  - easily changing a relay with the minimal time.
  - easily procuring a relay as spare from multi-vendors.
  - needing the minimal number of maintenance guys and knowledge for maintaining.
- Purposed Solutions
  - allocating the fewest functions to each device as much as possible.
  - purchasing size of a relay as small as possible. More bigger more difference of capabilities among vendors such as a number of reports , a number of logic gates , a number of CSWI , number of physical I/O . Consequently, in the case of the full capacity implementation of a relay, It may not be able to put all same functions of the relay to other relay of other vendor resulting in maintenance difficulties.
  - Preparing function compatible list (FCL) including configuration files for purchasing any spare relays

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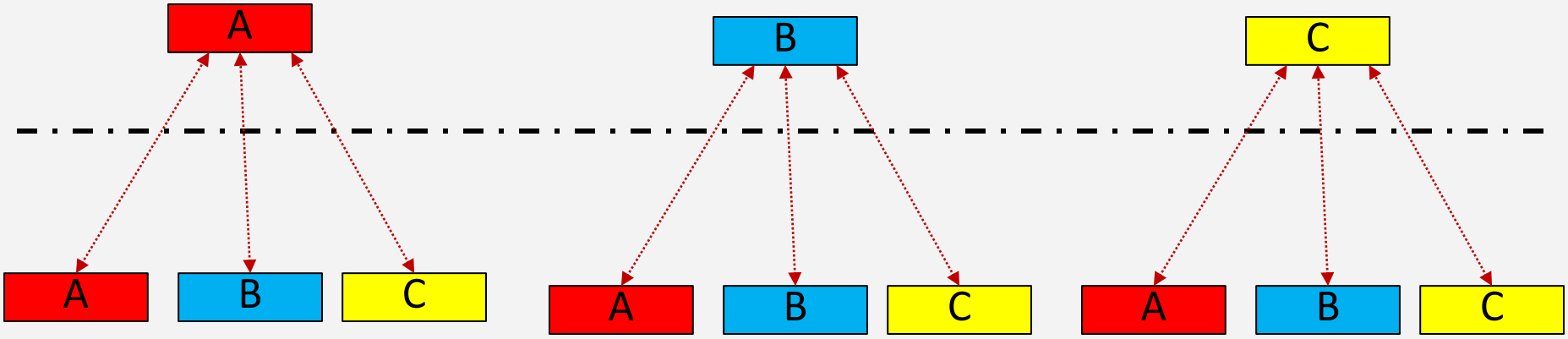
Function Compatible List (1)

Station Level



Bay Level

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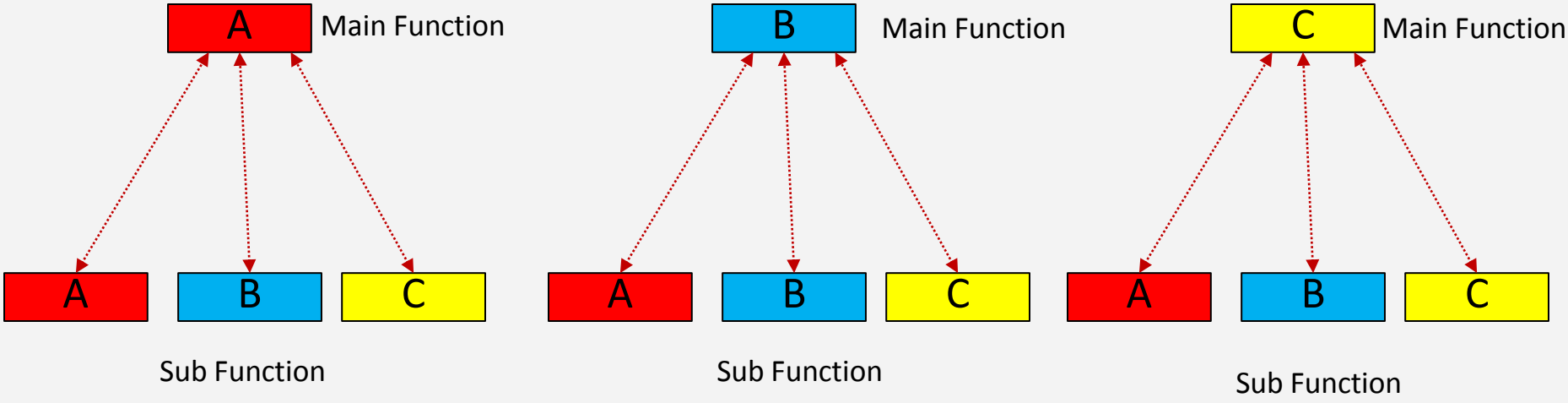
Function Compatible List (2)

Station Level



Bay Level

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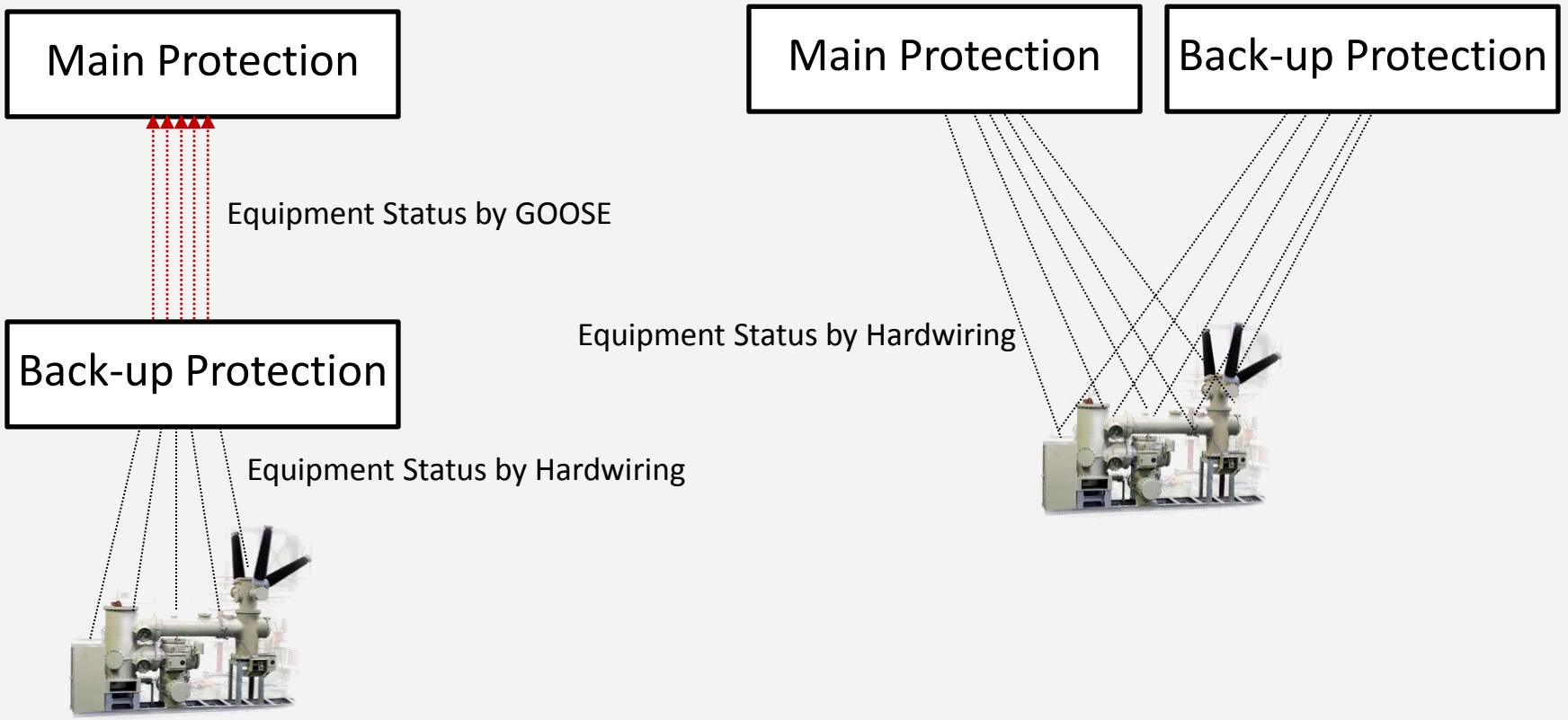
Number of Physical I/Os

Misunderstanding, proposed protective relays from a contractor may have not enough physical I/Os to support protection schemes with high reliability resulting in changing new protective relays and causing a project delay. During issue of the technical specification, MEA has found that one of the most important points is to specify minimal number of physical I/O of any protective relay to support the required functionality making bidders have the clearest view of what protective relays be proposed to MEA. Figure 2 shows two solutions that can do same functions, but they have different reliability level from serial and parallel arrangements.



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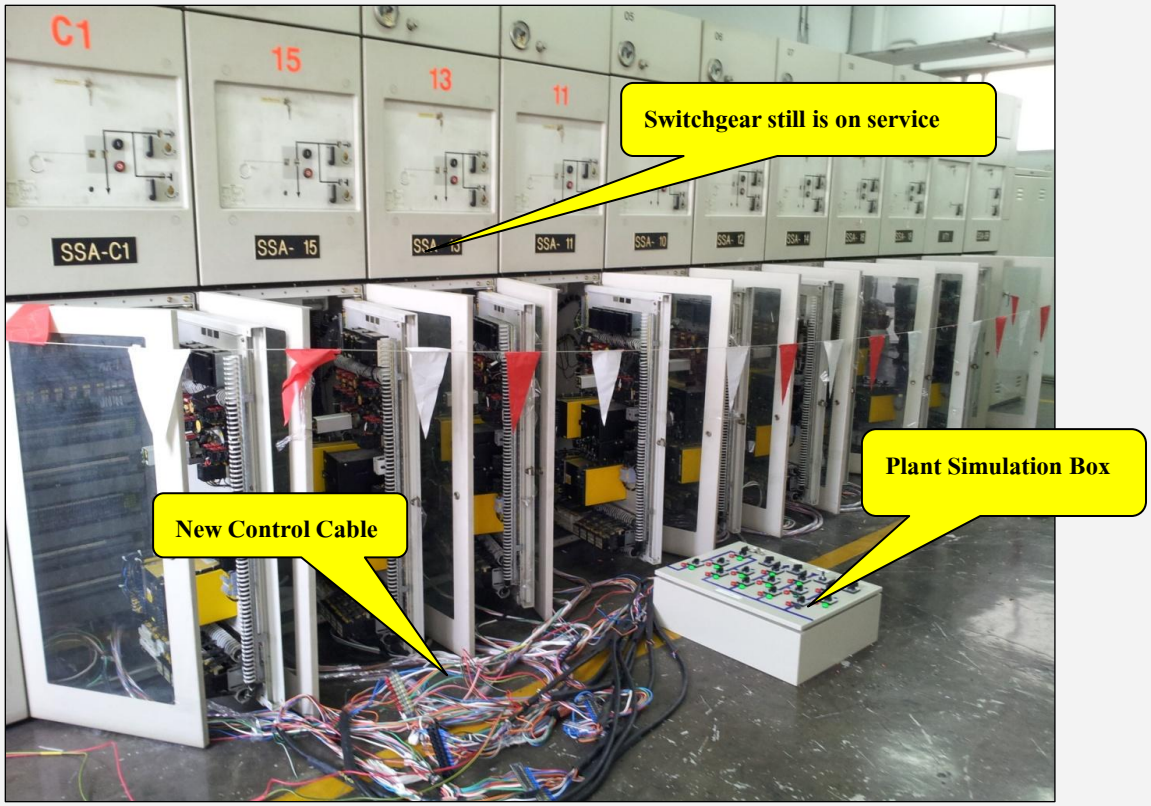
Sim Box

During the installation process of the SA devices in an existing substation, all the automatic, control and metering functions have to be tested to assure correct functioning when put in services. Due to shutdown time may be not long enough or difficult to fully perform all equipment tests causing project delay. Consequently, MEA has to use plant simulation boxes acting as substation equipments for testing all functions shown as Figure 4. Therefore the needed shutdown time of such substation is as short as the required time for checking equipment connections whether are correct



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Benefits (1)

- **Standardization**
- **Natural Resources Reduction with Modern Networking Technology**
- **Cost Reduction**
  - More Vender Competition
  - More Intelligence Functions
  - One Time Investment
- **Commissioning and Maintenance Time Saving**

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Benefits (2)

- **Open System Architecture**
  - Spare Parts Availability
  - Future Extension Convenience
- **Information support for system planning and system analysis**
- **Fully Automated Substation System**
- **Stability and Reliability for MEA Network Services**
- **Smart Substation to Support MEA future Smart Grid Project**

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Thank you for your attention.