GE's **eLumina**™ HVDC Control System
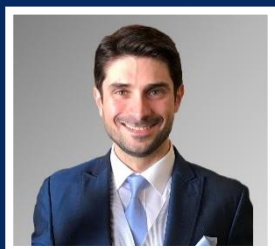
Leandro Vacirca
Product Manager for HVDC Control Systems

> "Utilizing nearly **60 years** of **HVDC expertise** along with a powerful **Model-Based Design** methodology, GE has combined **cutting-edge computing** technology with **standardized application software** to deliver a **reliable, high-performance** system"

GE Makes Major Investment in HVDC

New HVDC COE Building

2017

- World class office space for over 500 employees
- High capacity VSC and LCC valve manufacturing facility

New HVDC Simulation Lab

2017

- Contract system validation
- Multi-project test capacity, >45 RTDS™ racks
- Multiple fully equipped customer FAT test suites

New Valve Test Facility

2018

- Completely programmable voltage and current test waveforms
- 6000A test capability for VSC and LCC valves
- Accelerates production and development type tests

GE investing in HVDC technology to WIN!!

Customer Outcomes

Rapid Project **Delivery**	Maximized **Performance**	Robust & Resilient **Design**	Compact **Footprint**	Digital **Analytics**
+150 Configurable SW modules	**+10x** computing platform power	**80%** fewer wires	**50%** smaller footprint	Built with **operational analytics, Cyber-secured**
30% faster cycle		**100%** automatic testing	**40%** fewer cabinets	

Designed to address today's and tomorrow's grid challenges

(*) Disclaimer: all values shown above are "up-to" numbers that vary depending on HVDC scheme configuration

GE Introduces **eLumina**™ Control System

HVDC Control System for the New Grid

Maximized System Availability & Reliability

Improved system resiliency through simplified, fully-redundant system architecture that **maximizes system availability**
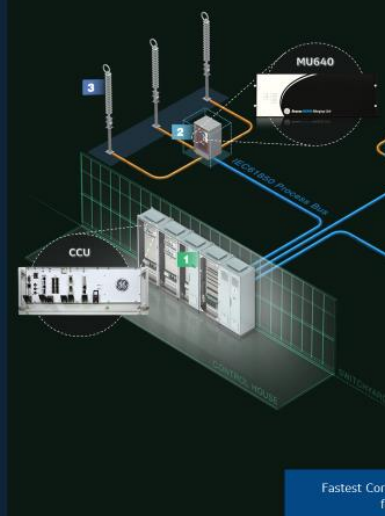
- IEC61850 compliant for ultimate interoperability
- Dual-redundant converter control with seamless changeover
- Triple-redundant converter protection
- Modular, Secure, Simple
- Maximized availability and increased reliability
- Cyber-secure compliant with utility practice and regulations (ex. NERC/CIP)

Converter Control & Protection Cabinet (Lane 1)
Converter Protection Cabinet
Converter Control & Protection Cabinet (Lane 2)

Simple to build, robust and reliable

High Performance

First HVDC solution to implement a world-class digital measurement system fully based on **IEC61850**

- Full digital integration of all voltage and current sensors via new fast merging units (MU640)
- High-speed process bus technology compliant with IEC61850 and IEC61869 standards
- Robust, ultra-fast and low-latency sensor data gathered over redundant Ethernet and fiber optic communication networks
- Fastest core computing unit (CCU) in the industry, enabling a more flexible and adaptive HVDC solution

MU640
CCU

Fastest Core ... for ...

Compact Footprint

Using a modular approach to our controls platform combined with cutting-edge computing technology, GE's latest generation of control system reduces the form factor and footprint.

~40% Reduction in total cabinets count

~30% Reduction in weight

- Reduced complexity
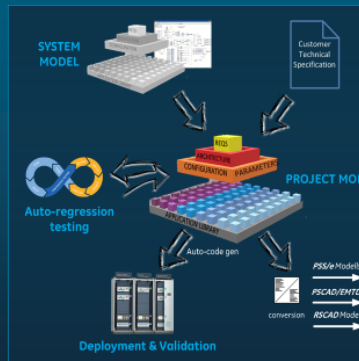- Lower power usage
- Significant reduction in audible noise

ELECTRICALLY AND
MECHANICALLY SIMPLIFIED

~50% SMALLER FOOTPRINT

Proven Software and Optimized Delivery

eLumina™ Suite provides a **proven HVDC application software** and **industry-best tool chain** to enable ~30% reduction in delivery cycle

- **eLumina™ HVDC Software**
  90% standard and configurable HVDC applications built from **150+** proven software components

- **Single Source of Truth process**
  Allows to validate system performance across multiple simulation tools from the **very same source**

- **eLumina™ Brilliant Software Factory**
  Automatic regression test engine ensures improved quality of as-delivered software


SYSTEM MODEL
Customer Technical Specification
PROJECT MOD...
Auto-regression testing
Auto-code gen
PSS/e Models(s)
PSCAD/EMTDC
conversion
RSCAD Models
Deployment & Validation

Introducing **eLumina**™ Explorer

- Modern HTML5 web interface
- Real-time visualization
- Configuration and commissioning
- Analyze transient fault records
- Signal historian

Examples:
- Real-time status
- Live debugging capability
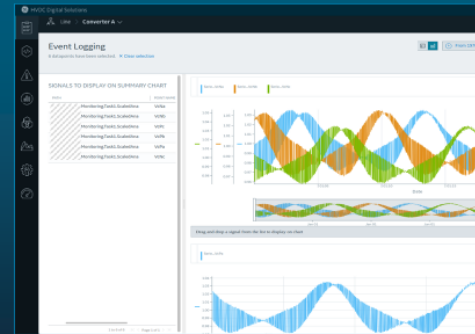
eLumina™ Analytics

An analytics platform enabled by the HVDC control system

- Data connectivity
- Advanced computing power
- Analytic engines that generate insights
- Intuitive visualization

Outcomes
- Reduced maintenance
- Reliability and Availability improved
- Predict & diagnose assets to avoid unplanned outages
- Asset life-cycle optimization
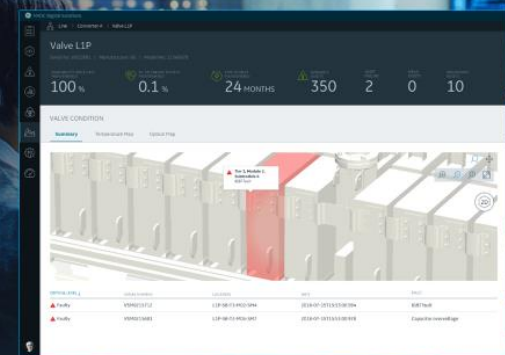
eLumina™ - Product Qualification

Type Tests Plan

- EN 61000-4-2 – **Electrostatic Discharge Immunity**
- EN 61000-4-3 – **Radiated RF Immunity**
- EN 61000-4-4 – **Electrical Fast Transients Immunity**
- EN 61000-4-5 – **Voltage Surge Immunity**
- EN 61000-4-6 – **Conducted RF Immunity**
- EN 61000-4-8 – **Power Frequency Magnetic Field Immunity**
- EN 61000-4-11 and EN61000-4-29 – **Voltage Dips and Short Interruptions Immunity**
- EN 61000-4-16 – **Power frequency**
- EN 61000-4-17 – **A.C. component in d.c. (ripple)**
- EN 61000-4-18 – **Slow damped oscillatory wave**
- EN 60255-26:2013 clause 7.2.13 – **Gradual shutdown/start-up**
- EN 55011 – **Radiated Emissions (30 – 1000 MHz)**
- EN 55032 – **Radiated Emissions (1 – 6 GHz)**
- EN 55011 – **Conducted Emissions**
- EN 60068-2-1:2007 – **Test Ad: Cold : -20C / -10 C 16 hours (*)**
- EN 60068-2-2:2007 – **Test Bd: Dry Heat :- +55 Deg C, 16 hours**
- EN 60068-2-78:2013 – **Test Cab: Damp Heat, Steady State:- 10 days at 40deg C and 96 % humidity**
- EN 60068-2-30:2005 – **Test Db: Damp Heat variant 2:-- 90 to 96 RH @ 40 deg C ramped to /from 95-100 RH @25 deg C 24 H + 6 * 24 hour cycles**
- BS EN 60255-21-1:1996 (IEC 255-21-1:1998) - **Vibration (Class 1)**
- BS EN 60255-21-2:1996 (IEC 255-21-2:1998) - **Shock and Bump (Class 1)**
- EN60068-3-3 AG5, EN60068-3-3 Perf level III, EN60255-21-3 Class 1, IEE693-2005 Perf level high – **Seismic**
- Ingress Protection: **IP42**

Type Tests Status

Type Tests	Result
EMC	
Conducted Emissions & Immunity	**Passed**
Radiated Emissions & Immunity	**Passed**
Electrostatic Discharge	**Passed**
Surge Immunity	**Passed**
Transient Immunity	**Passed**
Environmental	
Cold	**Passed**
Dry Heat	**Passed**
Damp Heat Steady State & Cyclic	**Passed**
Vibration/Shock/Bump	**Passed**
Seismic	**Passed**
IP	**Passed**

eLumina™ - Type Tests (Lab Photographs)

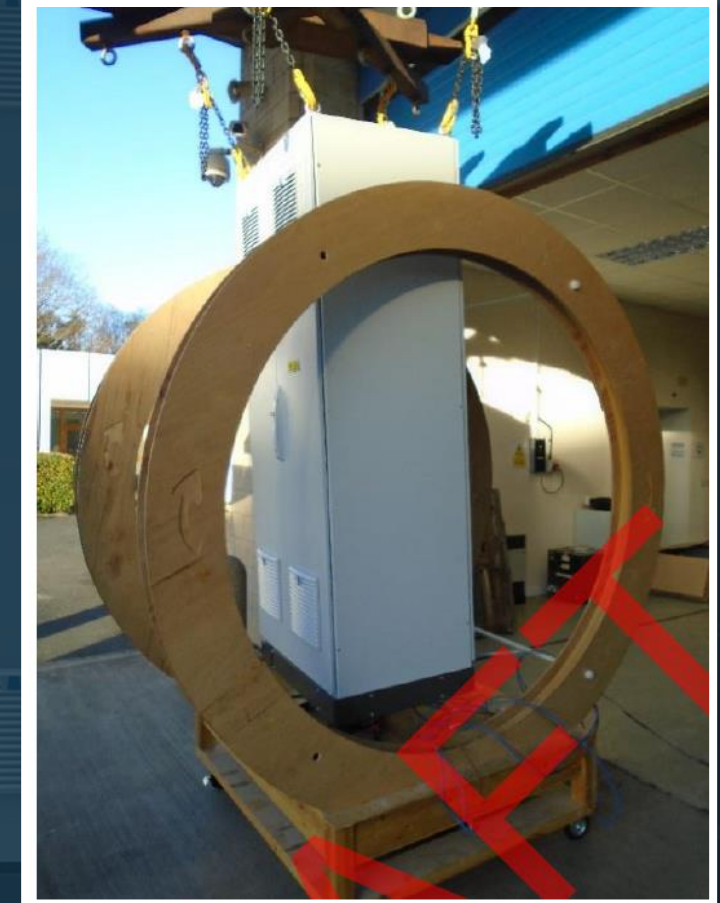**Environmental**
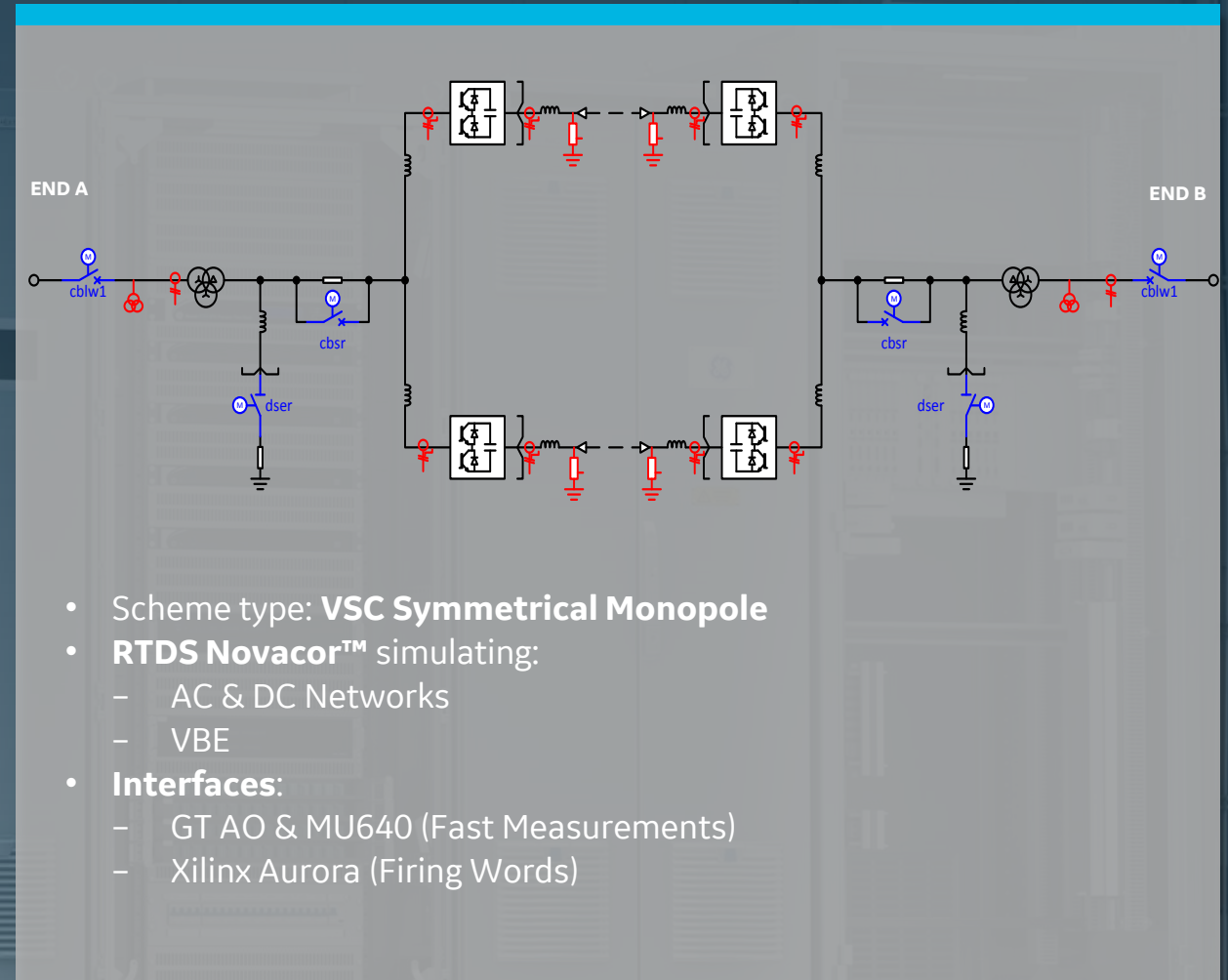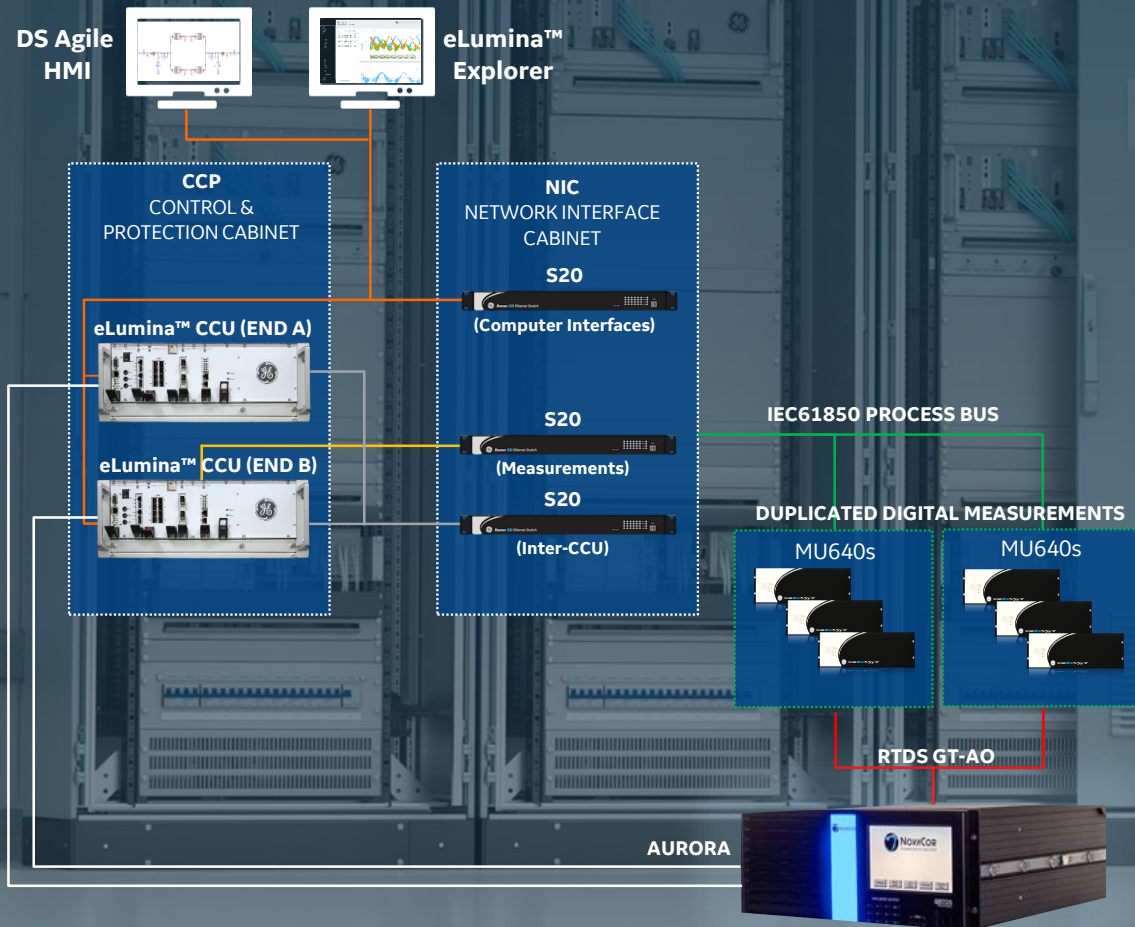

Vibration

EMC

Seismic

Magnetic

HVDC Application Software Demonstrated

1. End to End Power Transfer (using DW3 App SW)
2. Power Flow Reversal
3. Reaction to Voltage Depression on AC network

DS Agile HMI

eLumina™ Explorer

CCP
CONTROL & PROTECTION CABINET

eLumina™ CCU (END A)

eLumina™ CCU (END B)

NIC
NETWORK INTERFACE CABINET

S20
(Computer Interfaces)

S20
(Measurements)

S20
(Inter-CCU)

IEC61850 PROCESS BUS

DUPLICATED DIGITAL MEASUREMENTS

MU640s

MU640s

RTDS GT-AO

AURORA

END A

END B

cblw1

cbsr

dser

cbsr

dser

cblw1

- Scheme type: **VSC Symmetrical Monopole**
- **RTDS Novacor™** simulating:
  – AC & DC Networks
  – VBE
- **Interfaces**:
  – GT AO & MU640 (Fast Measurements)
 – Xilinx Aurora (Firing Words)

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System Architecture
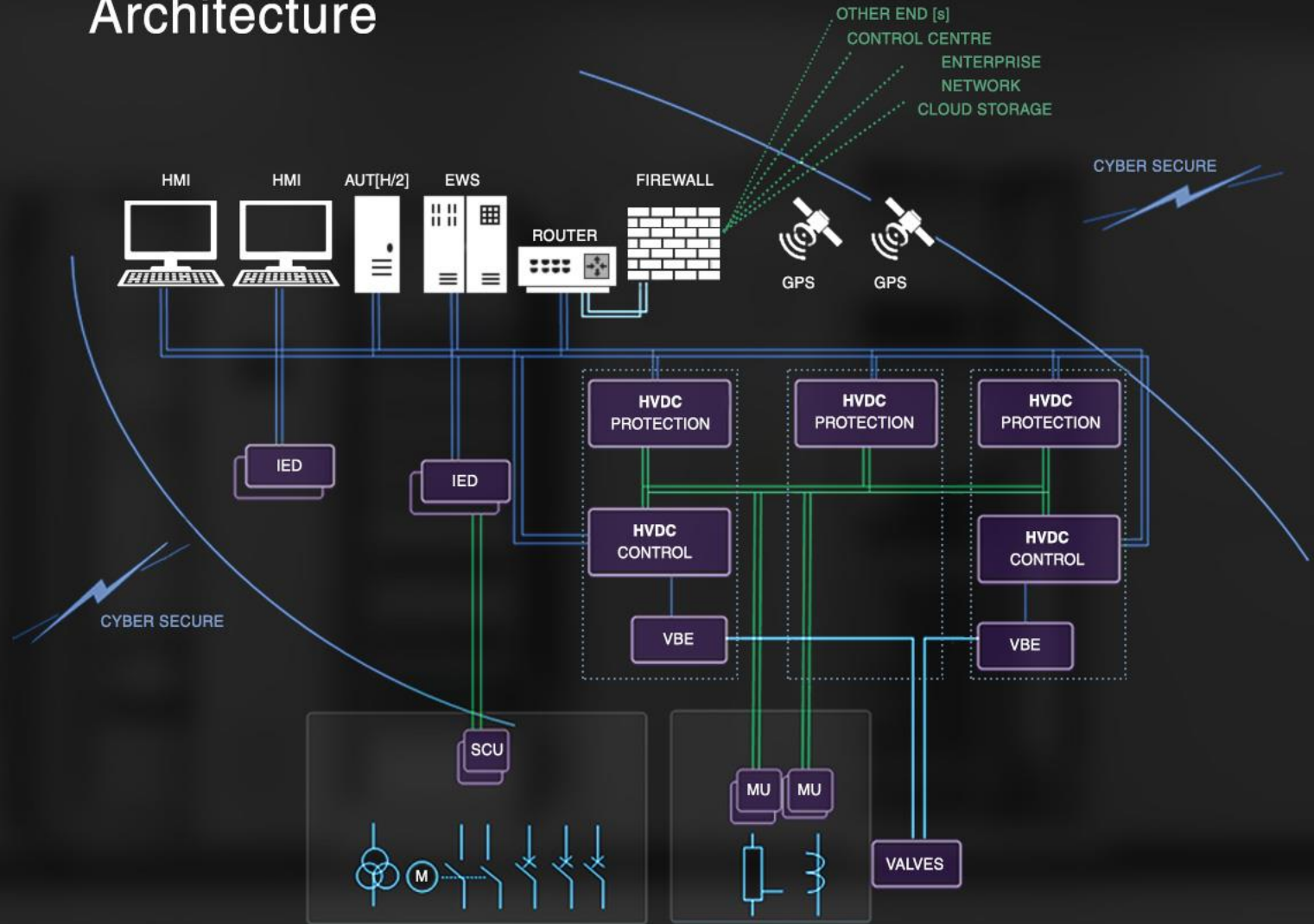
Designed for **>99.9%** availability

Pole and Bipole
Control Architecture

Duplicated Control and triplicated Protection systems for each pole end

- Complete electrical and mechanical segregation between Control and Protection

- Any one cabinet can be switched off/on during power transmission

- All plant I/O is connected via IEC61850 compliant, high speed, fiber optic communication links

- Bipole functionally hosted by control core computing units (CCUs)

- Copper wiring is virtually eliminated **-80%**

- Footprint reduced by **-50%**
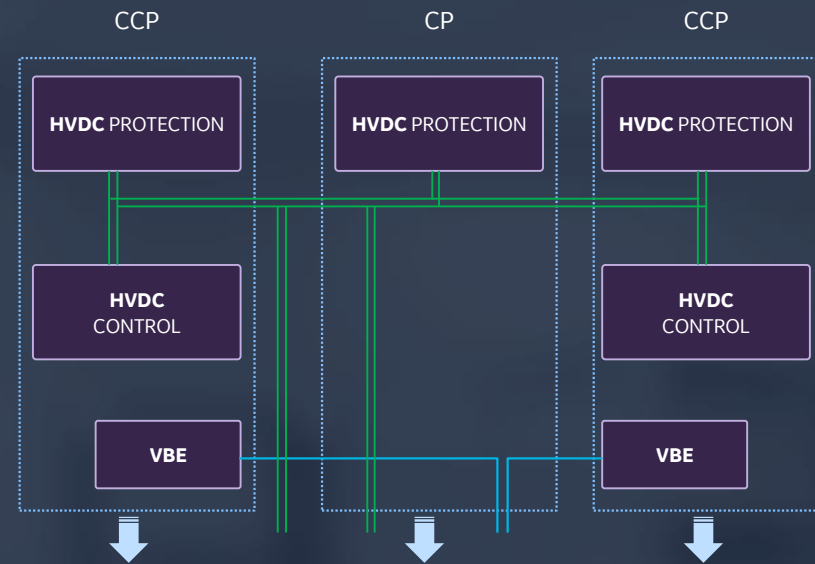
Core Computing Unit - **CCU**
for Control and Protection

Provides the **high performance, real time computing platform needed** to execute HVDC control and protection applications to meet today's and tomorrow's demands

- Designed as Line Replaceable Units (LRU) for simplified maintenance and spares management

- Complies with OpenVPX Standard (ANSI/VITA 65-2017) used in long life and high availability applications such as Avionics

- Type-tested for harsh EMC, environmental and mechanical environments mandated by IEC61850-3

- Optimized for executing industry-leading Simulink® Model-Based HVDC applications

- Fast and simplified installation with as few as 3 fibers connections

- Duplicated power supply for high reliability
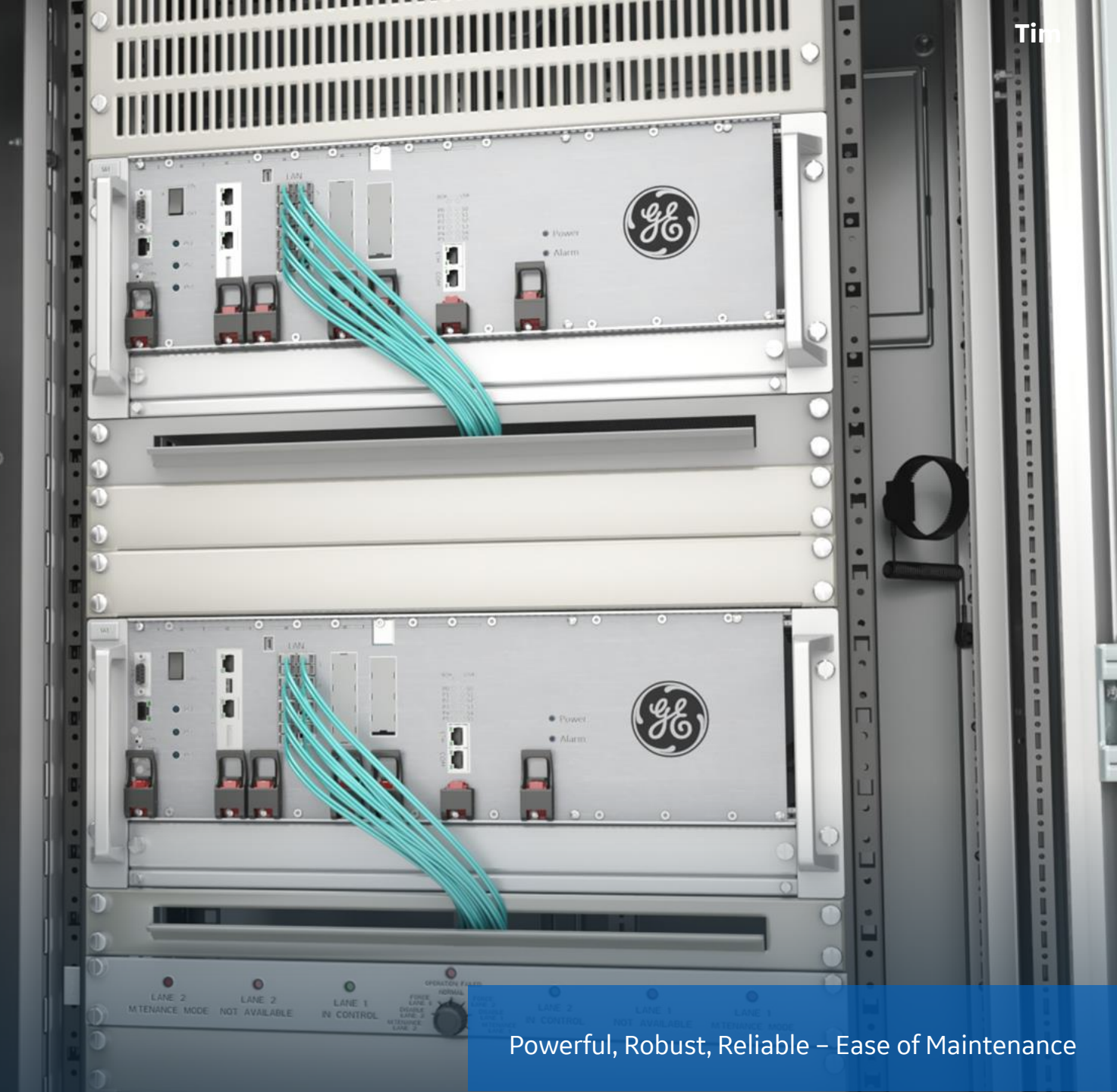
Powerful, Robust, Reliable – Ease of Maintenance

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HVDC DIGITAL SUBSTATION

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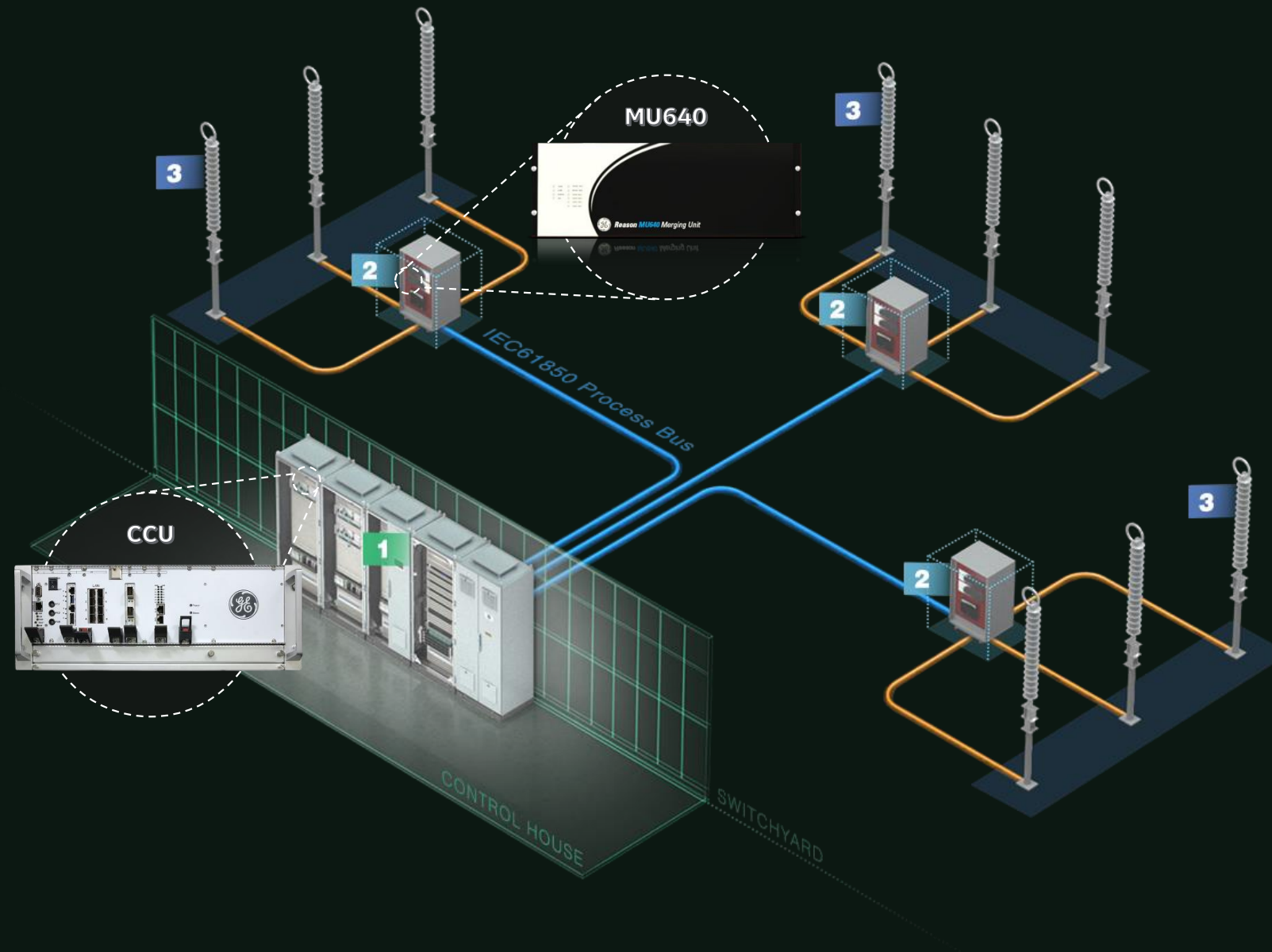
1	Network Interface cabinet w/ Fiber Optics
2	Remote Interface Cabinet w/ MU640 Merging Unit
3	Primary Equipment

Fastest Core Computing and Merging Units for HVDC applications

Network Interface Cabinet - **NIC**

The digital hub coordinating all communications between the HVDC system elements. Interconnects control and protection racks and digital substation via duplicated optical networks

- Two NICs are required for a Pole or a Bipole

- Proven and ruggedized gigabit optical ethernet network switches (GE S20 family)

- All network paths are duplicated via PRP or from source

- IEEE1158 v2 PTP is used to provide an accurate (1us) time system

- Type-tested for compliance with HVDC substation level requirements dictated by IEC61850-3

- Low power, thermally efficient and reliable design

- High reliability, full optical interconnections, no media converters

1	GE Reason RT430 Precision Time Clock
2	GE Reason S20 Industrial Ethernet Switches
3	IEC61850-compliant industrial servers
4	Optical Communication Patch Panel

Network Interface Cabinet

Network Interface Cabinet

REMOTE INTERFACE CABINET

LEARN **MORE**

Fully optical ruggedized digital communication Hub
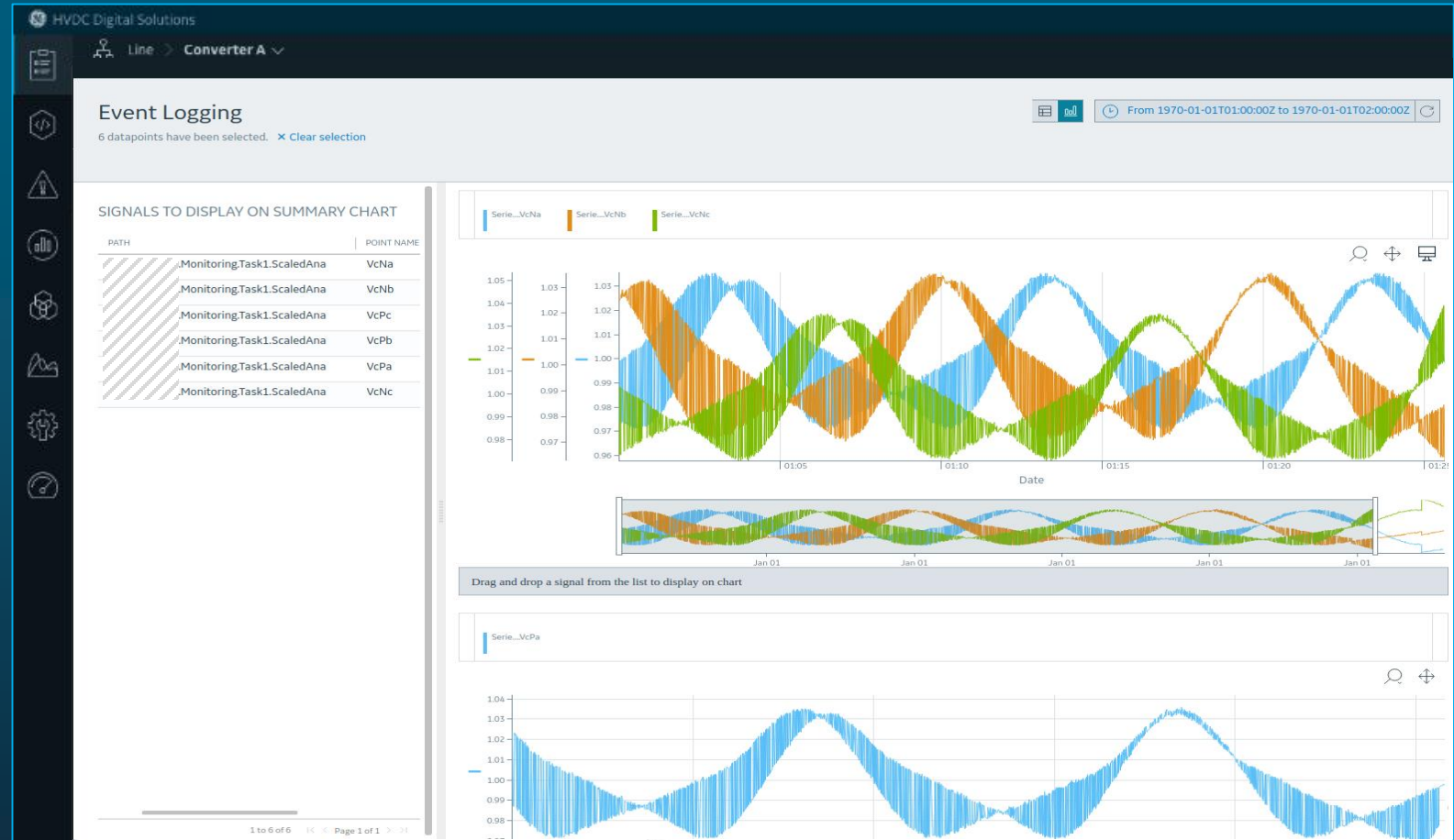
Introducing **eLumina**^{TM} Explorer

- Modern HTML5 web interface

- Real-time visualization

- Configuration and commissioning

- Analyze transient fault records

- Signal historian

Examples:

- Real-time status

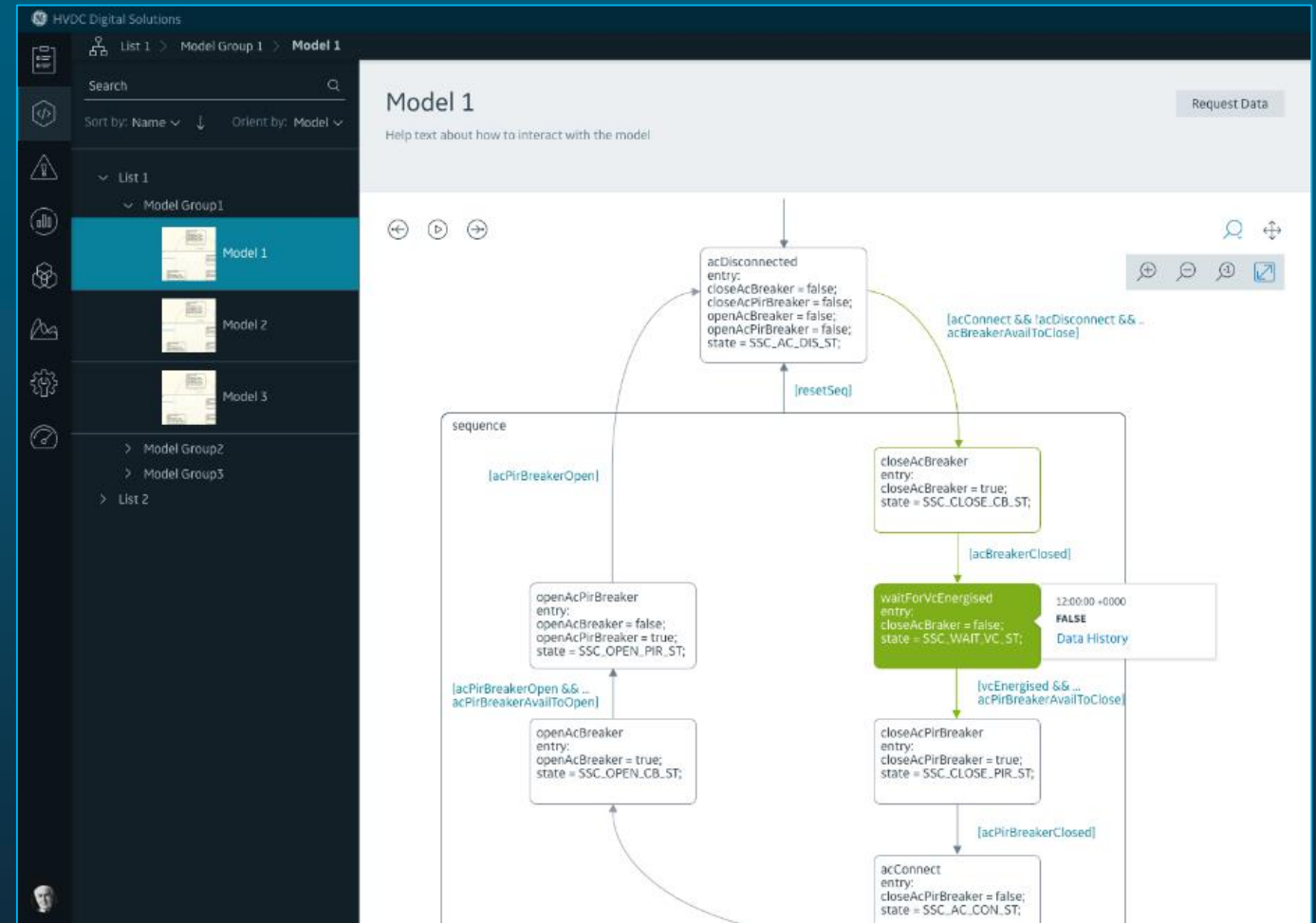- Live debugging capability

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QUESTIONS