2020 Research Portfolio

161—Information and Communication Technology

Program Description

Changes for 2020: *Project sets 161B, "Applied Information and Communication Technology for Transmission," and 161C, "Applied Information and Communication Technology for Distribution," are sunsetting. The work being done in these project sets is being moved to the appropriate programs in the Transmission and Substations, Distribution and Grid Operations and Planning areas. A new Project Set—161H, "Geographic Information (GIS) Informatics"—is being launched. This new project set conducts R&D on geographic or geospatial information systems (GISs) and will engage personnel who work with GISs or who use results that come from these systems.*

Utilities are deploying communications, computing, and information technologies to enable grid modernization applications, such as wide area monitoring and control, asset management, distribution automation, integration of distributed energy resources (DER), and demand response. Companies face significant challenges when deploying these technologies, including:

- Selecting the technologies that best meet current and future business needs while minimizing the risk of early obsolescence and vendor lock-in
- Creating an overall architecture that integrates the many intelligent devices, communications networks, and enterprise systems to leverage resources and provide information to all users
- Managing the tremendous amount of data generated
- Creating pervasive, resilient communications networks that can enable multiple applications

The Information and Communications Technologies (ICT) Program addresses these challenges by conducting research in the following areas:

- **Interoperability**. The program accelerates the industry's migration toward interoperability by making technical contributions to standards development efforts, providing training to utilities, developing reference implementations and organizing interoperability tests of developing standards, and collaborating with utilities on the demonstrations of emerging standards.
- **Telecommunications**. The program provides leadership in communications standards development, provides tracking and analysis of communications technologies, develops the tools and techniques to effectively plan and design communications networks, and conducts laboratory and field tests to evaluate the performance of evolving and emerging technologies.

- **Enterprise and Grid Architecture**. The program creates artifacts that help to improve the state of the art in enterprise architecture and develops guides to help utilities with standards-based systems integration.
- **Advanced Metering**. The program leads an industry effort to develop open, interoperable, and advanced metering systems; it develops best practice guides for the operations and maintenance of advanced metering infrastructure (AMI) systems; and it investigates approaches for maximizing the value of AMI systems.
- **Connectivity and Integration of Intelligent Edge Devices Consumer Internet of Things (IoT) Devices with Utility Systems**. The program is developing requirements and informing standards-making efforts for integrating and managing grid-edge devices with utility systems.
- **Data Management**. The program is documenting industry best practices for how data are acquired, validated, stored, protected, and processed—and how accessibility, reliability, and timeliness are ensured. The program also is advancing the Common Information Model (CIM) standard.

Research Value

The ICT program provides information and tools that are designed to provide members with immediate value while it conducts longer-term R&D to help guide the industry toward a highly connected, interoperable future.

In the near term:

- IT departments may reduce the time and cost of integration and management from guides that provide best practices for enterprise architecture, systems integration, and substation and AMI data management.
- Telecommunications departments may reduce cost and the risk of early obsolescence of equipment by applying best practices for network operation, maintenance, and management, and tools for effectively planning and designing multi-technology communication networks.
- Metering departments that plan to implement advanced metering systems may receive value when developing their procurement from the industry AMI database and resource center. They may also reduce cost and risk by using the Wi-SUN reference meter tool. Companies that have already deployed AMI systems may reduce operation and maintenance costs by applying the information from the program's suite of best practice guides.

In the long term, members can benefit from R&D and industry leadership to advance interoperability standards for advanced metering systems, DER, demand response, and enterprise system integration. This could reduce capital and integration costs and reduce the risk of vendor lock-in.

Approach

The approach for providing value in the ICT Program involves multiple strategies:

- **Requirements Development**. The program defines the functional and nonfunctional requirements for advanced applications, such as the coordinated control of groups of

DER devices and the next generation of advanced metering systems. This typically requires gathering a significant group of diverse stakeholders to develop and analyze use cases.

- **Advancing Standards Development, Certification, and Adoption**. The ICT staff leads or participates in many industry standards development activities, often accelerating standards development through technical contribution. Staff participate in industry alliances and user groups that are working to develop interoperability profiles and certification test scripts. The program has developed a list of open-source references to help vendors implement emerging standards.
- **Technology Evaluation, Laboratory Testing, and Field Demonstrations**. The program conducts work in EPRI laboratories where staff take part in assessment of emerging standards, equipment, and communications architectures. The program also performs field demonstrations of emerging standards and technologies in coordination with utilities.
- **Industry Case Studies, Best Practices, and Guidebook Development**. The program documents utility experiences as they implement early-generation technologies and applications. Experiences are captured through utility immersions, interviews, and case studies. The program also develops go-to reference books to help utilities plan for, design, deploy, and maintain new technologies or applications.
- **Technology Transfer**. The program uses a variety of approaches to share research results, including technical reports, white papers, newsletters, webcasts, and workshops.

Accomplishments

The ICT Program has delivered valuable information that has helped its members, the industry, and the public in numerous ways:

- *Cloud Integration Guidebook, 3rd Edition* (3002012478) provides guidance for enterprise architects and senior managers for optimizing cloud architecture.
- *GIS Leading Practices Guidebook: Data Cleanup Methods with Cost-Benefit Analysis Guidance* (3002010509) identifies leading practices for GIS data quality, data completeness, and integrations based on a series of utility immersions.
- Wi-SUN Meter Test Tool (WISUND), version 1.0 (3002010501), enables utilities to independently evaluate Wi-SUN products for compatibility and interoperability.
- *DER/DR Protocol Reference Guide: 2nd Edition* (3002013621) provides a concise digest of communications protocols for DER/DR—from maturity to the current state to potential applications.
- The research in *Remote Device Management Assessment* (3002012588) assesses the current state of remote device management as implemented by leading suppliers in this area. Both architecture and functions are evaluated.
- *Strategic Fiber in the WAN: Exploration of Synergistic Fiber Network Deployment for Utility Smart Grid/DA and 5G Mobile Network Operators* (3002013389) researches expanded fiber deployment in distribution grids, based on leveraging and partnering with commercial wireless carriers.
- *FAN Technology Performance Evaluation* (3002013393) provides results of the FAN testing platform for assessment of network performance in peer-to-peer applications

and applying quality-of-service parameters for relative prioritization on multi-service FANs.
- *Information Technology (IT)/ Operations Technology (OT) Convergence Guidebook* (3002012479) explores the leading practices based on interviews with utility CIOs.
- *Utility Enterprise Architecture Guidebook, Third Edition* (3002012476) contains guidance for enterprise architects and senior managers to apply standards *in a* practical setting.
- *Revenue Protection Guidebook* (3002008943) provides best practices for effective and efficient revenue protection programs.

Key Activities

In 2020, the ICT Program will deliver the following:

- Updates to technical guidebooks that provide immediate value by sharing leading practices based on past research and industry collaboration:
  - DER Protocol Reference Guidebook
  - Enterprise Architecture Guidebook
  - Revenue Protection Guidebook
  - Strategic Fiber Guidebook
  - Telecommunication Standards Guidebook
  - Geographic or Geospatial Informatics Guidebook
- Advancing interoperability of equipment and systems:
  - Evaluating the State of Functional and Communications of Inverter-Based DER/DR: Interoperability Evaluation and Market Survey
  - Reference Implementation of DLMS/COSEM Access Point
  - Interoperability Testing on the Private WAN in Multi-Vendor MPLS and Carrier Ethernet Networks
  - Geographic or Geospatial Standards Development for Augmented and Virtual Reality
- Training resources:
  - CIM Primer, 6th Edition
  - Training Curriculum for Information and Communication Technologies for Monitoring, Management, and Configuration of DER/DR

Estimated 2019 Program Funding

$6.0M

Program Manager

Don von Dollen, 650.855.2210, dvondoll@epri.com

PS161A: Emerging Technologies and Technology Transfer

This project set provides tracking and analysis of the rapid advances in smart grid standards and communications technologies so that members can minimize risk when planning and procuring equipment. It investigates new, groundbreaking information and communication technology (ICT) issues and technologies that might impact utility investments. The ICT program provides members with a group of established experts to capture and analyze this information and provide insightful feedback to utilities. The project set promotes technology transfer for the entire ICT program through webcasts and newsletters and provides the overall industry coordination and high-level technology transfer activities related to the ICT technology needed to support smart grid applications.

P161.033 Smart Grid Standards Tracking and Analysis

Key Research Question

Utilities are making large investments in equipment and infrastructure that enable applications such as situational awareness, distribution automation, integration of distributed energy resources, and demand response. These investments are highly dependent on data and communications standards, such as the Common Information Model (CIM), IEC 61850, IEEE 1547, and OpenADR. The challenge is that there are many standards available, and all are evolving. Many utilities are finding it overwhelming to track this complex and dynamic landscape that could have a tremendous impact on their business.

Objective

The objective of this project is to provide up-to-date information on standards development activities and an analysis on the impact that these activities can have on electric utilities.

People who will be interested in the results from this project are those responsible for “grid of the future” planning, advanced technology leaders, IT architects designing the infrastructure to support the future grid, and project engineers who can use the information and analysis when planning and implementing technologies.

Results will be presented through monthly webcasts that will focus on a specific standard, technology, or application and provide members with a forum for exchanging concerns and ideas with their peers.

Research Value

Although utilities realize the impact that standards can have on equipment and infrastructure investments, most do not have the resources to actively participate in standards development activities. EPRI’s staff have deep technical expertise, and EPRI makes a substantial investment for staff members to participate in standards development activities and associated efforts.

The standards tracking, and analysis provided by this project can:

- Inform utilities of the potential effect of activities on existing equipment and infrastructure
- Help utilities to plan smart grid deployments
- Help utilities minimize cost and risk when selecting technologies

Approach

EPRI's technical staff is engaged in organizations working to promote interoperability within the electricity sector, including the Institute for Electrical and Electronics Engineers (IEEE), the International Electrotechnical Commission (IEC), the National Institute of Standards and Technology (NIST), the U.S. Department of Energy (DOE), and the Wi-SUN Alliance. The staff provides leadership and makes contributions to these organizations to advance interoperability within the industry. It also works directly with utilities to demonstrate emerging standards.

This project will leverage the technical staff's deep engagement in standards activities to provide members with information and analysis on standards development, implementations, interoperability, testing, and certification. Information provided to members describes what is going on in the complex standards community and explains the impact that these activities can have on electric utilities and the investments that they are making.

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Webcasts	Monthly webcasts on standards development activities		12/31/2020
Summary of Interoperability Tracking and Reporting by the ICT Program in 2020	Packages the presentation material that will be developed and presented on various interoperability topics during 2020		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002013481	Summary of Interoperability Tracking and Reporting by the ICT Program in 2018	Packages the presentation material that was developed and presented to members on various interoperability topics during 2018	December 19, 2018
3002010237	Summary of Interoperability Tracking and Reporting by the	Packages the presentation material that was developed and presented to members on	November 7, 2017

	ICT Program in 2017	various interoperability topics during 2017	

P161.035 White Papers on Emerging Information and Communication Technologies (ICT)

Key Research Question

Content that tells the story of why the research is needed, background information, and issue or opportunity being addressed by the project or task. Recommend 1-2 paragraphs:
Issues around information and communications technologies (ICT) surface quickly, and utilities need fast answers and solutions. This project will develop a series of white papers that investigate and analyze emerging ICT issues. With input from ICT program advisors, EPRI staff will identify topics for these white papers throughout 2020.

Past white papers have included:

- *Light(er)weight Protocols for Lower-Capability Edge IoT Devices* (3002013478)
- *Blockchain: Early Activity for Utilities* (3002009889). Blockchain is an emerging digital technology
  acting as a distributed ledger to record transactions. The paper explains what blockchain is, its associated capabilities, and applications in the utility industry.
- *Artificial Intelligence: Concepts for Electric Power* (3002010236): This paper examines broadly the past, present, and future of artificial intelligence with respect to the electricity industry.

Objective

The white papers will provide members with information and insight into emerging issues. The studies will provide an analysis of the identified issue/s and options for the path forward.

The audience will be different for each white paper, depending on the topic. Papers could address issues faced by IT departments, communication groups, or transmission, distribution, or substations engineers. Papers could be targeted to an executive or highly technical audience. A series of webcasts will summarize the findings of the white papers.

Approach

As topics are identified, a member of EPRI's technical staff will author the white paper. In some cases, a contractor might be engaged to supplement EPRI's expertise. A group of advisors might be brought together to further refine the topic of the white paper and provide feedback during its development.

Research Value

The true value of the white papers lies in the collaborative' s ability to quickly identify a significant emerging issue, study it, and determine actions to address it. To ensure that relevant issues are being addressed and actionable results are being produced, EPRI staff will solicit input from the ICT program advisors in identifying and defining the issue and developing white papers.

The papers will explain the issue and propose recommendations for solutions going forward. The papers will also make recommendations for further research and may result in a future ICT project.

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
White papers	Two or three papers on urgent topics associated with smart grid implementations		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002007825	The Value of Direct Access to Connected Devices	This paper identifies the values of direct, standard, and open access to devices. These terms are defined and contrasted with alternatives.	January 24, 2017
3002007842	Distributed Intelligence: Current Industry Landscape and Next Steps	This paper identifies potential impacts across the utility enterprise, summarizes the current landscape and challenges, and finally provides research recommendations to bridge gaps in order to achieve a future vision related to distributed intelligence.	December 27, 2016
3002006917	Opportunities and Hesitations Associated with Open AMI Systems	This paper examines important nontechnical considerations in support of implementation of an open AMI system. The issues covered include the responsibility for integration of the system components, which entities provide the required maintenance expertise, and potential economic effects on the industry.	December 21, 2015

P161.058 Technology Transfer for the ICT Program

Key Research Question

The value of the R&D results developed through the Information and Communications Technologies (ICT) Program is realized when someone makes use of them.

Three steps are involved in successfully delivering the results of our research:

- *Identify the end user*. The end user is the person who will use and benefit from the research result.
- *Make the end user aware of the result*. Educate the end user on the results by posting an abstract on social media sites frequented by the end user, presenting at technical conferences, publishing in magazines, and so forth.
- *Direct engagement with the end user*. Once the end user is aware of the results, we will provide a deeper understanding by publishing a technical report, holding a webcast, or conducting a workshop.

Objective

This project will provide tech transfer support for the entire ICT program and will focus on the first two steps in the delivery process—identifying the end users and making them aware of the results. The individual project sets will address the third step in the delivery process, which is direct engagement with the end user.

Approach

This project will provide tech transfer support by producing the following:

- *Monthly tech transfer webcasts.* Each webcast will focus on the results from a specific project and will be targeted for a general audience. More detailed information on the project results will be available through the relevant project set.
- *A program newsletter*. The newsletter will have short articles that describe program activities and project results.
- *An annual program review*. The annual review summarizes the research results produced by the program each year and shares success stories on how members have used and benefited from the results.

Research Value

The value of the research results developed by the ICT program is realized when people ultimately use and benefit from them. This project connects end users to the research results.

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
ICT program newsletter	Monthly newsletter with brief articles on program activities and research project results.		Multiple

Monthly tech transfer webcasts	Each webcast will focus on the results from a specific project.		Multiple
Annual program review	Provides a summary of the research results produced by the ICT program and success stories on how members have used and benefited from program results.		December 2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002015439	*Information and Communication Technology (ICT) 2019 Research Portfolio and 2018 Annual Review*	This brochure provides 2019 research plans and 2018 key research results for EPRI's Program 161, Information and Communication Technology (ICT).	March 4, 2019

PS161D: Applied Information and Communication Technology for Distributed Energy Resources and Demand Response

Utilities are embracing the flexible operations from distributed energy resources (DER), which can play a key role in a modern, optimized, and integrated grid. These DER—both in-front and behind the-meter solar, energy storage, electric vehicles, and demand response—support the grid by providing utilities and their customers with multiple options for balancing generation and energy consumption across the grid. This provides flexibility to choose the most cost-effective options and can enable future states, such as microgrids, renewable energy targets, and simultaneous grid services from DER/DR.

The communications, control, and associated analytics of data from DER/DR are essential to making this happen. Successful information and communication practices for DER/DR can support field operations, simplify integration and long-term maintenance of the DER/DR interfaces, support modularity and options when choosing DER/DR components and the systems to manage them, and support the many demands of utility use cases. The goal of this project set is to research the evolving needs for communication technologies, architectures, and methodologies to support the communications with smart solar, storage, and loads. Through our membership, we create an ecosystem where we can address these barriers as a collaborative effort.

This project embraces the differences in utility DER/DR goals and roadmaps by performing research that can help utilities at any stage of DER/DR integration. This includes industry leaders targeting full integration (control and monitoring) of both in-front and behind-the-meter DER/DR or utilities more focused on reducing costs and optimizing existing operations, such as the monitoring and operation of large-scale storage or solar plants. The project set has activities that support both the immediate future (optimizing existing operations) and longer term (strategic vision).

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 and Distributed Generation (P94), End-Use Energy Efficiency and Demand Response (P170), Integration of Distributed Energy Resources (P174), Distribution Operations and Planning (P200), Understanding Electric Utility Customers (P182), and Advanced Buildings (P204) programs.

P161.049 Enabling Open, Interoperable DER—Standards, Testability, and Embracing DER/DR Abilities

Key Research Question

Distributed energy resources (DER) and demand response (DR) technologies and analytics can support flexibility, reliability, and resiliency on the grid through leveraging their operational flexibility (for example, by operating energy storage, calling on demand response flexibility in loads, or using smart inverter functionalities). Realizing this goal needs alignment from various industry stakeholders, including manufacturers of in-front and behind-the-meter DER/DR to develop devices with native DER/DR technologies and communication capabilities to support flexible grid services. Such services can be used by utilities that develop programs that support customer participation in these services; utility commissions that support the use of DER/DR for grid services; standards organizations that develop standards-based protocols to streamline operation of these services, including the monitoring of DER/DR; and third parties that develop tools and testing resources to verify that these systems will work together as intended.

EPRI participates and contributes to this mission through EPRI collaborative projects, coordination and development support for standards activities, and working groups. The goal in EPRI's participation is to provide technical contributions by informing industry standards, developing methods for robust interoperability testing, and leading working groups to expand the capabilities of protocols to support the capabilities of DER/DR and the needs of the grid. The discussions on the development and/or use of interoperability standards are often extensive and consist of a large group of varied stakeholders. Often, the result of these discussions is a written product, a referenceable document with the final decisions of the group. What is not published are the conversations and background of why those decisions were made. In addition to participating in these industry events and working groups, EPRI will share background information and perspectives about why a standard is evolving in a certain way, updates on revisions to standards, and overviews on the work we are involved with on each standard. EPRI will discuss potential barriers of adoption or gaps in the standards and work with members to identify opportunities to overcome the barriers and fill the gaps.

- How are current standards evolving for use by DERs? What standards are mature for use?
- What is the status of the testability of communication standards?
- Does the functionality of today's standards match respective application in the field?
- What are the known interoperability issues, and how are they being addressed by the industry?
- Is additional work needed to carry open, interoperable DER/DR from concept to implementation?

- In RFPs, what language is needed to ensure that DER/DR and their management systems meet the intended application and capture the appropriate level of detail of standards?

Objective

Working groups and standards that focus on the capability for disparate DER/DR to provide grid services and the communications capabilities needed to leverage them are important for the many stakeholder groups to come together to develop end-to-end solutions. Information about these groups, the ongoing discussions, and the insights into the reason the discussions are advancing the way they are important for utilities. These discussions will inform their company's roadmaps and how they will effectively leverage DER/DR in their service territory.

In this project, EPRI will:

- Summarize current standards efforts in the industry from EPRI's participation in standards activities and government projects.
- Identify gaps and barriers in standards, testability of standards, and their pairing to the services that DER/DR can provide.
- Develop tools to support the testability and adoption of open, interoperable DER/DR. EPRI will support member utilities and their project partners in using these tools.

Approach

EPRI will take a multi-faceted approach in this project. EPRI will provide summaries (webcasts, reports, or other) to transfer information about the standards and debrief members on government projects or supplemental projects in the same domain, with the goal of informing members and spurring discussion among the collaborative. EPRI will host discussions with members about barriers or gaps in standards and their respective testability, and the PS161D team will conduct collaborative research with end-use programs to pair the flexible behavior of DER/DRs with grid services and capture them in relevant standards.

Research Value

The results of this project will give utilities and the public insight on emerging standards and issues associated with existing standards. These standards can support field operations, simplify integration and long-term maintenance of the DER/DR interfaces, support modularity and options when choosing DER/DR components and the systems to manage them, and support the many demands of utility use cases. This information will allow utilities to make better-informed decisions when purchasing equipment and systems to realize these benefits.

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Informational Webcasts	EPRI will provide summaries to transfer information about the standards and debrief		Throughout 2020 – 12/31/2020

	utilities on government projects or supplemental projects in the same domain, with the goal of informing members and spurring discussion among the collaborative.		
Evaluating Transactive (Price-Based) Load Signals (Technical Update)	This project will explore the role of price signals, their communication, and their effectiveness. This project leverages a CEC-funded activity where California utilities are applying new, state-of-the-art transactive signals to incentivize customer response. This project will take the findings from this project and explore pricing capabilities (and gaps) on the market today.		12/31/2020
EPRI DER/DR Integration Toolkit (Technical Update)	This ongoing deliverable is a compilation of test tools designed to support the development and testability of control systems, including DERMS and DRMS systems and devices (solar, storage, and demand response technologies). The team will update the summary report each year to reflect the latest capabilities of the tools.		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002016139	2019 PS161D Informational Webcast Summary		Pending 2019
3002016138	EPRI's Distributed Energy Resources Integration Toolkit		Pending 2019
3002016144	Test Procedure for Validating DNP Application Note AN2018-001 in		May 8, 2019

	Distributed Energy Resources: Example Test Procedure for Evaluating Conformance to DNP Application Note AN2018-001— "DNP3 Profile for Communications with Distributed Energy Resources"		
3002016335	Enhancing Grid Resiliency Through Improving Capabilities to Manage Communicating Energy Storage and Solar Systems: Expanding Standards and Developing Tools to Enable DNP3 Support of Storage Use Cases		May 8,2019
3002015355	Open Source DER Outstation for DNP Application Note AN2018-001: Reference Implementation of DNP Application Note AN2018-001— "DNP3 Profile for Communications with Distributed Energy Resources"		February 25, 2019
3002013623	EPRI's Distributed Energy Resources Integration Toolkit: An Overview of EPRI Tools for Testing and Implementing Open Protocols		December 28, 2018
3002013622	Emulating Smart Solar Inverters and Energy Storage Systems on Communication Networks: An Overview of EPRI's Distributed Energy Resource Simulator		December 28, 2018
3002013625	Overview of EPRI's DER Simulation Tool for IEC 61850 Protocol Driver Agents: Open Source Software to Support Testing and Development of IEC-61850 in Smart Inverters		December 31, 2018
3002014840	*From Innovation to Standards: Technology Evolution*		December 28, 2018
3002013478	Lightweight Messaging Technologies for the Energy Internet of Things: An Introduction		December 28, 2018
3002014087	EPRI IEEE 2030.5 Client User's Manual		July 18, 2018
3002013875	Consumer Devices Functional Specification for Photovoltaic Support		July 13, 2018
3002012290	Transactive Incentive Signals to Manage Energy-Consumption (TIME):		April 30, 2018

	The System- and Market-Based Transactive Load Management (TLM)		
3002011045	Common Functions for Heating, Ventilation, and Air Conditioning Devices		December 13, 2017
3002009852	Overview of EPRI's Simulation Tool for Emulating Smart Water Heaters on Communication Networks: An Introduction to EPRI's Smart Water Heater Simulator		December 11, 2017
3002009853 superseded by **3002013623** *see* above	EPRI's DER Integration Toolkit: An Overview of EPRI Tools for Testing and Implementing Open Protocols		December 28, 2018
3002009851 superseded by **3002013622** see above	Overview of EPRI's Simulation Tool for Emulating Smart Solar Inverters on Communication Networks: An Introduction to EPRI's Smart Solar Inverter Simulator		December 2017
3002009849	Applying Standards-Based Demand Response to Support Solar Integration: A Summary of EPRI Testing at the National Renewable Energy Laboratory (NREL)		November 8, 2017
3002011591	IEEE Standard 1547™ — Communications and Interoperability: New Requirements Mandate Open Communications Interface and Interoperability for Distributed Energy Resources		July 31, 2017
3002007825	The Value of Direct Access to Connected Devices		January 24, 2017

Related Research

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 and Distributed Generation (P94), End-Use Energy Efficiency and Demand Response (P170), Integration of Distributed Energy Resources (P174), Distribution Operations and Planning (P200), Understanding Electric Utility Customers (P182), and Advanced Buildings (P204) programs.

Applicable Programs:

161, 183, 18, 94, 170, 174, 200, 182, 204

P161.050 Interoperability Assessments—Study of Control Protocols and Potential Barriers to Interoperability

Key Research Question

Utilities and their customers are connecting distributed energy resources (DER)—including solar photovoltaic (PV) systems, energy storage, electric vehicles, and demand responsive loads—into the grid in increasing numbers. As more DER/DR are added, they become key—or even critical—components for managing grid reliably. At this stage, appropriate and secure protocols and standards need to be applied in products and validated for safe and effective operation of the grid. Utilities will need to understand the capabilities of the DER/DRs and identify barriers to tying into existing or next-generation control systems (interoperability). In addition to the capabilities of these DER/DRs, the maturity and market's application of these standards are other drivers in the utility's ability to apply them. Therefore, EPRI will analyze the maturity of these standards, including adoption, governance and maintenance, applicable devices and technologies, example implementation, available test tools and certification, references in regulatory documents or industry requirements, and the standards' placement in the DER/DR control architecture.

Example research questions include:

- What are the availability, capabilities, and role of standardized communication protocols for DER/DR, including IEEE 2030.5, IEEE 1815/DNP3, IEC-61850, SunSpec/MESA Modbus, CTA-2045, and OpenADR?
- What drivers in the industry could impact the maturity of these protocols, including regulations, industry requirements, or other drivers for adoption?
- How does each protocol approach and address security and data privacy?
- Which EPRI projects and utilities have applied these communication protocols?
- What is the proliferation of standardized information models and data models over communication protocols to streamline interconnection and long-term access to DER/DR?
- What is the current state of the art for connectivity to DER?
- What is the penetration of communication protocols in products and systems today?
- Do today's DER and their associated control systems interoperate with other manufacturers' products as expected?
- What are the new developments or initiatives for DR/DER protocols?

Objective

Open protocols and standards can enable plug-and-play DER/DR; however, experience says that even with the most robust standards, unforeseen barriers can arise. These might include barriers from misinterpretations of or vagueness in standards, improper application of protocols and standards in products, gaps in functionality, or the maturity and adoption of the standards themselves. This project evaluates these barriers. The benefit to addressing these issues is that it can improve field operations, simplify integration and long-term maintenance of the DER/DR interfaces, support modularity and options when choosing DER/DR components and

the systems to manage them, and support the many demands of utility use cases. This project will identify and study these standards and protocols using lab and field studies to understand barriers in the interconnection and interoperability of DER/DR so that they can be addressed ahead of utility deployments. Examples include:

- Evaluating standard data models over communication protocols
- Testing of DER/DR on the market to understand the maturity of communication standards, data models, and mapping functional responses
- Evaluating "interoperability" standards that reference multiple standards together for the sake of interoperability (IEEE 1547-2018, AHRI-1380, and so on)
- Evaluating how IT practices must evolve with the rising number of communicating DER/DR, including firmware revisions, protocol translations, and data structures
- Identifying and addressing interoperability considerations, including volatility of DER/DR settings, limits on DER/DR polling frequencies, multiple interfaces in DER/DR (customer, manufacturer, utility), and reliability of communications capabilities in DER/DR

Approach

EPRI's Information and Communications Technologies (ICT) team has experience working with utilities, manufacturers, and standards bodies to develop the next generation of connected DER/DR. EPRI contributed to the development process by testing devices from manufacturers to identify barriers and potential solutions, and then provide this information back to the manufacturers and standards bodies. This process has been successful and can be attributed to the creation of the first open-standards-based smart inverters, development of the first interoperability test procedures (IEEE 1547-2018, IEEE P1547.1), and development of CEA-2045 standard and subsequent devices. This project will follow a similar process. The key is to develop key criteria with the members of the project, assess product interoperability against test tools created by EPRI and other third parties, and deliver the results to utilities, manufacturers, and standards bodies to help accelerate maturity and highlight potential gaps. EPRI will also update *the EPRI Protocol Reference Guidebook*. The *EPRI Protocol Reference Guidebook* is a concise, stylized, digest-like overview of communication protocols that allows readers to make 1:1 comparisons of specific aspects of the protocol, including where a protocol fits into the greater communication architecture and the types of DER/DR it currently supports. The *EPRI Protocol Reference Guidebook* also includes a maturity model that evaluates the maturity of key traits of the protocols.

Research Value

This project will identify and study these protocols using lab and field studies to understand barriers in the interconnection and interoperability of DER/DR so that they can be addressed ahead of utility deployments. The value to members is awareness of existing standards, issues, and solutions that can streamline the integration of DER/DR and reduce costs for operation and maintenance.

Anticipated Deliverables

Title	Short Description	Date
EPRI Protocol Reference Guidebook – 4th Edition - Technical Update	This deliverable is a concise, stylized, digest-like overview of communication protocols that allows readers to make 1:1 comparisons of specific aspects of the protocol, including where a protocol fits into the greater communication architecture and the types of DER/DR it currently supports. The deliverable also includes results of a maturity analysis of each protocol informed by industry knowledge and EPRI research. EPRI will continue to expand the guide to include protocols for managing individual and groups of DER/DR and will consider next steps to expand the document, including network and communication technologies like XML, JSON, HTTP, XMPP, and MQTT.	12/31/2020
Evaluating the State of Functional and Communications Interoperability in Inverter-based DER/DR: Interoperability Evaluation and Market Survey - Technical Update	This deliverable will assess the interoperability aspects – both functional and communication – of inverter-based DER available on the market today. The EPRI team will purchase products on the market and perform both communications and functional testing to evaluate the state of known interoperability gaps. This includes proper mapping between communicated intent and functional response; interactions between utility, vendor, and customer interfaces; polling frequency limitations; unlocking inverter's "smart" capabilities; and others. The project will evaluate existing "interoperability test procedures" (IEEE P1547.1) to assess their ability to increase likelihood of interoperability occurring the field. Exploratory testing and surveys of existing smart inverter deployments will be performed to help name potential gaps not yet formally identified. The goal of this activity is to identify interoperability gaps and notify the industry to help the industry address	12/31/2020

	them before they are experienced widely in the field. The team will also perform an assessment of the market including the penetration of open protocols and smart inverter functions in products to date. This is a continuation of 2016-2019 efforts. This effort will be collaborative between PS161D, Applied Information and Communication Technology for Distributed Energy Resources and Demand Response and PS174B, Smart Inverters and Grid Supportive Devices.	
Evaluating the State of Functional and Communications Interoperability in Demand Response Technologies: Interoperability Evaluation and Market Survey - Technical Update	This activity is similar to *Evaluating the State-of-the-Art of Interoperability in Inverter-Based DER/DR: Interoperability and Industry Evaluation*, but it focuses on the demand response domain. Inverter-based DER/DR and demand response technologies can both provide services to utilities. However, the control architectures, customer engagement models, and capabilities are unique. This project is similar to the other in that it will evaluate the availability of DER/DR that support interoperability standards, including communication protocols, functional requirements, and industry requirements (AHRI-1380, EnergyStar, or Title 24). This effort will be collaborative between EPRI's P170 and P161 programs.	12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002016140	Protocol Reference Guide – 3rd Edition		Pending 2019
3002016141	State-of-the-Art in Demand Response Protocols: Interoperability and Industry Evaluation		Pending 2019

3002016099	State-of-the-Art in Inverter-Based DER: Interoperability and Industry Evaluation		Pending 2019
3002013621	Protocol Reference Guide: Understanding the Characteristics of Communications with Distributed Energy Resources		December 2018
3002013473	Assessment of Interoperability Achieved Through IEEE Standard 1547-2018 and IEEE P1547.1: Results from EPRI Interoperability Testing and Market Research		December 2018
3002009854	Evaluation of SunSpec Modbus for Distributed Energy Resources: Results from EPRI Interoperability Testing and Market Research		December 2017
3002009462	Results from Inverter Interoperability Assessment Using the SunSpec Specification: Summary of EPRI's Testing of Communications in Residential Solar		December 2016
1026542	Modular Communication Interface Interoperability Workshops: Laboratory Evaluation of the CEA-2045 Demand Response Interface		October 2013

Related Research

The work in this project is coordinated with and designed to complement the work performed in EPRI's Cyber Security (P183), Electric Transportation (P18), Energy Storage and Distributed Generation (P94), End-Use Energy Efficiency and Demand Response (P170), Integration of Distributed Energy Resources (P174), Distribution Operations and Planning (P200), Understanding Electric Utility Customers (P182), and Advanced Buildings (P204) programs.

Applicable Programs:

161, 183, 18, 94, 170, 174, 200, 182, 204

P161.051 Utility Case Studies on Communicating with DER—Highlighting Experiences, Best Practices, and Barriers

Key Research Question

Utilities across the world have started to deploy communicating distributed energy resources (DER), demand response (DR), and distributed energy resources management systems (DERMS) for reliable grid management and increase the share of renewable resources.

Protocols and processes that can be used to manage DER/DR are not new to the industry. Utilities have vast experience in managing grid systems. However, what is new is the application of these protocols, technologies, and approaches to in-front and behind-the-meter DER/DR.

In addition, the various ownership models, electrical placement on the grid, and control interfaces mean that there are many communication architectures and technologies for DER/DR integration, each with varying capabilities and limitations. Some architectures involve deployment and management of utility-owned infrastructure, whereas others use existing systems owned and managed by other entities. Some approaches could require significant effort on the part of the consumer to commission and manage, but they might offer the consumer valuable features. Others might be simpler to deploy but are limited in terms of the use cases that can be supported.

With these efforts underway, utilities are making both business and technical decisions and learning about how these decisions are impacting the success of their utility's DER/DR architecture and programs. This project will capture these activities across the industry and extract key lessons learned so that members of the project can learn and adapt from the experiences of others.

Objective

Industry forerunners using communication and control technologies for DER/DR—including California, Europe, and Japan—are paving the way for DER/DR through aggressive research and pilot programs. As more are diving into communicating with DER/DR, it will be important to understand their experiences to move forward as an industry. This project will support this by researching the following:

- Case studies from member utilities
- Existing and planned DER/DR architecture
- Key takeaways, including best practices and significant barriers
- The impact that communications metrics (bandwidth and latency) and choice of protocol have on control algorithms, the control applications, and the application protocols for DER/DR
- The business metrics and motivators to begin communicating with DER/DR

Approach

EPRI has several demonstration projects underway with utilities. Collaboratively, the teams are working on implementation of communicating DER/DR and their integration into the utility grid and associated grid control systems. EPRI will draw on these experiences to identify case studies to document and provide analysis. These case studies will be summarized and shared with the members through webcasts, reports, or other methods.

Research Value

The results from this project will help utilities and the public learn from the architectural, technical, and business decisions of other utilities and then adopt their own plans to increase

the value of grid modernization activities. Utilities and the public will receive insight from these results, which could help when identifying technology and architectural approaches.

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Repository of RFP Language and Standards for Communicating DER/DR: An Ongoing Study of Requirements to Simplify the Integration and Interconnection of DER/DR – Technical Update	The industry has experience communicating with field resources, and the protocols for managing DER/DR have been around for years. However, their mainstream adoption in the DER/DR domain are not. This activity helps increase confidence that utilities are asking for the right things for their specific DER/DR application by providing guidance on how to reference different subcomponents of communication protocols, what certification or standards can be referenced to increase the likelihood of seamless integration, and what known barriers to interoperability must be addressed in utility requirements or RFPs.		12/31/2020
Repository of Lessons Learned from Utility Case Studies: An Ongoing Study of Barriers and Successes in Utility Deployments of Communicating DER/DR – Technical Update	This activity will capture information related to DER/DR and their integration into utility communication and control networks. This includes use cases, RFP repositories, and other member-input information. The topics will be decided with input from members to understand key questions, and then surveys will be used to collect information from applicable utilities to understand their experiences. This is a continuation of ongoing work. In 2019, this activity included a survey of the business drivers behind utilities communicating with DER/DR. Each year, the specific		12/31/2020

	case study topics are selected with input from member utilities. The activity may be conducted jointly with other EPRI programs as appropriate.		

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002013624	The Economics of Customer and Grid Connectivity and Grid Interoperability: Evaluation of the Potential Impacts of Interoperability in Utility Economic Analyses and Program Design		December 31, 2018
3002008853	2016 CTA-2045 Summit Overview and Presentations		December 9,2016
3002004652	EPRI Smart Grid Demonstration		October 22, 2014
1025008	Automated Demand Response Today		March 29, 2012

Related Research

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 and Distributed Generation (P94), End-Use Energy Efficiency and Demand Response (P170), Integration of Distributed Energy Resources (P174), Distribution Operations and Planning (P200), Understanding Electric Utility Customers (P182), and Advanced Buildings (P204) programs.

Applicable Programs

161, 183, 18, 94, 170, 174, 200, 182, 204

P161.052: Bigger Picture – Preparing for End-to-End Integration of DERs

Key Research Question

Utilities are embracing new energy goals, with a push to move centralized generation to distributed generation technologies with renewables as a significant energy source. This will invariably lead to variability in supply, both temporally and spatially. To address this challenge, utilities are increasingly looking to flexibility from distributed energy resources (DER), including smart inverter-based DERs (energy storage and solar) and demand response (DR) to help maintain grid reliability and stability through intermittency in renewable generation.

This requires end-to-end integration of DERs—including DER in the planning and operation of the electricity grid and to expand its scope to include DER operation. An important transformative technology application is reliable and secure communications in DER/DR. This capability gives utilities visibility into DER/DR to enhance planning, control to change operating parameters in DER/DR to adjust to changing grid conditions, and dispatch capabilities to call on the flexibility of these systems when the need arises. As the utilities develop their DER integration roadmaps to include communicating DER/DR and end-to-end integration of DER, it is important to step back and look at the bigger picture and understand the different technical and business elements that must come together to make it happen. This includes evaluating technical, business, and architectural decisions that allow for the seamless integration of this new transformative technology into the grid, utility systems, and practices.

In contrast to P161.051 (Utility Case Studies on Communicating with DER—Highlighting Experiences, Best Practices, and Barriers), which captures lessons learned from utility experiences, this project focuses on research to understand how the many components of a DER/DR roadmap (including communicating DER/DR) come together and the technologies, processes, and systems that can streamline this integration and reduce long-term operation and maintenance costs.

Example research questions are:

- The complexity to operate, monitor, and configure large amounts of DER/DR scales as the number of DER/DR increases. Aggregation systems can streamline this. How can utilities seamlessly integrate with aggregation platforms, such as third-party aggregator services, microgrid and advanced energy communities, building or campus management systems, distributed energy resource management systems (DERMS), or demand response systems?
- Communicating with large numbers of DER will require telecommunication technologies (cellular, customer-owned internet, utility networks) to facilitate their communication capabilities. What are the requirements for these use cases?
- Communication protocols for DER monitoring, control, and management are not new, but their data models for DER and application to DER use cases are. What training is needed to prepare the existing and future workforces for these new challenges?
- In response to this grid transformation, what training, processes, and technologies are needed to complement existing industry experience?

Objective

The research on DER/DR spans multiple organizations at EPRI, including information and communication technology (ICT), distribution and planning, solar, energy storage, and demand response. In this ICT project, the focus is enabling innovation and competition among providers of DER/DR integration applications by safeguarding interoperability and the ease of integration of these systems to support sustainability and scalability of utility systems.

Approach

EPRI has been advancing the building blocks for communicating DER/DR by working with stakeholder groups to update standards, providing guidance on managing groups of DER/DR to utilities and vendors, implementing architectural references for the industry, and creating simulation tools to emulate devices to encourage testability. The approach to this project is to continue to develop guidance and tools as needed to support the development and testing of communicating DER/DRs.

Research Value

This project will create tools and guidance to help utilities integrate new transformative communication technologies in DER/DR and support the investment in of these resources into associated control systems and their integration into the grid. The goal is to support members in looking at the bigger picture to prepare for the end-to-end integration of DER/DRs.

Anticipated Deliverables

Title	Short Description	Date
Responsibility Matrix for Direct, Open Access to Communicating Distributed Energy Resources and Demand Response Technologies: Understanding Industry Stage Gates and the Members of the Industry Responsible Technical Update	Utilities are developing roadmaps to guide the deployment of DER/DRs in their service territory. Success requires that technology and business practices adapt to this changing environment. The parties responsible for these adaptations include utility and industry stakeholders. This activity will research who handles advancements needed for the different stages-gates required for successful integration of communicating DER/DR. It will evaluate which industry or utility stakeholders are responsible for making each aspect of end-to-end interoperability happen. The activity will consider the varying degrees of DER/DR penetration at different member utilities and how that changes industry state-gates.	12/31/2020
Communication Architecture Requirements for Smart Inverter Use Cases—Phase Two Technical Update	The use cases for communicating DER/DR vary from providing more granularity into grid operations to support monitoring to dispatch and operation to balance power flows. Each use case has a distinct set of technical requirements. This activity considers advanced use cases of smart inverters and pairs them with the communication technology/architecture requirements, functional, and protocol/standard choices needed to implement them. This includes network types, protocols, uptime, redundancy, latency, bandwidth, and other considerations.	12/31/2020

	This is a continuation of the 2018 effort that focuses on near-term use cases. This effort will be collaborative between PS161D, Applied Information and Communication Technology for Distributed Energy Resources and Demand Response; PS161G, Telecommunications; and PS174B, Smart Inverters and Grid Supportive Devices.	
Training Curriculum for Information and Communication Technologies for Monitoring, Management, and Configuration of DER/DR - Technical Report and Digital Components	This activity will create the framework for a curriculum to train the current and next generation of utility engineers, with a focus on the information and communication technologies required for monitoring, managing, and configuring DER/DR. This project leverages the efforts from a Department of Energy project to develop university curricula to educate the next generation of engineers. This activity will supplement this by working with member utilities to understand the curricular needs and to develop and test updated curricula with utility staff.	12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002016142	Evaluation of Translation Capabilities in Distributed Energy Resources Management Systems (DERMS)		Pending 2019
3002016143	Communication Requirements for Smart Inverter Use Cases		Pending 2019
3002013480	Mounting Importance of Communications to Monitor and Control Distributed Energy Resources		December 28, 2018
3002014800	Common Information Model (CIM) Compliance Testing: November 2018 Summary of Results		December 31, 2018
3002012960	Assessment of Integrated Energy Technologies Research: Flexible Loads, Distributed Solar, Energy Storage, and Electric Vehicles		December 31, 2018

3002013484	Integration of DER Technologies: Preliminary Test Results		December 2018
3002014321	Managing Integrated Distributed Energy Resources Programs: Communications, Cyber Security, and Architecture		August 13, 2018
3002009857	DER Grouping Methods and Considerations for Operations: A Study on the Different Approaches for Creating and Managing Groups of DER and the Impact on Operations		December 29, 2017
3002011233	Common Information Model Compliance Testing for Distributed Energy Resource Group Management: October 2017 Summary of Results		December 22, 2017
3002008215	Common Functions for DER Group Management, Third Edition		November 4, 2016
3002003035	DER Enterprise Integration: Interoperability Workshop Results		December 31, 2014

Related Research

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 and Distributed Generation (P94), End-Use Energy Efficiency and Demand Response (P170), Integration of Distributed Energy Resources (P174), Distribution Operations and Planning (P200), Understanding Electric Utility Customers (P182), and Advanced Buildings (P204) programs.

Applicable Programs

161, 183, 18, 94, 170, 174, 200, 182, 204

PS161E Enterprise Architecture and Integration

Key Research Question

Fundamentally, enterprise architecture is about mitigating risk. The driver, then, is to determine the best tools, processes, reference models, and technology that enable the core capabilities of enterprise architects (and related architecture disciplines).

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 put the best tools and techniques into the hands of enterprise architecture practitioners, with an eye to the unique needs and operating environments of utilities. This research will help enterprise architects do their jobs better and

help utilities establish a foundation for execution—that is, the agility utilities will require in an environment marked by an increasing pace of change.

P161.029 Enterprise Architecture

Key Research Question

Developing a solid enterprise architecture is a best practice for aligning business capabilities with information technology. To this end, a mature enterprise architecture includes a series of development steps to ensure that any given architecture is informed and driven by business requirements, not the technology *du jour*. This process creates a "foundation for execution" (accomplished by eliminating redundant systems and harmonizing remaining existing systems) to reduce risk and increase organizational agility over time. Although some lines of business might do this occasionally, an enterprise architecture system is a center of excellence for these practices.

However, few utilities have mature enterprise architecture practices and expertise. Additionally, one of the more popular frameworks for developing enterprise architecture in the utility, The Open Group Architecture Framework (TOGAF), does not address any given industry, but rather provides a generic process that must be customized for any organization that wishes to use it. The key need, then, is to have a set of best practices or an architecture development methodology that can leverage resources such as TOGAF or other industry references and then systematically apply them in the utility industry to provide guidance for utility architecture practitioners.

Objective

This project will tackle problem areas in the enterprise architecture space to provide specific guidance. For enterprise architecture as a whole, this could be a deliverable that speaks any given architecture domain (following TOGAF), such as a business, application, or technology architecture. This research will address the gaps between standards and provide specific guidance to enterprise architecture practitioners on the "how"—how do you apply this process in a specific utility context, what are the artifacts (inputs/outputs to the processes), and how are they used?

Approach

This research uses workshops with subject matter experts to review enterprise architecture best practices to determine application within the TOGAF framework. Additionally, this work seeks to identify utility industry standards and processes, create new deliverables where gaps exist, and develop a repository of templates and guides that fill the gap between generic practices and those specifically needed by utilities.

Research Value

This project helps members and the public by:

- Closing the gap between generic processes defined for multiple industries by creating guidance specifically for the utility industry.
- Creating templates for each phase of The Open Group Architecture Framework (TOGAF), guided by the sensibilities, needs, and constraints of utilities.
- Increasing enterprise architecture maturity at utilities, which helps hold down IT costs, increases business agility (enabling utilities to respond to changes in their environment more quickly), and reduces risk by highlighting and more completely understanding the impact of changes to utility systems. In short: respond faster and reduce surprises.
- Identifying complementary activities and how they are synched with enterprise architecture activities, such as the Project Management Office (PMO) or the Information Technology Infrastructure Library (ITIL).

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Enterprise Architecture Guidebook, Fifth Edition (Technical Report)	Incorporates updates from prior EPRI research in enterprise architecture and findings from utility workshops to expand this body of knowledge		12/31/2020
Digital Transformation: Aligning Operations and IT, Third Edition (Technical Report)	Explores the critical success factors, organizational maturity, and drivers of the convergence of information technology and operations technology		12/31/2020
Common Information Model (CIM) Primer, Sixth Edition (Technical Report)	Walks the reader through the basics of the common information model to more advanced topics, such as power system models and application integration		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002007873	Utility Enterprise Architecture Guidebook, 2nd Edition	Provides descriptions and templates for developing utility architecture	September 20, 2016
3002007875	Business Architecture Development	Use case importer; extension into the enterprise architect	March 24, 2017

		application for importing EPRI IntelliGrid use cases	
3002011054	Utility Business Services Repository	A set of approximately 400 utility business services diagrammed using the ArchiMate enterprise architecture language	April 28, 2017
3002009976	Enterprise Architecture (EA) and Information Technology Infrastructure Library (ITIL): Aligning Governance	A review of how EA and ITIL methodologies are complementary processes and how together they support LEAN architecture principles	March 6, 2018
3002012476	Utility Enterprise Architecture Guidebook, 3rd Edition	Provides descriptions and templates for developing utility architecture	May 14, 2018
3002012477	CIM Primer, 4th Edition		June 14, 2018
3002012479	IT/OT Convergence: Leading Practices Guidebook		June 22, 2018

P161.041 Enterprise Systems Integration

Key Research Question

What is required to reduce the distance to integration? (This concept is from the GridWise Architecture Council white paper, “GridWise Interoperability Context-Setting Framework”).

Although new operational systems bring new capabilities to utility operations, the integration of these new systems with legacy systems remains a challenge. Research has shown that standards-based interfaces can reduce these barriers and their associated costs and increase developmental agility, which ultimately benefits customers by facilitating the bringing of new capabilities to market.

This research focuses on service-oriented architecture (SOA) that allows for “loosely coupled” systems that further facilitate agile systems integration. Although the maturity of standards for systems integration has improved (for example, in 2013, IEC 61968-100 was published, providing common information model–based integration guidance), there are still new use cases that need to be explored and leading practices developed. This research will also seek to discover or develop reusable, core integration patterns that can be used to frame and accelerate an integration project.

Objective

The deliverables of this project will serve as resources for system integrators and solution and enterprise architects as they seek to understand integration options and challenges and to leverage best practices related to SOA-based systems integration.

Approach

This research reviews current literature and vendor offerings and gathers information from utility subject matter experts and early adopters. In this way, we can learn where and how utilities have had success leveraging SOA and how they handle maintenance of SOA interfaces. Proof-of-concept integration might also be developed in EPRI's laboratories.

Research Value

With the added pressure on IT to hold down maintenance costs and meet security requirements while improving the flexibility and speed of deployment, this research provides practical guidance on the maintenance of SOA-based integration.

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Cloud Integration Guidebook: A Guide for Enterprise Architects, Fifth Edition	Covers the basics of cloud archetypes, portfolio management evaluation criteria, CAPEX/OPEX considerations, and integration patterns/models based on ArchiMate		

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002005727	Cloud Integration Guidebook	Covers the basics of cloud archetypes, portfolio management evaluation criteria, and CAPEX/OPEX considerations	12/28/2015
3002007876	Service-Oriented Architecture Versioning and Maintenance	Leading practices for maintenance on Web services used for systems integration	10/24/2016
3002012478	Cloud Integration Guidebook 3rd Edition		12/13/2018

superseded by 3002012478 see above	Utility Cloud Integration Guidebook, Second Edition: A Guide for Enterprise Architects –		12/28/2017

P161.057 Architectural Impacts of Disruptive Technologies

Key Research Questions

What are the impacts of disruptive technologies on business capability? Can a methodology be developed to aid utility impact assessment? How should utility roadmaps be updated to reflect these impact assessments?

Objective

The pace of innovation, when sustaining an organization's existing competencies (both human- and technology-based), has limited impact on operations and can be predictably reflected in application roadmaps. However, competence-*destroying* innovation can render existing investments obsolete. Being informed in a timely manner allows stakeholders to make appropriate portfolio and architecture management decisions, thereby reducing risk and enabling utilities to better deploy new capabilities to serve customers in a timely manner that minimizes disruption.

Approach

Using research that EPRI has developed to build business capabilities models, the characteristics of various disruptive technologies will be reviewed against the capability models. This review will attempt to discern what business capabilities and applications that support them might need to be updated, and how application roadmaps might need to be updated to reflect changes in investment to take advantage of new capabilities and to manage legacy applications.

Research Value

Understanding disruption impacts arms utilities and other stakeholders with information that helps to offset risk and reduce architectural debt and make informed updates to investment resource plans, which in turn allows utilities to best serve their customers.

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Business Impact Assessment Methodology, Second Edition (Technical Update)	Example of an impact assessment of disruptive technologies against a generic utility business capability model		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002009987	Utility Business Capability Archetype and Impact Analysis	This white paper explores how to create business capability models for different archetypes of utilities.	December 29, 2017
3002011054	Utility Business Architecture Service Repository	A repository of business architectures using ArchiMate. Documents a set of business processes, leveraging a list from NIST.	April 28, 2017

PS161F Advanced Metering Systems

Key Research Question

Advanced metering infrastructure (AMI) is being deployed by utilities worldwide. The performance of these systems, their reliability, and consumer trust of them are crucial to the utility business, and many challenges must be addressed. Solid-state metering and communication technologies of AMI are new and evolving rapidly, 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 life cycle. Present systems are largely custom-designed or proprietary, not standards-based—the consequences are vendor lock-in, heightened risk of obsolescence, and poor interoperability.

This project set consists of the whole of EPRI research in metering and advanced metering systems, bringing together communications and meter-specific research previously conducted in separate programs. This project set aids utilities in optimizing existing system utilization and in discovering the full value of AMI-collected data; accelerates and guides the development of emerging standards and architectures to enhance interoperability, innovation, and marketplace competition; and identifies best practices for the support of system operations and monitoring of systems. Finally, the project set will investigate solid-state meters with regard to accuracy, reliability, and tamper resistance.

P161.032 Achieving Open, Interoperable Advanced Metering Systems

Key Research Question

The present state of the advanced metering industry and advanced metering infrastructure (AMI) depends heavily on custom designs and proprietary systems. Although some standards have been created, maturity is lacking, and adoption has been selective. As a result, interoperability and interchangeability of devices have not occurred, and there have been unnecessary cost and complexity in system design, selection, and integration as well as vendor lock-in that could inhibit innovation and limit functionality. Technology improvements and third-party communication systems are rapidly changing the landscape of available options and architectures, exacerbating the challenges of selecting next-

generation technologies.

Objective

This project will help utilities design, select, integrate, and deploy AMI systems based on standards, helping to reduce lifetime costs and improve performance. The project aims to improve the open options that are possible and accelerate availability in the marketplace. The project will provide technical references, performance assessments, and evaluation tools for AMI system components. Through software "upgradeability," existing assets can be more readily integrated with products and software from other manufacturers, and dependencies on existing vendors can be reduced.

Approach

This project is developing a comprehensive reference architecture and code implementation for open AMI. It tracks the industry status and monitors the key activities that are defining AMI technologies and system architectures, and it provides members with concise updates. The project directly contributes to activities that accelerate the development of the most valuable standards. This is achieved by engaging experts in their respective fields and facilitating open working groups to develop consensus materials. Laboratory and field evaluations are conducted to assess performance and interoperability of emerging system components. This project is coordinated with the Power Quality (P1) and Distribution Systems (P180) programs.

Research Value

The results of this project provide value by:

- Guiding AMI system changes and upgrades, aiding in progression to open, interoperable AMI systems
- Migrating existing systems toward more open systems, reducing vendor dependency over time
- Reducing or avoiding vendor lock-in, thereby increasing competition and reducing procurement and operating costs
- Allowing stakeholders to collaboratively provide input to standards development

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Reference implementation of DLMS/COSEM access point (Technical Resource)	Implements a version of a wireless access point		12/31/2020
Wireless Access Point Functions and	Describes the functions and requirements of a wireless access		12/31/2020

Requirements (Technical Update)	point and makes suggestions for performance testing		

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002015769	DLMS/COSEM (Device Language Message Specification/Companion Specification for Energy Metering) to International Electrotechnical Commission (IEC) 61968-9 Mapping		Pending December 2019

P161.043 Advanced Metering Systems Operations and Management

Key Research Question

Best practices for advanced metering infrastructure (AMI) system operations and management are not well known or documented. Utilities are just now planning or have recently deployed their first AMI system. For many companies, owning and operating large communications networks are new endeavors, and the requisite domain expertise is being developed internally.

AMI systems are made up of thousands—in some cases, millions—of nodes, each of which must remain reliably connected. Data must be collected frequently in order to satisfy billing requirements and support customer service. In spite of this scale and performance, the total operating cost must be kept low compared to other communication systems. Service calls for even a small percentage of meters per year are not practical and would be cost-prohibitive on any scale.

Objective

This project provides insights into all aspects of AMI system operation and management by addressing processes throughout the life cycle, including new system acquisition, day-to-day management, and ultimate replacement. In many cases, this insight is in the form of best practice guidebooks that identify practices designed by industry experts and successfully employed by other utilities.

Approach

The aim of this project is to develop a comprehensive set of advanced metering operations and maintenance (O&M) best practices. Specific topics are prioritized to identify the areas of greatest and most pressing need. The products of this research are collaborative—representing the best of learning-by-doing and sharing results. EPRI engages experts and facilitates interest groups to identify and document the best practices in each area. These interest groups seek to engage the utility personnel who are directly involved with the O&M

process at hand as well as AMI vendors, service providers, consultants, and domain experts to help guide the development of the best practice.

This research anticipates that utilities will apply the best practices, helping to refine the guidebooks as new methods are discovered going forward. In this sense, the interest groups can continue as domain-specific communities with a common interest. The work being done in this project is coordinated with and designed to complement the work related to other distribution sensors being done in the Substations (P37) and Distribution Systems (P180) programs.

Research Value

This project helps utilities and their customers by:

- Identifying ways to reduce time and cost in operating and maintaining advanced metering systems
- Streamlining AMI system procurement, deployment, and integration
- Identifying processes that can reduce operating costs
- Mitigate risks by providing insights into the system's health and remaining useful service life
- Mitigate risk by proactively identifying and correcting meter issues

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Guidebook for Revenue Protection, Second Edition (Technical Update)	Updates the first edition of the Revenue Protection guidebook		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002008943	Revenue Protection Guidebook, First Edition: Utilizing Advanced Metering Infrastructure		December 31, 2016

P161.044 Optimizing Advanced Metering System Value and Utilization

Key Research Question

Advanced metering infrastructure (AMI) systems have the potential to support a wide range of uses. AMI data can provide value across the utility enterprise and may be processed in

innovative ways to improve distribution operations, planning, distributed resource integration, customer service, and more. The industry is only beginning to study these ancillary uses. Performance and capabilities vary from system to system, making it difficult to know what options are practical for each. Specific algorithms and system configurations that yield the best performance for each system or data use need to be developed and published so that they can be freely and consistently implemented by manufacturers.

Objective

This project helps utilities optimize the use and value of AMI investments. The research is aimed at discovering the full range of uses that can be supported by a given system type, documenting optimal algorithms, and using them to transform AMI data into useful information. The project also seeks to identify applications that cannot be effectively supported, saving members time and effort.

Approach

This project performs state-of-the-industry assessments to provide utilities and the public with insights into how AMI systems are being used successfully. It also identifies attempted AMI system uses that have been unsuccessful and seeks to understand why. This project also develops data processing algorithms and simulation tools to help utilities and vendors implement new AMI functionality in an optimal way and to process AMI data for maximum benefit. The work in this project is coordinated with and designed to complement work being done in the Electric Transportation (P18), Energy Storage and Distributed Generation (P94), End-Use Energy Efficiency and Demand Response (P170), Integration of Distributed Energy Resources (P174), and Distribution Systems (P180) programs.

Research Value

Applying the results of this project might help utilities with the following:

- Make informed decisions about how to best use their company's AMI system and the data that it produces
- Increase the overall benefits derived from AMI system investments
- Identify advanced metering system applications that provide value to the public, consumers, utilities, and the grid overall
- Optimize the utilization of AMI data, recognizing additional benefits without additional cost
- Reduce the time needed to show return on investment

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
AMI Data Analytics Survey (Technical Update)	Gathering data from vendors and operators, this report describes various tools that currently exist, how		12/31/2020

	they work, and how they compare to each other.		

PS161G Telecommunications

Telecommunication is essential to utilities and has an increasingly critical role in the operation of the integrated grid. In grid modernization, telecom supports higher penetration of distributed energy resources (DER) and a greater reliance on sensors to provide situational awareness. No single technology can meet all the widely varying requirements, resulting in complex and heterogeneous telecom networks that are challenging to manage.

The project set addresses challenges that utilities face with respect to telecommunications:

- Planning a scalable, multi-service network that meets current and future needs
- Leveraging technologies and best practices from commercial telecom operators (both wireline and wireless)
- Resolving barriers to complete the transition of the WAN to packet technologies
- Evaluating new business models and partnerships to make fiber deployment in more locations economically viable
- Enabling wider use of wireless networks by identifying suitable licensed, wireless spectrums
- Identifying the optimal wireless technologies for field area networks (FANs)
- Stewarding the standards to enable interoperability and interchangeability
- Identifying the best roles for commercial wireless and shared networks and navigating the transition to 5G networks
- Developing approaches to maximize the performance of wireless technologies in unlicensed spectrums and developing strategies for alternatives when unlicensed bands can no longer support desired utility applications
- Developing best-in-class telecom network management, visualization, 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

P161.053 Wide Area Networks

Key Research Question

The wide area network (WAN) is the backbone of the utility telecom infrastructure. As new requirements and applications are deployed, the WAN must expand in capacity and geographic presence.

In the WAN physical plant, additional fiber must be deployed, but the economics are challenging. New approaches are needed to enable a viable business case for fiber. These approaches could involve innovative materials and construction techniques and/or leveraging opportunities with other entities that also need fiber-rich metropolitan networks.

In the network architecture, the transition to fully packet-based networks is still underway. There is a need to understand the available technologies and the best practices for network architecture, configuration, and operation. These include the use of packet networks for protection and evaluating the potential applicability of software-defined networking (SDN) and network function virtualization (NFV) to the WAN for IT and OT networks. The next-gen optical network architecture becomes possible when the physical plant is fully fiber.

Objective

The objectives of the project include:

- Understand trade-offs between private and leased WAN circuits
- Ensure that latency requirements for teleprotection are met when running over packet networks, under normal and abnormal circumstances
- Identify, analyze, and quantify business cases for expanded fiber deployment, including opportunities arising from IT/OT convergence
- Identify, analyze, and evaluate best practices for WAN operation and management and for improving WAN reliability and availability

Approach

- Evaluation and assessment of opportunities and partnerships for fiber deployment, including fiber-to-the-home (FTTH) technology, fronthaul for distributed antenna systems, and 5G small cells and smart city applications
- Evaluation of hybrid fiber/wireless architecture and deployment models
- Testing and evaluation of new technologies for time synchronization, teleprotection support, and transport for operational networks (carrier ethernet [CE] and time-sensitive networking [TSN]), including: 1) approaches for quality of service and link layer cyber security, 2) evaluation of synchronous ethernet (SyncE) and related time synchronization methods, 3) evaluation of the meshing of multi-protocol label switching (MPLS), and 4) CE in a system
- Evaluation and case studies about best practices for operating and maintaining the WAN and fiber plant
- Evaluation of non-fiber WAN technologies—high-capacity microwave, satellite, and others

Research Value

- Cost savings and risk avoidance resulting from strategic network planning and adoption of standards, leveraging best practices from the industry
- Increased operational effectiveness for telecom and reduction of outages through better situational awareness
- Improved reliability and lower cost for teleprotection circuits, enabling more advanced protection schemes

- Improved ability to plan and deploy an expanded, higher-density, fiber-based WAN while creating new economic and business opportunities
- Ability to more rapidly scale and expand the telecom network to meet business requirements
- Delivery of public benefit from telecom's enablement of grid efficiency improvements, increased use of DER, and improved reliability of electricity delivery

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Evaluation of TSN for Time Synchronization and Latency-Critical WAN Applications – Tech Update	Evaluation and testing of TSN standards-compliant devices for latency management and other techniques for timing synchronization and distribution in the packet WAN, for utility operational needs and partnerships.		12/31/20
Strategic Fiber Guidebook - Technical Update	Update guidebook by developing and validating joint fiber build business models. Continued development of fiber interconnection database.		12/31/20
Microwave Interference Evaluation for 6-GHz Links - -Technical Update	Evaluate susceptibility of microwave equipment used in the 6-GHz band to interference from unlicensed systems, such as Wi-Fi and Carrier LAA/MuLTEfire.		12/31/20

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002015939	Telecom data isolation techniques and NERC CIP requirements		Dec 2019
3002015940	Strategic Fiber Guidebook		Dec 2019
3002015941	Teleprotection over Packet Guidebook		Dec 2019
3002013385	Managing Timing and Latency in Packet WANs		August 30, 2018
3002013389	Strategic Fiber in the WAN: Exploration of Synergistic Fiber Network Deployment for Utility Smart		October 31, 2018

	Grid/DA and 5G Mobile Network Operators		
3002009793	Strategic Fiber Handbook—Phase 1		March 31, 2017
3002009785	Leased Circuit Requirements for Protection		May 30, 2017
3002009783	Serial to Packet Protection Workshop: Test Results		May 30, 2017
3002009802	Framework for Mitigating Telecom Services to Software Defined Networking, and Network Function Virtualization		August 30, 2017
3002009784	Serial/Time Division Multiplexing (TDM) Replacement: Technology Options for Packet-Based Replacement of TDM Circuits		August 31, 2017
3002009794	Strategic Fiber Workshop		August 31, 2017
3002009797	Strategic Fiber Handbook—Phase 2: Innovative Models Case Study		December 31, 2017
3002009805	Utility Telecom Planning Framework and Reference Guide		June 29, 2018

Related Research

Black Sky Communications Evaluation (EPRI report 3002013919)
Latest issue of *Smart Grid Communications Intelligencer* newsletter (3002015952)
Latest issue of *Communications & Connectivity Technology Newsletter* (3002014754)

P161.054 Field / Neighborhood Area Networks

Key Research Question

Utilities are faced with demands to provide communication to an increasing number of field devices, and the average amount of data from each device is also increasing. At the same time, there is a critical shortage of suitable spectrum to operate a field area network (FAN) using wireless technologies. Unlicensed spectrum is crowded and unpredictable, and there are ongoing concerns about the cost and availability of commercial cellular services. Utility FANs must continue to perform at a high level, especially during manmade or natural disasters. This highlights the question of the appropriateness of relying on commercial service providers versus a utility's investment in its own communications infrastructure.

There is a wide variety of wireless products available, but standards and interoperability are limited. Because of these factors, no single technology suitable for FAN implementation can meet requirements for reliability, performance, and cost. Ongoing development of standards for the multiple FAN technologies provides a path forward, but the tradeoffs of the overall system architecture are still challenging.

Objective

The objectives of this project include:

- Understand and define the tradeoffs between private wireless networks and commercial cellular
- Achieve reliability and resilience in a multi-technology wireless network
- Improve interoperability and coexistence (understanding how wireless technologies work together, identify potential conflicts) in the FAN
- Understand options for licensed and shared spectrum for FAN applications and private long-term evolution (LTE) networks
- Successfully implement and manage prioritization and quality of service (QoS) on constrained or impaired wireless networks
- Successfully use unlicensed spectrum, understanding current capacity limits and future trends that could impact capacity
- Understand low-power, wide-area sensor networks (LPWANs), Internet of Things (IoT) networks, and 5G networks—and their effectiveness and fitness for utility purposes

Approach

- Evaluate performance, cost, and reliability factors for private wireless networks and commercial cellular.
- Advance standards and testing for certification of interoperable FAN technologies
- Define and test methods for achieving reliability and resilience in a multi-technology wireless network. Evaluate and test combinations of private utility FAN, commercial cellular, advanced metering infrastructure (AMI) networks, and customer broadband. Examine techniques for hybrid solutions, failover, connection sharing with forwarding and meshing. Examine the scalability of networks, including optimal addressing approaches for internet protocol.
- Evaluate and test licensed and shared spectrum for FAN applications, including options for implementing private LTE networks.
- Develop and test approaches to implement and manage prioritization and QoS on constrained or impaired wireless networks.
- Develop and test techniques for optimizing operation in unlicensed spectrum, including analysis of spectrum occupancy and noise.
- Evaluate emerging technologies for LPWAN, IoT, and 5G networks for their effectiveness and fitness for utility use.
- Understand life cycle and transition of legacy wireless to the FAN.
- Coordinate with other EPRI programs and project sets to determine telecom requirements to support grid applications in the field.

Research Value

The following benefits may be achieved from the results of this project:

- Cost savings and risk avoidance resulting from strategic network planning, adoption of scalable network architectures, and leveraging best practices from the industry
- Improved operational effectiveness for telecom and reduction of outages through better situational awareness
- Improved interoperability and longer life cycles for installed FAN network equipment and reduced vendor lock-in
- Improved knowledge and ability to select the optimum type of spectrum for the FAN, and maximum performance and value from the network
- Improved knowledge and ability to select the optimal technologies for FAN implementation, based on test results and industry case studies
- Improved network performance, reliability, and availability to serve critical applications
- Public benefit derived from telecom's enablement of grid efficiency improvements, increased use of distributed energy resources (DER), and improved reliability of electricity

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Communications Network Requirements for advanced DER, Phase 2 - Technical Update	Continued development of communications network requirements for advanced DER applications. Joint project with 161D and P174 to define the communications network requirements for DER, the applicability of FAN, and LPWAN technologies.		12/31/2020
Evaluation of Commercial and Private NB-IoT for FAN Use Cases - Technical Update	Analysis and testing of commercial and private NB-IoT with selected FAN use cases to determine applicability and available performance.		12/31/2020
Next-Generation FAN Testing Platform - Technical Update	Update and extend FAN test platform with new capabilities; expand documentation.		12/31/2020
FAN Capacity Offload - Technical Update	Evaluate FAN augmentation with bands such as 3.65-GHz CBRS, 4.9-GHz Public Safety, and 5.8-		12/31/2020

	GHz ISM for selective capacity expansion while maintaining a primary licensed control channel.		
Coordinating DER Anti-Islanding Protection Using 5G Technology	Phase two of testing, using Ultra Reliable Low Latency Communication (URLLC) 5G prototype in field test environment		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002015943	Design and Deployment of Private LTE		12/31/2019
3002016143	Communications network requirements for DER applications		12/31/2019
3002017158	Coordinating DER Anti-Islanding Protection-Using 5G Technology (Phase One – Lab Testing with eMBB)		12/31/2019
3002013392	Optimizing Wireless Spectrum: Operation and Coexistence in Sub-1GHz Unlicensed Spectrum		12/22/2018
3002013393	FAN Technology Performance Evaluation		12/31/2018
3002015944	Additional FAN Performance Testing		12/31/2019
3002009805	Utility Telecom Planning Framework and Reference Guide		6/29/2018
3002009791	Low-Power Wide-Area Networks: Overview, Characteristics, and Applications		6/5/2018
3002009787	Unlicensed Noise Floor Study		5/31/2018

3002009788	Private LTE—Options and Opportunities		12/28/2017
3002011195	IEEE 802.16S Overview		4/24/2017
3002009792	Public Networking and Shared Networks: Architecture and Operation		8/23/2017
3002009790	A Case Study of the Quality of Service Feature from Commercial Cellular Carriers: The Impact of Quality of Service on Bandwidth, Connectivity, and Reliability Improvements at Ameren		6/14/2017
3002009786	Utility Telecom Taxonomy and Architecture for Field Area Networks		5/5/2017

Related Research

- Persistent Wi-Fi™ Platform for Connected Devices Demonstration. 3002011409
- *Black Sky Communications Solution Evaluation* 3002013919 (05-31-2018)
- *Smart Grid Communications Intelligencer* (newsletter series) Latest Issue: 20, Winter/Spring 2018 3002012471
- *Communications Connectivity Technology Newsletter* (series) Latest Issue: December 2017 3002011576

P161.055 Telecommunications Planning and Management System

Key Research Question

Modern utility telecommunication networks are heterogeneous and complex. Various types of network technologies are used to implement different network tiers and to optimize for application- or location-specific requirements. Long-term success requires best-in-class processes, systems, and tools for management and planning, which are continually evolving. Utility telecom managers need an understanding of the best approaches for network planning and management. This includes incorporation of visualization techniques and identifying actionable network performance metrics.

New networking technologies developed for commercial carriers (such as software-defined networking [SDN] and network function virtualization [NFV]) need to be evaluated for applicability in multi-service utility IT and OT networks. The strategic planning processes must be considered carefully to ensure that network expansion and upgrade cycles are aligned with grid infrastructure and operational upgrades that rely on the telecom network.

Objective

The objectives of this project include:

- Develop insight and analysis on best practices for utility telecom network management.
- Understand how networks can be configured to ensure that every served application receives the appropriate levels of priority, performance, and reliability.
- Understand how SDN and NFV can be applied to improve flexibility and resilience and reduce costs, without sacrificing cyber security.
- Develop and evaluate techniques to improve the process of securely provisioning field devices.
- Develop more accurate network modeling, planning, and simulation tools.
- Develop a quantification of economic value derived from the integrated telecom network.
- Leverage service-oriented architecture, the infrastructure technology information library, and best practices from carriers.
- Identify and implement best tools for automation and documentation (logical network inventory as well as physical), including identification of naming conventions from carrier best practices.

Approach

- Test and evaluate (through case studies) best practices and approaches for telecom network management.
- Develop more accurate planning, modeling, and simulation tools.
- Develop quality-of-service methodologies that securely configure, monitor, predict, and adapt prioritization of data across the network, regardless of the specific technology mix.
- Evaluate and test SDN in an integrated hybrid network involving multiple communications technologies.
- Evaluate technologies for effective, low-latency support of peer-to-peer communication for use in field message bus scenarios.
- Develop and evaluate methods for self-configuration, zero-touch provisioning of devices.
- Evaluate new developments in networking technologies, such as Named Data Networking.

Research Value

The following benefits may be achieved through the results of this project:

- Cost savings resulting from strategic network planning, adoption of standards, and leveraging best practices from the industry
- Improved operational effectiveness for telecom, reduction of outages through better situational awareness, and higher availability of telecom networks
- Higher internal customer satisfaction through high-reliability telecom services, with performance and reliability that meet application requirements
- Improved ability to plan and deploy advanced networks, creating new economic and business opportunities
- Ability to accurately plan telecom network expansion and growth in conjunction with grid expansion
- Ability to more rapidly scale and expand the telecom network to meet business requirements
- Public benefit derived from telecom's enablement of grid efficiency improvements, increased use of DER, and improved reliability of electricity delivery

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
NMS and MOM capabilities, metrics, and interconnections - Technical Update	Evaluation of Network Management System and Manager of Manager systems, and metrics and interfacing capabilities. Implications of NERC CIP and Electronic Access Point—how to unify management across boundary, evaluation of SDN to enable interoperability across interfaces		12/31/2020
Multi-technology provisioning architecture - Technical Update	Develop a reference architecture for implementation of 3GPP standards for provisioning GSMA services on the equipment of multiple network types and technologies		12/31/2020
Best practices for IP network planning and architecture for IPv4 and IPv6 - Technical Update	Develop, document, and evaluate best practices for IP network planning and architecture to support the concurrent use of IPv4 and IPv6		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002015946	Optimizing provisioning and device management		21 Nov 2019
3002013394	The Role of Geospatial Information Systems in Utility Telecommunication Infrastructure Management		December 19, /2018
3002013395	Zero-Touch Provisioning White Paper		November 28, 2018
3002013403	Evaluation of SDN in Utility Operational Networks		December 20, 2018
3002009786	Utility Telecom Taxonomy and Architecture for Field Area Networks		May 5,2017
3002009800	Telecommunication Network Management System Survey Report: First Edition		May 31,2017
3002009802	Framework for Migrating Telecom Services to Software Defined Networking, and Network Function Virtualization		August 30,2017
3002009805	Utility Telecom Planning Framework and Reference Guide		June 28, 2018
3002009803	Creating Telecommunications Metrics for the Electric Sector		December 22, 2017

Related Research

Persistent Wi-Fi™ Platform for Connected Devices Demonstration. 3002011409
Black Sky Communications Solution Evaluation 3002013919 (05-31-2018)

P161.056 Telecommunication Standards Tracking and Analysis

Key Research Question

Although standards such as LTE and Wi-Fi have revolutionized consumer and commercial wireless, many utilities remain constrained by proprietary communications systems. Standards development is an ongoing process, with existing standards continuing to evolve and new standards continually being proposed and developed. A two-way flow of information is needed to ensure a desirable outcome for utilities and their telecom needs. First, the standards groups need input from participants who can contribute and articulate the requirements and desires of

the utility industry. Second, the utility industry needs to be informed of the standards development pipeline and their relevance and impact for their own planning cycles and procurement.

Objective

Utility telecom networks use a combination of wireless, copper, and fiber media and operate wireless networks in both licensed and unlicensed spectrums. The licensed spectrum may be utility-owned or accessed through a commercial cellular operator. Standards-based communications technologies enable interoperability, vendor choice, a broader product ecosystem, and ultimately lower costs. Of the wide range of wireless communications technologies that are deployed today or might be deployed in the future, many originate from standards development activities that are engaged and tracked by this project.

Approach

- Identify and participate in the development of new standards with impact and relevance to utility telecommunications.
- Represent the needs and requirements of electric utilities through leadership and contribution to the standards process.
- Propose new standards developments when a gap or need is identified.
- Enable coordination between multiple standards supporting utilities and other vertical applications through the IEEE 802.24 Technical Advisory Group.
- Inform members of activities and the standards development pipeline through regular newsletters. Provide context and explanation of how the standards can be applied and their potential impact.
- Develop and maintain an annually update guidebook with a high-level description of telecom and communications standards, their roadmap, utility applications, and interrelationships.

Research Value

The following benefits may be achieved through the results of this project:

- Cost savings resulting from strategic network planning, adoption of standards, and leveraging best practices from the industry
- Standards development outcomes that incorporate utility needs and requirements, resulting in cost saving and life-cycle benefits
- Understanding available standards and the pipeline of future standards, which enable informed discussions with vendors regarding procurement decisions
- Improved ability to plan and deploy advanced networks, creating new economic and business opportunities
- Ability to accurately plan telecom network expansion and growth in conjunction with evolution of network technologies and grid expansion
- Ability to more rapidly scale and expand the telecom network to meet business requirements

- Public benefit derived from telecom's enablement of grid efficiency improvements, increased use of DER, and improved reliability of electricity delivery

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Comms Intelligencer newsletters - Tech Update	Development of two Comms Intelligencer newsletters throughout the year, highlighting key activities and progress, derived from participation and tracking of standards development related to telecommunications, especially wireless standards.		12/31/2020
Telecom Standards Guidebook – Technical Update	Second annual update, adding new information and updating existing standards. A high-level description of telecom and communications standards, their roadmap, utility applications, and interrelationships.		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Published Date
3002015951	Telecom Standards Guidebook	28-Oct-2019
3002015954	Smart Grid Communications Intelligencer, Issue 24, Fall 2019	Dec 2019
3002015952	Smart Grid Communications Intelligencer, Issue 23, Spring 2019	12-Jun-2019
3002012473	Smart Grid Communications Intelligencer, Issue 22, Fall 2018	26-Nov-18
3002012472	Smart Grid Communications Intelligencer, Issue 21, Summer 2018	31-Jul-18
3002012471	Smart Grid Communications Intelligencer, Issue 20, Winter/Spring 2018	26-Mar-18
3002010452	Smart Grid Communications Intelligencer, Issue 19, Fall 2017	11-Oct-17
3002010451	Smart Grid Communications Intelligencer, Issue 18, Spring/Summer 2017	6-Jun-17
3002009755	Smart Grid Communications Intelligencer, Issue 17, Winter 2017	31-Mar-17
3002007447	Smart Grid Communications Intelligencer, Issue 16, Fall 2016	28-Sep-16
3002007446	Smart Grid Communications Intelligencer, Issue 15, Spring/Summer 2016	5-Jul-16
3002007445	Smart Grid Communications Intelligencer, Issue 14, Winter 2016	15-Feb-16

3002005096	Smart Grid Communications Intelligencer, Issue 13, Fall 2015	30-Sep-15
3002005095	Smart Grid Communications Intelligencer, Issue 12 Spring 2015	2-Jun-15
3002005094	Smart Grid Communications Intelligencer, Issue 11, Winter 2015	30-Jan-15
3002002699	Smart Grid Communications Intelligencer, Issue 10, Fall 2014	30-Sep-14
3002002698	Smart Grid Communications Intelligencer, Issue 9, Spring 2014	29-May-14
3002002697	Smart Grid Communications Intelligencer, Issue 8, Winter 2014	6-Feb-14
3002001141	Smart Grid Communications Intelligencer, Issue 7, Fall 2013	23-Sep-13
3002001076	Smart Grid Communications Intelligencer, Issue 6, Spring 2013	29-May-13
1025757	Smart Grid Communications Intelligencer, Fall 2012	10-Sep-12
1025756	Smart Grid Communications Intelligencer, Spring 2012	15-Jun-12
1024655	Smart Grid Communications Intelligencer, Winter 2011/2012	30-Dec-11
1024654	Smart Grid Communications Intelligencer, Fall 2011	17-Oct-11

PS161H Geographic Informatics

EPRI has been conducting research in electric utility geographic or geospatial information systems (GIS) since 2012. Geographic or geospatial applications are now expanding well beyond traditional utility GIS because of new capabilities:

- New aerial, space-based and ground-based image-capture capabilities are rapidly expanding the amount and types of available geographic data.
- Advanced applications are being enabled with GIS data, such as augmented, virtual, and mixed reality (AR/VR/MR) technologies. These are now collectively referred to as *extended reality* (XR). Digital field workers are interacting with physical assets in new ways.
- Geospatial technologies are increasingly embedded in all consumer systems, driven by new autonomous systems (unmanned aerial vehicles, self-driving cars, robotics), and they are often connected with Internet of Things platforms and sensor networks.
- Fast analytics can now be performed on extremely large geodata sets, paving the way for the application of machine learning and AI techniques for data quality improvements.

The Geographic Informatics program focuses on the science and technology of acquiring, storing, cleaning, modeling, analyzing, producing, presenting, and disseminating geographic data sets. Collaborative research projects in this program will enable utility GIS professionals to:

- Understand the expanding role of GIS and geospatial platforms at electric utilities
- Prepare for rapidly growing data volumes delivered by new imaging and data collection systems
- Master GIS data quality and data management challenges
- Develop geospatial standards to support expanding XR applications
- Deliver new geodata services for advanced planning and operations applications

161.059 Geographic Information Systems (GIS) Data Practices

Key Research Question

Investments in geographic information systems (GISs) at electric utilities have spanned more than 30 years now, making these systems a critical and foundational enterprise application. In recent years, geographic or geospatial and computing technologies across all industries have accentuated the role of GIS as a platform for geospatial services. This brings a challenge to GIS professionals at utilities because GIS now not only serves in its traditional role as a system of record, but it also serves to support market differentiation and even to support innovation across the utility enterprise.

This project aims to prepare electric utility GIS professionals to deliver improved geodata services to an expanding spectrum of utility individuals and systems. The project also will help GIS professionals understand how trends in the geospatial industry are affecting their management of geospatial information and investments.

Objective

The objective of this R&D is to identify applications and methods to automate cleanup of GIS data and improve planning and operations models. This project will address the following common gaps in geospatial data management at electric utilities:

- Immature data, incomplete system models, and insufficiently accurate modeling
- Inability to visualize and evaluate datasets
- Immature standards and vendor lock-in
- Duplicate data and incomplete metadata
- Difficulty with quickly and accurately onboarding precise asset data
- Inability to accurately establish a valuation of information assets over time

Approach

This research will build a guidebook on geospatial informatics that will be updated annually as a core deliverable for P161H funders. Geospatial informatics is the science and technology infrastructure dealing with the acquisition, storage, modeling, analysis, production, presentation, and dissemination of geographic data sets and services.

EPRI has been delivering GIS research since 2012, focused on GIS data quality, data cleanup, conflation, and metadata management. Research projects also identified innovative methods for AI-based asset detection and geolocation using low-cost imagery. This project will consolidate EPRI research insights into a valuable “evergreen” resource for electric utility GIS professionals.

The project team will work with the GIS task force to establish their preferred priorities for a baseline document for geospatial data management.

The project will also “future-cast” by developing a fully digital deliverable that reflects the rapidly advancing technologies influencing geospatial systems at utilities. This deliverable will address key GIS trends:

- New aerial, space-based and ground-based image capture
- Extended reality (XR) technologies (including augmented, virtual, and mixed reality)
- Broad consumer adoption of embedded geospatial technologies, especially within autonomous systems
- Expanded smart city and IoT initiatives with sensor networks
- AI and machine learning; fast analytics on extremely large geodata sets

Research Value

This research is designed to help GIS professionals at member utilities that are deploying advanced distribution applications and related management systems, all of which must be continuously updated with accurate and timely data. This requires:

- Accurate models suitable for consuming applications
- Procedures for ensuring the integrity of the data supply chain
- Delivering the right data at the right time in the right location for engineers, planners, and digital field workers

This research also contributes societal benefit in the form of faster renewables integration and grid decarbonization, improved worker safety, and enhanced grid reliability resiliency.

Key Activities

Activity	Date	Completion Status
Complete survey design and development.		
Survey GIS Task Force for priorities on guidebook content and future development.		
Develop and publish first edition of guidebook.		
Develop and publish next-generation GIS deliverable		

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Geospatial Informatics Guidebook - Technical Update	This deliverable will consolidate key content from past guidebooks on GIS Data Quality, into a report suitable for annual updates in the future.		
Next-Generation GIS -Technical Resource	A fully digital and interactive deliverable for educating electric utility GIS professionals and their internal customers on the expanding role of GIS. This deliverable may		

	incorporate video, infographics, expert interviews, story maps, graphics, or other digital content.		

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002007921	Electric Utility Guidebook for Geographic Information Systems Data Quality: Metadata		September 14, 2016
3002006006	Electric Utility Guidebook for GIS Data Quality: Conflation		September 18, 2015
3002003036	Electric Utility Guidebook on Geospatial Information System (GIS) Data Quality		October 21, 2014

P161.060 Geographic Information (GIS) Applications

Key Research Question

Extraordinarily rich application functionality is becoming available soon for digital field workers. Extended Reality (XR) solutions will allow them to see and utilize visually rich, context-sensitive, streaming geo data, 3D objects, imagery and more. Utility GIS professionals must prepare to support the geographic or geospatial data needs of these applications. Geo-related (locational “where”) information is necessary for placing and orienting XR content correctly – formatted for rendering and coordinate-referenced in 3D space to surrounding features.

This project will develop **Geospatial Requirements for XR Applications**, working with augmented reality research specialists to more clearly define GIS contributions to augmented reality, virtual reality, and mixed reality applications. The project will ensure current standards efforts (such as the World Wide Web Consortium’s Immersive Web standard) will address emerging electric utility needs. The project will answer questions related to interoperability of geospatially-referenced data capture, management, search, delivery, and presentation with emerging 3D XR solutions.

Objective

This project will explore the interoperability requirements for electric utility GIS systems to support our XR future. Specific objectives are:

- Enable rapid technology adoption through understanding data needs via a real-world pilot and testbed.
- Encourage sharing of expertise and development resources providing early market insight.
- Reduce technology risk through development and testing of interoperability standards.
- Influence market development toward choices that fit well with existing electric utility GIS environments, providing a transition path to the future.

Approach

This project provides an opportunity for project members to mutually define, refine, and evolve GIS service interfaces and protocols in the context of hands-on experience and feedback. The project team will orchestrate and address development that is needed in many areas:

- Formal consensus and de facto agreements among utility-focused GIS and AR vendors
- Ongoing industry collaboration such as the AR for Enterprise Alliance (AREA) AR Security Framework
- Important established Open Geospatial Consortium (OGC) standards like glTF, CityGML, IndoorGML, and ARML2.0.
- Web constructs like W3C WebXR Device API, HTML5 and CSS

The project will work with other programs at EPRI to uncover challenges associated with existing GIS environments at member utilities. This will ensure recommendations address practical needs and provide an implementation path forward.

Research Value

The electric industry is encountering new strategic demands because of climate change impacts as well as the transformation of energy provisioning. Utilities have invested deeply in Geographic Information Systems and data; those substantial investments must soon be redirected into geographic or geospatial platforms that can service 3D AR and VR needs. The orchestrations that result from this project will enable electric utility GIS, CAD and BIM systems to migrate from restricted 2D digital displays into systems that can support immersive 3D environments. This will support not only the needs of utility field workers and control center operators, but also the needs of external groups such as incident managers, public safety officials, and fire and rescue teams.

Key Activities

Activity	Date	Completion Status
Coordination with The Open Geospatial Consortium (OGC)		September 2019
Project start		January 2020
Draft research complete		August 2020
Fall Advisory presentation		September 2020
Research note complete		November 2020

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Geospatial Requirements for XR Applications - Technical Update	This Technical Update will identify future requirements for utility GIS systems in light of emerging augmented reality, mixed reality, and virtual reality applications. The report will recommend specific actions necessary to support enterprise-level standards for integration.		12/31/2020

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002013117	Reality Computing: A Guide to Augmented Reality, Mixed Reality, Virtual Reality, and Extended Reality	Explores augmented, mixed, and virtual reality (AR, MR, and VR) and necessary tools to create higher fidelity applications.	December 13, 2018
3002014696	Augmented and Mixed Reality Training for the Smart Grid	Evaluated augmented reality and mixed reality for a just-in-time training solution.	December 17, 2018
3002011490	Detection and Geolocation of Power Distribution Infrastructure Using Public Domain Photographic Imagery	Provided foundational understanding of methods for improved asset georeferencing using low-cost imagery and neural networks.	September 6, 2017
3002003020	GIS as a Situational Awareness Platform: Innovative Uses of GIS in Network Operations	Early research identifying the role of GIS in supporting broader situational awareness	October 15, 2014

P161.061 Geographic Information (GIS) Analytics and Visualization

Key Research Question

GISs at electric utilities support many applications in grid operations and planning by providing an accurate network model and detailed facility information useful for planning studies and operations.

Further research on the GIS contribution to accurate models is needed now because higher DER penetration is driving more sophisticated grid studies at most utilities. Timely, sufficiently accurate network and DER representation is a new and significant challenge. Most system planners and the GIS professionals who support them do not have a mutual understanding of these changing modeling requirements, nor a methodology for assessing the GIS contribution to model fidelity and accuracy.

Objective

This research project is co-funded by P200E (Modeling and Simulation for Distribution Resources) and P161H (Geographic Informatics), with the goal of identifying requirements and best practices for GIS data management in support of advanced planning analytics.

Approach

EPRI's past research has outlined requirements for modeling circuit elements and various DER types. Modeling needs have been examined from multiple perspectives (system modeling, resource modeling, and grid impacts). This project will leverage past research as a basis for surveying project participants and GIS Task Force members.

Researchers will assess the maturity of existing data management processes that support the modeling needed for various distribution assessment methods (static load-flow, quasi-static load-flow, fault analysis, harmonics, dynamic, electromagnetic transient, and reliability).

Research Value

Project members will gain practical insight into the requirements imposed by various advanced distribution planning analytics on the GIS and related applications; methodologies that are working well at other utilities, to provide accurate models; and recommendations that can be incorporated into distribution planning investment roadmaps.

Key Activities

Activity	Date	Completion Status
Assemble an inventory of modeling requirements based on past EPRI research and other industry resources		
Complete survey design and development		
Survey GIS Interest Group, project participants, and other		

available parties for current practices		
Complete project workshop for validating results		
Complete Technical Update report		

Anticipated Deliverables

Title	Short Description	Implementation Category (Nuclear Only)	Date
Enhanced Grid Modeling Workshop - Workshop	Mid-project workshop to evaluate survey results		12/31/2020
Enhanced Grid Modeling for Advanced Planning Analytics (Technical Update)	Note: this is a cross-program, joint deliverable with P200E		

Past EPRI Research on Topic

Product ID	Title	Short Description (link to new project)	Published Date
3002011007	Distribution Planning Guidebook for the Modern Grid	Examines modeling requirements for circuit elements, energy storage, and other aspects of distribution networks	April 5, 2018
3002007976	Distribution Modeling Guidelines: DER Modeling Recommendations for Distribution System Assessments	Examines distribution modeling needs related to DER	December 22, 2016

Applicable Programs

P161, Information and Communication Technology
P200, Distribution Operations and Planning