# Acknowledgement

# Team

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# Need for Data

## High Solar Penetration Distribution Grids

# Monitor/Control BTM Devices

**Extend secure utility reach behind the meter to achieve:**

Situational Awareness → DER Control → Robust Grid

**Reliability**
Reduce/Prevent **INTERNAL** Risks/Failures

**Security**
Reduce/Prevent **EXTERNAL** Risks/Failure

**Resiliency**
Tolerate **INTERNAL/EXTERNAL** Failures
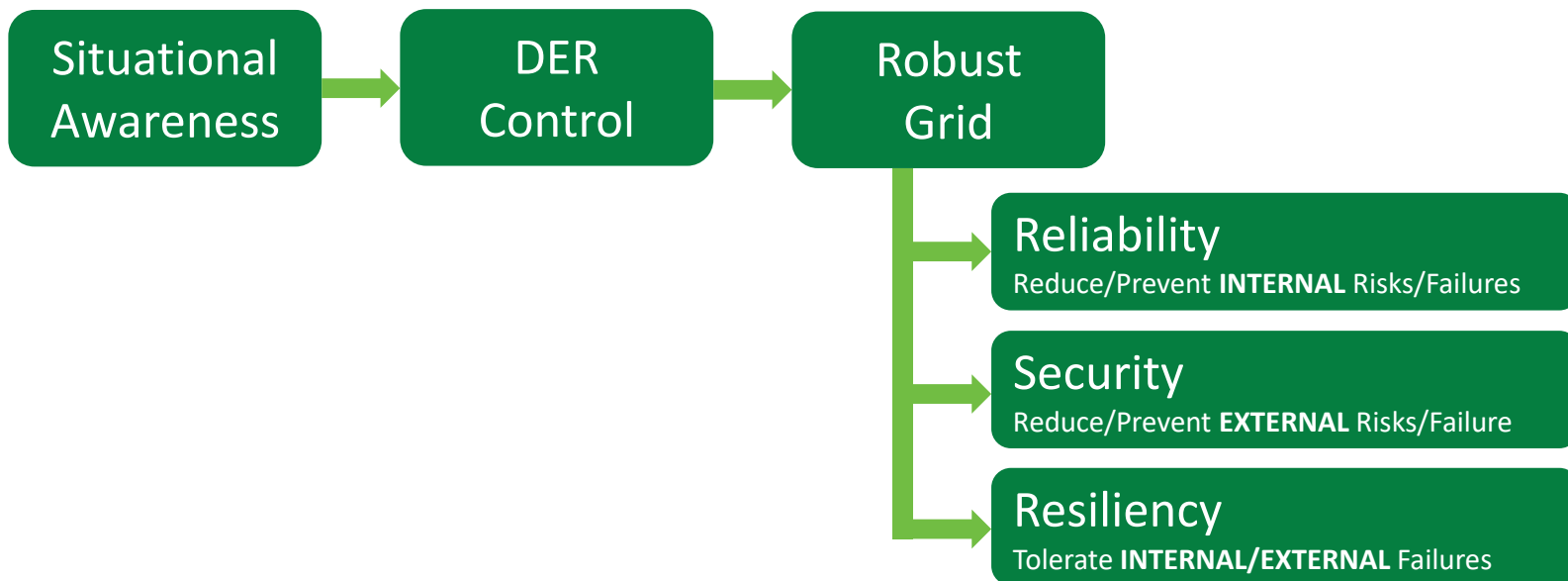
# Situational Awareness

## Monitor BTM devices

- Monitor performance of DER and grid
- Increase operational flexibility – optimize grid operations
- Improve safety – detect faults and disturbances
- Increase reach and affordability of DER – customer participation
- Solve technical, economical, and regulatory challenges

# DER Control

## Control BTM devices

- Improve performance of DER and Grid
- Deploy diverse DER options behind the meter
  - EVs, residential storage, demand response, dispatch DER
- Take advantage of grid-planning tools
  - Time of use controls
- Use advanced analytics
- Improve safety

# Robust Distribution Grid

## Reliable, Secure, and Resilient

- Prevent, withstand, and recover from cyber attacks
- Harden against and recover from natural disasters
- Detect, mitigate, and recover from faults
- Improve grid reliability metrics under high DER penetration
- Increase energy diversity
  - EVs, residential storage, demand response
- Lower operational costs

# Data Challenges

**High Solar Penetration
Distribution Grids**

# Data Generators (Publishers)

## End devices provide data in multiple formats
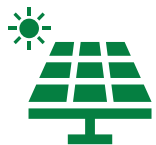
Modbus, DNP3, 2030.5

Bacnet, Ethernet/IP

Modbus, Ethernet/IP, SNMP

EtherCAT, Ethernet/IP

OCPP, ISO15118

Bacnet, Canbus, Ethernet/IP

DNP3, 61850, 2030.5

Modbus, MID, DNP3

# Data Access

## Direct access to generated data is inadequate

- End devices have existing communication channels to proprietary cloud systems
  - Some have APIs (REST or otherwise) to cloud systems
- Sampling intervals are not uniform and in order of several minutes
  - Data may not be timestamped
- Accessibility is limited to manufacturer and device owner
  - Upstream (commercial cloud, utility ADMS/DERMS) communication limited
- Temporal resolution and type of data is not sufficient for situational awareness
  - External sensors may be required

# Data Storage

## Local database and management missing

- Produced data must be consumed immediately – no (limited) local storage
- Data management insufficient for robust DER control
  - Historical data cannot be queried
  - Minimal data management for device operation, interaction with subsystems, or local interfaces

# Edge Intelligence

## Local computing capabilities non-existent

- Interface to end device intelligence limited to parameters and configuration
- Capabilities limited to manufacturer provided platforms
- Limited built-in analytics
- Little to no cybersecurity or physical security

# Edge Intelligent Devices

## High Solar Penetration Distribution Grids

# Intelligent Edge Platform

## Open technology platform solution

- The edge platform acts as an interface between intelligent end devices and utility/open cloud
- Use open software standards
  - IEC61131-3 and real-time capabilities
  - Support for high level languages (Python, C++, MATLAB) - Advanced analytics
  - Open Linux OS - Support for containers
  - Advanced cybersecurity
- Vendor agnostic hardware platforms

# Edge Platform



**Edge Platform**

| Control Power | Open Operating System | | |
|---|---|---|---|
| Battery Backup | IEC61131-3 | RTOS | FPGA |
| Communication Links | Protocol Converter | Local Storage | Cellular |
| I/O Interface | Meterology | Historian Database | Cybersecurity Modules |
| GPS | Time Synchronization | Data Concentrator | Utility Switches |
| HMI | Visualization | Analytic Modules | RF/MIMO |

End Devices ⟷ LAN ⟷

Sensors Actuators ⟷

Internet — Commercial Cloud
MQTT; REST API

FAN — Utility ADMS, DERMS
DNP3; IEEE2030.5

# EID Feature Comparison

| Feature | Utility Data Concentrator | EID |
|---|---|---|
| Ruggedized industrial hardware | ✔ | ✔ |
| Multi end device (DER) hardware interfaces | ✔ | ✔ |
| Cloud communication channels | ✔ | ✔ |
| Digital and Analog IO | ✔ | ✔ |
| IEC61131 – Real time and industrial automation | ✔ | ✔ |
| Local storage historian | ✔ | ✔ |
| Standard utility/industrial protocols | ✔ | ✔ |
| Protocol conversion | ✔ | ✔ |
| Time synchronization – GPS, NTP, PTP | ✔ | ✔ |
| Machine-to-machine (peer) communication | ✔ | ✔ |

# EID Feature Comparison (Cont.)

| Feature | Utility Data Concentrator | EID |
|---|:---:|:---:|
| IT firewalls and user authentication | ✔ | ✔ |
| NERC CIP and CAISO RIG certified | ✔ | ✖ |
| Open platform – Linux OS access | ✖ | ✔ |
| High level language support – Python, C++, Matlab | ✖ | ✔ |
| Use open-source libraries, containers, and software | ✖ | ✔ |
| Protocol development e.g., IEEE 2030.5, non-standard, or future | ✖ | ✔ |
| Intrusion and anomaly detection – OT cybersecurity | ✖ | ✔ |
| IOT protocols for cloud (AWS, Google, Azure) integration | ✖ | ✔ |
| Vendor agnostic COTS platform | ✖ | ✔ |

# EID Hardware Proof of Concept

- COTS (Commercial Off-The-Shelf)
  - Proven long life in multiple installation environments
  - Repairable system
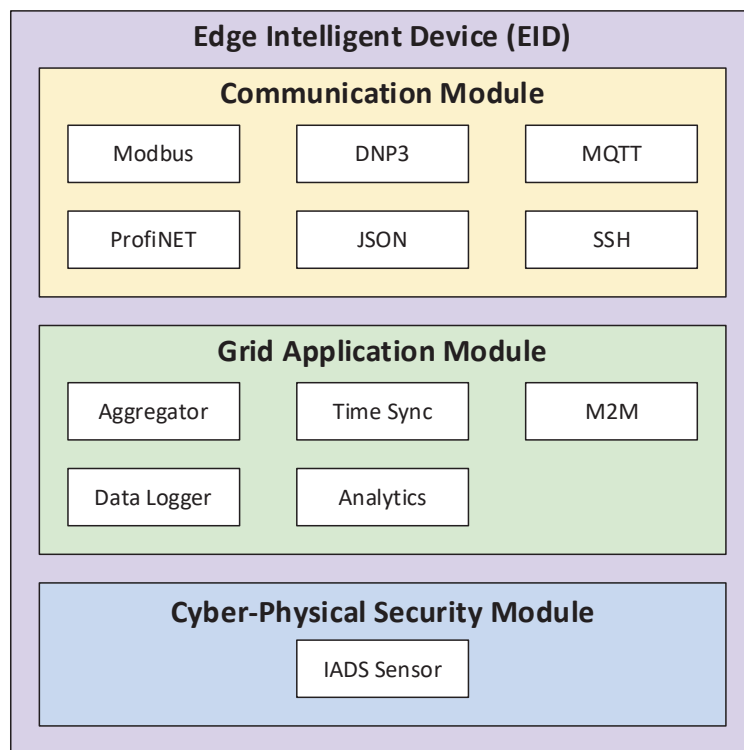  - Easy maintenance
  - Adaptable and scalable
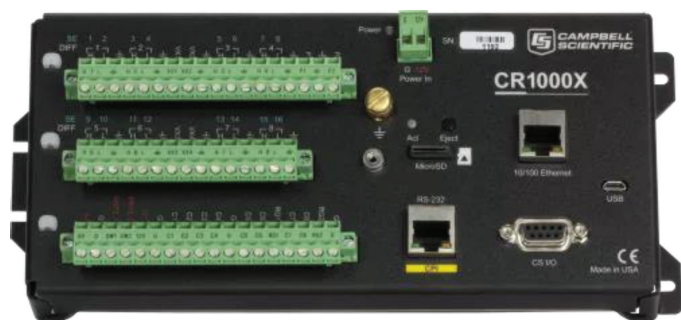
**PLCNxt® from Phoenix Contact**



**cRIO®/LabView® from NI**

# EID Software Architecture



**Edge Intelligent Device (EID)**

**Communication Module**

| Modbus | DNP3 | MQTT |
| --- | --- | --- |
| ProfiNET | JSON | SSH |

**Grid Application Module**

| Aggregator | Time Sync | M2M |
| --- | --- | --- |
| Data Logger | Analytics | |

**Cyber-Physical Security Module**

IADS Sensor

# Vendor Agnostic

# UL508A Industrial Control Panel

- UL Listed
  - Accepted by AHJ and utilities
  - Field installation ready
- US $2000 sell price
  - Per distribution transformer

# Thank You

**Dr. Devarajan Srinivasan**
**srini@poundra.com**