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Convergence of OT, IT, and Digitalization

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Abstract

Salt River Project (SRP) is experiencing a significant Energy Transformation, driven by the transition to renewable energy resources, electrification, deployment of distributed energy resources (DER), the emergence of western energy markets, and new technologies supporting near real-time analytics, automation, and artificial intelligence (AI) paralleled by a Digital Transformation. This presentation will explore the convergence of Operational Technology (OT) and Information Technology (IT), emphasizing both the opportunities and challenges this transformation creates. Particular attention will be given to the business-side complexities of digitalization, where siloed and overlapping data sources often hinder integration and limit value creation. Practical considerations and strategic approaches will be highlighted to demonstrate how organizations can overcome these barriers and realize the full potential of OT/IT convergence.

Introduction

In a power industry increasingly driven by computers and software, digital transformation is an often-used term that refers to the transition of traditional processes to those that use digital technologies. This transformation has been ongoing for decades, as paper records gave way to databases, mechanical devices were replaced by microprocessor-driven ones, and hand-written calculations evolved into spreadsheets and specialized software tools.

More recently, digital transformation has centered around data-driven decision making and its applications, particularly as technology has evolved to support growth of the volume, quality, and accessibility of data. Enhanced monitoring, communication, and data systems have enabled increasingly sophisticated control and operations strategies, impacting long-established paradigms in the power grid.

Despite these changes, the basic structure of grid has remained relatively constant: customer loads are connected through the distribution and transmission network to generation resources and markets. Instead, the drivers for these changes have been associated with the energy transformation, as traditional generation sources and operating models evolve to accommodate new technologies and a more decentralized and flexible grid.

These developments have been underpinned by digital technologies, which have required new processes, infrastructure, tools, and ways of thinking to leverage effectively. The convergence of Information Technology (systems that manage data, information, and business processes) and Operational Technology (systems that monitor and control physical processes) has become increasingly critical, as this digital transformation calls for greater integration of both data and grid operations.

Transformation Drivers

At Salt River Project (SRP), the primary drivers of change stem from the energy transformation, impacting nearly every element of the power system ecosystem. Changes in customer usage patterns, driven by electrification and the growing adoption of technologies such as solar, storage, and microgrids, coupled with the integration of inverter-based resources on the bulk electric system along with larger commercial and industrial loads, have resulted in dynamic variability of both electricity supply and demand which introduces a greater need for system flexibility.

Energy demand growth is another significant driver for change at SRP, with a projected increase of more than 50 percent over the next ten years. Coupled with the shift toward renewable energy—requiring a higher proportion of inverter-based resources such as an additional 12 GW of solar by 2035—system nameplate capacity is expected to approximately double to meet this growth. SRP anticipates a substantial challenge over the next decade to execute this level of investment, alongside corresponding demands on engineering, planning, and operational capabilities.

In addition to growth itself, the opportunity to integrate electricity markets and grid operations across the western United States, Canada, and Mexico places further demands on SRP's operations, engineering, and planning capabilities. This western market integration requires increased interoperability between utilities and entities, particularly in data sharing, energy management systems (EMS), market systems, and forecasting tools.

Finally, increasingly extreme weather events, and growing physical and cyber security threats, have driven the need for improved system resiliency. Beyond physical hardening and system diversification, the need for more operational flexibility and visibility calls for greater data capabilities in situational awareness, forecasting, grid operations, and resource planning.

Across all of these drivers, data and digital technologies play a central role in enabling the coordination, control, and operational capabilities required to address them effectively. In particular, data-driven decision making will become increasingly critical as system requirements and operating paradigms continue to evolve. Advances in analytics and artificial intelligence are well positioned to support this transition, enabling greater automation, deeper data integration, and more adaptive grid operations.

Challenges – Past, Present, and Future

The central role of data in enabling grid transformations naturally points to the need for a unified platform that supports integration and data exchange across systems. However, utilities have traditionally been slow to adopt more integrated data models, as challenges in data quality and

alignment, responsibilities for governance, and cybersecurity considerations have been barriers to successful implementation.

Utilities have historically been risk-adverse, and a culture focused on safety and reliability has often led individual departments to prioritize established proven practices over broader and more collaborative changes [1]. As a result, data has historically been generated and managed within departmental silos, with each team maintaining practices, methodologies, and data sets according to their own engineering or technical needs. This approach generally results in fragmented data with some degree of redundancy, and ambiguity over which set is truly representative of the system.

Efforts to develop a unified, system-wide view, or use data from multiple departments for holistic analytics and decision-making, can be challenged by inconsistent conventions (naming and references) across departments that are complications to effective alignment. The limitations of these siloed data sources become more pronounced as greater integration is desired, and can often require large-scale cleanup or transformation efforts prior to use.

Beyond technical aspects of the data itself, organizational responsibilities and questions of ownership can add additional friction, particularly given the importance of long-term governance to keep data usable. One-time cleanup or transformation efforts are of limited benefit if required conventions cannot be maintained over time.

Cybersecurity has increasingly been a pervasive consideration in the development and use of digital technologies, especially as integration and accessibility are required across a broader range of users and geographical locations. Addressing cybersecurity challenges requires a combination of technical controls, a culture of security consciousness, and designated mechanisms that facilitate sharing data with approved vendors and internal parties.

Finally, a shift to digital technologies requires a workforce with a data and automation-minded outlook to effectively use. Future engineers and utility personnel will need to be proficient in maintaining data conventions, in addition to their traditional areas of expertise. While these resources are becoming less constrained as automation and software technologies before more central to utility operations, the power industry as a whole is still adjusting to becoming data managers as well as engineers.

IT/OT Convergence Strategy

The implementation of digital transformation initiatives increasingly requires the fusion of Information Technology (IT) and Operational Technology (OT) to enable data-driven decision making and grid controls. Although both environments have typically evolved independently due to different priorities, the emerging need for capabilities that combine real-time sensors and

controls with traditional data systems necessitate more deliberate coordination and planning between the two. This convergence can impact almost every aspect a utility's operations, from Grid Operations (EMS and SCADA integration with IT data and analytics platforms) to Cybersecurity (increased exposure across substations and field assets) to Business and Customer Systems (billing integrated with grid data). Each of these integrations between IT and OT realms and systems will require careful consideration to enable compatibility in data, operations, and security.

At SRP, like most utilities, this is a long and never-ending journey. While the IT/OT convergence has been happening for many decades, the pace of change has been accelerating and the need to evolve organizational capability is becoming more critical. This realization became evident about 6 years ago and led to a strategic goal to establish a formal OT Strategy & Governance program [2]. OT organizations had previously evolved organically and resulted in a reactive and fragmented approach that limited orchestration with the IT and Cyber Security organizations. The development of this program was a unified effort across the business, OT, IT and cyber security organizations and centered across three key pillars.

The first pillar was the establishment of governance, so each entity had representation and there was a means to make decisions.

The second pillar focused on integrated planning and developed a common roadmap across technology domains. Initially, this roadmap highlighted existing and planned projects and allowed the organization to better align these efforts and identify gaps. Annual iterations have incrementally improved the orchestration of a holistic view across the wide body of work.

The third pillar is the most important and focused on the workforce across three key areas: organizational design, resource strategy and employee development. The initial priority was to define clear organizational roles and responsibilities which lead to a project called "OT Transformation" and resulted in improved alignment across the organization.

A critical success factor for this transformation included commitment to several guiding principles. One key principle centered around functional alignment of roles and standardization of process while balancing continued specialization for critical OT functions against consolidation of common services and support for an enterprise view.

At the heart of this enterprise view is the leveraging of data as a strategic asset. This principle is supported by several projects worth noting within the OT Roadmap.

- The data initiative includes multiple projects centered around improving data management capabilities including architecture, modeling, integrity, integration and analytics.

- A grid modeling strategy was established that includes development of a standard CIM-based grid model that will be used for multiple purposes related to planning, engineering and operations across generation, transmission and distribution.
- A Protection, Automation & Control (PAC) Digital Transformation program to better manage configuration and operational data across our fleet of intelligent field devices, while better enabling device management, compliance and analytics.
- The execution of a Substation Virtualization strategy to virtualize protection and control logic within substations that will enable more visibility and advanced data analytics for the electric grid.

The SRP OT Strategy & Governance Program has been an important step to allow SRP to manage a more complex and quickly changing electric system. However, like many journeys, this is only a step and there is much more that will be needed to enable the electric system of the future.

Practical Considerations and Strategic Approaches

Once an overall digital transformation and IT/OT convergence strategy has been established, effectively applying it to specific initiatives requires more detailed considerations for approach, scope, and implementation planning. Although the term digital transformation is often associated primarily with automation, a comprehensive approach must also account for supporting elements such as people, process, governance, and data. Moving directly into transformation initiatives without addressing these factors increases the risk of siloed and fragmented outcomes – mirroring many of the challenges these efforts are intended to resolve.

Clear scoping is critical to prevent uncontrolled expansion of effort, particularly when multiple departments are involved. Large initiatives involve numerous moving parts, making it essential to define objectives, target capabilities, supporting tools and systems, and extent of data and integration required to drive the capabilities. Properly establishing scope and boundaries allows initiatives to be planned effectively and helps avoid unchecked expansion, redundancies, and siloed implementations (such as overuse of single-objective dashboards). Finally, effective scoping also identifies which departments must be involved in the initiative, enabling team alignment, clear accountability, and development of an appropriate governance plan. This is especially important given the continued trend for IT/OT convergence. Both teams must be involved in transformation initiatives, with clearly defined roles and responsibilities.

Building upon clear scope, the development of an implementation plan provides a foundational roadmap of efforts and tasks while minimizing uncertainties, redundancies, and oversights. Transformation initiatives can encounter challenges or friction when implementation progresses from one target capability to the next without deliberate consideration of requirements,

transitions, and interdependences between tasks and solutions. Comprehensive planning helps address persistent challenges, including differences in data and capabilities between departments, inconsistency in data sources and long-term governance practices, and potential redundancy in overlapping, or outright contradictory, efforts.

This planning typically covers the following aspects:

- Assessment of the current state of capabilities and supporting elements, identification of gaps and areas of improvement, and evaluation of solutions within the transformation initiatives.
- Evaluation of existing tools and systems to determine whether they can achieve the desired capabilities; if not, identification of appropriate expansion or replacement solutions aligned with the initiative strategy and logistical considerations (costs, effort, and resource requirements).
- Development of an implementation roadmap, outlining task sequencing and progression, buildout of capabilities, integration for data and process, and involvement of teams.
- Ongoing revision to the roadmap throughout the implementation process to accommodate shifting priorities, emerging challenges, and external factors.

While the specific tasks and sequencing within these implementation plans will vary by utility, several common elements have consistently emerged across multiple transformation initiatives. First, data serves as a foundational driver of most digital solutions, and achieving data readiness – particularly across multiple sources or departments – often requires additional cleanup, processing, or collection efforts to ensure alignment and reliable utilization. Second, processes must be clearly defined to establish how solutions are used within broader workflows, particularly in relation to adjacent tasks and responsibilities. Finally, adoption by utility personnel – along with clearly defined accountability and governance responsibilities – is essential to prevent solutions from becoming underutilized or abandoned. Although the methods for addressing these elements may differ based on each utility's structure and conventions, including them into the implementation plan ensures they become an integral part of the transformation initiative.

SRP's transformation initiatives incorporate both the scoping and planning considerations described above. This approach provides a solid foundation and plan for implementation, while ensuring alignment with the overall OT Strategy and Governance Program, as well as departmental needs and goals.

Implementation and Lessons Learned

Transformation initiatives across North American utilities have revealed a number of recurring friction points. Although these are generally considered in some form at the planning stage, addressing them can be a significant challenge during actual implementation efforts.

Data underpins nearly all digital solutions, yet its complexity and quality are often underestimated. Factors such as existing state (form and format), quality (consistency and completeness), alignment mechanism (commonality between sources), and availability (accessibility for applications) will impact the readiness and reliability of its use to drive target capabilities. As a result, most software initiatives begin with an assessment of data readiness and identification of the measures needed to enable consistent and reliable use. These often lead to data cleanup initiatives to correct naming conventions, formats, alignment mechanisms, or supporting metadata. For example, applications that require data from protection device settings repositories require reliable methods to identify system elements (substations, lines), devices (relays), and settings revisions (files).

Beyond single sources, alignment for multiple sources requires a consistent mechanism to link equivalent data elements. For example, the name or identifier of a transmission line must be consistent across systems – an alignment that is not always present within utility data. Addressing these discrepancies often requires implementation of an intermediary translation layer to establish equivalency between different sources. Alternatively, some organizations, including SRP, have chosen to modify source data directly to a defined standard, enabling automatic alignment. While this approach introduces additional governance and maintenance requirements, automatic alignment also significantly reduces downstream friction and complexity when actually utilizing the data.

Where significant gaps exist, large-scale data collection efforts may be needed. Proactive consideration of intended applications and use cases for the data at the planning stage can ensure that necessary data is collected comprehensively in a single effort, rather than needing subsequent collection initiatives to address missing data. Further, data collection strategy may call for additional infrastructure, particularly when field visits are required. For example, a large-scale data collection initiative at one utility involved site visits to numerous substations to document protection equipment (including photographic evidence). Successfully executing this effort required both a centralized data collection platform integrated with mobile devices, and a clearly defined set of collection parameters aligned with the intended downstream applications.

Beyond data, workflow processes are often overlooked, as implementation efforts tend to focus on the solutions themselves. However, effective solutions must satisfy more than their own technical and data requirements; they must also support the broader tasks, responsibilities, and workflows they are intended to enhance. How a given solution integrates with other processes (existing or projected) – where it fits within the end-to-end workflow – is a critical factor in successful adoption and continued use by utility personnel. When this alignment is insufficient,

even technically effective solutions may struggle to see long-term continued use. For example, automation-assisted protection modeling and simulation tools can offer significant benefit to relay settings, compliance, and wildfire mitigation measures; however, without consideration for short-circuit model update and relay deployment processes, these solutions may become much less effective or even seen as a burden by the team.

Equally crucial to data, processes, and technical capability, personnel considerations can be given insufficient attention in favor of more direct factors. Team agreement and buy-in are crucial to successful adoption of solutions, especially teams that may span multiple departments. As an operational concern, expertise gaps in team members need to be identified early, with mitigation measures in place to avoid omission of crucial data or capabilities. For example, the different attribute needs for load flow and short-circuit studies typically result in incompatible system models between Transmission Planning and Protection/Control departments. Consolidation of modeling responsibilities into a single team requires consideration for the needs and practices of both departments.

In addition to needing cross-departmental buy-in, engineers and technical staff within individual departments must also commit to adopting the implemented solution. As utility personnel are increasingly tasked with additional responsibilities, the burden of adoption associated with new solutions needs to be carefully considered. Teams need to understand the value proposition of any given solution, especially if they reduce the overall time and effort rather than add complexity to their workload. One organization has addressed this challenge through an incremental improvement approach [3]. Solutions are introduced in a gradual manner, allowing engineers to build familiarity and competency before additional capabilities are deployed. This phased approach helps reduce resistance and friction to the new solutions and promote more sustained use.

Finally, long-term governance is generally acknowledged, but not specifically addressed in detail. This factor can run a gamut of aspects, including data updates and continued data quality and alignment, maintaining solutions and interfaces through technical and software evolutions, long-term roles and responsibilities among personnel, and continued upgrades to capabilities and data. For example, some organizations have adopted tighter data input standards and controls to ensure continued compatible formatting and alignment. Others have leveraged automation-based validation checks to identify data with invalid or unexpected formats or content, and as a means to continuously perform quality control on the data.

Conclusion

The power industry is undergoing significant change to support energy transformation, impacting nearly every element within the power system ecosystem. Utilities are increasingly turning to

digital solutions to help address these changes. As the transition of traditional processes to those that use digital technologies increase in complexity and scope, the need for convergence between Information Technology and Operational Technology will become greater, especially beyond simple automation. Clear scoping and implementation planning provide initiatives with structure and boundaries, representing a defined scope, team and responsibilities to avoid overlooked pitfalls such as redundancies and incompatibilities. Implementation efforts across North America have revealed recurring challenges in data readiness, workflow process definition, and team buy-in. These all serve as barriers to successful adoption of digital solutions, preventing the realization of the broader benefits of digital transformation and OT/IT convergence.

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