SDG&E EPIC Program Overview

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Presented by: Frank Goodman, SDG&E
EPIC Symposium
February 7, 2018

EPIC-1

1. **Smart grid architecture demonstrations**
2. Visualization and situational awareness demonstrations
3. Distributed control for smart grids
4. **Demonstration of grid support functions of distributed energy resources (DER)**
5. Smart distribution circuit demonstrations

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EPIC-2

1. Modernization of distribution system and integration of distributed generation and storage

2. Data analytics in support of advanced planning and system operations

3. Monitoring, communication, and control infrastructure for power system modernization

4. System operations development and advancement

5. Integration of customer systems into electric utility infrastructure

6. **Collaborative programs in RD&D consortia:**

   - **Unmanned aerial systems data lifecycle management and deep learning**

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EPIC-3 (pending approval)

1. Integration of battery and photovoltaic systems into utility operations
2. Energy storage performance evaluation
3. Application of advanced metering infrastructure (AMI) data to advanced utility system operations
4. Safety training simulators with augmented visualization
5. Unmanned aircraft systems (UAS) with advanced image processing for electric utility inspection and operations
6. Repurposing post electric vehicle batteries for utility, commercial, and mass transit applications
7. Demonstration of multipurpose mobile battery for port of San Diego and/or other applications

SDG&E Integrated Test Facility in Escondido

SDG&E EPIC website

www.sdge.com/epic

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Demonstration of Grid Support Functions of Distributed Energy Resources (DER) EPIC-1, Project 4

Presented by: Amin Salmani, SDG&E
EPIC Symposium
February 7, 2018

Outline

- Project objectives
- Module 1: Value assessment of grid support functions of DER
  - Project approach, real-time modeling, test scenarios, laboratory experiment performance, analyses, project findings
- Module 2: Demonstration of communication standards for grid support functions of DER
- Module 3: Pre-commercial demonstration of EPRI DRIVE DER hosting capacity tool

Project objectives

- Demonstrate grid support functions of DER, to assess value in improving **distribution system characteristics** and **operations**
- Determine **operational requirements** for control and dispatch of specific grid support functions in viable application situations
- Pilot tests for grid support DER functions to observe how well they operate in specific locational and operational situations

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Project approach

Module 1

- Developed Real-Time Digital Simulator (RTDS) model for a typical distribution circuit for use in Power Hardware in-the-Loop (PHIL) demonstration
- Conducted PHIL testing using grid simulator, inverter, and a DC source to study response of an actual small-scale inverter in different DER grid support scenarios
- Tested different use cases in PHIL setup to assess value of DER grid support functions
- Documented procedure, findings, and value propositions for grid support functions in a comprehensive final report

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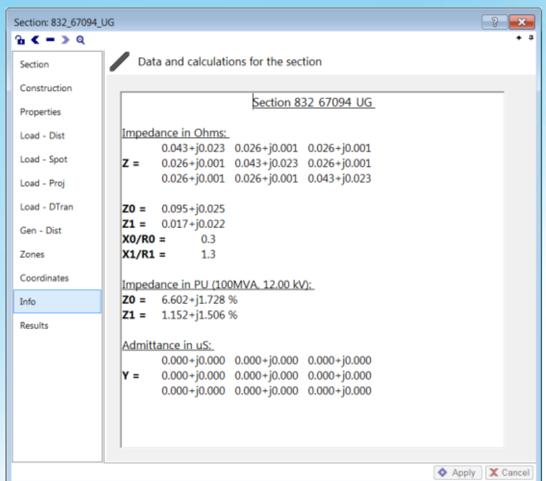
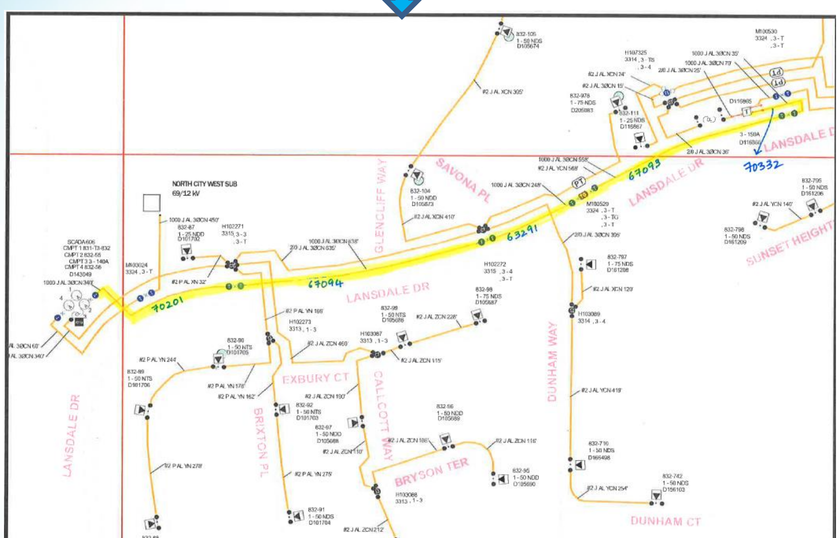
RTDS model development

Module 1

Translation of Synergi section and load data into RSCAD



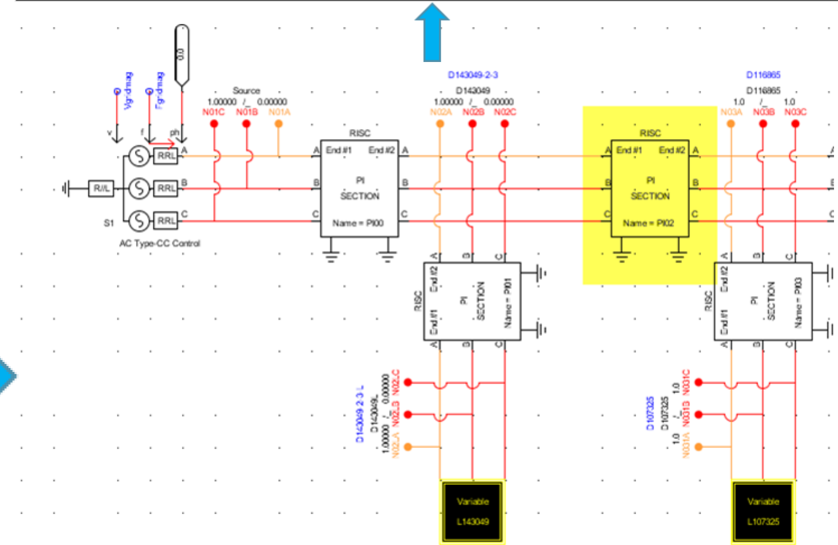


lf_rtds_sharc_sld_PI3

PARAMETERS | MONITORING SELECTIONS | MONITORING NAMES | CONFIGURATION | PROCESSOR ASSIGNMENT

Name	Description	Value	Unit	Min	Max
f	Line frequency	60.0	Hz	0.01	
Rp	+ve sequence series resistance	0.048	ohms	1.0e-10	
Xp	+ve sequence series inductive react.	0.062	ohms	1.0e-10	
Xcp	+ve sequence shunt cap. reactance of line	99999	Mohms	1.0e-10	
Rz	Zero sequence series resistance	0.271	ohms	1.0e-10	
Xz	Zero sequence series inductive react.	0.071	ohms	1.0e-10	
Xcz	Zero sequence shunt cap. react. of line	99999	Mohms	1.0e-10	
split	Split the Icon ?	NO		0	2

Update | Cancel | Cancel All



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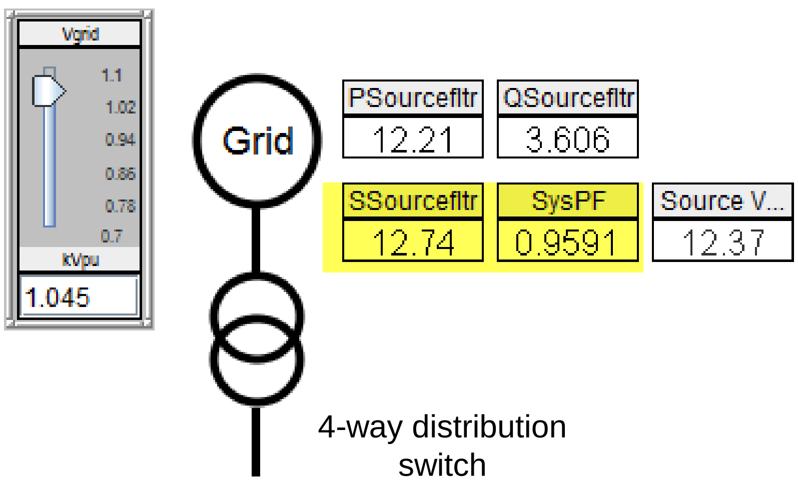
RTDS model development

Module 1

Model validation

- RTDS power flow program was run for different scenarios and compared with Synergi model
- Power flow results verified with and without DER sources in the circuit

Load Type	Total kVA	Total pf	A kVA	A pf	B kVA	B pf	C kVA	C pf
Distributed	12440	96.37	4134	96.35	4165	96.35	4142	96.41
Spot	0	100.00	0	100.00	0	100.00	0	100.00
Large Customer	0	100.00	0	100.00	0	100.00	0	100.00
Capacitor	0	100.00	0	100.00	0	100.00	0	100.00
Generator	0	100.00	0	100.00	0	100.00	0	100.00
Losses	377	64.01	123	60.87	118	64.81	137	66.06
Total Load	12752	95.91	4233	95.87	4263	95.93	4257	95.93
Demand	12391	95.66	4124	95.64	4135	95.66	4133	95.67
Connected loads								
Connected kVA	27091		9199		9039		8854	
Connected Customers	2478		928		834		715	
Conneced kWH	1087801		367887		381431		338483	



Test scenarios

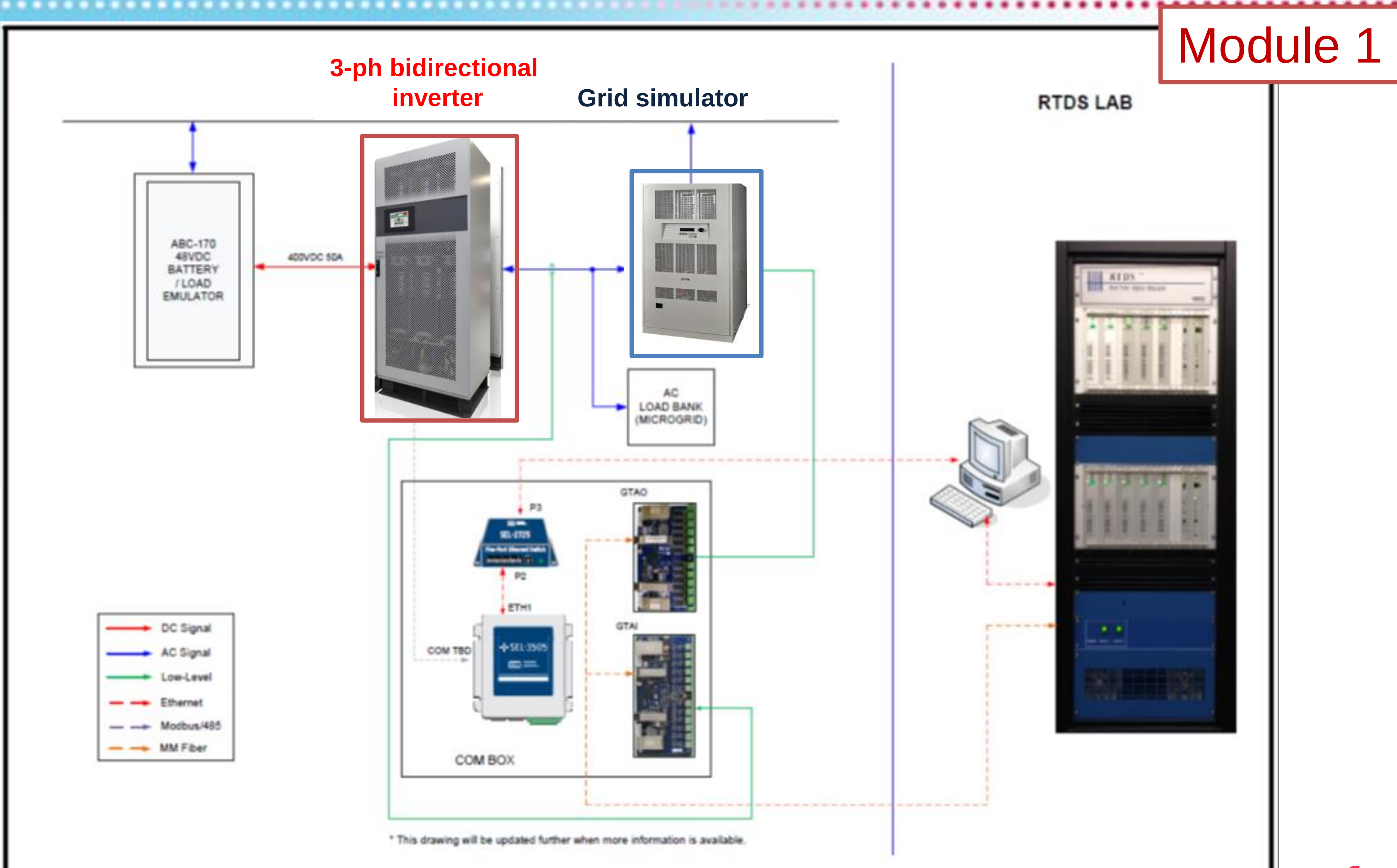
Module 1

Device under test (DUT) designed generically so it can be moved around circuit at different locations

Four test scenarios

- Scenario 1 – single DER close to a substation
- Scenario 2 – single DER on a complex circuit with several controllable devices
- Scenario 3 – single DER at end of a feeder
- Scenario 4 – multiple, diverse types of DER on same circuit

Power hardware in-the-loop



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DER inverter grid support functions

Module 1

Test 1 – Limit maximum active power output

Test 2 – Schedule active power output

Test 3 – Volt / watt function

Test 4 – Volt / VAr function

Test 5 – Frequency / watt function

Test 6 – DER response to emergencies

Test 7 – Spinning reserve

Test 8 – Black start

Test 9 – Load leveling

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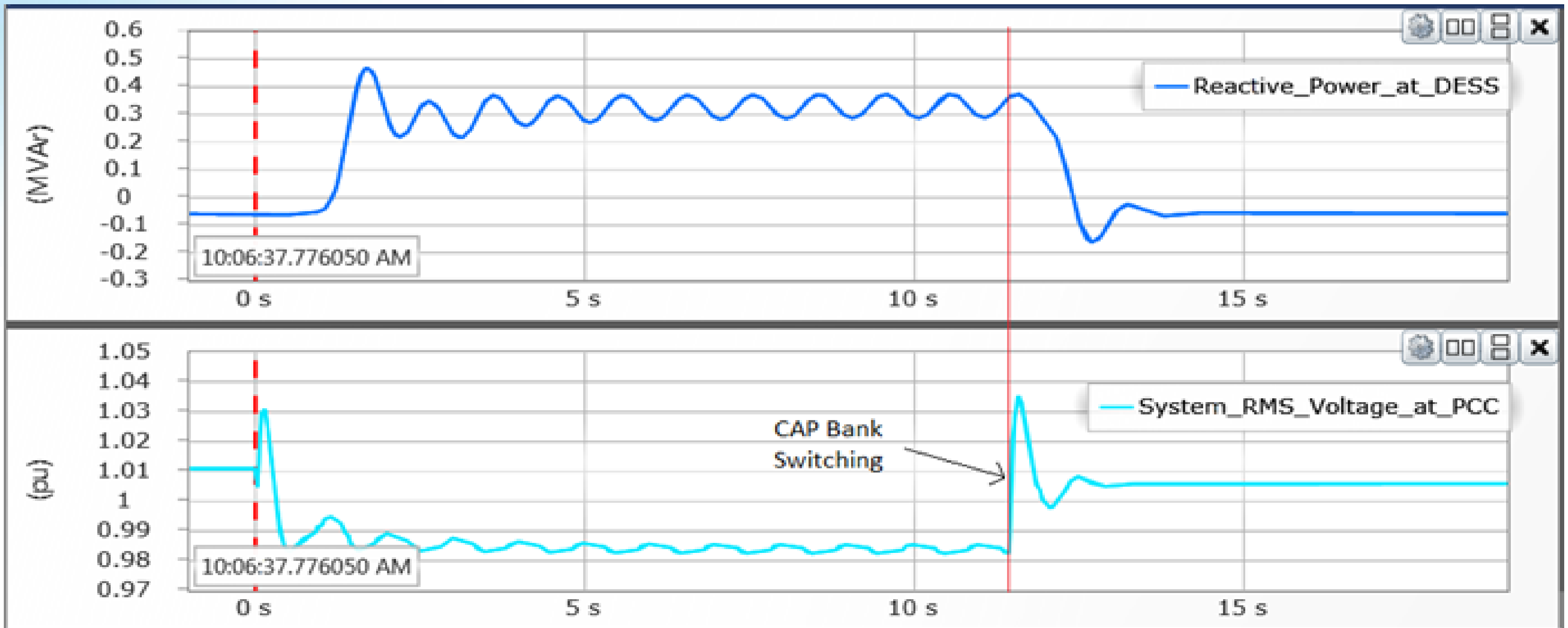
Volt/VAr function

Module 1

- DER regulates injected VAr to maintain bus voltage to reference value
- DER responds to voltage fluctuations by increasing its reactive power at low-voltage conditions and decreasing its reactive power during high-voltage conditions
- DER reacts to the voltage disturbance faster than traditional devices (i.e., cap banks)
- Droop setting determines amount of VAr regulated for percent change in voltage



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Project findings

Module 1

- DER in volt/VAr provides **greater reliability** and **operational efficiency** by improving voltage profile along the feeder
- Volt/VAr function acts **faster** than traditional voltage regulating devices (i.e., voltage regulators, capacitor banks)
- It can decrease switching or tap change operations of traditional device; thus, **increase assets life**
- Frequency/watt provides reliability when other intermittent renewable sources of energy reduce output by providing additional output to counter changes in DER output
- DER in frequency/watt mode acts as quick reacting source **to mitigate frequency fluctuations**

Project findings

Module 1

- With blackstart functionality, DER can be used to start microgrid during system outage to feed local load
- With load leveling, DER system can be set to follow the load, meaning it responds to load changes during high- and low-loading conditions
- Volt/watt function curtails DER output and maintains system voltage at nominal value so other DER sources can be turned on in a highly DER-penetrated circuit
- In general, autonomous grid support functions (i.e., volt/VAr, frequency/watt, and load leveling) provide ability for DER to contribute to **distribution system stability** and help **mitigate disturbances**

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Communication standards for grid support functions of DER

Module 2

Project Purpose

- Demonstrate communication standards for grid support functions of DER
- Assess how the choice of communication standard can impact functionality of DER

Approach

- Demonstration and evaluation of IEEE 2030.5, the default communications protocol for CA Rule 21
- Analysis of results
- Recommendations for steps leading to industry adoption

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Pre-commercial demonstration of DRIVE

Hosting capacity methodology overview

Module 3

	DRIVE	SDG&E iterative tool	Comments
DER Locations Analyzed	All feeder locations	User selected feeder locations	**DRIVE will compare results at locations selected in the iterative analysis**
DER Scenarios Analyzed	Distributed (multi-site) and Centralized (single-site) DER hosting capacity scenarios	Centralized (single-site) DER hosting capacity scenario	**Compare centralized (single-site) DER hosting capacity scenario**
Model Analyzed	Substation and Single Feeder Served	Substation and All Feeders Served	**Adjacent feeders on the substation bus will be aggregated to the substation bus for the DRIVE analysis**
Load Level Considered	Two load conditions	576 load conditions	**DRIVE will analyze one load condition and those results will be compared to the same load condition of the iterative analysis**
Hosting Capacity Metrics	Voltage, Thermal, Protection	Voltage and Thermal	**Select voltage and thermal hosting capacities compared**

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Questions?

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Collaborative Programs in RD&D Consortia
EPIC-2, Project 6

Presented by: Ngoc Bui, SDG&E
EPIC Symposium
February 7, 2018

Outline

Project 6: Collaborative Programs in RD&D Consortia

Module: UAS data lifecycle management and deep learning demonstration

- Project objectives and focus area
- Approach
- Use cases
- Outcomes
- Findings and recommendation
- Questions

Project objectives and focus area

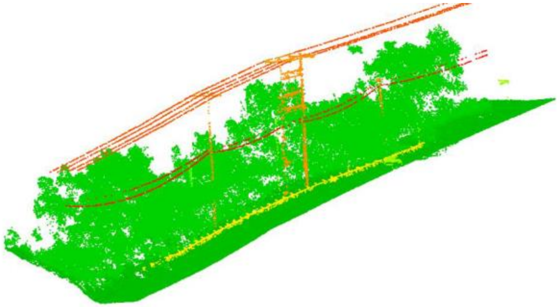
- The objective of EPIC-2, Project 6 (Collaborative Programs in RD&D Consortia) is to accomplish highly leveraged demonstration work through industry collaborative R&D organizations
- Focus of this module was on pre-commercial evaluation and demonstration of applications of unmanned aircraft systems (UAS) and data management solutions to improve the asset management processes

Approach

- Demonstrate existing UAS infrastructure in new applications
- Develop use cases and requirements for UAS and other types of data in multiple business units
- Data collection and ingestion into multiple platforms (test systems)
- Demonstrate data lifecycle management
- Demonstrate advanced data analytics
- Comprehensive final report

Use cases

- Asset identification on distribution lines
  - Avian cover (used as a test case)
  - Advanced analytics on RGB images, LIDAR etc
  - Demonstrate value for visual inspection and maintenance



- Vegetation encroachment identification
  - Identify vegetation within a buffer zone
  - Assist in vegetation trimming and management
- Remote asset management
  - Data ingestion and metadata cataloging in vendor platforms
  - Enable remote visualization and management of assets

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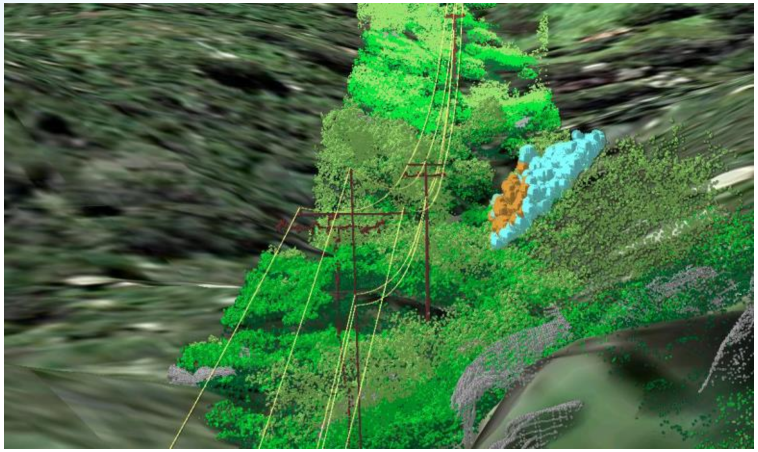
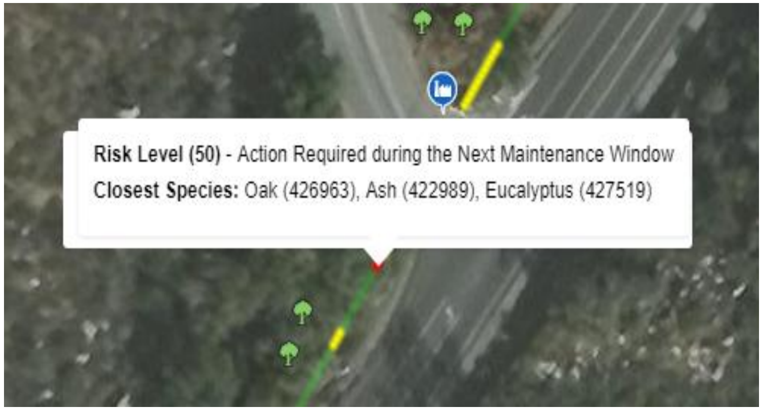
Outcome: Avian cover identification

- Demonstrated machine learning capability with variations in the accurate identification of avian covers.
- Results from using four vendor platforms
  - Vendor A: Reported 85% of covers with 70% precision and 80% accuracy. Required 300 minimum pixels for learning.
  - Vendor B: Used manual identification of oblique and NADIR imagery.
  - Vendor C: Reported 99% of covers with 99% precision and 95% confidence. Analyzed photos where covers were 100 pixels or less.
  - Vendor D: Recommended to define a process that set up data collection requirements, processing, & information disseminating to all business units.

Outcome: Vegetation encroachment identification

- Demonstrated machine learning capability with identification of vegetation encroachment keeping SDG&E compliance with CPUC regulation.
- Results from using four vendor platforms
  - Vendor A: Analysis completed using a rectangular buffer zone with parameters for sag and sway that enlarge the area, was able to identify encroachments in multiple 3-meter segments between pole assets with respect to existing vegetation.
  - Vendor B: Identified vegetation by assigning points distance that were color coded. (10ft flag as red, 10-12ft as yellow, and 12-15 feet as green.
  - Vendor C: Used color coding of vegetation within an area and output data that measures distances to structure. User specify the distance desire for reporting.
  - Vendor D: Calculated encroachments using a planar distance to wire parameter and height of tree.





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Outcome: Remote asset management

- LiDAR and imagery to catalog assets in remote areas and demonstrate change management
- Metadata tagging of relevant data for remote asset management
- Results from using four vendor platforms
  - Vendor A: Provided data collection and retention outline
  - Vendor B: Tied images to the closest pole asset based on image location, pole ID's added automatically
  - Vendor C: Recommended a 3-tiered data management platform
  - Vendor D: Recommended to define a process that set up data collection requirements, processing, & information disseminating to all business units.

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Findings and recommendation

- UAS and other data from other technologies can be used for remote inspections and effective asset management.
- Machine learning and advanced data analytics on images from multiple data sources is feasible for remote asset identification and management.
- These methods enable development of cost-effective remote inspection programs.
- These methods ensure safety of personnel/property during inspections or emergency situations.
- Additional evaluation and demonstration of UAS technology for multiple stakeholder groups (land management, environmental management, etc) is recommended to derive maximum benefit from these new technologies.

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Questions?

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Smart Grid Architecture Demonstrations Program
EPIC-1, Project 1

Presented by: Molham Kayali, SDG&E
EPIC Symposium
February 7, 2018

Outline

- Project objectives
- Project focus areas
- Use cases
- Findings
- Questions

EPIC-funded communication standards-related projects

Smart grid architecture demonstrations

Focus: Communications standards for integration of feeder equipment and DER into networked automation

Modernization of distribution system and integration of distributed generation and storage

Focus: IEC 61850 in substation network

Monitoring, communication, and control infrastructure for power system modernization

Focus: Open field message bus (OpenFMB)

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Project objectives

- Perform pilot demonstrations of key candidate prototype building blocks of the SDG&E smart grid architecture to determine their suitability for adoption in the architecture
- Document the results and make recommendations on whether specific building blocks should be adopted
- Provide demonstration results to the SDG&E interdepartmental smart grid architecture team to support the implementation phase for any building blocks adopted

Project focus areas

1

- Architecture baseline and development

2

- Pre-commercial demonstration of IEC 61850 for feeder and substation applications

3

- OpenFMB / IEC 61850

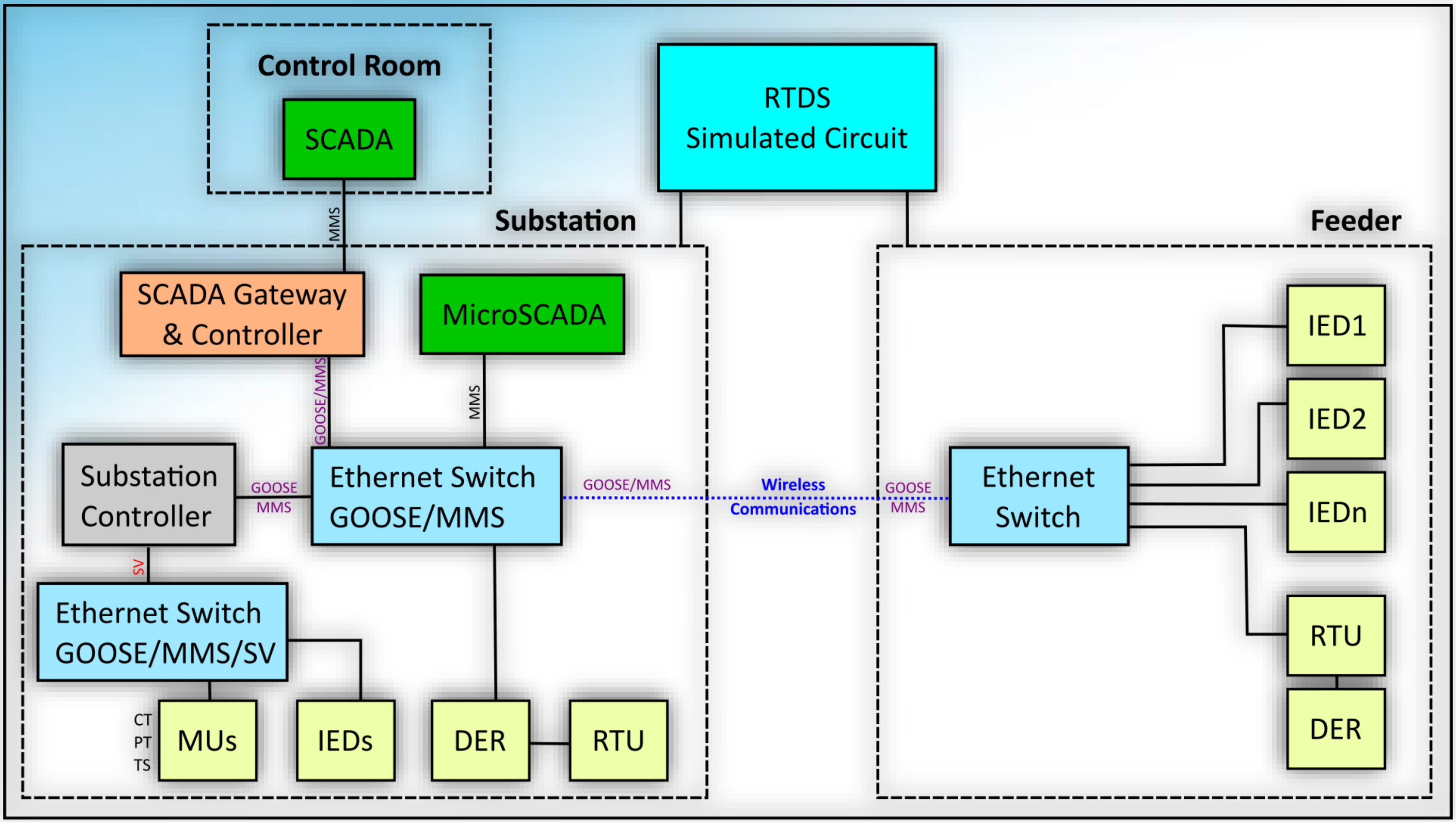
Architecture development

Domains
- Bulk Generation
- Transmission
- Distribution
- DER
- Customer premises

Zones
- Process
- Field
- Station
- Operation
- Enterprise
- Market

Interoperability layers
- Business
- Function
- Information
- Communication
- Component

Pre-commercial demonstration of IEC 61850



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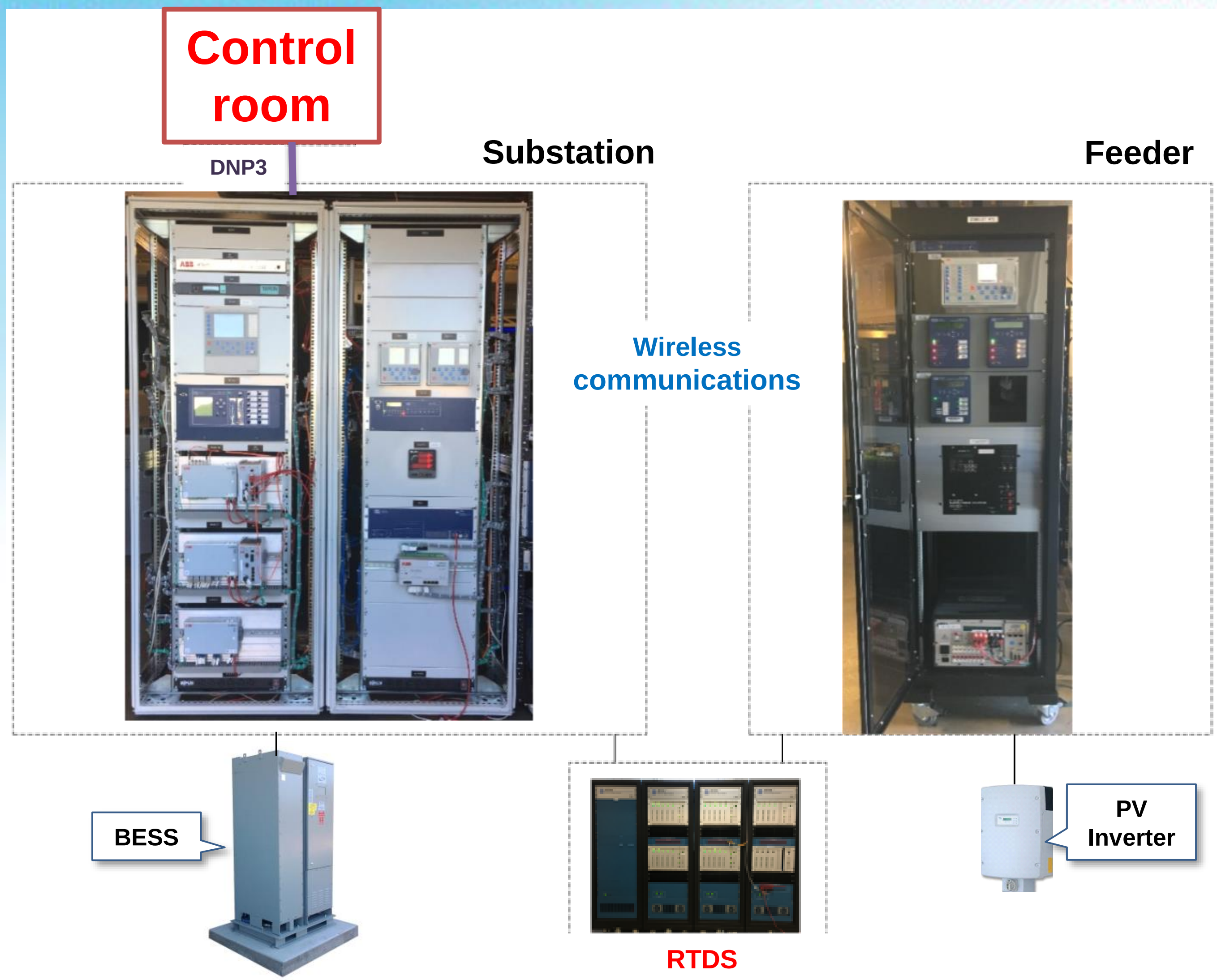
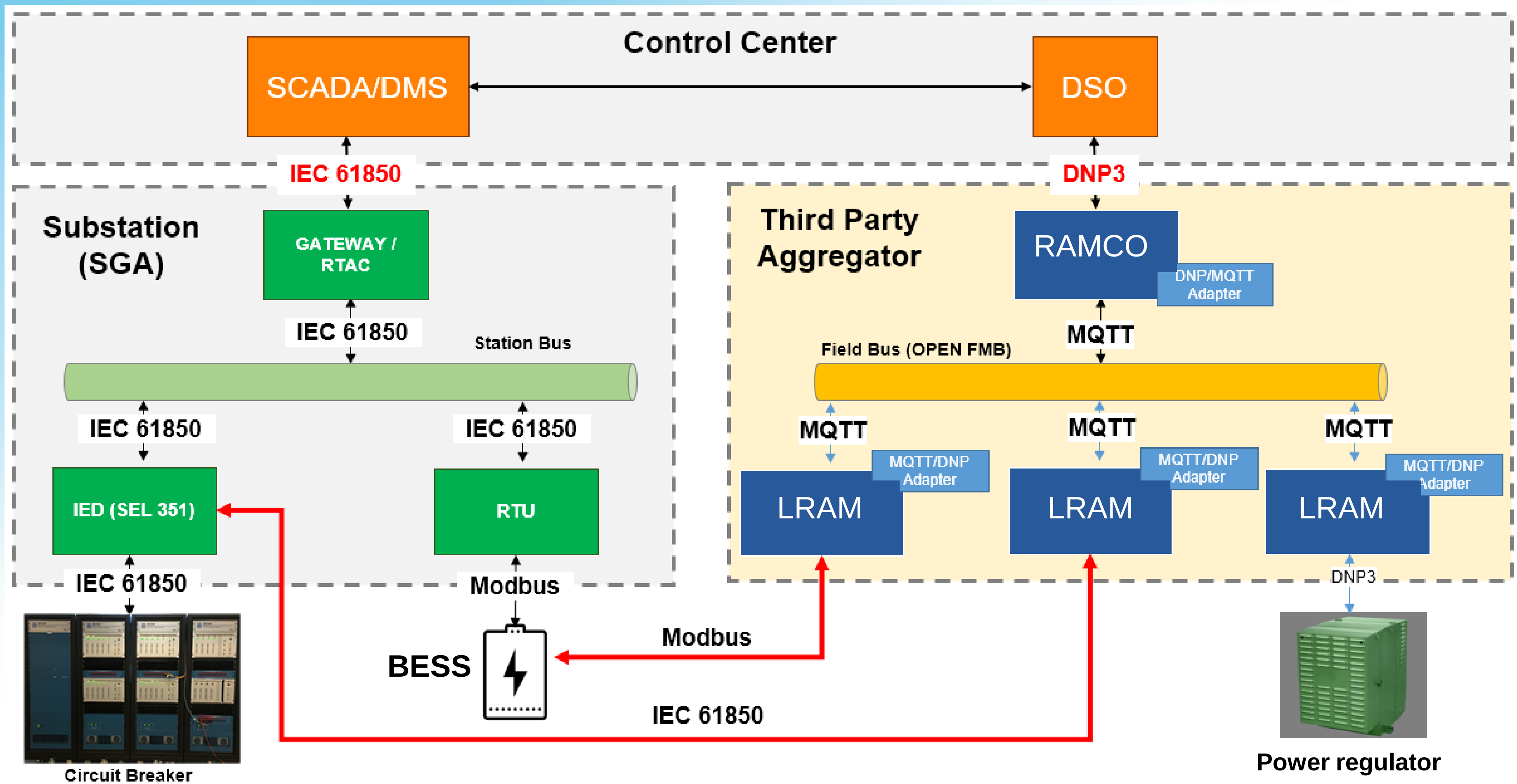
Demonstration setup



OpenFMB / IEC 61850



Use cases

- Full lifecycle asset provisioning
- Maintenance testing
- Breaker failure scheme
- Automatic transfer
- Improved protection coordination
- DER Control mode change
- Grid support using DER
- Emergency load management
- Dynamic emergency load control and management
- Dynamic circuit load management
- Volt-VAr control

Key findings

- **Architecture**
  - Potential architecture changes are needed due to the ongoing proliferation of DER and other IEDs and their impact on distribution operations
- **IEC 61850 provides the following benefits**
  - Test/maintenance features are safer and faster than traditional approaches
  - Reduction in engineering and testing effort in the 25-30% range
  - GOOSE consistently out-performed the traditional hard-wired breaker-failure-initiation scheme
  - Protection performance could be significantly improved
  - Improve power system operations due to peer-to-peer capabilities

Key findings

- **OpenFMB / IEC 61850**
  - Without nascently available OpenFMB devices, IEC 61850 performs better for high speed protection applications.
  - OpenFMB serves well at the transition between control center and devices on the field.

Questions?

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Thank you for your attention!

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