Interoperability Strategic Vision Overview

GMLC 1.2.2 Interoperability

Steve Widergren, Pacific Northwest National Laboratory

10 May 2017

GMLC Interoperability Technical Review Meeting
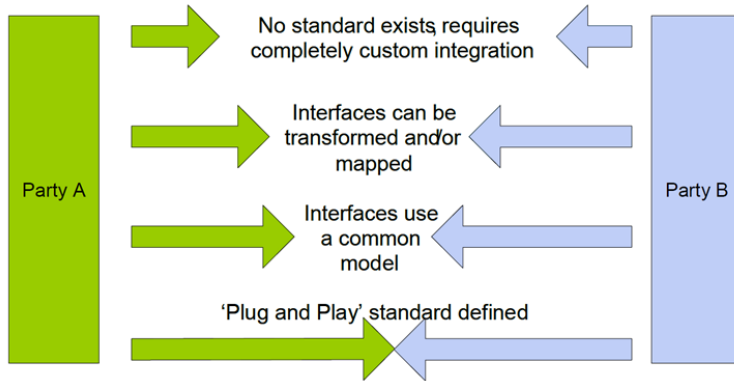
AEP Ohio, Gahanna, OH

Project Summary

The ability of two or more systems or components to exchange information and to use the information that has been exchanged.
ISO/IEC/IEEE 24765

GRID MODERNIZATION INITIATIVE U.S. Department of Energy

Project Description

Align stakeholders on a strategic vision for devices and systems integration and develop measures and tools to support interoperability
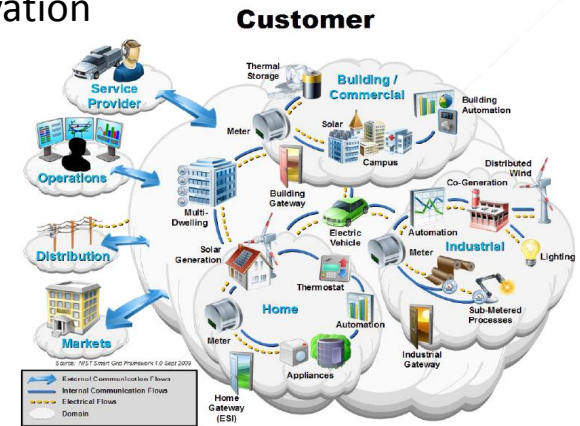
Party A

- No standard exists, requires completely custom integration
- Interfaces can be transformed and/or mapped
- Interfaces use a common model
- 'Plug and Play' standard defined

Party B

Cross-cutting Issues

Interoperability Categories

	Configuration & Evolution				Operation & Performance			Security & Safety		
	Shared Meaning of Content	Resource Identification	Discovery & Configuration	System Evolution & Scalability	Time Synch & Sequencing	Transaction & State Management	Quality of Service	Security & Privacy	Logging & Auditing	System Preservation
Organizational (Pragmatics) 8: Economic/Regulatory Policy	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
7: Business Objectives										
6: Business Procedures										
Informational (Semantics) 5: Business Context										
4: Semantic Understanding										
Technical (Syntax) 3: Syntactic Interoperability										
2: Network Interoperability										
1: Basic Connectivity	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

Value Proposition

- ✓ Reduction of cost and effort for system integration
- ✓ Improve grid performance, efficiency and security
- ✓ Increase in customer choice and participation
- ✓ Establishment of industry-wide best practices
- ✓ Catalyst of innovation

Customer

Service Provider, Operations, Distribution, Markets
Thermal Storage, Building / Commercial, Building Automation, Meter, Solar, Campus, Distributed Wind, Co-Generation, Multi-Dwelling, Building Gateway, Electric Vehicle, Automation, Industrial, Meter, Lighting, Solar Generation, Thermostat, Sub-Metered Processes, Home, Automation, Industrial Gateway, Meter, Appliances, Home Gateway (ESI)

Source: NIST Smart Grid Framework 1.0 Sept 2009
External Communication Flows / Internal Communication Flows / Electrical Flows / Domain

Expected Outcomes

- ✓ Establish an interoperability strategic vision
- ✓ Describe the state, challenges, and path forward to advance interoperability
- ✓ Offer tools to facilitate gap analysis, develop roadmaps, and demonstrate vision concepts
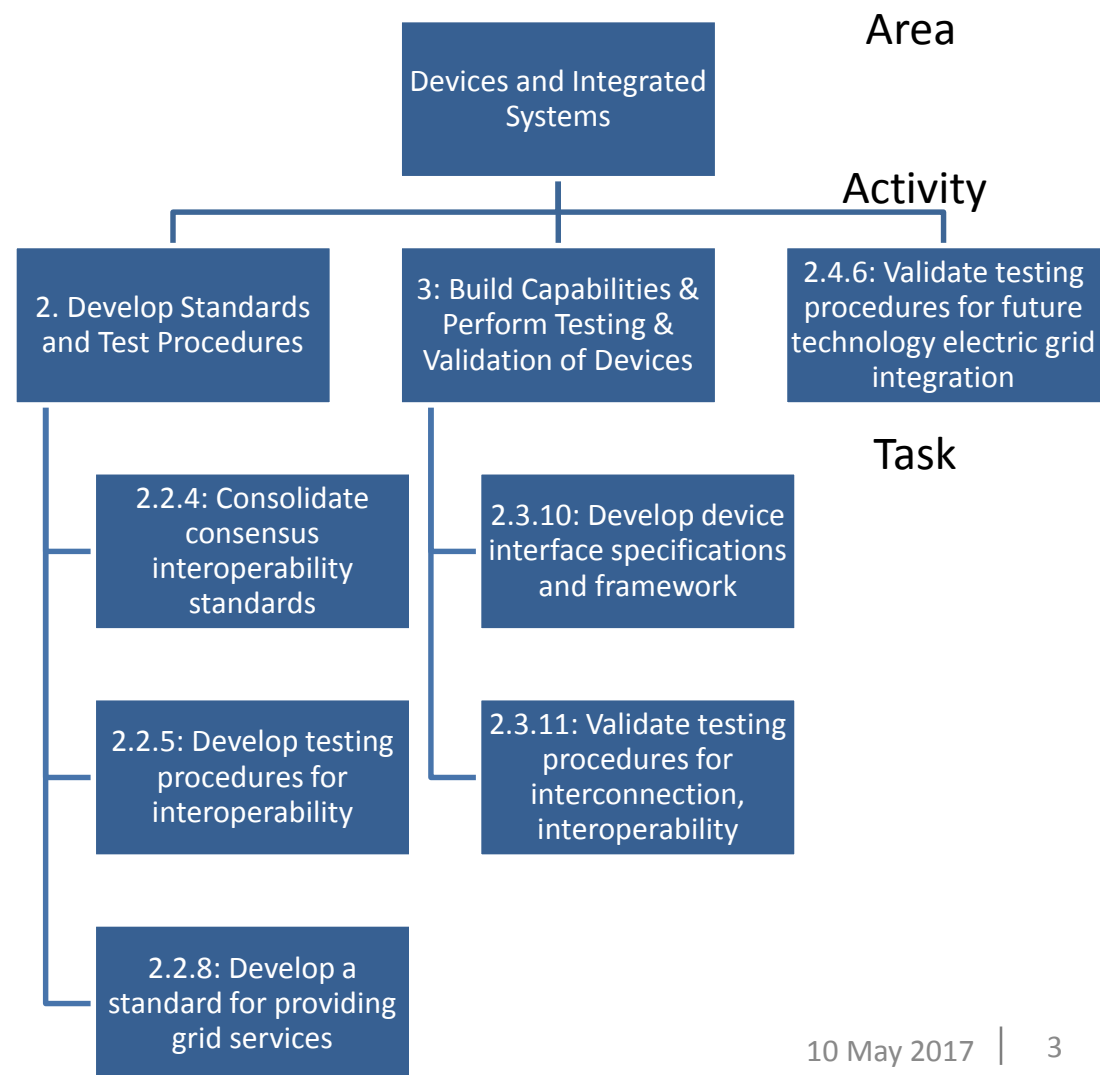
Interoperability Relationship to Grid Modernization Initiative

Quadrennial Energy Review (QER) 6th recommendation: *Improve grid communication through standards and interoperability*
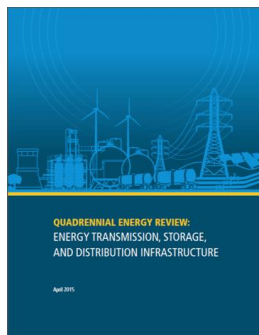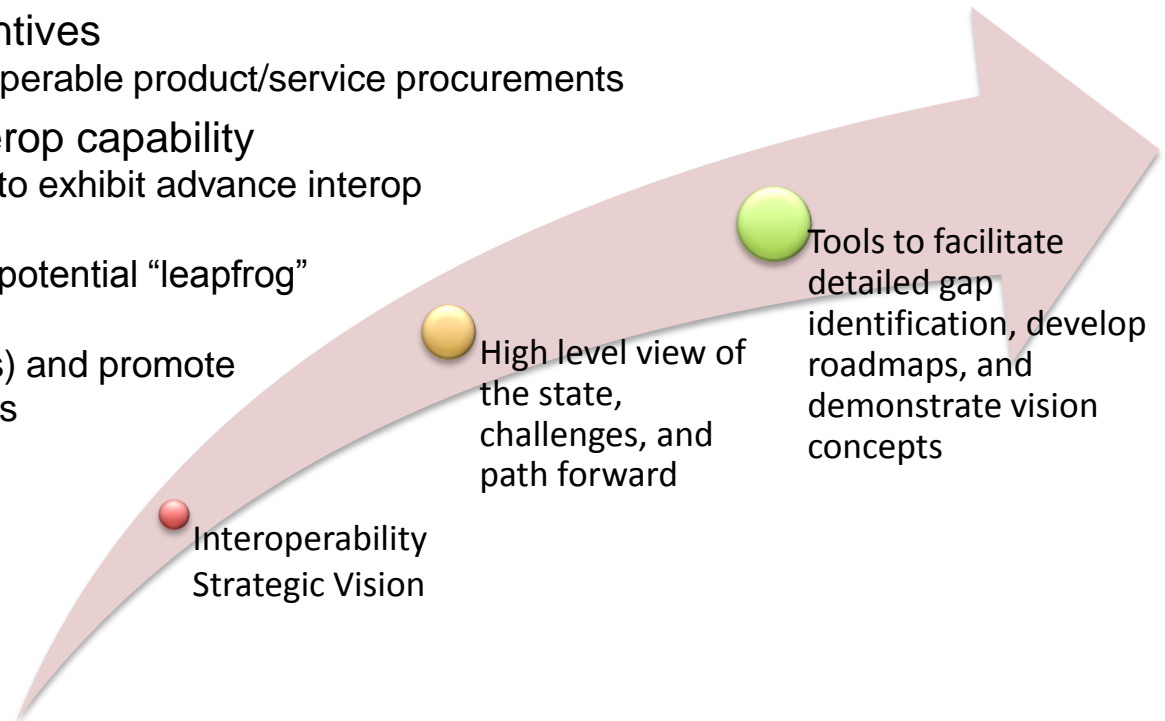
Multi-year Plan:

Frames interoperability as a fundamental quality that needs attention for grid modernization. The chart shows some of the main activities with linkages

Area

Activity

Task

Devices and Integrated Systems

2. Develop Standards and Test Procedures

3: Build Capabilities & Perform Testing & Validation of Devices

2.4.6: Validate testing procedures for future technology electric grid integration

2.2.4: Consolidate consensus interoperability standards

2.3.10: Develop device interface specifications and framework

2.2.5: Develop testing procedures for interoperability

2.3.11: Validate testing procedures for interconnection, interoperability

2.2.8: Develop a standard for providing grid services

Topics

► Project approach

► Progress to date

► Interoperability strategic vision

- ☐ Discussion framework
  - Concepts and models for interoperability
  - Business drivers – grid services
  - Actors, stakeholders, and ecosystems
- ☐ State of interoperability
- ☐ Desired integration experience
- ☐ Criteria for measuring interoperability
- ☐ DER interoperability path forward

► Agenda review

Approach

▶ Strategic vision
- ☐ State of interoperability and desired integration experience
- ☐ Document with stakeholder buy-in, socialization

▶ Gaps & roadmaps
- ☐ Tools to measure interoperability/ease of integration
- ☐ A roadmap methodology for technology communities to set goals and a path to achieve them

▶ Industry engagement incentives
- ☐ Tools to encourage interoperable product/service procurements

▶ Demonstrate visionary interop capability
- ☐ Industry directed contest to exhibit advance interop concepts
- ☐ Identify priority gaps and potential "leapfrog" capabilities
- ☐ Conduct project/contest(s) and promote results for follow-on efforts

Interoperability Strategic Vision

High level view of the state, challenges, and path forward

Tools to facilitate detailed gap identification, develop roadmaps, and demonstrate vision concepts

Declaration of Interoperability

We, the participants in the GMLC Interoperability program, based upon our collective resolve and industry experience, set forth these principles, enumerated below, aligned with the Department of Energy's congressionally mandated charter to convene, adopt, and deploy tools and techniques to enable interoperability to create a more reliable, secure, affordable, flexible, sustainable, and resilient electric power system. We believe this industry-led approach can, by following these principles, develop the needed solutions to achieve these goals.

We recognize that a lack of cost-effective interoperability creates onerous and ongoing problems for system integration and operation.

> It wastes energy. **>** It wastes money. **>** It wastes time. **>** It impedes goals of renewable generation and grid performance.

Our future electric power system must easily integrate great numbers of an evolving mix of intelligent, interacting systems and components. Achieving this state requires the advancement of interoperability and the principles that support it; this is a shared challenge requiring alignment across all electric system stakeholders. It is therefore necessary to articulate interoperability goals and requirements and establish a strategic vision for interoperability.

Interoperability is "The ability of two or more systems or components to exchange information and to use the information that has been exchanged". Interoperability also refers to the steps required to achieve this state, which directly relates to the level of effort to successfully integrate systems or components. With this understanding, we recognize the following principles:

- Systems or components need to interact according to agreements at their interface boundaries.
- A system architecture description needs to clearly identify the interface points where systems or components may interact.
- Interoperability concerns need to pervade across a heterogeneous mix of technologies, business practices, and deployment approaches.
- Stakeholders need to participate in the process to develop, use, and maintain interoperability standards, conventions, and supporting capabilities such as certification programs, registries, and security policies.

The principles above require changes in today's technologies, business practices, and deployment approaches, to promote interoperability and simplify the integration experiences.

We hereby recognize that improving stakeholder agreement on clear interface definitions and mechanisms to simply and cost-effectively integrate systems and components will catalyze the realization of a more efficient and secure electric system sensitive to our operational, economic, and ecologic needs. And in response, we join in the efforts to advance interoperability of the future electric system and commit to changing technologies and business processes to accomplish this mission.

ISO/IEC/IEEE 24765: Systems and software engineering — Vocabulary. International Organization of Standards. 2010.
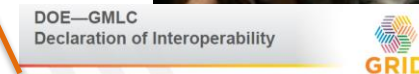
Progress to Date

- ✓ <u>Drafted</u> foundational documents
  - ➢ Declaration of Interoperability
  - ➢ Interoperability Strategic Vision
  - ➢ Interoperability Maturity Model (IMM)
  - ➢ Interoperability Roadmap Methodology

- ✓ Stakeholder engagement – <u>critical!</u>
  - ➢ 16 partner organizations, regular 7 web meetings
  - ➢ Sep 2016 stakeholder technical meeting
    - ➢ Consensus voiced through unanimous vote in favor of the project's objectives and plan
    - ➢ Interoperability goals/requirements statements tested
  - ➢ Nov 2016 outreach at SGIP annual meeting reviewed Declaration, interop criteria, and roadmap methodology plan
  - ➢ Apr 2017 Public Utilities Fortnightly article
  - ➢ Several presentations: AHR Expo, ISGT…
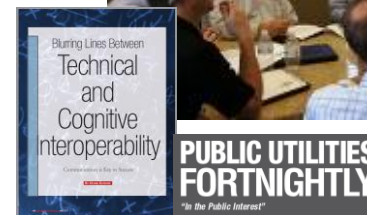
► Layered decomposition coordination framework

► Defined interface points for integration
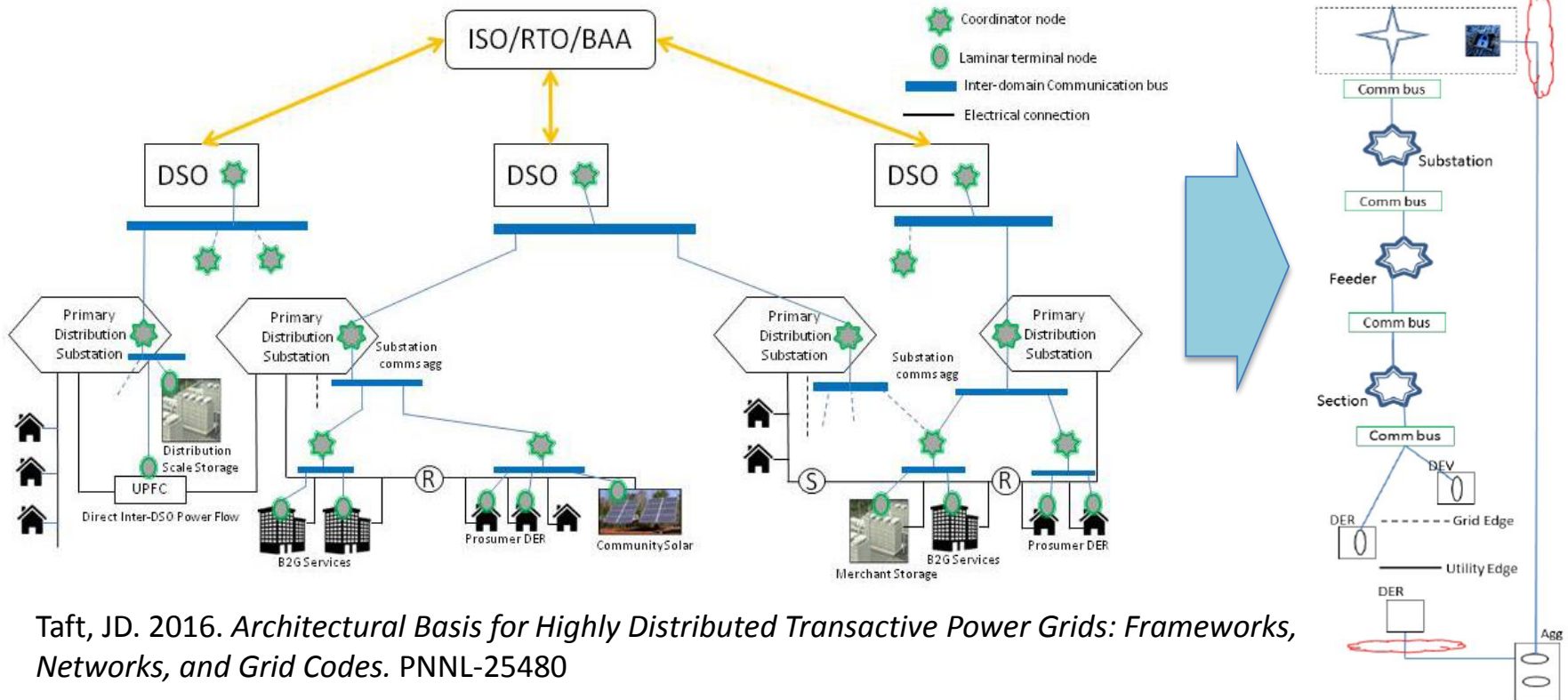
Taft, JD. 2016. *Architectural Basis for Highly Distributed Transactive Power Grids: Frameworks, Networks, and Grid Codes.* PNNL-25480

9

Example:
Components for DER to Grid Integration

DER Facility

Interacting Party ↔ | Energy Service Interface | Facility Management System | ↔ DER Equipment

External integration

Internal integration

Places for focusing interoperability activities
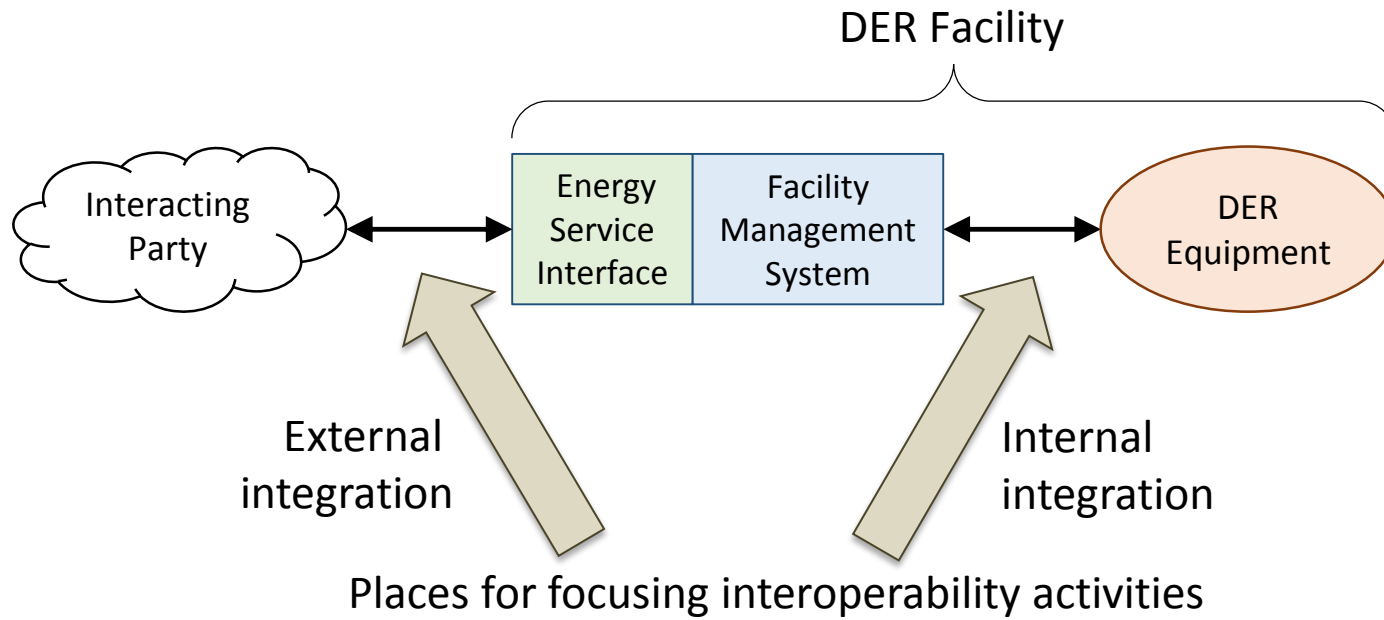
Purpose

- ☐ Preserve layered decomposition coordination framework pattern
- ☐ Separate concerns on networking, cybersecurity, and privacy
- ☐ Acknowledge separate "ecosystems" of business propositions internal and external
- ☐ Encourage common business processes to reduce the number of specialized interfaces
  - E.g., eliminate/reduce dependence of external interface on equipment type

General DER Facility Conceptual Model
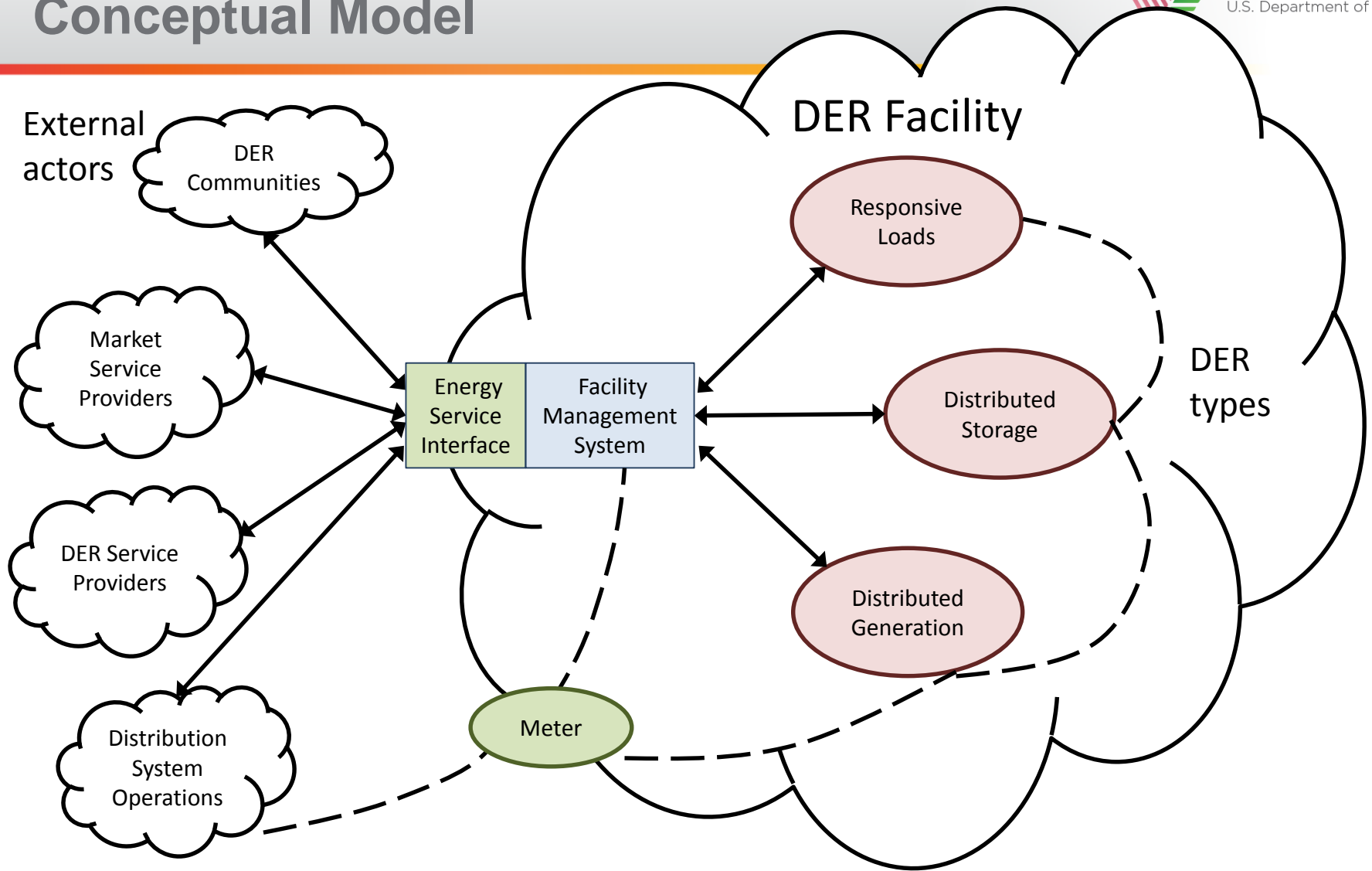
The sets of arrows and dotted lines represent areas of focus for discussing interoperability issues

Grid Services – Drivers for DER Integration

- ► Peak capacity management
- ► Energy market price response
- ► Capacity market dispatch
- ► Frequency regulation
- ► Spinning reserve
- ► Ramping (a new type of service)
- ► Artificial inertia (a new type of service)
- ► Distribution voltage management (a new type of service)

* Preliminary from GMLC 1.4.2 input to GMLC 1.2.1 common grid services list

Actors, Stakeholders, and Ecosystems

Actors

- ► DER Operations
  - ☐ Responsible for DER operation
- ► DER Communities
  - ☐ Collection of DER that work together
- ► DER Service Provider
  - ☐ Equipment monitoring, diagnostics, and troubleshooting
- ► Market Service Provider
  - ☐ Aggregator of DER
- ► Distribution System Operations
  - ☐ Responsible for the reliable operation of the distribution system

Stakeholders

- ► DER operators (managers, owners, and users)
- ► DER communities
- ► DER service providers
- ► Market service providers
- ► Distribution system operators
- ► DER equipment suppliers (hardware manufacturers)
- ► DER energy management system suppliers (s/w automation suppliers)
- ► Communications infrastructure and service providers
- ► Regulators and government agencies
- ► Trade associations, industry consortia, and standards development organizations
- ► Testing and certification organizations

Integration Ecosystems

- ► Communities of organizations with business alignment to drive standards, testing, branding, policy in one or more "technology integration areas"
- ► Example technology integration areas
  - ☐ Electric vehicles
  - ☐ Photovoltaics, smart inverters
  - ☐ Commercial building loads
  - ☐ Residential loads
  - ☐ Metering

- ► Need help to identify and describe these integration ecosystems

- ► More on this later…

Interop Context-Setting Framework (GWAC)

http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf
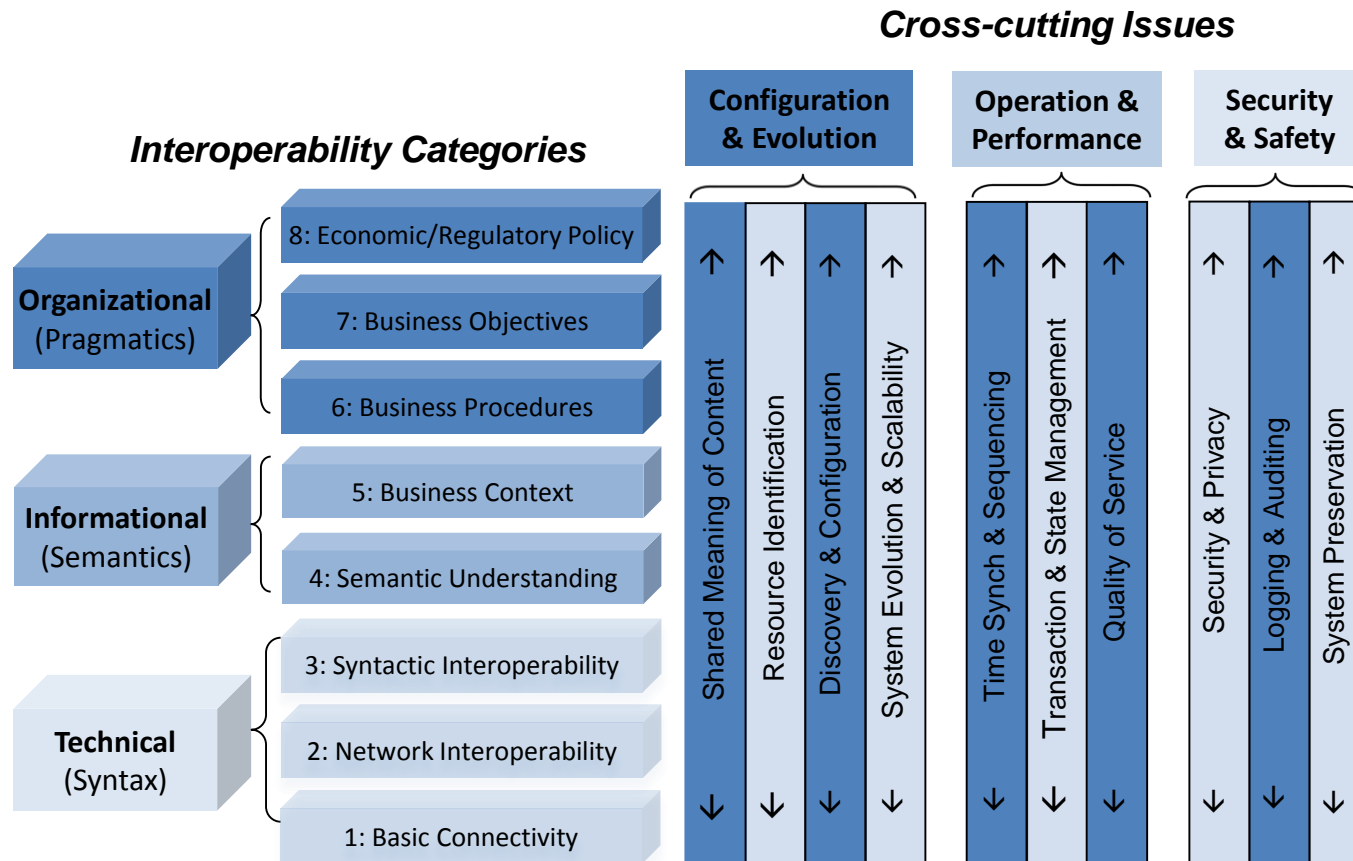
DER Connectivity Framework

Interoperability Categories (GWAC Stack)

DER Automation Zones (ASHRAE-Purdue model)

DER Actor Domains (Conceptual Model)

Organizational

Informational

Technical

Management (business, enterprise)

Supervisory (facility coordination, operations)

Control (application specific control)

Devices (I/O, local control)

DER Operations

DER Communities

DER Service Providers

Market Service Providers

Distribution System Operations

Transmission services work through market and distribution

State of Interoperability Observations

Using the GWAC Interop Context-Setting Framework categories…

► Technical state
   ☐ Mature set of communications networking standards and protocols
      • Many to choose from, wired and wireless
   ☐ Integration ecosystems pick their own set of standards-based profiles
   ☐ Cybersecurity is getting attention, but legacy standard vulnerabilities an issue

► Informational state
   ☐ Informational models generic, SCADA-oriented, but richer standards emerging
   ☐ Modeling approaches tend to support read/write, direct control approaches rather than service-oriented techniques
   ☐ Modeling methods and tools differ in technology integration areas
   ☐ Harmonization of information models hampered by legacy modeling approaches that challenge transformation

► Organizational state

- Grid service programs for using grid-edge resources
  - Many different programs offered by utilities depending on facility size
  - Grid services defined differently for each utility
    - ◆ load-shedding, peak capacity management, spinning reserve, time of use, critical peak pricing
  - The concept of an ESI is not embraced and often equipment-type dependent and not coordinated at the facility level
  - Usually direct control-oriented design
  - Where markets exist, aggregators use proprietary system interfaces to DER
- Regulatory and legislative policy
  - Regulatory compact encourages regulated return on capital investments, not least cost supplier
  - Policies encourage technology-specific investments such as PV or wind with no communications for operations coordination (e.g., net metering)
  - Where communications are used, policies tend to be technology-specific

Desired Integration Experience
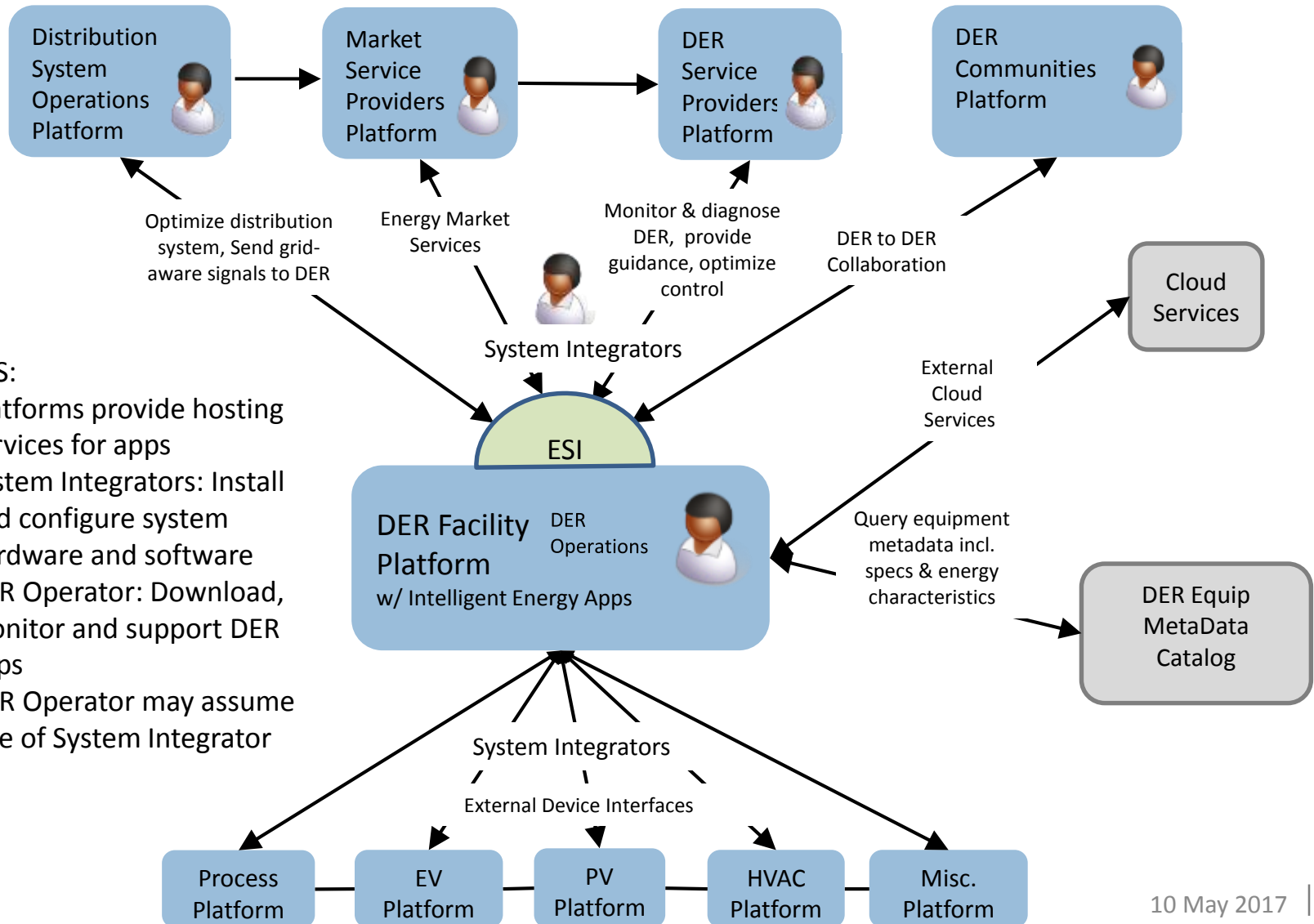
NOTES:
1. Platforms provide hosting services for apps
2. System Integrators: Install and configure system hardware and software
3. DER Operator: Download, monitor and support DER apps
4. DER Operator may assume role of System Integrator

Distribution System Operations Platform

Market Service Providers Platform

DER Service Providers Platform

DER Communities Platform

Optimize distribution system, Send grid-aware signals to DER

Energy Market Services

Monitor & diagnose DER, provide guidance, optimize control

DER to DER Collaboration

System Integrators

ESI

DER Facility Platform
DER Operations
w/ Intelligent Energy Apps

External Cloud Services

Cloud Services

Query equipment metadata incl. specs & energy characteristics

DER Equip MetaData Catalog

System Integrators

External Device Interfaces

Process Platform

EV Platform

PV Platform

HVAC Platform

Misc. Platform

10 May 2017 | 19

Market Service Provider Story

- ► MSP works with wholesale energy providers to create buy/sell forward products
- ► MSP runs a forward contracts market for energy that exposes an interface
- ► Buildings Operator (BO) connects to this interface using apps provided by the MSP or third parties
- ► BO configures his app and devices to select contracts automatically
- ► As agent for BO, app buys/sells contracts according to anticipated and historical consumption
- ► In monthly billing period, BO and MSP reconcile contract performance. BO's app uses this information to improve future contract selection

Market Service
Provider Platform

ESI

Buildings
Platform   Buildings
Operations
w/ Intelligent Energy Apps

External Device Interfaces

Process
Platform

HVAC
Platform
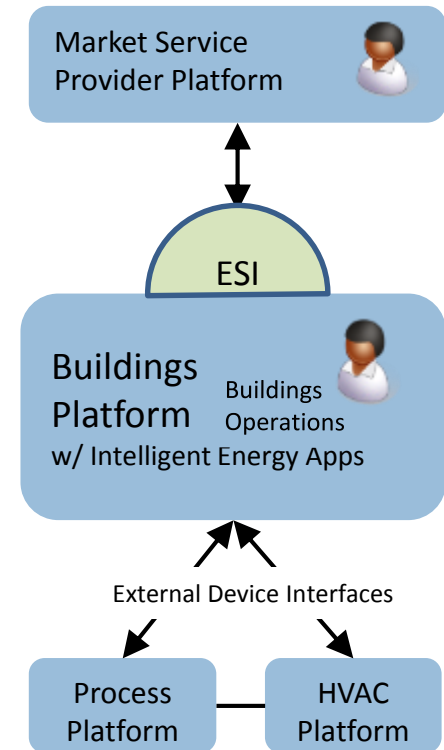
Interop Challenge: What needs to be established *behind the scenes* to support the integration of the components in this story in a scalable, evolvable, secure manner across a changing set of actors and technology solutions providers?

Measuring Interoperability

► Challenge: How can we measure interoperability characteristics to simplify integration?

► Approach: an interoperability maturity model (IMM)

  ☐ Identify criteria whose existence contributes to achieving interoperability

    • E.g., unambiguous resource identification, information models, security policy defined

  ☐ Define levels of maturity

  ☐ Create a maturity model with testable statements for each criteria

  ☐ Propose a scoring system

► Application: describe state of interoperability and identify gaps in an integration area
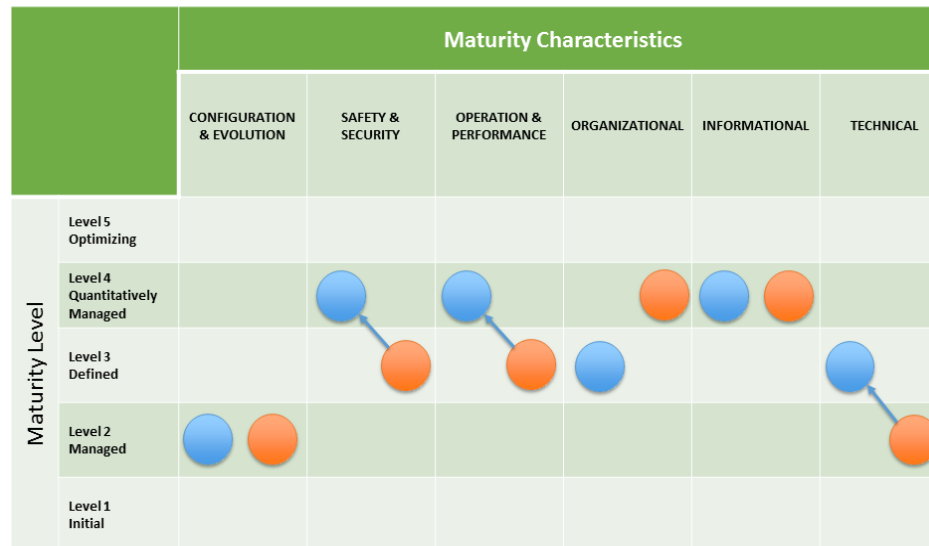
Roadmap Methodology
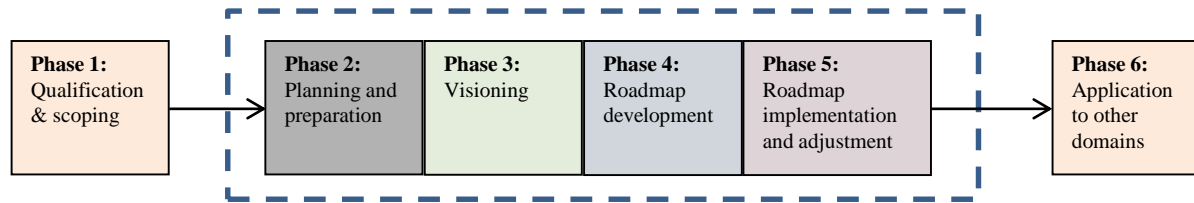
- ▶ Emphasizes stakeholder engagement
- ▶ Incorporates interoperability maturity model (IMM) for state and gaps
- ▶ Desired outcome
  - ☐ Identify gaps and barriers
  - ☐ Resolve benefits and priorities
  - ☐ Milestones, precedence, and timelines
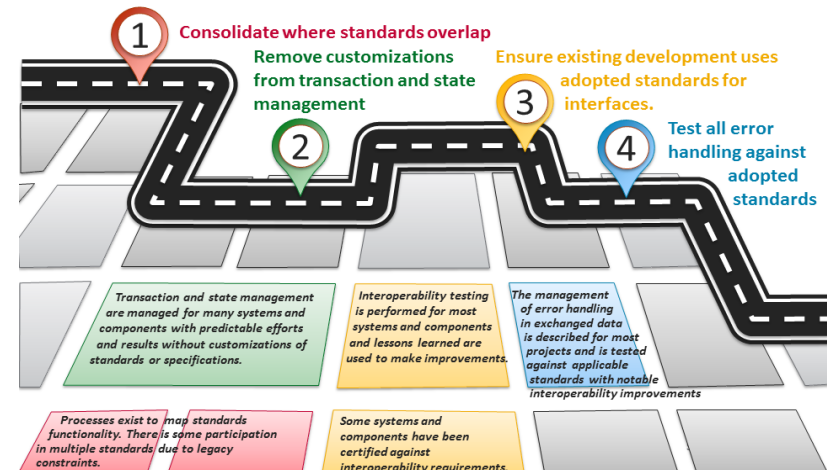
Back to Integration Ecosystems:
Example: Electric Vehicles Integration

► Business drivers

□ EV owner/operators: affordable and convenient energy provision to assets

□ Auto manufactures and charging suppliers: serve all EVs and complete transactions effectively

□ Market service providers (aggregators): use flexibility for grid services

□ Distribution operators: ensure operations are reliable and use flexibility for distribution operations grid services (voltage and distribution capacity management)

► Major organizations

□ International car companies, charge station suppliers, distribution utilities, governments, standards organizations

□ Conveners:

• DOE and EC's Joint Research Center's EV smart grid interoperability centers

• SAE, IEEE, ISO standards organizations

• CHAdeMO, Charin, Global InterOP, Open Charge Alliance (OPCC) consortia

Integration Ecosystem Example: Photovoltaics, Smart Inverter

► Business drivers

- ☐ PV system host: least cost and/or environment sensitive energy provision
- ☐ State policies in CA, HI, NY… to encourage PV deployment
- ☐ Market service providers: integrate turnkey PV systems and consider flexibility for grid services
- ☐ Distribution operators: ensure operations are reliable and use flexibility for distribution operations grid services (voltage and distribution capacity management)

► Major organizations

- ☐ Distribution utilities in states with PV policies, PV and smart inverter suppliers, state PUCs, standards organizations
- ☐ Conveners:
  - States: CA, HI, NY…
  - SunSpec Alliance, SEPA, EPRI, Solar Energy Industries Assoc, Utility Variable-Generation Integration Group, MESA consortia

Integration Ecosystems Example: Commercial Buildings Responsive Load

► **Business drivers**
   ☐ Buildings owner/operators: least expensive energy provision to meet building process and comfort demands
   ☐ Buildings automation suppliers: energy efficiency and comfort with potential payback from supplying grid services
   ☐ Market service providers (aggregators): use flexibility for grid services
   ☐ Distribution operators: ensure operations are reliable and use flexibility for distribution operations grid services (e.g., distribution capacity management)

► **Major organizations**
   ☐ States: Buildings automation and equipment suppliers and integrators, distribution utilities, governments, standards organizations
   ☐ Conveners:
      • States: CA, NY, MN, HI…
      • OASIS, ASHRAE standards organizations
      • ZigBee Alliance, OpenADR Alliance consortia

Integration Ecosystems Example: Metering

► Business drivers

- Federal and state policies to encourage advanced meter deployment to support grid services using dynamic rates
- Market service providers: measure flexibility for grid services and reconciliation
- Distribution operators: remote on/off, meter reading, monitor and compensate for operations to ensure reliable operations

► Major organizations

- State regulators, distribution utilities, meter suppliers, standards organizations
- Conveners:
  - NEMA, IEEE, ISO, IEC standards organizations
  - Association of Edison Illuminating Companies, NEMA, Utilities Telecommunications Council consortia

Premise: Engage Ecosystems

► Integration ecosystems are communities of organizations that are motivated to work together to enable market deployments in a technology area

► The community drives standards, testing, branding, policy, and other things for the benefits that come with making interoperability easy

► It's hard for one organization to create an ecosystem, so teaming is needed, though there will be champions and followers

► While amorphous and evolving, these communities have the reasons and critical mass to invest in interoperability improvement roadmaps

Discussion Question: If ecosystems are not engaged, what alternatives are there to advance interoperability?

Path Forward (abridged)

▶ **Vision**: socialize definitions, concepts, architecture of the strategic vision

▶ **Ecosystems**: identify an ecosystem to trial roadmap methodology and interoperability measurement tools. Support roadmap execution

▶ **Culture change**: develop pro-forma interoperability performance language with, by, and for industry, applicable to technology procurement contracts

▶ **Characteristics**: develop plans to advance interoperability criteria across grid modernization related ecosystems (e.g., resource identification, registration and discovery, scalability, error handling, synchronization)

▶ **Security & privacy**: develop best practices for policy statements to incorporate into interface specifications

▶ **Interface contract model**: establish/adapt a framework to capture technical, informational, and organizational interface agreements in machine-readable form

▶ **Education**: develop introductory material on interoperability, its benefits, and how to advance it

Government Role Considerations

► Convene stakeholders for alignment on strategic vision

► Engage integration ecosystem to measure state of interoperability and apply roadmap methodology

► Sponsor demonstrations of advanced interoperability capabilities

► Adopt interoperability performance criteria in government procurement specifications (lead by example)

► Support tools to advance interoperability

    ☐ E.g., establish registration framework of devices/systems for unique identification and authentication

Agenda

► This morning
   - ☐ Integration ecosystems panel

► This afternoon
   - ☐ Ecosystems landscape breakout session
   - ☐ Measuring interoperability – the IMM
   - ☐ Use of Interoperability criteria breakout session

► Tomorrow morning
   - ☐ Roadmap methodology
   - ☐ Roadmap interactive demonstration
   - ☐ Summary and next steps

► Tomorrow afternoon
   - ☐ Tour of AEP Dolan Technology Center

A Hearty Thank You to

Begin by Listening
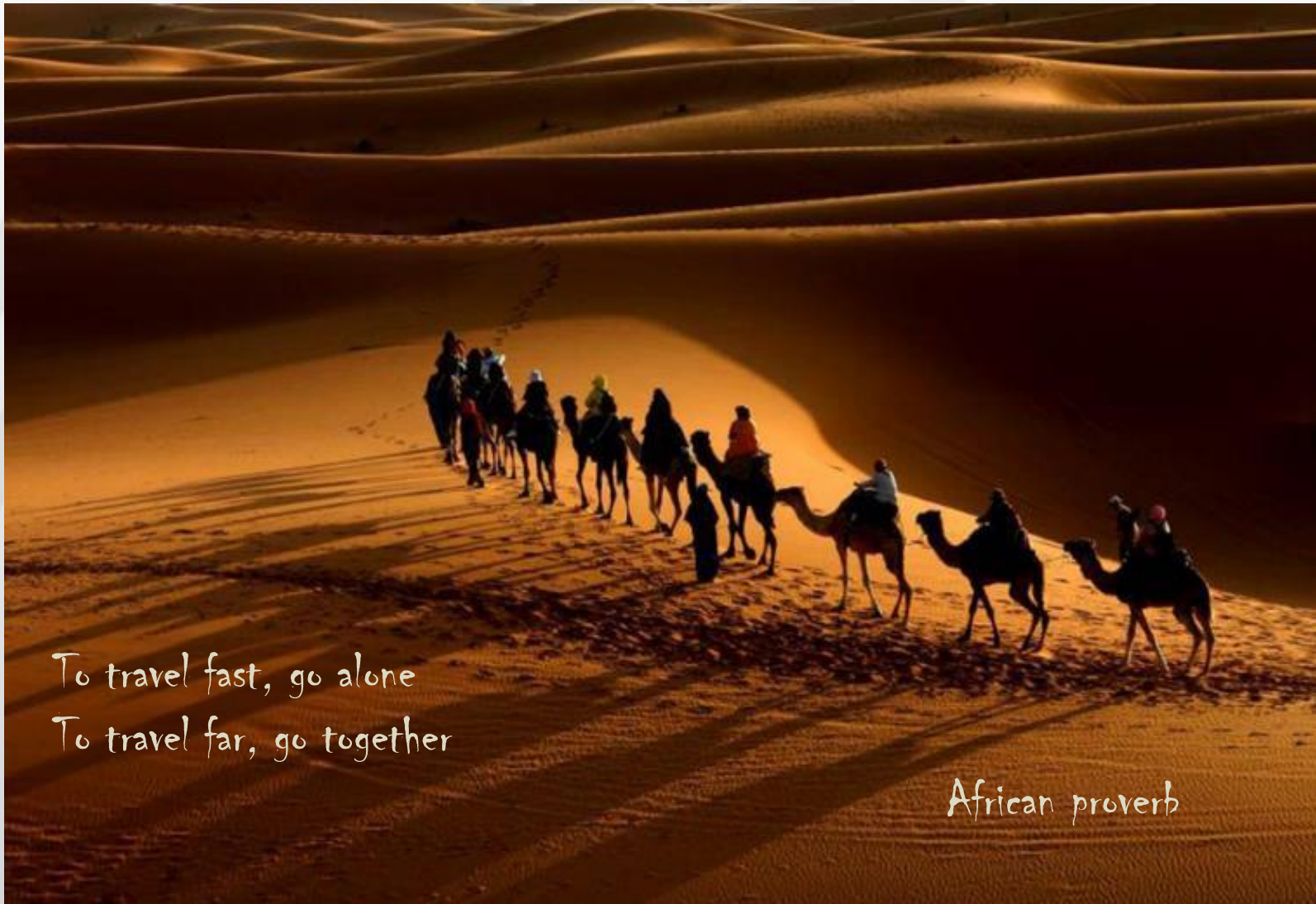
To travel fast, go alone
To travel far, go together

African proverb