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Use of Geographical Tracking Tools for Smart Grid Pilot Implementation

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SUMMARY

National Grid is currently in the final stages of implementing its Smart Grid Pilot in the city of Worcester, Massachusetts. This project, one of the most comprehensive of its kind, required coordination across many organizations, including those not typically involved in grid or customer side implementations. The level of complexity of such coordination made conventional collaboration and project management tools inadequate. Additionally, the introduction of geographical variability in the planning and implementation process made the use of geospatial tools not only necessary but essential.

The present work will describe National Grid's experience with the development and use of a centralized geospatial tool to design and plan installations, coordinate resources and share information across all the groups involved in the pilot.

KEYWORDS

Smart Grid Pilot, Geographical Information System, Project Management.

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1. INTRODUCTION

National Grid presented a proposal to the Massachusetts Department of Utilities (Mass. DPU), in accordance with the 2008 Green Communities act of Massachusetts [1], seeking approval for the implementation of a Smart Grid Pilot (Pilot) in the City of Worcester, Massachusetts. The proposal was subsequently approved by the Mass. DPU in August of 2012 [2]. The intent of the Pilot is to evaluate the efficacy of new technologies installed in two main fronts: grid and customer facing sides. The grid side includes equipment designed to improve power quality, visibility and system reliability. On the other hand, the customer side concentrates on customer choice and energy conservation. This paper focuses on how the use of Geospatial data directly and positively impacted the design and implementation of the grid side portion of the Pilot.

Historically, most of the devices installed on National Grid's distribution feeders lacked communication or remote control capabilities. In contrast, all the devices considered for the Pilot have been specified with real-time two-way communication capabilities providing monitoring and control. Under these conditions, and given the nature of the communication infrastructure selected (3.65GHz WiMAX), the geographical location of the devices and the characteristics of the terrain in the area played a crucial role in the planning and commissioning phases. This represented a change from the traditional way that distribution line equipment implementations are planned and executed. Under this new scenario**,** relocation or modifications made to planned devices required changes affected a higher than usual number of groups, making traditional planning processes impractical. The need to keep all departments informed, aligned and aware of the geographical location of the devices to be installed made the implementation of a central source of information with geographical capabilities essential for the progression of the project. Finally, deciding to present the data in a graphical form helped the parties involved to quickly identify problems, conflicts or inneficiencies resulting in faster resoultions.

This paper presents the characteristics, philosophy and benefits of the introduction of a new mapping tool for the quick delivery of the grid facing portion of National Grid's Smart Grid Pilot.

2. SMART GRID PILOT CHARACTERISTICS

The grid facing portion of the Pilot includes several features and/or experiments such as:

Table 1 Features and experiments included in the grid facing portion of the Smart Grid Pilot

Feature/Experiment	General Description
Distribution Automation	Installation of approximately 65 Advanced Distribution Automation (ADA) switches across the 11 feeder Pilot's area
Advanced Capacitor Control	Capacitors with centralized communications and local controls that can be fully integrated into the future OMS/DMS system for centralized control
Advanced Monitoring	Installation of monitors in critical locations (capacity bottlenecks, distributed generation sources, electric vehicle charging installations, etc.) to collect and report detailed information to be used in modeling and analysis
Remote Fault Indication	Installation of Faulted Circuit Indicators with communication capabilities to improve reliability by reducing the time required to patrol feeders looking for the cause of the interruption
Advanced Recloser Technology	Installation of several reclosers with advanced reclosing capabilities

These experiments are being deployed to benefit approximately 15,000 customers, involving 5 substations and 11 13.8kV feeders covering 160 miles of UG and OH primaries. In all, National Grid automated 188 devices as part of the pilot.

As shown in Figure 1, the design called for the devices to communicate via 3.65GHz WiMAX to their assigned base station so real time information can be transmitted back to the National Grid control center or directly to peer switching devices.

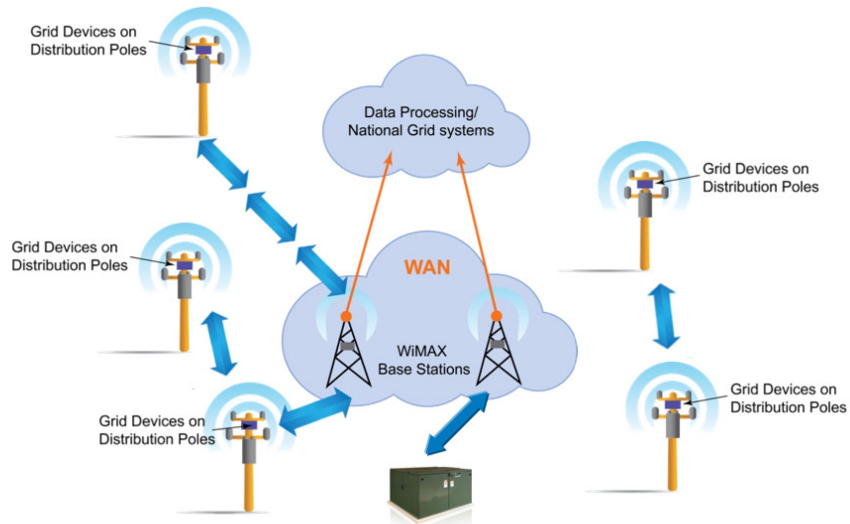

Figure 1 General diagram of the Communication's Architecture

The selection of the specific locations for the experiments required an analysis of the topology of the feeders and topography of the terrain in the area. In total, 188 devices are being deployed with 13 radio base stations to enable communication to all the components. As shown in Figure 2, the devices were distributed along several feeders in different areas of the city of Worcester, Massachusetts.

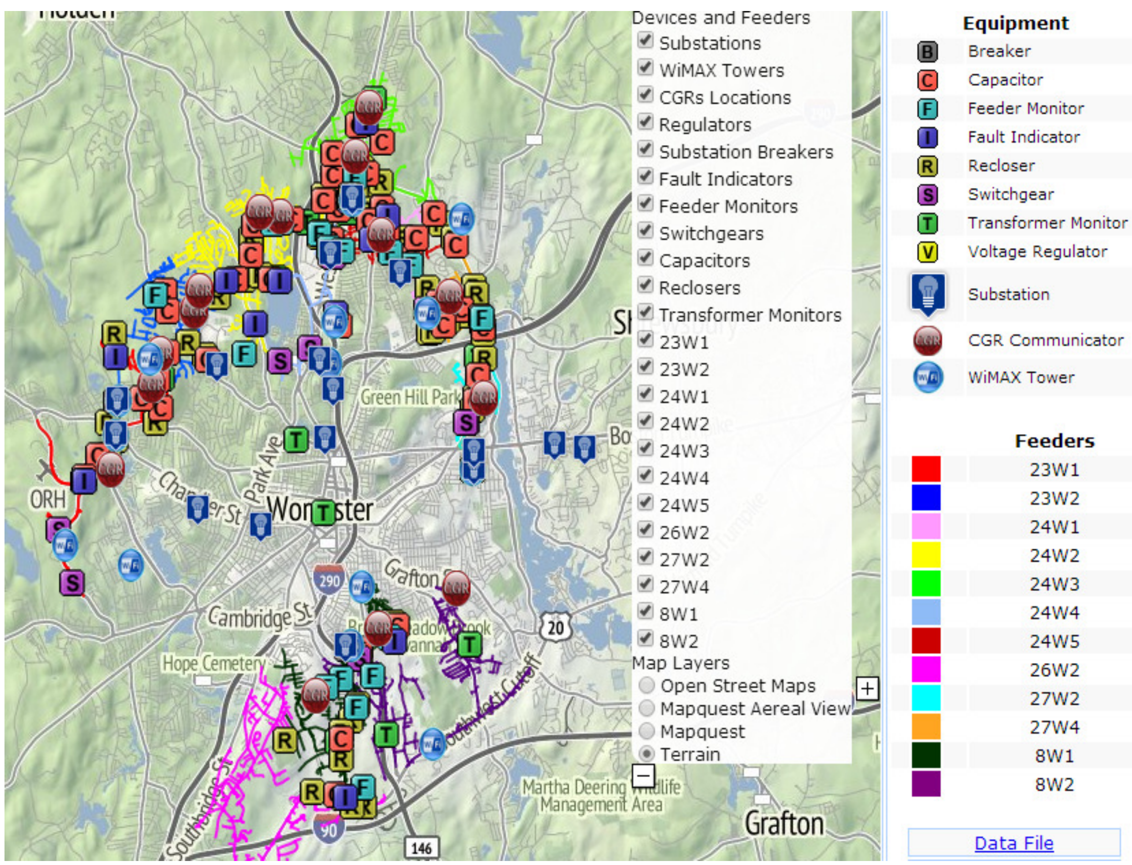

Figure 2 Geographical location of the devices from the Smart Grid Pilot

To successfully implement the grid facing portion of the project, several National Grid departments, as shown in Table 2, needed to coordinate their activities.

Table 2 National Grid departments involved in the deployment of the Smart Grid Pilot

Departments Involved in the deployment of the Smart Grid Pilot	
Advanced Engineering	Information Systems
Substation Engineering	Communication Engineering
Control Center/EMS	Control & Integration
Protection & Telecom Ops	R&D
OH Construction	UG Construction
Distribution Design	Training
Operations & Maintenance	Substation Construction
Procurement	Project Management

Since most of the experiments that were part of the proposal required non-standard equipment, all of the regular procedures and resources normally utilized for design and installation needed to be reviewed. This review showed the need for a different type of analysis and coordination of resources. As a result, a centralized database designed as a back-end solution (holding the information related to all the devices) and a front-end interface, in the form of a SharePoint website with a mapping tool (so users from different departments could access the most up to date information), were implemented. The use of SharePoint as the interface for sharing information was straight forward since National Grid already uses this collaboration tool. This resulted in a quick implementation and fast immersion for the new users.

3. STRUCTURE OF THE SOLUTION

SharePoint services have a wide range of collaboration tools available, one of the most basic ones: the capability to hold tables of data that can be shared among users. This basic feature was the cornerstone for the implementation of an application to share information with the different departments simultaneously. Figure 3 shows a diagram of the information shared across the different National Grid functions related to the Smart Grid Pilot.

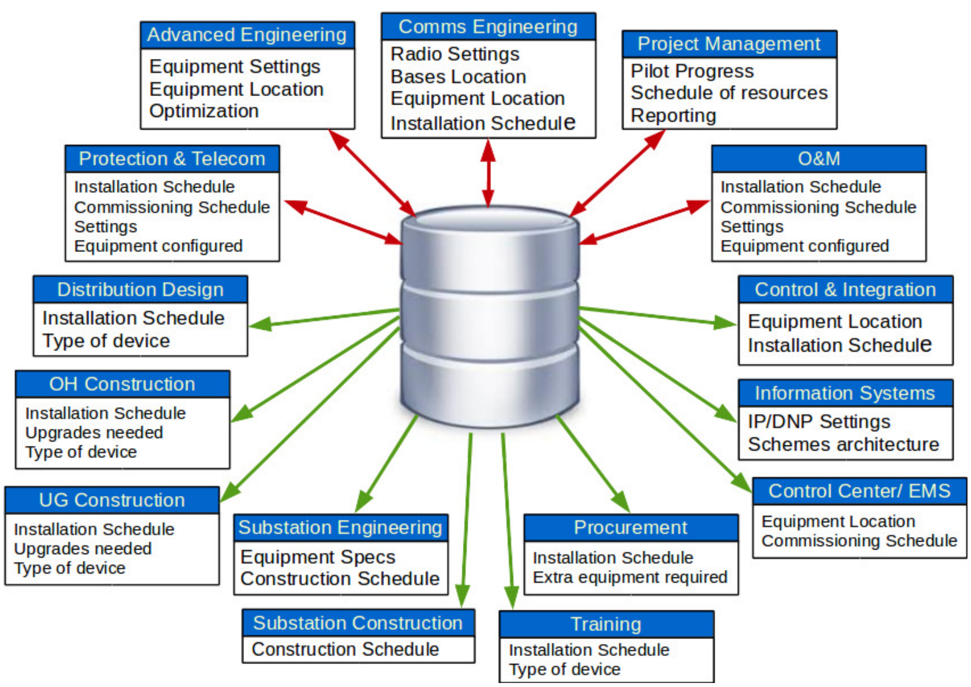

Figure 3 Flow of information from the different departments (red indicates read and write)

Figure 3 shows in red the flow of information coming from the groups in charge of putting data into the database and in green the typical recipients or users of the information required to complete their tasks related to the pilot.
Although a common source of information is helpful to keep the departments in synch, the dependency on geographic characteristics makes the incorporation of a mapping interface an invaluable feature. Commercial mapping tools normally require the deployment or use of a separate platform, making their implementation pricey and complicated for a realativelly small project. A few Open Source map data providers, such as OpenStreetMaps [3], have made available to the public Application Program Interfaces (API) that allow the incorporation of map tiles and geographical tools into users' interfaces. These APIs allow developers to create mapping environments where tiles with certain geographical details can be loaded to satisfy the requirements of their applications. Servers that provide free map tiles services are maintained by certain providers such as Mapquest [4]. Therefore, the implementation of a mapping tool used to display the location of the devices in this Pilot was possible without having to deploy a separate, and potentially costly, service inside the corportate network. The implementation required the incorporation of the available APIs into the native SharePoint structure code so it was able to read from the database and properly display all the elements on the map. Since the interface only generates a "canvas" where the local secured data (available only to authenticated users) is displayed, no risk of external visibility is present.
The implementation required detailed data of the geographical location for the distribution line devices as well as descriptive files for the entire infrastructure involved in the implementation, i.e. feeders, substations, base stations, etc. Figure 4 shows a diagram of the data needed and a structure of the required implementation.

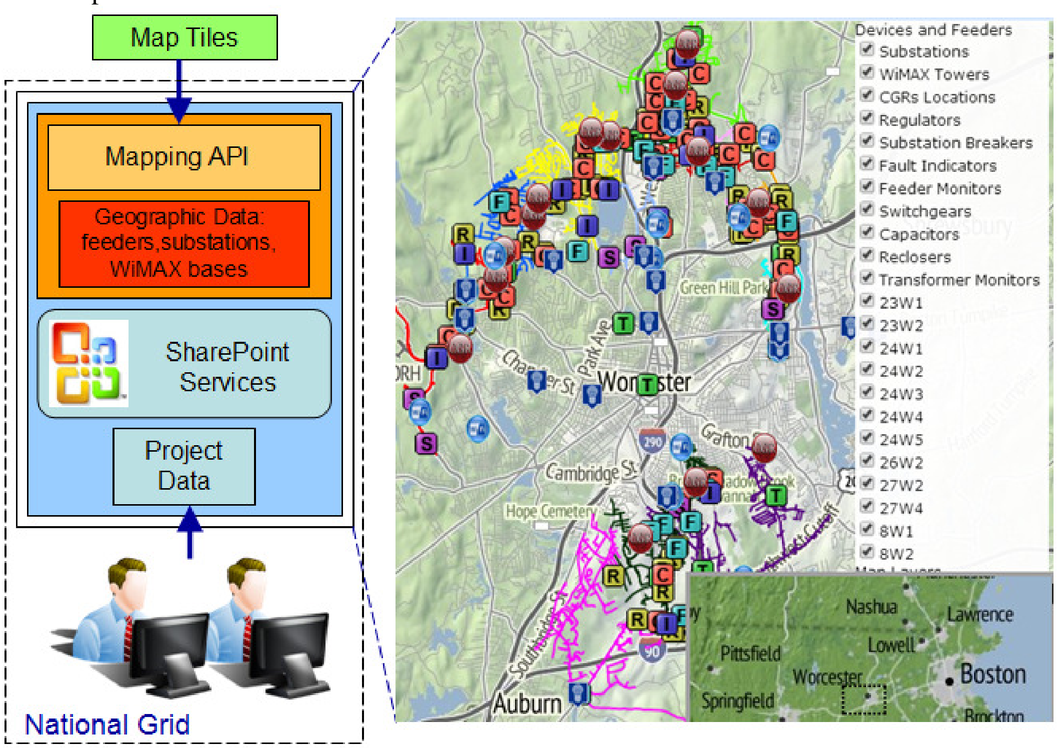

Figure 4 Information flow and resulting visualization

As shown in Figure 4, the new mapping interface incorporates the code provided by the API which now resides inside the SharePoint code and is run on demand every time that user accesses the portal. This required the introduction of JavaScript code into SharePoint's ASP.NET environment in a way that the result can be read by the user's browser to display all the data. As this is done dynamically, the code needed to be embedded in the portion of the ASP.NET code that reads data from the SharePoint database. That way, every time a user updated data on the Project Data table, the information was displayed accordingly in the map.

Special requests were made by the departments involved to have several pieces of information displayed for each single device as a way to help them to make decisions when designing the scope of the experiments. Figure 5 shows an example of the information available in the map for each single device. The information displayed is read dynamically from the main database and displayed when the user requests it. In this manner, for example, when Comms or Engineering were making changes to the specific locations and/or data of the devices, Project Management was immediately aware of those changes and was able to coordinate work more efficiently.

Another request, as shown in Figure 6, was for the application to hold the setting files of all the devices involved to serve as a repository. This step was crucial when assigning work to the technicians that were setting up the units in the lab and commissioning them on the field. During the commissioning process, sometimes the communication parameters needed to be modified by the Communications Engineering group. By holding the latest set of files on the database the technicians in the field were able to download the most recent version speeding up the commissioning process. Conversely, sometimes field conditions required settings to be changed by the technicians during commissioning. Those modification were then uploaded back and retained in the database as a way to keep a repository for future troubleshooting. In addition to the settings, files with information relevant to the installation were also provided for all the devices. For example, some of the devices required their phasing to be consistent with the distribution system's protection schemes. As such, the workers needed to have specific information about the phasing arrangements at the particular location so they could install and commission the equipment in the correct sequence. This saved time and reduced confusion during the installation process, especially since some of the work was done by contractor crews that were less familiar with the area.

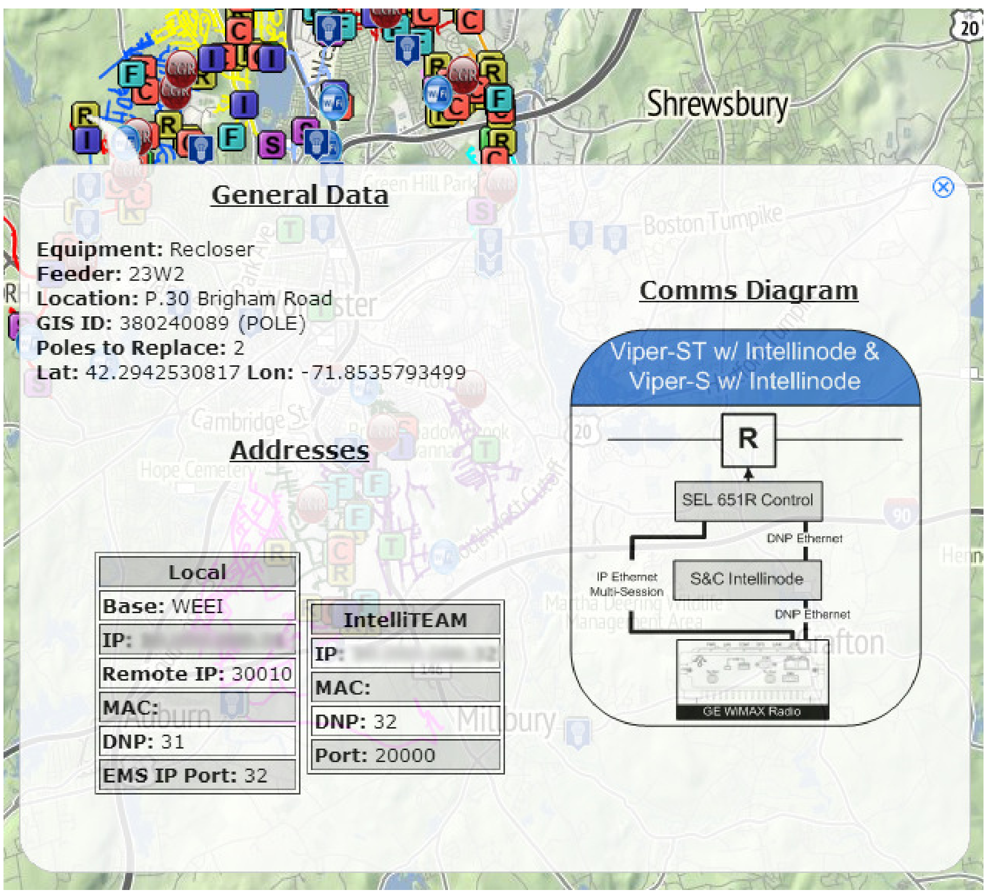

Figure 5 Sample of information detail for the devices

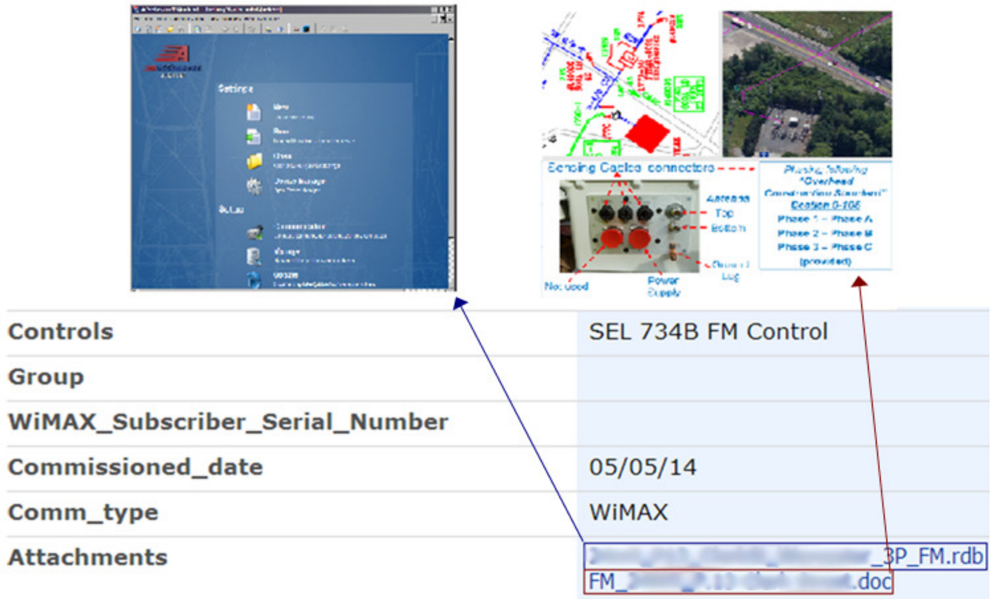

Figure 6 Files stored per device including settings and diagrams for physical installation

4. BENEFITS OF GIS EANBLED MAPPING TOOL IMPLEMENTATION

Several benefits, realized by most of the groups involved in the implementation process, were obtained by the use of this tool. These benefits can be summarized as follows:

Design and Planning Support: During the initial stages of planning for this project, there were several engineers working on different experiments for the Pilot. Without the use of a geographical tool for planning, some of the devices with similar functionalities were initially going undetected. Once all the devices with the right attributes were mapped together it was clear that some redundancies on functionality existed. For example: a feeder monitor installed a couple of poles away from a Capacitor Controller would add no particular value to the quantities to be measured as the Capacitor Controller will capture virtually the same data. The same type of situation occurred with Faulted Circuit Indicators placed near intelligent devices in the branches downstream. As all of the intelligent devices specified in the pilot report status back to the Control Room in real time the existence of a Faulted Circuit Indicator in a zone with several devices would translate into redundancy and will add no additional value to the fault indication process.

Communication's Infrastructure Development: One of the most important benefits of a geographical tool for this kind of implementation is the development of the communication infrastructure. Distance to devices, local terrain and line of sight to the base stations are key components of RF design. By using a geographical tool, visualization of the coverage area of base stations can help to determine the devices that can be reached within a reliable distance. At the same time, the use of topographical layers permitted the communication engineers to make an assessment of potential problems with the line of sight from the devices' antenna to the base stations. Since the team employed a radio system operating at 3.65GHz, line of sight between the device and the base station is required. Using a topographical overlay on the mapping interface, the engineers could readily identify RF barriers and recommended the necessary adjustments.

Construction Planning: Using a centralized geographical tool to schedule work facilitates the efficient use of resources by targeting specific locations for sequential installations. Devices that are of similar kind in a relatively close area can be scheduled at the same time reducing the time and cost of implementation. Additionally, this targeted approach of installing and commissioning by device type and geography allowed our crews to become more efficient as they progressed yielding improved installation rates.

Project Management: By having visibility of the status of all the components in a centralized way, project managers can prepare and coordinate resources better. An example of this is the preparation of equipment. Establishing the settings for a piece of equipment to be installed required the involvement, in general, of two groups: Protection & Telecom (PTO) and Operations & Maintenance (O&M). As most of the equipment included in the pilot was not standard (i.e. new to National Grid and not normally available in stock), project management had to make an effort to coordinate the receiving of new equipment and streamline the set-up process so there were no delays. To be ready for installation, a piece of equipment needed to have a radio installed and configured by a telecom technician and then, depending on the device, an O&M or PTO technician would take the unit for specific set-up. This process required the coordination and sequencing of tasks for three different groups to avoid downtime. By having a centralized place for scheduled dates and progress on the units, a project manager was able to identify what units were already configured by the Telecom technician and were waiting for attention of either Protections or O&M or vice versa. The same holds true for installation. Having an indication that the unit was already configured by all the required technicians, the construction crews, Control Center/EMS and the commissioning technicians could then be scheduled to process a unit on a specific date. The centralized nature of the data in conjunction with the ability to update it in real-time provided the Project Management office with up-to-date information it needed to be able to respond to queries from upper management or other interested parties.

Construction: Since the data informed the approach and sequence of installations, the process went fairly smooth. Depending on the state of the distribution system at the time of installation of a device, particularly devices with protection capabilities, it was necessary to disable system reclosing for upstream devices. The engineers and system operators could quickly consult the geospatial interface to view which existing devices would be impacted to ensure the proper switching orders could be established.

Commissioning: Since the devices required integration to National Grid's EMS system, coordination of different resources for their activation was a delicate process. Because of the nature of the communication technology employed and the way that some of the work was outsourced, the tasks during commissioning involved: inspection to validate proper construction, verification and update of settings for the device and its radio, alignment of the antenna to the correct azimuth, coordination with EMS for database changes and validation of communications to the device before activation. This sequence required the presence on the field of PTO, O&M, OH and/or UG construction. Given the number of devices and the timeframe selected for commissioning, all the different groups needed to be coordinated before the commissioning technician was available to activate the device with the assistance of the Control Center/EMS. At the same time, the progressive availability of the WiMAX stations made the use of the centralized source of information more valuable, as project management was able to identify which devices would be visible from their base station and therefore ready for commissioning.

Reporting: As the project was approved with a certain timeframe for implementation, and given the importance for National Grid's modernization plan, there was a need to provide a great degree of visibility of the progress made by the implementation of the Pilot. As such, the centralized database was essential in the creation of several reports indicating the progress made by the different groups and at any given time.

The compatibility of SharePoint with all the Office Suite applications made the creation of automated reports that were easy to present straight forward. The simplicity of the integration provided an easy way for different departments or users to create their own customized reports with the information they needed. For example, if an engineer needed to know what devices were (a) installed, (b) had a radio and (c) was reporting to a base station already in-service, a simple query could be executed or a report could be created in Excel.

5. CONCLUSIONS, COMMENTS AND FUTURE WORK

As National Grid's Smart Grid pilot is reaching its final stage, the lessons learned during the process become apparent. At the beginning, several groups were working in a coordinated way but without using the right communications and data sharing tools to be efficient. A lot of time was being spent verifying several disparate sources of information with groups creating their own databases, often in Excel. As the progression of the pilot required the groups to collaborate more closely, the need for a centralized source of information became apparent as bad data from stale Excel files crept into the process. Further, the geographical nature of the implementation required the exploration of a different kind of tool. To avoid the implementation of a stand alone and costly application that would take too much time to set up, a simpler route was taken by leveraging the existing systems already available within National Grid's toolbox. By making use of the geospatial information of the devices to be installed and National Grid's existing assets, an open source mapping tool was able to be incorporated into National Grid's SharePoint environment. This tool allowed the sharing of information between the parties to be easier and clearer for everyone resulting in a reduction of time spent in the planning, management, commissioning and reporting activities. The integration of a database with a geospatial interface provided a quick and easy perspective for engineers and management to see, at a glance, the status of the project. At the same time, the repository nature of the applcation was crititcal to support the troubleshooting of specific problems that emerged.

One of the key positive elements of this implementation is the increased visibility and collaboration that was obtained. The fact that different groups were able to review, correct and supplement the same source of information, made the progression of the activities smoother. The simplicity and readiness of information to the different levels of the National Grid's hierarchy brought confidence in the progress of the project and allowed key players to make the changes in real time when necessary.

Additional value to the information gathered will be demonstrated during the evaluation of the Pilot's results. By having historical information of progression, sequence and resources involved, the calculation of benefits will become less cumbersome and more intuitive.

For future implementations, National Grid is already working on different solutions to geographically track projects of different nature. By using ESRI ArcGIS services [5], National Grid is designing a new set of tools that will provide tracking and reporting of activities and information in a more intuitive way. As National Grid moves forward with its modernization plan, these tools would become essential to the decision making process of future initiatives.

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