



**IEEE 1547-2018
Interoperability: The
Coming Revolution in DER
Integration**



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Today's Presenters

- **James Mater, GM, Smart Energy, QualityLogic**

James is one of the industry-leading experts on smart grid standards, interoperability, and the maturity of eco-systems of products based on these standards. James has given dozens of presentations and authored multiple papers on interoperability in the smart grid. He is a member of both the IEEE 1547.1 and 1547.2 Work Groups.



- **Steve Kang, Sr. VP Engineering, QualityLogic**

Steve is a leading technical expert on IEEE 2030.5 and CA Rule 21 based Common Smart Inverter Profile (CSIP) implementation guide. He has been involved with IEEE 2030.5 since 2010 and has taught hundreds of people around the globe on IEEE 2030.5. Steve is leading the QualityLogic IEEE 1547.1 test tool effort.



QualityLogic's Role in the Smart Energy Industry

- **QualityLogic focused on Smart Energy Testing**
 - IEEE 2030.5 and OpenADR (Approved Certification Test Tools)
 - Standards Training & Consulting
- **QualityLogic is a Contributor to IEEE 1547 and UL 1741**
 - Member of IEEE 1547-2018 Work Group
 - Member of IEEE 1547.1 WG and 1547.1 Interop WG
 - Member of IEEE 1547.2 and 1547.2 Interop WG
 - Member of UL 1741 STP
 - First vendor to offer a 1547.1 Interop Test Tool
- **QualityLogic Has Been involved With 2030.5 Since 2010**
 - Only SunSpec approved test harness for 2030.5/CSIP
 - Used by NRTLs and End Users to perform 2030.5 Testing/Certification
- **Active in Standards Development**
 - IEEE 2030.5, UL 3001, CSIP, 1547/1547.1, SAE, OpenADR

Current IEEE 2030.5 Testing Solutions



- **IEEE 2030.5 for CA Rule 21/CSIP Certification Testing**
 - Used by 6 NRTLs/Labs and many vendors for SunSpec Certification
- **Published CALSSA Application Guide**
 - CALSSA Testing Pathway allows non 2030.5 inverters to be verified and listed on CEC
 - Explains how to use QualityLogic Test Tool to verify CALSSA Testing Pathway
- **Published Phase 3 Functions 2 & 3 Testing Application Guide**
 - Explains how to use QualityLogic Test Tool to verify UL 1741 SA17 and UL 1741 SA18 tests
 - SA17 – Enter Service (Energize/Connect). Includes use of Enter Service settings
 - SA18 – Limit Max Active Power Mode. Includes use of FreqDroop/FreqW
- **Relevance to 1547.1**
 - Leveraging our 2030.5 expertise and tools for 1547.1 Interop testing which must be done with a named protocol

In This Webinar We'll Cover



- **IEEE 1547 Background**
- **The Interop requirement in IEEE 1547-2018**
- **Why there an Interop requirement in a "safety" standard**
- **Conforming to the new Interop requirement**
- **Challenges in testing and certifying the Interop requirements**
- **QualityLogic's test tools for validating IEEE 1547 Interop conformance**
- **Test system architecture and features**
- **Introduction schedule and who will be using the test tools**
- **Questions and Answers**

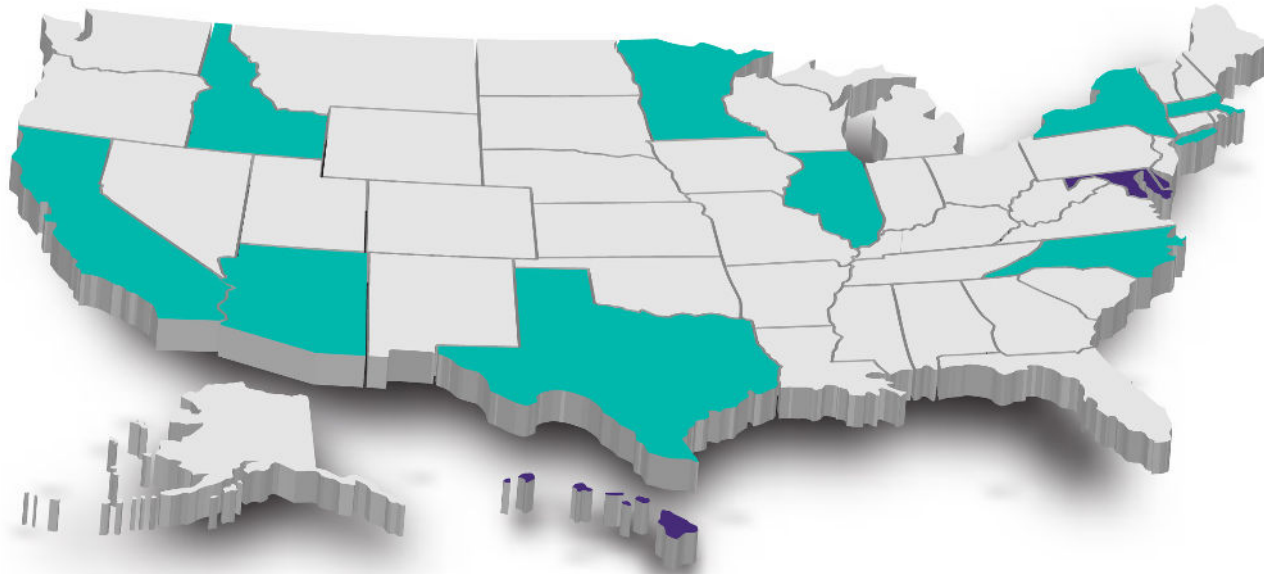
IEEE 1547 Background



- **IEEE 1547 and 1547.1 were initially approved in 2003 after 3 years of intense debate and development**
 - Designed to standardize behavior in abnormal conditions of interconnected DER. Primary concerns were grid stability and safety.
- **For the United States, the Energy Policy Act of 2005 established IEEE 1547 as the interconnection standard for distributed generation resources**
 - *Interconnection services shall be offered based upon the standards developed by the Institute of Electrical and Electronics Engineers: IEEE Standard 1547 for Interconnecting Distributed Resources with Electric Power Systems, as they may be amended from time to time.*
- **Revised in 2014 to address changing grid requirements for DER**
 - Made changes to sub clauses related to voltage regulation, voltage response to Area EPS abnormal conditions, and frequency response to Area EPS abnormal conditions.
 - IEEE 1547.1 was also revised in 2014 and 2015.
- **IEEE 1547 was revised again in 2018 and 1547.1 approved in 2020**
 - As DERs were seen as potential grid resources, the need for additional functionality and interoperability drove the most recent 1547 update.
 - The need for communications was recognized in the standard for the first time.

Adoption of IEEE 1547 in the US

- Open docket or activity
- Mandated by Jan, 2022



Based on information from the "Forum on Inverter Grid Integration Issues (FIGI)", November 20, 2020, Minutes".

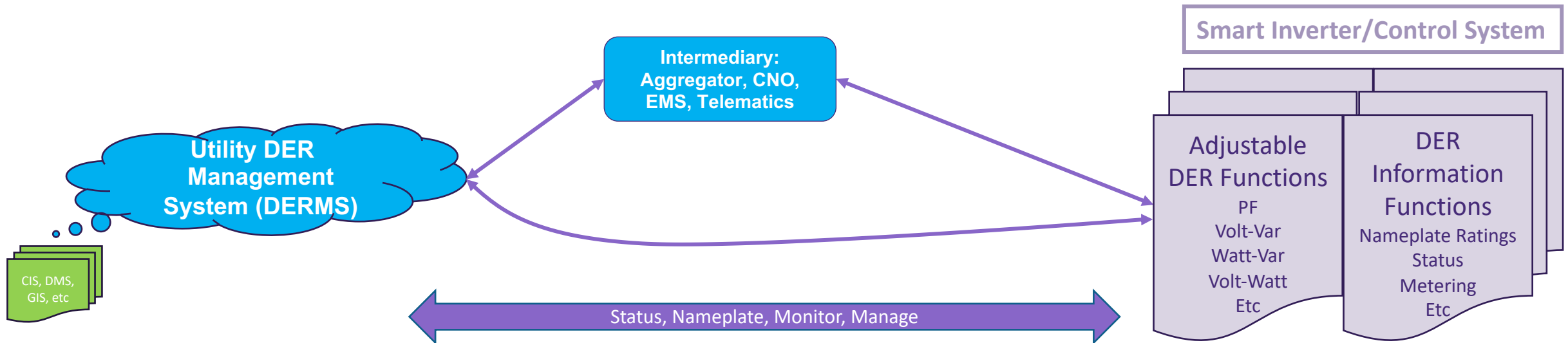
Why Interoperability in a Safety Standard?



- **IEEE 1547 has evolved to be both a functional and safety standard – i.e., in order to be a “safe” grid resource, the functionality has had to become much more sophisticated and standardized**
- **A critical aspect of “safety” is to be able to configure, monitor and manage DERs in a standardized way to insure both effective protection and control of the grid by distribution system operators.**

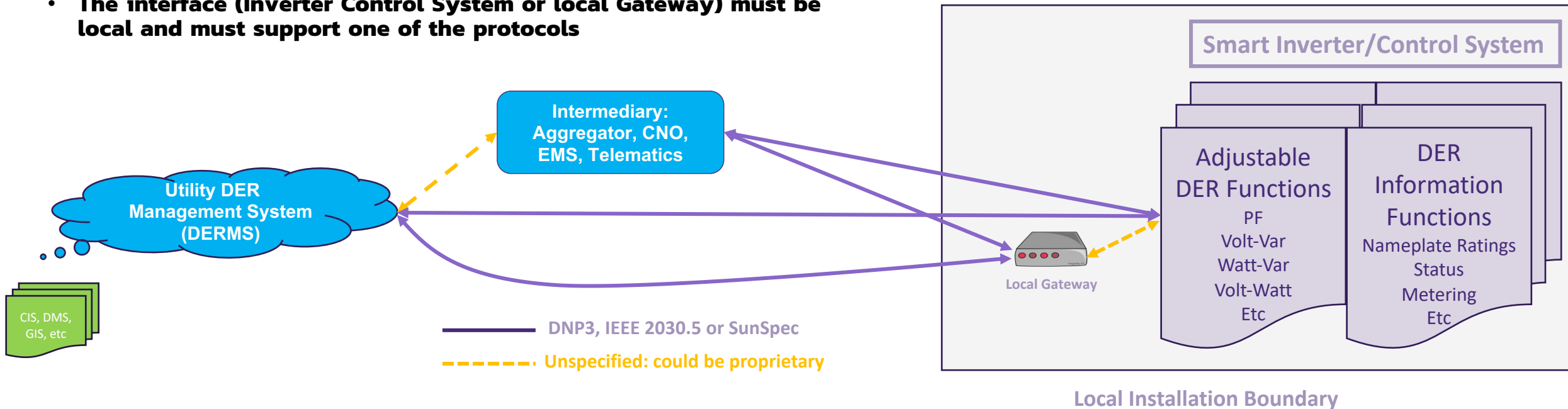
Need for Interoperability

- **With required programmable functions, communications is also required**



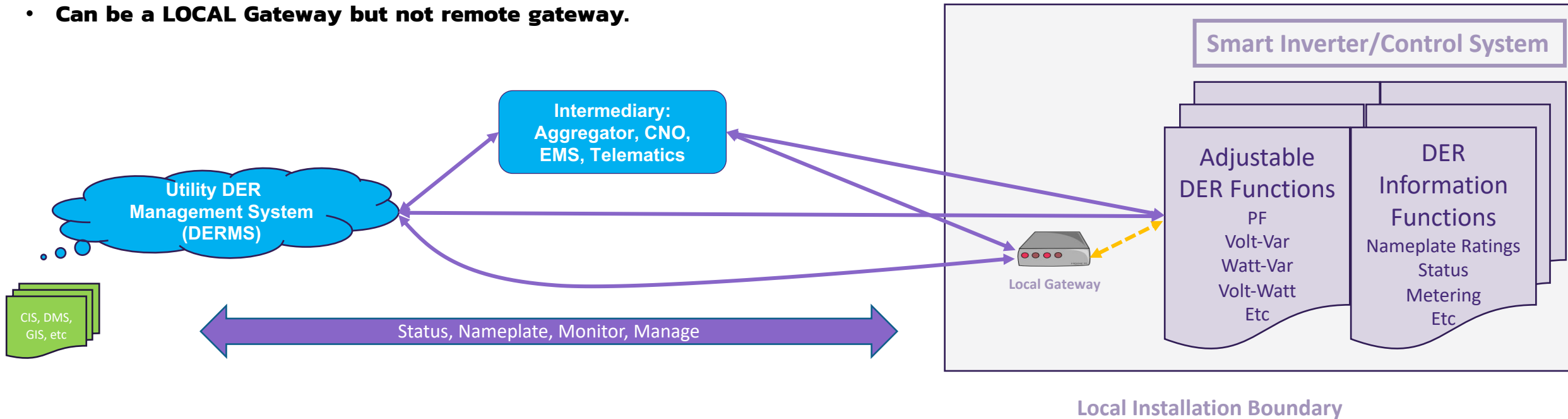
Specified Application Protocols

- **1547 Interop requires compliance using one of 3 named protocols.**
 - IEEE 1815 DNP3
 - IEEE 2030.5
 - SunSpec Modbus
- **The interface (Inverter Control System or local Gateway) must be local and must support one of the protocols**



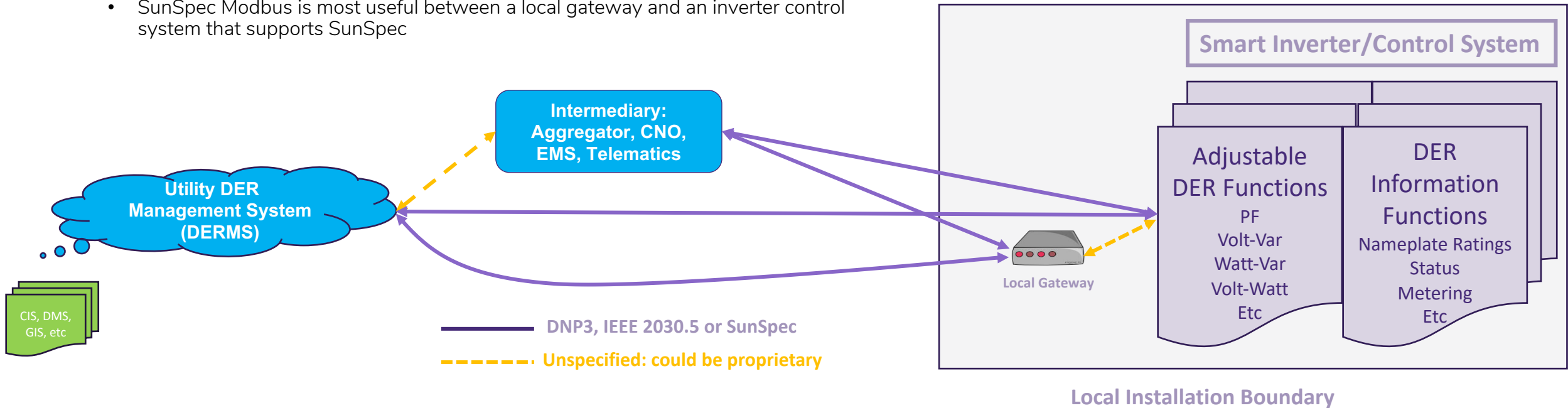
Interop is Local

- **1547 Interop is local, not cloud-based or remote. This is to insure standard communications in the event of a network failure.**
- **Can be a LOCAL Gateway but not remote gateway.**



Which Protocol to Use?

- **The 3 named protocols have differing strengths and applications.**
 - IEEE 1815 DNP3 is best suited for larger scale DERs operated as part of real-time SCADA
 - IEEE 2030.5 is best suited for internet based, behind-the-meter DER where greater security and group management are required
 - SunSpec Modbus is most useful between a local gateway and an inverter control system that supports SunSpec



Important Limitations of 1547.1 Interop



- **Interoperability conformance to IEEE 1547.1-2020 can be achieved by demonstrating interoperability using only one of the identified protocols**
 - DNP3, IEEE 2030.5 or SunSpec
- **Interoperability requirements are limited to validating that the IEEE 1547-2018 inverter adjustable functions and information occurred correctly in the inverter**
 - Essentially spot checking the type tests with a small sample of potential settings changed through communications
- **Additional communications on nameplate ratings, configuration information and monitoring information are included in the interoperability conformance requirements**
- **Interoperability conformance in IEEE 1547-2018 *is NOT* a protocol conformance test.**
 - Features like security, group management, device capabilities, device discovery, etc., are not required to be tested in the conformance testing for IEEE 1547.1-2020
- **Importantly, although communications security is a critical DER issue, it is not included in IEEE 1547-2018 or IEEE 1547.1.**

DER Protocol Testing vs Functional Testing



- **Protocol testing** – validates that messages are received and properly understood. But not that a device performs as instructed. Does not require any simulation and inverter monitoring equipment.
- **Functional testing of DERs** – validates that the 1547 functions operate as specified. Requires grid/DC simulators and monitoring equipment.
- **IEEE 1547.1 Interop testing** – is functional testing driven by the named protocol. Not a full protocol test.

Certifying IEEE 1547.1 Conformance



- **IEEE 1547.1 is a Conformance specification but not a certification specification – i.e., inverters are not IEEE 1547.1 certified**
- **UL 1741 is the official industry standard for certification of inverter safety and includes numerous safety tests in addition to the IEEE 1547.1 conformance tests.**
- **UL 1741 SB is the updated version that incorporates the testing requirements in IEEE 1547.1**
- **Interop testing is implicit in UL 1741 SB but there are challenges:**
 - This is the first-time communications testing have been incorporated into UL 1741 certification testing. As we work through the actual effort to implement the Interop tests, we are seeing the weaknesses in the IEEE 1547.1 specification that need to be clarified.

IEEE 1547.1 Conformance



Certified under UL 1741 SB

IEEE 1547.1/UL 1741 SB Conformance Background



- **IEEE 1547.1 defines the test procedures for verifying inverter's functionality**
 - Includes interoperability section (Section 6) that leverages 2030.5, DNP3 and SunSpec
 - Approved by IEEE in March 2020
- **UL 1741 SB updated to reflect latest 1547.1 test requirements**
 - Approved and issued September 2020
- **Testing by NRTLs and vendors require various test equipment that interacts with the target inverter**
 - Grid simulators, power analyzer, DC/PV simulator, Oscilloscope and others
- **1547.1 Interoperability test section requires use of the protocols to trigger/monitor the inverter**
 - 47 individual tests defined in 1547.1 for interop section
 - Leverages “Type” functional tests in 1547.1 Section 5
- **A NRTL has stated that total 1547 tests may take months to conduct**

1547.1 Interoperability Test Section

- Four different test categories that includes 47 test areas
- Nameplate data – verify nameplate data can be read from the DER
- Configuration Information – verify that DER settings can be read/written and take effect
- Monitoring Information – verify that DER reports set of metered data
- Management Information – verify that DER can act upon set of grid functions as requested thru protocol

Table 44—Management Information Test List

Test	Management Function	Adjustable Settings (References to IEEE Std 1547-2018)	Criteria (References to functional test criteria within this document)	Notes
1	Constant Power Factor Mode	10.6.2, Table 30	5.14.3.3	
2	Voltage-reactive power mode	10.6.3, Table 31	5.14.4.3 and 5.14.5.3	
3	Active power-reactive power mode	10.6.4, Table 32	5.14.7.3	
4	Constant reactive power mode	10.6.5, Table 33	5.14.8.3	
5	Voltage-active power mode	10.6.6, Table 34	5.14.9.3	
6	Voltage trip test	10.6.7, Table 35	5.4.2.4 (over voltage trip settings) and 5.4.3.4 (undervoltage trip settings)	
8	Frequency trip test	10.6.8, Table 37	5.5.1.4 (over frequency trip) and 5.5.2.4 (under frequency trip)	
9	Frequency droop (frequency/power or frequency-watt) test	10.6.9, Table 38	5.15.2.3 (above nominal frequency) and 5.15.3.3 (below nominal frequency)	
10	Enter service and Cease to energize and trip tests	10.6.10, Table 39, 10.6.11	5.6.4	NOTE—This management function relates to permit service.
11	Limit maximum active power test	10.6.12, Table 40	5.13	

The New QualityLogic IEEE 1547.1 Conformance Test Tool



- New 1547.1 FTS tests to cover the 1547.1 interoperability tests and functional Type tests
- End to end testing to verify DER communication and power level functionality starting with 2030.5
 - SunSpec & DNP3 will be added based on customer's demand
- Automate management and monitoring of power test equipment
- Reporting of monitored data from data collection devices such as power analyzers and oscilloscopes
- Supports use of Python scripts to modify test behavior and further customization by user
- Customizable test values to handle regional grid code differences
- To the extent feasible, support analysis of the test results to determine pass/fail or provide decision support to the test engineer
- Supports the IEEE 1547.1 Results Reporting Format
- Provides familiar test tool interaction as the CSIP Certification Test Tool

Product Components



- **QualityLogic 1547.1 Tool has the following product components**
- **1547.1 DER Protocol Messaging Component**
 - To support 1547.1 protocol requirements: 2030.5, SunSpec Modbus and DNP3
- **Test Equipment Automation**
 - To automate the manual steps in managing the various equipment: grid simulator, power analyzer, etc.
- **Test Analysis**
 - Collect and provide analysis of the data collected for each test case executed
- **Test Values customization**
 - Users can change defaults values to suit their regional grid codes, etc.

QualityLogic's 1547.1 and 2030.5 Test Tools Preview

The image displays two screenshots of the QualityLogic IEEE 2030.5/1547.1 Client Tester software interface.

Left Screenshot: Test Suite Configuration (CORE)

Test Suite: CORE
 Type: CORE
 Name: Core
 Result: [Empty]

Requirements Summary:

Total Requirements	306
Unchecked Requirements	306
Passed Checks	0
Failed Checks	0
Warning Checks	0

Test Cases Table:

Tag	Name	Result
<input type="checkbox"/>	CORE-001-Client - HTTP Header Test	
<input type="checkbox"/>	CORE-002-Client - HTTP Response Test	
<input type="checkbox"/>	CORE-003-Client - Polling Interaction T...	
<input type="checkbox"/>	CORE-004-Client - List Handling Test	
<input type="checkbox"/>	CORE-005-Client - Basic Time Test	
<input type="checkbox"/>	CORE-009-Client - Advanced End Dev...	
<input type="checkbox"/>	CORE-010-Client - Function Set Assign...	
<input type="checkbox"/>	CORE-011-Client - Advanced Function...	
<input checked="" type="checkbox"/>	CORE-012-Client - Basic DER Program...	
<input type="checkbox"/>	CORE-013-Client - Advanced DER Pro...	
<input type="checkbox"/>	CORE-014-Client - Basic DER Settings Test (Power Generating)	
<input type="checkbox"/>	CORE-018-Client - Basic Subscription ...	
<input type="checkbox"/>	CORE-019-Client - Advanced Subscrip...	
<input type="checkbox"/>	CORE-021-Client - Randomized Events...	
<input type="checkbox"/>	CORE-022-Client - Responses Test	
<input type="checkbox"/>	CORE-023-Client - Superseding Test	

Right Screenshot: Test Suite Configuration (1547 MANAGEMENT)

Test Suite: 1547 MANAGEMENT
 Name: 1547 Test
 Result: [Empty]

Requirements Summary:

Total Requirements	306
Unchecked Requirements	306
Passed Checks	0
Failed Checks	0
Warning Checks	0

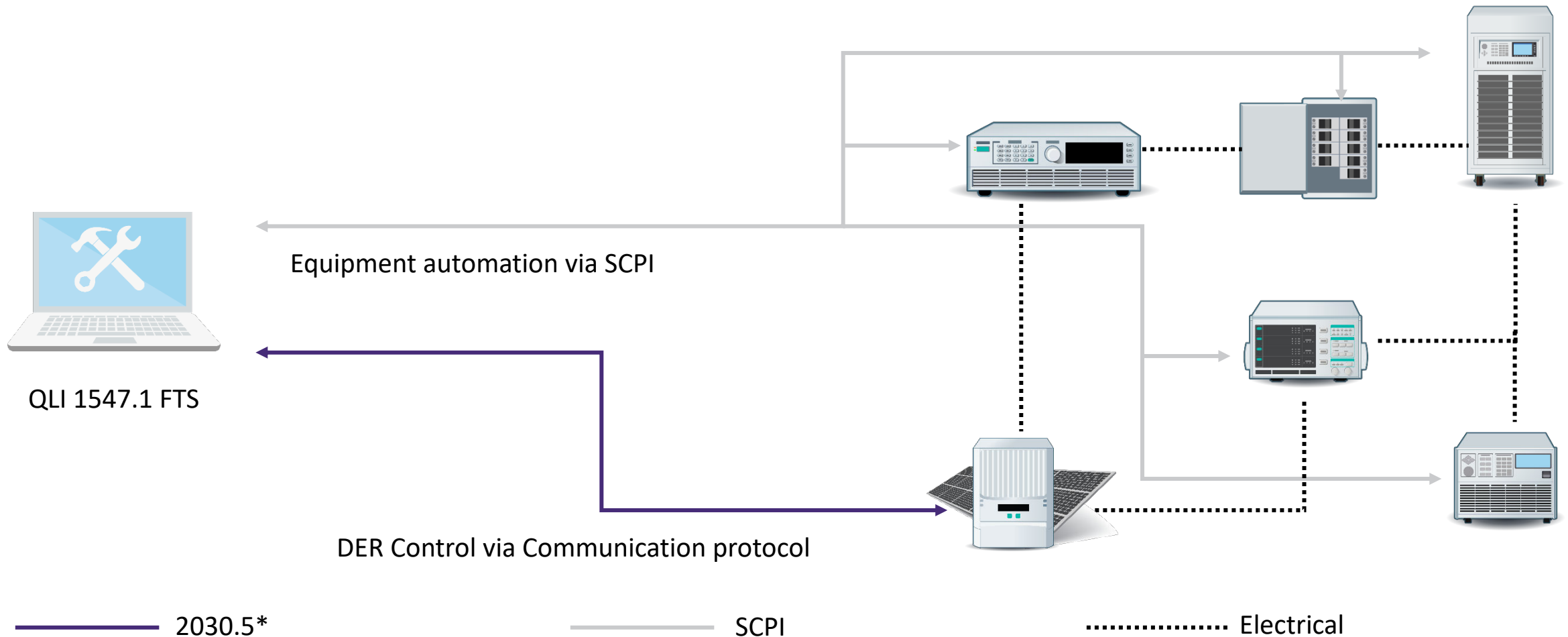
Test Cases Table:

Tag	Name	Result
<input type="checkbox"/>	Management-CONSTANTRP-Client-...	
<input type="checkbox"/>	Management-VOLTWATT-Client-A - ...	
<input type="checkbox"/>	Management-VOLTWATT-Client-B - ...	
<input type="checkbox"/>	Management-VOLTWATT-Client-A' - ...	
<input type="checkbox"/>	Management-VOLTWATT-Client-B' - ...	
<input checked="" type="checkbox"/>	Management-HVRTMT-Client - High ...	
<input type="checkbox"/>	Management-LVRTMT-Client - Low ...	
<input type="checkbox"/>	Management-HFRMT-Client - High Frequency Trip mode	
<input type="checkbox"/>	Management-LFRTMT-Client - Low F...	
<input type="checkbox"/>	Management-FREQDROOPO-Client - ...	
<input type="checkbox"/>	Management-FREQDROOPU-Client - ...	
<input type="checkbox"/>	Management-SERVICE001-Client - S...	
<input type="checkbox"/>	Management-SERVICE002-Client - S...	
<input type="checkbox"/>	Management-SERVICE003-Client - S...	
<input type="checkbox"/>	Management-SERVICE004-Client - S...	
<input type="checkbox"/>	Management-SERVICE005-Client - S...	
<input type="checkbox"/>	Management-SERVICE006-Client - S...	
<input type="checkbox"/>	Management-MAXLIMW-Client - Limit...	

Summary Table:

Code	PASS Count	FAIL Count	WARN Count
GEN.001	0	0	0
GEN.002	0	0	0
GEN.003	0	0	0
GEN.004	0	0	0
GEN.005	0	0	0
GEN.006	0	0	0
GEN.007	0	0	0
GEN.008	0	0	0
GEN.009	0	0	0
GEN.013	0	0	0
GEN.014	0	0	0
GEN.015	0	0	0
GEN.016	0	0	0
GEN.017	0	0	0
GEN.018	0	0	0
GEN.019	0	0	0
GEN.020	0	0	0
GEN.021	0	0	0
GEN.022	0	0	0
GEN.023	0	0	0
GEN.024	0	0	0
GEN.025	0	0	0

1547.1 Product Design



**DNP3/SunSpec protocol optional*

Summary



- **Interoperability is required because of the programmable functions in smart inverters**
- **Adoption is in process in a number of US states**
- **IEEE 1547.1 Conformance is a functional test, not a protocol test**
- **Can be done with one of 3 protocols**
- **Inverter interface must a local interface**
- **Industry's only 2030.5/CSIP Certification Test Tool expanded to support 1547.1 interoperability testing**
- **Leading NRTLs (UL, Intertek, TUV Rheinland others) committed as Accelerator customers**
 - Helping to shape the product direction and requirements
- **Vendors can use the same version that NRTLs use – product available now to customers**
 - Reduces certification testing risks and issues
- **For more information, please contact QualityLogic at info@qualitylogic.com**