Standards and Test Procedures for Interconnection and Interoperability
(GMLC 1.4.1)

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Sheraton Pentagon City – Arlington, VA

Standards and Test Procedures for Interconnection and Interoperability (GMLC 1.4.1)
High Level Summary

Project Description

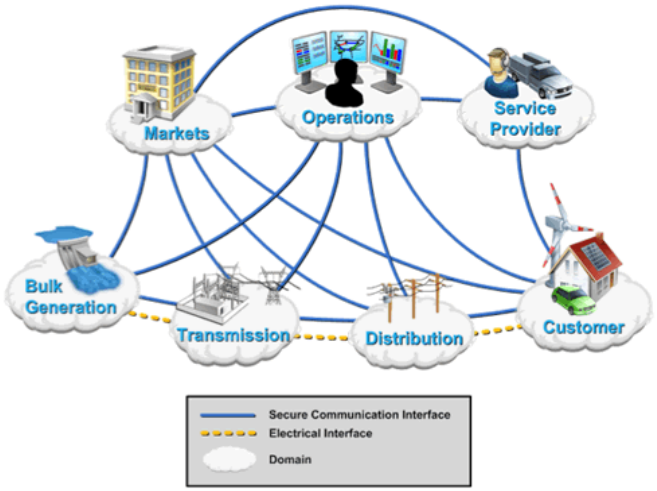
- **Accelerate the development and validation** of interconnection and interoperability standards
- Ensure **cross-technology compatibility** & harmonization of requirements

Project Objectives

- ✓ Interconnection and interoperability gap analysis & prioritization of high impact areas
- ✓ Standards coordination and harmonization for key grid services and devices
- ✓ Develop new testing procedures

Value Proposition

- **Improve coordination** of advanced generation and storage assets
- **Enable expansion** of markets for key devices
- **Eliminate barriers** that may be addressed by improved standards



Standards and Test Procedures for Interconnection and Interoperability (GMLC 1.4.1)
Project Team

Project Team and Roles

NREL – Overall Lead, Inverters/PV
ANL - Automotive applications
LBNL - Responsive loads
SNL - Inverters/Energy storage
ORNL - Microgrids
PNNL - T&D automation, responsive loads

PROJECT FUNDING			
Lab	FY16 $	FY17$	FY18 $
NREL	$240,000	$240,000	$240,000
PNNL	$240,000	$240,000	$240,000
LBNL	$240,000	$240,000	$240,000
SNL	$160,000	$160,000	$160,000
ANL	$160,000	$160,000	$160,000
ORNL	$80,000	$80,000	$80,000
INL	$80,000	$80,000	$80,000
Total	$1,200,000	$1,200,000	$1,200,000

Industry Observers/Advisors/Partners

Bulk Electric System Operators
NY ISO | PJM

Utilities / Trade Groups
Duke Energy | TVA | Southern Co.
Oncor | Entergy | NRECA

Standards Development
IEEE | ASHRAE | SunSpec
SGIP | NIST

Trade Groups
EPRI | NRECA

Vendors & Manufacturers
Intel | Sunpower | Fronius
Enphase

Consulting/Academic
Enernex | MIT Lincoln Labs

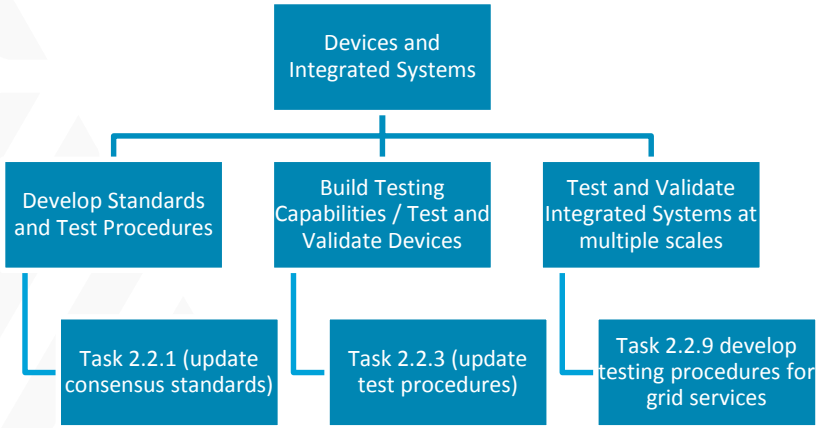
Standards and Test Procedures for Interconnection and Interoperability (GMLC 1.4.1)
Relationship to Grid Modernization MYPP

This project directly aligns with MYPP Activities

- Activity 2: Develop Standards & Test Procedures
- Activity 3: Build Testing Capabilities / Test and Validate Devices

Also aligns with:

- Activity 4: Test and Validate Integrated Systems at multiple scales
- Task 2.2.1: Update consensus interconnection standards
- Task 2.2.3: Update testing procedures for interconnection standards
- Task 2.2.9: Develop testing procedures for evaluating the ability of devices to provide grid services



Standards and Test Procedures for Interconnection and Interoperability (GMLC 1.4.1)
Approach

Task	Description	Key Issues
1.1	Conduct preliminary gap analysis	• Identification of relevant standards
1.2	Develop prioritization framework	• Focus on grid services (developed by GMLC 1.4.2) • Identify prioritization areas & score (market size, time to fill gap, locational urgency + resource relevance, technical difficulty
1.3	Initial standards coordination	• Identify specific standards to address

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Key Project Milestones

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Milestone (FY16-FY18)	Status	Due Date
Preliminary gap analysis	Complete	9/30/16
Gap prioritization framework	Complete	2/28/18
Gap analysis recommendations	Complete	3/31/17
Year 1 Annual SMART Milestone Standards & codes forum	Delayed	4/1/17
Year 1 Annual SMART Milestone Annual report	In progress	4/1/17
Develop test procedures	Upcoming	Q2 2017
Validate test procedures	Upcoming	Q3 2017
Standards coordination	In progress	3/31/17 + throughout

Connecting Communications to Interoperability

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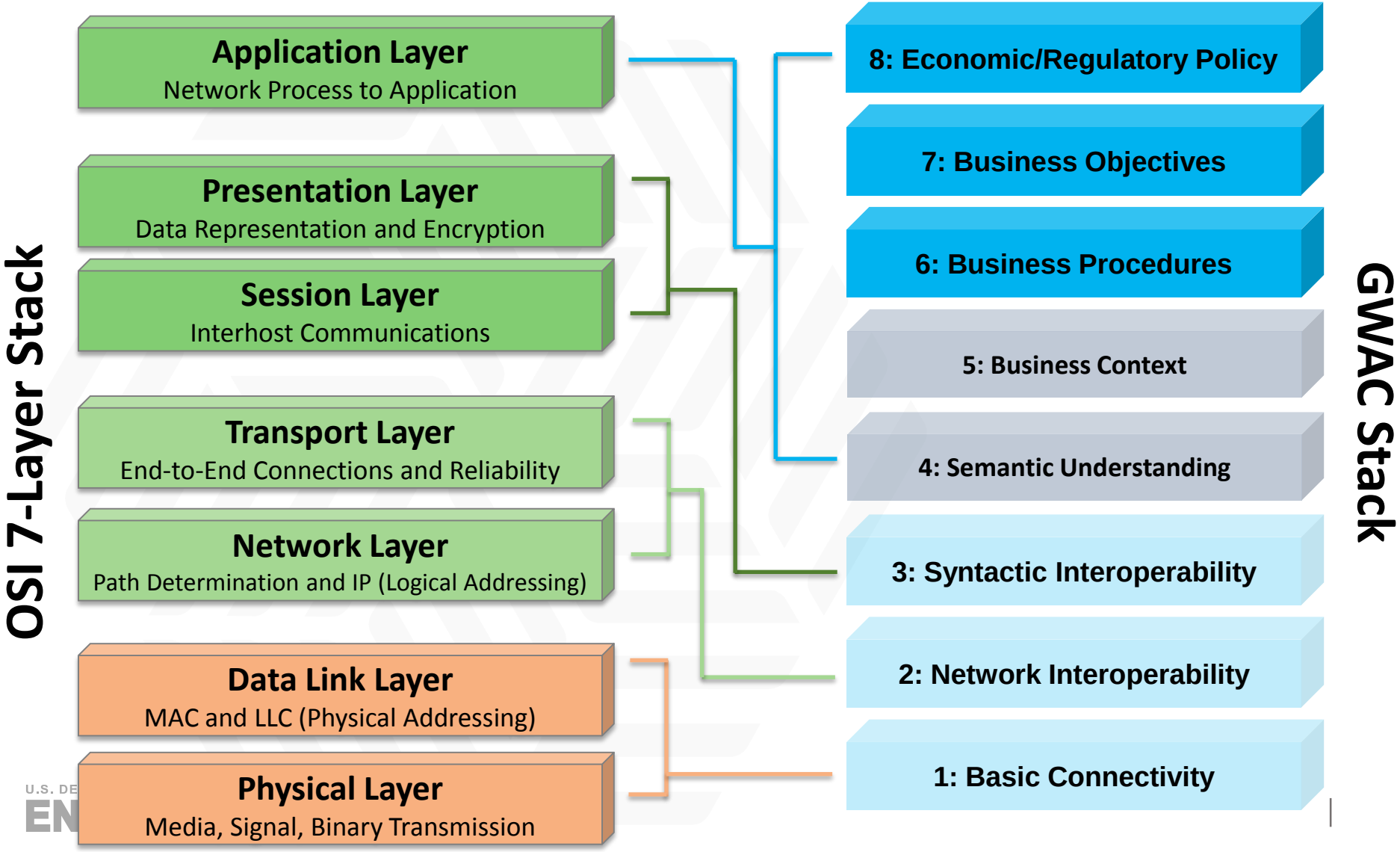
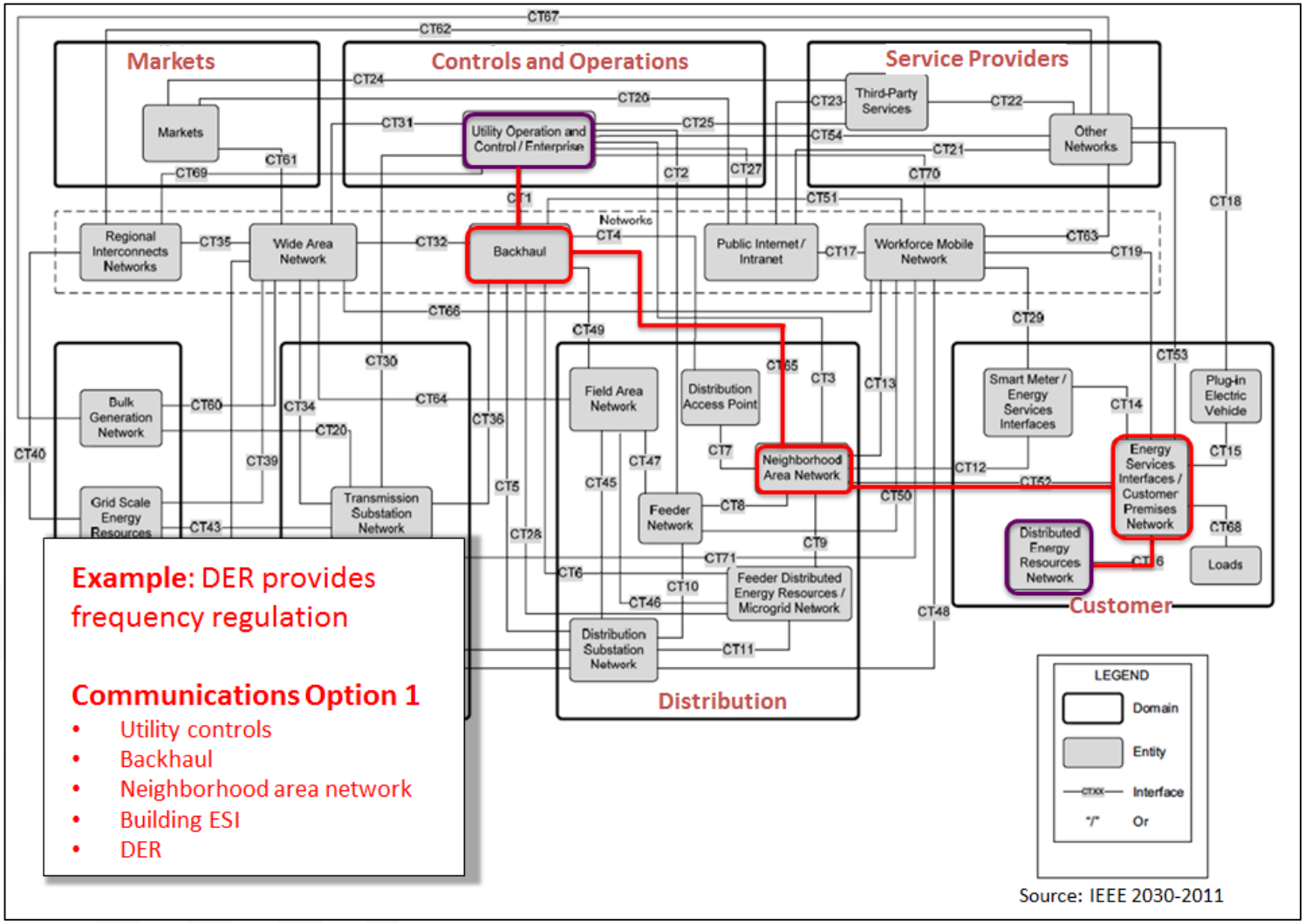


Example of communicating grid service need from utility operations to customer-sited DER



GWAC Stack Layer	Inverter-Based Systems (Generation and Storage)	Vehicles	Building Energy Management System (Responsive Loads, Generation)	Microgrids
6-8	• Grid service defined by policy or economic market (e.g., CA Title-24 DR requirements) • Grid service enabled as a business objective • Entity provides signal requesting grid service • DER/Building/Microgrid are able to respond to request for grid service • Device controls are defined for providing grid service			
5	• Data modeling relevant for providing a specific grid service			
4	• SunSpec Alliance PV Models • SunSpec/MESA Device Models • OpenFMB	• Vehicle data models	• OpenADR 2.0	• IEEE P2030.7 • IEEE P2030.8
3	• IEEE 2030.5 (SEP 2.0) • IEC 61850-90-7 • IEC 61850-7-420 • DNP3 • IEEE 2030.2 • IEEE 1547.3 • Modbus	• SAE J2847/3 (supports SEP2.0) • SAE J2847/2 •	• OpenADR 2.0 • ASHRAE 201 (FSGIM) • ASHRAE 135 (BACnet-WS) • IEC 14908 (LONmark) • IEEE 2030.5 • OBIX • OASIS EMIX • Modbus	• Modbus • TCP/IP • DNP3 Need Harmonization
2	• TCP/IP • ZigBee • DNP3 • Canbus	• TCP/IP • UDP • FTP • HTTP	• TCP/IP • DALI • ZigBee	• TCP/IP • DNP3 • Canbus
1	• Twisted Pair • CTA-2045 • IEEE 802.3 (Ethernet) • IEEE 802.11 (Wi-Fi) • IEEE 802.15.4 (Thread)	• Twisted Pair • CTA-2045 • IEEE 802.3 (Ethernet) • IEEE 802.11 (Wi-Fi) • SAE J1772 (PLC) • SAE J2931/4 (PLC) •	• IEEE 802.3 (Ethernet) • IEEE 802.11 (Wi-Fi) • IEEE 802.15.4 (Thread)	• Twisted Pair, RJ-45, CTA-2045 • IEEE 802.3 (Ethernet) • IEEE 802.11 (Wi-Fi) • IEEE 802.15.4 (Thread)
0	• IEEE P1547 • IEEE P1547.1 • UL1741 • IEEE 2030.2	• SAE J3072 (enables conformance to IEEE 1547.1) • SAE J2894-1 (PQ)	• N/A except for generation that needs to follow IEEE 1547	• IEEE 1547.4

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Accomplishments to Date – Gap Prioritization Summary

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	Inverter-Based Systems (Electric Energy Storage, PV Systems)				Electric Vehicles				Responsive Loads & Generation			
Grid Services	ENERGY	REG, RESERVE, RAMP	VOLTAGE MGMT	ARTIFICIAL INERTIA	ENERGY	REG, RESERVE, RAMP	VOLTAGE MGMT	ARTIFICIAL INERTIA	ENERGY	REG, RESERVE, RAMP	VOLTAGE MGMT	ARTIFICIAL INERTIA
Market size	0.72	0.72	1.00	0.20	0.40	0.32	0.20	0.00	0.76	0.76	0.76	0.28
Time to fill gap	0.83	0.83	0.83	0.17	0.50	0.33	0.20	0.03	0.23	0.17	0.17	0.17
Locational urgency & resource relevance	0.50	0.50	0.50	0.50	0.40	0.40	0.25	0.00	0.75	0.75	0.75	0.5
Technical difficulty	0.80	0.80	0.80	0.80	0.40	0.32	0.24	0.40	0.80	0.40	0.40	0.12
Gap Priority Score	0.71	0.71	0.78	0.42	0.43	0.34	0.22	0.11	0.64	0.52	0.52	0.27

low opportunity — high opportunity

Gap Prioritization Summary

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Recommendations

Inverter DER

1. Affirm updates in forthcoming revision of IEEE 1547
2. Update DNP3, IEEE 2030.5, IEC 61850, and SunSpec/MESA Modbus protocol maps

Responsive Loads

1. Update OpenADR and ASHRAE standards
2. Explore capability and requirements for IEEE 2030.5 (SEP2)
3. Continue work on transactive energy for building/controllable loads
4. Explore the requirements for standardizing the energy services interface

Electric vehicles

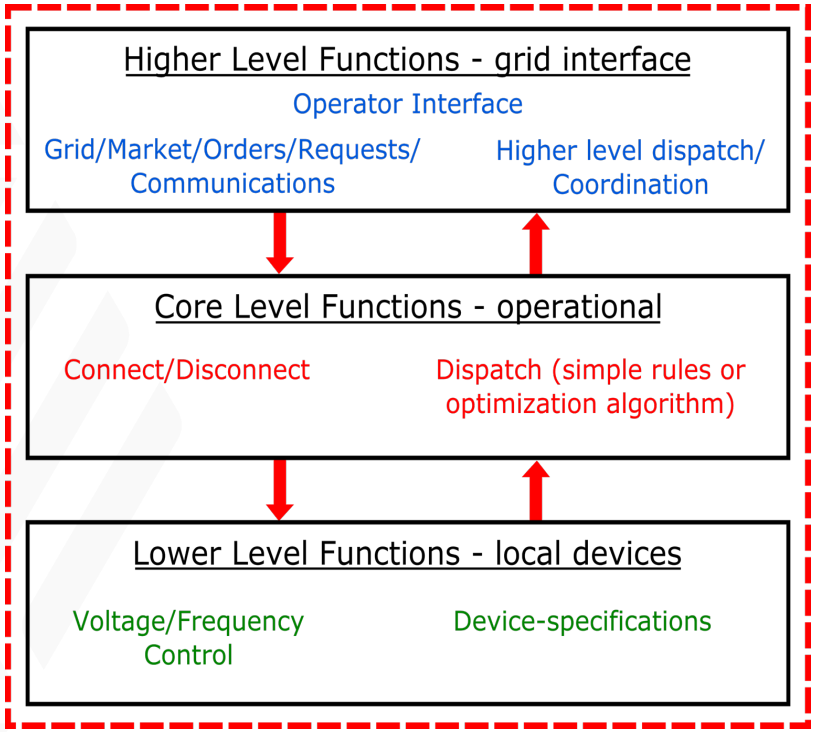
1. Update SAEJ3072

Additional Potential Gap Areas

1. Responsive equipment characterization for grid services information model
2. Cyber-physical security standard for grid-edge devices
3. Grid-responsive building standard (standardization of CA Title 24)

Standards and Test Procedures for Interconnection and Interoperability (GMLC 1.4.1) Accomplishments to Date

- Stakeholder Engagement
  - GMLC Workshop 9/2016 (Denver, CO)
  - SGIP 2016 Grid Summit 11/2016 (Washington, DC
  - GMLC workshop, 3/2017 (Atlanta, GA)
- Publications
  - Gap Analysis and Prioritization (3/2017)
- Lessons learned
  - Prioritization is important but not straight forward
  - Some key barriers are not technical
  - Some additional global gaps may need to be addressed in cases where no broad standards exist



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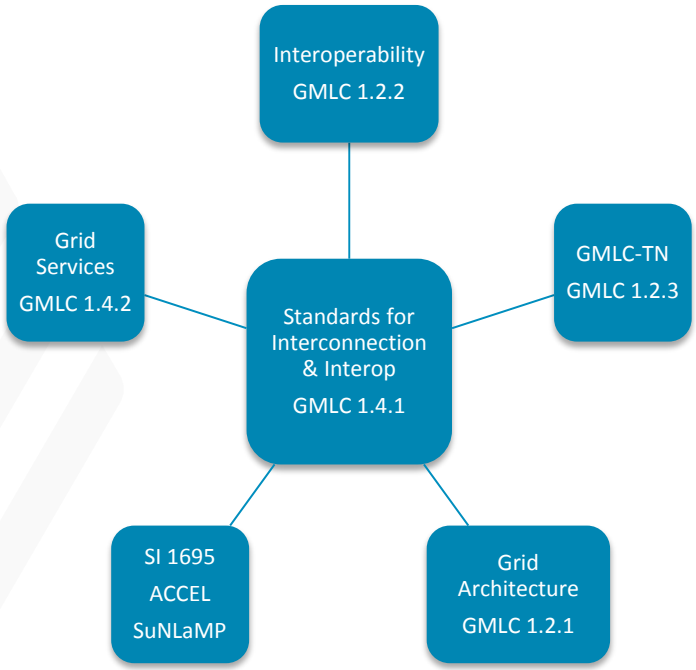
Response to December 2016 Program Review

Recommendation	Response
Need a way to prioritize what to work on	The team has spend considerable time on developing a method to do this,. results are in.
Since IEEE 1547 is in the process of being updated, how do we engage with the IEEE process so they incorporate the cross-technology approach being used in this project?	IEEE 1547 is expected to enter balloting period in 2017, including a public comment period. This is a good opportunity to provide recommendations.
Please better define the industry observers/advisors/partners. Do not lump these all into one group. This project requires a lot of industry support.	Industry observers/advisors/partners have been better defined

Standards and Test Procedures for Interconnection and Interoperability (GMLC 1.4.1)
Project Integration and Collaboration

- Close coordination with GMLC 1.2.2 Interoperability Topic 1.2.2 team □ overall interoperability strategic vision
- GMLC 1.4.1 team □ near-term standards and test procedures
- Scenarios will be coordinated across Grid Services, and interoperability projects
- Test procedures may be housed with GMLC 1.2.3
- Will coordinate with ACCEL team to ensure efforts complement each other and do not overlap

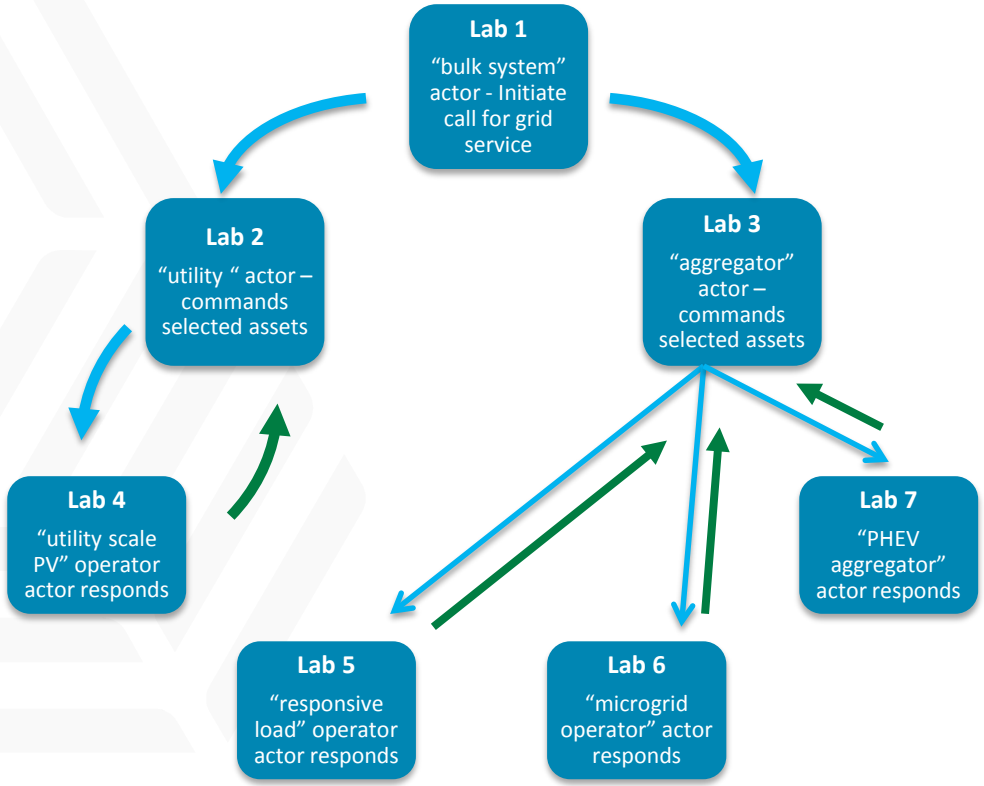


Communications:

- GMLC Workshop 9/2016 (Denver, CO)
- SGIP 2016 Grid Summit 11/2016 (Washington, DC)
- GMLC workshop, 3/2017 (Atlanta, GA)

Next Steps

- Review feedback from stakeholders
- Recommendations to SDOs
- Decision on additional topic areas
- Identify focus for test procedures
- Development of demonstration to test end-to end execution of grid services by relevant grid edge devices
  - Utilizes DOE laboratory assets to show state of the art in standards and to identify gaps
  - Provides exercise of grid service concepts as well as devices



Concept of proposed demonstration of end-to-end grid service command and execution