From Reaction to Pro-action: Modernizing the Grid Control Room

By Kristen Sanderson

The Grid Control Room Today

Walking into most busy control rooms today and you would be struck by the heightened sense of urgency and organized chaos that saturates the low-lit room—it's a bee hive of activity. Operators sit in front of a multitude of monitors, stacked or arranged in semi-circles around them. Most operators are set up with five monitors, but some can have as many as 11 depending on the number of systems and level of automation deployed by the utility. Upon closer inspection, one would see that the monitors display data and information from multiple systems—from Outage Management Systems (OMS) to Distribution Management Systems (DMS) to websites/portals and email applications. If you were to ask the operator why so many monitors, it would become clear that they need to work with multiple systems as no single system is able to meet all operational needs. One would also find that the majority of systems weren't actually connected—or not connected well enough that a single system would suffice to provide all the data required to manage grid operations.

On top of the digital view provided by the multitude of screens, most operators would also be working with reams of paper. Often detailing different work packages for the day or safety logs used to track field crews, as well as redlined hard copy maps, providing "recently" updated views of the network.

As a typical workday moves forward, operators deftly switch between radio, phone, chat and email, working with data on-screen and paper backups and notes. Switching steps and safety measures are typically confirmed and repeated over radio and phone lines, ad hoc work can be sent via text message to field personnel with responses and work order status updates returned the same way, and finally, meter information, where available, is checked on-screen to assess a customer's status.

As operators monitoring neighboring zones swap paper switching schedules, loud audible alarms sound, announcing higher voltage trips, signalling bigger issues and pushing up operators' urgency levels. Eventually, a lull in the hectic workflow allows the control room team to catch up on paperwork required for regulatory compliance; in some companies, this effort requires bringing in additional staff.

As our modern distribution systems evolve, so too must the 'brain' of the operation. Without this evolution, utilities risk creating costly inefficiencies in work processes, utilizing inaccurate data to make critical operational and business decisions which may result in extended outage durations, non-compliance with regulations and increased customer dissatisfaction.

To ensure effective and efficient management of today's modern grid utilities need a better way...

Addressing this Challenge and the Future Needs of the Grid Operations Center

The reality of today's distribution networks and tomorrow's modern grids makes it clear that any solution must focus on the user experience of the operator and the operators' ability to sift through the "noise." Operators must be able to prioritize data inputs as they appear and streamline and simplify interaction with the growing number of devices (digital and paper-based) and systems built with integrated intelligence that are required to visualize and manage a dynamic distribution network.

Having deep domain knowledge and understanding of DMS, OMS and Energy Management Systems (EMS) systems, it was clear to the team at GE that a convergence of technologies and platforms would be required to meet the evolving needs of today's utilities... but to ensure we developed an effective solution we needed to start with the fundamentals.

To address this challenge we needed to re-confirm and gain further insights into the working world of a modern utility control room. Following best practices and industry standards for software design and development, our main activities included product and market discovery, user observation and co-design.

The Research

With over 30 years of experience in the utility space, GE is an experienced veteran. However, the GE team wanted to take a fresh look at the problem. To achieve this, we leveraged the new GE Software Center of Excellence to bring in product design experts, user experience research and design to our existing expertise.

To begin, we had to cement and re-confirm our detailed understanding of the control room, the staff who work there

and the activities performed within. We embarked on a learning and observation phase, digging deep into the workings and pain points of the control room with the end goal being to define a new paradigm for visualizing and managing active networks.

Gathering design experts with product, customer and utility experience, the team collaborated on product and market discovery, user observation and co-design. A vital part of the discovery and observation phases included working with four utility companies across two continents, representing over 20 million customers. The team emerged with a clear understanding of how control rooms tick, and a greater appreciation and grasp of the challenges and pain points of control room operators. Observations from these phases were analyzed and distilled into a set of insights and opportunities for improvement, resulting in a new design vision for the control room and management of active distribution networks that represented an immense departure—a paradigm shift—from current and traditional systems and capabilities. This new design vision was then validated and fine-tuned across global regions.

In the Control Room – Lessons Learned

Working with operators in the control room netted the team insights on the top priorities and pain points of the operator. Safety, transparency and situational awareness were clear priorities across all utilities. Based on the multitude of disconnected or siloed systems, paper-based work reports and redlined maps, the ability to support workflow was also a clear pain point along with the communication systems, system usability and tools needed to support and provide the network view.

Safety

System operators all expressed safety as their primary responsibility—of both the crews and the public at large. The standard approach to maintaining safety tended to be a laborious task of piecing together information from multiple applications across multiple screens and combining it with information coming through other communication channels, such as phones, radios and control room conversations, to form a "comprehensive" picture.

In many instances the team observed that operators responsible for field crew safety relied on their experience and knowledge to a much greater extent than on system tools created for the purpose. For many utilities, the challenge of maintaining this experience and knowledge had been magnified by the impact aging workforce, with utilities seeing experienced personnel leaving the control room. Some utilities had developed their own applications and protocols to track safety information—and in some cases reported moving back to paper logs.

Transparency

Transparency is becoming increasingly important in managing customer and regulator perceptions and expectations with regards to utility performance. Operators the team interviewed cited transparency as an emergent high priority for utilities and indicated that they were frequently measured against performance metrics by regulators. The ability to clearly and effectively communicate power restoration time frames were shown to be critical to customer satisfaction. Regulators require utilities to report actions and operations accurately, and in some regions this information is used to assess penalties.

In today's control room, record keeping and reporting is often delayed until after the actual control room work and field work is completed. This creates a tremendous amount of rework, negatively impacting the accuracy and clarity in the data and the timely communication of this data and situational/network status.

Situational Awareness

Today's modern distribution networks generate a lot of data to show the operator, yet it was clear during the team's observations that presenting more data in greater detail did not equate to situational awareness. Displays crammed with data, colors and icons confused and disengaged users. White backgrounds in a low light environment caused eye strain. Blinking and audible alarms further exacerbated the confusion. Several operators voiced a concern that the system generated too many alarms, making it difficult to identify, prioritize, and respond to critical items. Yet conversely, operators depended on alarms to assemble the story of the current network state. For some operators the first order of the day was to review alarms.

The network view is also a critical aspect. Depending on the current task of managing the network or directing crews, operators switched between geographic and schematic representations of the network spread across multiple sources. These different representations included those digitized across at least one of the screens in front of them, on paper, and sometimes on the walls or wall boards around them. At any one time, the information in two or more of these representations were combined by the user to achieve situational awareness.

Communications

Communication channels and systems are the mechanism used to meet all other priorities—and observations clearly confirmed that this was the source of much of the controlled chaos in the control room. Operators had a wide array of analog and digital mechanisms available—including radio, phone, ea mail, messaging, system applications, paper, etc., as communication media and channels. These channels were augmented by conversations with fellow operators and other audible signals of importance in the control room. Operators spent a significant amount of effort multitasking across the various communication mechanisms. In many cases, operators were observed simultaneously speaking to multiple crews across radios and phones while coordinating actions with the operator next to them. As the control room got busier, operators had to select which communication channels to pay attention to or ignore in order to continue working, at the risk of missing critical information from the field.

Work Processes and Tools

To accomplish their goals, operators used a variety of systems to organize and manage workflows. Information was gathered via email, spreadsheets and paper. When directing switching plans, operators were observed working with printouts in front of them along with digital versions on screen. In many cases print outs were used to facilitate work across multiple operators in the control room. In addition, a significant amount of work was planned, coordinated and approved via verbal communication, making it difficult to record, track, and analyze work tasks after the work was completed.

The work of an operator is inherently asynchronous. Each specific task has its own lifecycle that is rarely straightforward. Breaks and interruptions are common, and retaining context throughout the lifecycle is a difficult challenge. User interface components

such as pop-up and modal dialogs often end up hidden behind other windows, aggravating the situation. It was clear that most screens were not designed to task—to facilitate work for the user. At a more granular level, operators must complete many repetitive tasks, making them very sensitive to the number of mouse-clicks, movements and switching between keyboard and mouse to complete tasks. Many operators maintained that paper was the most effective multitasking tool.

Usability

A consequence of operators' continued struggle with the multitude of disjointed systems is a severe lack of confidence in said systems. While current systems contain a multitude of user-configurable preferences and options, many operators don't have the time to become familiar with and take advantage of them. When presented with features that applied to the applications they commonly interacted with, many operators were surprised and completely unaware of them. Users preferred the systems to be configured for them. The lack of confidence in digital systems led to paper-based approaches and manual systems persisting alongside technology. Moving to a new era of usability necessitates solving this challenge.

The Paradigm Shift on Network Visualization and Work Management

To overcome the current situation observed in the control room and present a new visualization paradigm for the active network era, it was necessary for the solution to address the four main challenges: magnify awareness and safety, standardize data presentation and visualization, simplify alarm management and streamline workflow and knowledge sharing.

To magnify safety and awareness, a macro view of the network status had to be maintained, with information about crews and field personnel clearly standing out in the system. Magnifying required details without losing sight of the overall view of the network had to be possible. Minimizing visual noise so that critical details became obvious was imperative.

The use of common iconography, colors and visual semantics achieves standardized data presentation and visualization. Common formats for specific tasks reduce confusion and steep learning curves. Standardization is critical in creating a common language that can then lead to better discussion across a wider group of people, fostering further improvements in visualization moving forward.

Streamlining workflow and knowledge sharing necessitates intelligent data entry, connected workflows and the ability to externalize system operations. Intelligence must be built-in to the user interface such that the work required to complete reporting is minimized and the operator retains a big picture visualization of the network and key metrics to support external communications.

Simplifying alarm management empowers operators and improves performance. Current visualization solutions that allow operators to filter and sort alarms are helpful, but more is needed. Operators must have different methodologies of aggregating and visualizing alarms and events to maintain perspective and awareness of the network.

A New User Experience

Our research and analysis led to the development of a new design vision that takes advantage of identified insights and opportunities. The design presents a new dashboard and navigation concept, and a new methodology for supporting workflows on the active network. This design concept manifests itself through an optimized three-screen layout, comprising the dashboard, the network diagram and the work page—eliminating the need for many monitors and multiple mouse/keyboard sets. With regards to operational workflows, they are integrated, optimized and streamlined. Throughout the new design, color palette and iconography are simplified to reduce visual noise. Color is utilized to highlight important information to the user thus drawing the eye. Taken all together, this design vision represents a revolutionary change in current system visualizations.

Dashboard and Navigation

Traditional systems have largely supported an application launcher pattern that is a pervasive industry standard. When a user had a task to accomplish, the appropriate application(s) were selected from the available menu for execution. In this pattern, it was necessary that the operator knew what application was required to complete work. In many cases, several applications within the same system were required to complete a specific workflow or task.

In the new paradigm, the dashboard forms the center of attention and work for an operator. This pattern brings forward key information from the underlying system(s) and enables operators to access work pages designed around a specific workflow. Work pages are constructed using known patterns for data tables, forms and diagrams, thereby standardizing interaction patterns. Work pages bring together all aspects of the system required to complete a specific task, and are described further in the Workflow section below.

Historical User Interface - Multiple separate applications and workflows

System operators have traditionally needed to access multiple applications to obtain network information. This is an inefficient process and requires extensive knowledge of the system and applications.

Instead of a traditional alarm interface, task list or a map, the operator is presented with a dashboard of critical information. The dashboard enables a wide array of information to be aggregated for the operator and acts as the primary interface to navigate within the system. Some key new concepts include user-configurable widgets, communications, an overview map, notifications and alarms.

One of the key changes in the new design is the use of simplified "widgets" in the dashboard—essentially mini-apps that display a small amount of information on-screen. The pre-defined and customizable widgets aggregate specific KPIs and alarm information, showing pertinent metrics with indicators of change. When user-configured thresholds are reached, brief color modulation is used to alert the operator to the change. The operator can then click on the widget to navigate to the appropriate work page interface. This enables a new and valuable concept—**data finds the user**—making it easier for an operator to filter and prioritize issues and work. This concept works similar to applications on a smart phone. Operators can select widgets in their dashboard based on the work and geographic area they are responsible for. This allows widgets to be relevant for all users, including upper management.

PowerOn™ Advantage User Interface - Single Integrated Dashboard

With PowerOn Advantage, operators can now access network information via a single, integrated dashboard. Streamlined work flows enable efficient network management.

An overview map enables operators to maintain perspective across the entire network, maintaining situational awareness. A set of overlays can provide pertinent information such as weather, outages or regional specific information such as seismic data. This map allows operators to retain a full view of the network at all times, facilitating their safety and situational awareness responsibilities.
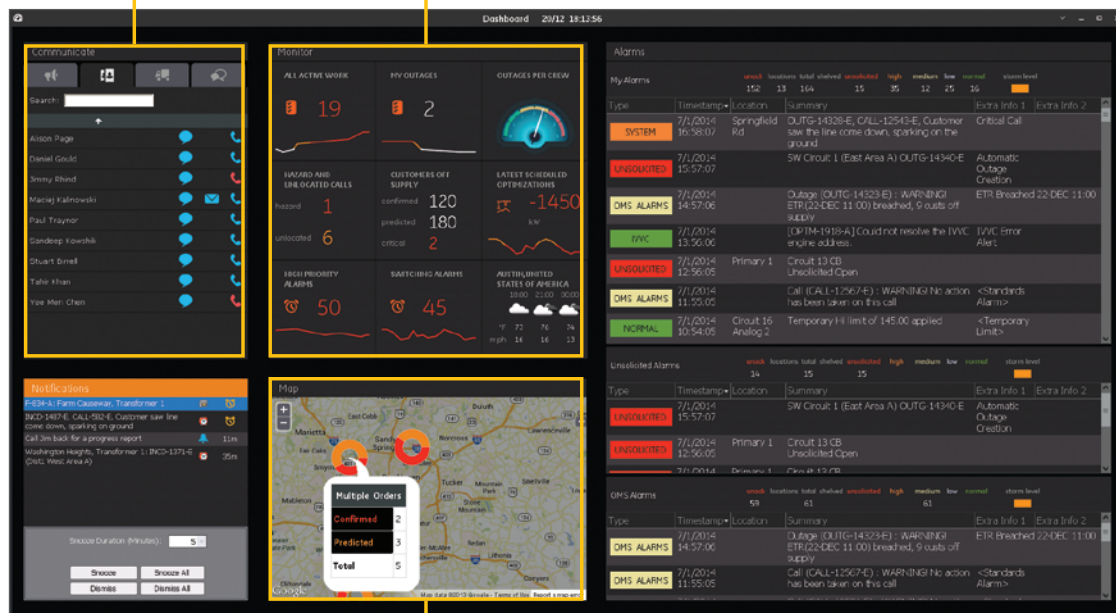
Communication is another key component of the dashboard. This visualization enables an integrated view of communications for voice, chat and video—both internally and externally. While utilities will continue to have several mechanisms for communication, this interface enables them to integrate these methods on the back-end so the operator has an integrated view. In addition to integrating the forms of communication, it is also necessary to link communication to the ongoing work. Keywords within messages are utilized to link critical information from communication to specific jobs like hashtags in Twitter®. This enables critical information to be linked to work in progress without overburdening the lines of communication, facilitating recording/tracking as well as event analysis.

Designed to keep the operator at the terminal and eliminate the need to switch between digital screens and paper printouts, a notification panel is integrated into the display, enabling operators to manage their multitasking environment. Operators can set notifications for a specific task, workflow, alarm or any other need by dragging and dropping, right-clicking menus or typing. When a notification expires, the operator's eye is drawn to the item with color and brief modulation. Navigation is enabled to the specific context where possible. With these notifications operators are able to manage the multitasking nature of their work and eliminate the need for handwritten notes.

Alarms are still a necessity in the system. Operators can select groups of alarms to view based on areas of interest. For example, operators may wish to see low- and medium-voltage alarms, but not maintenance alarms. The operator can configure the system to see both the textual alarms and overall metrics for that category. Similar to the widgets, the operator would select the groups of alarms pertinent to their role, thus reducing the strain and stress on operators as they plan and prioritize unplanned and planned work.

As with the widgets, the dashboard itself is configurable. Operators can select what information to display on their dashboard as it fits their role. The new dashboard concept extends the view of the system previously provided by the alarm interface in traditional systems. It changes the interaction of the operator with the system in a revolutionary way. In this new design, data finds the user without overwhelming them, and each user is empowered to configure the system to meet their needs. As the dashboard is consistent across roles, learning time is significantly reduced and work rotation is made easier.

The Dashboard

Communication Module

The Communication Module provides a seamless way to contact various people inside and outside the control room. Includes one-click call, email, chat and SMS.
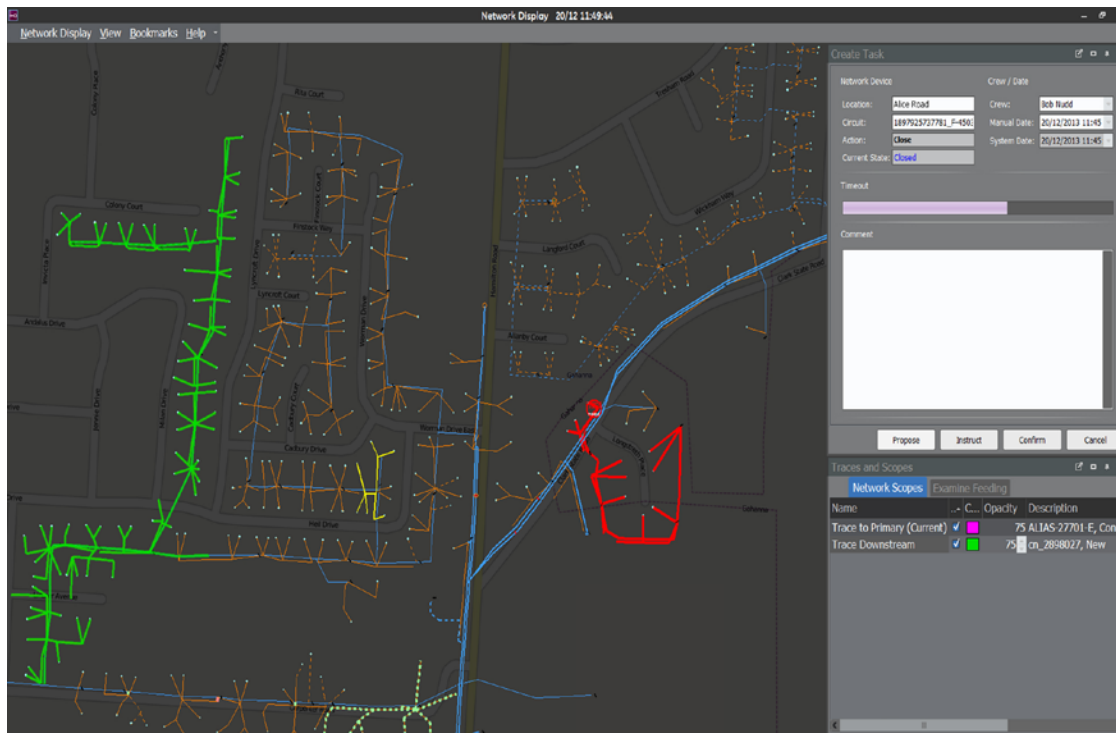
Dashboard Widgets

These user-configurable, animated widgets provide high-level status summaries of items related to the user's role. When an item requires immediate attention, the widget distinguishes itself with a visual cue.

Map Overlay Module

The Map Overlay Module provides an overview of the region or operator's area of responsibility with pre-defined and configurable layers of information that can be overlaid.

The Network Diagram

The Network Diagram with Dialog Area

Workflow

In the new design paradigm, work is presented to the operator in a combination of diagram and work pages. The network diagram enables operators to work in the context required for the task at hand. Operators can use the schematic, geographic, or a split view to achieve the task at hand. The screen below shows the overall diagram concept. The ability to add specific magnifications enables operators to see details required for a given task while enabling them to retain perspective across a wider area. The ability to retain that perspective enables operators to maintain the context of safety within the system.

Work pages can be a combination of forms, tables and diagrams. They are specifically designed to have all necessary information available for the task at hand. Since operators must switch between multiple simultaneous workflows, dynamic tabs enable multitasking between different jobs, maintaining the context of each. Pop-up dialogs are avoided in favor of dialog areas that are built-in to the right side of the work pages. By using the same usability patterns throughout the system, the operator gains familiarity with the system, enabling them to focus on work order, tasks and performing network optimization and SCADA control.

As work is completed, the layout of the work page includes the required reports with intelligence to pre-fill data, thus facilitating completion of documentation alongside work, to gain transparency, improve reporting accuracy and ensure compliance with regulatory requirements.

Conclusion

Our future brings a much more active network due to grid complexity, challenging our ongoing commitment to keep our people and the public safe. The need for transparency to, and engagement of, both our customers and our regulators is becoming as important as our system operations. The existing environment of digital solutions does not adequately address the operational needs of managing and optimizing modern, active distribution networks. If nothing changes, this inadequacy will continue to be demonstrated through the proliferation of manual systems that act as barriers to progress. The current pattern of incremental change does not fully address these challenges. We must streamline work and tools to move beyond this impasse. Revolutionary change of current visualization tools must be employed to effectively operate and manage complex systems. Our research and the resulting design vision—including the dashboard, network diagram and work pages—offers a new visualization that addresses the pain points observed throughout our research and will revolutionize operations in a new active network era, presenting an innovative departure from traditional systems. Leveraging this work in the latest release of the PowerOn™ Advantage product, GE has defined a new user interaction for grid modernization. The PowerOn Advantage ADMS addresses the grid complexity of an active network, provides effective visualization of all work across the grid, optimizes the network's performance, and supports the need for greater stakeholder engagement to deliver reliability, productivity, and efficiency.

To schedule a demo of the PowerOn Advantage ADMS today, contact davedaly.adms@ge.com

imagination at work