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making connections

asset management and the smart grid

ASSET MANAGEMENT IS MORE important than ever for electric utilities. Many power systems have assets that are aging, investment is limited, and at the same time we are introducing new technologies on the grid that must be maintained as part of overall asset management systems. Investment in new monitoring and communications infrastructure (often referred to as the smart grid) is opening new opportunities for improved asset management strategies. However, the smart grid is also introducing new challenges in the management, integration, and analysis of tremendous amounts of data that can be available. This issue explores the relationship between the smart grid and asset management—new technologies, systems, opportunities, challenges—and approaches being taken around the world to deal with the new asset management challenges.

One of the key challenges in taking advantage of the smart grid for asset management applications is the integration of data and information from a wide variety of systems. The National Institute of Standards and Technology (NIST) developed a framework for interoperability of smart grid systems and technologies (see the conceptual model for this framework in Figure 1). The framework identifies multiple "domains" associated with the smart grid. Interoperability of systems is required both within individual domains and across domains. Asset management functions primarily fall into the operations domain, as shown in Figure 2 from the interoperability framework. The assets themselves are part of the generation, transmission, and distribution systems—the challenge is taking advantage of investments in sensors, communication infrastructure, and information management systems across these domains to optimize the asset management function.

The asset management function is a decision-making process that involves balancing of conflicting drivers:

- ✔ cost (of assets, of replacement, of maintenance)
- ✔ performance (efficiency, impact on reliability, impact on security)
- ✔ risk (of failure, of reliability impacts, of security impacts).

Understanding and characterizing these drivers across the life cycle of assets is the primary challenge of asset management, and this is where the smart grid can help. We have compiled a variety of contributions that will help us understand how new technologies such as sensors, new communication infrastructures, new information systems, and new analytics are helping improve the overall asset management functions. We will start with overview discussions of how the smart grid impacts asset management approaches.

Ron Wallace, from IBM, provides an introduction to the overall issues and importance of the smart grid in the first article. The concept of "service management" for the smart grid provides a framework for improving the asset management function. The smart grid enables on-demand access to data and information that is used to better manage, automate, and optimize operations and processes throughout the utility. There are numerous systems that must work together in the smart grid—the old model of point-to-point integration of these systems is giving way to the concept of an enterprise service bus. A service management platform provides a way for utility companies to manage the services they deliver with their enterprise and IT assets. It provides a foundation for managing the assets, their configuration, and the interrelationships that are key to delivering services. It also provides a means of defining workflow for the instantiation and management of the services being delivered. Gathering and analyzing data from advanced meters, network components, distribution devices, and legacy SCADA systems provides a solid foundation for automating service management. When combined with the information available in their asset management systems, utility companies can streamline operations and make more efficient use of valuable resources.

In the next article, we look at the example of Long Island Power Authority (LIPA), courtesy of Michael Hervey and Predrag Vujovic. LIPA operates with a business model of fully outsourcing its electric business operation, including system operation and its asset maintenance. LIPA is the owner of the assets and shares the role of asset manager with a service provider. This

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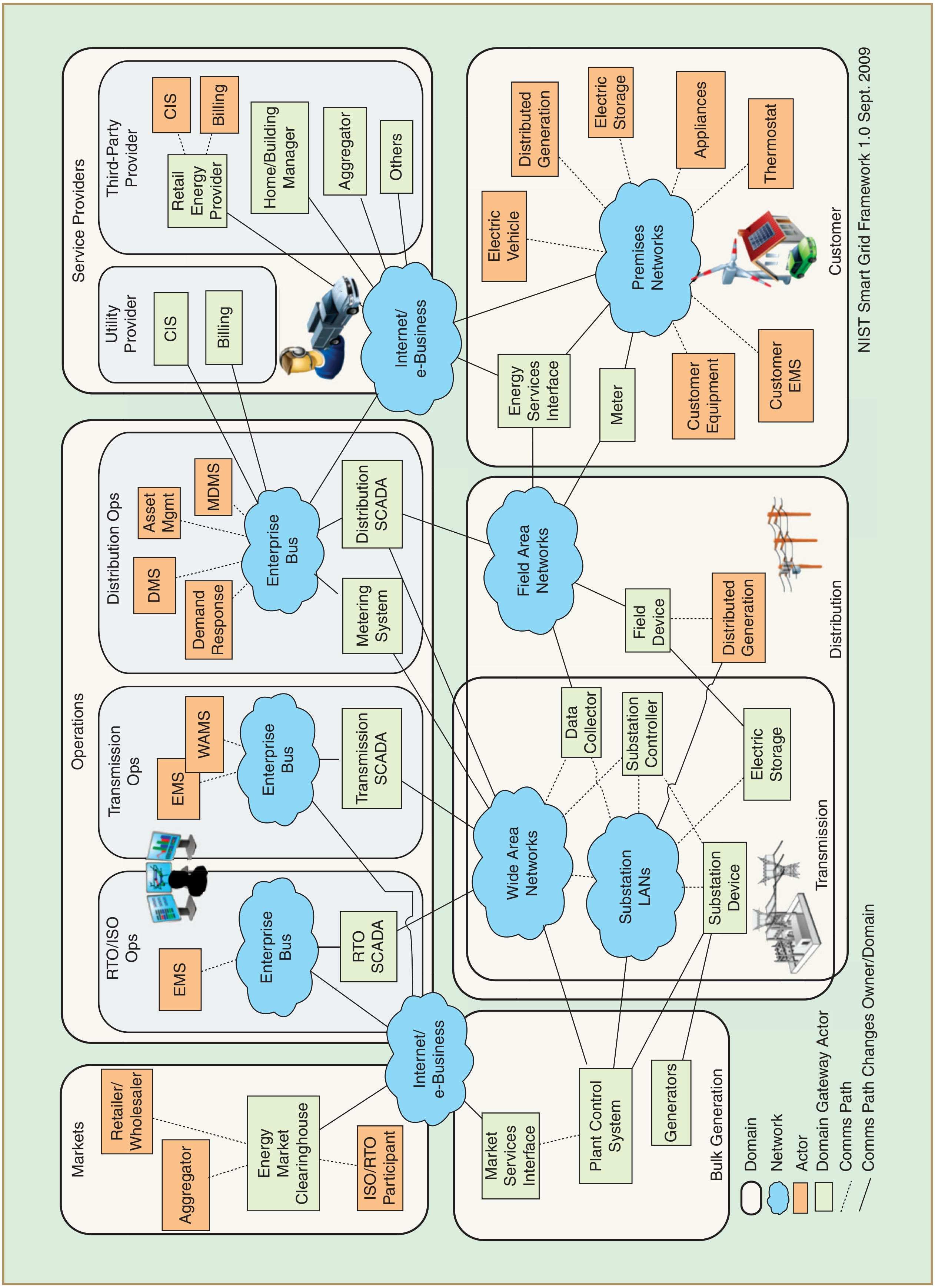
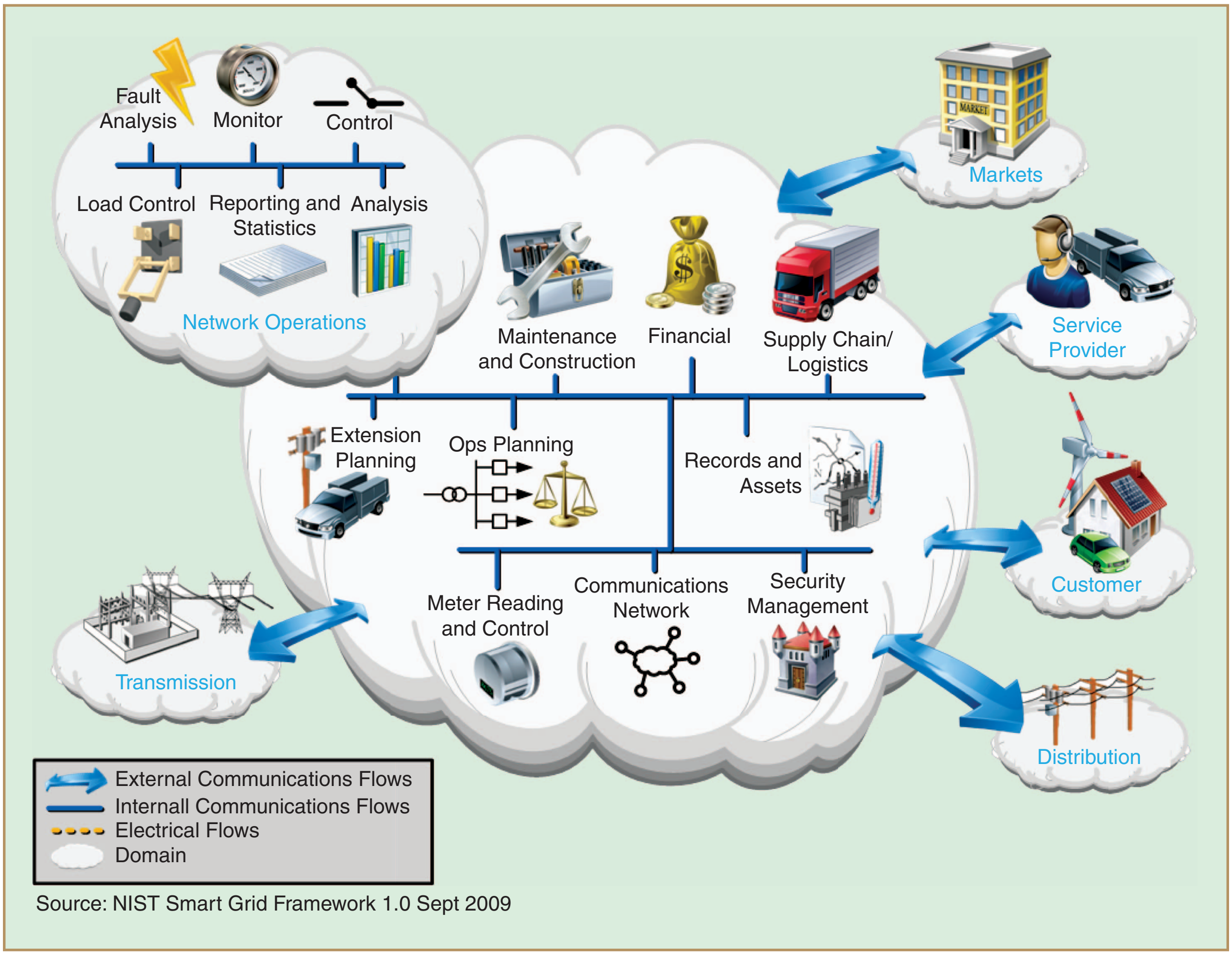


figure 1. Conceptual model for interoperability of smart grid systems. (Used with permission from NIST.)



Source: NIST Smart Grid Framework 1.0 Sept 2009

figure 2. Operations domain from the NIST interoperability framework. (Used with permission from NIST.)

adds complexity in managing data and critical IT systems for managing assets and operating the grid. This is one of the reasons that LIPA decided to develop and implement a comprehensive and strict enterprise information management (EIM) strategy, along with the supporting business processes. At the core of the system is a common information model (CIM)-based enterprise semantic model (ESM), customized software development life cycle (SDLC), process templates, and LIPA's IT technical architecture design. Data modeling and technical architecture are based wherever possible on open design concepts with standards-based solutions aiming to achieve "near-plug-and-play" interoperability for future data and systems integration. This system is a model for interoperability of systems in the context of the smart grid.

Mladen Kezunovic has been working on the next generation integration of substation data for many years at Texas A&M. Integration of data available from Intelligent Electronic Devices (IEDs) like digital relays and digital fault recorders (DFRs) can support advanced asset management and system operations functions. Taking advantage of industry standards for substation integration like IEC 61850 and the CIM, data management and data processing functions can be defined which use the integrated data for advanced applications like fault location and circuit breaker maintenance.

Sean Gregerson moves from the substation data integration requirement to the data integration needs at the enterprise level. The potential for advanced applications that can take advantage of intelligent monitoring devices and widespread sensors is tremendous. However, there must be systems to collect, archive, and analyze the information these technologies provide. Online equipment condition-monitoring technologies are a critical part of an overall asset management strategy in the smart grid, and these systems must take advantage of advanced data management systems. Today's data management solutions involve data historians that can manage and process tremendous amounts of data, maintain the resolution of the data, and provide convenient access to the data for advanced applications and visualization tools.

Bhavin Desai leads a significant research effort at the Electric Power Research Institute (EPRI) that focuses on assessment of asset health, asset databases, and asset performance. Bhavin has coordinated two contributions for this issue that deal with next-generation approaches for asset management in substations. In the first contribution, Bhavin, along with Matt Walther and James Haufler, outlines a new risk-based management approach for circuit breakers that is being implemented at Con Edison. Circuit breakers can be a significant component of a utility's maintenance budget. Many utilities have moved away from traditional maintenance approaches that are based on time and number of operations and moved towards reliability-centered maintenance (RCM) and condition-based maintenance (CBM) approaches. The article describes a new circuit breaker maintenance ranking (CBMR) tool that ranks the need for maintenance based on operating environment, life history, and other factors, enabling users to identify high-risk units. Focusing limited resources on high-risk units is far more cost effective than inspecting an entire circuit breaker population in which most units are in good operating condition. This approach uses readily available data from utility historical records, computerized maintenance management systems, and rating guides. Algorithms have been developed that combine standard operating and maintenance information along with information about breaker application and design to provide meaningful, risk-based inferences on a continuing basis about the equipment's expected condition and need for maintenance. The Con Edison application of this ranking and risk assessment approach is highlighted to illustrate the savings that can be achieved.

The second article that Bhavin coordinated, with Michael Lebow, deals with transformer ranking and performance assessment. Transformers are often the most expensive assets in substations, and tools for risk and performance assessment can be especially valuable in prioritizing maintenance as well as identifying potential problems. These risk and performance assessment tools can be integrated into smart grid implementations, making information from these tools available to the parts of the company that need it and enabling decision making based on the tools. The article describes a set of algorithms that provide information based on actual equipment condition, maximizing the value of data most utilities already collect—these are referred to as analytics for substations asset performance (ASAP). These tools must account for the time dimensions of risk; the dynamics of equipment state changes; the assessment of hypothetical risk mitigation approaches; and differences in operating practices, business rules, and philosophies. Even with all these factors and variables, it is important that the tools allow for quantitative risk assessments where appropriate. The approach is illustrated using transformers as an example. The methodology ranks transformers based on their operating environment and life history, weighing factors such as thermal life consumption, lightning exposure, short-circuit magnitude and duration, oil test results, and connected load criticality. The ranking enables identification of high-risk units for more detailed testing and analysis. Focusing critical resources on high-risk units is far more cost effective than providing the same level of review for an entire transformer fleet, in which most units are in good operating condition. This approach uses readily available data from utility historical records, computerized maintenance management systems, and test results.

There is no question that a better understanding of asset condition can support better decision making with respect to asset maintenance and replacement. A critical area of development to support better asset condition assessments is in the area of sensors. This is a topic where new technologies are being applied to power system applications in very exciting ways. EPRI has an extensive research program around advanced sensors and is demonstrating many new technologies in actual field applications. Some of the most exciting advancements are described in the article by Andrew Phillips, who directs this research area. His coauthors in this article are Sanjay Bose and Bruce Rogers. These advancements include the following:

- ✔ **Backscatter sensors.** These are sensors that use the same technology as inventory management systems for large department stores and the same technology as the easy pass lanes on the highway, radio frequency identification (RFID). Current or temperature sensors are embedded on a chip with RFID technology so that insulators, arresters, or any other asset can be interrogated remotely to determine information about the condition.
- ✔ **Antenna array.** Antenna arrays can be configured in a substation to detect electromagnetic interference and triangulate to the exact location where the interference is coming from. This allows detection of arcing conditions before the condition results in device failures.
- ✔ **Three-dimensional acoustics.** Acoustic sensors can provide a three-dimensional picture of where arcing is coming from inside a transformer. Pinpointing the location of the problem can help determine the best approach for maintenance and solving the problem quickly.

- ✔ **Online frequency response analysis (FRA).** FRA has been used for many years to help determine the condition of transformer windings over time. Applying this technology online for the continuous assessment of transformer condition can provide extremely valuable information about transformer condition without taking the transformer out of service.
- ✔ **Online infrared inspection.** Many equipment problems are related to heating. Infrared inspections are a traditional way of identifying problem conditions. Developing online infrared inspection systems that monitor for arcing and overheating will provide an extremely valuable tool for continuous assessment of asset condition.

Of course, all these new sensor technologies need communications and advanced processing support to be valuable for asset management applications. This is where integration with smart grid technologies comes in—turning the data from sensors into information that can be used for decisions.

The next article takes us from the substation out onto the distribution system. The BC Hydro Distribution Maintenance staff put together a description of the distribution asset strategy and planning (DASP) process at BC Hydro. The document is edited by Ed J. Mah. The article describes the processes and tools used by BC Hydro to plan for the maintenance and replacement of existing assets. These processes focus on the development of long-term plans for maintaining reliability, related to the ongoing maintenance requirements of distribution equipment as well as anticipated end-of-life of BC Hydro's aging asset base. DASP uses a structured process to develop plans for distribution asset maintenance and capital replacement—set objectives; define asset performance; assess condition; build plan; and execute plan, evaluate effectiveness. This structured approach to distribution asset management is an example of industry best practices that can be a valuable example for many utilities.

The distribution asset that receives the most attention from an asset management point of view is the tremendous amount of underground cable installed as part of distribution infrastructure. Cable systems are a difficult asset management challenge—there are aging issues, many factors affect performance, monitoring is difficult, and maintenance is both difficult and expensive. Matt Olearczyk directs the distribution cable research at EPRI, Nigel Hampton is the program manager for reliability research at NEETRAC, and Josh Perkel is a research engineer in the assessment group there. EPRI and NEETRAC have been collaborating to advance the state of the art in cable diagnostics and also to characterize the performance of existing cable diagnostics tools. The article describes the latest research results in the area of cable diagnostics, testing, maintenance approaches, and risk assessment. Neil Weisenfeld, director of the cable testing facility at Con Edison, adds a perspective on the value of cable testing and continuous assessment of cable failures to understand causes and to better assess risk of failure in existing cable systems.

One of the most significant investments in the smart grid is advanced meters. Advanced metering is being deployed to reduce costs of meter reading, to allow implementation of dynamic rates, and to help customers save energy through better information about energy use. However, advanced meters can also be valuable to enhance asset management on the distribution system. One example of how advanced meters can help improve distribution asset management is with distribution transformers. This application was demonstrated by Philadelphia Electric and is described by Glenn Pritchard. This could become increasingly important with increased penetration of electric vehicles in the future. Many other applications of the tremendous amount of data available from advanced meters can be envisioned.

Finally, Olivier Huet, Christian Guillaume, and Christophe Gaudin from EDF provide a European perspective and describe a particular collaborative initiative that is designed to improve asset management practices and strategies for all of the collaborative members. The initiative is called SmartLife and is designed to coordinate transmission and distribution asset management activities across a number of European utilities. It has two main objectives:

1) Optimize the management of (aging and future) assets using a primary criterion of maximizing the value in terms of performance compared to the renewal cost.
2) Modernize the grid through innovations.

The initiative was started in 2009, and there have already been important lessons related to asset performance and aging.

In the "In My View" column, Paul Myrda from EPRI provides the editorial perspective for the issue, focusing on the need for interoperability and data management to achieve asset management objectives in the smart grid. This is the way we started our discussion with the emphasis on interoperability established in the NIST smart grid interoperability framework, and Paul reinforces this message that the smart grid will only enable new functionality for asset management if we make sure that we take advantage of the wide range of systems that will have valuable information for asset management functions and make sure that we can manage the data from these disparate systems effectively.

Thanks to all of the authors for bringing together this variety of perspectives on a critical topic for the electric power industry.