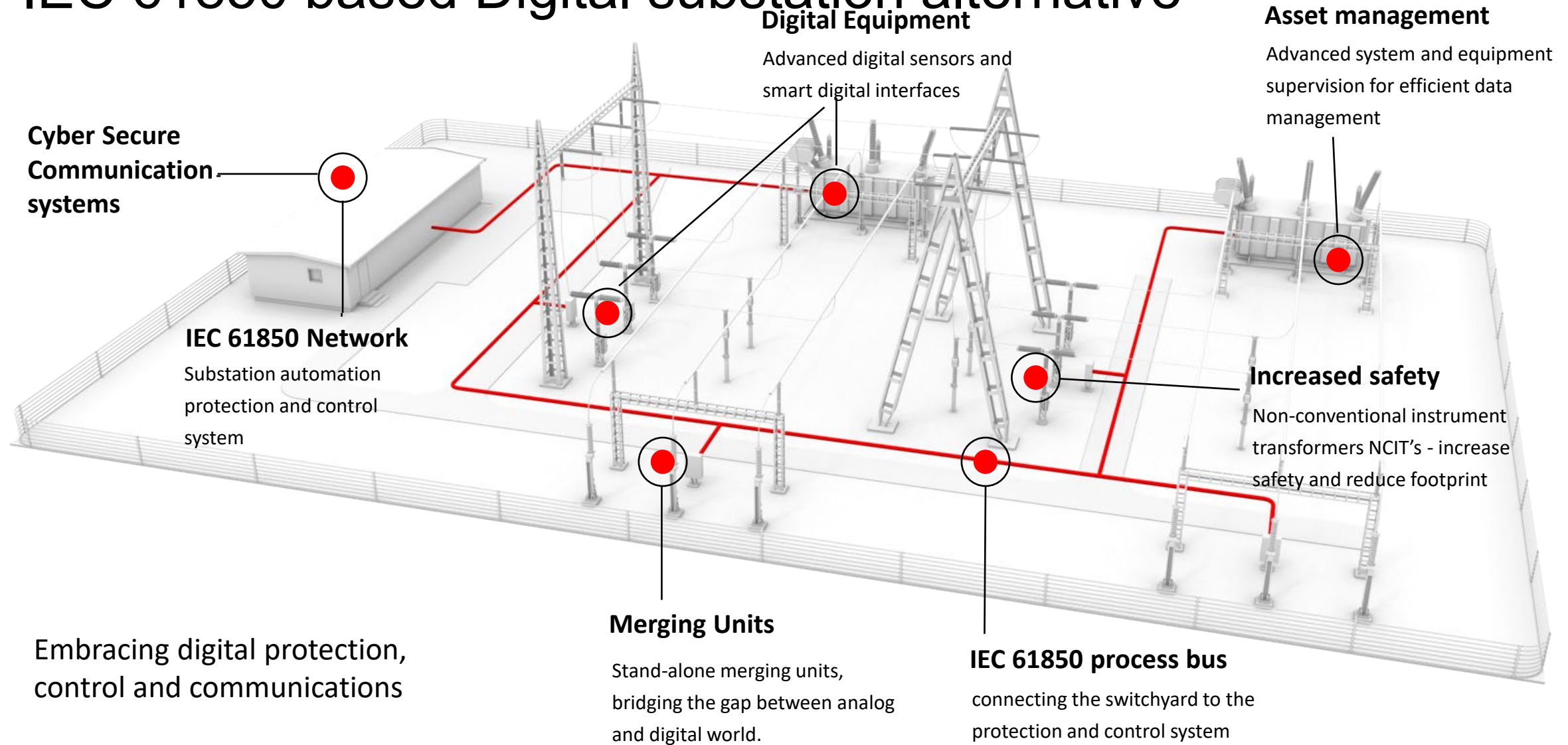# Testing Challenges of a Complete PAC Digital Substation

Bharadwaj Vasudevan, Jake Groat, Benton Vandiver III, Hitachi Energy

76th Annual Conference for Protective Relay Engineers
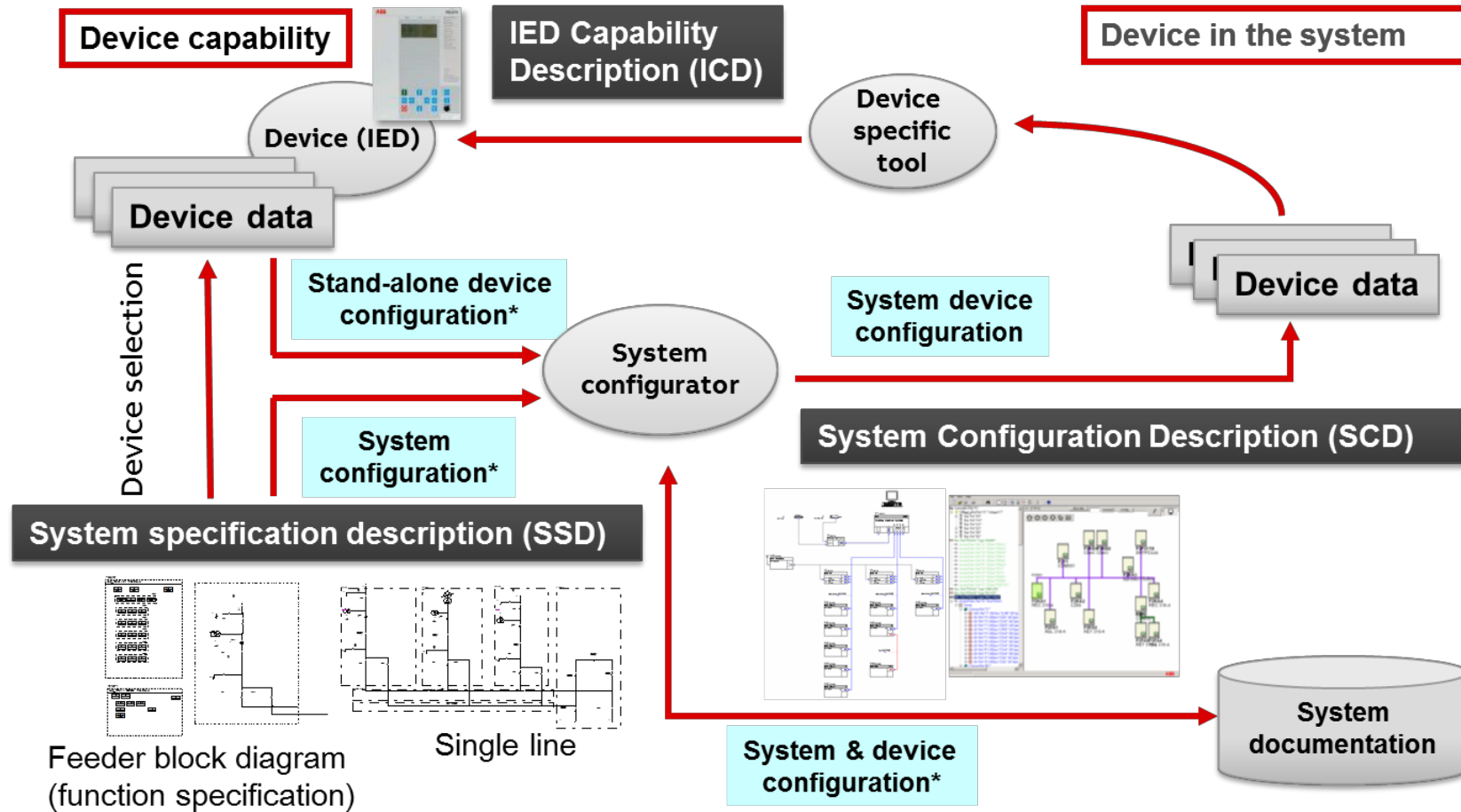
College Station, TX USA April 2023

# IEC 61850 based Digital substation alternative

**Digital Equipment**

Advanced digital sensors and smart digital interfaces

**Asset management**

Advanced system and equipment supervision for efficient data management

**Cyber Secure Communication systems**

**IEC 61850 Network**

Substation automation protection and control system

**Increased safety**

Non-conventional instrument transformers NCIT's - increase safety and reduce footprint

Embracing digital protection, control and communications

**Merging Units**

Stand-alone merging units, bridging the gap between analog and digital world.

**IEC 61850 process bus**

connecting the switchyard to the protection and control system

# Testing Challenges

- **Challenge #1 – getting the SCD correct is a MUST to feed the correct communication exchange data to the Testing Tools for testing the complete PAC Digital Substation**

- *Challenge #2 – Ensuring that all IED's with the SCD imported properly perform their functions and that all their services are configured correctly to communicate to the connected substation network(s).*

- *Challenge #3 – Perceived challenges with Process bus testing usually reflects on setting up the test plan itself, the rest of the testing is pretty much the same as in a conventional test set environment.*

- *Challenge #4 – Understanding the IED's IEC61850 architecture and configuration to make the translation to the digital inputs and outputs substituted in the functional tests. This is necessary to build trust of the digital processes and services of the IED and trust of the modern test set.*

- *Challenge #5 – Understanding that the SCD contains all the interlocking and communications of the entire digital substation and that a single test can verify multiple levels of the PAC system.*

- *Challenge #6 – Making the commitment to the IEC 16850 architecture and related standards that create the ability to engineer and test the future of the complete PAC digital substation.*

# IEC 61850 based Engineering Workflow

# Testing Challenges

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# Data Model Description for PIOC function

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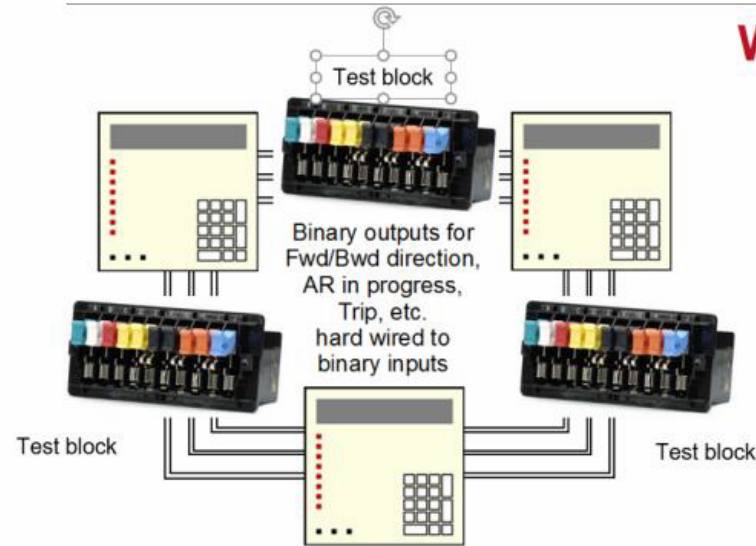
# Functional Test of Characteristics
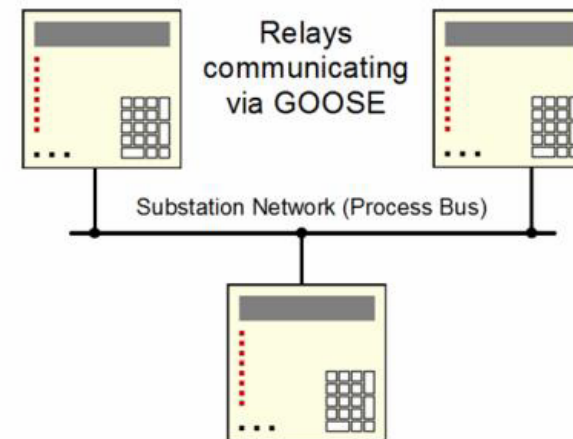
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# Scheme Tests made easier using GOOSE



Wiring: Copper versus GOOSE

Test block

Binary outputs for Fwd/Bwd direction, AR in progress, Trip, etc. hard wired to binary inputs

Test block

Test block

> GOOSE
  > fast inter-device communication
  > replaces hard-wired connections

> Applications:
  > Interlocking
  > Reverse busbar blocking
  > Trip signals

Relays communicating via GOOSE

Substation Network (Process Bus)

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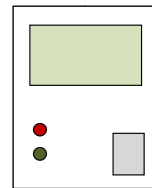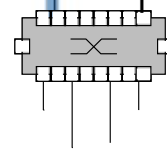
# SCADA Tests of system

# Testing Challenges
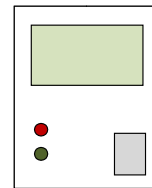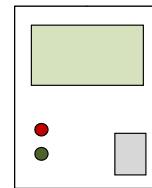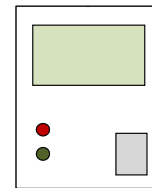
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# Summary

- Not all aspects of the digital substation are addressed here, the network design, operational procedures, cyber security best practice, just to name a few are not considered. Existing test and commissioning processes of a conventional substation can be easily adapted for a digital substation.

- By using automated test scripts, the whole test plan can be organized and automated. The resulting report can be prepared/published much faster than from a traditional manual test procedure.

- Only a few engineering/test tools have been showcased in this paper that helped with test troubleshooting. The IEC 61850 standard itself has evolved over the last few years and has provided a lot of new features like the LGOS, LSVS and LTRK to online monitor GOOSE & SV streams and all the MMS-based services, respectively.

- There are also Logical Nodes available today to monitor the error statistics of the IED and Switch communications ports which helps with communication supervision for any network topology. There are even tools available today which utilize the built-in features from the standard and provide the users with options to test, commission, diagnose and maintain the digital substation.

- To fully utilize the benefits of the standard, a strong importance must be given to the engineering of the digital substation and resulting SCD file by using a standard conformant system engineering tool. Conformance guidelines are there to verify tool compliance.

- In this paper we attempt to highlight the usability of the standard itself. It's a proven global standard that can improve any utility design.