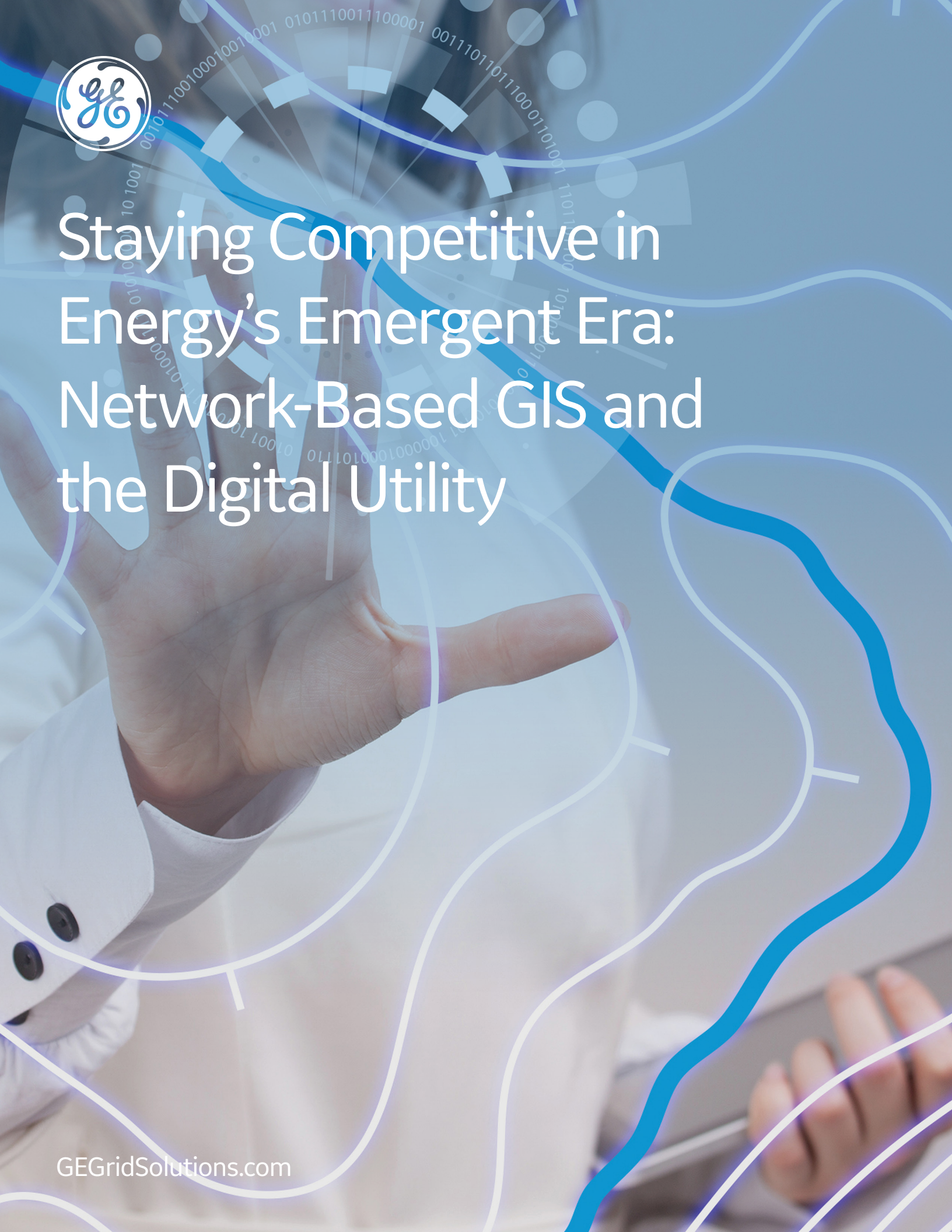

Staying Competitive in Energy's Emergent Era: Network-Based GIS and the Digital Utility

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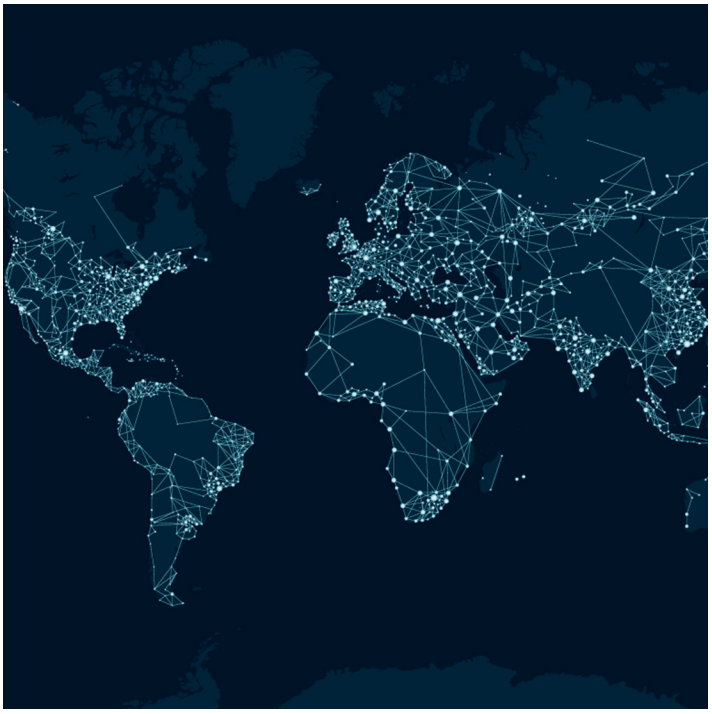

By 2019, utilities will need to learn how to integrate externally originated asset, market, and grids data and 30% will invest in Distributed Energy Resource Management Systems.[1]

The successful marriage of modern technology and geographic mapping has prompted an exponential jump in expectations regarding what can be known or anticipated about security, industry, scientific, humanitarian, and even human assets around the world. With increasingly powerful data analysis tools and insights from geographic information systems (GIS), everyone from industrial engineers to international relief organizations, from farmers to firefighters, wants to leverage location intelligence. Even the everyday Uber or Lyft user today expects the company to know exactly where she is and how long it will take for her ride to arrive. The hungry business traveler in a foreign locale expects to quickly find a restaurant nearby by viewing all of his options on a map.

Similarly, industry decision makers today want real-time access to the data needed to monitor, maintain, and update all assets — no matter how remote. Rich, accessible data is nowhere more important than in the energy sector, where every decision can impact network resilience, security, and safety.

Existing GIS systems seek to address these challenges. Traditional geospatial offerings enable grid planning, design, and construction as well as monitoring, and maintenance. But GIS mapping alone is no longer sufficient. The influx of information from distributed energy resources (DERs) is daunting — with physical and virtual assets deployed across the grid. Meanwhile, competitive advantage is found in aggregating DERs' potential capabilities to provide positive net value to the grid through avoided infrastructure investments, improved resilience, and clean energy integration benefits.

Energy sector network complexity is further exploding as the grid is redefined by increased regulatory pressures for reliability, safety, and efficiency, and the need to actively adapt to peak, outage, or curtailment needs. At the same time, a proliferation of interconnected smart devices are now capable of multi-directional communication providing greater visibility into the network. The utility is also expected to share data more quickly, publicly, and visually — and is facing increased public and shareholder scrutiny of asset optimization and existing processes and systems with an eye to improved service availability and reliability, energy efficiency, device life, asset utilization, and more.

Keeping pace with industry pressures, geospatial technology is evolving to offer increasingly detailed visualizations. Adding to the understanding of where all assets are on a GIS map, new software solutions provide added insight into each asset's health now, both historically and predictively. With the resulting fused data realized in a Network Digital Twin (NDT), utilities can analyze the impact of weather events or potential innovations to anticipate impacts all the way downstream to the customer level. For instance, the utility could capture average wind speeds at different heights as well as information about solar radiation, the electricity grid plan, transport infrastructure, and more to evaluate risks relating to a potential energy project investment.[2]

To further detail the ways in which a modern network-based GIS system is a key step in positioning the utility for digital transformation this paper will explore:

- Challenges with existing GIS systems
- The role of Network Digital Twin in utility transformation
- The GE difference
- Future directions for geospatial technologies

Ultimately, by integrating the grid with the high-end capabilities of geospatial technology seen in Network Digital Twins, utilities gain new opportunities to be creative and leverage the power of machine learning and artificial intelligence to influence asset maintenance, reduce operational costs, impact risk assessment, and improve change management. First, though, let's review the current reality utilities face with regards to geospatial technology and data insights.

Challenges with Existing GIS Systems

"Disruption" is the business buzzword of this decade, and the utility sector has been deeply impacted. Today grid management relies heavily on IT systems. Yet current environments often consist of several monolithic systems, and even multiple versions of each of these, which can complicate efforts to gain true insights into all of the subsets of tasks necessary to operate the grid and serve utility customers.

The utility looking to embrace digitalization seeks to rely less on individual experts and more on intelligent systems with an understanding of the grid built in. However, the nature of the existing systems and how people use them gets in the way. Operators use GIS to plan and update the normal state of the network. They use SCADA and distributions systems to monitor and manage the operational grid. An outage management system (OMS) assists with locating, assessing, and coordinating grid restoration efforts. The OMS/DMS may be combined into an Advanced Distribution Management System (ADMS), but to date many utilities have typically managed DERs independently with Demand Response Management Systems (DRMS) and Energy Management Systems (EMS), too. As a result, the grid software portfolio is a complex tool.

Specialists in each department rely on different systems and tend to have little or no knowledge of how other teams' systems contribute to overall operations and business processes. Communication across these silos is often suboptimal with information transfer most often relying on fragile transform techniques that are resistant to change. Often IT budgets drive change programs with the specific intent NOT to have any impact on other existing systems and thus not considering the wider business benefits that can be realized.

Recognizing the need to adapt to this changing environment is the first stage in developing a long-term cohesive strategy. The decision whether to replace an existing system or augment existing capabilities provides options for utilities at different maturity stages. The cost of migration and retooling needs to be offset against the long-term benefits of an integrated solution. Utilities must explore where existing solutions can be augmented with new innovations.

Taking an end-to-end approach is key to unlocking future potential, and when deciding which vendor to partner with, utilities should consider the vendor's experience in the energy sector, future investment plans, and ability to evolve as the industry changes.

Integrating with Network Digital Twin and other innovative technologies in a single portfolio provides an intelligent ecosystem to support modern grid simulations. With proven architecture, out-of-the-box integration, and system agnosticism, the right solution offers performance and scalability along with easy upgrades and consistent visibility from the edge to the cloud and on-prem to provide a full view of all utility assets.

Network Digital Twin and the Transformation Journey

With the evolution of location technology, utilities have gained access to an important new analytical asset. The network-based GIS system consolidates silo boundaries to give insight into the entire grid's asset health and performance, in addition to the "where" of the location intelligence, and reduces operational complexity.

Utilities with a network-based GIS system can bring GIS, business system, and asset data together in one place — a Network Digital Twin. The NDT reflects the uniqueness of each individual network to allow simulation of how that distinct network would behave if, say, load changes, rooftop solar is added, or there is a particularly stormy or hot season.

The NDT is a digital representation of the utility's physical world or physical assets providing a full virtual model of the delivery system tying equipment, wiring, and other components into a cohesive whole. The digital twin offers views to existing, future, and historical network data and enables modeling events, network changes, electrical flow, labor, and other parameters that would affect the operation of the physical asset or network. Plus, the NDT presents a single consistent interface for data from existing systems [e.g., GIS, ADMS (DMS / OMS), EMS] and from the edge from FEPs / RTUs, PMUs / PDCs, Smart Meters, and other external systems that need to interact with these resources.

The NDT's real-world representation of the characteristics of the power grid adds value by helping the utility:

- Understand operation and prediction at the asset level
- Drive optimized performance and maintenance at the individual level
- Aggregate views of multiple assets for optimization at the operations level
- Analyze historical service and operational data
- Deliver measurable improvements in availability and reduce maintenance and inventory carrying costs
- Rethink business models and how to offer new value and service.

As the electricity grid changes — evolving with the advent of solar panels, storage, microgrids, electric vehicles, and the resulting demand for greater energy efficiency and transparency — utilities are seeking to monitor, maintain, and manage multidirectional flow of energy with an eye to operational efficiency. With solar in the lead as the fastest growing distributed power globally, utilities are driven to distributed energy management system implementations and expansions.[3] Yet, while DERMs are operational tech, there are industry changing opportunities for utilities embracing a strategy that achieves IT and OT integration.[4]

Digitalization represents the best opportunity to achieve IT/OT convergence, increase innovation, reduce cost, and manage risks. By bringing all digital applications together in an efficient and easily visualized manner, the NDT provides the utility with greater operational insight, in real-time, at a higher level — without having to rebuild and reconfigure the existing GIS systems. For instance, with awareness of the connectivity of circuits, breakers, transformers etc. to the grid as a whole, the NDT helps utilities identify exactly where a problem may occur (in whatever scenario is being run) and how that issue could be mitigated (well before it happens). Or, with the twinned representation enabling modeling with historical information, utilities can explore what happened on the grid in the past and learn whether different maintenance, operational parameters, or configurations will mitigate similar problems in the future.

The NDT represents a fresh new way of thinking about grid design and planning, work management, operational systems, storm restoration, digital workers, and more. "Well-designed digital twins of assets could significantly improve enterprise decision making. They are linked to their real-world counterparts and are used to understand the state of the thing or system, respond to changes,

Network Digital Twin powerfully shares a comprehensive view of the grid across the utility. NDT software connects physical systems with the capabilities of the digital world, accumulating operational information, asset location, environmental data, and much more to build breadth and depth on-prem, at the edge, and in the cloud. In order to remain competitive in today's market, utilities need NDT's common data fabric and forward-looking, fact-based view of the network.

— Patric McElroy,
VP, Chief Software Engineer, GE Power

improve operations, and add value."[5] As the Industrial Internet of Things (IIoT) expands, the NDT layers computational resources to deal with the increasing volumes of data from throughout the enterprise. The NDT also offers embedded intelligence through the use of machine learning to enable users to focus more on data-driven decision-making rather than data entry and driving the system.

Further, each individualized department gains the flexibility to interact with information that may previously have been more difficult to access. With NDT, the geospatial awareness of the records maintenance and design departments can be efficiently melded with the insights of the operational control group or those who manage outage so that all these views of the same assets can be reflected in a holistic way. This adaptable architecture can eliminate utility functional silos by breaking down the walls between information sources such as GIS, EMS, and DMS. With NDT, the utility brings all its existing data sources together into a single visualization, while still abiding with regulations such as the NERC-CIP.

Whereas ECC/SCADA, ADMS, or operational systems such as GIS each hold their own views of the network at various voltage levels and switching states, the NDT can get information from all those systems with minimal impact on the actual operational or control room systems. This allows the utility to more quickly adapt to new technologies and utilize new capabilities as the NDT minimizes the areas within the software that interact directly with a given technology.

Ultimately, the NDT is a single, reliable, up-to-date network model supporting operations, maintenance, planning, mobile, and other user types, helping utilities make better maintenance, operating, and replacement decisions.

Addressing Utility Challenges with Network Digital Twin

Utilities face many challenges as the industry rapidly evolves. Here are several attributes to look for when considering network-based GIS support for utility roles.

Challenge	NDT Opportunity
Reduced plan, design, and build cycle time	Planning tools to support detailed electrical grid engineering
Rapid adoption of renewables and DER proliferation.	Accurate, up-to-date view of the entire electrical grid and assets
Dynamic needs from consumer smart home devices or Industrial customers	Up-to-date network load data showing available connectivity.
Need to detect and adapt to ever-changing IT/OP landscape while minimizing disruption	Support for planning and provisioning based on accurate network data while providing access to capability in the field to streamline processes
Delivery of electrical grid performance to regulatory standards, minimizing operating expense	Efficient allocation and dispatch of teams for network faults and outages with access to network data for field crews (including outsourced contractors)
Complex and expensive integration between legacy systems	Simpler integration through use of loosely coupled, standards-based, integrations

Network Digital Twin in Action

Power outages cause customer frustration — there's no way around that. However, the Network Digital Twin (NDT) can help utilities better address the key challenge of outage notifications.

In most cases an asset fails unexpectedly and the utility must perform reactive maintenance. Teams scramble to figure out the actual grid configuration to be able to tell which customers are actually impacted.

The utility, of course, would rather be proactive and provide customers advance affirmative notification of an outage, an expected duration of the outage, and ongoing updates.

With NDT, it takes only a few mouse clicks in the real-world representation of the grid to see an asset's health is changing, reconfigure the grid accordingly, or dispatch a specific crew to solve an identified failure mode, and also send out affirmative notifications to any downstream customers.

In addition to improving customer experience, access to NDT information can help predict outages and enable more targeted troubleshooting to repair asset failures.

The GE Difference

Drawing on 25 years of experience with network modeling and managing customer's assets, all the way down to the low-voltage distribution level, GE offers deep domain knowledge in real-time control systems, GIS, and asset management. With Smallworld™, GE provides combined asset management and ADMS/OMS functionality in a single solution providing a holistic view of the network from generation through consumption.

Providing high fidelity data into the management of all utility networks, even understanding the subnetwork's circuits and feeders, has been GE's focus for decades. Our electric tracing by network type, phase and circuit is an out-of-the-box standard functionality, established for years. Modeling substation internals to support white space management, non-incident connectivity, and maintaining full circuit and circuit section with the ability to identify all associated customers, equipment, structures, and conductors are core, established functions of GE's Smallworld Electric Office.

GE is not starting from scratch developing new solutions. The largest, most complex utilities in the world already use GE's Smallword for modeling transmission and distribution networks using geospatial databases of many terabytes. With support for the entire range of functionality from one vendor/Help Desk, GE's Smallworld provides complete domain models and applications and saves the utility time and effort by automating workflows per best practices in the industry sector.

The NDT is the latest innovation building on GE's Digital Energy portfolio of solutions transforming the way in which utilities view their grids. GE's NDT further improves financial and electrical system performance by integrating data and leveraging machine learning and automation to look beyond individual assets, facilities, or fleets of facilities to provide network-level insights.

Smallworld Customers Navigate the Energy Transition in Europe

Distribution system operators (DSOs) face dramatic, rapidly paced changes. Europe, in particular, has been at the forefront of energy sector disruptions. With solar panels, low voltage networks, and a rise in electric transportation — to name just a few — the DSO must strategize to support energy transitions. Several have already partnered with GE to build out functionality, develop schematics, and create a basic system of records drawing also on DMS and ERP data, while also enabling geospatial analysis in one integrated platform — Smallworld.

"When you see the velocity of the changes coming up with the energy transition I don't think we can cope with building all of the functionality ourselves," according to Wil De Jong, Business Information Manager at Enerxis[6]. He adds, through partnership with GE and the power of Smallworld, the Dutch DSO is better able to move forward with standardized products on GIS, DMS, and SAP perspectives.

Stedin, another Netherlands-based DSO, leverages Smallworld and its partnership with GE to "innovate and change way more rapidly," according to Mark Van Den Brink, CIO[7]. The real challenge is in supporting the energy transition is understanding how to do more with its existing data while replacing legacy systems and introducing a high level of standardization. This demands a company culture change, Van Den Brink acknowledges, but with Smallword in place Stedin can transform from a traditional company into one using data to support energy transition without the same CAPEX involved historically.

Likewise, ORES, faces a competitive market for electricity and gas in southern Belgium, according to Benjamin Feye, Smart Grid Program Manager[8]. Yet, with Smallworld, the DSO has increased its knowledge of the energy transfer and flows on its networks and has implemented an enterprise asset management system to create new processes around asset performance and the investment process. Without a clear view of the future, ORES appreciates a partnership with GE's energy management experts, Feye said. "The expertise of GE in terms of the specific work of a DSO is very high and impressive."

Running on a smaller hardware footprint than its competitors does not mean GE's Smallworld has compromised on functionality, scalability, or data integrity. GE's solution is technology agnostic and ingests network data using the IEC Common Information Model (CIM) format. If an existing system of record can produce information in this international standard for describing electricity networks, that information can be loaded into the NDT. Plus, Smallworld's flexible integration capabilities include simple file exchange, API, or Web Services and standard integration to SAP and CIM-based integrations with real-time systems (ADMS, EMS).

Electric Office also supports full network geographic or schematic visualizations with 2016 enhancements significantly improving mapping capabilities. Construction prints combine views of the network (e.g., geographic, schematic, and internal) with relevant construction notes and instructions. Meanwhile, easier-to-use plotting applications aimed at both adhoc and repeatable mapping processes provide optimized workflows to reduce manual rework. GE's partnership with Google further enhances the visualizations against various background layers and sources.

While GE's competitors have only recently begun to migrate to portal services-based architecture, Smallword's proven Client-Server platform has a history of providing full life process support and powerful back-end microservice capabilities with GE's Predix* IIoT platform supporting digital twin and enterprise digital transformation and analytics needs.

Dealing with a single experienced vendor for GIS and applications simplifies partnerships, and GE's NDT simultaneously meets the goals and responsibilities of everyone from the field technician to the network manager. GE's technological portfolio can enhance any digital worker's productivity. With geospatial technology, design tech, and workforce mobile management capabilities, GE supports utility workers on-premise and out in the field. Even the casual user interface can access a wide variety of data formats and additional data layers and easy-to-use map production and analysis can be extended easily from desktop to Web via GSA Lite.

Smallworld, after all, was created based on the input and experience of more than 700+ utility customers worldwide. That's one reason that instead of relying on several development languages, Smallword 5.0 and above versions are supported by Java and Magik — with GE resources available to help with either at a reasonable rate.

While the integrated, cohesive Smallworld portfolio lets vendors own the platform and the application on their own terms, GE customers have been known to work collaboratively to share experiences and ideas with the technology. Together they are working with GE to shape best practices and build the best product to address the needs of the utility industry now and in the future.

Driving Outcomes

- Reduce new construction costs by up to 10% by enabling utilities to study performance of additions in NDT
- Improve outage measures by 10% without additional network investment due to the current and accurate network view
- Extend equipment life up to 10% through improved, targeted maintenance
- Drive more efficient and automated designs to improve productivity by up to 15%
- Provide all participants access to one network data source. This can lead, for example, to up to 15% increase in inspection and maintenance productivity through integrated office and field activities.

Future Directions for Geospatial Technologies

Network-based geospatial technologies are the foundation of grid management transformation. By 2019, 75% of utilities will be using some form of APM, leading to an improvement of up to 10% in operational performance. As utilities move to modernize with digital offerings, the NDT represents an immediate opportunity to employ predictive analytics and provide additional value quickly without the challenge of a large, disruptive change to existing mission-critical systems.

Keeping pace with the rapid rate of evolution in the ecosystem can net significant opportunities for the forward-thinking utility. As the industry moves to further leverage digitalization through drones, augmented and virtual reality, blockchain, and other IIoT evolutions, the need for a fully connected and fully comprehensive grid representation is clear.

Going forward, the new utility network requires a solution offering:

- **Connectivity** Based not only on geographic coincidence (x, y, and z) but also between devices that aren't coincident.
- **Containment** Allowing management of structures in the network that contain devices or have other devices or objects attached.
- **Communicativeness** Enabling multiple connection points, expanded validation framework, and export capabilities.
- **Transparency** Expanding network tracing and basis source management with built-in support for schematic designs.
- **Support** Making network functionality insights available to varied users on any device, anytime and anywhere.

Effective asset management is the key to future business success. Utilities are being called upon to reduce costs, simplify technology, and standardize processes while managing their systems on a more granular level than they ever have before. To do this effectively, they require the data and analytical power that NDT digitalization provides.

Conclusion

Utilities face many industry changes. The NDT's new approach to managing information and processes is a stepping stone in transitioning to the digitalization of geospatial asset management to support network planning, design, analysis, maintenance, and operations. Avoiding the arduous task of replacing source systems, GE's Smallworld suite and NDT approach provide the transformative power utilities need to achieve maximum business results.

GE brings a rich understanding of geospatial technology and domain-specific asset management to its integrative core platforms and capabilities and its support of networks and operations. Keeping abreast of the scope of the changes utilities are facing, GE's well-developed portfolio reliably meets industry demands and prepares proactive utility players to make the most of individual assets by providing all-encompassing network understanding.

[1] ***"IDC FutureScape: Worldwide Utilities 2017 Predictions."*** *IDC. November 2016.*

[2] ***"Digitalization and Energy."*** *International Energy Agency. September 2017.*

[3] ***"IDC FutureScape: Worldwide Utilities 2017 Predictions."*** *IDC. November 2016.*

[4] *North American DER Management Systems 2017-2021 Market Evolution, Competitive Analysis, and Forecast. GTM Research. July 2017.*

[5] *Gartner: Top 10 Strategic Technology Trends for 2018, David W. Cearley, Brian Burke, Samantha Searle, Mike J. Walker, October 2017.*

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[6] *Enerxis & GE [Video].*

[7] *Stedin & GE [Video].*

[8] *ORES & GE [Video].*

About GE Power

GE Power is a world energy leader that provides technology, solutions and services across the entire energy value chain from the point of generation to consumption. We are transforming the electricity industry by uniting all the resources and scale of the world's first Digital Industrial company. Our customers operate in more than 150 countries, and together we power more than one third of the world to illuminate cities, build economies, and connect the world.

Imagination at work