September 2018

Information and Communication Technology Roadmap

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ICT Vision and Mission:

Information and Communication Technology

The Vision of the ICT program:
An electricity infrastructure that is highly connected, highly interactive and highly interoperable.

The Mission of the ICT program:
Enable efficient data communications, integration and analysis through leadership, collaboration, standards and technology innovation.

Information and Communication Technologies are foundational for enabling functions related to decisions and actions along the energy value chain from the transmission system, through the distribution system, and down to end devices. Through secure connectivity, the power system can better integrate advanced digital functionality to become more flexible and resilient. Challenges to overcome include the sheer volume of data; interfacing with proprietary systems; varying life-cycle timescales between utility assets and new connected devices; and effective integration into the power system. The overall roadmap development process is depicted below. It includes the development of aspirational future states, a gap analysis between the future and current state, and action plans to address the identified gaps. EPRI staff has collaborated with numerous industry stakeholders to identify over 20 future states, the associated gaps, and action plans to bridge those gaps over the next 3-5 years within EPRI's research portfolio. Each subsequent year, EPRI staff has reevaluated and updated the roadmap based on our research findings and technology advances.

FUTURE STATE

Document current state of:

- Technology Development
- Technology Implementation
- Integration and operational strategies
- RD&D Activities

Determine Future State:

- Technology performance and cost
- Technology implementation
- Integration and operational strategies

GAP ANALYSIS

- Determine gaps between the current and future states
- Gaps can be associated to technology performance, implementation issues, experience, etc.
- Prioritize the gaps

ACTION PLAN

- Sequencing and prioritization of recommended RDD&D activities
- Funding amounts
- Coordination and timing with other activities and programs
- Technical performance and cost targets for promising technologies
- Critical indicators of success

Information and Communication Technology Roadmap

Information and Communication Technology (ICT)

Applied ICT for Transmission (161B)	Applied ICT for Distribution (161C)	Applied ICT for Distributed Energy Resources (DER) (161D)	Enterprise Architecture and Integration (161E)	Advanced Metering Infrastructure (AMI) (161F)	Telecommunications (161G)
GRID DOMAINS					

PROGRAMS DEFINE ACTION PLANS

Action Plans and Project Definitions:

What we need to do to bridge the gaps to achieve the Future States.

Actions are taken through a variety of different project types within EPRI, as described below.

Transmission

Distribution

Energy Utilization

Annual Research Portfolio: EPRI's offering of collaborative, membership funded research work for a given year. All annual research portfolio purchases are based on EPRI's research year (the calendar year). These offerings are made available each June for the subsequent research year.

Supplemental Project: Some research projects are not part of the annual research portfolio, they are executed as supplemental projects. These supplemental projects are done more as one-off projects; they can be single or multiple funder projects.

Technology Innovation Project: Technology Innovation allows members to leverage their long-term investment (10+ years) in collaborative research that may create entirely new markets, products and services, increase the public benefits of efficient, clean affordable energy and ensure the competitiveness of the energy enterprise.

Pre-Demonstration Project: EPRI program to fund R&D that would enable a large scale demonstration project. For example, a pre-demonstration project that laid the foundation for the multi-year, collaborative was the Field Area Network (FAN) Demonstration project.

Government Project: A project that EPRI has been awarded through a government entity such as the U.S. Department of Energy, California Energy Commission or the New York State Energy Research and Development Authority. Awards are typically made by these organizations through an open, competitive solicitation process.

Workshops and Forums: EPRI meetings, direct interaction with one or more potential customers can take place via face-to-face meetings, workshops, conference calls, or webcasts and are defined as technical deliverables. Forums or interest groups are formed by advisors and stakeholders that also meet on a regular basis throughout the year.

Mission, Drivers, and Future States

ACTION PLANS BRIDGE THE GAPS

MISSION

ICT—
Enable efficient data communications, integration and analysis through leadership, collaboration, standards and technology innovation

DRIVERS

- Interoperability
- Data management
- Pervasive communications and computing
- Integration of intelligent field equipment, edge devices, mobile workforce and consumer IoT devices with utility systems

Action Plans	FUTURE STATES
GIS data quality → Precise system and data models → Standardized data structures → Capitalize on available high-speed, precision, time-stamped data → Increasing intelligence through standards and integration	Data Management
Interoperable DER/DR → Validated communications and control architectures for DER/DR → Optimized practices for connecting DER/DR	DER Standards
Enterprise architecture maturity → Integration maturity → Business efficiency: IT / OT convergence → Standards and certification → Agile enterprise	Enterprise Architecture and System Integration Maturity
Open, interoperable AMI systems → Established and proven best-practices for AMI system O&M → Optimized AMI system utilization and value	Optimal AMI Utilization and Interoperability
Interoperable and reliable field area networks → Optimal use of available spectrum → Wide area networks use packet based technology → Expansion of fiber backbone → Fully integrated network management system → Interoperability of telecommunications systems through standards	Pervasive Telecommunications

Information and Communication Technology Roadmap

Information and Communication Technology (ICT)

Applied ICT for Transmission (161B)	Applied ICT for Distribution (161C)	Applied ICT for Distributed Energy Resources (DER) (161D)	Enterprise Architecture and Integration (161E)	Advanced Metering Infrastructure (AMI) (161F)	Tele-communications (161G)
GRID DOMAINS					
FUTURE STATES	**FUTURE STATES**	**FUTURE STATES**	**FUTURE STATES**	**FUTURE STATES**	**FUTURE STATES**
Standardized Data Structures	Precise System and Data Models	Interoperable DER/DR	Enterprise Architecture Maturity	Open, Interoperable AMI Systems	Interoperable and Reliable Field Area Networks
High-Speed Precision Time-Stamped Data	Connected Workforce and Devices	Validated Communications and Control Architectures for DER/DR	Integration Maturity	Established and Proven Best-Practices for AMI System O&M	Optimal Use of Available Spectrum
Capitalize on Available High-Speed Precision Time-Stamped Data	Increasing Intelligence Through Standards and Integration	Optimized Practices for Connecting DER/DR	Business Efficiency: IT/OT Convergence	Optimized AMI System Utilization and Value	Wide Area Networks Use Packet-Based Technology
			Standards and Certification		Expansion of Fiber Backbone
			Agile Enterprise		Fully Integrated Network Management System
					Interoperability of Telecommunications Systems Through Standards

ICT Program Overview

The Information and Communications Technology (ICT) Program addresses challenges to reduce utility risks by conducting research, development, and demonstrations in:

- **Interoperability**–EPRI accelerates the industry's migration towards interoperability by leading industry activities, making technical contributions to standards development efforts, training utilities, organizing interoperability tests, developing transition strategies, and collaborating with utilities on demonstrations of emerging standards.
- **Communications**–EPRI provides leadership in communications standards development, tracks and analyzes communications technologies and conducts laboratory and field tests to evaluate the performance of evolving and emerging technologies.
- **Enterprise Architecture/Systems Integration**–EPRI creates artifacts to improve the state of the art in enterprise architecture and develops guides to help utilities with standards-based systems integration.
- **Advanced Metering**–EPRI leads an industry effort to develop open, interoperable advanced metering system and develops best practices guides for operations and maintenance.

Program Manager, Don Von Dollen, dvondoll@epri.com

Applied ICT for Transmission (161B)

This project set provides technical guidance for ICT items of interest to transmission-focused organizations. Utilities continue to invest in sensor technologies that provide real-time information for managing the grid and grid assets. Among these are asset condition monitors, phasor measurement units (PMU) that deliver precise, time-stamped grid status and video cameras for substation security monitoring. All of these technologies require effective data management approaches and a robust communications infrastructure; however, many utilities face the daunting challenge of interfacing a wide variety of legacy and modern data sources that may also vary across operating companies acquired over the years.

The complexity, sophistication, and importance of transmission network analysis tools necessary for effective grid operation and planning is growing. Improved data management and traceability along with effective substation data transport and handling provides a reliable source of data for effective grid operations. Furthermore, the development of substation meta data helps to provide data context. In addition, proper data management techniques that archive aged data and ultimately delete this data when no longer relevant or useful, should be considered.

Coordinated, standards-based network model management across the operations, planning, and protection domains offers sizable potential benefits in reduced engineering labor and increased accuracy of utility network models. It offers even greater promise in creating the seamless network model infrastructure on which forward-looking Transmission and Distribution (T&D) applications will be built.

Enhanced grid and asset management are assisted by new extraction tools “unlocking” data from proprietary data sources and placing it in open platform technologies. The resulting integration of data sources along with improved analytic tools help to make data more useable by planning, operations, and maintenance. Today there is an ever increasing spectrum of external data sources that may be helpful to utilities. The expansive growth in “Big Data” tools and analytics may provide new efficiencies in transmission operations, planning, and maintenance functions. This is especially true with geospatial data that may identify location specific impacts or trends.

Utilities also own a wide array of legacy sensory devices that monitor asset condition with numerous protocols. This array requires a diverse set of mechanisms to get data out of the devices, because many of the legacy devices will continue to be relied on for years. Interoperable communications architectures and device management and standards will be key to the reduction in labor costs through improved remote device management. Continuing the current approach of visiting each device to upgrade firmware is simply not sustainable.

The overall objective of the ICT for Transmission Systems project set is to establish flexible and robust communications infrastructure and data management approaches to maximize grid and network resiliency. The results of this work could ultimately help utilities reduce long-term O&M expenditures and improve system reliability and resiliency.

Research Drivers

- Opportunities to optimize grid operation and management of related assets
- Increasing demand for real-time information
- Expanding use of synchrophasors and video for grid monitoring
- Necessity to extend legacy system lifespans
- Stricter requirements for remote device management

RD&D

- Methods for managing synchrophasor and other data
- Methods for effectively managing network analysis data
- Standards enabling asset condition monitoring applications
- Standards gap analysis and mitigating measures

Value

- Effective strategies for integration of legacy and new monitoring equipment
- Increased asset reliability through standards based integration
- Decreased operating and maintenance costs
- Network model foundation created for advanced transmission analytics

Project Set Lead: Paul Myrda, pmyrda@epri.com

161B Applied ICT for Transmission – Future State: Standardized Data Structures

Standardized Data Structures

Future State: Standardized data structures to provide reusable asset condition information will be widely adopted.

Description: Well-defined standards based data model for power system analytics including the communications infrastructure suitable to support advanced grid operations applications, analytics, and visualizations including the following:
- Accurate data models
- Procedures for ensuring data integrity
- Right data available in the right format

Gaps Addressed:
- Well-defined data model for asset management analytics (asset, environmental, usage, etc.)
- Having data and communications infrastructure that supports advanced grid operations applications and visualizations
- Having standardized data structures to provide asset condition information with well-defined data models

Action Plan: Develop a Comprehensive Data Model that addresses the entire set of requirements needed by the SMEs (Subject Matter Expert) to effectively design the data model for asset health/condition.
- Work collaboratively with Transmission and Substations (T&S) SMEs and Advisors and the Asset Health Focus community to describe comprehensive data models and interoperability at all "layers" for major transmission assets
- Get results of work incorporated into industry standard
- Future T&S products would build upon the models developed

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002012586** Substation Data Management (2018) • Develop a well defined data model for asset management analytics	Assess the effectiveness of head end systems in receiving standards based data such as IEC 61850	Develop a data and communications infrastructure capable of supporting advanced grid operations applications	Linking in of other relevant contextual data to support advanced grid operations applications
SUPPLEMENTAL – **3002010845** ADAPTIVE SUBSTATION ARCHITECTURE FOR SUPERVISORY CONTROL AND DATA ACQUISITION, TELEPROTECTION, AND MORE			
Adaptive Substation Architecture requirements to support the transition to digital substations			

VALUE
- Effective strategies for integration of legacy and new monitoring equipment
- Increased asset reliability through standards based integration
- Decreased operating and maintenance costs

DELIVERABLE TYPE
Report, investigate results

ARP PROJECT
P161.048: Interoperable Communications Architectures Device Management Standards

TIES TO OTHER PROGRAMS
Substations (P37),
Grid Operations (P39),
Grid Planning (P40)

High-Speed Precision Time-Stamped Data

Future State: The infrastructure that supports high-speed precision time-stamped data management and communication will be operational to all required end nodes.

Description: Utilities should be able to deploy devices without communications being a barrier including the following:

- Appropriate comprehensive communications solution for all applications
- Expand deployment incrementally and co-exist with legacy devices
- Vendor interoperability
- Different devices can be implemented
- Differences in semantics and physical layers

Gaps Address:

- Secure collection, transport, and management of T&S asset information from diverse asset sensing systems, types, and vintages
- Having an effective approach to enable interoperability of new technologies while still accommodating legacy technologies
- Transitioning from non-standard communications technologies to standardized ones across utility operations
- Developing reliable and effective communications to support both routine and critical applications
- The value of replacement options and experience when selecting alternative technologies when retiring legacy communications

Action Plan: Secure T&S Asset Information Infrastructure

Develop a resilient and secure end-point to end-point infrastructure that can provide T&S asset information from a broad and diverse set of asset sensing systems, types, and vintages into a common repository suitable for use by utility staff.

- Inventory asset sensing systems
- Identify types–by asset
- Need agreement of terminology
- Vintages–versions of systems and details on data and protocols

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
3002009870 Develop a systematic approach for transitioning from non-standard communications technologies to standardized ones across utility operation	Developing an effective approach to enable interoperability of new technologies while still accommodating legacy technologies	Develop secure collection, transport, and management of T&S asset information from diverse asset sensing systems, types, and vintages	Investigate the feasibility of converting non-standards based data into standards based at the point of origin thereby reducing the variety of data transported
SUPPLEMENTAL – **3002014011** AUTOMATING DISTRIBUTED NETWORK PROTOCOL POINT TAG CREATION			
Automated Distributed Network Protocol Point Tag Creation using standards based approach			

VALUE

- Quicker deployment of individual devices that are plug-n-play compatible
- Extension of standards via testing and certifications

DELIVERABLE TYPE

Investigate results, demonstration(s) with report(s), and standards updates

ARP PROJECT

P161.046: Substation Data Management Infrastructure

TIES TO OTHER PROGRAMS

Grid Operations (P39), Cyber Security (P183)

Capitalize on Available High-Speed Precision Time-Stamped Data

Future State: Utilities will capitalize on all available, relevant high-speed precision time-stamped data.

Description: All relevant data is made available to utility staff to enable comprehensive assessment of situations of interest including the following:

- Data is seamlessly made available to utility staff and can be directly analyzed
- Sensors installed on the grid provide insight and not data
- Data warehouses are for mining and analytics

Gaps Addressed:

- Value proposition for effective asset health data integration
- Lack of the required data and communications infrastructure along with non-standard data models limits decision making
- Having other relevant asset information that is beneficial to operations made available in the control center such as asset condition, etc.
- The ability to quantify the feasibility and benefits of effective grid data integration

Action Plan: Value of Asset Health Data Integration
Educate the industry on the feasibility, approaches, and benefits of asset health data integration.

- Cost/Benefit done on all appropriate R&D projects
- Develop metrics to measure performance
- Develop effective data management and data processing
- Develop a suitable approach to provide for distributed intelligence–consider contextualizing the data and push the data analytics to the edge

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002009871** Integration of Internal and External Data for Informed Decisions • Develop an approach to have other relevant asset information that is beneficial to operations made available in the control center such as asset condition, etc.	Assess the benefits of associating meta data to operating data to assure data is relevant and verifiable as useful in the context it's being applied	Assess the benefits of associating meta data to operating data to assure data is relevant and verifiable as useful in the context it's being applied	Reassess the further need for other information beneficial to operations be made available in the control center

VALUE

- Effective strategies for integration of legacy and new monitoring equipment
- Increased asset reliability through standards based integration
- Decreased operating and maintenance costs

DELIVERABLE TYPE

Investigate results

ARP PROJECT

P161.047: Extraction and Integration of Data Sources

TIES TO OTHER PROGRAMS

Transmission Modernization Demo (TMD), Substations (P37), Grid Operations (P39)

Applied ICT for Distribution (161C)

The Applied Information and Communication Technology for Distribution Project Set seeks to inform and provide utilities with the methods to capture and maintain accurate data, techniques to access the right data in the right location at the right time, interoperable standards, ability to integrate and connect legacy and modern devices, requirements to enable a mobile workforce, and value assessments for implementing research.

The primary goal is to integrate smart devices and workers with back office systems, such as geospatial information systems, distribution management systems, outage management systems, work management systems, asset management systems, and customer information systems. The research seeks to enhance situational awareness by advancing interoperability between field devices, visualization systems, and back office systems by determining device and system requirements, industry leading practices, and advancing interoperability standards.

The research also aims to address data quality, validation, visualization, and management for real-time distribution applications. The research in this project set is closely coordinated with and designed to complement the research in the Distribution Systems Program (P180) and Distribution Operations and Planning Program (P200).

Research Drivers

- Enable the workforce of the future
- Increase distribution operational efficiency
- Improve data quality
- Enhance standards and information sharing

RD&D

- Data sharing and visualization techniques for improved situational awareness
- Practices to enable the movement of intelligence to the edge of the grid
- Tools to assess and improve data quality of geospatial information system (GIS) and other systems
- Common Information Model (CIM) and other standards development for device and systems integration

Value

- Increased workforce and operational efficiencies
- Improved data accuracy by addressing data quality issues
- Identify and mitigate gaps in GIS standards
- Reduced integration and operational costs through standards enhancement and utilization

Project Set Lead: Jared Green, jgreen@epri.com

Precise System and Data Models

Description: Utilities need the capabilities to deploy advanced distribution applications and management systems using a common distribution power system model that is continuously updated with accurate and timely data from grid connected devices. The research focuses on the following:
- Accurate models
- Procedures for ensuring data integrity
- Right data in right location

Gaps Addressed:
- Ability to visualize data for immediate insights
- Detailed standards and vendor adoption
- Mature data and system models leading to improvements in system and workforce operations and efficiencies
- Single repository with global enterprise access to data to limit the amount of data that needs to be stored and maintained
- Fast, accurate collection and transmission of data
- Information life cycle management requirements defined for modern data needs leading to clear value of data over time

Action Plan: Improve Accuracy and Transferability of Data Between Systems
- Define and contribute to the develop of tools, techniques, and standards to enable deployment of more advanced distribution applications and management systems using a common information model populated with relevant data
- Identify incomplete portions of and incorporate results of research into standards
- Document leading practices and develop procedures to maintain quality of data
- Refine cost-benefit methodologies for data and data models and build upon value proposition of having precise data
- Define leading visualization techniques and develop ways to better visualize data

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002007921** Published multi-year guidebook on GIS • **3002007922 & 3002010510** Developed algorithms and techniques to clean and maintain system data • **3002010509** Conducted GIS immersions with utilities • **3002011696** Developed and demonstrated geo-locating algorithms using terrestrial images • GIS interest group	• Standards development • Data analytics for maintaining accurate data • Advanced platform agnostic asset identification	• Standards development • Data analytics for maintaining accurate data • Advanced demo and technology assessment using automated recognition and cataloging of above-ground and below-ground assets	• Standards development • Data analytics for maintaining accurate data • Data integrity techniques for systems beyond GIS
SUPPLEMENTAL – **3002009807** DISTRIBUTION GEOGRAPHIC INFORMATION SYSTEM AND GRID MODEL DATA MANAGEMENT			
• Definition of methodology for design of data architecture for grid model data management • Initial set of deep-dives with utilities exploring existing practices • Development of initial Reference Model coordinated with the IEC CIM • Utility engagement in use of 360 degree imagery and machine learning for asset identification • Outreach to related tool vendors and to interested industry groups	• Completion of utility deep-dives • Validation of Reference Model through deep-dive use cases and industry review • Initial mapping of project Reference Model to IEC CIM • Utility validation of machine learning-based asset identification • Exploration of data management architecture support for mobile workforce	• GIS/grid model management tool requirements • Standards gap identification and standards development • Utility and vendor demonstrations • Continued sharing of project results at industry events	Socialize data management architecture

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Major Past Accomplishments	2019	2020	Future
SUPPLEMENTAL – UNMANNED AERIAL SYSTEM (UAS) ADVANCEMENT THROUGH OPEN STANDARDS; AUTOMATED GIS ASSET LOCATION			
	UAS Advancement Through Open Standards - Standards development and aerial-based asset identification cataloging (proposal)	• UAS Advancement Through Open Standards - Interoperability testing and demonstration (proposal) • Automated GIS Asset Location – Field demonstration of technology (proposed)	

VALUE

Improved data quality leading to a comprehensive and accurate model of the distribution system

DELIVERABLE TYPE

Report(s), software/ algorithm(s), and/or standards update(s)

ARP PROJECT

161.018: Precise System and Data Models

TIES TO OTHER PROGRAMS

Distribution Systems (P180) and Distribution Operations and Planning (P200)

Connected Workforce and Devices

Description: Utilities need to arm their workforce with devices and sensors to enable a safer, more knowledgeable workforce.
The research focus includes the following:
- ICT reliability and performance requirements for wearable technologies
- Permit the seamless integration of wearable computers
- Allow for interoperability of connected technologies

Gaps Addressed:
- Requirements and standards for the interoperability of modern grid components with legacy ones
- Modularity or separation of communications from devices to permit product innovation and cost reductions
- Availability and applicability of wearable technologies to address improved safety and operational efficiencies in near real-time
- Realize the full benefits of emerging technologies associated with the connected, mobile workforce requirement

Action Plan: Achieve Full Connectivity and Interoperability of Distribution Devices and Wearable Technologies
- Enhance standards for innovative solutions that expands interoperability of devices and enables wearable technologies
- Extend augmented reality (AR) standards to improve workforce efficiency and safety
- Determine the extent that wearable technology and augmented reality can improve workforce efficiency and safety
- Document benefits of wearable technologies

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
	• Standards development • ICT considerations for virtual reality (VR) training • Integrating GIS with augmented reality • Guidebook to augmented reality applications – an ICT perspective	• Standards development and interoperability testing • Technology assessment for the distribution utility worker • Future proofing augment reality	• Standards development and interoperability testing • Integrating the Voice Assistant for the Utility Worker • Brain-machine interface for the system operator
SUPPLEMENTAL – COMMON DATA MODEL FOR AUGMENTED REALITY			
• **3002006615** Field Force Data Visualization: Applying Augmented Reality-Accelerated augmented reality solutions • **3002009258** Program on Technology Innovation: State of the Art of Wearable Enterprise Augmented Reality Displays • **1024304** Field Force Data Visualization • **3002007925** Mobile Workforce Survey: Connected Workforce and Devices Project • AR interest group • Surveyed utilities on AR/VR/MR, usefulness of 3D models and architectures, and future needs	• Informational webcasts relating to industry needs and software and hardware gaps of the technology • Assist with developing 3D standards, conducting related interoperability tests of protocols • Document high-impact use cases related to the control room and distribution workforce • Publish a beta code repository for the industry	• Partner with IEEE/IEC to overcome technical and enterprise challenges the Common Data Model • Continue the improvement of the 3D standards and conducting related interoperability tests of protocols • Enhance the code repository for the industry	• Publish videos and websites on how to implement the Common Data Model • Foster enterprise adoption of AR and contribute to standards develop

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Major Past Accomplishments	2019	2020	Future
TECHNOLOGY INNOVATION (TI) PROJECT – DIGITAL UTILITY WORKER			
	Assessment of the Applicability of a Voice Assistant for the Utility Worker	Demonstration of the Voice Assistant for the Utility Worker (proposed)	

VALUE

- Work towards plug-n-play compatibility for distribution devices
- Extension of standards via testing and certifications.
- Timeliness of access to data
- Efficiency increase in performance of work

DELIVERABLE TYPE

Demonstration(s) with report(s), use cases, and standards updates

ARP PROJECT

P161.031: Connected Workforce and Devices

TIES TO OTHER PROGRAMS

Distribution Systems (P180), Distribution Operations and Planning and Occupational Health and Safety (P62)

161C Applied ICT for Distribution – Future State: Increasing Intelligence Through Standards and Integration

Increasing Intelligence Through Standards and Integration

Description: Only knowledge moves, data is processed at the optimal location including the following:
- Data is processed at the collection point before it is moved
- Sensorization of the grid means big insight and not "big data"
- Data warehouses are for mining, not collecting bits and bytes

Gaps Addressed:
- Having access to the right data in the right location at the right time to provide actionable intelligence where needed (involves defining data, devices, subsystems, and/or systems of the modern grid and the supporting data analytics)
- Having a hierarchical control architecture for distributed computing
- Having access to processing power of field hardware to enable local decision-making capabilities where applicable

Action Plan:
- Determine most advantageous location for distribution intelligence to reside
- Establish the framework for moving data analytics and decision-making from the back-office systems to the edge of the grid
- Develop requirements document for distributed intelligence
- Document and create algorithms/applications to process data at the device level
- Create a cost-benefit analysis methodology to evaluate the value of data in the time domain

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002007928** Created standards for information exchanges such as the Outage Data Initiative (ODI) • Published early version of the distributed intelligence guidebook	• Standards requirements • Distributed intelligence and grid modernization guidebook • Demo of distributed intelligence applications	• Standards requirements • Distributed intelligence and grid modernization guidebook with cost-benefit analysis • Demo of distributed Intelligence applications	• Standards requirements • Distributed intelligence and grid modernization guidebook with cost-benefit analysis • Co-simulation of different control architectures
SUPPLEMENTAL – OUTAGE DATA INITIATIVE (ODI)			
• **3002010511** Mapped advanced distributions applications and grid functions to architecture and control strategies • **3002007923** Matched advance applications and management system requirements with comms. performance	Interoperability testing and implementation of standard to interface to first responder networks		
TECHNOLOGY INNOVATION (TI) PROJECT – EDGE OF THE GRID APPLICATIONS			
	Embedding of utility defined applications in distribution relay (proposal)	Embedding of utility defined applications in distribution voltage controller (proposal)	

VALUE
- Increased efficiencies in distribution and field O&M
- Enhanced operational capabilities with intelligence pushed to the edge of the grid
- Knowledge is transferred not just data

DELIVERABLE TYPE
Report(s), software/algorithm(s), and/or standards development

ARP PROJECT
161.040: Increasing Intelligence Through Standards and Integration

TIES TO OTHER PROGRAMS
Distribution Systems (P180) and Distribution Operations and Planning (P200)

Applied ICT for Distributed Energy Resources and Demand Response (161D)

Information technologies and communications are key to realize the benefits of distributed energy resources (DER) and enable grid modernization. The DER technologies, including solar, energy storage, electric vehicles, and demand response, play a key role in a modern, optimized, and integrated grid by helping utilities address issues—including the intermittency and variability of renewables—and enable future states like microgrids, transactive energy, and smart and connected cities. The communications and control of DER is key to making this happen. The goal of this project set is to break down barriers in the communications, control, and monitoring of smart solar, storage, and loads to enable a cross-functional architecture capable of meeting demands of the modern grid. Through our membership we create an ecosystem where we can address these barriers and provide solutions, as a collaborative effort.

The Integrated Grid[1] is a broad concept that requires collaboration between subject matter experts across the industry. The work in this project is coordinated with and designed to complement the work in EPRI's Cyber Security (P183), Electric Transportation (P18), Energy Storage (P94), End-Use Energy Efficiency and Demand Response (P170), Integration of Distributed Renewables (P174), Distribution Operations and Planning (P200), and Understanding Electric Utility Customers (P182) Programs.

[1]http://integratedgrid.com/

Research Drivers

- A need for a flexible grid in reaction to the increasing penetration of DER including renewables
- Utility interest in communications systems to control and aggregate DER and DR
- Expanding diversity of demand responsive loads
- Increasing deployment of customer and third-party owned DER and DR
- Standards and protocols needed to support a scalable control architecture including DER and DR

RD&D

- Evaluation of communication standards for DERs through studies, lab testing, and demonstrations
- Development of control system designs, device simulators, and open-source software to develop and validate implementations
- Capture key takeaways from utility demonstrations
- Activities to engage utilities, networks, and end-device stakeholders in open communication architectures

Value

- Increase the cost effectiveness of grid modernization
- Understand the business and technology impacts of different architectural approaches
- Identify and mitigate barriers for interoperability and interchangeability of DER
- Accelerate the availability, testability, and functionality of vendor products and systems

Project Set Lead: Ben Ealey, bealey@epri.com

161D Applied ICT for DER and DR – Future State: Interoperable DER/DR

Interoperable Distributed Energy Resources including Demand Response

Future State: Field proven and industry recognized approaches for interoperability including mature communications capabilities in products, robust and recognized open-standards, and verified interoperability in the field.

Description: Maturity in interoperability and interconnection standards and their implementation in products increase the likelihood that DER, DR, and control systems are fully interoperable out-of-the-box.

Characteristics of this future state include:
- Open, interoperable protocols are widely used, applied in the field, and meet the needs of stakeholder use-cases
- Industry stakeholders have experience with implementing open standards in products and protocol implementations have reached maturity
- Open, interoperable standards exist for every level of the communications and control architecture

Gaps Addressed:
- Gaps in functionality, security risks, and barriers to interoperability exist; not all standards are mature and interoperability standards are in development;
- Utility guidance for DER/DR product manufacturers to implement and validate standards in their products for various DER applications.
- Coordination in between interoperability and interconnection standards
- Approaches to accommodate customer-owned technology that may include Internet of Things and independent DER systems
- Transition strategies to include both new and legacy systems

Action Plan:
Collaborate with utilities, vendors, manufacturers, and other industry stakeholders to provide feedback on opportunities, gaps, and best practices to encourage adoption and produce the necessary tools for success. This includes:
- Assessment of communication and control approaches within DER/DR integration pilots, demos, and deployments
- Perform laboratory and field evaluations of DER, DR, protocol and standards, and control systems to evaluate interoperability, identify risks, and highlight best practices
- Develop and extend feature-sets for open-source clients and test tools to support industry stakeholder entry into open, interoperable standards
- Collaborate with other EPRI programs and stakeholder groups to identify additional DER-related functionalities that can be achieved through communication and interconnection standards
- Industry coordination and standards evolution including collaboration and leadership in standards development organizations via direct contributions and participation on behalf of members

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002009850** Development of maturity models to identify areas of focus for different protocols • **3002011045, 3002008217** Create information models for next generation DR/DER • **3002009854, 3002009462** Lab testing of DER to identify and track interoperability issues • **3002009853** Develop testing and development resources for DR, DER, and control systems • **3002013473** (2018) Assessment of interoperability achieved through new grid codes • **3002009853** Open source stacks for DER protocols	• EPRI Protocol Reference Guide – 3rd Edition • Industry evaluation of inverter-based DER and demand response technologies • Interoperability testing of inverter-based DER and demand response technologies • Grid interoperability and market facilitation of flexible demand through harmonized standards and test procedures	• EPRI Protocol Reference Guide – 4th Edition • Requirements for standards-based integration of disparate DER technologies • Evaluate conformance testing opportunities • Gap analysis of interoperability and interconnection standards for DER	• Evaluate next-generation DER/DR standards • Identify and address gaps in interoperability through the application of EPRI maturity models • Maintain EPRI's existing open-source stacks for DER protocols – CTA-2045, OpenADR, IEEE 2030.5, IEC-61850, IEEE 1815 (DNP3)

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Major Past Accomplishments	2019	2020	Future
SUPPLEMENTAL PROJECTS – **3002009694** INFORMATION AND COMMUNICATIONS TECHNOLOGY AND SECURITY ARCHITECTURE FOR DISTRIBUTED ENERGY RESOURCES INTEGRATION			
• Perform laboratory evaluations of secure DER integrations • Map use cases to DERs and protocols	• DER standards and protocols interest group (DER-SIG) • Technical plan for harmonization of der standards and protocols • Interoperability and interconnection standards roadmap for DER	Pending	Pending
GOVERNMENT PROJECTS			
• Gap analysis of functionality in DER/ DR communication protocols • Proposed revisions of IEEE 1815 (DNP3) for smart inverters • DNP3 and SunSpec interfaces for EPRI's Solar Inverter Simulator and OpenDERMS 2.0 • Develop open source stacks for smart inverter protocols - IEEE 2030.5, IEEE 1815 • Calculation of pricing signals for transactive energy networks	• Supporting field deployments across DER types and domains • Develop conformance testing framework for smart inverters - IEEE 2030.5 & IEEE 1815 • Expansion of ICT-based modeling and simulation tools • Evaluating pricing signals in transactive energy frameworks	Supporting field deployments across DER types and domains	Upcoming Awards

VALUE

- Insight on emerging standards and issues associated with existing standards
- Accelerate interoperability of DER and DR through testing, test tools, and open source clients

DELIVERABLE TYPE

Reports, webcasts, workshops, software, algorithms, and/or reference designs

ARP PROJECT

P161.049: Enabling Open, Interoperable DER – Standards, Testability, and Pairing to DER/ DR Abilities
P161.050: Product Assessments – Evaluating Communication Interfaces and the State of the Art for DER Architecture and Methods for Integrating DER

TIES TO OTHER PROGRAMS

Cyber Security (P183), Electric Transportation (P18), Energy Storage (P94), End Use (P170), Integration of Distributed Renewables (P174), Distribution Operations & Planning (P200), and Understanding Electric Utility Customers (P182) Programs

Validated Interconnection and Control Architectures for DER/DR

Future State: Interconnection and control architectures for DER/DR are confirmed effective and field-proven to allow seamless integration of control systems (DERMS, DRAS, ADMS) to the individual DER and DR resources across the distribution system.

Description: As utilities are exploring methods for integrating resources across the distribution system it is increasingly important that the communications and control architectures are designed to allow connection of a variety of distributed energy resources regardless of model, manufacturer, or type without significant modification or costs. Characteristics of this future state include:

- Architectures with scalability and maintainability considered in the initial design
- Aggregation methodologies that support multiple, complex use-cases
- DER and DR management systems with flexible communications systems
- End-to-end security in the architecture
- Control systems that are inherently designed to work collectively with distributed intelligence

Gaps Addressed:

- The concept for a hierarchical architecture exists but the protocols and standards lack some capabilities for end-to end use-cases. Informational models may need development
- DER and DR management systems are new with few vendors available. The industry needs guidance on understanding different communications architectures and how to validate them so they can make informed decisions and confirm they are implemented properly
- Distributed intelligence needs to be further explored to understand opportunities so architectures can be modified to accommodate them

Action Plan:

- Host workshops and working groups to identify and fill gaps in protocols and standards related to management systems
- Produce DER and DR management system reference designs and device simulations to support development and testing of architectures
- Evaluate methods to maximize the utilization and scalability of all resources across the communication architecture

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002011233, 3002008215** DER Group Management Interop • EPRI OpenDERMS 2.0 implementation • **3002009852, 3002009851** Smart inverter, energy storage, and water heater simulators – communications • **3002012960, 3002013474** (2018) Evaluation of systems to integrate control of energy storage, controllable loads, and PV	• Assessment of communications architecture requirements for near-term smart inverter use cases • DERMS/ADMS Interoperability Workshop – upstream and downstream interfaces	• Case studies of utility architectural decisions • Continue determining communication and control requirements for DER applications	• Evaluate architectures of smart cities • Industry engagement through working groups and interops • Guidance on developing monitoring requirements
SUPPLEMENTAL PROJECTS – **3002009694** INFORMATION AND COMMUNICATIONS TECHNOLOGY AND SECURITY ARCHITECTURE FOR DISTRIBUTED ENERGY RESOURCES INTEGRATION			
Develop and demonstrate secure communications architectures across DER types	Field deploy solutions to demonstrate, evaluate, and document DER approaches	Pending	Pending

Continued next page

Major Past Accomplishments	2019	2020	Future
GOVERNMENT PROJECTS			
• **3002009849, 3002011500** Evaluate communication architectures to enable high penetration of solar • Develop capabilities for integrating communications in system modeling • Advanced DMS and DERMS testbed • Match use cases in New York state to DR capabilities through open protocols	• Perform and analyze software/hardware in-the loop testing on DER architectures • Demonstration of state-of-the-art DR technologies in New York state • Increasing hosting capacity for solar using controllable loads • Interactions of smart inverters at high penetration	• Continue software/hardware in-the loop testing on DER architectures • Evaluate New York demonstration for key takeaways	Pending Awards

VALUE

- Discover how architectural decisions can improve utilization and scalability of communication architectures
- Tools and software to improve testability and evaluations of DER and DR control systems

DELIVERABLE TYPE

Reports, webcasts, workshops, software, algorithms, and/or reference designs

ARP PROJECT

P161.052: DER and DR Management Systems – ICT Systems for Aggregation Monitoring and Management

TIES TO OTHER PROGRAMS

Cyber Security (P183), Electric Transportation (P18), Energy Storage (P94), End Use (P170), Integration of Distributed Renewables (P174), Distribution Operations & Planning (P200), and Understanding Electric Utility Customers (P182) Programs

161D Applied ICT for DER and DR – Future State: Optimized Practices for Connecting DER/DR

Optimized Practices for Integrating Communicable DER/DR

Future State: Practices for connecting DER/DR in a communications architecture mature with multiple, well documented case studies.

Description: Protocols and standards regulate how some aspects of the communication architecture are developed however the decisions made outside of the scope of these protocol and standards can have equally large business and technical impacts on the final architecture. Characteristics of this future state include:

- Practices are well documented and studies clearly link decisions to outcomes
- Solid understanding of the relationship between communications metrics (bandwidth and latency), choice of protocol, and application details – specific control algorithms, the control applications, monitoring requirements, and interconnection requirements.
- Industry stakeholders recognize and understand the business and technical impacts that different practices have on the final architecture

Gaps Addressed:

- Some case-studies exist for end-to-end architectures however the state-of-the-art is still in its infancy but expected to rise quickly based on the number of field studies in the industry today
- Approaches for managing the utilization and sharing of DER devices and/or systems of devices among business applications have not been fully explored

Action Plan:

Evaluate utility experiences to:

- Explore the different metrics that indicate business and technical impacts on the final architecture
- Document case studies from member utilities and identify key takeaways including best practices and significant barriers

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002009857** Define steps to creating the ideal architecture for managing DER in aggregate • **3002013624** Identify the financial considerations of open, interoperable communications in utility programs (2018)	• Repository of interoperability issues to inform RFPs and validation testing (DER.EPRI.COM) • Developing training for the new generation of workforce in ICT-based applications of DER technologies	• Evaluate impact of communications decisions in field demonstrations • Identify effective aggregation practices for DER	• Metrics for measuring interoperability • Guidance on conducting inter-utility conversations to refine practices for integrating communicable DER/DR • Pairing data analytics applications with ICT system requirements
SUPPLEMENTAL PROJECTS – **3002009694** INFORMATION AND COMMUNICATIONS TECHNOLOGY AND SECURITY ARCHITECTURE FOR DISTRIBUTED ENERGY RESOURCES INTEGRATION			
• Study DERMS opportunities and markets • Repository of DERMS RFP Language (DER.EPRI.COM) • Certification framework for CTA-2045 • Requirements for end devices and control systems/ head ends • Support of new AHRI standard for open, connected, residential HVAC systems	• Document utility approaches for • DER/DR control Architectures • Support of CTA- 2045 pilots and programs	Pending	Pending

VALUE

Inform decision making and understand how different approaches impact business and technical considerations

DELIVERABLE TYPE

Reports, webcasts, workshops, software, and/or algorithms

ARP PROJECT

P161.051: Utility Case Studies in DER Architecture – Experiences, Best Practices, and Barriers

TIES TO OTHER PROGRAMS

Cyber Security (P183), Electric Transportation (P18), Energy Storage (P94), End Use (P170), Integration of Distributed Renewables (P174), Distribution Operations & Planning (P200), and Understanding Electric Utility Customers (P182) Programs

Enterprise Architecture and Integration (161E)

Fundamentally, enterprise architecture is about mitigating risk. Enterprise architects mitigate risk and provide value to the organization by:

- Reviewing systems for fit of purpose across the whole of the organization;
- Working with business managers to harmonize the application portfolio;
- Reducing redundancies that increase operations and maintenance costs;
- Reviewing emerging technology for impacts to application roadmaps

The research of this project set aims to equip enterprise architecture practitioners with the latest tools and techniques, with an eye to the unique needs and operating environments of utilities. High functioning enterprise architecture teams help utilities establish a foundation for execution—that is, the agility utilities will require in an environment marked by an increasing pace of change.

Research Drivers

- Need to identify key requirements, principles, and reference models
- Necessity to envision enterprise's future state and associated business capabilities
- Desire to leverage existing capabilities to maximize limited resources and prior investments

RD&D

- Best practices for enterprise architecture and integration
- Advancement of standards-based systems integration capabilities
- Business Efficiency via Information Technology (IT) and Operations Technology (OT) convergence findings

Value

- Align business, operations, and IT strategy around enterprise architecture
- Translate strategy into enterprise capability
- Mitigate risk and create a foundation for enterprise architecture and integration execution

Project Set Lead: Dr. Gerald Gray, ggray@epri.com

Enterprise Architecture Maturity

Future State: Improved Enterprise Architecture Maturity.

Description: Enterprise Architecture (EA) as a practice aligns business (operations) and IT. Mature practices help utilities hold down costs, mitigate risks, and increase agility. EA maturity in the utility industry ranges from ad hoc to mature. Some utilities are well equipped, while others are struggling. Enabling enterprise architecture maturity includes the following:

- Integrate operations to move beyond "successful silos" (IT landscapes, not IT landfills)
- Arm utilities with reusable templates, components, patterns, and reference models
- Promote and develop leading EA practices

Gaps Addressed:

- Develop a means to measure enterprise architecture maturity
- Address the lack of business architecture training/ resources for enterprise architect practitioners
- Provide a common set of agreed upon actors/ roles; EA, IT, business don't even speak the same "language"
- Address the lack of collaboration space for EA practitioners to create utility specific architecture components

Action Plan: Determine the Resources Required to Improve EA Maturity

- Continue to benchmark EA maturity level
- Act on identified gaps, business language, collaboration space, and lack of EA related resources for utilities

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002007873** EA Guidebook, 2nd Edition • Understanding enterprise architecture–ITIL complements	• **3002012476** EA Guidebook, 3rd Edition • CIM Primer, 4th Edition	• EA Guidebook, 4th Edition • CIM Primer, 5th Edition • IT/OT Guidebook, 2nd Edition	• EA Guidebook, 5th Edition • CIM Primer, 6th Edition • IT/OT Guidebook, 3rd Edition

VALUE

Data quality indices for utilities (accuracy, completeness, consistency, timeliness, security, and fit for purpose)

- EA Maturity Assessment
- EA Practitioner workshops

DELIVERABLE TYPE

Reports, templates, and Enterprise Architecture Training Program

ARP PROJECT

P161.041: Enterprise System Integration

TIES TO OTHER PROGRAMS

Cyber Security (P183)

Integration Maturity

Future State: Improve Enterprise Integration Maturity

Description: Reducing the distance to integrate; lower the cost/effort of integration. Enabling Enterprise Integration Maturity addresses the following:

- Challenges of continued vendor interoperability
- Device dependency; need to eliminate vendor lock-in
- Differences in semantics and physical layers
- Determine highest priority use cases not addressed by standards
- Create a library of integration guidebooks, that map to IEC IRM (Interface Reference Model), and increase the maturity of each interface over time

Gaps Addressed:

- Addressing the lack of infrastructure to enable rapid standardization and adoption of new measures for protocols such as found in the Common Information Model (CIM) standards
- Addressing the lack of metrics/state that indicate IEC Interface Reference Model maturity, market adoption

Action Plan: Develop the Use Cases for CIM–Contribute to the Appropriate SDOs

While various parts of CIM are very mature, e.g. meter reading, as new use cases continue to be identified, such as enterprise integration of DER, extensions for OpenFMB. These use cases need to be vetted and contributed into the respective SDOs. There is also an imperative to develop these use cases in accordance with international standards.

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002009978** Cloud Integration Guidebook, 2nd Edition • DER enterprise Integration, Phase II • DER enterprise integration work leads to the development of ICE 61968-5 standard	• Cloud Integration Guidebook, 3rd Edition • Added utility case studies to the Cloud Integration guidebook	• Cloud Integration Guidebook, 4th Edition • DER Enterprise Integration, Phase III	Cloud Integration Guidebook, 5th Edition

VALUE

Number of CIM profiles close "actionability" gap (test scripts, certification) CIM Compliance for vendor products

DELIVERABLE TYPE

Demonstration(s) with report(s) and standards updates, software artifacts, and code examples

ARP PROJECT

P161.031: Connected Workforce and Devices

TIES TO OTHER PROGRAMS

Cyber Security (P183)

Business Efficiency: IT/OT Convergence

Future State: Align Information Technology (IT) and Operational Technology (OT).

Description: In some organizations IT and OT are not pulling in the same direction; an imperative for the integrated grid. As the devices that are deployed on distribution and transmission systems have greater communications and processing capabilities, utility operating groups will need to have skill sets that were once the domain of IT. When these two parts of the organization are not working together it introduces inefficiencies into the organization.

Gaps Addressed:
- Addressing the limited insight into the current state of the strategies and implementation for Business Efficiency: IT/OT convergence

Action Plan: Determine Keys to Successful and Optimal IT/OT Alignment
- Survey leaders of both the IT/OT groups to determine keys to success, cogent strategies, how resources are aligned with application portfolios
- Cost/benefit assessment to determine metrics associated with efficiencies
- Identify the leading practices that help utilities align their resources

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
Cost/benefit analysis	• Best practices guidebook • Publication of the first IT/OT Guidebook	IT/OT Guidebook is moved under core EA task	

VALUE

Creating a reference for utilities struggling with IT/OT convergence issues that includes application portfolio management, strategies, leading practices, and a cost benefit framework so that utilities can make their own value assessment

DELIVERABLE TYPE

Reports

ARP PROJECT

P161.042: Business Efficiency: IT/OT Convergence

TIES TO OTHER PROGRAMS

Cyber Security (P183)

Standards and Certification

Future States: Standards and Certification

Description: Need to close the "actionability" gap between standards on paper and referenceable, certifiable integration. Details regarding Standards and Certification include the following:

- Supporting the CIM Testing Compliance Committee
- Updating the semantic test harness with a growing body of CIM test cases

Gaps Addressed:

- Addressing the lack of infrastructure to enable rapid standardization and adoption of new measures for protocols such as found in CIM
- Addressing the lack of metrics/state that indicate IEC Interface Reference Model market adoption

Action Plan: Develop Test Scripts from Standards Documentation and Identify Any Modifications That Are Required to Make Them Actionable

While codified standards are an important step in integration maturity they are often open to interpretation. Further, when people attempt to implement a standard this often reveals issues in how messages might be defined, for example optional data elements that in fact are required to support interoperability. This effort will work to convert standards into test scripts that improve the clarity of expectations to promote interoperability. Identifying these gaps are critical to improving and reducing the distance to integrate

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• CIM compliance event • Hosting first of its kind, CIM Compliance Test	• CIM compliance event • Added 61968-9 and 61968-6 to the testing event	• CIM compliance event • Adding 61968-3 (ODI) to the testing event	CIM compliance event

VALUE

Percent of profiles that have test and certification available

DELIVERABLE TYPE

Demonstration(s), test scripts, standards compliant integration artifacts, e.g. XSDs, WSDLs

ARP PROJECT

P161

TIES TO OTHER PROGRAMS

Cyber Security (P183)

161E Enterprise Architecture and Integration – Future State: Agile Enterprise

Architectural Impacts of Disruptive Technologies

Future State: Agile Enterprise

Description: Disruptive technologies are "competence destroying"; they fundamentally alter how business is conducted and processes are executed. These are different that "sustaining" innovations that simply make a process a bit better; a bit faster. Disruptive technologies can have significant impact on utility business capabilities.

Gaps Addressed:

- Business architecture is often one of the least well understood aspects of enterprise architecture. This activity will provide examples of using an impact assessment on a utility business capability model

Action Plan: Develop Example Impact Assessments based on various Disruptive Technologies

- Some examples of disruptive technologies, such as blockchain, Internet of Things (IoT), and augmented reality, will be used to provide example business impact assessments to a generic utility business capability model. These examples will highlight areas where architects and business leaders may want to re-evaluate their application portfolios and will also remove some of the mystery around the use of business capability models.

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
		Business Capability Assessment	Business Capability Assessment

VALUE

This assessment is a "business accelerator". By performing a business impact assessment against a generic utility business capability model, it will help architecture practitioners and senior managers have a better sense of how these types of technologies will impact their own, unique business capabilities.

DELIVERABLE TYPE

White paper

ARP PROJECT

P161

TIES TO OTHER PROGRAMS

Varied, depending on the technology explored each year.

Advanced Metering Infrastructure (161F)

Advanced metering systems are being deployed by utilities worldwide. The performance of these systems, their reliability, and their trust by the consumer are crucial to the utility industry. There are many challenges that must be addressed. The solid-state metering and communication technologies of AMI are new and rapidly evolving, and the methods for optimizing their utilization and value are still developing. Investments in AMI are among the largest being made by utilities, resulting in a need for high-quality asset management throughout the system lifecycle. Because of the lack of standards, present systems are largely custom-designed or proprietary, resulting in vendor lock-in, heightened risk of obsolescence, and lack of proper support.

This project set comprises the whole of EPRI research in metering and advanced metering systems, bringing together communication research and meter-specific research that were previously conducted in separate programs. This project set aids members in optimizing existing system utilization and in discovering the full value of AMI-collected data. It accelerates the development of emerging standards and architectures to enhance interoperability, innovation, and marketplace competition. Best practices are identified for the support of system operations and monitoring. Solid-state meters are investigated in regard to accuracy, reliability, and tamper resistance.

Research Drivers

Large investments in Advanced Metering Infrastructure (AMI) pose challenges and opportunities:

- Needs to avoid vendor lock-in
- Emerging O&M best practices – improving operational efficiency
- Exploiting full value from systems and data

RD&D

- Advance interoperability through accelerating standards
- Assess advanced meter performance
- Discover uses that optimize existing system value
- Identify industry best practices for AMI management

Value

- Realize a greater return on AMI investments
- Conduct high quality asset management through system life cycle
- Reducing business risks of obsolescence and product performance

Project Set Lead: Ed Beroset, eberoset@epri.com

161F ICT for Advanced Metering Infrastructure – Future State: Open, Interoperable AMI Systems

Open, Interoperable AMI Systems

Future State: Open, Interoperable AMI Systems.

Description: Enable utilities and other system integrators to build-out AMI systems from best-in-class sources of supply. This includes using meters, routers, and access points from multiple sources of supply, enhancing competition, and improving quality. Open, Interoperable AMI systems include the following:

- Products being open platforms such that applications can be independently developed and deployed
- Headend systems that can be compatible with multiple network types and provided by any company
- Ability to seamlessly leverage, to the extent desirable, existing communication infrastructure
- Availability of an unbiased, vendor-neutral implementation of the communication stacks accelerates availability of products

Gaps Addressed:

- Existing AMI networks (both RF and PLC) are proprietary due to lack of standards at both the lower (Phy/MAC) and application layers
- Existing standards are competing and there is lack of consensus regarding their use
- Supporting multiple NAN technologies: Lack of standards for system backhaul
- Enabling intelligence at the edge: Standards for meters to have consistent functionality and applications
- Methods and architectures for leveraging other communication infrastructures (e.g. internet) are not developed

Action Plan: Enable Multi-Vendor Interoperability and Interchangeability at Strategic Points Throughout AMI Systems

- Develop a suite of AMI-related protocol reference implementations, from application layer to physical layer protocols
- Form stakeholder groups, facilitate recurring working sessions to develop AMI backhaul use cases and standard messages
- Develop AMI reference head-end system to enable application integration testing

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• Reference Wi-Sun protocol stack, open source • **3002010501** Wi-SUN Meter Test Tool (WISUND), version 1.0 • Reference DLMS/COSEM application layer	• DLMS/COSEM to IEC 61968-9 mapping • Metering and CIM report	• "Open backhaul" methods and messages • Reference AMI headend – enabling application integration testing	Assessment of available meters and devices with Wi-Sun compatibility

VALUE

Availability of AMI-related products in the marketplace that are interoperable and interchangeable

DELIVERABLE TYPE

Report(s), software/ algorithm(s), working groups, and/or standards contributions(s)

ARP PROJECT

P161.032: Open, Interoperable Advanced Metering System

TIES TO OTHER PROGRAMS

Power Quality (P1), Grid Support Functions and Connectivity (P174B), Technologies Evaluation and Assessment (P180G), Understanding Electric Utility Customers (P182)

Established and Proven Best-Practices for AMI System Operation and Management

Future State: Established and Proven Best-Practices for AMI System Operation and Management.

Description: A comprehensive collection of AMI best-practices, each being broadly applied by utilities and iteratively improved. Best-practices for key O&M processes are precisely documented and widely utilized by utilities including the following:

- Requirements development, RFP, and selection
- System deployment
- Performance monitoring and management
- Prognostics and health management
- Revenue protection

Gaps Addressed:

- No documented best-practices for AMI operation and management
- Duplication of efforts to define and document practices
- No forum, resource, or entity to document, compile, manage, and disseminate AMI-related practices
- Vendor feedback regarding utility O&M needs

Action Plan: Develop and Document Utility Best-Practices for All Aspects of AMI System Operation and Management

Develop a library of AMI best-practices, addressing:

- Performance optimization
- Health management
- End-of-life monitoring
- Deployment and replacement planning
- Storm recovery and AMI restoration
- Revenue Protection

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002008943** Revenue Protection Guidebook, First Edition: Utilizing Advanced Metering Infrastructure • **3002010502** Guidebook for AMI system disaster management and restoration • **3002013399** Guidebook for AMI Data Management, First Edition (2018)	Guidebook for Revenue Protection, 2nd edition	Guidebook for AMI network management and performance optimization	Guidebook for AMI system RFP and deployment processes, including evolving, hybrid networks

VALUE

- Number of best practice guidebooks developed
- Breadth of utility use/ application of the practices
- Ongoing efforts to refine and improve

DELIVERABLE TYPE

Report(s), software/ algorithm(s), and/or standards update(s)

ARP PROJECT

P161.043: Advanced Metering Systems Operations and Management

TIES TO OTHER PROGRAMS

Distribution (P180)

Optimized AMI System Utilization and Value

Future State: Optimized AMI System Utilization and Value.

Description: Utilities will have a clear understanding of the range of uses and applications that can be effectively supported by their AMI systems and AMI data. Specific guidance on how to employ these uses will be available. Optimized system utilization and value will be achieved through:

- Up-to-date data on global AMI deployments and uses
- Comprehensive development and documentation of methods and algorithms for metering-related applications
- Field evaluation of new/emerging uses
- Improved AMI integration with internet, cellular and other utility systems for optimized overall utilization

Gaps Addressed:

- Lack of understanding of what applications the present generation of AMI can support
- Inaccurate GIS data regarding metering assets and connectivity
- Lack of knowledge of what AMI system and data uses are in practice and on what AMI technologies
- Lack of algorithms and data analytics for optimizing the use of AMI-derived data
- Lack of methods for effectively integrating AMI with distribution operations

Action Plan: Enable the Full Value of AMI Systems to be Realized

- Establish online utility repository for AMI system deployments and uses
- Map capabilities to communication technologies and architectures
- Accelerate the development of new AMI data analytics uses–such as automatic meter phase and transformer association

Major Past Accomplishments	2019	2020	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002010503** Online AMI RFP Language Repository – a structured and searchable library or RFP text components • **3002013401** Next Generation AMI System Design and Utilization – Case Studies in Utility Innovation Expanded AMI Use Case Database (2018)	Guidebook for AMI Data Analytics AMI Data Analytics Survey	Developing and field testing new AMI system uses and data analytics	AMI analytic algorithms repository

VALUE

- Quantity of documented application use cases
- Guidance on what system types are suitable for each

DELIVERABLE TYPE

Web repository(ies), report(s), software/ algorithm(s), and/or standards contribution(s)

ARP PROJECT

P161.044: Optimizing Advanced Metering System and Management

TIES TO OTHER PROGRAMS

Power Quality (P1), Understanding Electric Utility Customers (P182), Distribution Modernization Demonstration (DMD)

Telecommunications (161G)

The Telecommunications Project Set addresses the multiple, complex challenges that utilities face including the following:

- Planning a scalable, multi-services network that can meet current and future needs;
- Leveraging technologies and best practices from commercial telecom (wireline and wireless) operators;
  - Evaluate partnerships and new business models to make it economically viable to deploy fiber in more locations;
  - Support the completion of a fully packet-based network for applications and circuits still using legacy technologies;
- Enabling wider use of wireless networks by identifying suitable licensed spectrum;
- Identifying the optimal wireless technologies for field area networks;
- Stewarding the standards to enable interoperability and interchangeability;
- Identifying the best roles for commercial wireless and shared networks, and navigating the evolution to 5G networks;
- Enhancing performance of existing wireless technologies in unlicensed spectrum and evaluating options for alternatives when unlicensed bands are no longer able to support desired utility applications; and
- Developing best-in-class network management and control systems that take advantage of advances such as Software-defined Networking (SDN) and Network Functions Virtualization (NFV), while maintaining reliability, resilience, and cyber security.
- Advancing telecom network planning capabilities to support rapid growth in communicating devices through modeling, simulation, and testing.

Research Drivers

The need to develop strategic assets, so utilities can maintain and achieve future outcomes:

- Design reliable, resilient, flexible, and secure telecom networks to support advanced grids
- Tools to manage complex, mission critical telecom networks
- Migrate from today's networks and legacy equipment to future telecom network

RD&D

Development of telecommunication strategic architecture and roadmap decision tree for utilities

Value

Collaborative with multiple utilities to gain perspectives based on practical experiences

Project Set Lead: Tim Godfrey, tgodfrey@epri.com

Interoperable and Reliable Field Area Networks

Future State: Interoperable and Reliable Field Area Networks.

Description: A ubiquitous, interoperable field area network that has the necessary reliability to support multiple applications and can adapt to network impairments.

Gaps Addressed:
- Lack of interoperability for specific wireless technologies for certain bands and applications
- Lack of mechanisms to incorporate multiple wireless technologies for improving reliability and resilience
- Lack of effective prioritization sufficient to enable operation in impaired state while meeting application requirements

Action Plan:
- Engage in and support standards development for technologies and spectrum that currently lack standards
- Evaluate and test combinations of Private Utility FAN, Commercial Cellular, AMI networks, customer broadband. Determine reliability and cost metrics for each and in combinations. Examine techniques for hybrid solutions, failover, connection sharing with forwarding and meshing
- Evaluate wireless technologies for performance of Prioritization

Major Past Accomplishments	2019	2020	Future
3002013393 FAN Technology Performance Evaluation (2018)	Define the communications network requirements for DER applications	Evaluate opportunities to standardize FAN operation in licensed spectrum for channel widths below 100 KHz	Distributed intelligence in the edge device to reduce traffic and enable autonomous operation
3002009792 Public Networking and Shared Networks – Architecture & Operation	Develop approaches for multi-mode FAN nodes, with adaptive path selection and failover	Extend multi-mode FAN to interoperate with AMI, private FAN, and customer Broadband	Wireless networks adaptive to RF conditions and network density
3002009788 Private LTE – Options and Opportunities	Document best practices for design and deployment of Private LTE	Evaluate integration and migration of LMR and voice to private LTE	Software Defined Radio (SDR) applications
3002009790 Testing QoS on Commercial Cellular	Develop application specific profiles for QoS parameters	Develop, simulate, and test dynamic network reconfiguration due to damage or impairment	Provisioning and managing large numbers of sensor devices
3002009791 Low Power WAN Technologies		Evaluate NB-IoT utility applications, and stand-alone, private operation	Evaluate dynamic adaptive spectrum access and multi-band operation for the FAN
3002009786 Wireless Taxonomy and Architecture			

VALUE
- Increased communications resilience
- Reduced risk when migrating to new technologies
- Understanding technology options
- Multi-services capabilities

DELIVERABLE TYPE
Evaluation and testing with reports and standards updates

ARP PROJECT
P161.054: Field/Neighborhood Area Networks

TIES TO OTHER PROGRAMS
Substations (37), Distribution Systems (180), End-Use, Energy Efficiency, and Demand Response (P170), Integration of Distributed Energy Resources (P174), Electric Transportation (P18), Energy Storage and Distributed Generation

Optimal Use of Available Spectrum

Future State: Optimal Use of Available Spectrum.

Description: The network can make optimal use of available spectrum including licensed, unlicensed and shared.

Gaps Addressed:
- Crowding and interference in unlicensed spectrum results in lack of reliability and inadequate performance
- Lack of adequate channel bandwidth in licensed spectrum limits data capacity and thus servable applications
- Lack of understanding of operational constraints resulting from spectrum sharing mechanisms such as database controlled Spectrum Access Systems

Action Plan:
- Understanding the current and future occupancy and availability of unlicensed spectrum
- Evaluate and test systems using licensed control channel, and unlicensed transfer channel for private utility FAN, providing reliability and bandwidth
- Research best in class mechanisms for dynamic spectrum access, opportunistic sharing, etc. Is there a technical solution that meet utility requirements in a shared spectrum environment?

Major Past Accomplishments	2019	2020	Future
3002009786 Wireless Taxonomy and Architecture	Develop parameters for shared operation in 406-420 MHz spectrum	Pilot Deployment of private LTE in 406-420 MHz	Retrofit Next generation SDR platform (lower cost, more precision)
3002011195 IEEE 802.16S Overview	Data Analytics from unlicensed spectrum occupancy analysis	Simulation and possible prototype of 700 MHz Upper A block + 4.9/5.8 GHz FAN	Support of other band pairs, potential field testing
RF Mesh FAN – Wi-SUN Reference Design	Standards for NB-IoT operation in additional Sub-1GHz bands	Analysis of existing systems and techniques for split band operation	Evaluation of "mid band" shared spectrum potentially opened by FCC (3.6 to 7.1 GHz)
3002013392 Optimizing Wireless Spectrum (2018)		Evaluation of available SAS systems for shared bands and impact on FAN performance	Field testing of SAS based FAN operating in 3.6 GHz CBRS band

VALUE

- Determining the best match between requirements and wireless technologies
- Increased communications resilience
- Understanding technology options to reduce risk when migrating and deploying networks

DELIVERABLE TYPE

Evaluation and testing of approaches for identifying, avoiding, and managing interference in unlicensed spectrum, and managing operation in shared spectrum

ARP PROJECT

P161.054: Field/Neighborhood Area Networks

TIES TO OTHER PROGRAMS

Substations (37), Distribution Systems (180), End-Use, Energy Efficiency, and Demand Response (P170), Integration of Distributed Energy Resources (P174), Electric Transportation (P18), Energy Storage and Distributed Generation

Wide Area Networks Use Packet Based Technology

Future State: Wide Area Networks Use Packet Based Technology.

Description: Wide area networks will use the latest packet based technology and deliver reliability and latency performance to meet present and future requirements.

Gaps Addressed:
Utilities are challenged to transition from TDM networks to packet technology

Action Plan:
- Evaluate technology, test and document best practices for implementing packet based networks for critical application
- Evaluation and case studies on best practices for operating and maintaining the WAN

Major Past Accomplishments	2019	2020	Future
3002009783 Protection over MPLS Workshop, Test Plan, Results (2017)	Evaluate Time Sensitive Networking technologies for critical applications such as teleprotection	Perform basic interoperability testing of multi-vendor MPLS and CE in a private network	
3002009784 Serial/TDM replacement (2017)	Ensuring telecom data isolation techniques (DWM, virtual circuits, VLANs, MPLS, etc.) adhere to NERC CIP requirements		
3002009785 Leased circuit requirements for protection (2017)		Evaluate MPLS and Carrier Ethernet (CE) service offerings from carriers	
3002013385 Managing Timing and Latency in Packet WANs (2018)	Evaluating achievable precision of network-based time synchronization using TSN over packet-based transport	Evaluation of available SAS systems for shared bands and impact on FAN performance	Field testing of SAS based FAN operating in 3.6 GHz CBRS band
3002013403 Evaluation of SDN in Utility Operational Networks (2018)	Develop requirements and test scenarios of SDN for OT. Develop virtual SDN testbed and reference architecture for OT networks	SDN in the FAN and network edge device	Expand SDN testbed to include new solutions, additional test scenarios

VALUE

- Increased communications resilience, reliability, and lower cost for WANs and teleprotection circuits, enabling more advanced protection schemes
- Cost savings and risk avoidance resulting from strategic network planning, adoption of standards, convergence of IT/OT, leveraging best practices from the industry
- Understanding technology options—ability to more rapidly scale and expand the telecom network to meet business requirements and new opportunities

DELIVERABLE TYPE

Evaluation and demonstrations with reports and standards updates

ARP PROJECT

P161.053: Wide Area Networks

TIES TO OTHER PROGRAMS

Substations (37), Distribution (180), End-Use, Energy Eff., and DR (P170), Integration of DER (P174), Electric Transportation (P18), Energy Storage and Distributed Generation (94)

Expansion of Fiber Backbone

Future State: Expansion of Fiber Backbone.

Description: Expansion of the reach of the fiber backbone to support the backhaul requirements of rapidly growing FAN bandwidth, and in some cases fiber is deployed as an alternative to a wireless FAN.

Gaps Addressed:
Challenges making economic and business case for broader fiber deployment

Action Plan:
- Understanding of the best practices for fiber deployment
- Exploring potential partnerships and business models for fiber, including hybrid fiber/wireless architecture and deployment models.

Major Past Accomplishments	2019	2020	Future
3002009793 Strategic Fiber Handbook Phase 1	Evaluate innovative fiber technologies that have the potential to enable deployment deeper in the power network	Work with UTC UtiliSite Council to develop or validate joint fiber build business models	Assist member utilities that are participating in Smart Cities initiatives
3002009797 Strategic Fiber Handbook Phase 2 – Innovative Business Models Case Studies	Produce a comparison study of conventional OSP (field splicing) versus a pre-terminated OSP system, to include cost and schedule impacts	Work with cable manufacturer(s) to develop prototypes of hybrid primary power/fiber optic cable types	Develop detailed use cases for hybrid primary power/fiber optic cables (O/H and U/G) to include splicing/termination methods and procedures
3002009785 Leased circuit requirements for protection (2017)		Evaluate MPLS and Carrier Ethernet (CE) service offerings from carriers	
3002013389 Strategic Fiber in the WAN (2018)	Evaluate inter-utility fiber interconnections	Cost benefit study of fiber monitoring systems (e.g. Ntest FiberWatch)	Field test hybrid primary power/fiber optic cable types

VALUE

- Increased WAN availability, reliability, and capability to meet new business requirements
- Reduced risk when migrating to new technologies, improved operational effectiveness for telecom, reduction of outages through better situational awareness
- Improved ability to plan and deploy an expanded, higher density fiber-based WAN, while creating new economic and business opportunities

DELIVERABLE TYPE

Evaluation and analysis, with reports and workshops

ARP PROJECT

P161.054:
Field/Neighborhood Area Networks

TIES TO OTHER PROGRAMS

Substations (37), Distribution (180), End-Use, Energy Eff., and DR (P170), Integration of DER (P174), Electric Transportation (P18), Energy Storage and Distributed Generation (94)

Fully Integrated Network Management System

Future State: Fully Integrated Network Management System.

Description: A fully integrated network management system incorporating best practices from commercial carriers provides detailed, relevant and actionable metrics to support network planning and operation.

Gaps Addressed:
- Independent, non-integrated network management systems for each network technology provide a disjointed view of operational status
- Lack of information and network metrics needed to inform telecom planning
- Inability to understand telecom requirements resulting from increasing density of communicating devices on the system

Action Plan:
- Evaluate manager of manager systems and their access to underlying telecom metrics
- Evaluate applicability of metrics to understand current network operation and future requirements
- Develop a co-simulation platform with the ability understand electrical system behavior dependencies on telecom performance

Major Past Accomplishments	2019	2020	Future
3002009800 Manager of Manager Survey Results (2017)	Evaluate telecom planning approaches for achieving redundancy and resilience, including "islanding" of telecom while maintaining functionality through distributed intelligence and field message bus	Refine NMS requirements list, facilitate vendor webcasts and dialog with NMS vendors to increase their understanding of the utility end-user	Refine requirements for NMS / MoM based on progress. Document status – Report v2.0. Evaluate potential for standardization
3002009802 Software defined networking (SDN) Standards and Applications (2017)	Optimizing provisioning and device management		
3002009803 Creating Tele-communications Metrics for the Electric Sector (2017)	Develop initial Requirements document (1.0) of utility network metrics. (Include this in discussions with NMS vendors)	Develop use cases and ask NMS vendors to demonstrate product conformance. NMS tools and Network equipment would be added into EPRI Telecom lab	Refine requirements for network metrics to v2.0. Evaluate potential for standardization
3002009805 Roadmap and Framework for Telecom Planning (2018)	Extensions to the telecom planning framework, including evolution of traffic modeling	Enhance integration with telecom planning framework. Develop use cases and ask NMS or MoM vendors to demonstrate product conformance	

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Major Past Accomplishments	2019	2020	Future
Telecom Initiative Co-Simulation Framework (2017)	Develop additional wireless models	Expanded partnerships with national labs co-simulation activities	Evaluate and possibly prototype hybrid simulation and networking (communication hardware in the loop)
3002013394 Integration of GIS Visualization in Telecom Network Management (2018)	Evaluate applications of AR and VR for the NOC		

VALUE

Improved operational effectiveness for telecom, reduction of outages through better situational awareness, and higher availability of telecom networks

- Improved ability to plan and deploy advanced networks, creating new economic and business opportunities, understanding technology options
- Improved internal customer satisfaction by providing high reliability telecom services, with performance and reliability that meet application requirements now, and anticipate future business opportunities

DELIVERABLE TYPE

Analysis, demonstrations with reports and standards updates

ARP PROJECT

P161.055: Telecommunications Planning and Management Systems

TIES TO OTHER PROGRAMS

Substations (37), Distribution Systems (180), End-Use, Energy Efficiency, and Demand Response (P170), Integration of Distributed Energy Resources (P174), Electric Transportation (P18), Energy Storage and Distributed Generation

161G Telecommunications – Future State: Interoperability of Telecommunications Systems Through Standards

Telecommunication Standards Tracking and Analysis

Future State: Interoperable Telecommunications Systems.

Description: Standards based telecom solutions are available for all aspects from WAN to FAN to network management. Interoperability between technologies is enabled by a standardize architecture based on multi-services networking.

Gaps Addressed:
Proprietary communications technologies implemented individual for each application
- Multiple incompatible technologies implemented across the utility performing the same function
- Stranded assets due to early obsolescence of non-standard systems

Action Plan:
- Comms Intelligencer Newsletters highlighting key standards activities and progress from participation and tracking of standards development related to telecommunications, especially wireless standards
- Annual guidebook of telecom and communications standards, their roadmap, utility applications, and interrelationships

Major Past Accomplishments	2019	2020	Future
Issue 1: 1024654 Smart Grid Communications Intelligencer: Fall 2011 **Issue 2: 1024655** Smart Grid Communications Intelligencer: Winter 2011/2012 **Issue 3: 1025756** Smart Grid Communications Intelligencer: Spring 2012 **Issue 4: 1025757** Smart Grid Communications Intelligencer: Fall 2012 **Issue 5: 1024295** Smart Grid Communications Intelligencer: Winter 2012/2013 **Issue 6: 3002001076** Smart Grid Communications Intelligencer: Spring 2013 **Issue 7: 3002001141** Smart Grid Communications Intelligencer: Fall 2013 **Issue 8: 3002002697** Smart Grid Communications Intelligencer: Winter 2013/2014 **Issue 9: 3002002698** Smart Grid Communications Intelligencer: Spring 2014 **Issue 10: 3002002699** Smart Grid Communications Intelligencer: Fall 2014 **Issue 11: 3002005094** Smart Grid Communications Intelligencer: Winter 2015 **Issue 12: 3002005095** Smart Grid Communications Intelligencer: Spring 2015	Comms Intelligencer Newsletters highlighting key standards activities and progress from participation and tracking of standards development related to telecommunications, especially wireless standards Investigate options for engaging with 3GPP for standardization of sub-1GHz utility spectrum	Expand tracking and engagement with PES Power Systems Relaying & Control (PSRC) and Power System Communications and Cybersecurity (PSCC) committees	Evaluate potential for engagement with IETF in areas related to utility telecom and IoT

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Major Past Accomplishments	2019	2020	Future
Issue 13: 3002005096 Smart Grid Communications Intelligencer: Fall 2015 **Issue 14: 3002007445** Smart Grid Communications Intelligencer: Winter 2016 **Issue 15: 3002007446** Smart Grid Communications Intelligencer: Spring/Summer 2016 **Issue 16: 3002007447** Smart Grid Communications Intelligencer: Fall 2016 **Issue 17: 3002009755** Smart Grid Communications Intelligencer: Winter 2017 **Issue 18: 3002010451** Smart Grid Communications Intelligencer: Spring-Summer 2017 **Issue 19: 3002009755** Smart Grid Communications Intelligencer: Fall 2017 **Issue 20:** Smart Grid Communications Intelligencer: Winter/Spring 2018			
	Telecom Standards Guidebook - A high-level description of telecom and communications standards, their roadmap, utility applications, and interrelationships, updated annually		

VALUE

- Improved awareness of standards in development and their potential impact
- Improved interoperability of telecom systems, resulting from development and deployment of relevant standards

DELIVERABLE TYPE

Newsletters and annual standards guidebook tech update

ARP PROJECT

P161.056: Telecommunication Standards Tracking and Analysis (2019)

TIES TO OTHER PROGRAMS

Substations (37), Distribution Systems (180), End-Use, Energy Efficiency, and Demand Response (P170), Integration of Distributed Energy Resources (P174), Electric Transportation (P18), Energy Storage and Distributed Generation

Glossary and Acronym Definitions

A
ACM: Asset and Configuration Management
ADMS: Advanced Distribution Management Systems
AHR: Air-conditioning, Heating, and Refrigeration Institute
AMI: Advanced Metering Infrastructure
ANL: Argonne National Laboratory
ANSI C12.22: American National Standard for Protocol Specification for Interfacing to Data Communication Networks
APPA: American Public Power Association

B
Backhaul: The backhaul portion of the telecommunications network comprises the intermediate links between the core network, or backbone network and the small subnetworks at the "edge" of the entire hierarchical network
BES: North American Bulk Electric System
Bitcoin: A cryptocurrency and a payment system
BlockChain: A distributed database that maintains a continuously-growing list of ordered records called blocks

C
CBRS: CItizens Broadband Radio Service, is a 150 MHz broadcast band of the 3.5 GHz band (3550MHz to 3700MHz) historically used by the United States government for radar systems
CCOMS: Cyber combat simulator
CE: Carrier Ethernet
CE: Customer Edge (Telecommunications)
CEC: California Energy Commission
CIM: Common Information Model
CIP: Critical Infrastructure Protection
CM: Configuration Management
COP: Common Operating Picture
COTS: Commercial Off-the-Shelf
CPM: Cyber Security Program Management
CS: Cyber Security

D
DER: Distributed Energy Resources
DERMS: Distributed Energy Resource Management System
DLMS/COSEM: IEC series of standards specifying electricity meter data exchange
DMD: Distribution Modernization Demonstration
DMR: Digital Mobile Radio
DMS: Distribution Management System
DNP3: Distributed Network Protocol
DR: Demand Response
DRAS: Demand Response Automation Server
DRMS: Demand Response Management System
DWDM: Dense Wavelength Division Multiplexing is an optical multiplexing technology used to increase bandwidth over existing fiber networks. DWDM works by combining and transmitting multiple signals simultaneously at different wavelengths on the same fiber

E
EA: Enterprise Architecture
EDM: External Dependencies Management
EEI: Edison Electric Institute
EPIC: California Electric Program Investment Charge
EPRI: Electric Power Research Institute

F
FAN: Field Area Network
FCC: Federal Communications Commission
FLISR: Fault location, isolation, and service restoration

G
GIS: Geospatial Information System

I
ICS: Industrial control systems environment
ICT: Information and Communications Technology
IDS: Intrusion Detection System
IEC: International Electrotechnical Commission
IoT: Internet of Things
IOUs: Investor owned utilities
IP: Internet Protocol
IPS: Intrusion Protection System
IR: Incident Response
IRM: Interface Reference Model
ISOC: Integrated Security Operations Center
IT: Information Technology
ITAF: Integrated Threat Analysis Framework
ITEF: Internet Engineering Task Force
ITIL: Information Technology Infrastructure Library

L
LMR: Land mobile radio

M
MG: Microgrid
MOM: Message-oriented middleware
MPLS: Multi Protocol Label Switching
MVNO: Mobile virtual network operator

N
NAN: Neighborhood Area Network
NaN: Stands for not a number, is a numeric data type value representing an undefined or unrepresentable value
NESCOR-Cybersecurity: National Electric Sector Cyber Security Organization Resource
NFV: Network Functions Virtualization
NIS: Network and Information Security
NMS: Network management station
NOC: Network operations center
NRECA: National Rural Electric Cooperative Association
NREL: National Renewable Energy Lab
NTest FiberWatch™: NTest Inc., Develops and manufactures FiberWatch™, the worlds leading Remote Fiber Test System (RFTS) that monitors the physical integrity of fiber -optic networks

O
O&M: Operation and Maintenance
ODI: Outage Data Initiative
OFDM: Orthogonal Frequency Division Multiplexing
OH: Overhead
OMS: Outage Management System
OpenADR: Open Automated Demand Response
OpenESB: Open Enterprise Service Bus
OpenFMB: Open Field Message Box

OpenWMS: Open Workflow Management System
OSI: Open Systems Interconnection
OSP: Open Settlement Protocol
OT: Operational Technology

P
P25: Project 25 (or APCO-25) Standards for digital radio communications
PDP: Pre-Demonstration Project
PHY: Is an abbreviation for the physical layer of the OSI model and refers to the circuitry required to implement physical layer functions
PHY: PHYsical Layer
PHY and MAC: PHY chips handle the physical layer (Layer 1 of the OSI model), while MAC chips handle the data link layer (Layer 2 of the OSI model). MAC is Media Access Control which will control the transfer of data from PHY
Physical Layer L1: In the seven-layer OSI model of computer networking, the physical layer or layer 1 is the first and lowest layer. The implementation of this layer is often termed PHY
PLC Network Technology: Power Line Carrier, a system for carrying data communications over existing power line conductors
PMU: Phasor measurement units
PSCC: Power System Communications and Cyber Security
PSRC: Power Systems Relaying & Control
PV: Photovoltaics
PVNO: Private virtual network operator

Q
QoS: Quality of service

R
RF: Radio Frequency includes frequencies from 3 KHz to 300 GHz
RF LAN: Radio Frequency-Local Area Network
RM: Risk Management

S
SA: Secure Authentication
SANS: The SANS Institute was established in 1989 as a cooperative research and education organization. SANS is the most trusted and by far the largest source for information security training and security certification in the world
SAS: Spectrum Access System, as in the context of spectrum sharing
SCRAM: Security, cyber, risk assessment methodology
SDN: Software-defined Networking
SDO: Standards Development Organization
SME: Subject Matter Expert
SOA: Service-Oriented Architecture
SPN: Supplemental Opportunity

T
T&D: Transmission and Distribution
T&S: Transmission and Substations
TDM: Time-division multiplexing
TETRA: Terrestrial Trunked Radio
TI: Technology Innovations
TMD: Transmission Modernization Demo
Transport Layer L4: Transport layer is a conceptual division of methods in the layered architecture of protocols in the network stack in the Internet Protocol Suite and the Open Systems Interconnection (OSI). In the OSI model the transport layer is most often referred to as **Layer 4**
TVM: Threat and Vulnerability Management

U
UAS: Unmanned aerial system
UG: Underground
UTC: Utilities Technology Council

V
VLAN: Virtual local area network
VoLTE: Voice over **LTE** (Long Term Evolution)
VPP: Virtual Power Plant

W
WAN: Wide Area Network
Wi-Sun: An alliance developing and promoting open interoperable industry standards for smart utility network communications
WSDL: An XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information. The operations and messages are described abstractly, and then bound to a concrete network protocol and message format to define an endpoint

X
XSD: (XML Schema Definition), a recommendation of the World Wide Web Consortium (W3C)

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