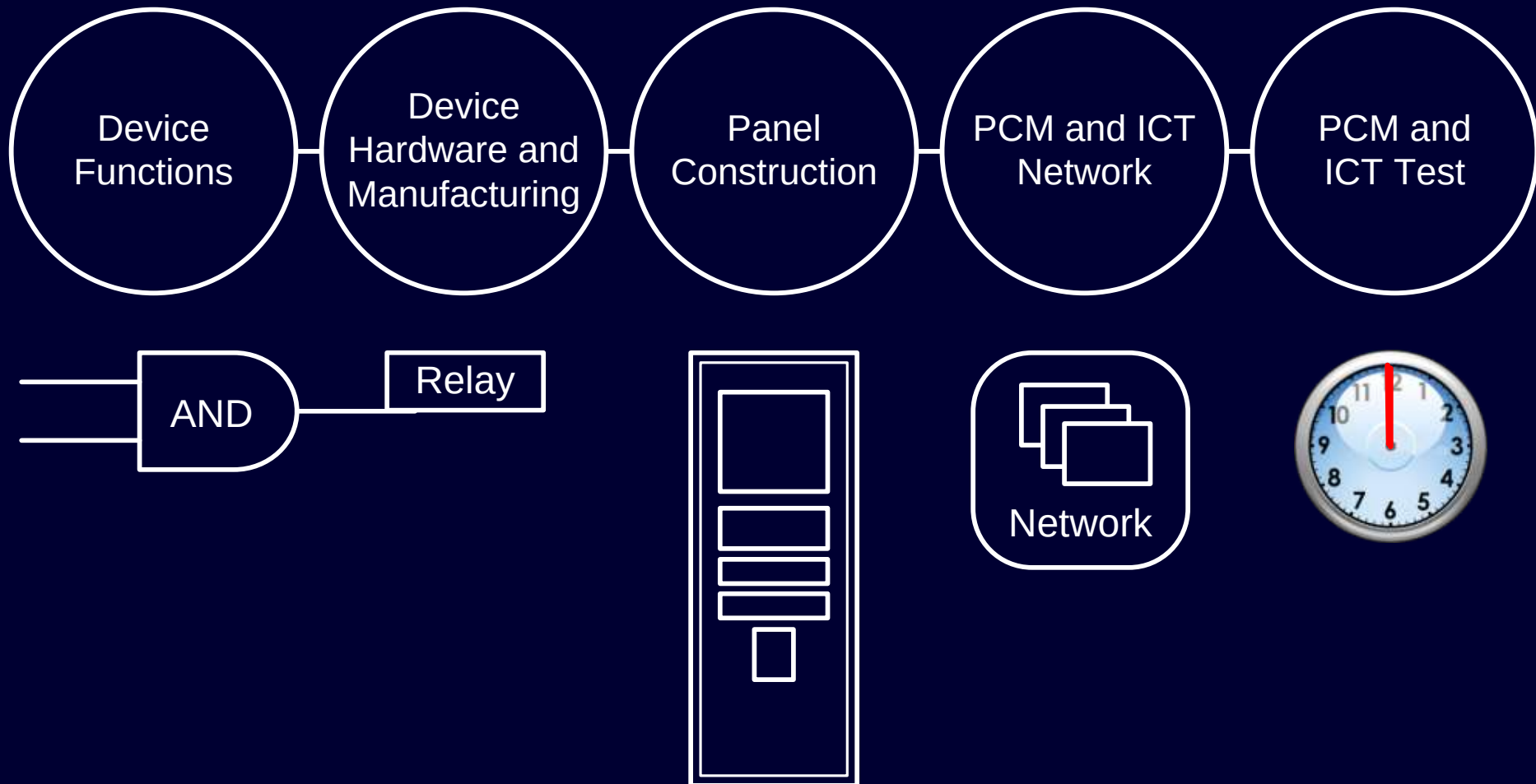


Collaboration Leads to Modular Protection and Control Solutions That Satisfy IEC Security and Dependability Requirements

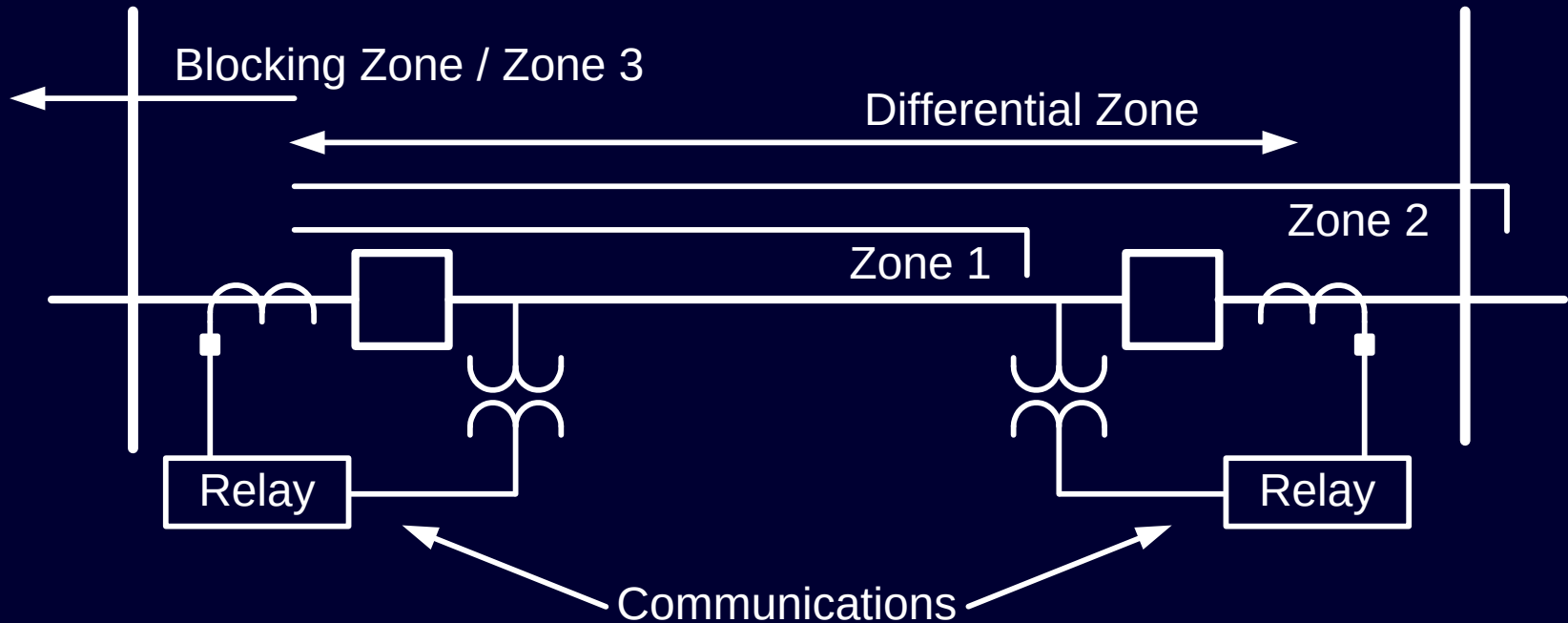
David Dolezilek and Fernando Ayello
Schweitzer Engineering Laboratories, Inc.

Collaborative Steps for Successful Protection, Control, and Monitoring



One of Several PCM Functions

Communications-Assisted Protection

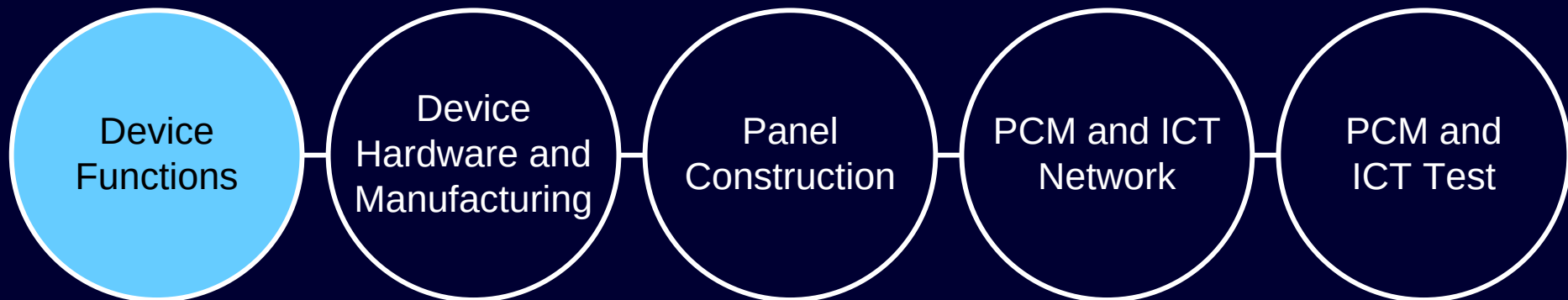
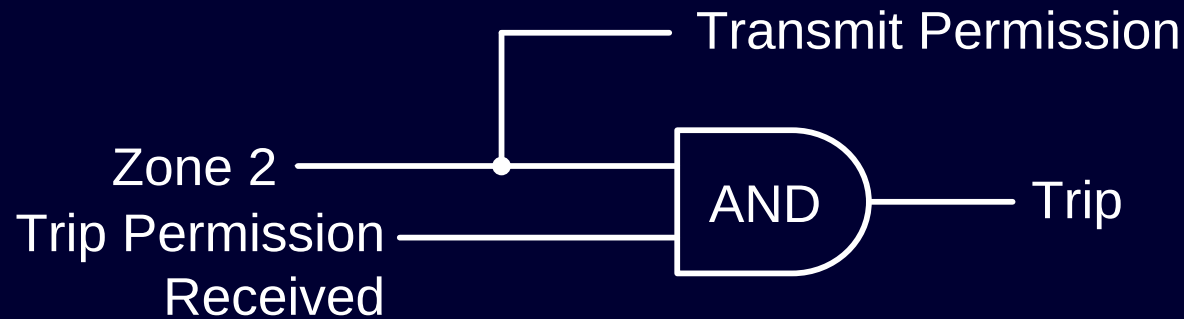


Message Delivery Performance Criteria Defined by International Standards

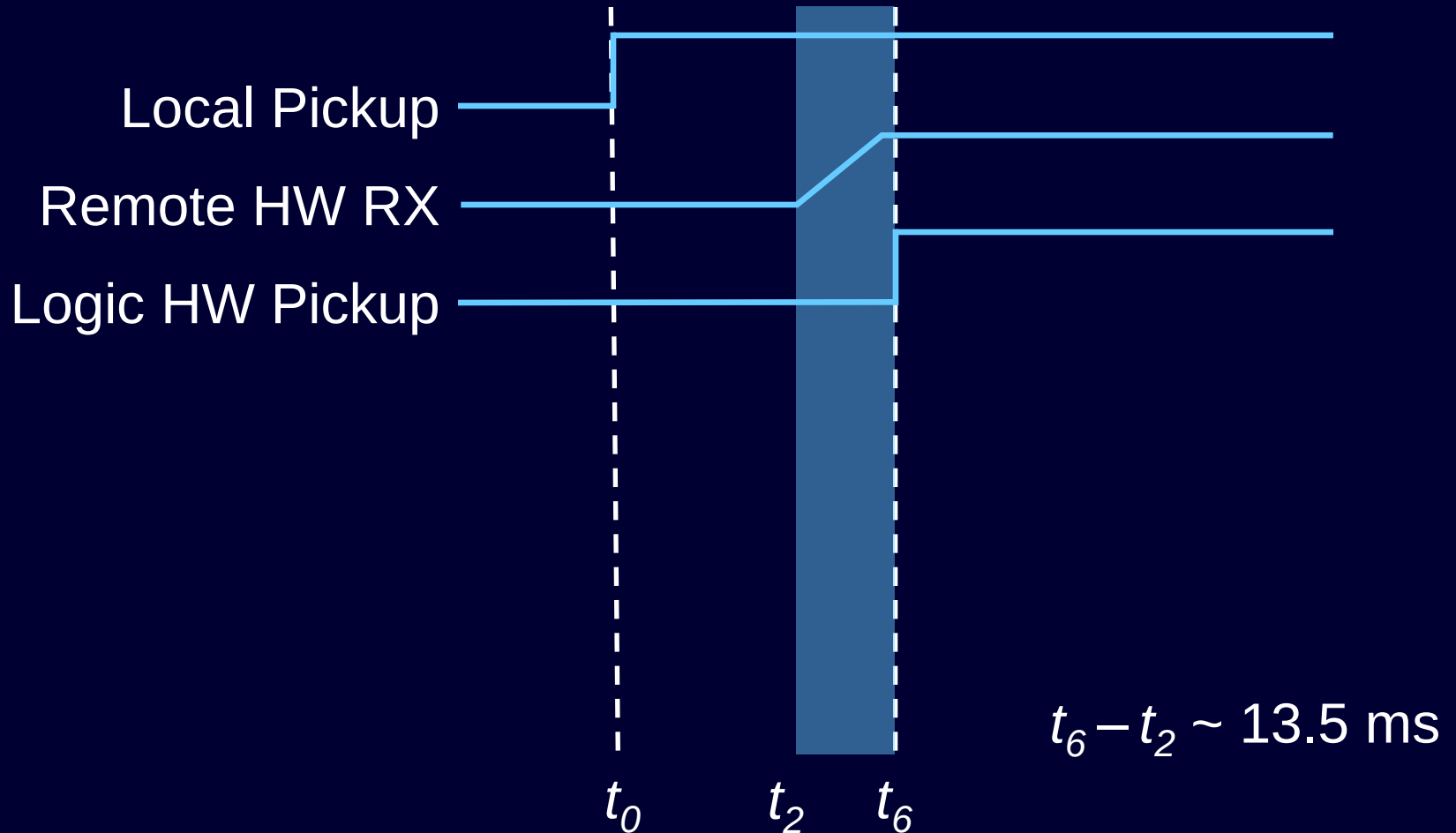
- IED **performance** requirements (IEC 61850, IEC 60834, ISO / IEC 15802, IEEE 802.1)
- **Latency** specifications (IEC 61850, IEC 60834, ISO / IEC 15802, IEEE 802.1)
- **Speed** (IEC 61850)

Logic Inputs and Outputs Become Digital Communications Signals

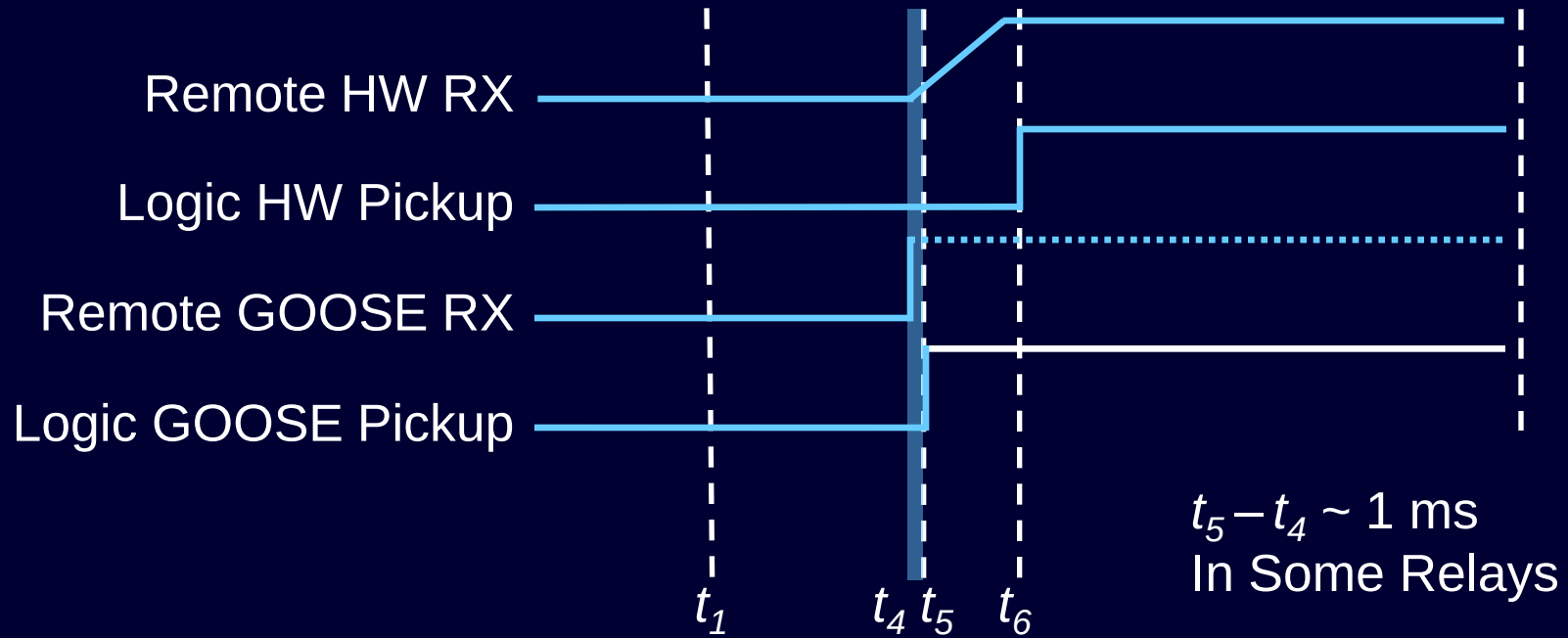
POTT Logic



Hard-Wired Signal Pickup Detected After Voltage Rise, Filter, and Debounce



Logic GOOSE Pickup Based on Message, Not Voltage



Device
Functions

Device
Hardware and
Manufacturing

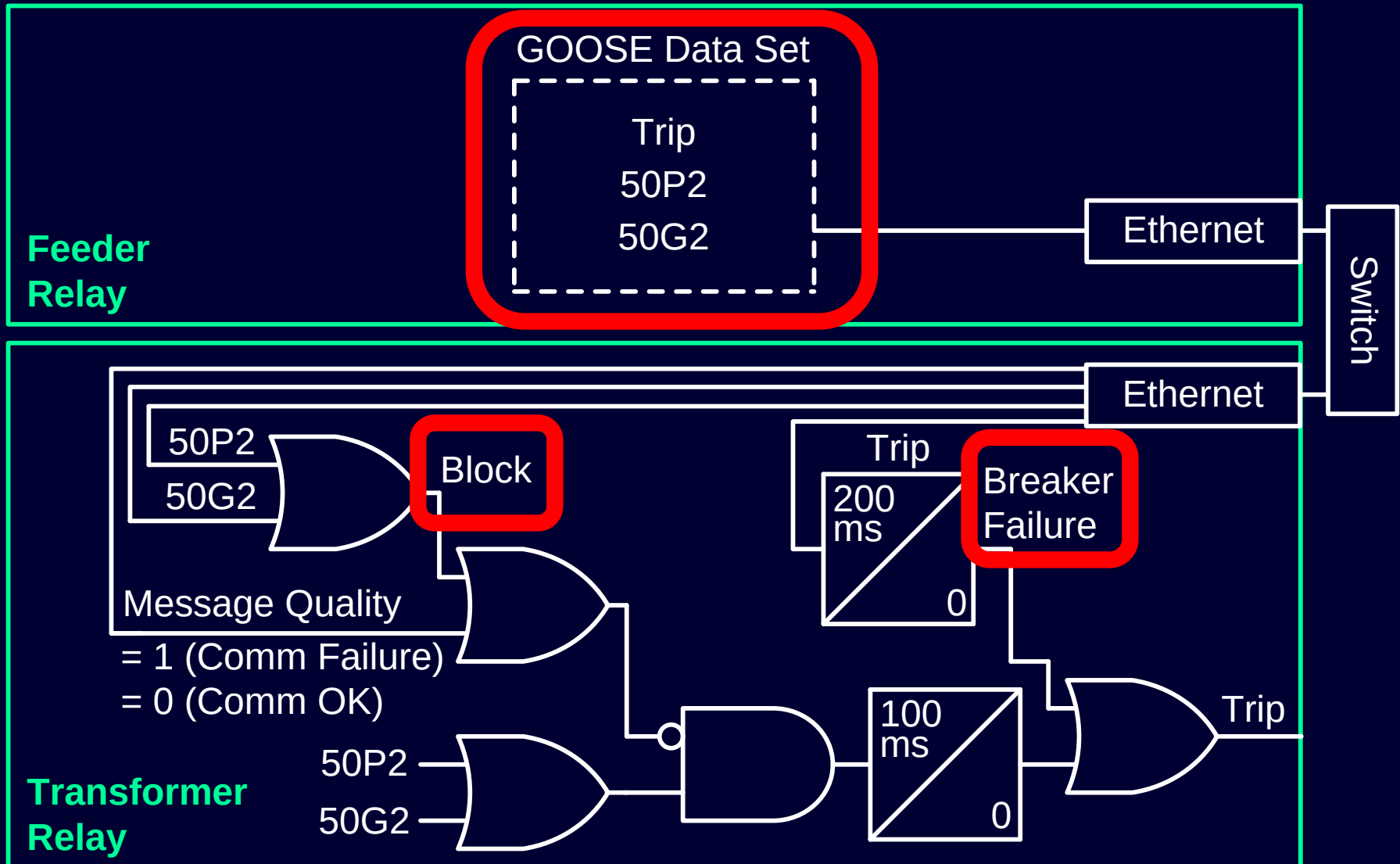
Panel
Construction

PCM and ICT
Network

PCM and
ICT Test

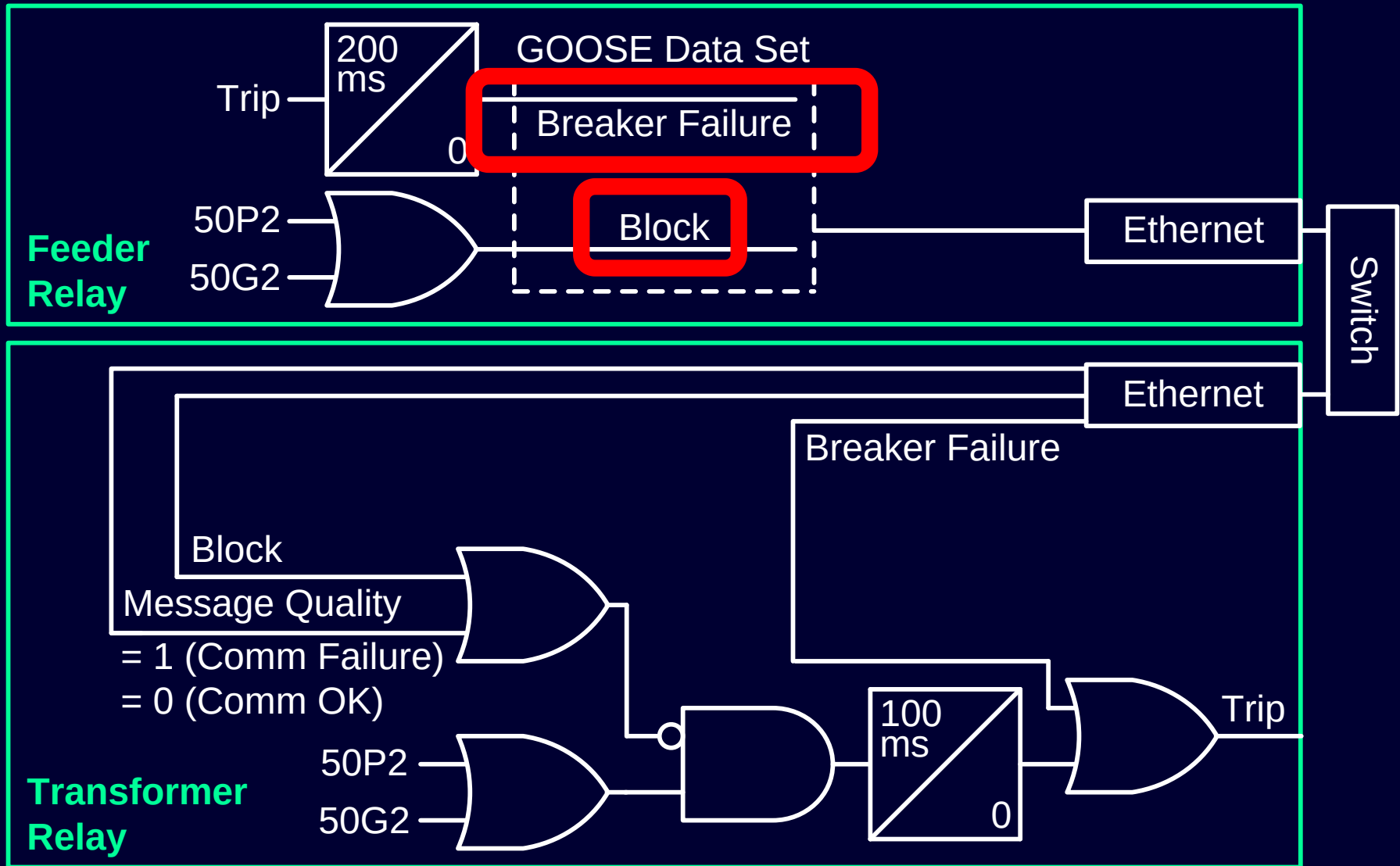
Bus Relay Breaker Failure Logic

Feeder Publish Status



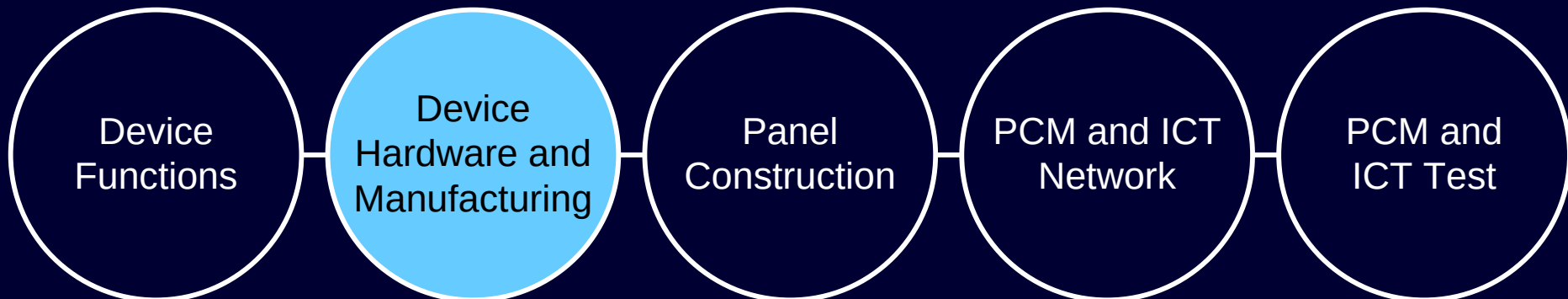
Bus Relay Breaker Failure Logic

Feeder Publish Information



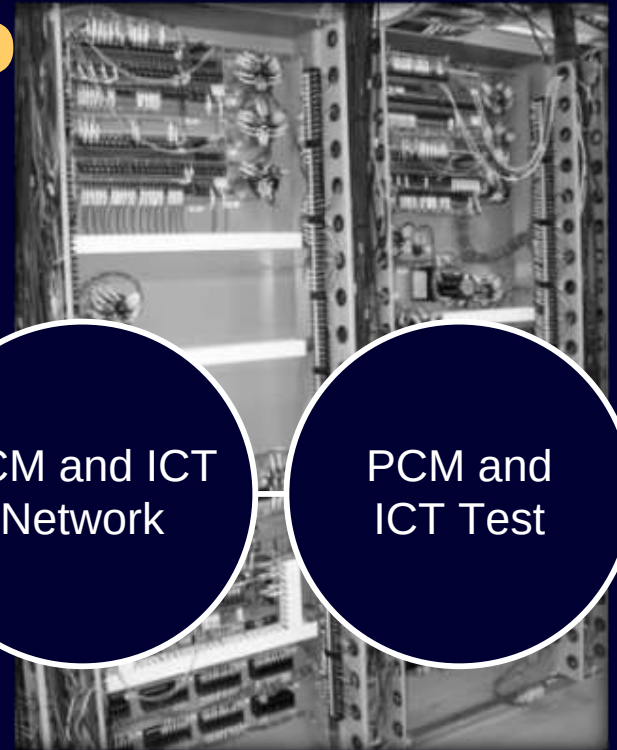
Device Performance Criteria Defined by International Standards

- Dependability and security requirements (IEC 61850, IEC 60834)
- Availability requirements (IEC 61850, IEC 60834, IEEE 802.1)
- Reliability metrics (IEC 61850, IEEE 1613, IEC 60870)



Traditional Approach

44 Wires



Traditional Approach

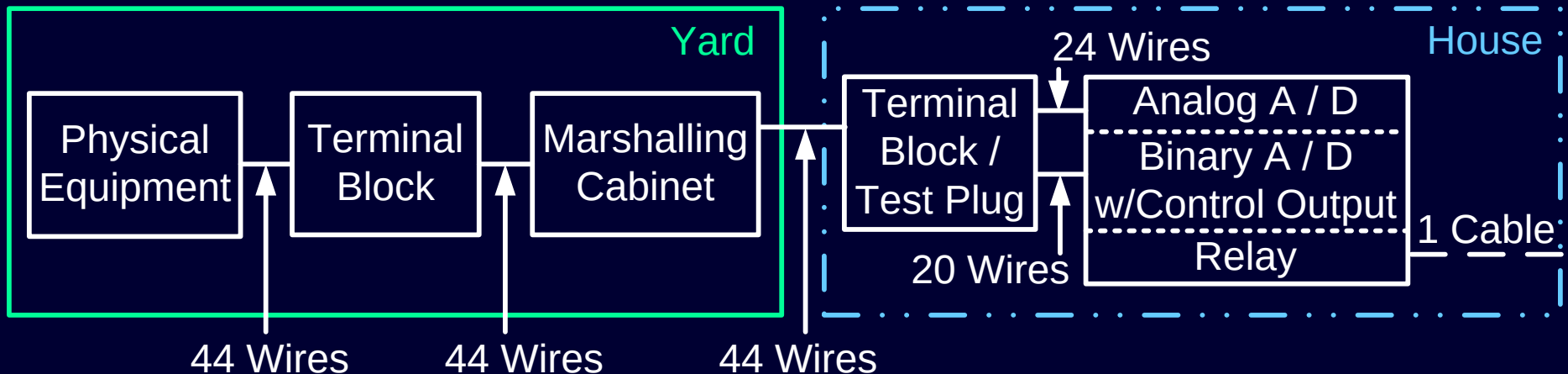
Device
Functions

Device
Hardware and
Manufacturing

Panel
Construction

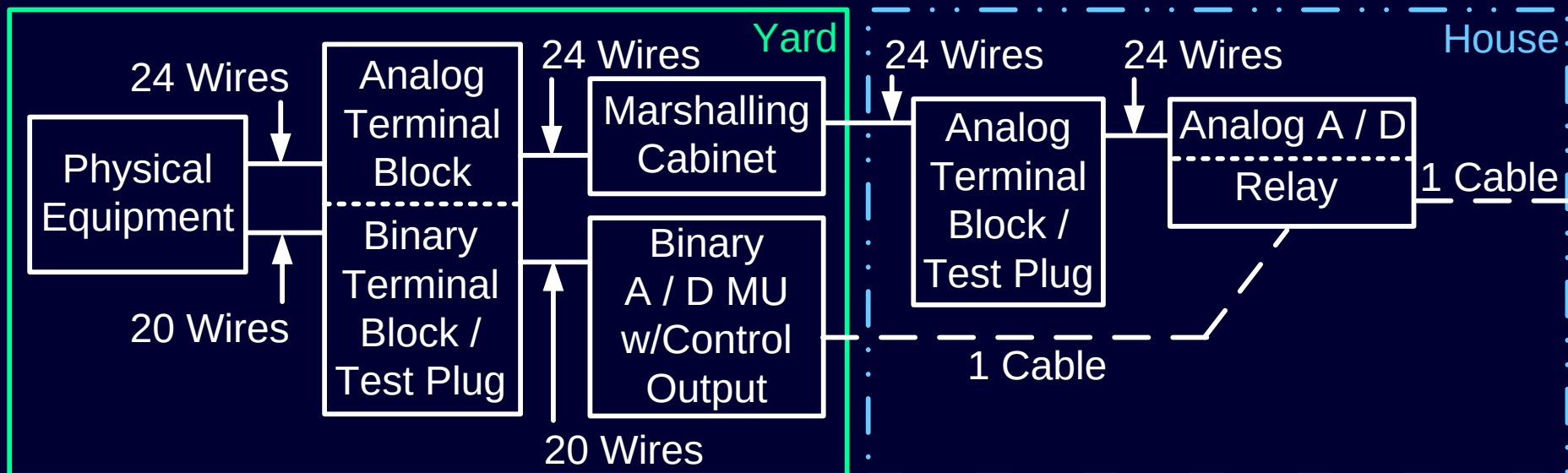
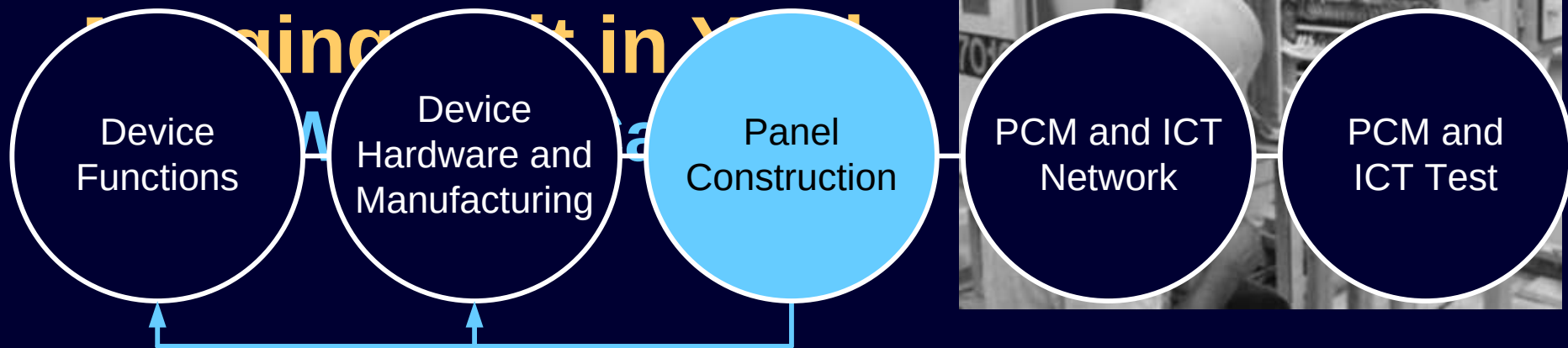
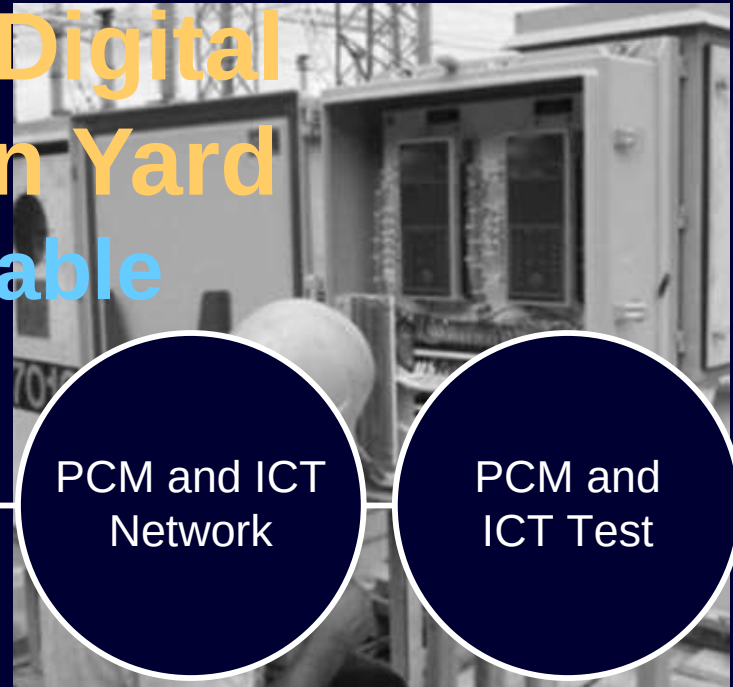
PCM and ICT
Network

PCM and
ICT Test

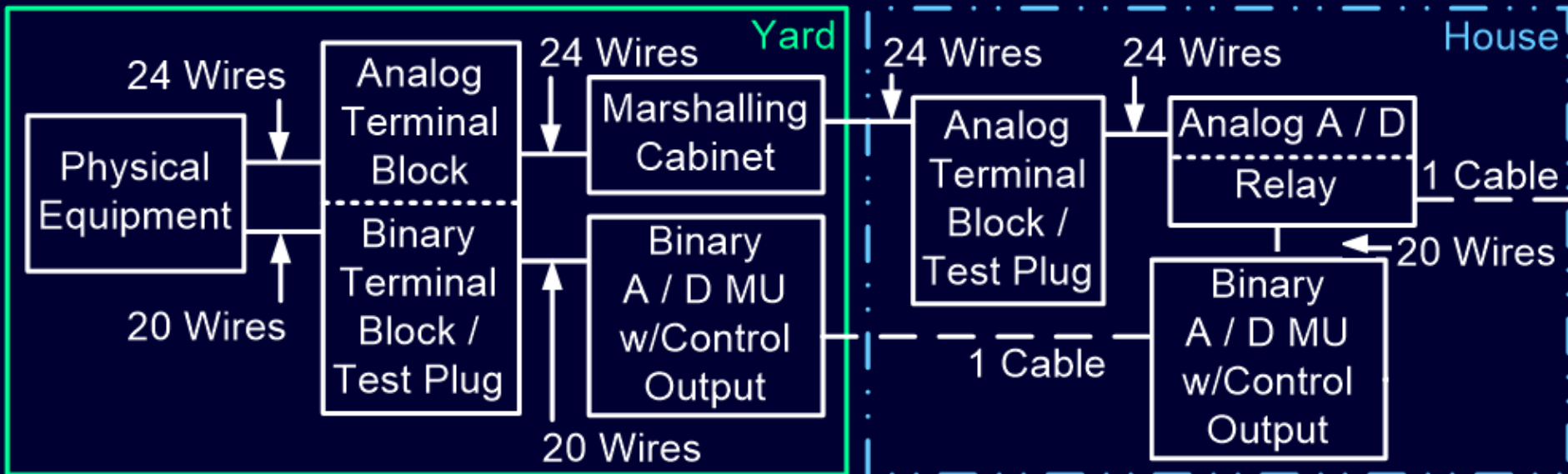
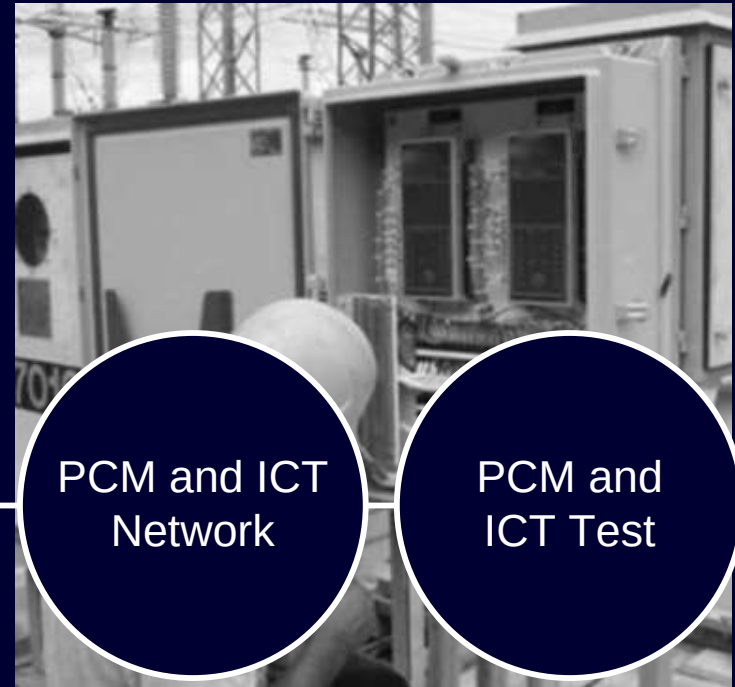
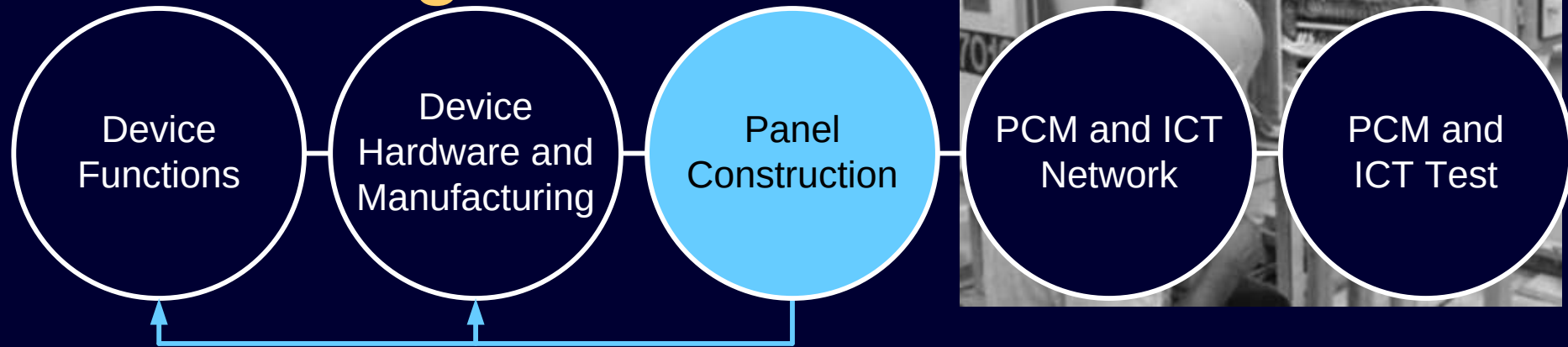


Binary I/O Via Digital Merging Unit in Yard

Binary I/O Via Digital Cable

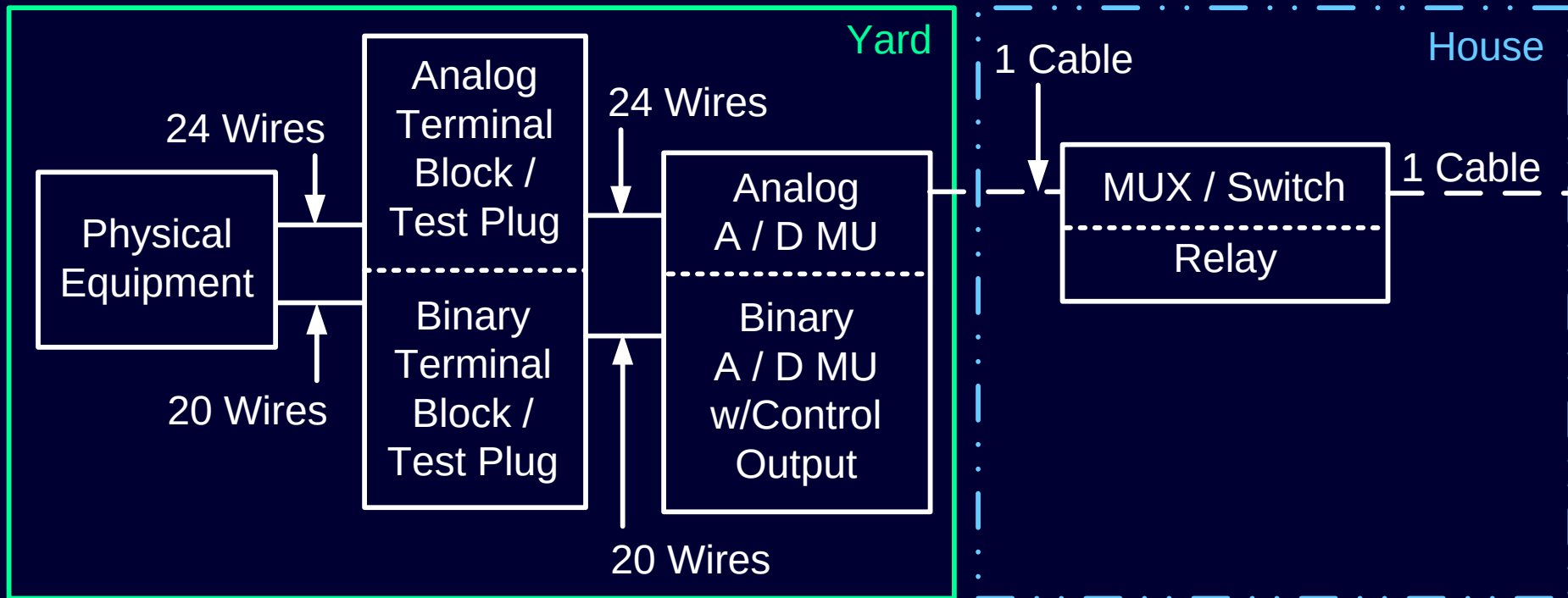


Binary I/O Via Two Digital Merging Units – Existing Methods



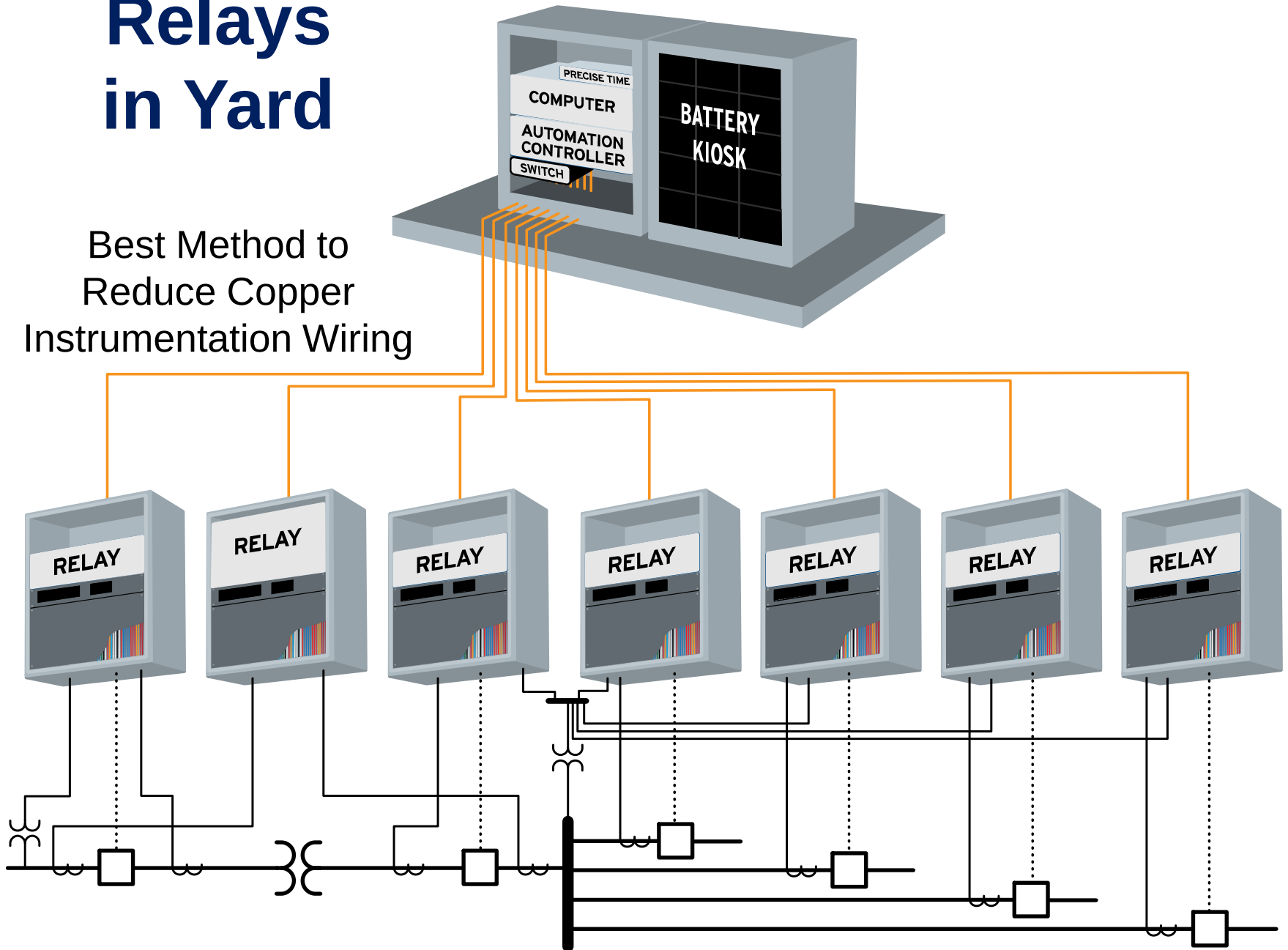
All I/O Via Merging Unit in Yard

0 Wires, 1 Cable

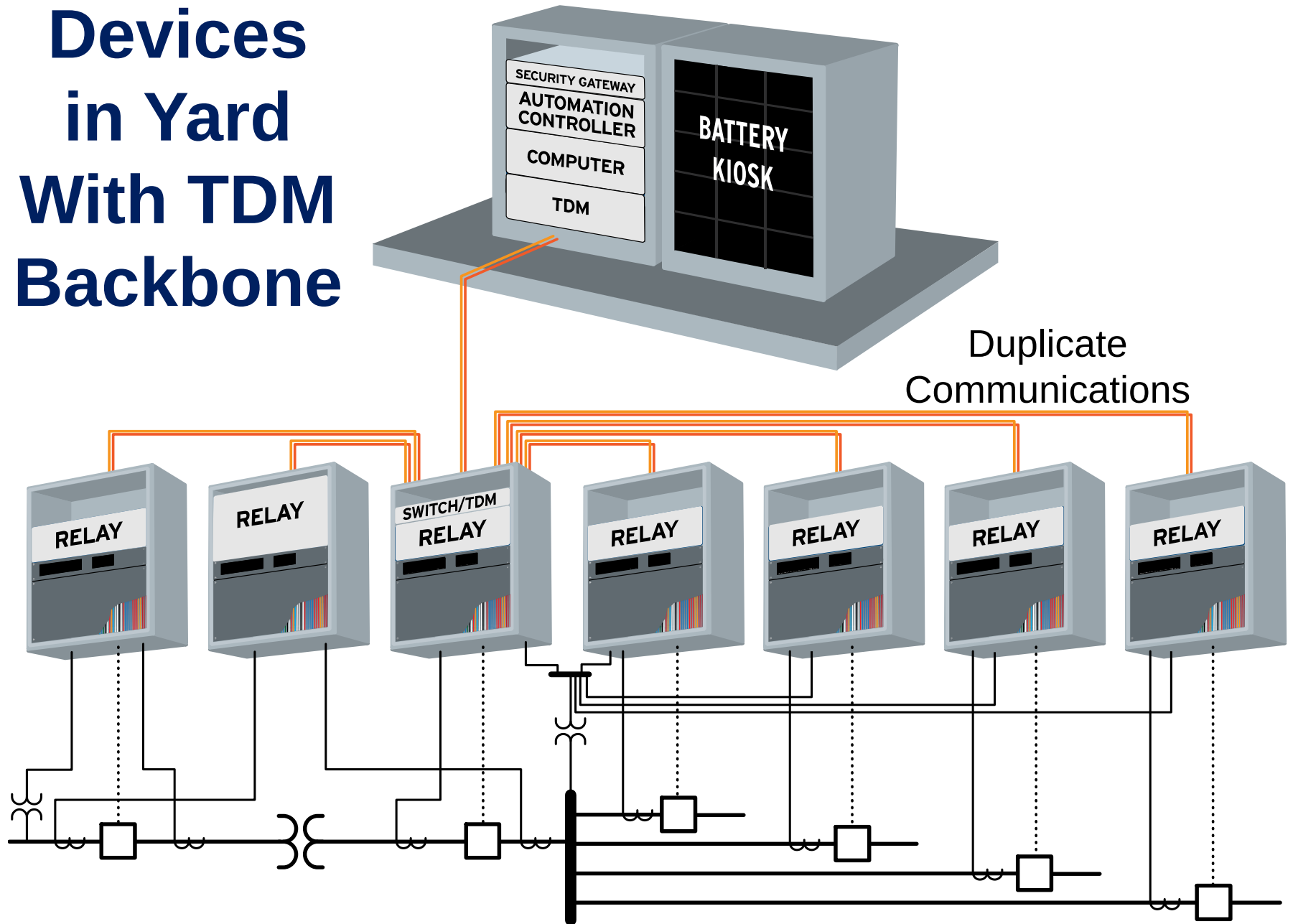


Relays in Yard

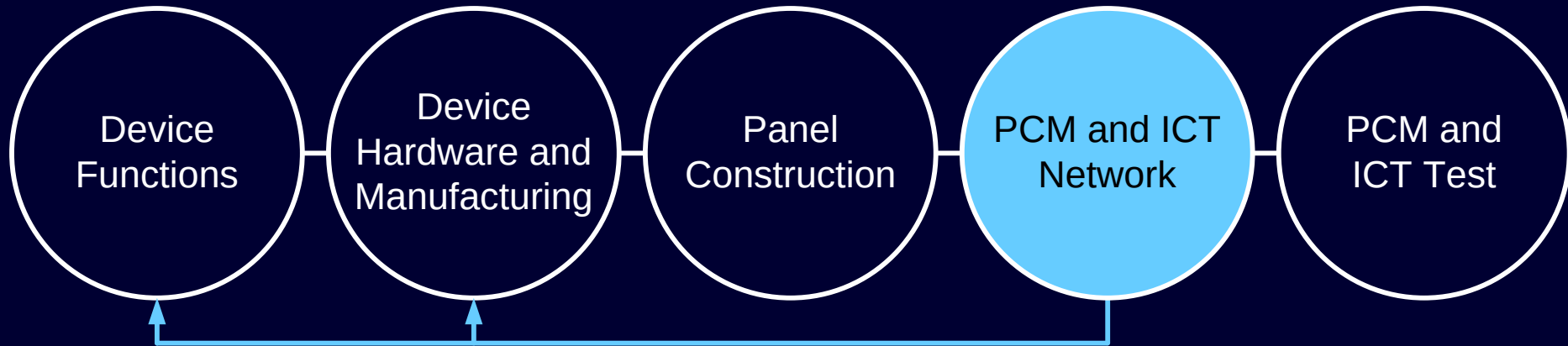
Best Method to
Reduce Copper
Instrumentation Wiring



Devices in Yard With TDM Backbone



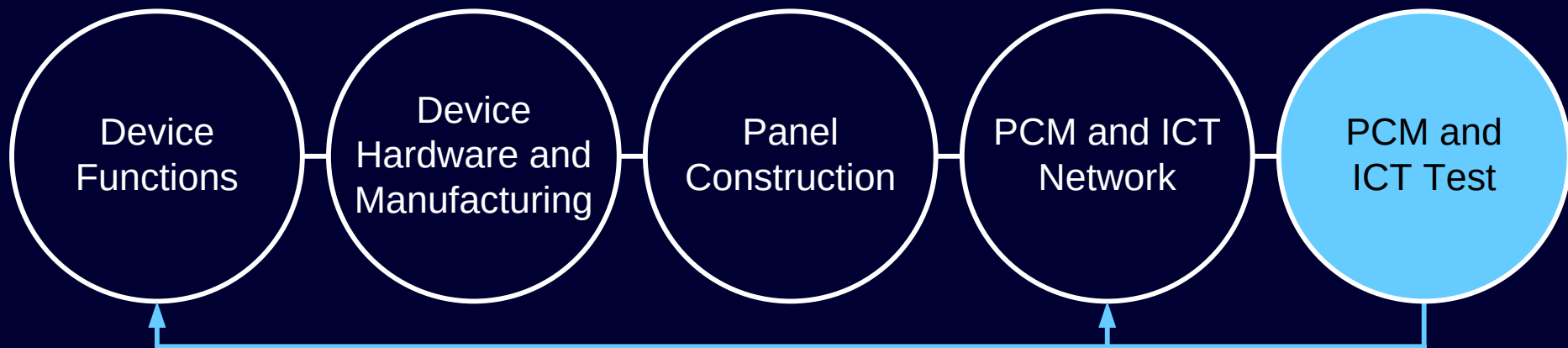
Collaborative Steps Identify Features and New Network Devices



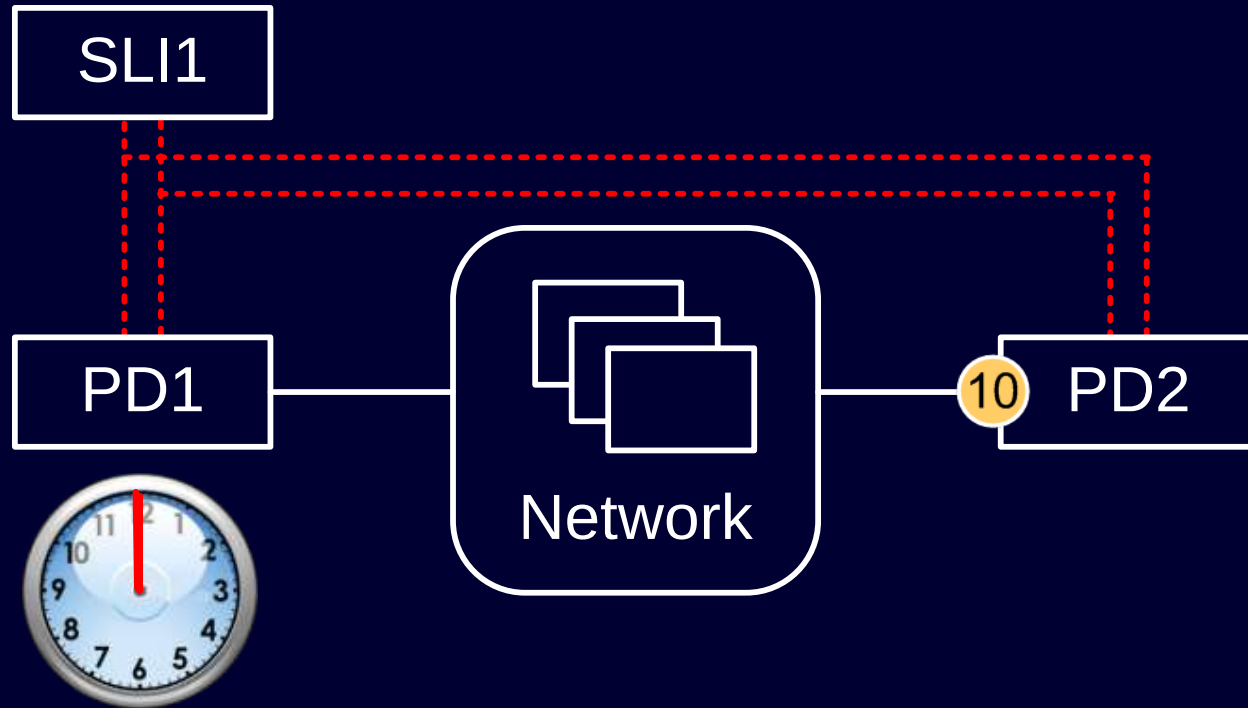
ANSI / IEEE C37.2 protective device function numbering

- 16 – data communications device
- 21 – distance relay
- 51 – ac inverse-time overcurrent relay

Standards Define Required Testing



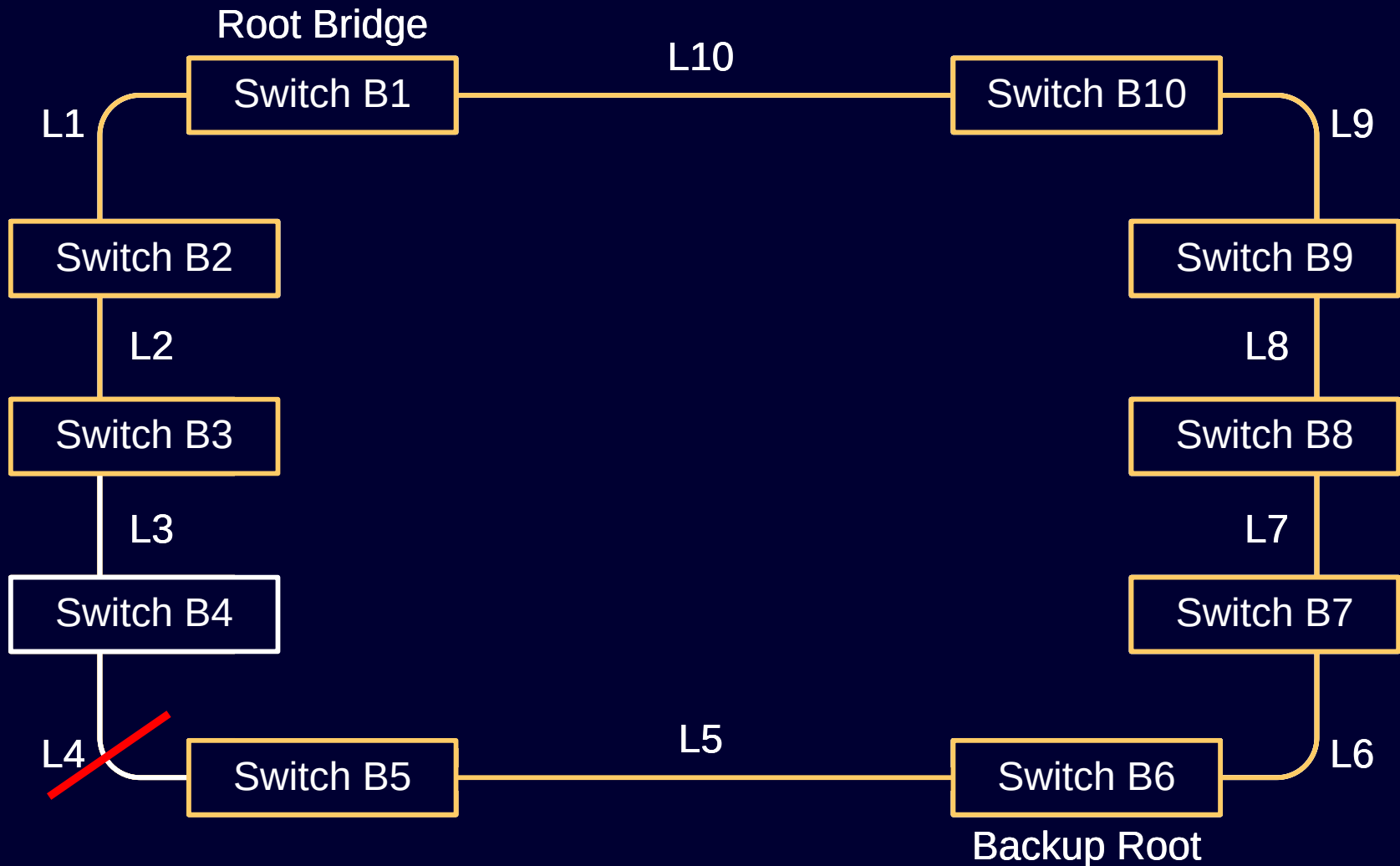
Verify Times for Signal Exchange Triggered by Contact Input



— · — IRIG-B
- - - - - Wiring
—— Ethernet

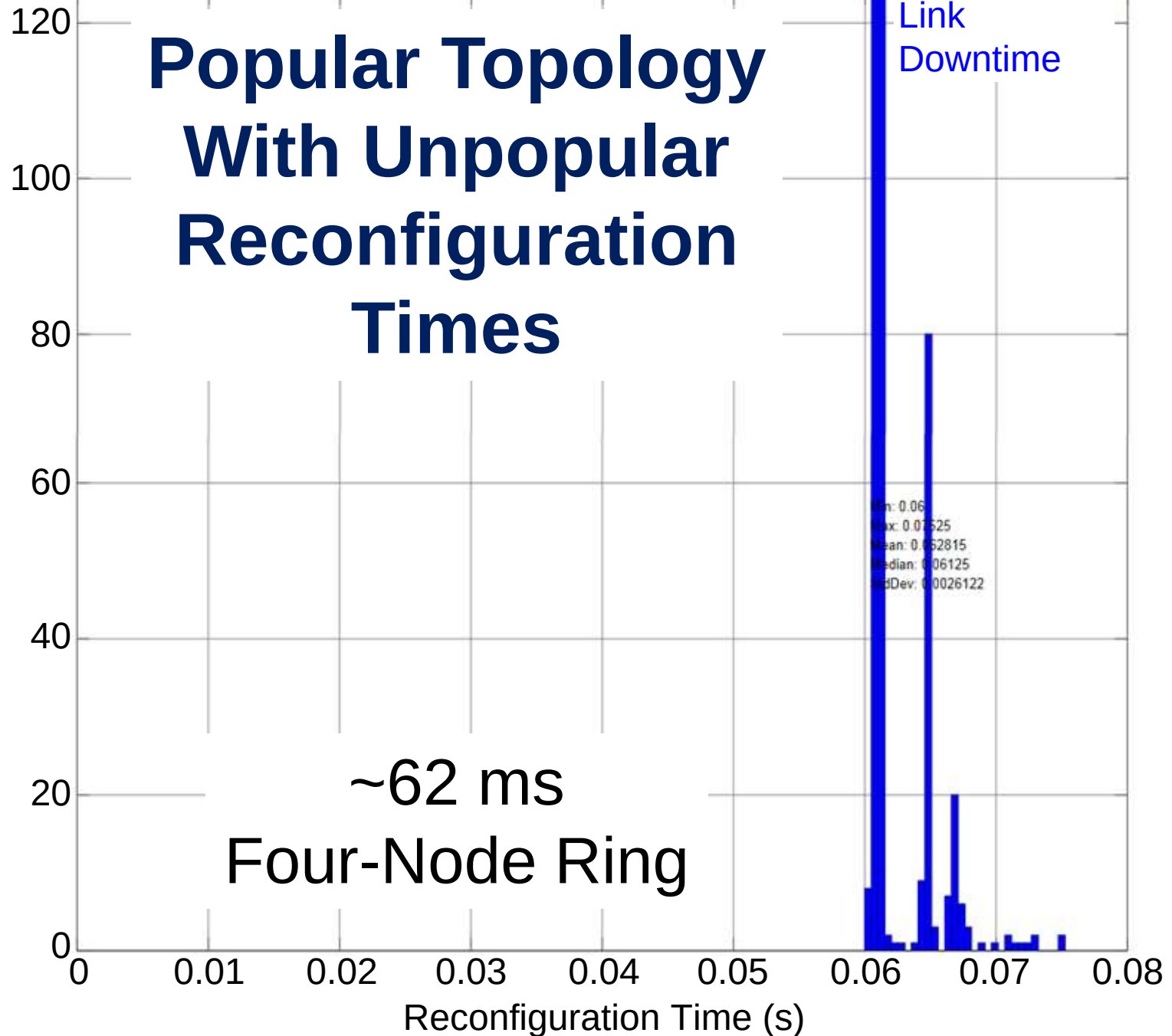
PD = Physical Device
SLI = Synchronized Logic IED

Sample Ring Test Topology

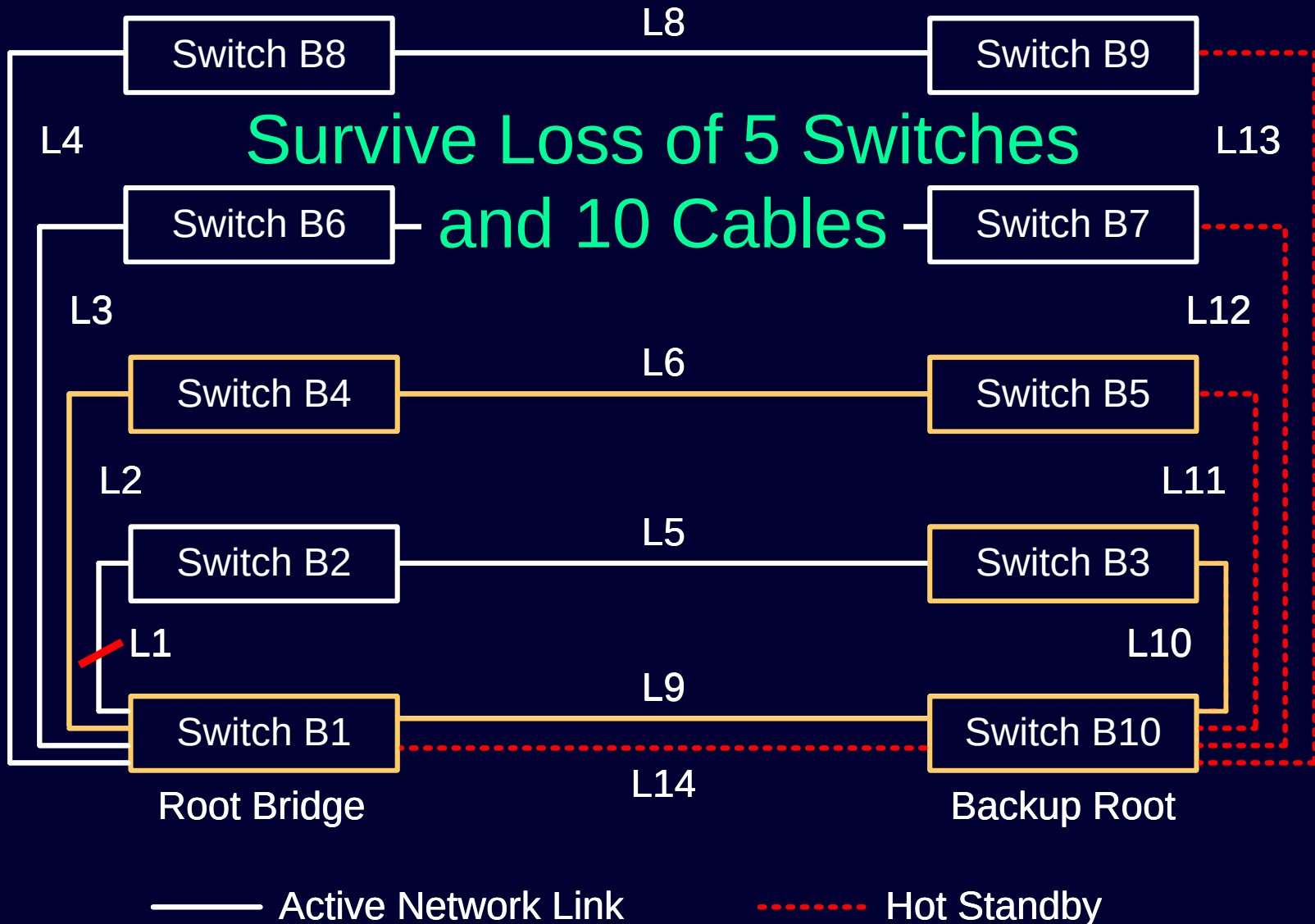


Popular Topology With Unpopular Reconfiguration Times

Samples

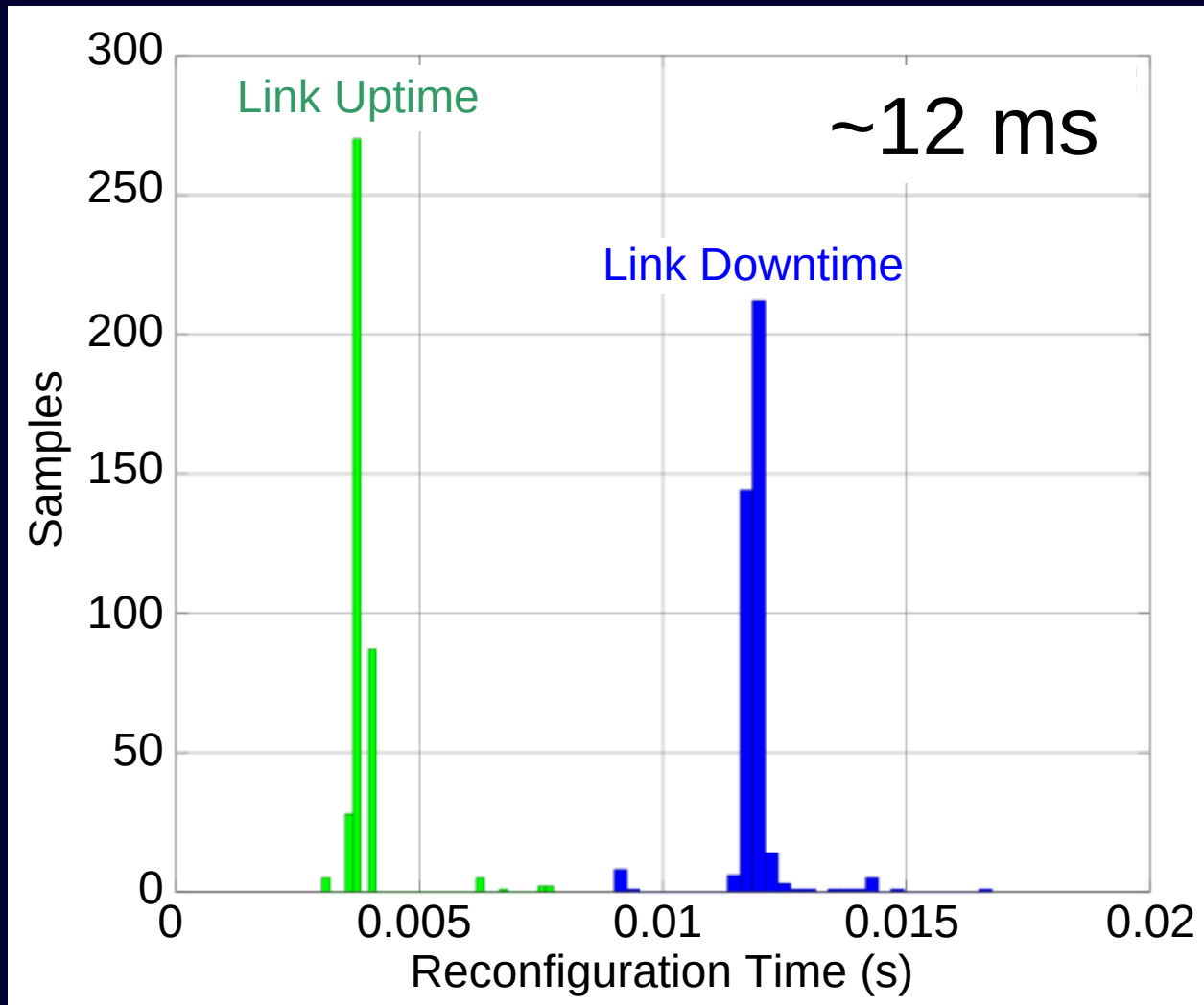


Sample Ladder Test Topology

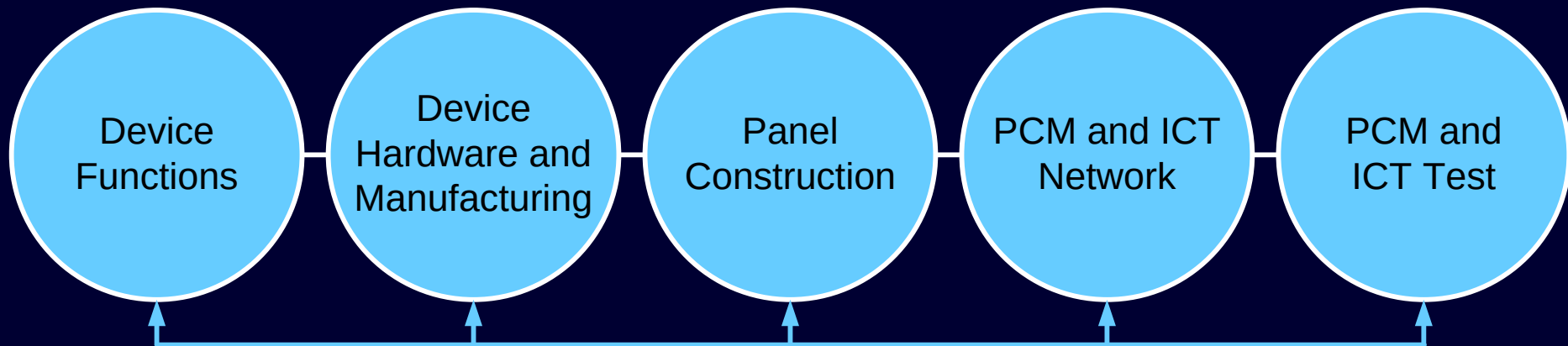


Ladder Tests Prove Fast Reconfiguration

10-Node Ladder



Collaboration Creates Specifications, Solutions Based on IEC Standards

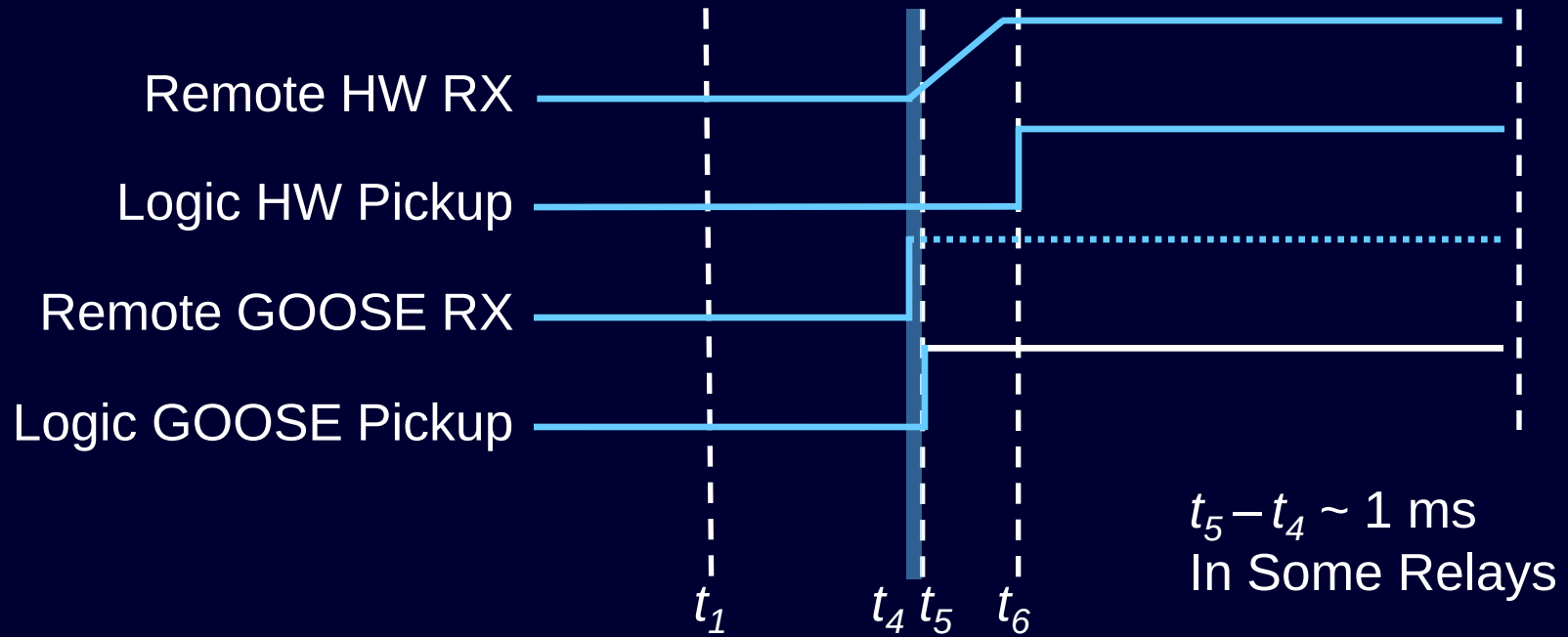


Specification	Standard			
	IEC 61850	IEC 60834	IEC 15802	IEEE 802.1
Signal latency < 3 ms 99.99% of time	✓	✓	✓	✓
Signal latency < 18 ms remaining 0.01% of time	✓	✓	✓	✓
Reconfiguration < 15 ms always	✓	✓		✓
Unique MAC and VLAN ID per message	✓			✓
Immediate reaction to GOOSE receipt by IED	✓			
Zero dropped GOOSE every 24 hours	✓	✓		
Fewer than 9 extra messages every 24 hours	✓	✓		
High availability via high MTBF devices	✓	✓		

Case Study: Increasing Reliability, Dependability, and Security of Digital Signals via Redundancy and Supervision

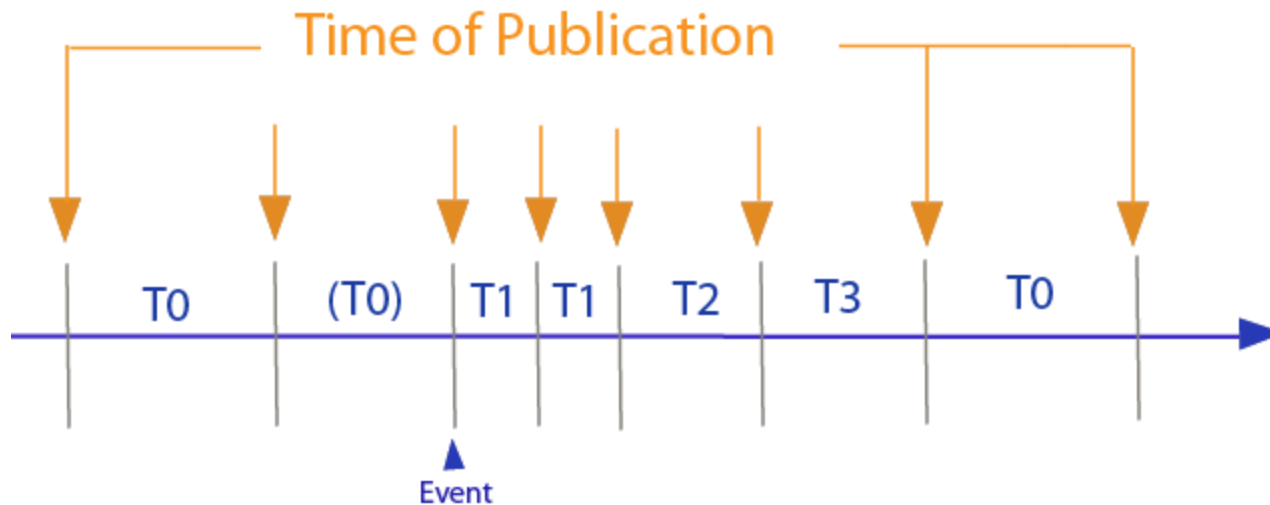
P. Franco, G. Rocha, and D. Dolezilek
Schweitzer Engineering Laboratories, Inc.

Logic GOOSE Pickup Based on Message, Not Voltage

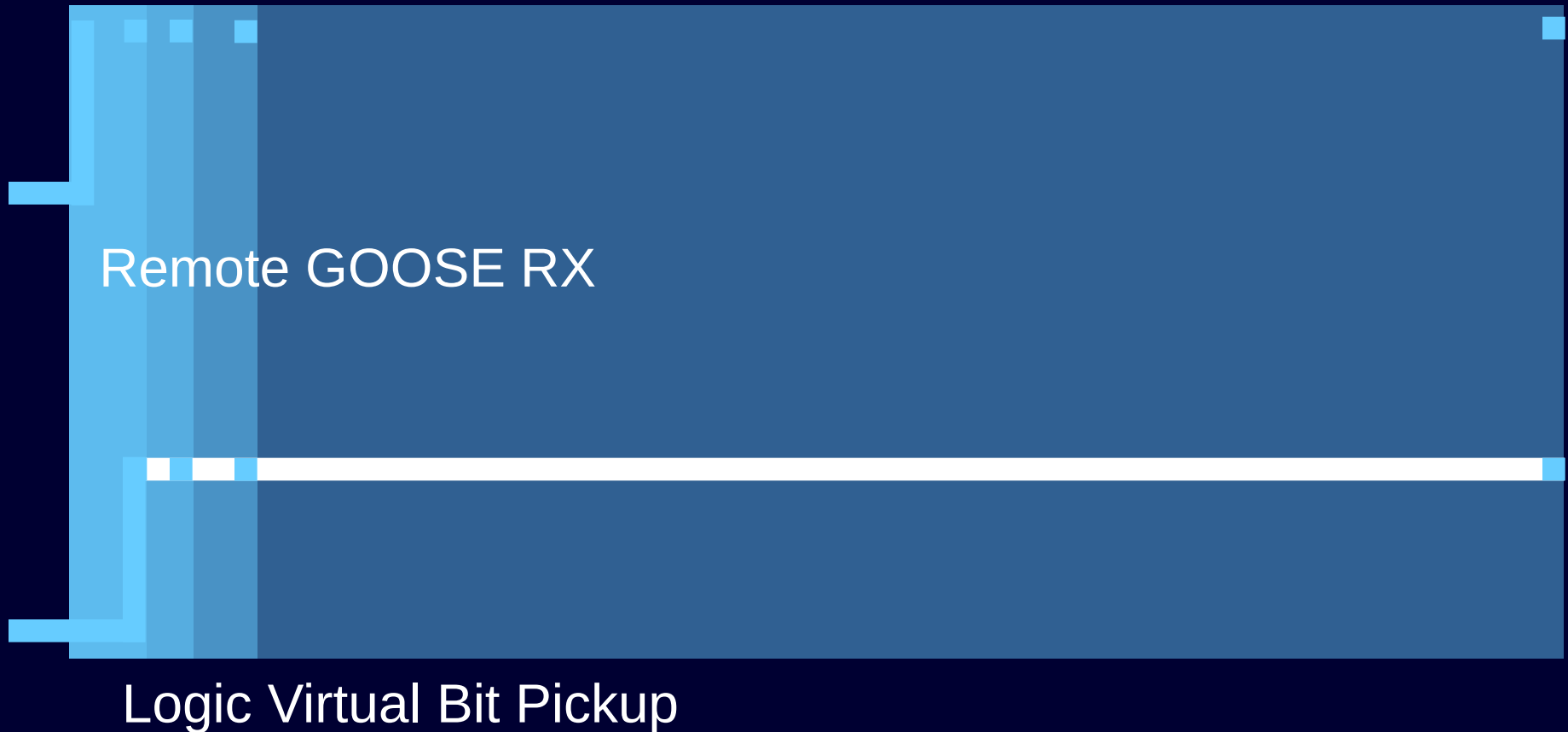


Publisher to Subscribers “Expect to Hear From Me in x msec or Sooner”

- Publishers increment “sequence” the calculate and report time to live (ttl) with data set
- Ttl informs subscriber duration data will be “known good”



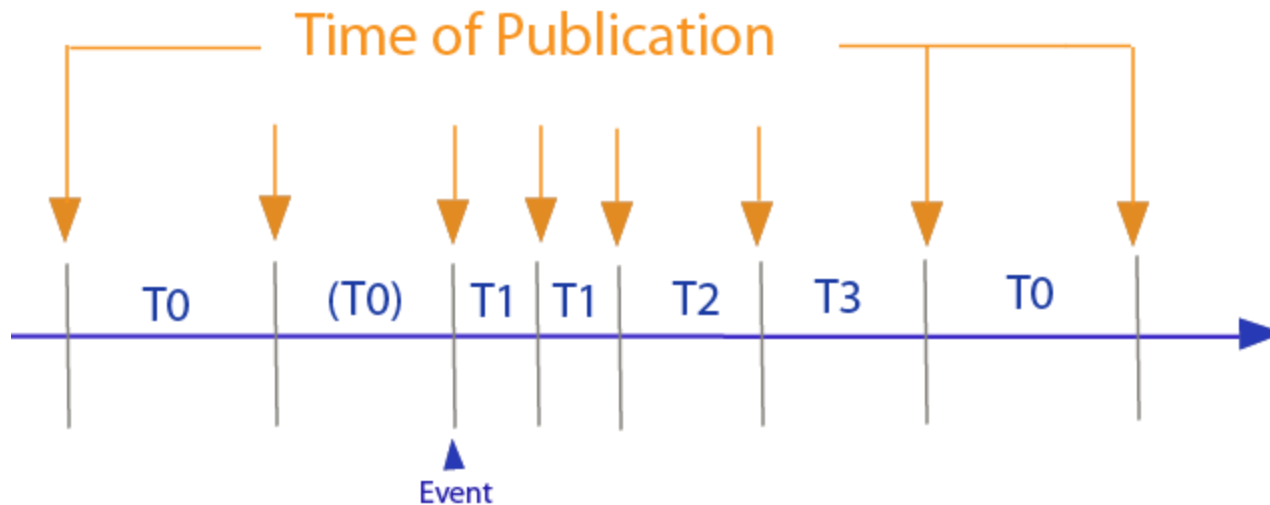
Remote Logic Pickup Triggered by First Received Packet Containing Signal



Confirmed 4, 8, 16, and 1000 ms

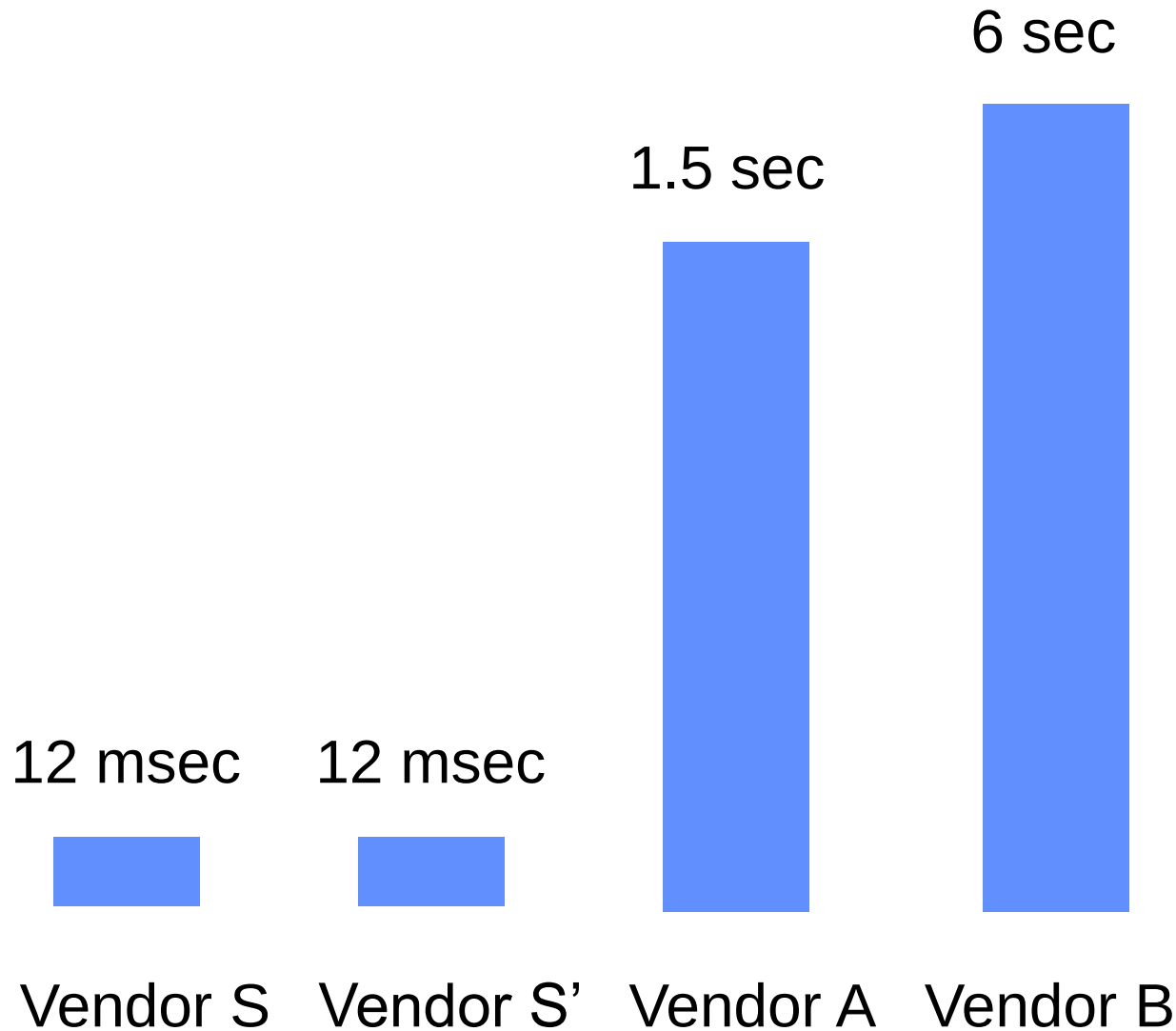
Subscriber Uses Health of Virtual Wiring Interconnection in Logic

- Subscribers constantly calculate time to wait (ttw), based on ttl within each message
- Subscriber considers data “stale” when ttw expires

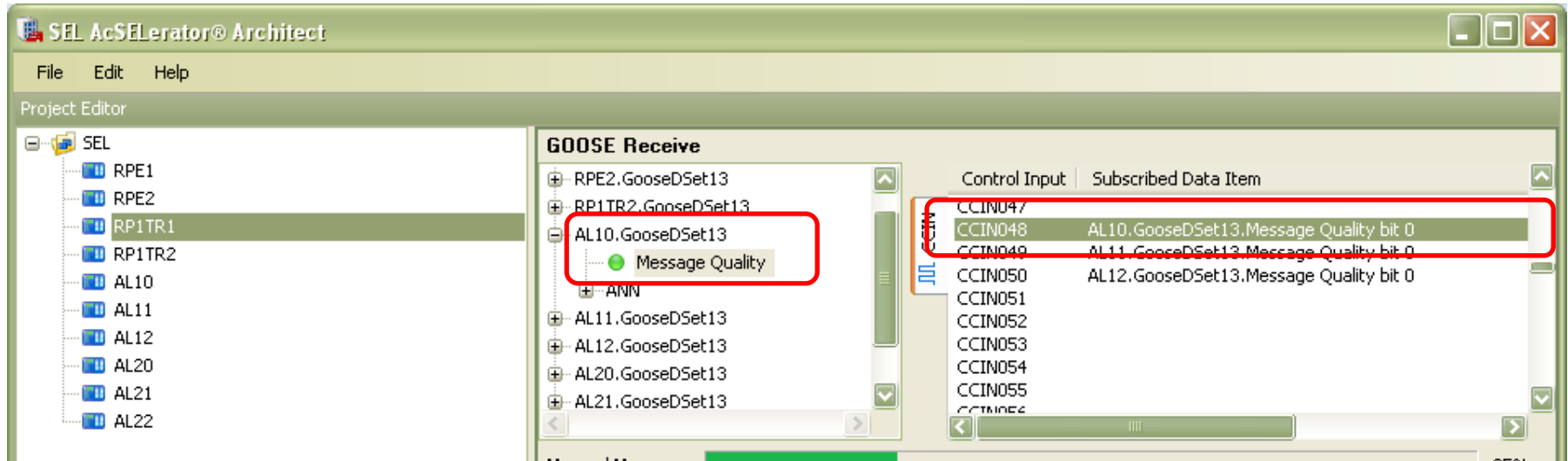


Vendor S		Vendor S'		Vendor A		Vendor B	
Time since last message	Time allowed to live	Time since last message	Time allowed to live	Time since last message	Time allowed to live	Time since last message	Time allowed to live
N/A	12	N/A	12	N/A	500	N/A	2000
4	24	4	12	~.1	500	94	2000
8	48	4	24	~.1	500	500	2000
16	96	8	2000	2	500	1000	4500
32	192	1000	2000	4	500	1000	4500
64	384	1000	2000	8	500	1000	4500
128	768	1000	2000	16	500	1000	4500
256	1536	1000	2000	32	500	1000	4500
512	1999	1000	2000	64	500	1000	4500
1000	1999	1000	2000	128	500	1000	4500
1000	1999	1000	2000	256	500	1000	4500

Time for IED to Detect Failed Communications

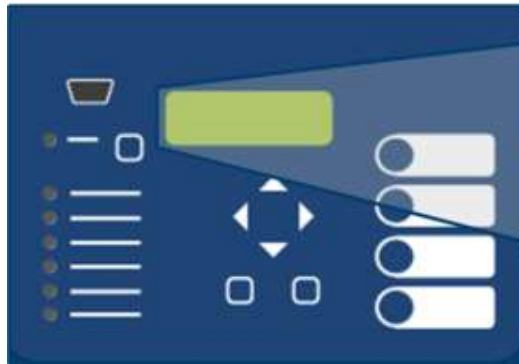


Message Quality is the Value Calculated by Supervising the GOOSE Subscription



Subscriber IED Name	Publisher IED Name	Subscribed Data Item
A_INCOMING_BKR_1	FDR_1	FDR_1.Info_From_FDR_1.PRO.BK1XCBR1.Pos.stVal bit 0
A_INCOMING_BKR_1	FDR_1	FDR_1.Info_From_FDR_1.PRO.BK1XCBR1.Pos.stVal bit 1
A_INCOMING_BKR_1	FDR_1	FDR_1.Info_From_FDR_1.Message Quality bit 0
A_INCOMING_BKR_1	FDR_2	FDR_2.Info_From_FDR_2.PRO.BK1XCBR1.Pos.stVal bit 0
A_INCOMING_BKR_1	FDR_2	FDR_2.Info_From_FDR_2.PRO.BK1XCBR1.Pos.stVal bit 1
A_INCOMING_BKR_1	FDR_2	FDR_2.Info_From_FDR_2.Message Quality bit 0

Message Quality Differentiates Silence From Failure



C_AI_G00=FAILED
B_AI_G00=NORMAL

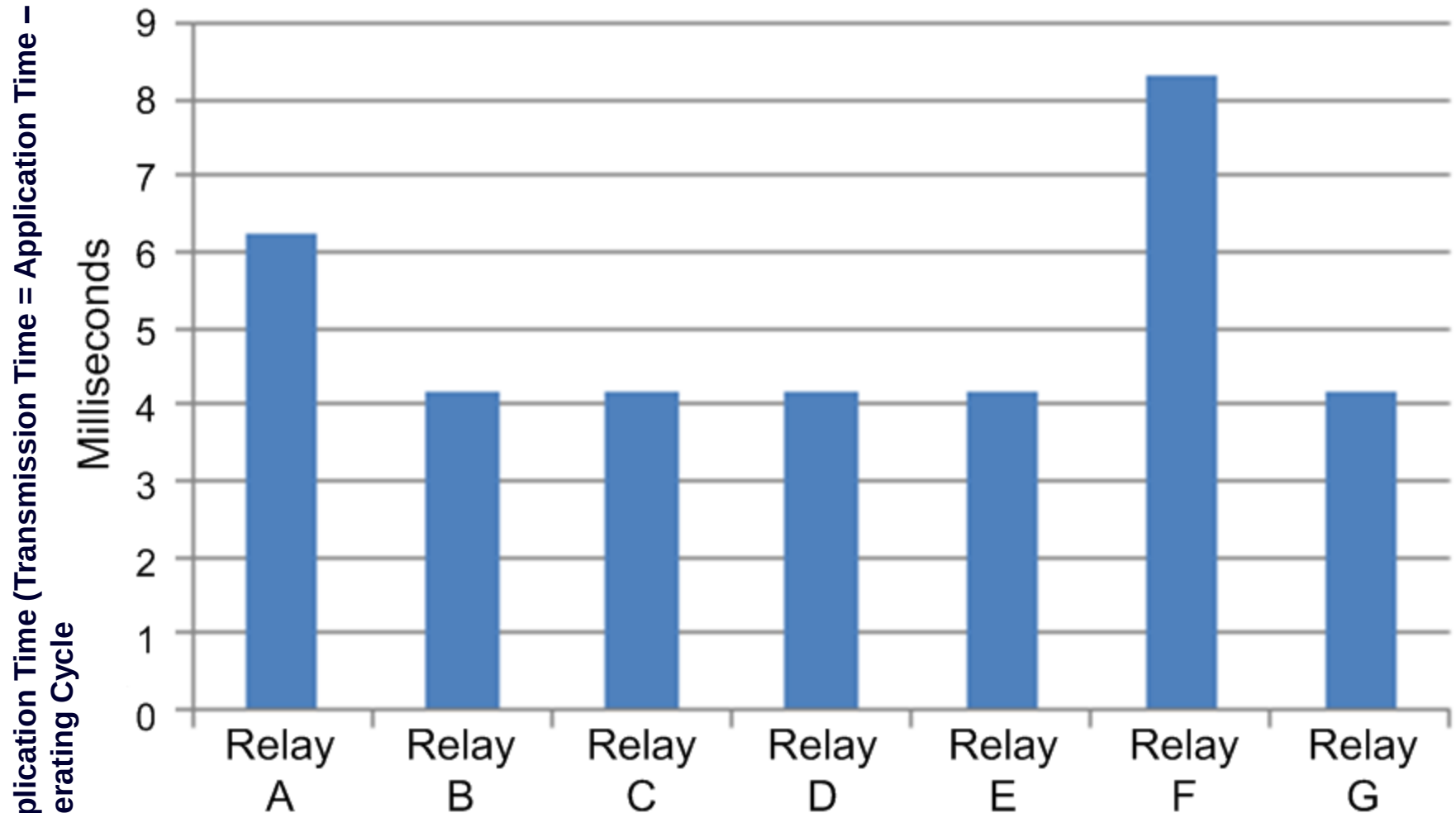


To	"David Dolezilek" <dave@selinc.com>
cc	
bcc	
Subject	Warning: OASIS SUBSTATION GOOSE FROM IED B1 FAILED

Dave - This note is to inform you that IED A at the Oasis Substation has detected that the GOOSE messages from IED B1 have failed. (Specific instructions can be included here. This note can be sent to one individual or a group of technicians)

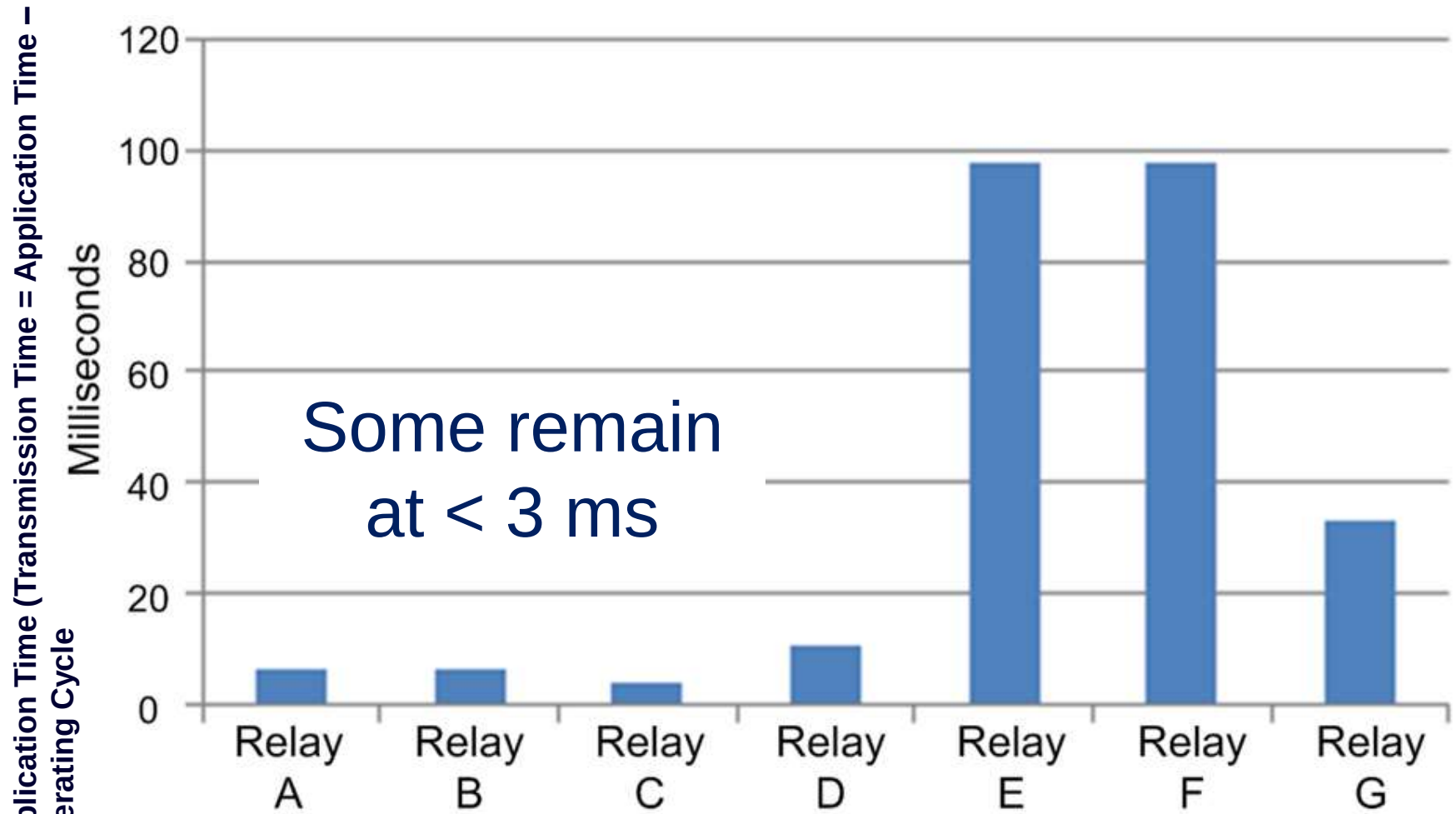
Average Application Times

**Application Time – Operating Cycle = Transmission Times
< 3 ms for Most Devices, Single Small Message**



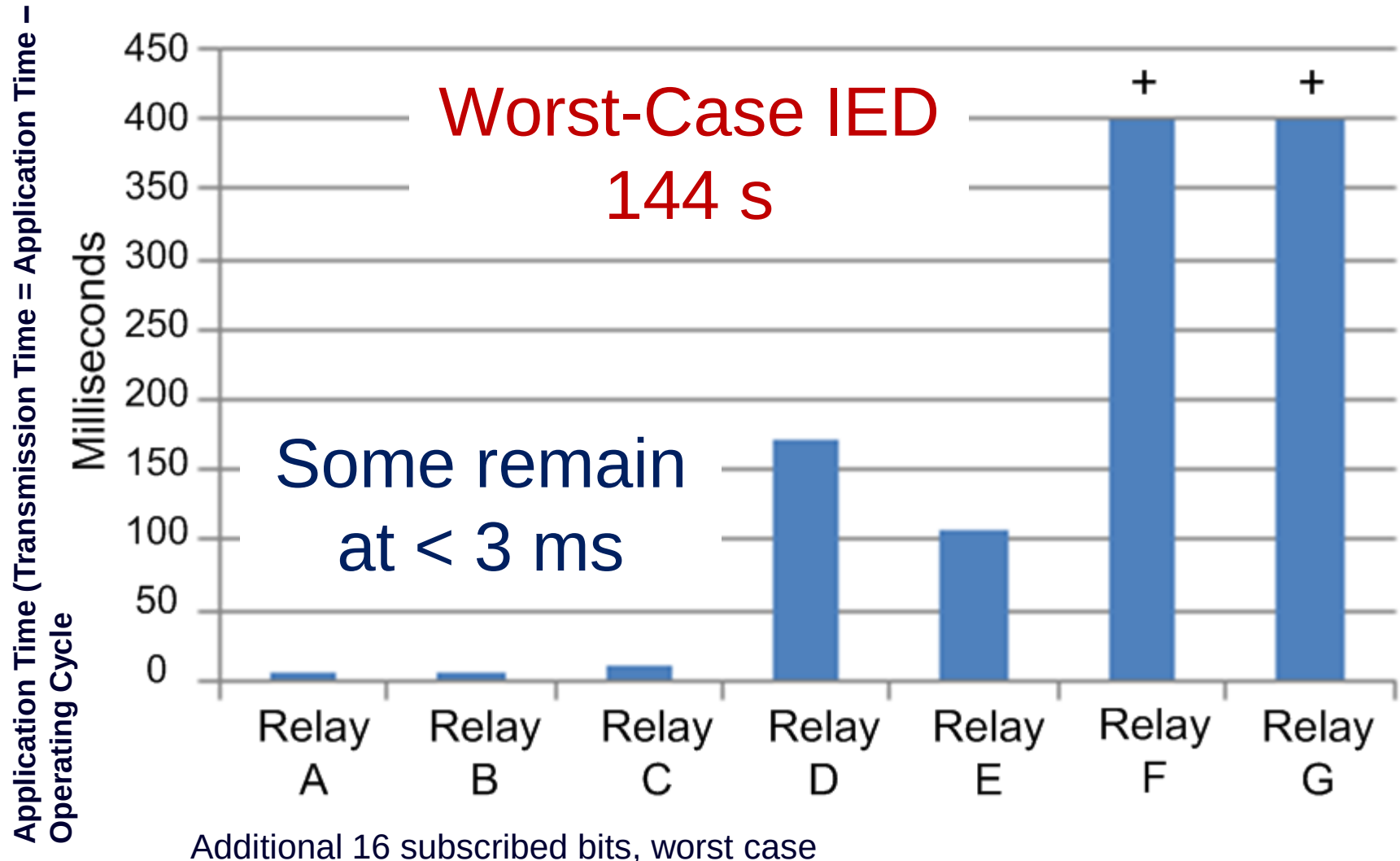
Average quiescent test case results

Worst-Case Times Vary Depending on Devices Processing Design

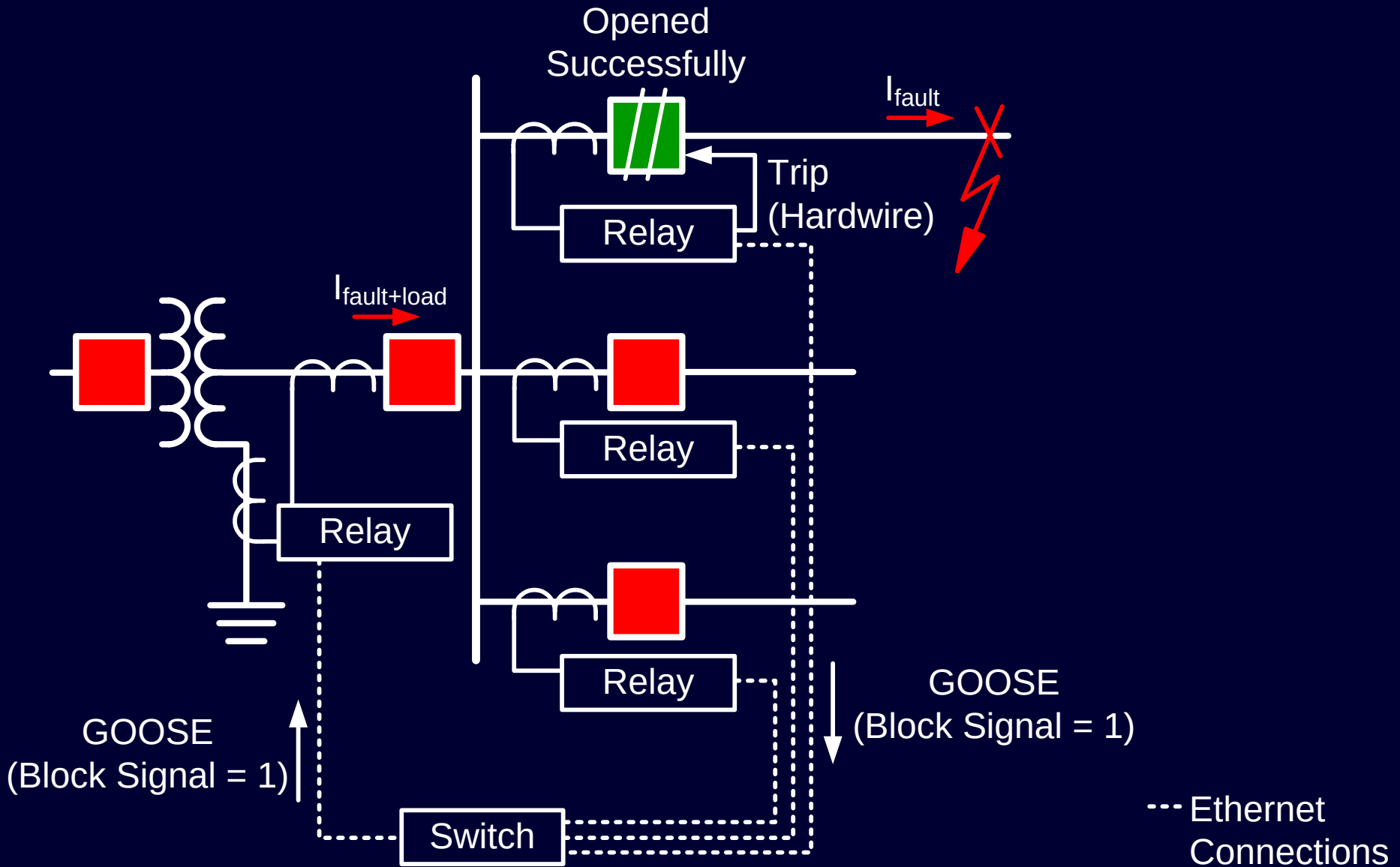


Worst-case quiescent test case results

Some Devices Fail Dramatically Processing Additional Messages

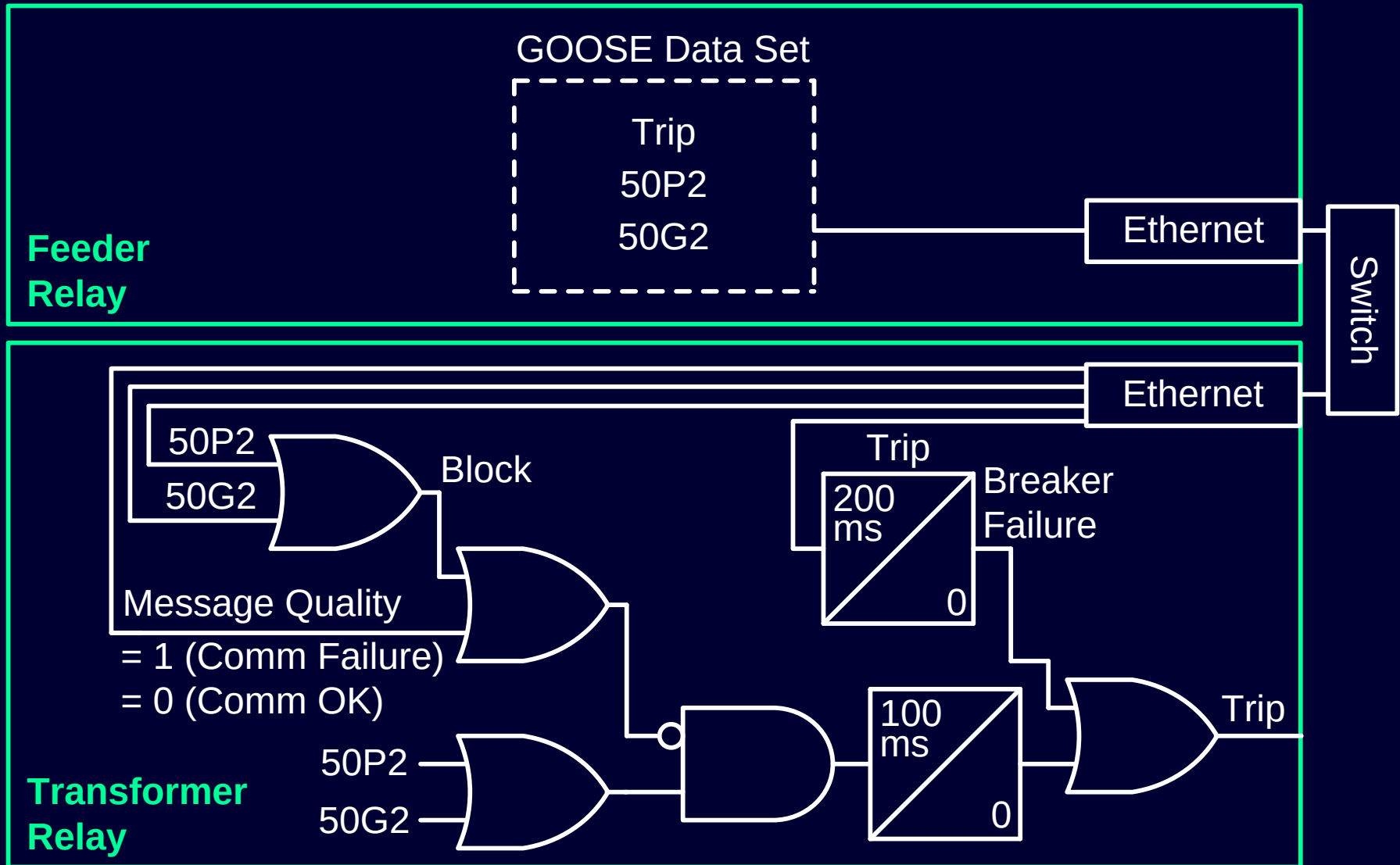


GOOSE Messages Allow Fast Trip



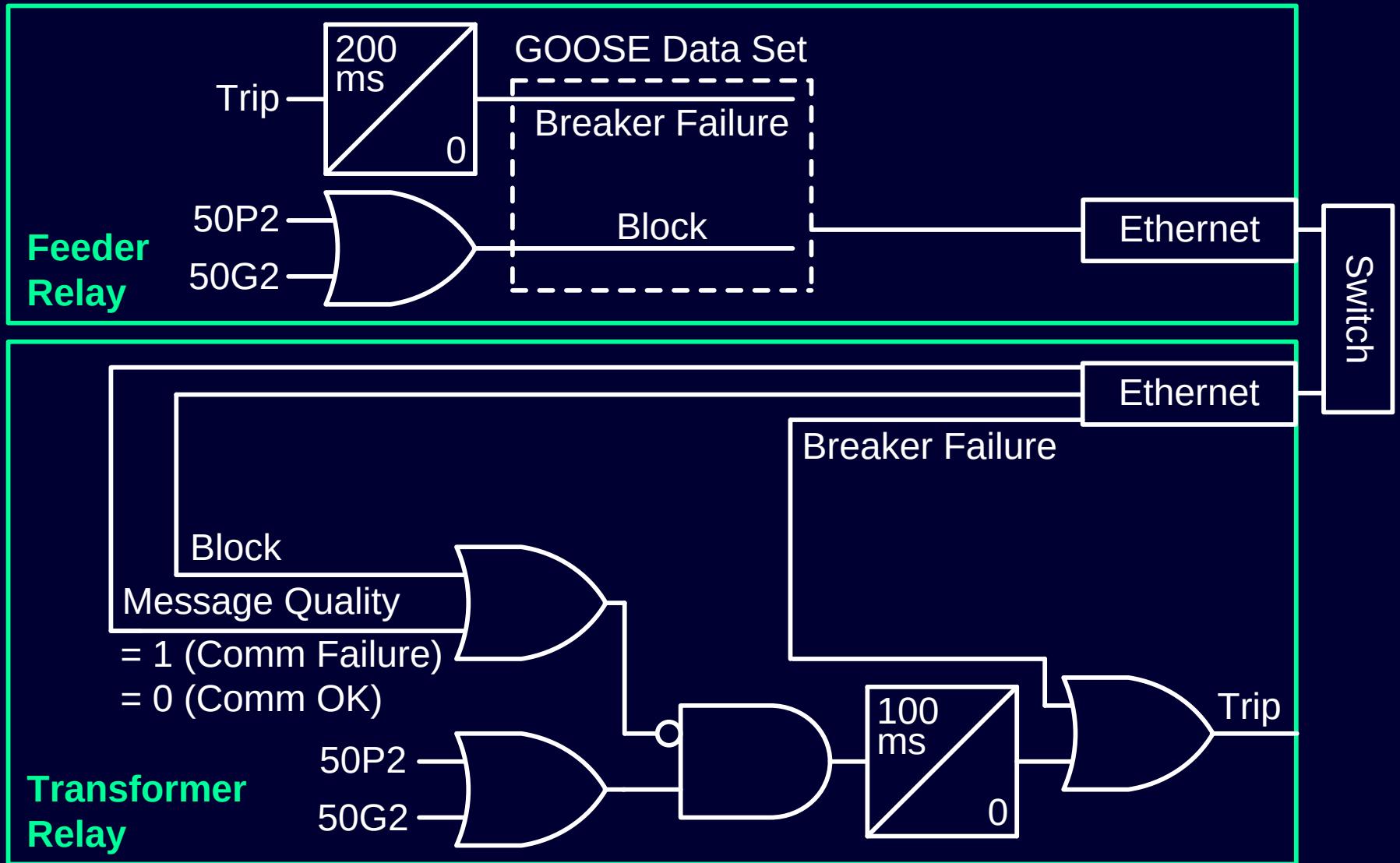
Bus Relay Breaker Failure Logic

Feeder Publish Status

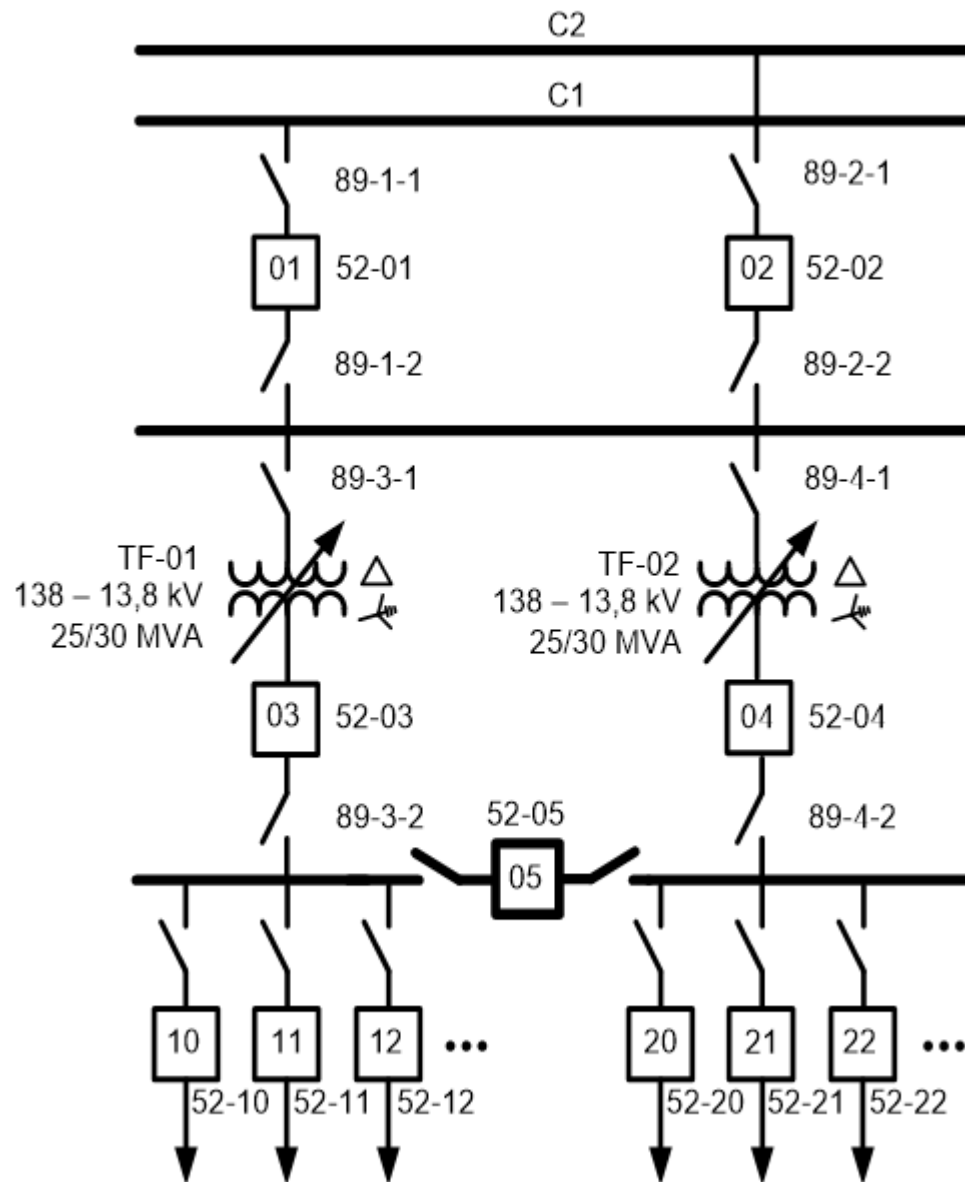


Bus Relay Breaker Failure Logic

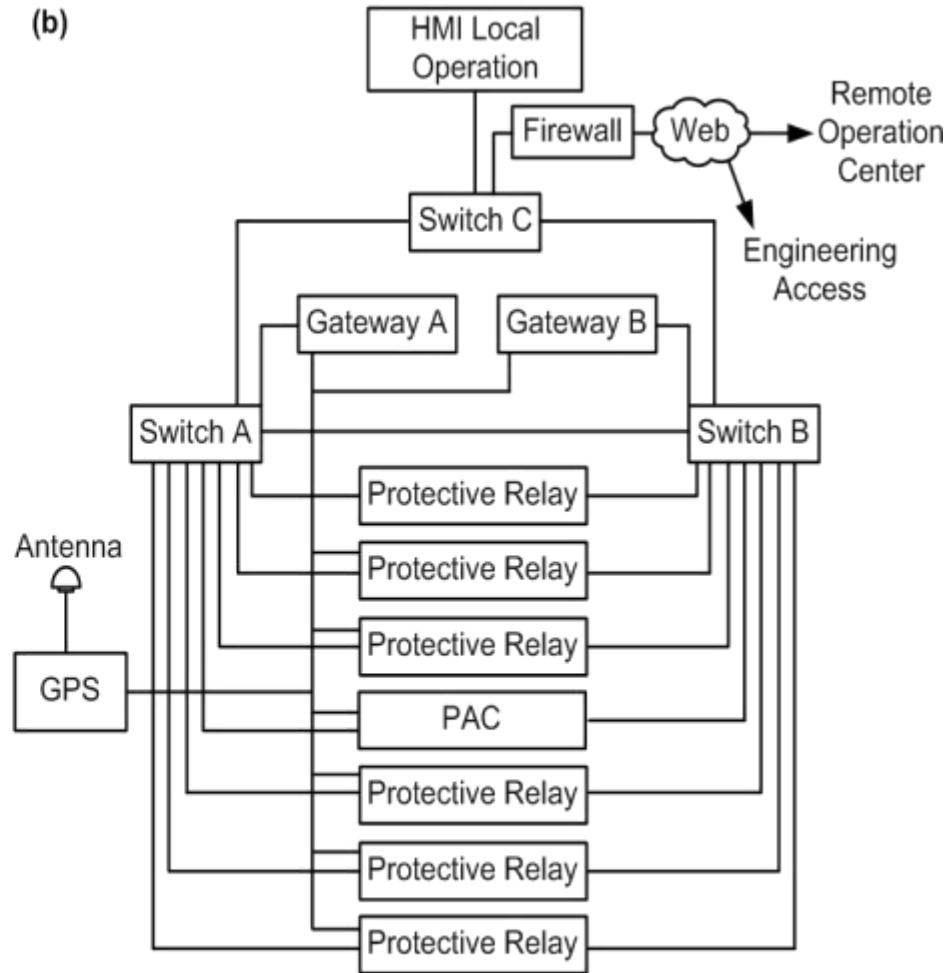
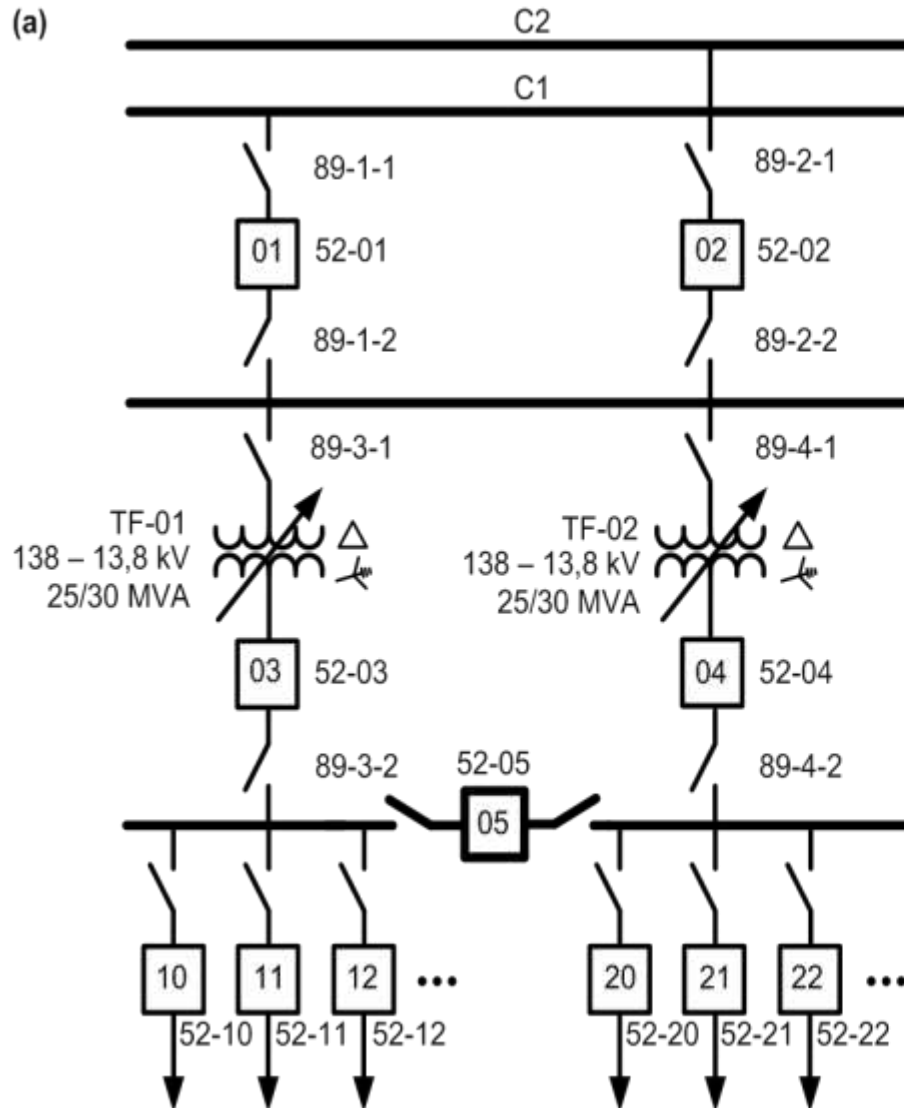
Feeder Publish Information



Consider a More Complicated Substation

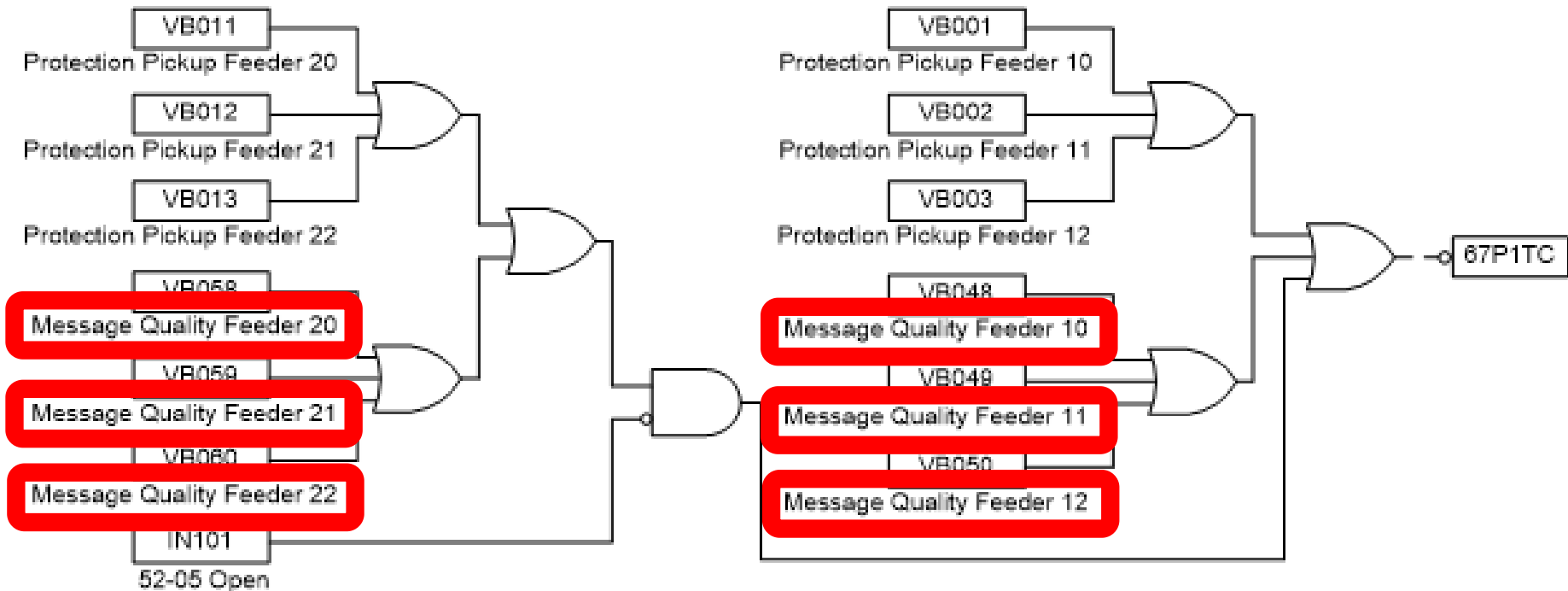


One Line and Associated PCM System



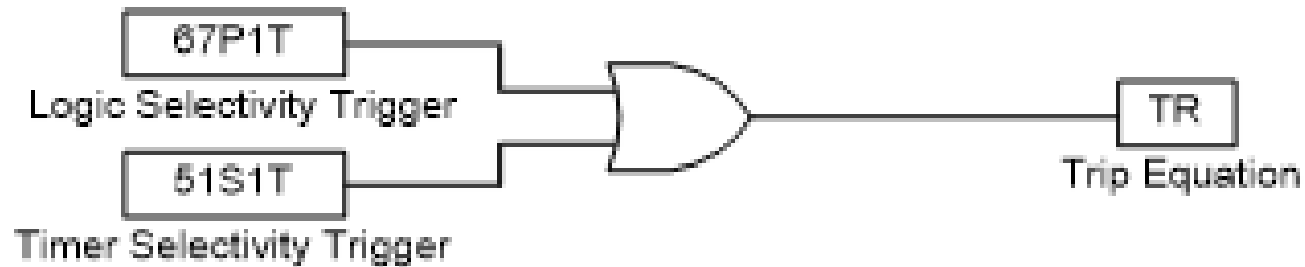
Understand Communication Loss May Prohibit Learning of Protection Pickup

Busbar Protection - Logic

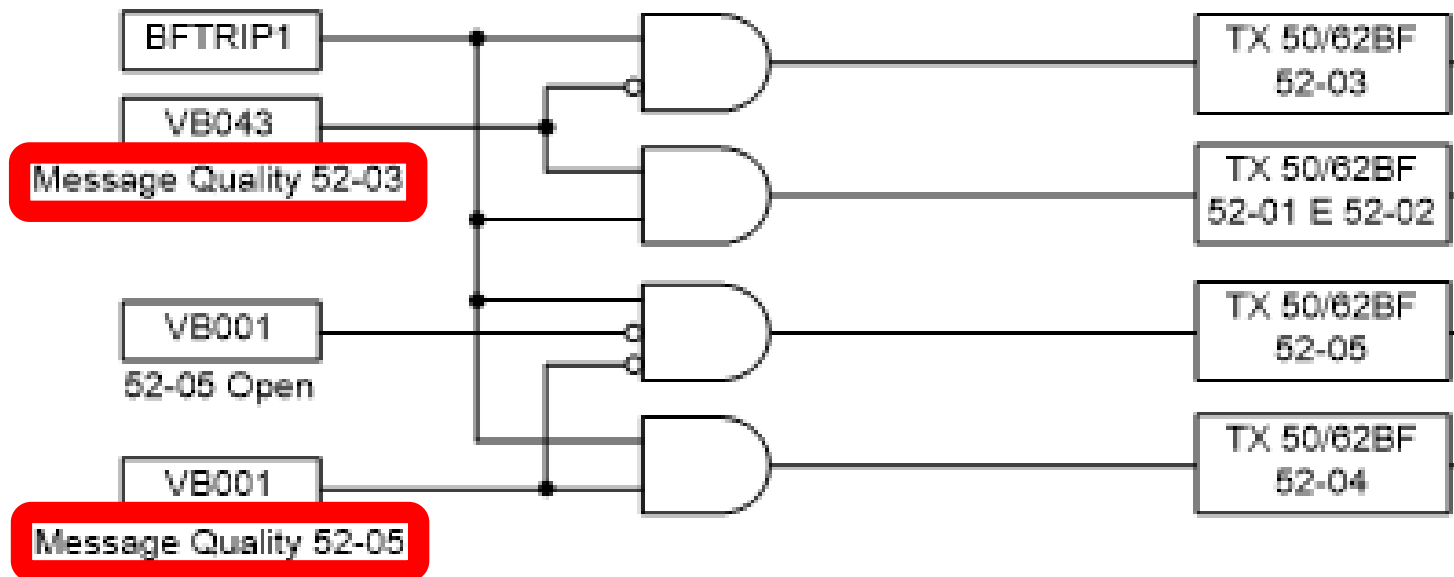


**Does one or more the feeder detect overcurrent?
If no, am I hearing from them?**

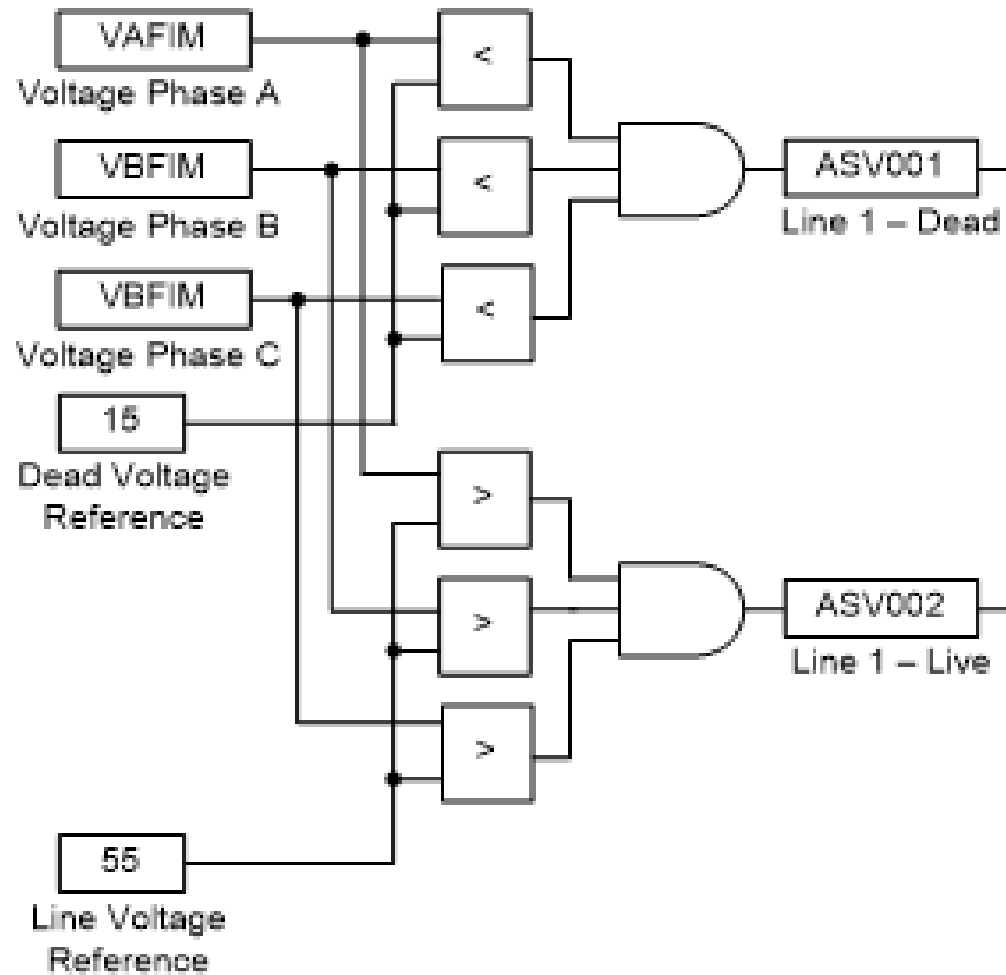
Busbar Protection – Blocking Logic



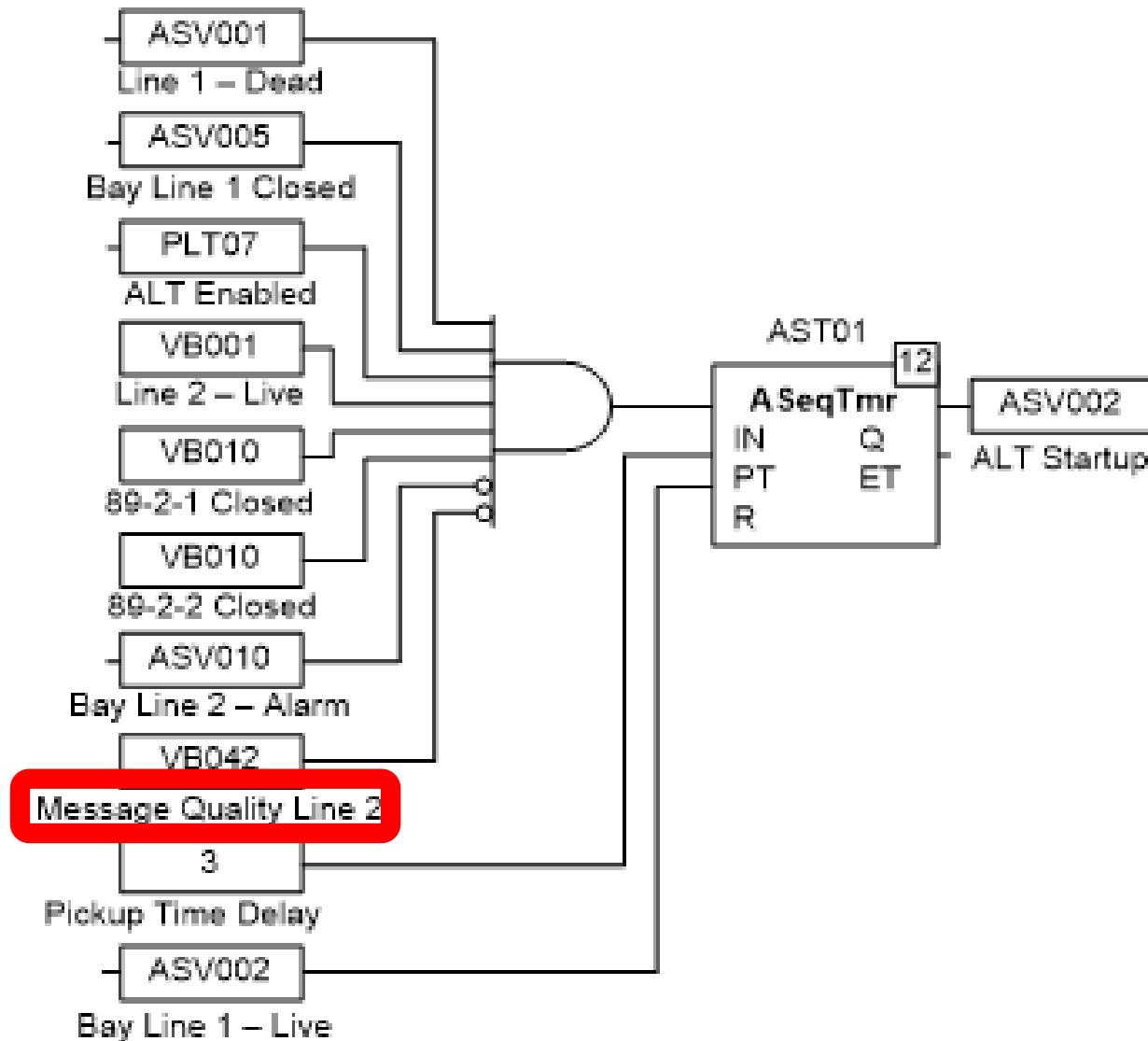
Breaker Failure (50BF) Protection



Detection of Line Status



Automatic Line Transfer



Questions?