EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Roadmap

ICT Information and Communication Technology

Program Roadmap

January 2020

ICT Vision and Mission:

Information and Communication Technology

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

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

Information and Communication Technologies are foundational for enabling functions related to decisions and actions along the energy value chain from the transmission system, through the distribution system, and down to end devices. Through secure connectivity, the power system can better integrate advanced digital functionality to become more flexible and resilient. Challenges to overcome include the sheer volume of data; interfacing with proprietary systems; varying life-cycle time scales between utility assets and new connected devices; and effective integration into the power system. The overall roadmap development process is depicted below. It includes the development of aspired future states, a gap analysis between the future and current state, and action plans to address the identified gaps.

EPRI staff has collaborated with numerous industry stakeholders to identify over 20 future states, the associated gaps, and action plans to bridge those gaps over the next 3-5 years within EPRI's research portfolio. Each subsequent year, EPRI staff has reevaluated and updated the roadmap based on our research findings and technology advances.

FUTURE STATE

Technology performance and cost

Technology implementation

Integration and operational strategies

GAP ANALYSIS

Determine gaps between the current and future states

Gaps can be associated to technology performance, implementation issues, experience, etc.

Prioritize the gaps

ACTION PLAN

Sequencing and prioritization of recommended R&D activities

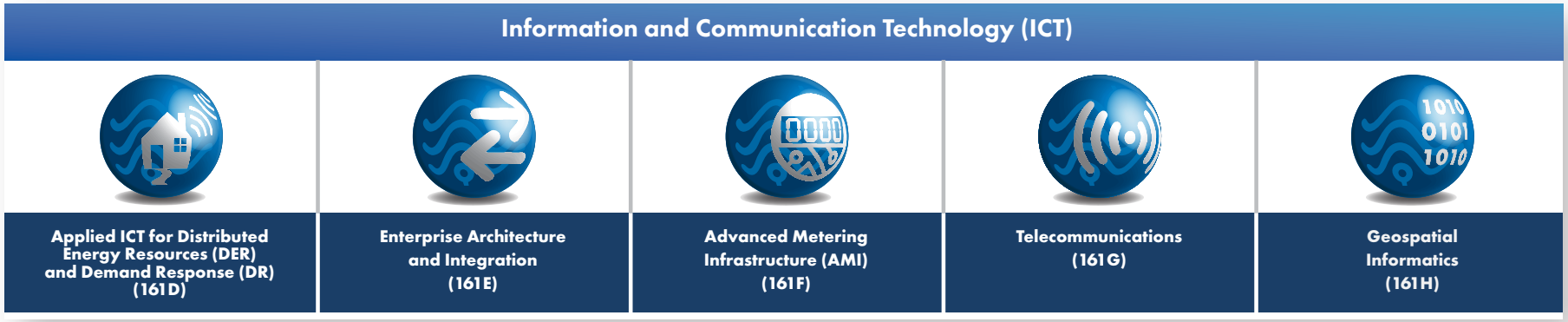
Funding amounts

Coordination and timing with other activities and programs

Technical performance and cost targets for promising technologies

Critical indicators of success

ICT Roadmap



PROGRAMS DEFINE ACTION PLANS

Action Plans and Project Definitions:

- What we need to do to bridge the gaps to achieve the Future States
- Actions are taken through a variety of different project types within EPRI, as described below

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

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

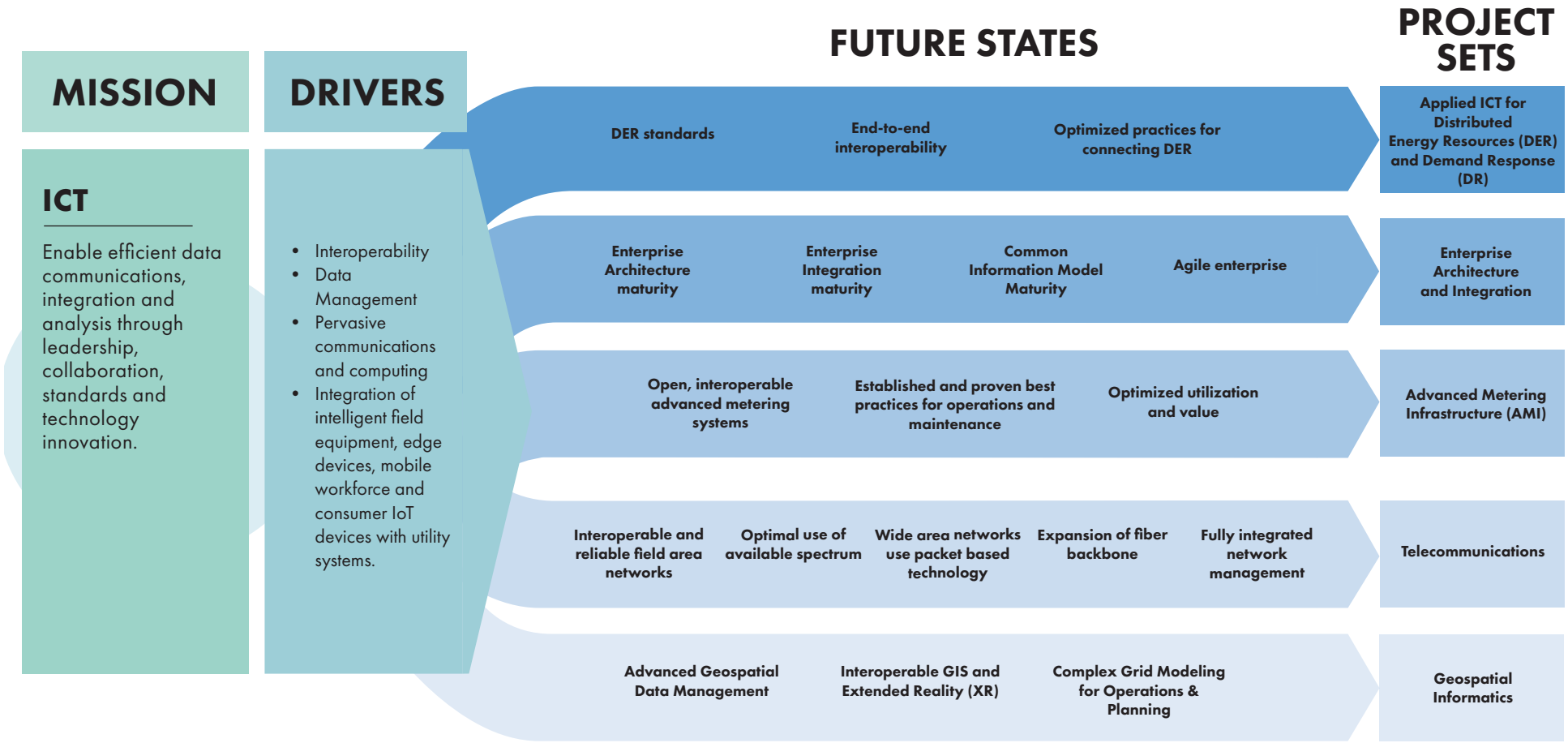
Technology Innovation Project: Technology Innovation allows members to leverage their long-term investment (10+ years) in collaborative research that may create entirely new markets, products and services, increase the public benefits of efficient, clean affordable energy and ensure the competitiveness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

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

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

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

Mission, Drivers, and Future States



ICT Roadmap

Information and Communication Technology (ICT)

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

FUTURE STATES

Interoperable, Certifiable Standards that Embrace Grid and DER/DR Flexibility

End-to-End Interoperability for DER/DR and DER Systems

Effective and Field-Proven Practices for Communicating with DER

Maturity in the Technologies, Processes, and Systems to Embrace Communicating DER

Enterprise Architecture and Integration (161E)

FUTURE STATES

Enterprise Architecture Maturity

Standards and Certification

Enterprise Integration Maturity

Agile Enterprise

Advanced Metering Infrastructure (AMI) (161F)

FUTURE STATES

Open, Interoperable AMI Systems

Established and Proven Best-Practices for AMI System O&M

Optimized AMI System Utilization and Value

Telecommunications (161G)

FUTURE STATES

Interoperable and Reliable Field Area Networks (FAN)

Optimal Use of Available Spectrum

Wide Area Networks (WAN) Use Packet Based Technology

Expansion of Fiber Backbone

Fully Integrated Network Management System

Geospatial Informatics (161H)

FUTURE STATES

Advanced Geospatial Data Management

Interoperable GIS and XR

Complex Grid Modeling for Operations & Planning

ICT Program Overview

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

Interoperability–EPRI accelerates the industry's migration towards interoperability by leading industry activities, making technical contributions to standards development efforts, training utilities, organizing interoperability tests, developing transition strategies, and collaborating with utilities on demonstrations of emerging standards.

Communications–EPRI provides leadership in communications standards development, tracks and analyzes communications technologies and conducts laboratory and field tests to evaluate the performance of evolving and emerging technologies.

Enterprise Architecture/Systems Integration–EPRI creates artifacts to improve the state of the art in enterprise architecture and develops guides to help utilities with standards-based systems integration.

Advanced Metering–EPRI leads an industry effort to develop open, interoperable advanced metering system and develops best practices guides for operations and maintenance.

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

Utilities are embracing the flexibility of distributed energy resources to play a key role in a modern, optimized, and integrated grid. The resources – both in-front and behind the-meter solar and 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 like microgrids, renewable energy targets, and simultaneous grid-services from DER/DR.

The communications, control, and associated analyzed data from DER/DR is key to making this happen. This includes information and communication guidelines, standardized data points/parameters to simplify integration and long-term maintenance of the DER/DR interfaces, open-interfaces to support modularity of DER components and the systems to manage them, and communication capabilities to back-up the many demands of utility use cases. The goal of this project set is to perform research on the evolving needs for communication technologies, architectures, and methodologies to support communications with smart solar, storage, and loads. Through our membership we create an ecosystem where we can address these barriers as a collaborative effort with member utilities and the industry.

This project set embraces the differences in utility DER/DR goals and roadmaps by providing research that can help utilities at any stage of DER/DR integration. That means supporting utilities at all stages of DER/DR integration including 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 like the monitoring and operation of large-scale storage or solar plants. The project set has activities that support both the near-term (optimizing existing operations) and long-term (strategic vision).

The work in this project is coordinated with and designed to complement the work in EPRI's Cyber Security for Power Delivery and Utilization (P183), Electric Transportation (P18), Energy Storage and Distributed Generation (P94) (P94), Customer Technologies (P170), Integration of Distributed Renewables (P174), Distribution Operations and Planning (P200), Understanding Electric Utility Customers (P182) and Advanced Buildings (P204) programs.

[1]**http://integratedgrid.com/**

Research Drivers

- A need for a flexible grid in reaction to the increasing penetration of DER including renewables
- An industry need for guidelines, specifications, standards, and connected criteria that detail how to process and respond to a common set of information exchanged with any application or device through a communication interface
- Value streams from DER interoperability including simplified integration and long-term O&M, streamlined data integration, and support for modularity and options for DER and DER systems
- Utility interest in communications systems to control and aggregate DER and DR
- Increasing deployment and diversity of customer and third-party owned DER and DR
- A need for evaluating communication standards for DERs through studies, lab testing, and demonstrations

Value

- Increase the cost effectiveness of grid modernization
- Awareness of standards, issues, and solutions that can streamline integration of DER/DR and reduce costs for operation and maintenance over the life of the asset
- Learn from the architectural, technical, and business decisions of others to inform grid modernization roadmaps/activities and align them for success
- Tools and guidance to help utilities integrate and support investments in new transformative communication technologies in DR/DR

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

Interoperable, Certifiable Standards that Embrace Grid and DER/DR Flexibility

Future State: Field-proven and industry-recognized standards for interoperability including mature communications capabilities in products; robust and recognized open-standards and associated data models; and verified interoperability in the field using these standards.

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

Characteristics of this future state include:

- Open, interoperable standards are widely used, applied in the field, and meet the needs of utilities, aggregates, customer, and other grid-oriented use-cases
- Clear, industry-accepted examples of how open standards reduce the cost and effort for initial integration of DER and O&M over the life of the system
- Open, interoperable standards exist for every level of the communications and control architecture
- Data models are well understood and harmonized across relevant communications standards
- Robust certification processes exist for validating standards implementations in DER and DER management systems

Gaps Addressed:

- Certification for DER/DR standards exist but do not cover all standards and applications
- Coordination in-between different interoperability and interconnection standards in the DER domain
- Approaches to accommodate customer-owned technology that may include Internet of Things (IoT) and independent DER systems
- Standards may not embrace next-generation requirements (e.g. transactive energy or group management support)

Action Plan:

Collaborate with utilities, vendors, manufacturers, standards organizations, and other industry stakeholders to provide feedback on opportunities, gaps, and best practices to encourage adoption and produce the necessary tools for success. This includes:

- Industry coordination and standards evolution including relaying relevant findings from integration pilots, demos, and deployments through collaboration and leadership in standards development organizations
- Perform laboratory and field evaluations of DER, DR, protocol and standards, and control systems to evaluate interoperability, identify risks, and highlight best practices
- Develop and extend feature-sets for open-source clients and test tools to support industry stakeholder entry into open, interoperable standards
- Collaborate with other EPRI programs and stakeholder groups to identify additional DER-related, grid-facing benefits that can be achieved through communication and interconnection standards
- EPRI will provide summaries (webcasts, reports, or other) to transfer information about the standards and debriefs utilities on government projects or supplemental projects in the same domain
- EPRI will host discussions with members about barriers or gaps in standards and their respective testability;
- EPRI's PS161D team will work collaboratively with end-use programs to pair the flexible behavior of DER/DRs with grid services and capture them in relevant standards

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002016139, 3002011591, 3002014840, 3002013478** Informational Webcast Series, Tech Transfer to Standards, and Tracking Industry Trends • **3002013622, 3002009852,** DER/DR Simulators for Testing, Evaluating, and Modeling Communicating DER/DR • **3002007825** The Value of Interoperability and Direct Access to Connected Devices	• Informational Webcast Series, Tech Transfer to Standards, and Tracking Industry Trends • Technical Support to Industry Standards • Incentivizing Customer Responses to Support Grid-Flexibility Using Price-Based/ Transactive Signals • Maintenance and Support for Applying EPRI DER/DR Integration Toolkit	• Evaluate the Effectiveness of Conformance Testing Programs in Achieving Interoperability – Fill Gaps • Repository of Relevant Certifications for Achieving Grid Interoperability	• ICT Capabilities for Management of Simultaneous Services in Energy Storage Systems • Library of DER Profiles: Requirements for DER to Participate in Use-Cases and Grid Services • Recommendations for ICT Language in Interconnection Agreements per IEEE 1547-2018

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161D Applied ICT for DER and DR – Future State: Interoperable DER/DR Future State: Interoperable, Certifiable Standards that Embrace Grid and DER/DR Flexibility

Major Past Accomplishments	2020	2021	Future
SUPPLEMENTAL PROJECTS			
• **3002015355, 3002013625, 3002014087, 3002011483, 3002009782, 3002007431 3002007432, 1026753** Open Source Implementations of DER Standards (CTA-2045, DNP, IEC-61850, 2030.5, OpenADR) • **3002013875, 3002011045, 3002008217, 3002008215** Functional Specifications for Individual and Groups of Communicating DER	• Certification Framework for CTA-2045 • DER Standards and Protocols Interest Group (DER-SIG) • Technical Plan for Harmonization of DER Standards and Protocols	• Collaborate with Standards Organizations and Stakeholders to Harmonize DER Standards and Protocols • Modeling of Communication and Control Architectures to Understand Ideal Architectures	Demonstrate Effectiveness of Transactive Pricing Signals for Bulk and Distribution Services
GOVERNMENT PROJECTS			
• **3002016138, 3002013625, 3002009750** Tools for Development, Testing, and Modeling of Open Standards in DER • **3002012290** Evaluation of Benefits of Transactive Pricing Signals for Utilities and Customers • **3002016144** Conformance Testing Frameworks for DER Standards (IEEE 2030.5, IEEE 1815, CTA-2045)	• Grid Interoperability and Market Facilitation of Flexible Demand Through Harmonized Standards and Test Procedures • Update DER/DR Simulators and OpenDERMS 2.0: Update to meet IEEE 1547-2018 and Rule 21 Requirements • Recommendations for Transactive Load Management Signals in a Market Context • Develop Interoperability Plans for Industry Demonstrations and Pilots	• Supporting Field Deployments Across DER Types and Domains • Develop Interoperability Plans for Industry Demonstrations and Pilots	Upcoming Awards

VALUE

- Keep up-to-date on the pulse of the industry through insights on emerging ad existing standards
- Guidance on the right standards to support field operations, ease of data integration, 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
- Accelerate interoperability of DER and DR through testing, test tools, and open source clients

DELIVERABLE TYPE

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

ARP PROJECT

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

TIES TO OTHER PROGRAMS

Cyber Security for Power Delivery and Utilization (P183), Electric Transportation (P18), Energy Storage and Distributed Generation (P94) (P94),Customer Technologies (P170), Integration of Distributed Renewables (P174), Distribution Operations & Planning (P200), and Understanding Electric Utility Customers (P182) programs

End-to-End Interoperability for DER/DR and DER Systems

Future State: All stakeholders (utilities, manufacturers, service providers, etc.) have access to guidelines, specifications, and standards that describe how to process and respond a common set of information exchanged with any application or device through a communication interface that is specified in an open standard. Interoperability occurs end-to-end; from the head end to the component.

Description: Interoperability is the ability of two or more systems to exchange information and to process and respond to the information that has been exchanged. In this context, end-to-end interoperability is the capability "plug-and-play" with DER/DR technologies that are interoperable with other related devices and systems from IT to OT technologies. Characteristics of this future state include:

- Standards are robust, certified, and industry stakeholders have experience with implementing them in devices and systems
- Guidelines, specifications, and standards exist that blend communications requirements with functional/behavioral requirements
- Utility programs, grid-codes, and industry specifications call out specific requirements for open standards
- Documented use-cases exist showing successful end-to-end interoperability in all DER domains (solar, storage, flexible loads, and electric vehicles)

Gaps Addressed:
Gaps in functionality, security risks, and barriers to interoperability exist; not all standards are mature and interoperability standards are in development:

- Lack of understanding in the nuances of different interoperability standards, communication standards, and associated data models which can prevent interoperability
- Utility program designers / interconnection teams need tools to translate between various interoperability standards
- Technical solutions are needed to address connectivity related needs including firmware management of DER, security, and handing defunct models of DER
- Terminology is not the same in all domains and standards which can lead to confusion and therefore interoperability issues
- Distributed intelligence needs to be further explored to understand opportunities so architectures can be modified to accommodate them

Action Plan:
Collaborate with utilities, vendors, manufacturers and other industry stakeholders to provide feedback on opportunities, gaps, and best practices to encourage adoption and produce the necessary tools for success This includes:

- Field and laboratory testing to identify barriers in the interconnection and interoperability of DER/DR so that they can be addressed ahead of utility deployments
- Assessment of communication and control approaches within DER/DR integration pilots, demos, and deployments
- Testing of DER/DR on the market to understand the maturity of communication standards, data models, and mapping functional responses
- Evaluating connected-criteria that pull functional and communication requirements together for the sake of interoperability (IEEE 1547-2018, CA Rule 21, EnergyStar, AHRI-1380)
- 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.

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161D Applied ICT for DER and DR – Future State: End-to-End Interoperability for DER/DR and DER Systems

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002016140, 3002013621, 3002009850** DER Protocol Reference Guidebooks: Protocol Comparisons and Maturity Analysis • **3002016141, 3002016099, 3002013473, 3002009854, 3002009462** Evaluating Interoperability Achieved by Industry Guidelines, Specifications, and Standards, Addressing Gaps • **3002014812, 3002016662** Laboratory and Field Evaluation of DERMS Interoperability	• Industry Updates and Webcasts on Industry Guidelines and Specifications for Achieving Interoperability • EPRI Protocol Reference Guide – 4th Edition • Guidelines for Achieving Interoperability in Interconnection or Program Requirements • Repository of Interoperability Barriers in DER/DR • Market Study on Penetration of Interoperability Guidelines, Specifications, and Standards	• EPRI Protocol Reference Guide – 5th Edition • Performance Evaluations of Network Interfaces in DER/DR • Evaluate effectiveness of ICT technologies for microgrid and other grid resiliency applications	• EPRI Protocol Reference Guide • Demonstrate Cooperative Use of Solar, Storage, and Controllable Loads for Grid-Facing Services • Demonstrate the End-to-End Integration of 100s of Makes and Models of DER through Open Interfaces • Evaluation of Capabilities of Network Gateways on the Market
SUPPLEMENTAL PROJECTS			
• **1026542** Evaluation of CTA-2045 Interfaces • **3002014812**, **3002016662** Laboratory and Field Evaluation of DERMS Interoperability • **3002017116** Understanding the Uses and Value of Utility DER Gateways	• Interoperability and interconnection standards roadmap for DER • CTA-2045 and OpenADR Demos • Develop and Demonstrate Capabilities of DER Network Gateways for Control Integration • Developing Guidance for Incorporate Interoperability Into DER/DR Programs	• Open source stacks for translation between inverter protocols - IEEE 2030.5, IEEE 1815, SunSpec Modbus • Documentation of Protocol Mapping Between Solar, Storage, and Demand Response Protocols	Reference Design for DER Gateway for Easing and Securing Network Integration

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161D Applied ICT for DER and DR – Future State: End-to-End Interoperability for DER/DR and DER Systems

Major Past Accomplishments	2020	2021	Future
GOVERNMENT PROJECTS			
3002009849, 3002016335 Evaluation of Standards-Based DER/DR Capabilities to Support Grid Needs	• Match Use Cases in New York State to DR Capabilities Through Open Protocols • Increasing Hosting Capacity for Solar Using Smart Inverters and Controllable Loads • Supporting Field Deployments Across DER Types and Domains • Expansion of ICT-Based Modeling and Simulation Tools • Recommendations for Transactive Load Management Signals in a Market Context	Upcoming Awards	Upcoming Awards

VALUE

- Awareness of existing standards, issues, and solutions that can streamline the integration of DER/DR and reduce costs for on-going operation and maintenance
- Receive updates on key lessons learned from utility field demonstrations and pilots
- Stay up to date on results from interoperability testing to understand how to develop robust RFP documents, interconnection requirements, and program requirements

DELIVERABLE TYPE

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

ARP PROJECT

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

TIES TO OTHER PROGRAMS

Cyber Security for Power Delivery and Utilization (P183), Electric Transportation (P18), Energy Storage and Distributed Generation (P94) (P94),Customer Technologies (P170), Integration of Distributed Renewables (P174), Distribution Operations & Planning (P200), and Understanding Electric Utility Customers (P182) programs

161D Applied ICT for DER and DR – Future State: Effective and Field-Proven Practices for Communicating with DER

Effective and Field-Proven Practices for Communicating with DER

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

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

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

Gaps Addressed:

- Some case-studies exist for end-to-end architectures however the state-of-the-art is still in its infancy with most projects being pilots or demonstrations. However, it is expected to rise quickly based on the number of field studies in the industry today and they will need to be documented
- Approaches for managing the utilization and sharing of DER devices and/or systems of devices among business applications have not been fully explored

Action Plan:

Evaluate utility experiences to:

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002017103** ICT for DER Case Studies – Business Justifications for DER Communications • **3002013624** Evaluation of the Potential Impacts of Interoperability in Utility Economic Analyses and Program Design • **1025008** Experiences and State of the Art of Demand Response	• Repository of RFP Language and Standards for Communicating DER/DR: An Ongoing Study of Requirements to Simplify the Integration and Interconnection of DER/DR • Repository of Lessons Learned from Utility Case Studies: An Ongoing Study of Barriers and Successes in Utility Deployments of Communicating DER/DR	• Utility Data and Metrics to Document Cost-Benefits of Interoperability of DER/DR • Evaluate Impact of Communications Decisions in Field Demonstrations • Repository of Lessons Learned from Utility Case Studies	• Use Case on Utility Evolutions to Support Communicating DER and Grid Flexibility • Use-Cases on Performance and Grid-Flexibility Benefits of Next-Generation Utility Platforms (DERMS, Customer Management)

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161D Applied ICT for DER and DR – Future State: Effective and Field-Proven Practices for Communicating with DER

Major Past Accomplishments	2020	2021	Future
SUPPLEMENTAL PROJECTS			
• **3002004652** EPRI Smart Grid Demonstrations • **3002008853** CTA-2045 Summit Overview and Presentations • **der.epri.com** Repository of DERMS RFP Language	• Document Utility • Approaches for DER/DR Control Architectures • The Role of Big Data Analytics for Electric Grid and Demand-Side Management • Programmatic Guidance for Developing Demand Response Programs to Embrace Interoperability	Pending	Pending

VALUE

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

DELIVERABLE TYPE

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

ARP PROJECT

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

TIES TO OTHER PROGRAMS

Cyber Security for Power Delivery and Utilization (P183), Electric Transportation (P18), Energy Storage and Distributed Generation (P94) (P94),Customer Technologies (P170), Integration of Distributed Renewables (P174), Distribution Operations & Planning (P200), and Understanding Electric Utility Customers (P182) programs

Maturity in the Technologies, Processes, and Systems to Embrace Communicating DER

Future State: Communicating with DER/DR and their integration into daily use are commonplace and well understood across the industry. Communicating DER are the current state in utility roadmaps the technologies, processes, and systems to embrace this integration are in place to reduce long-term operation and maintenance costs.

Description: As the utilities develop their DER integration roadmaps to include end-to-end integration of DERs, 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. Characteristics of this future state include:

- Ubiquitous use of standards, guidelines, protocols, data models, and specifications
- Architectures are built with scalability and maintainability in the initial design and support multiple, complex use-cases
- Technical requirements for integrating communicating DER are understood and systems and process have been upgraded to support their proliferation. This includes telecom, workforce, DMS, data, and other evolutions
- DER/DR, services, and management systems use flexible communications systems
- Control systems that are inherently designed to work collectively with distributed intelligence

Gaps Addressed:

- Standards, guidelines, protocols, data models, and specifications for DER/DR communications are based on standards and practices that have been around for a long time. However, the application and migration of these best practices to the DER/DR domain is new and not widely understood
- The concept for a hierarchical, scalable architecture exists but the protocols and standards lack some capabilities for end-to end use-cases. Informational models may need development
- Technical requirements for integrating communicating DER are not fully understood. Studies are needed to understand requirements for telecom, workforce, DMS, data, and other evolutions
- Next-generation utility platforms (DERMS, customer management, etc.) are new and the communication interfaces are still being understood. More work is needed to understand the required integrations and pair that with device requirements
- Distributed intelligence needs to be further explored to understand opportunities, so architectures can be modified to accommodate them

Action Plan: Determine the Resources Required to Improve EA Maturity

- Host workshops and working groups to identify and fill gaps in utility and industry needs to integration communicating DER
- Produce reference designs and device simulations to support development and testing of architectures
- Develop informational materials to share key transformations needed to support the end-to-end integration of DER
- Evaluate methods to maximize the utilization and scalability of all resources across the communication architecture

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161D Applied ICT for DER and DR – Future State: Maturity in the Technologies, Processes, and Systems to Embrace Communicating DER

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002016142** Evaluation of Translation Capabilities in Distributed Energy Resources Management Systems (DERMS) • **3002016143** Communication Requirements for Near-Term Smart Inverter Use Cases • **3002013480** Mounting Importance of Communications to Monitor and Control Distributed Energy Resources • **3002014800, 3002011233, 3002003035** Evaluation of Interoperability in DERMS Systems • **3002012960, 3002013484** Cooperative Applications for Flexible Loads, Distributed Solar, Energy Storage, and Electric Vehicles • **3002014321** Guide on Organizational Coordination Required Between DER Communications, Cyber Security, and Enterprise Architecture • **3002009857** A Study on the Different Approaches for Creating and Managing Groups of DER and the Impact on Operations	• Low-Cost Telemetry for DER Management to Enable Future Grid • Developing Training for The New Generation Of Workforce In ICT-Based Applications Of DER Technologies • Responsibility Matrix for Integration of Communicating DER/DR: Understanding Industry Stage Gates and the Responsible Stakeholders • Phase Two – Communication Architecture Requirements for Inverter Use Cases and Applications	• Case Studies of Utility Architectural Decisions • Continue Determining Communication and • Control Requirements for DER Applications • Guidance on Conducting Inter-Utility • Conversations to Refine Practices for Integrating Communicable DER/DR • Pairing Data Analytics Applications with ICT System Requirements	• Comparison of Analytics Opportunities for DER Data and Data Available Over DER Interfaces • Guidelines for ICT Capabilities of Next-Generation Utility Platforms • Security and Performance Requirements for Aggregator and Utility Networks Integrating DER/DR Technologies

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161D Applied ICT for DER and DR – Future State: Maturity in the Technologies, Processes, and Systems to Embrace Communicating DER

Major Past Accomplishments	2020	2021	Future
GOVERNMENT PROJECTS			
• Perform and Analyze Software/Hardware in-the-loop Testing on DER Architectures (NREL/Sandia) • Increasing Hosting Capacity for Solar Using Controllable Loads	• Interactions of Smart Inverters at High Penetration • Demonstration of State-of-The-Art DR Technologies in New York State • Demonstrate the Capability of Behind-The-Meter DER to Participate in Distribution and Bulk System Services • Cost-Effective Telemetry and Control	• Continue Software/Hardware in-the loop Testing on DER Architectures • Validating Functional Requirements Against Utility Use Cases – DOE/NYSERDA Demos	Pending Awards

VALUE

- Discover how architectural decisions can improve utilization and scalability of communication architectures
- Access to 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
- Support members in looking at the bigger picture to prepare for the various technical, organizations, and business changes needed to embrace end-to-end integration of DER/DRs

DELIVERABLE TYPE

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

ARP PROJECT

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

TIES TO OTHER PROGRAMS

Cyber Security for Power Delivery and Utilization (P183), Electric Transportation (P18), Energy Storage and Distributed Generation (P94) (P94),Customer Technologies (P170), Integration of Distributed Renewables (P174), Distribution Operations & Planning (P200), and Understanding Electric Utility Customers (P182) programs

Enterprise Architecture and Integration (161E)

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

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

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

Research Drivers

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

RD&D

- Best practices for enterprise architecture and integration
- Advancement of standards-based systems integration capabilities
- Digital transformation – providing business efficiency by aligning Operations and Information Technology (IT)

Value

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

Project Set Lead: Sean Crimmins, scrimmins@epri.com

Improved Enterprise Architecture Maturity

Future State: Enterprise Architecture Maturity.

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

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

Gaps Addressed:

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

Action Plan: Determine the Resources Required to Improve EA Maturity

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002015911** Enterprise Architecture Guidebook, 4th Edition • **3002015916** Digital Transformation: Aligning Information Technology and Operations, 2nd Edition	• Enterprise Architecture Guidebook, 5th Edition • Digital Transformation: Aligning Information Technology and Operations, 3rd Edition	• Enterprise Architecture Guidebook, 6th Edition • Digital Transformation: Aligning Information Technology and Operations, 4th Edition • Guidebook, 2nd Edition	• Enterprise Architecture Guidebook, 7th Edition • Digital Transformation: Aligning Information Technology and Operations, 5th Edition

VALUE

- Data quality indices for utilities (accuracy, completeness, consistency, timeliness, security, and fit for purpose)
- EA Maturity Assessment
- EA Practitioner Capability workshops

DELIVERABLE TYPE

Reports, templates, and Enterprise Architecture Training Program

ARP PROJECT

P161.041: Enterprise System Integration

TIES TO OTHER PROGRAMS

Cyber Security for Power Delivery and Utilization (P183)

Standards and Certification

Future State: Standards and Certification

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

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

Gaps Addressed:

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

Action Plan: Develop Test Scripts from Standards Documentation and Identify Any Modifications That Are Required to Make Them Actionable
While codified standards are an important step in integration maturity they are often open to interpretation. Further, when people attempt to implement a standard this often reveals issues in how messages might be defined, for example optional data elements that in fact are required to support interoperability. This effort will work to convert standards into test scripts that improve the clarity of expectations to promote interoperability. Identifying these gaps are critical to improving and reducing the distance to integrate.

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• CIM compliance event • Hosting first of its kind, CIM Compliance Test • CIM Compliance "Plug Fest" in conjunction with OpenFMB and IEC 61850 interoperability	CIM compliance transitions to CIM User's Group	Pending	Pending

VALUE

Percent of profiles that have test and certification available

DELIVERABLE TYPE

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

ARP PROJECT

P161

TIES TO OTHER PROGRAMS

Cyber Security for Power Delivery and Utilization (P183)

Enterprise Integration Maturity

Future State: Enterprise Integration Maturity

Description: Integration maturity contributes to the notion of an "agile enterprise". Integration maturity allows an organization to respond to change requests (driven by a changing environment or systems acquisitions) more quickly and in a more cost-effective manner rather than a "run to failure" mode that is often the case with utility IT.

Gaps Addressed: Lack of integration resources, standards, or frameworks to ease data integration challenges.

Action Plan: Develop data integration resources, framework, and patterns that enable enterprise architects to take a LEAN approach to architecture development.

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002015915** Cloud Integration Guidebook, 4th Edition • **3002015918** CIM Primer, 5th Edition	• Cloud Integration Guidebook, 5thrd Edition • CIM Primer, 6th Edition	• Cloud Integration Guidebook, 6th Edition • CIM Primer, 7th Edition	• Cloud Integration Guidebook, 7th Edition • CIM Primer, 8th Edition

VALUE

Percent of profiles that have test and certification available

DELIVERABLE TYPE

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

ARP PROJECT

P161

TIES TO OTHER PROGRAMS

Cyber Security for Power Delivery and Utilization (P183)

Agile Enterprise

Future States: Agile Enterprise

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

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

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
3002015913 Architectural Impacts of Disruptive Technology, First Edition (Docker/ Distributed DERMS)	Architectural Impacts of Disruptive Technology, 2nd Edition	Architectural Impacts of Disruptive Technology, 3rd Edition	Architectural Impacts of Disruptive Technology, 4th Edition

VALUE

Enterprise Architecture practitioners can review the guidebook to compare the outlined disruptive technologies, with their own application portfolios and roadmaps, to ascertain for themselves what the impacts may be. This also demonstrates the value and use of business capability models and use as a source for an impact assessment.

DELIVERABLE TYPE

Guidebook

ARP PROJECT

P161

TIES TO OTHER PROGRAMS

None

Advanced Metering Infrastructure (161F)

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

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

Research Drivers

Infrastructure (AMI) pose challenges and opportunities:

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

RD&D

Advance interoperability through accelerating standards:

- Assess advanced meter performance
- Discover uses that optimize existing system value
- Identify industry best practices for AMI management

Value

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

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

Open, Interoperable AMI Systems

Future State: Open, Interoperable AMI Systems

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

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

Gaps Addressed: Existing AMI networks (both RF and PLC) are proprietary due to lack of implementation of standards at both the lower (Phy/MAC) and application layers:

- Existing standards are competing and there is lack of consensus regarding their use
- Supporting multiple NAN technologies: Lack of standards for system backhaul
- Enabling intelligence at the edge: Standards for meters to have consistent functionality and applications
- Methods and architectures for leveraging other communication infrastructures (e.g. internet) are not developed

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

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• Reference Wi-Sun protocol stack, open source • **3002010501** Wi-SUN Meter Test Tool (WISUND), version 1.0 • Reference DLMS/ COSEM application layer	• DLMS/ COSEM to IEC 61968-9 mapping • Metering and CIM report	• "Open backhaul" methods and messages • Reference AMI headend – enabling Application integration testing	Assessment of available meters and devices with Wi-Sun compatibility

VALUE

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

DELIVERABLE TYPE

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

ARP PROJECT

P161.032: Open, Interoperable Advanced Metering Systemt

TIES TO OTHER PROGRAMS

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

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

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

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

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

Gaps Addressed:

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

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

Develop a library of AMI best-practices, addressing:

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002008943** Revenue Protection Guidebook, First Edition: Utilizing Advanced Metering Infrastructure • **3002010502** Guidebook for AMI system disaster management and restoration • **3002013399** Guidebook for AMI Data Management, First Edition (2018)	Guidebook for Revenue Protection, 2nd edition	Guidebook for AMI network management and performance optimization	Guidebook for AMI system RFP and deployment processes, including evolving, hybrid networks

VALUE

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

DELIVERABLE TYPE

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

ARP PROJECT

P161.043: Advanced Metering Systems Operations and Management

TIES TO OTHER PROGRAMS

Distribution (P180)

Optimized AMI System Utilization and Value

Future State: Optimized AMI System Utilization and Value

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

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

Gaps Addressed:

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

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

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002010503** Online AMI RFP Language Repository – a structured and Searchable library or RFP text components • **3002013401** Next Generation AMI System Design and Utilization – Case Studies in Utility Innovation Expanded AMI Use Case Database (2018)	Guidebook for AMI Data Analytics Data Analytics Survey	Developing and field testing new AMI system uses and data analyticst	AMI analytic algorithms repository

VALUE

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

DELIVERABLE TYPE

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

ARP PROJECT

P161.044: Optimizing Advanced Metering System and Management

TIES TO OTHER PROGRAMS

Power Quality (P1), Understanding Electric Utility Customers (P182), Distribution (P180)

Telecommunications (161G)

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

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

Research Drivers

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

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

RD&D

Development of telecommunication strategic architecture and roadmap decision tree for utilities

Value

Collaborative with multiple utilities to gain perspectives based on practical experiences

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

Interoperable and Reliable Field Area Networks

This Future State incorporates the following topic(s):

- FAN Testing and Evaluation
- FAN Commercial Cellular
- FAN Technology
- FAN Use Cases
- FAN Resilience
- FAN Connectivity at the Grid Edge

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

Gaps Addressed:

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

Action Plan:

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002015944** Additional FAN Performance Testing (2019) • **3002013393** FAN Technology Performance Evaluation (2018)	• Develop and document next-generation FAN Test Platform • IPv4 IPv6 – See Planning • Communications Network Requirements for advanced DER, Phase 2 • Application of 5G to DTT using URLLC - Field Testing • FAN Capacity Offload – selective use of higher-band spectrum	• Simulation 700 MHz Upper A block + 4.9/5.8 GHz split band FAN • Evaluation of available SAS systems for shared bands and impact on FAN performance	• Develop, simulate, and test dynamic network reconfiguration due to damage or impairment
• **3002009792** Public Networking and Shared Networks – Architecture & Operation (2017) • **3002009791** Low Power WAN Technologies (2017) • **3002009790** Testing QoS on Commercial Cellular (2017)	• Evaluate private and commercial NB-IoT	• Evaluate 5G Ultra-reliable low-latency communication (URLLC) networks • Evaluate commercial 5G eMBB for AR/VR and "Digital worker" in the field	• Demonstration of a PVNO (Private Virtual Network Operator) RAN (Radio Access Network) Sharing • Failover of Private LTE cores between utilities or operators

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161G Telecommunications – Future State: Interoperable and Reliable Field Area Networks

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002015943** Design and deployment of Private LTE (2019) • **3002011195** IEEE 802.16S Overview (2017) • **3002009141** FAN Demo Final Report (2016)	• NB-IoT: Standalone, Private networks. Comparison of capabilities of private vs commercial • New Spectrum (3GPP, non-3GPP, aggregated) MHz operation • Evaluation of Inter-Cell Interference Coordination (ICIC)	• Distributed intelligence in the edge device to reduce traffic and enable autonomous operation (Edge Cores) • Evaluate integration and migration of LMR and voice to private LTE • Develop application specific profiles for QoS parameters	• Develop approaches for traffic segmentation and management on multi-tier FAN, with higher performance top tier and lower performance tier (e.g. Wi-SUN) • Extend multi-mode FAN to interoperate with AMI, private FAN, and customer broadband • Develop approaches for traffic segmentation and management on multi-tier FAN, with higher performance top tier and lower performance tier (e.g. Wi-SUN)
• **3002017158** Phase 1 of 5G DTT for large scale DER – laboratory testing (2019) • **3002016143** Communications network requirements for DER applications Phase 1 (2019) • **3002009788** Private LTE – Options and Opportunities (2017) • **3002009786** Wireless Taxonomy and Architecture (2017) • **3002009141** FAN Demo Final Report (2016)	• Further development of telecom requirements for DER • Evaluation of standalone private 5G for digital terrestrial television (DTT) use case on large scale DER	• Designing the FAN for support of IPv4 and IPv6 • FAN Use Case Repository with traffic models • Supporting Unmanned aerial vehicles (UAVs) for Non-line-of-sight (NLOS) flight with the FAN	• Mobile worker, mobile workforce – adapting the FAN for support

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161G Telecommunications – Future State: Interoperable and Reliable Field Area Networks

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002009799** Pilot Testing Results, next phase continuation and collaboration plan (2018) • **3002009798** Persistent Secure Wi-Fi Connectivity at Grid Edge: Overview and Operation (2017)		• Evaluation of new Wi-Fi standards – 802.11ah and 802.11ax (Wi-Fi 6) • Long term connection stability, and maintenance at the grid edge	• Leveraging customer broadband • Defining IoT in the utility context
• **Fan Resilience**	• Innovation of resilient networks that can maintain critical function even when impaired • Application of multi-tier networks, heterogeneous networks, and distributed message bus architecture to optimize utility applications • Application of meshing, bridging, routing, and failover between different technologies	• Application of Quality of Service (QoS) for managing data flows in multiple application networks	• Explore multiple communications technologies (private wireless, public wireless carriers, cable, fiber, etc) to be integrated into a cohesive communications network • Develop approaches for multi-mode FAN nodes, with adaptive path selection and failover • What role can Software Defined Networking play in an integrated, hybrid network involving multiple communications technologies?

VALUE

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

DELIVERABLE TYPE

Evaluation and testing with reports and standards updates

ARP PROJECT

P161.054: Field/ Neighborhood Area Networks

TIES TO OTHER PROGRAMS

Substations (P37), Distribution Systems (P180), End-Use, Energy Efficiency, and Demand Response (P170), Integration of Distributed Energy Resources (P174), Electric Transportation (P18), Energy Storage and Distributed Generation (P94)

161G Telecommunications – Future State: Optimal Use of Available Spectrum

Optimal Use of Available Spectrum

Future State: Optimal Use of Available Spectrum

This Future State incorporates the following topic(s):
- FAN Spectrum

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

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

Action Plan:
- Understanding the current and future occupancy and availability of unlicensed spectrum
- Evaluate and test systems using licensed control channel, and unlicensed transfer channel for private utility FAN, providing reliability and bandwidth
- Research best in class mechanisms for dynamic spectrum access, opportunistic sharing, etc.

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002013392** Optimizing Wireless Spectrum: Operation and Coexistence in Sub 1GHz Unlicensed Spectrum (2018) • **3002005851** Assessment of Licensed Spectrum (2015)	• Evaluation of "mid band" shared spectrum for aggregation • Explore License Assisted Access (LAA) approach of licensed control channel, and unlicensed broadband private utility FAN	• Interference adaptation and mitigation in unlicensed spectrum • Quantifying levels and types of interference protocols and grid applications. • Pilot Deployment of private LTE in 406-420 MHz	• Evaluation of dynamic spectrum access, frequency agility opportunistic sharing, etc • Explore technical solution for utility requirements in a shared spectrum environment and wireless performance metrics

161G Telecommunications – Future State: Optimal Use of Available Spectrum

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002009786** Wireless Taxonomy and Architecture (2017) • **3002011195** IEEE 802.16S Overview • **3002013392** Optimizing Wireless Spectrum (2018)	• Develop parameters for shared operation in 406-420 MHz spectrum	• Next generation SDR platform for spectrum survey (lower cost, more precision, interference location) • Simulation and possible prototype of 700 MHz Upper nA block + 4.9/5.8 GHz FAN • Analysis of existing systems and techniques for split band operation • Evaluation of available SAS systems for shared bands and impact on FAN performance	• Retrofit Next generation SDR platform (lower cost, more precision) • Support of other band pairs, potential field testing • Field testing of SAS based FAN operating in 3.6 GHz CBRS band

VALUE

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

DELIVERABLE TYPE

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

ARP PROJECT

P161.054: Field/ Neighborhood Area Networks

TIES TO OTHER PROGRAMS

Substations (P37), Distribution Systems (P180), End-Use, Energy Efficiency, and Demand Response (P170), Integration of Distributed Energy Resources (P174), Electric Transportation (P18), Energy Storage and Distributed Generation (P94)

Wide Area Networks (WAN) Use Packet Based Technology

Future State: Wide Area Networks (WAN) Use Packet Based Technology

This Future State incorporates the following topic(s):

- Packet WAN
- Leased Circuits in the WAN
- Other WAN Technologies

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

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

Action Plan:

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002015941** Teleprotection over Packet Guidebook (2019) • **3002013403** Evaluation of SDN in Utility Operational Networks (2018 • **3002009783** Protection over MPLS Workshop, Test Plan, Results (2017) • **3002009785** Leased circuit requirements for protection (2017)	• Evaluation and testing of Time Sensitive Networking (TSN) standards-compliant devices for latency management and time synchronization on the WAN • Timing Synchronization and distribution in packet WAN, timing security, availability, resilience	• Develop requirements and test scenarios of Software-defined networking (SDN) for OT • Best Practices for a WAN network architecture. High Level Requirements, criteria. Trace the criteria to the specification and implementation	• Develop virtual SDN testbed and reference architecture for OT networks • Perform basic interoperability testing of multi-vendor MPLS and Carrier Ethernet (CE) in a private network
• **3002015939** Telecom data isolation techniques and NERC CIP requirements (2019) • **3002009784** Serial/TDM replacement (2017) • **3002009785** Leased circuit requirements for protection (2017)	• Evaluate MPLS and CE service offerings from carriers • Evaluate Pros and Cons of carrier services vs privately owned	• Evaluate commercial LTE as a broadband WAN service. Reliability? Failover? Pseudo-wire support? QoS? • Interoperability / Interfacing between private MPLS and commercial MPLS	• Testing of commercial 5G services as part of the WAN

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161G Telecommunications – Future State: Wide Area Networks (WAN) Use Packet Based Technology

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
NEW for 2020 other WAN Technologies	Evaluate effect of potential unlicensed operation in 6 GHz band (LAA and Wi-Fi) on types of microwave systems currently used	Evaluation of microwave links, performance, and ability to integrate into multi-services networks	Evaluate new and emerging satellite technologies as WAN extension for challenging locations (e.g. SpaceX Starlink broadband constellation)

VALUE

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

DELIVERABLE TYPE

Evaluation and demonstrations with reports and standards updates

ARP PROJECT

P161.053: Wide Area Networks

TIES TO OTHER PROGRAMS

Substations (P37), Distribution (P180), End-Use, Energy Eff., and DR (P170), Integration of DER (P174), Electric Transportation (P18), Energy Storage and Distributed Generation (P94)

Expansion of Fiber Backbone

Future State: Expansion of Fiber Backbone

This Future State incorporates the following topic(s):
- Strategic Fiber in the WAN

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

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

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002015940** Update Strategic Fiber Handbook / Fiber Survey (2019) • **3002013389** Strategic Fiber in the WAN (2018) • **3002009793** Strategic Fiber Handbook Phase 1 • **3002009797** Strategic Fiber Handbook Phase 2 – Innovative Business Models Case Studies	• Rural Broadband Opportunities – Look into opportunities and implications for build-out • Hybrid wireless/ fiber architecture for high capacity - Fiber infrastructure backbone and "last mile" wireless for FAN • Cost benefit study of fiber monitoring systems (e.g. Ntest FiberWatch)	• Develop detailed use cases for hybrid primary power/fiber optic cables (O/H and U/G) to include splicing/ termination methods and procedures. Work with cable manufacturer(s) to develop prototypes of hybrid primary power/ fiber optic cable types. • Evaluation of improvements in fiber cable make-up and configurations • Produce a comparison study of conventional OSP (field splicing) versus a pre-terminated OSP system, to include cost and schedule impacts. • Identifying available services over fiber from carriers. Which carriers will do what?	• Evaluate and document fiber deployment architectures over the range of points of access from single point-to-point to PON • Collaborate and document experiences of member utilities that are participating in Smart Cities initiatives • What are the reliability factors of Fiber? Storm damage, physical damage, malicious attacks, compared to wireless interference/ jamming • Relative impact of solar flares and other activity, and EMP on the fiber plant

Fully Integrated Network Management System

Future State: Fully Integrated Network Management System

This Future State incorporates the following topic(s):
- Network Management
- Planning Framework
- Provisioning and Device Management

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

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

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002013394** Integration of GIS Visualization in Telecom Network Management (2018) • **3002009800** Manager of Manager Survey Results (2017) • **3002009803** Creating Telecommunications Metrics for the Electric Sector (2017) • **3002009802** Software defined networking (SDN) Standards and Applications (2017)	• Next step on Network Management System NMS and Manager of Managers MOM • Implications of CIP and EAP – how to unify management across boundary • Best practices for Integrated NOCs - architecture, design, implementation, demonstration • Interconnections and relationships of NOC to EMS and security ISOC	• Refine requirements for network metrics to v2.0. Evaluate potential for standardization • Investigate methods to achieve better visibility into the commercial cellular NMS?	• Evaluate potential uses of AR and VR in the Telecom NOC, demonstration • Simplification, automation of some situations • Field Force Data - access to connectivity over a variety of technologies • The role of AI in network management

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161G Telecommunications – Future State: Fully Integrated Network Management System

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002009805** Roadmap and Framework for Telecom Planning (2018) • Telecom Initiative Co-Simulation Framework (2017)	• Develop (update) database of FAN use cases with parameterizable traffic models (building on prior work in OpenSG) • Extensions to the telecom planning framework, including evolution of traffic modeling • Develop guidance and best practices for IP network planning and architecture for IPv4 and IPv6	• Develop guidance and best practices for telecom naming conventions to enable convergence of transmission/distribution GIS data with Telecom GIS data • Enhance integration of network management systems with telecom planning framework to enable metrics to drive planning of future state. Develop use cases and coordinate with NMS or MOM vendors to implement and demonstrate • Improved co-simulation modeling of widely used network technology and the most challenging grid applications for telecom • Develop additional wireless models for co-simulation	• Evaluate and possibly prototype hybrid simulation and networking (communication hardware in the loop) • Study (qualitative and quantitative) of reliability and resilience benefits of multi-technology redundant networks • Quantification of economic value derived from (future state) integrated telecom network • Expanded partnerships with national labs co-simulation activities • Evaluate and possibly prototype hybrid simulation and networking (communication hardware in the loop)

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161G Telecommunications – Future State: Fully Integrated Network Management System

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002015946** Optimizing provisioning and device management (2019) • **3002013395** Zero-Touch Provisioning White Paper (2018)	• Continuing research into device provisioning • Reference architecture and consideration of standards for provisioning GSMA services on all network types • Expand into management of devices settings (possible joint work with Distribution programs) • Evaluation Network Orchestration to automate service provisioning and failover management on the WAN	• Framework for intelligence at the edge • Reference architecture approach for embedded virtual machines in modems and edge devices, including their remote installation, provisioning, and management	• Evaluate the practicality of integrating AI with telecommunications management and planning • Identify the appropriate problem set and required data set to solve them • Use of SDN and NFV for zero-touch provisioning WAN services (crossover to WAN area)

VALUE

- For telecom, reduction of outages through better situational awareness, and higher availability of telecom networks
- Improved ability to plan and deploy advanced networks, creating new economic and business opportunities, understanding technology options
- Improved internal customer satisfaction by providing high reliability telecom services, with performance and reliability that meet application requirements now, and anticipate future business opportunities

DELIVERABLE TYPE

Analysis, demonstrations with reports and standards updates

ARP PROJECT

P161.055: Telecommunications Planning and Management Systems

TIES TO OTHER PROGRAMS

Substations (P37), Distribution Systems (P180), End-Use, Energy Efficiency, and Demand Response (P170), Integration of Distributed Energy Resources (P174), Electric Transportation (P18), Energy Storage and Distributed Generation (P94)

Telecommunication Standards Tracking and Analysis

Future State: Interoperable Telecommunications Systems

This Future State incorporates the following topic(s):
- Telecommunication Standards

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

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

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
3002015951 First edition of Standards Handbook *23 issues of Comms Intelligencer newsletter* (2012 – 2019) **3002015952**, **3002015954** 2019 Comms Intelligencer newsletters **Issue 1: 1024654** Smart Grid Communications Intelligencer: Fall 2011 **Issue 2: 1024655** Smart Grid Communications Intelligencer: Winter 2011/2012 **Issue 3: 1025756** Smart Grid Communications Intelligencer: Spring 2012 **Issue 4: 1025757** Smart Grid Communications Intelligencer: Fall 2012 **Issue 5: 1024295** Smart Grid Communications Intelligencer: Winter 2012/2013 **Issue 6: 3002001076** Smart Grid Communications Intelligencer: Spring 2013 **Issue 7: 3002001141** Smart Grid Communications Intelligencer: Fall 2013 **Issue 8: 3002002697** Smart Grid Communications Intelligencer: Winter 2013/2014	• Comms Intelligencer Newsletters highlighting key standards activities and progress from participation and tracking of standards development related to telecommunications, especially wireless standards • Telecom Standards Guidebook: A high-level description of telecom and communications standards, their roadmap, utility applications, and interrelationships, updated annually • Standardization of FAN operation in licensed spectrum for channel widths below 100 KHz. (narrowband)	• Investigate options for engaging with 3GPP for standardization of sub-1GHz utility spectrum • Additional engagement with PES Power Systems Relaying & Control (PSRC) and Power System Communications and Cybersecurity (PSCC) committees • Standards for NB-IoT operation in additional Sub-1GHz bands	• Evaluate need and opportunity for further standardization of "mid-bandwidth" P-MP FAN technologies • Evaluate potential and value of engagement with IETF in areas related to utility telecom and IoT

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

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
Issue 9: 3002002698 Smart Grid Communications Intelligencer: Spring 2014 **Issue 10: 3002002699** Smart Grid Communications Intelligencer: Fall 2014 **Issue 11: 3002005094** Smart Grid Communications Intelligencer: Winter 2015 **Issue 12: 3002005095** Smart Grid Communications Intelligencer: Spring 2015 **Issue 13: 3002005096** Smart Grid Communications Intelligencer: Fall 2015 **Issue 14: 3002007445** Smart Grid Communications Intelligencer: Winter 2016 **Issue 15: 3002007446** Smart Grid Communications Intelligencer: Spring Summer 2016 **Issue 16: 3002007447** Smart Grid Communications Intelligencer: Fall 2016 **Issue 17: 3002009755** Smart Grid Communications Intelligencer: Winter 2017 **Issue 18: 3002010451** Smart Grid Communications Intelligencer: Spring- ummer 2017 **Issue 19: 3002009755** Smart Grid Communications Intelligencer: Fall 2017 **Issue 20: 3002012471** Smart Grid Communications Intelligencer: Winter/Spring 2018			

VALUE

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

DELIVERABLE TYPE

Newsletters and annual standards guidebook tech update

ARP PROJECT

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

TIES TO OTHER PROGRAMS

Substations (P37), Distribution Systems (P180), End-Use, Energy Efficiency, and Demand Response (P170), Integration of Distributed Energy Resources (P174), Electric Transportation (P18), Energy Storage and Distributed Generation (P94)

Geospatial Informatics (161H)

EPRI has been conducting research in electric utility geographic or geospatial information systems (GIS) since 2012. Geospatial applications are now expanding well beyond traditional utility GIS because of the impact of emerging technologies:

- New aerial, space-based and ground-based image-capture capabilities are rapidly expanding the amount and types of available georeferenced data (LiDAR, hi-res and multi-spectral imagery, video streams, etc.)
- 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, creating unique opportunities as well as challenges
- Geospatial technologies are increasingly embedded in all consumer systems, driven by new autonomous systems (unmanned aerial vehicles (UAVs), self-driving cars, robotics), and they are often connected with Internet of Things (IoT) 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 Artificial Intelligence (AI) techniques for data quality improvements
- AI software development platforms have become increasingly capable and the cost to add AI functionality to GIS data analytics has fallen dramatically. Code and algorithms can now be easily embedded within the computing environments on field devices.

GIS professionals at EPRI funding utilities must continue to optimize the cartographic role of GIS while exploring the impacts of these trends, which can be disruptive. The Geospatial Informatics project set focuses on helping funders develop maturity in delivering geospatial data services. Project set funders will learn more about acquiring, storing, cleaning, modeling, analyzing, producing, presenting, and disseminating geospatial data via maps and applications to their customers, both within and outside of the utility enterprise.

Research Drivers

- Improve GIS data quality
- Enable the workforce of the future
- Leverage geospatial resources across the enterprise

RD&D

- Identify best practices for acquiring, indexing, organizing and curating geospatial data
- Demonstrate potential applications of AI [machine learning, neural networks, advanced algorithms] for improving GIS data quality
- Develop geospatial services to support expanding XR applications
- Enhance network model data management and exchange to support more advanced analytics in planning and operations

Value

- Increased workforce safety and operational efficiencies
- Reduced errors via improved data accuracy
- Identify and mitigate gaps in GIS standards
- Reduced integration and operational costs through standards enhancement and utilization

Project Set Lead: Randy Rhodes, rrhodes@epri.com

Advanced Geospatial Data Management

Future State: Electric utility GIS professionals are skilled in managing the rapidly growing volume and diversity of geospatial data.

Description: The long-held GIS role of mapping electric utility networks is changing. Computing power and network bandwidth is expanding, driving more use of mobile devices by field workers. The range of sensing devices are also expanding, offering new, increasingly precise methods for field "reality capture." Yet, most utilities struggle with the timeliness, accuracy and precision of their data. This project will focus on identifying best practices for geospatial data management at electric utilities.

Gaps Addressed:

- Immature data, incomplete system models, and insufficiently accurate modeling
- Inability to visualize and evaluate dataset quality
- Duplicate data and incomplete metadata
- Difficulty with quickly and accurately on-boarding precise asset data and closing work orders

Action Plan:

- Document leading practices and procedures to maintain quality of data
- Define and contribute to the development of tools, techniques, and standards for geospatial master data management
- Identify potential research insights from geospatial informatics resources
- Research leading data quality inspection and visualization techniques

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002007921** Electric Utility Guidebook for Geographic Information Systems Data Quality: Metadata • **3002007250** Data Cleanup Algorithms – Examples from a Geospatial Information System	• Geospatial Informatics Guidebook - consolidating past research content into a report suited to annual updates in the future • Next-Generation GIS Technical Resource – a digital and interactive deliverable on the expanding role of GIS	• Guidebook Updates • GIS Data Management Maturity Model • Applications of AI algorithms to GIS data quality challenges • Standards development for 3D and 4D data management	• Guidebook Updates • Standards development • Advanced AR and analytics-based field corrections for automatic redlining • Maintaining geospatial data integrity beyond GIS systems

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161H Geographic Informatics – Future State: Advanced Geospatial Data Management

Major Past Accomplishments	2020	2021	Future
SUPPLEMENTAL PROJECTS - **3002017823** ASSESSING GIS DATA QUALITY IMPROVEMENT OPTIONS			
• **3002017223** 2019 Update on Detection and Geolocation of Power Distribution Infrastructure Using Public Domain Photographic Imagery	• Investigate utility case studies in GIS data quality improvement • Benchmark improvement methods with geospatial analytics (text/graph analytics; spatio-temporal analytics; fusion/conflation analytics; machine learning/ neural networks) • Investigate opportunities to standardize GIS data quality metrics • Evaluate costs and benefits for different approaches	• Investigate advanced platform-agnostic asset identification • Leverage EPRI.AI data sets for algorithm improvement	Pending

VALUE

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

DELIVERABLE TYPE

- Guidebook for GIS Data Management – Technical Report
- Next Generation GIS – a technical resource for educating electric utility GIS professionals

ARP PROJECT

161.059: Geographic Information Systems (GIS) Data Practices

TIES TO OTHER PROGRAMS

Substations (P37), Distribution Systems (P180), Distribution Operations & Planning (P200)

Interoperable GIS and XR

Future State: Mobile and XR applications supporting 3D interaction with utility infrastructure are seamlessly integrated with utility GIS systems and geospatial platforms.

Description: Extraordinarily rich application functionality will be 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 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.

In this project augmented reality research specialists may more clearly define GIS contributions to augmented reality, virtual reality, and mixed reality applications. The project will research how current standards efforts (such as the World Wide Web Consortium's Immersive Web standard) can be harmonized with existing electric utility environments and needs. The research is centered around questions related to interoperability of geospatially-referenced data capture, management, search, delivery and presentation with emerging 3D XR solutions.

Gaps Addressed:

- Lack of consensus between experienced, utility-focused GIS vendors and emerging XR vendors regarding application architecture and interoperability requirements
- De facto standards in an emerging XR industry are not yet harmonized with proven standards already used in electric utility operations and planning, limiting interoperability with legacy utility systems
- Utilities find it difficult to develop a comprehensive governance approach for this application area

Action Plan:

- Evaluate paths to formal and de facto agreements among utility-focused GIS and AR vendors
- Evaluate Open Geospatial Consortium (OGC) standards like glTF, CityGML, IndoorGML, and ARML2.0 for utility use
- Evaluate security frameworks such as the AR for Enterprise Alliance (AREA) AR Security Framework
- Develop recommendations for standards development, testbeds, and interoperability testing

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161H Geographic Informatics – Future State: Interoperable GIS and XR

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002016147** Geospatial Data Integration in Augmented Reality Solutions for Electric Utilities • **3002014695** Using Virtual Reality to Train Utility Workers to Assess Storm Damage • **3002017159** 2019 Extended Reality Guidebook - Digital Transformation for Training and Telemetry	• Identify future requirements for utility GIS systems in augmented reality, mixed reality, and virtual reality applications • Develop guidelines for governance and integration standards for mobile and XR apps portfolio • Deliver Technical Report: Geospatial Requirements for XR Applications	• Define functional requirements in more detail for GIS and AR Cloud integration • Partner with cybersecurity team to define guidelines for cloud GIS deployment • Develop guidelines for GIS integration with virtual positioning systems • Case studies: BIM and 3D integration with GIS	Analyze impacts of 5G availability on AR Cloud performance

VALUE

The industry collaboration resulting from this project will enable electric utility GIS, Computer Aided Design (CAD) and Building Information Modeling (BIM) systems to have a migration path 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.

DELIVERABLE TYPE

Technical Reports, Taskforce Meeting Summaries

ARP PROJECT

161.060 Geographic Information (GIS) Applications

TIES TO OTHER PROGRAMS

Substations (P37), Distribution Systems (P180), Distribution Operations & Planning (P200)

Complex Grid Modeling for Operations and Planning

Future State: GIS systems are optimally configured to model the most important aspects of the transmission and distribution networks, substations, and customer-owned DER.

Description: GIS systems at electric utilities support many applications by providing an accurate network model and detailed facility information useful for grid planning studies and operations.

Further research on the GIS contribution to accurate models is needed now because higher fidelity of components within the model (including DER penetration) is required for more sophisticated grid studies at most utilities. Timely and sufficiently accurate network and DER representation is a new and significant challenge. Most system planners, and the GIS professionals that support them, do not have a mutual, shared understanding of these changing modeling requirements, nor a methodology for assessing the GIS contribution to model fidelity and accuracy. This research will enable both parties to adopt a recommended practice and avoid problems before they occur.

Gaps Addressed:

- Highly customized mapping and modeling practices that vary significantly among utilities, making it difficult to learn best practices
- Most utilities are uncertain about what data is needed, and what should be stored in the GIS
- Geoprocessing frameworks that manage data received from facility design and asset management applications often do not support end-user information and analytics needs (e.g. distribution system assessments - static load-flow, quasi-static load-flow, fault analysis, harmonics, dynamic, electromagnetic transient, and reliability).

Action Plan:

- Assemble an inventory of modeling requirements based on past EPRI research and other industry resources
- Survey P200E and P161H funders to prioritize deficiencies and needs
- Complete project workshops and deliver a technical report

Major Past Accomplishments	2020	2021	Future
ANNUAL RESEARCH PORTFOLIO			
• **3002011007** Distribution Planning Guidebook for the Modern Grid • **3002007976** Distribution Modeling Guidelines: DER Modeling Recommendations for Distribution System Assessments	• Survey design and delivery, and results • Enhanced Grid Modeling Workshop (focus initially on load-flow studies) • Enhanced Grid Modeling for Advanced Planning Analytics report (joint deliverable with P200E)	• Extend research to cover areas not addressed in 2021, such as fault studies and harmonics • Evaluate changing needs considering the trend toward T&D model fusion • Collaborate with GMDM project on functional requirements for network model management.	Incorporate requirements into CIM standards and model exchange interoperability testing

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161H Geographic Informatics – Future State: Complex Grid Modeling for Operations and Planning

Major Past Accomplishments	2020	2021	Future
SUPPLEMENTAL - **3002009807** DISTRIBUTION GEOGRAPHIC INFORMATION SYSTEM AND GRID MODEL DATA MANAGEMENT (GMDM)		SUPPLEMENTAL – APPLYING THE GMDM ARCHITECTURE	
• Definition of methodology for design of data architecture for grid model data management • Initial set of deep-dives with utilities exploring existing practices Development of initial Reference Model coordinated with the IEC CIM • Utility engagement in use of 360-degree imagery and machine learning for asset identification • Outreach to related tool vendors and to interested industry groups	• Completion of utility deep-dives • Validation of Reference Model through deep-dive use cases and industry review • Initial mapping of project Reference Model to IEC CIM • Socialize GMDM data management architecture • GIS/grid model management tool requirements • Standards gap identification	• Utility and vendor demonstrations • Continued sharing of project results at industry events • Exploration of data management architecture support for mobile and extended reality (XR) applications	Socialize GMDM data management architecture Expanded standards definition for network model exchange with field applications
SUPPLEMENTAL –**3002017776** GRID MODEL DATA MANAGEMENT (GMDM) VENDOR FORUM			
Tech Transfer Outreach to Vendor Community via Conference Events, Webcasts	• Improvement of the GMDM data management architecture via vendor review and feedback • CIM standards development to address gaps identified by GIS/GMDM project	• Demonstration of multi-vendor interoperability using the GMDM architecture • Improved CIM support for distribution network model data exchange	Deeper harmonization of CIM with OGC standards

VALUE

Practical insight into the requirements imposed by various advanced distribution planning analytics on the GIS and related applications; awareness of methodologies working well at other utilities; recommendations that can be incorporated into distribution planning investment roadmaps.

DELIVERABLE TYPE

Survey, workshops, and research reports

ARP PROJECT

P161.061: Geographic Information (GIS) Analytics and Visualization

TIES TO OTHER PROGRAMS

Distribution Operations and Planning (P200), and Understanding Electric Utility Customers (P182) Programs

Glossary and Acronym Definitions

A
AI: Artificial Intelligence
AMI: Advanced Metering Infrastructure
AR: Augmented Reality
AREA: AR for Enterprise Alliance
ARML2.0: OGC Augmented Reality Markup Language

B
Backhaul: The backhaul portion of the telecommunications network comprises the intermediate links between the core network, or backbone network and the small subnetworks at the "edge" of the entire hierarchical network
BIM: Building Information Modeling
BlockChain: A distributed database that maintains a continuously-growing list of ordered records called blocks

C
CAD: Computer Aided Design
CBRS: Citizens Broadband Radio Service, is a 150MHz broadcast band of the 3.5 GHz band (3550MHz to 3700MHz) historically used by the United States government for radar systems
CE: Carrier Ethernet
CE: Customer Edge (Telecommunications)
CIM: Common Information Model
CityGML: Is an open standardized data model and exchange format to store digital 3D models of cities and landscapes. It defines ways to describe most of the common 3D features and objects found in cities (such as buildings, roads, rivers, bridges, vegetation and city furniture) and the relationships between them.
CIP: Critical Infrastructure Protection

D
DER: Distributed Energy Resources
DERMS: Distributed Energy Resource Management System
DLMS: Device Language Message Specification
DLMS/COSEM: IEC series of standards specifying electricity meter data exchange
DMD: Distribution Modernization Demonstration
DMS: Distribution Management System
DOE: Department of Energy
DR: Demand Response
DTTV or DTT: Digital terrestrial television, sometimes also abbreviated

E
EA: Enterprise Architecture
eMBB: Enhanced Mobile Broadband
EMS: Element Management System
EPRI: Electric Power Research Institute
EAP: Extensible Authentication Protocol

F
FAN: Field Area Network
FCC: Federal Communications Commission

G
GIS: Geospatial Information System
glTF: Derivative short form of GL Transmission Format
3GPP: The 3rd Generation Partnership Project
GMDM: Grid Model Data Management
GSMA: Global System for Mobile Communications Association is a trade body that represents the interests of mobile network operators

I
ICT: Information and Communications Technology
ICIC: Inter-Cell Interference Coordination is defined in 3GPP release 8 as an interference coordination technology used in LTE systems. It reduces inter-cell interference by having UEs, at the same cell edge but belonging to different cells, use different frequency resources
IEC: International Electrotechnical Commission
IETF: The Internet Engineering Task Force is a large, open international community of network designers, operators, vendors and researchers concerned with the development of the architecture of the Internet and the related protocols for transport over the Internet.
IoT: Internet of Things
IIC: Industrial Internet Consortium
IndoorGM: is an OGC standard for an open data model and XML schema for indoor spatial information. It aims to provide a common framework of representation and exchange of indoor spatial information. It is defined as an application schema of OGC Geographic Markup Language (GML) 3.2.1.
IPv4: Internet Protocol version 4
IPv6: Internet Protocol Version 6
ISOC: Integrated Security Operations Center
IT: Information Technology

L
LAA: License Assisted Access
LiDAR: which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.
LMR: Land mobile radio
LTE: Long-Term Evolution
LEAN: The Lean concept of Gemba (Japanese for "go and see")

M
MOM: Message-oriented middleware
MPLS: Multi-Protocol Label Switching

N
NAN: Neighborhood Area Network
NB-IoT: Narrowband Internet of Things
NFV: Network Functions Virtualization
NOC: Network operations center
NREL: National Renewable Energy Lab
NLOS: Non-line-of-sight
NTest FiberWatch™: NTest Inc., Develops and manufactures FiberWatch™, the world's leading Remote Fiber Test System (RFTS) that monitors the physical integrity of fiber -optic networks
NYSERDA: New York State Energy Research and Development Authority

O
O&M: Operation and Maintenance
OpenADR: Open Automated Demand Response
OpenFMB: Open Field Message Box
OGC: Open Geospatial Consortium
OSP: Open Settlement Protocol
OT: Operational Technology

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

Q
QoS: Quality of service
QA/QC: is the combination of quality assurance, the process or set of processes used to measure and assure the quality of a product, and quality control, the process of ensuring products and services meet consumer expectations.

R
RAN: Radio Access Network
R&D: Research and Development
RF: Radio Frequency includes frequencies from 3 KHz to 300 GHz
RF Mesh: A globally recognized wireless network model, the consists of flexible radio nodes that operate in a self-guided, resilient manner.
RFP: Request for Proposal

S
SAS: Spectrum Access System, as in the context of spectrum sharing
SDN: Software-defined Networking
SIM: Subscriber Identity Module
SDR: Software Defined Radio

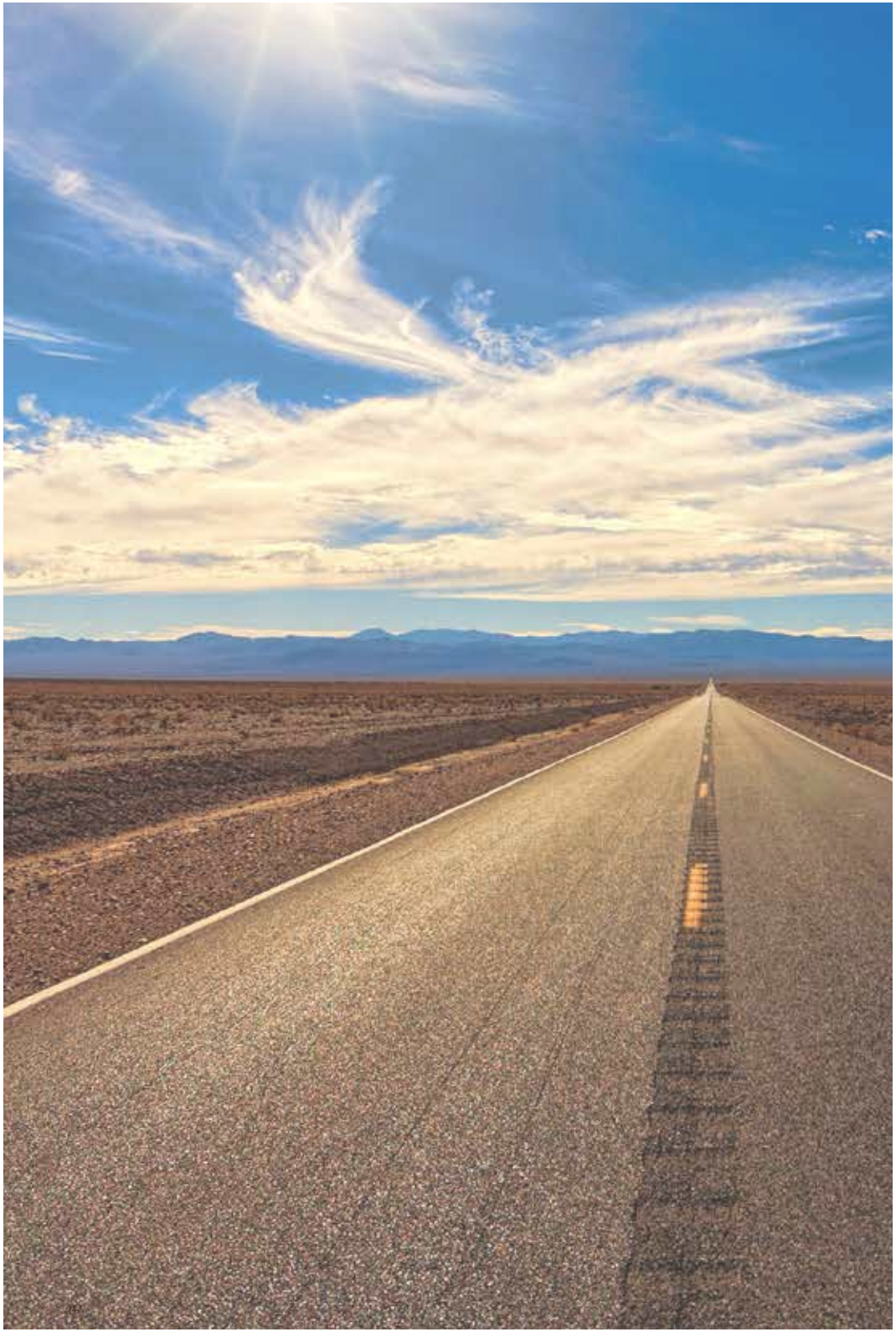
T
T&D: Transmission and Distribution
TDM: Time-division multiplexing

U
UAS: Unmanned aerial system
URLLC: Ultra-reliable low-latency communication
UTC: Utilities Technology Council

V
VR: Virtual Reality

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

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



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