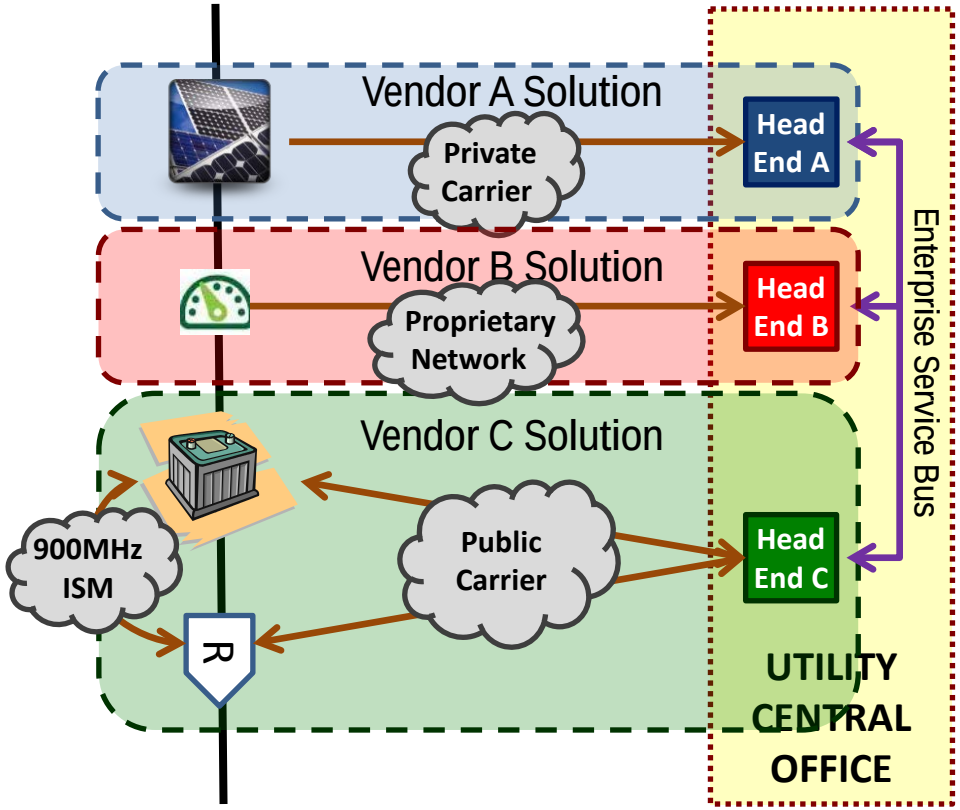
# Duke Energy Emerging Technology Office

# Adoption of an Open Field Message Bus (OpenFMB) Framework

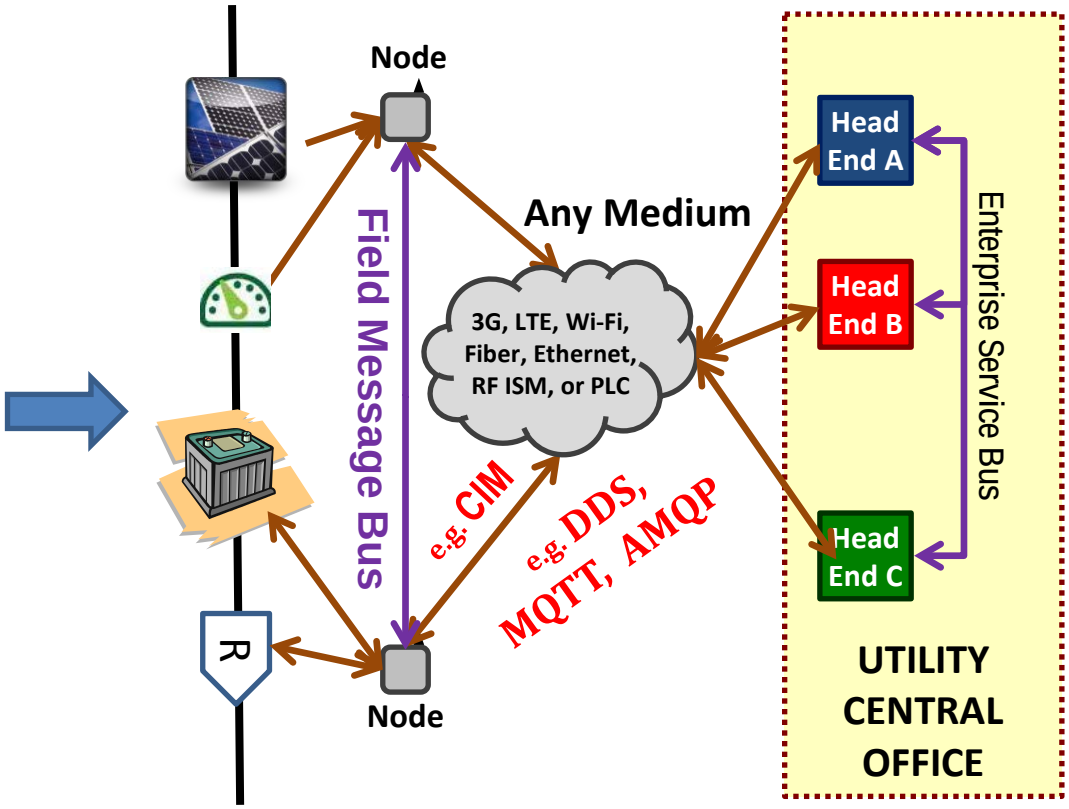
David Lawrence
Dwayne Bradley

# Enhancing DER Integration with OpenFMB




Key Observations:

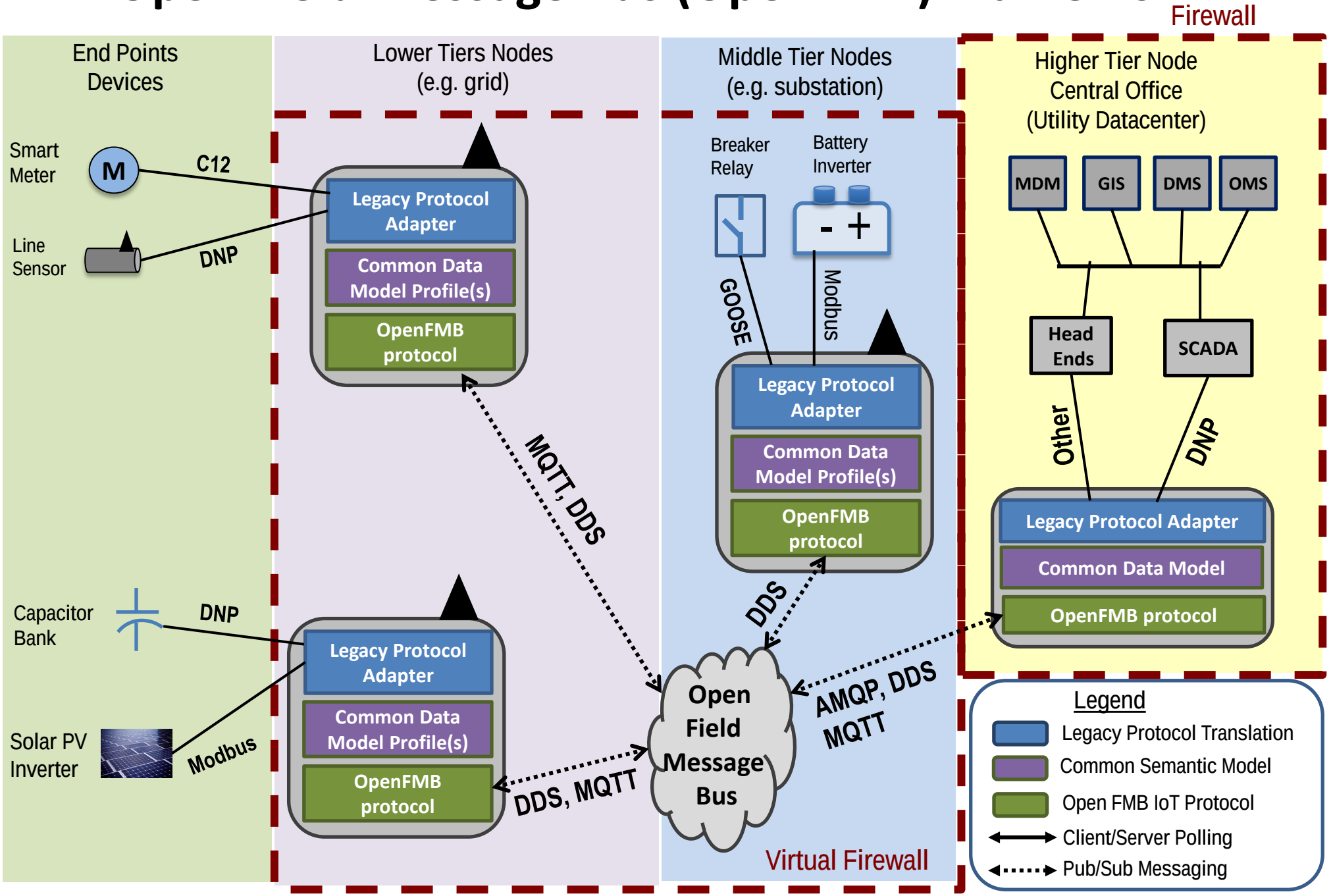
1. Single-Purpose Functions
2. Proprietary & Silo'ed systems
3. Latent , Error-prone Data
4. OT/IT/Telecom Disconnected
5. No Field Interoperability!




Key Observations:

1. Multi-Purpose Functions
2. Modular & Scalable HW&SW
3. End-to-End Situational Awareness
4. OT/IT/Telecom Convergence
5. True Field Interoperability!

# Open Field Message Bus (OpenFMB) Framework



# OpenFMB Operation: Federated Deterministic Exchanges

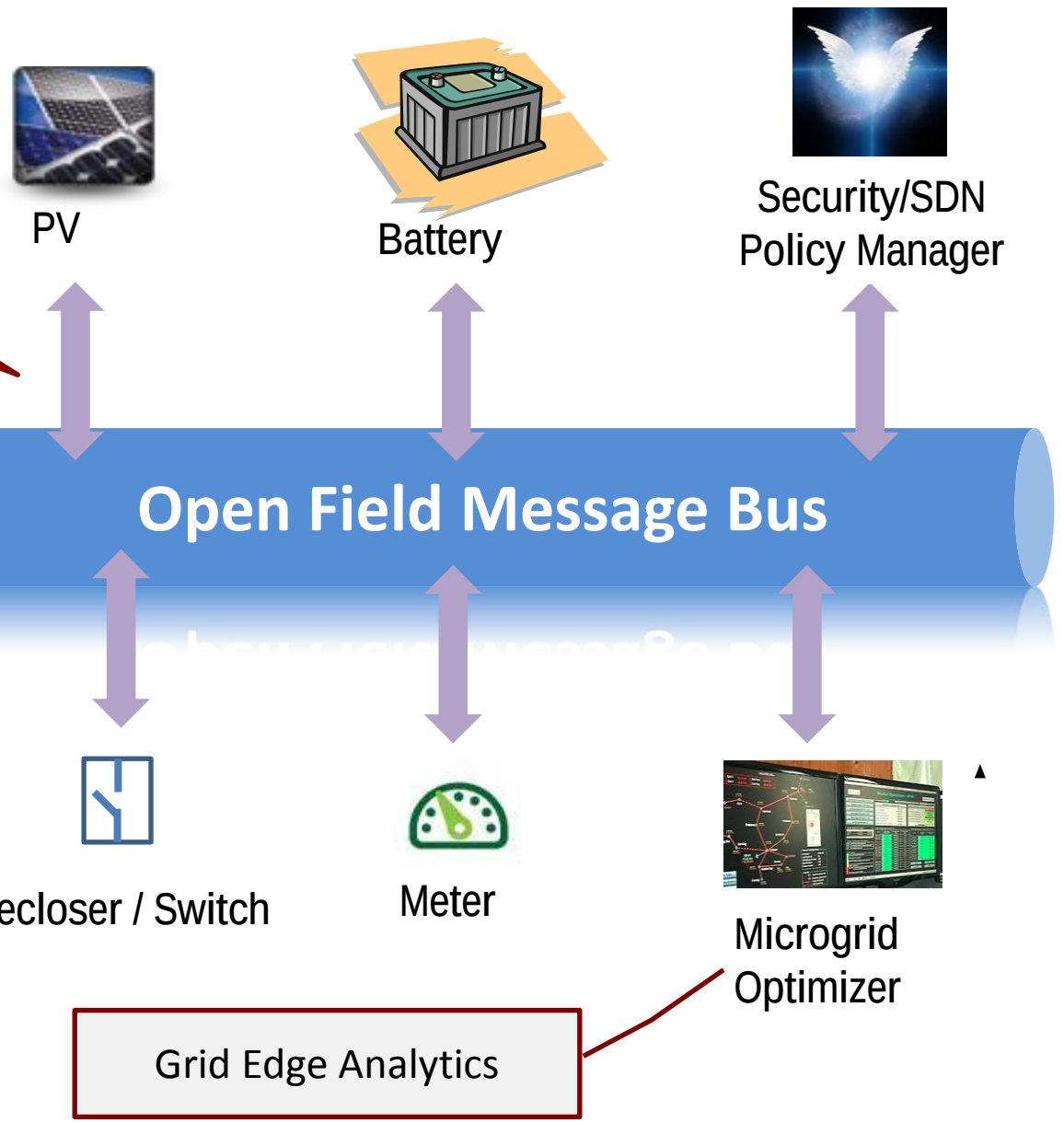
- Periodic Readings - Pub every few seconds or near-real-time
- Data-Driven Events – on status change in near-real-time

**Readings**

KW A/B/C
KVAR A/B/C
V A/B/C
I A/B/C
Phase Angle A/B/C
KWh
TimeStamp
State of Charge

**Status, Events, Alarms, & Control**

Trip / Close
TimeStamp



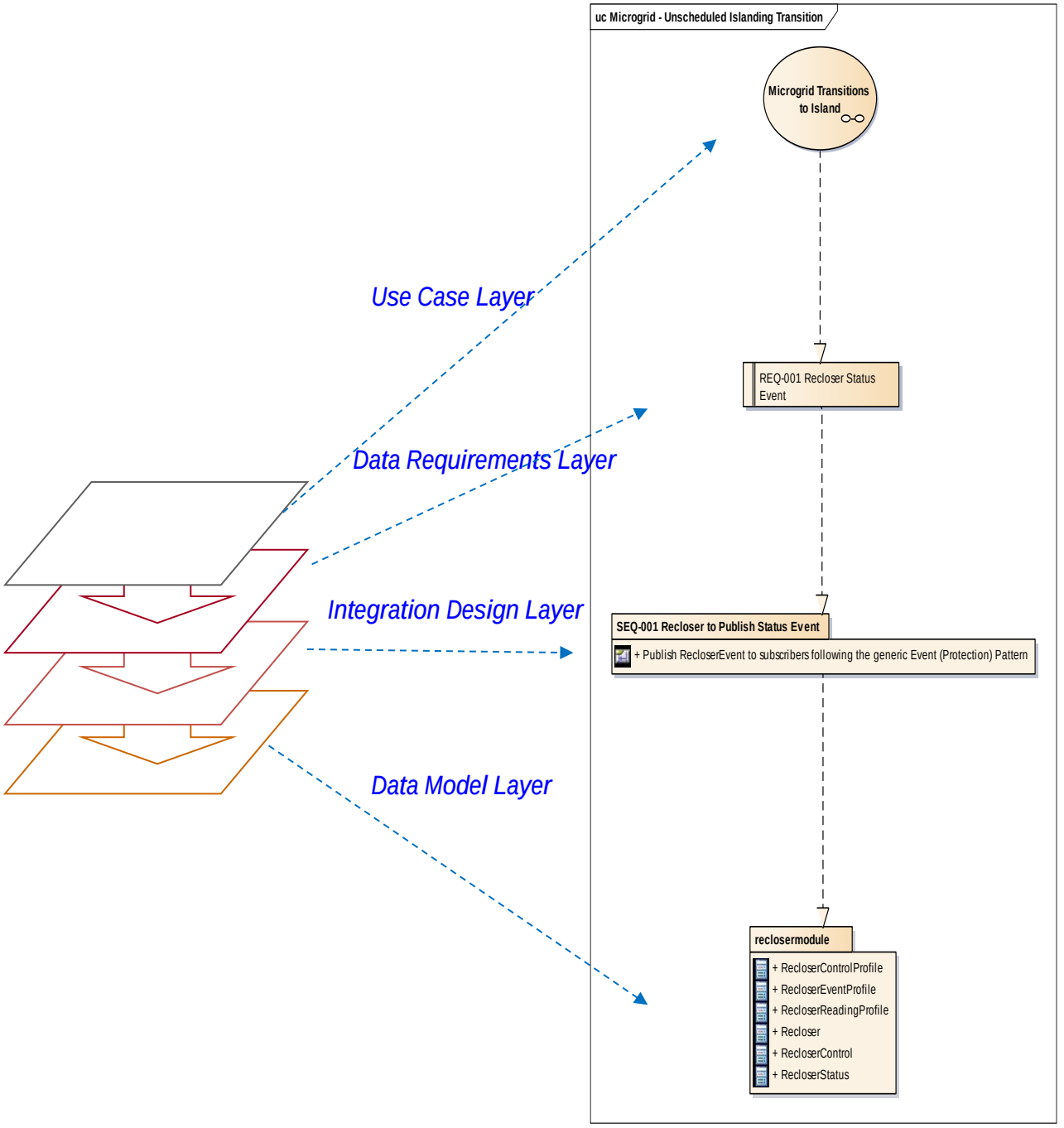
# OpenFMB Framework Life Cycle


- Business-driven solutions
- Functional and non-functional requirements
- Interaction and sequencing
- Profile of applicable, existing data model
- Common software definitions and language
- Software tools to allow actors to interoperate
- System integration and validation testing
- Updates and versioning

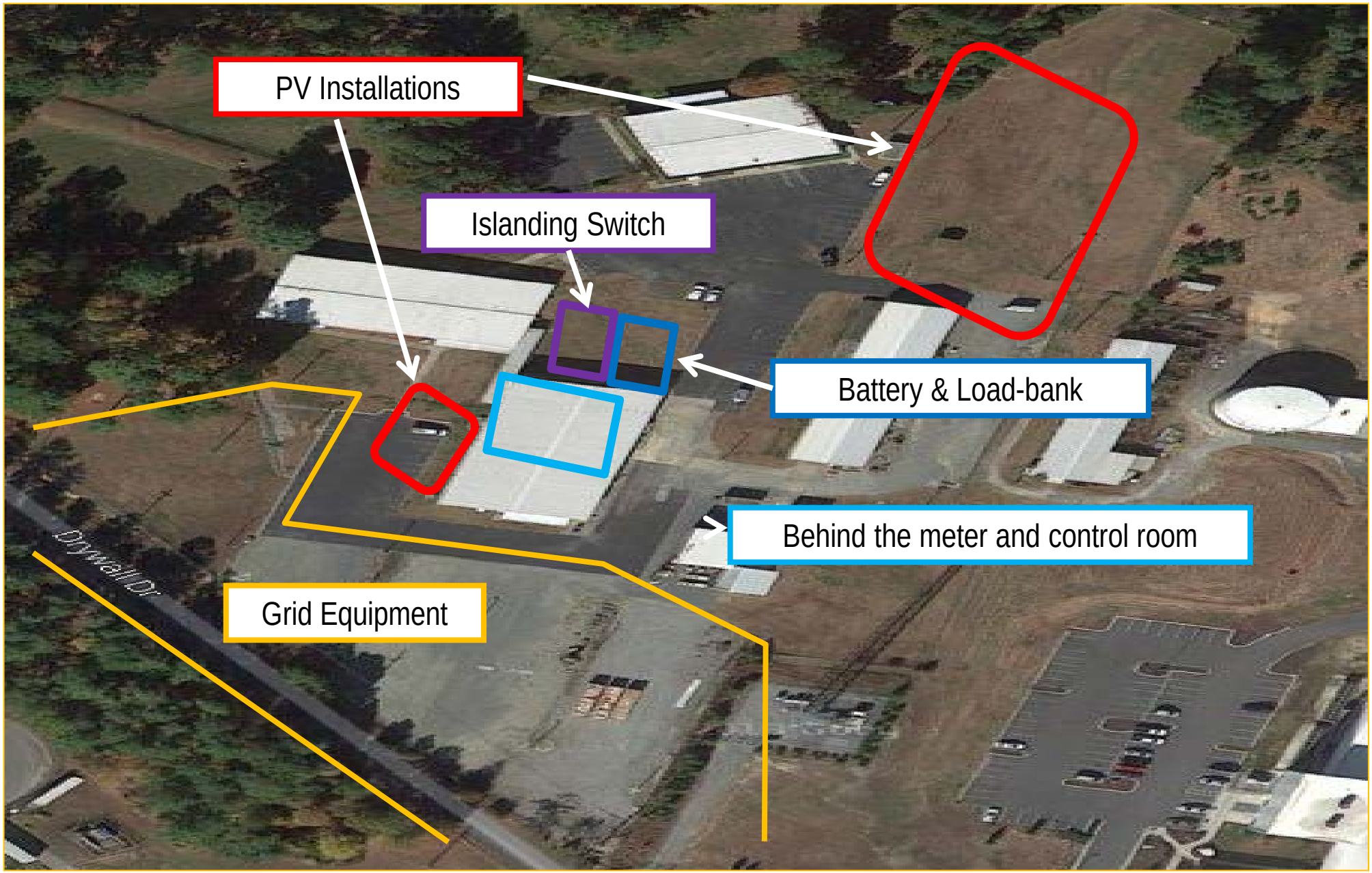
https://openfmb.github.io/

# OpenFMB Modeling Approach

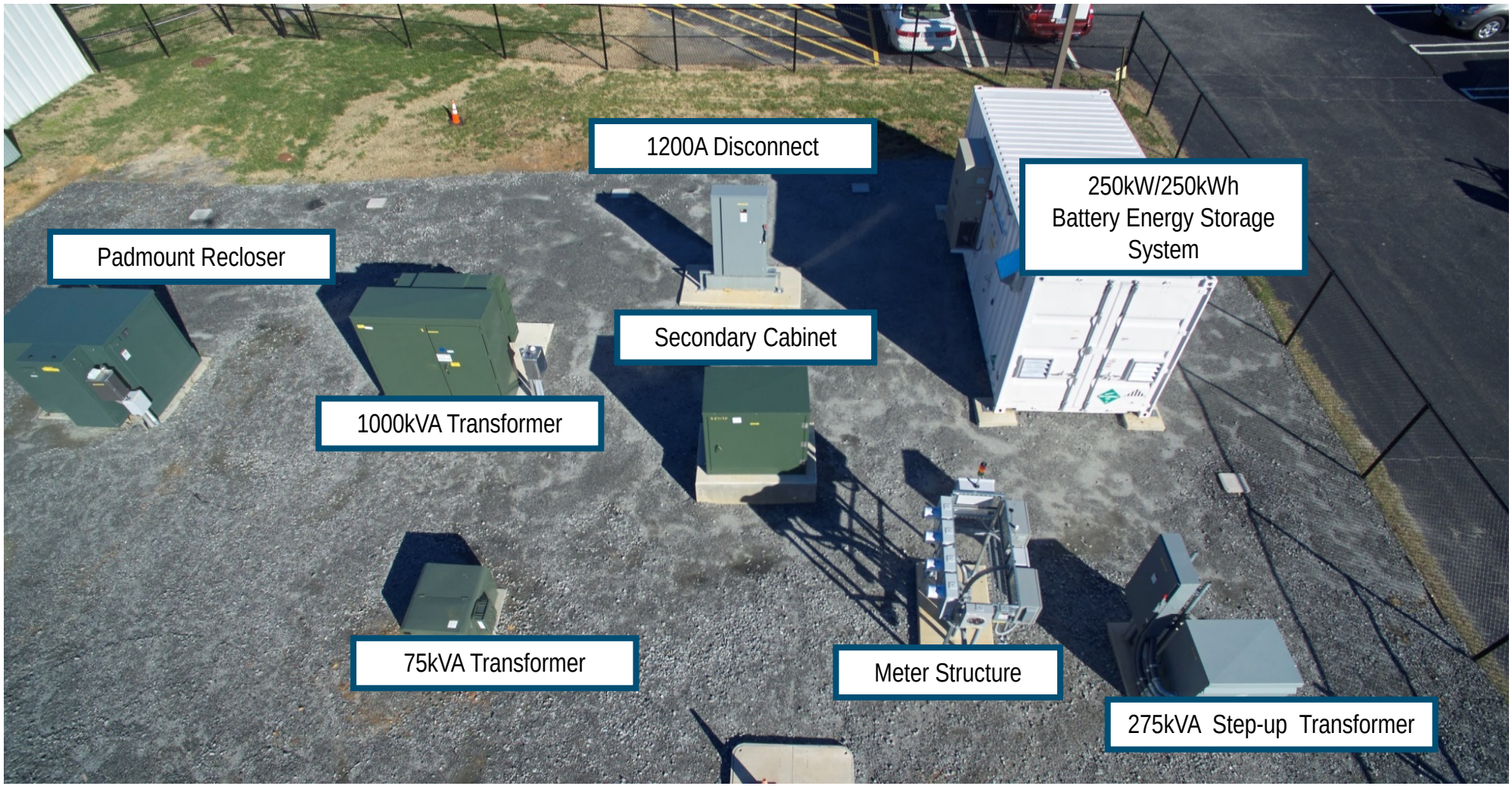
- Top-down business driven
- Layered architecture
  - Start with use cases and requirements
  - Structured in a single UML model
  - **Sparx EA** as modeling tool
  - Traceability among layers
- Model driven artifacts generation



# Duke Energy Microgrid Test Site: Mount Holly, NC

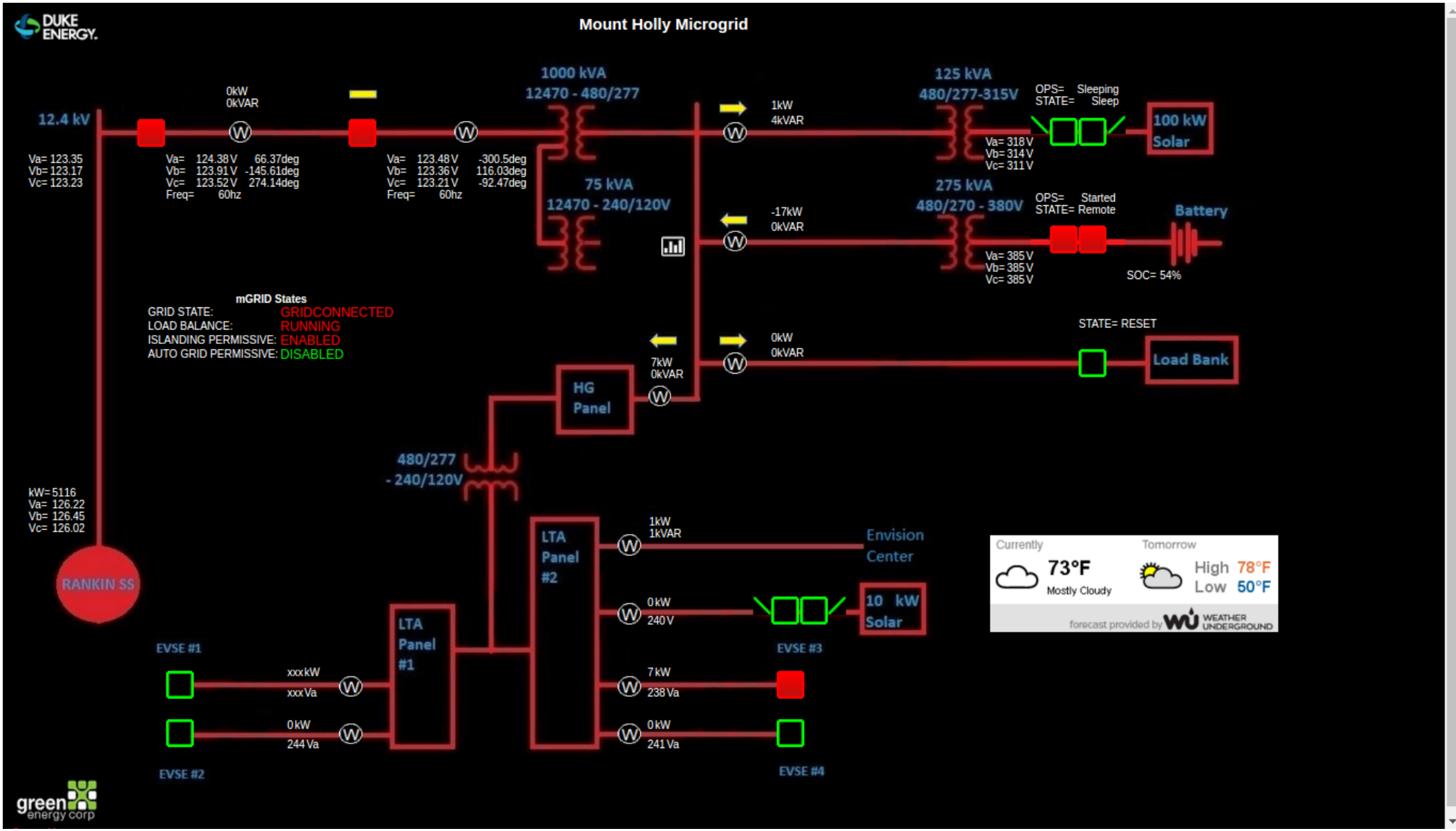


# Mount Holly Microgrid Components

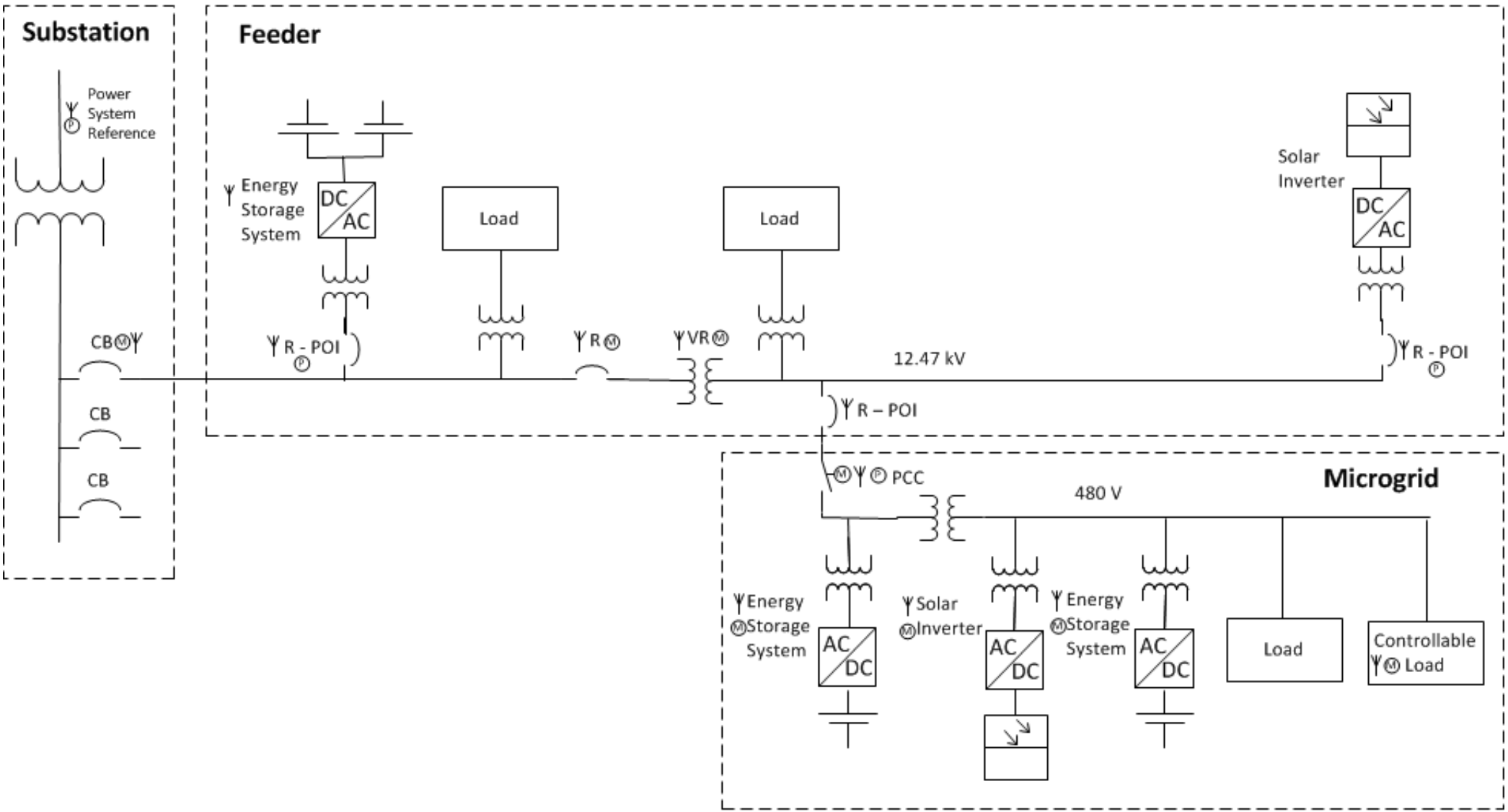



Not Pictured: 100KW PV system, 10KW PV rooftop, 500KW load-bank

# Mount Holly Microgrid One-Line Diagram



# 2017 Duke Energy Planned Pilot Circuit



# OpenFMB use-cases considered at Rankin/Mount Holly Sites

- Microgrid Management
  - Microgrid Optimization
  - Unscheduled Islanding Transition
  - Grid-to-Island Reconnection
- DER Circuit Segment Management
  - Primary Scenario: Voltage, Frequency, Power Factor support
    - DER Point of Interconnection (POI) Coordination
    - Point of Common Coupling (PCC) Coordination with Microgrid Use-cases
  - Secondary Extensions:
    - Solar Smoothing: Battery Optimization
    - Volt-Var Management: Power Factor Optimization
    - Peak Demand: Shaving/Shifting
  - Tertiary Extensions:
    - Distribution Transfer-Trip
    - Anti-Islanding: Inadvertent Island Detection
- Management Services
  - Visualization: Geospatial Mapping
  - Certificate/Key Management: Authentication/Authorization
  - Policy-based Configuration: Physical Tamper Detection

# Data Modeling

## Reference Models

Standard UML

### Reference Model

- Standards such as IEC 61968 / 61970 CIM & IEC 61850
- Provide objects and relationships for OpenFMB requirements
- Application independent, but defines all concepts needed for any application

## Context (Profile)

OpenFMB Profiles

### Contextual layer restricts information model and extends as needed

- Cherry-picking reference model for given profile
- Restrictions and extensions
- Mandatory and optional
- Propose extension to the standards / reference models

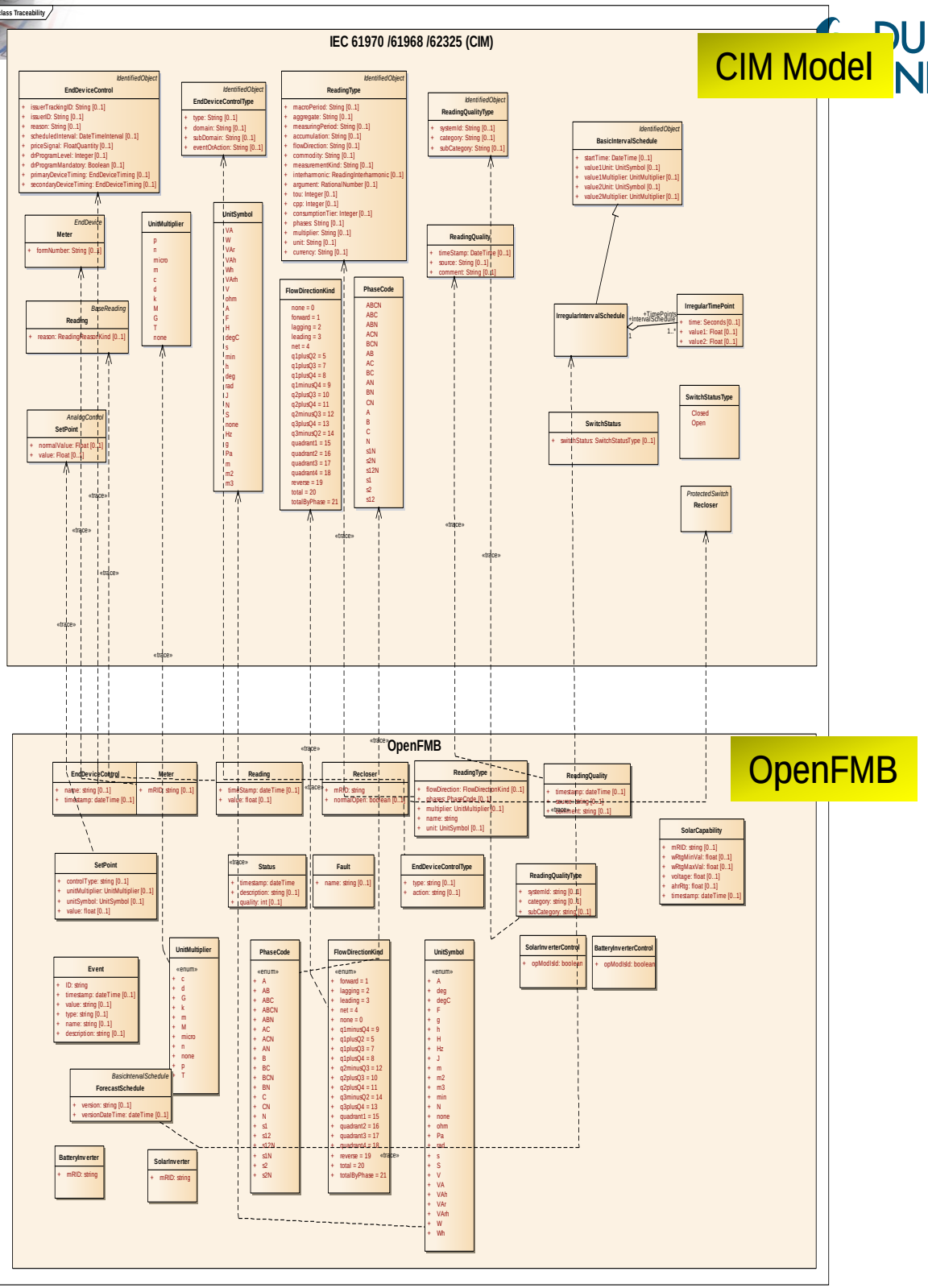
## Message Syntax

Message/File Format (XSD, IDL and etc.)

### Message syntax describes format for instance data

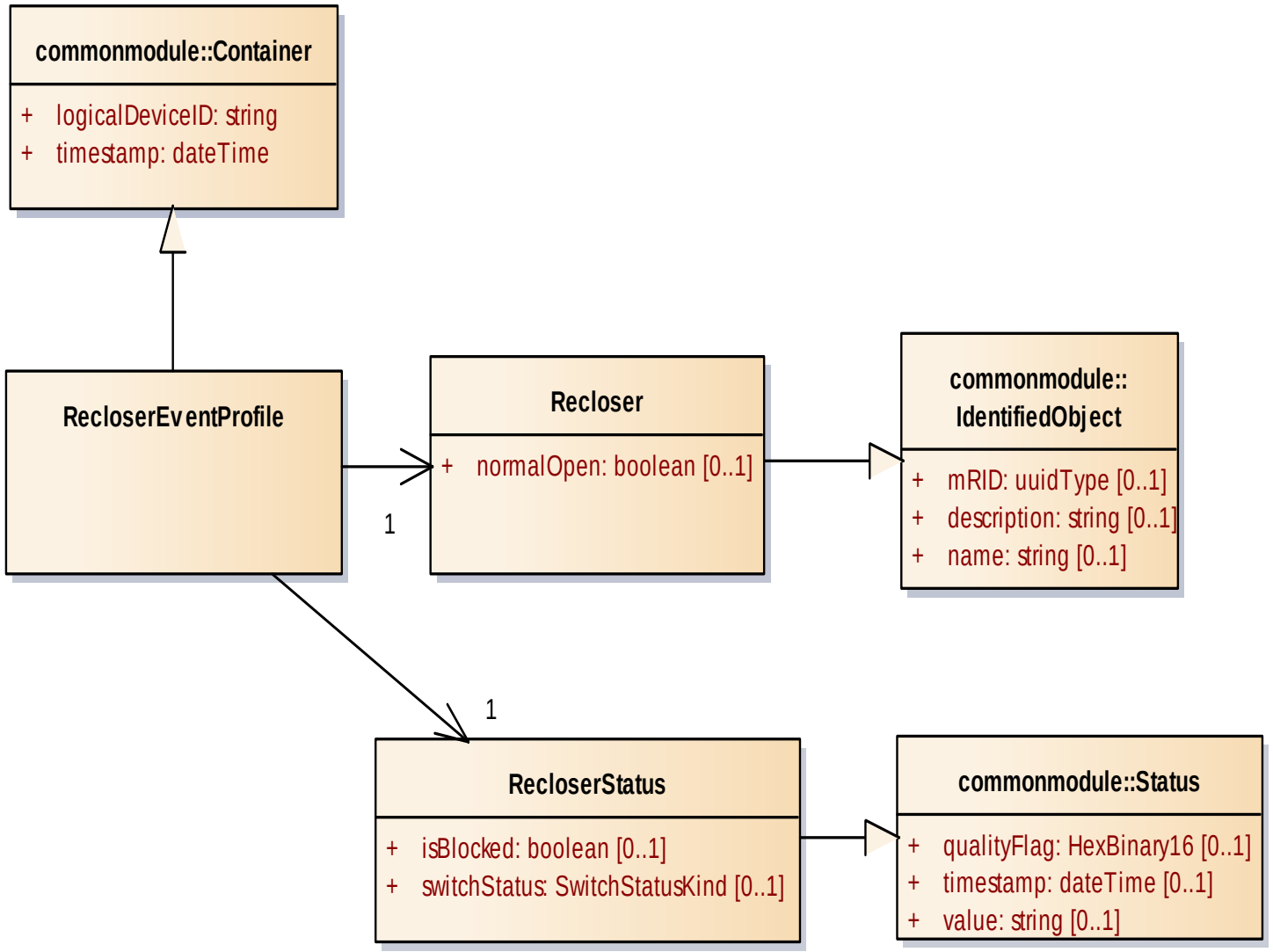
- Model driven artifacts generation
- Serialization of instance data
- May modify container or associations for message payloads
- Mappings to various technologies can be defined

# Traceability



# Platform Independent Model

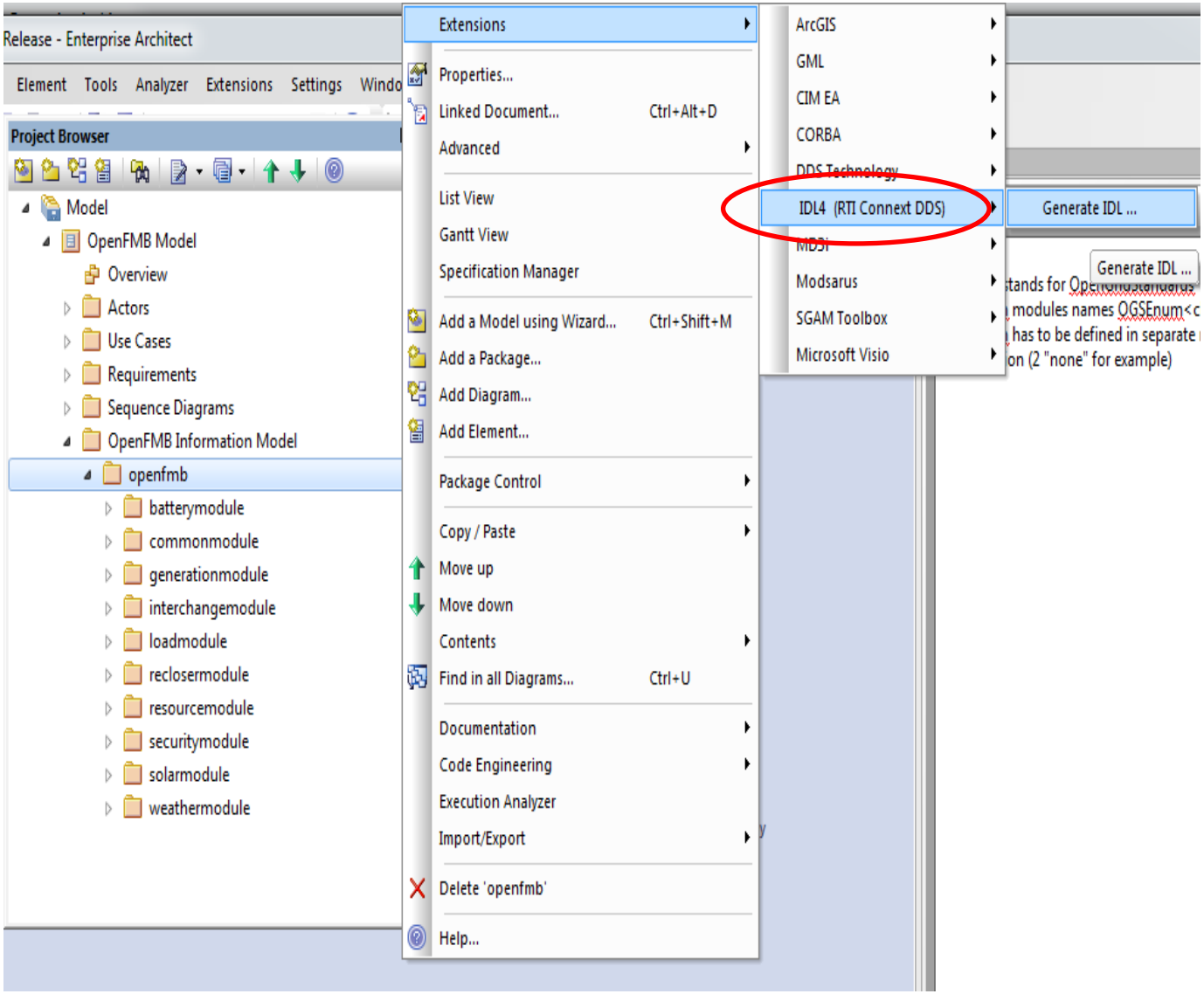
- Logical model (Profile) built based on the mapping



# IDL Generation Tool

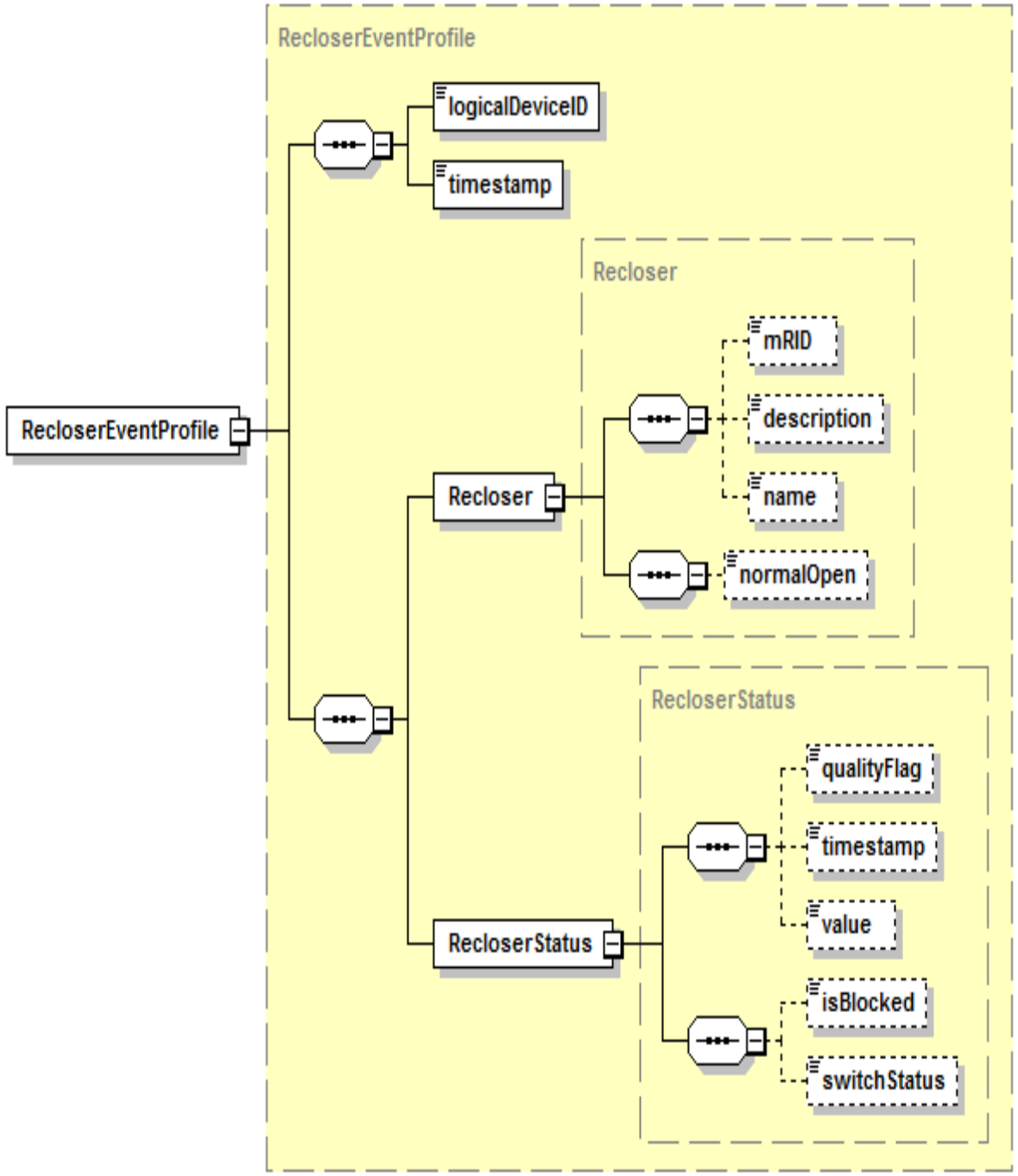
- RTI IDL4 for IDL generation
- Link to RTI plug-in

https://github.com/rticommunity/idl4-enterprise-architect/

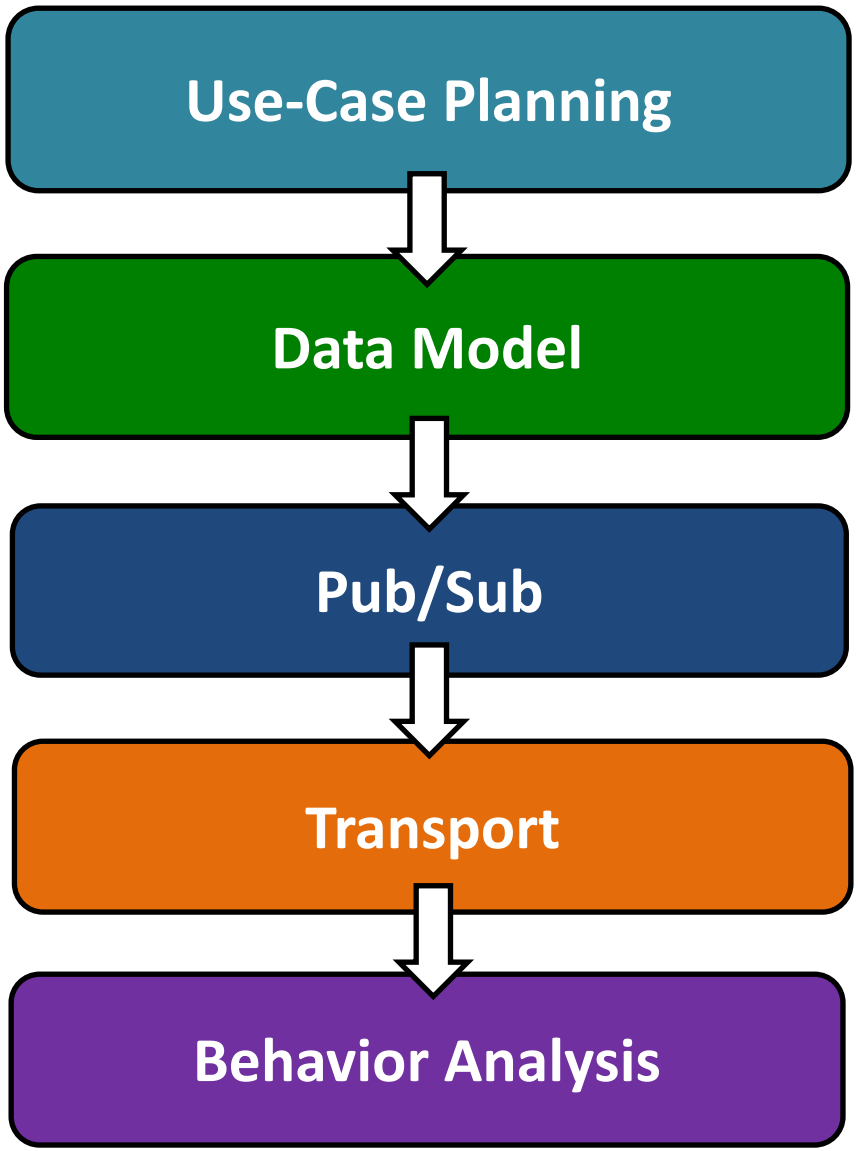


# Platform Specific Model

- Physical implementation artifacts such as XSDs & IDLs are generated from the logical model



# OpenFMB Security Analytics Framework




## Describe

**Identifying Normal Behavior & Good Actors: Commissioning, Updating & Operating**

## Define

**Profiles, Topics, Semantics, Behavior: Operational Functions & Security Policies**

## Messaging

**White-listed, Authenticated, & Encrypted Payloads: DDS Secure on top of the UDP/IP or TCP/IP**

## Transport

**Transport Layer Security (TLS) 1.2 or plug-in**

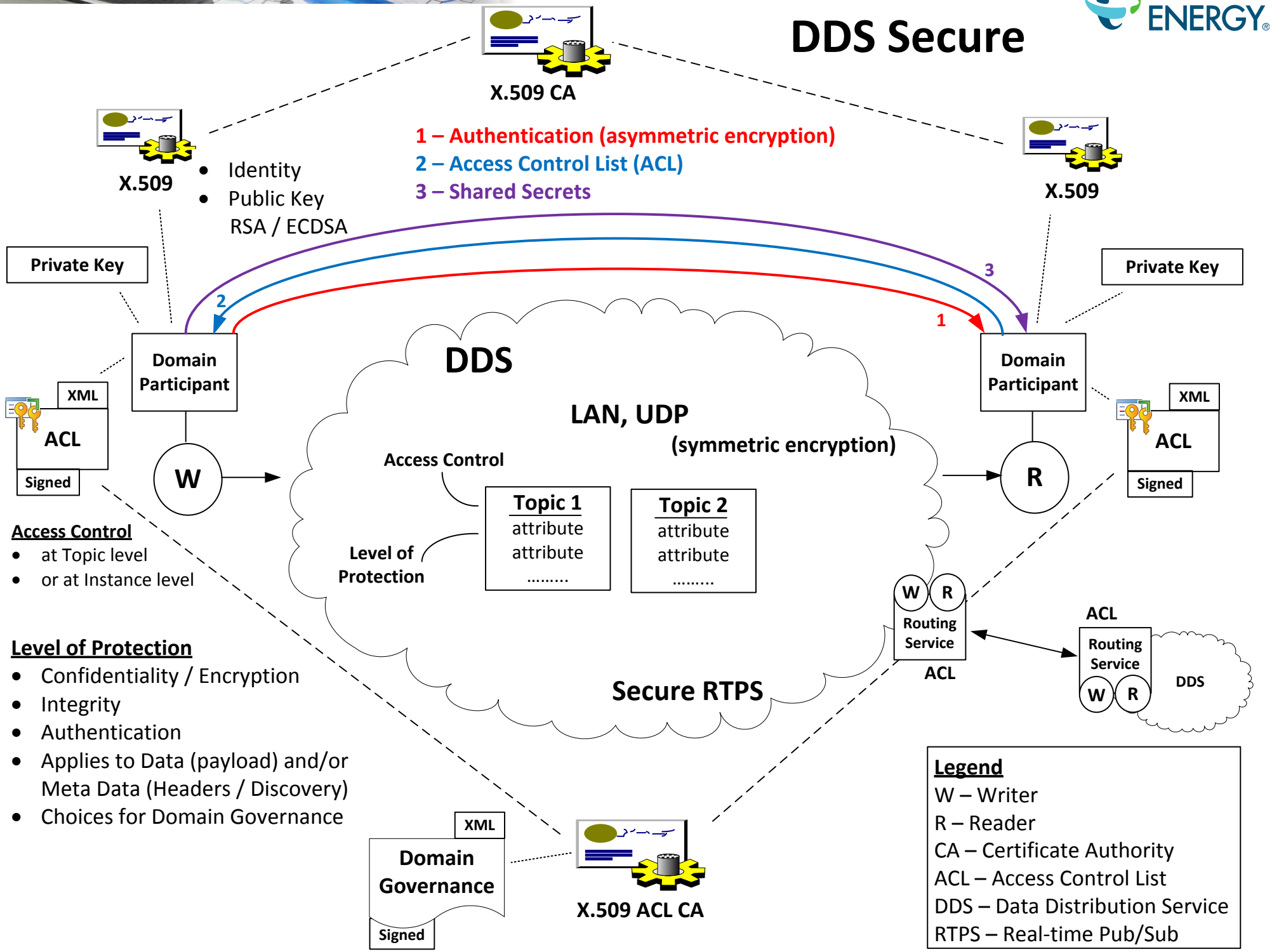
## Security Behavior Analysis

**Intrusion Detection & Machine Learning: Domain Knowledge: Detect, Isolate, Restore**

# Standard DDS Security Plug-in Capabilities

| | |
|---|---|
| Authentication | • Public Key Infrastructure (PKI) with a pre-configured shared Certificate Authority (CA)<br>• Digital Signature Algorithm (DSA) with Diffie-Hellman for authentication and key exchange |
| Access Control | • Specified via permissions file signed by shared CA<br>• Read and write data topics<br>• Control over ability to join systems |
| Cryptography | • Protected key distribution<br>• AES encryption<br>• HMAC-SHA for message authentication and integrity |
| Data Tagging | • Tags specify security metadata, such as classification level<br>• Can be used to determine access privileges (via plugin) |
| Logging | • Log security events to a file<br>• Distribute securely over DDS |

# DDS Secure

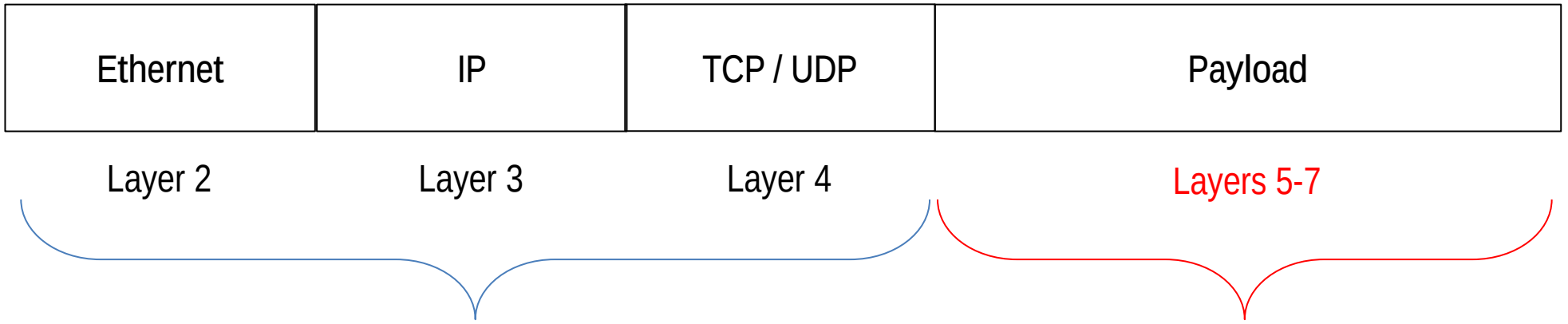



**Access Control**
- at Topic level
- or at Instance level

**Level of Protection**
- Confidentiality / Encryption
- Integrity
- Authentication
- Applies to Data (payload) and/or Meta Data (Headers / Discovery)
- Choices for Domain Governance

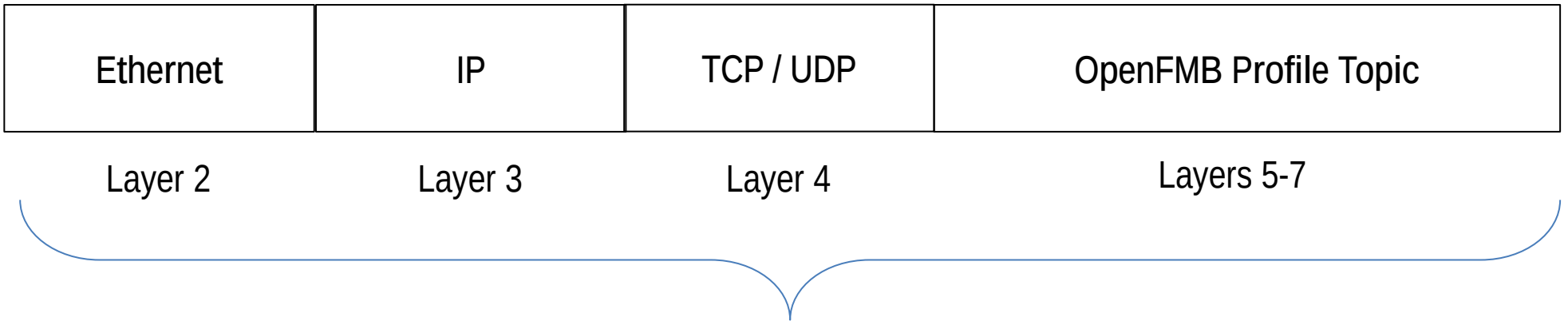
**Legend**
W – Writer
R – Reader
CA – Certificate Authority
ACL – Access Control List
DDS – Data Distribution Service
RTPS – Real-time Pub/Sub

# Integrating SDN into the OpenFMB Framework




SDN Flow Control:
Policy-based Network Management

Conventional SCADA protocols:
Unencrypted Raw Data




OpenFMB w/ SDN:
End-to-End Data Management with Whitelisted and Authenticated Topics

# Best Practices / Lesson Learned

- Clear understanding of Microgrids and distributed systems
- Great Teamwork needed across Standards, SGIP, NAESB, OMG, Utilities, and Vendor communities
- Use Case and Data Modeling Team consists of Power Systems, Data Modeling, Computer Architecture, and Embedded Systems Engineers
- Reliability & Determinism of Network & Protocols
- Deny-by-Default/White-listing and Traffic Engineering
- Intrusion Detection & Behavior Analysis
- Authentication, PKI, Certificates, Confidentiality, & Authorization
- Logging , Auditing, & Adherence to Standards
- Configuration, Security, Patch Management
- System Wide Visualization & Case Tracking
- Specific Procurement Language for Hardware and Systems

# Discussion – Q&A