

Integrating Desktop applications for Power System Restoration Drills

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The Midwest ISO (MISO), the Regional Transmission Operator (RTO) for much of central North America, facilitates an annual Power System Restoration Drill. The drill has more than 700 participants from the MISO's member companies, neighboring RTO's, and other power companies. In 2005 the MISO built an integrated process using ArcView, AutoCAD, and standard desktop applications to communicate system restoration efforts by all participants. During the drill members notified the MISO of what transmission lines were recently brought back into service, this information updated regional transmission system maps that were then distributed to all drill participants. This process was a cost effective enhancement, to other offline tools used for power system restoration drills, because of the clearly understood geographic diagrams.

Introduction – Midwest ISO

The Midwest Independent Transmission System Operator is an essential link in the safe, cost-effective delivery of electric power across much of North America. The Midwest ISO is committed to reliability, the nondiscriminatory operation of the bulk power transmission system, and to working with all stakeholders to create cost-effective and innovative solutions for the changing power industry. The Midwest ISO is a fully integrated regional transmission organization that assures industry consumers of unbiased regional grid management and open access to the transmission facilities under Midwest ISO's functional supervision. Midwest ISO optimizes the efficiency of the interconnected system, provides regional solutions to regional planning needs and continually minimizes any risk to reliability. The Midwest ISO is an independent, nonprofit organization that supports the constant availability of electricity in 15 U.S. states and the Canadian province of Manitoba. This responsibility is carried out by ensuring the reliable operations of nearly 94,000 miles of interconnected high voltage power lines that support the transmission of more than 100,000 MW of energy in the Midwest, by administering one of the world's largest energy markets, and by looking ahead to identify improvements to the wholesale bulk electric infrastructure that will best meet the growing demand for power in an efficient and effective manner. The Midwest ISO was approved as the nation's first regional transmission organization in 2001. The organization is headquartered in Carmel, Indiana with operations centers in Carmel and St. Paul, Minnesota.

Power System Restoration Drill

The MISO has directed an annual regional power system Restoration drill to train system operators in the restoration of the interconnected electric system since 2004. A partial or complete collapse of the interconnected electrical system in North America is possible and must be corrected expeditiously. Midwest ISO drill coordinators develop a unique drill scenario to make the power system restoration drill more realistic for drill participants. The unique scenario includes separation points, islands, failing communications, and timed disturbance events. Multiple regional transmission organizations have participated in the Midwest ISO power system restoration drills including PJM, IMO, and TVA. The 2006 Midwest ISO power system restoration drill had more than 700 individual participants from all the MISO member companies and some neighboring companies.

Power System Restoration Drill - Background

In 2004 Midwest ISO created Regional Drill Scenario maps based on the Midwest ISO Map of Operations, which was available and up to date. The Midwest ISO Map of Operations is a vector based transmission system topology map similar to the regional NERC maps that were widely recognized and used throughout the Midwest ISO's region. The Midwest ISO Map of Operations is an AutoCAD Lt drawing, with the file extension “.dwg”, and is based on stakeholder input and other sources. The drill scenario maps were well received by the Midwest ISO's and member company's drill coordinators.

Midwest ISO's drill coordinators requested that the regional drill scenario maps be updated on an hourly basis to geographically plot which lines had been restored to service and which were still out of service. The updated regional power system restoration drill scenario map was referred to as the regional power system restoration drill map.

The power system restoration drill map was manually updated centrally by a CAD specialist with data communicated to Midwest ISO system operators from member company drill participants during blast calls. Two Midwest ISO drill participants assisted in the collection of data. Each hour the work was saved divided into regions and converted into Autodesk's Drawing Web Format, drill participants could download their regions map and view it with a free viewer download from Autodesk. The end result was a high quality map that was updated every hour. The process used in 2004 had a few problems: communications, file size, file format, and update frequency.

Power System Restoration Drill - Problems

The communications and information flow from drill participant to CAD specialist and back to drill participant was inefficient, slow, and incomplete. During the 2004 power system restoration drill some lines were restored and not captured on the power system restoration drill map. Two additional Midwest ISO drill participants were required to assist the CAD specialist in updating the maps that could have been of use elsewhere. Slow communications and inconsistent reporting times overwhelmed the CAD specialist with updates some hours and left him idle for other hours during the drill.

The file size of the regional power system restoration drill maps was a concern. The regional power system restoration drill maps increased in file size with each posting. At the end of the drill the file size was at the limit of resource used to post them. The large file size also increased upload and download time further slowing the flow of information.

The file format was not well received by all drill participants. Most drill participants were unfamiliar with Drawing Web Format files. Some participants experienced problems downloading the viewer while others incorrectly installed or configured the viewer.

The primary criticism of the regional power system restoration drill maps was the low frequency of updates, and the hour long time span between updates. Regional power system restoration map updates should be more frequent to increase the value of them to drill participants. Midwest ISO system operator drill participants need accurate and timely information to communicate regional restoration possibilities and risks.

Power System Restoration - Solutions

To solve the problems with the regional power system restoration maps Midwest ISO needed a cost effective process and tool to communicate and display restoration efforts across the region. The tool and process had to be low cost due to budgetary concerns.

The Midwest ISO required that communications be comprehensive, clear, frequent and transmissible by the internet, phone (land line, cellular, and satellite), or fax. File sizes must be kept to a minimum to increase the speed of file transfers and to allow for specialized distribution methods. Additional display distribution methods should be considered and tested. The displays had to be in a widely used graphic format preferably with a free and easily obtainable and configurable viewer. The regional power system restoration drill map must be easily read so restoration decisions and opportunities could be identified and acted upon.

Power System Restoration Drill Tool

The Midwest ISO reviewed multiple tools based on the defined criteria to solve the problems with the regional power system restoration maps. All but two tools were quickly determined to be insufficient. The Midwest ISO in due course selected ESRI's ArcView product. ArcView would allow the Midwest ISO to implement this tool in time for the Restoration Drill and avoid the capital budgeting process. ArcView can directly read the CAD format of the Midwest ISO Map of Operations and creates an underlying database of the graphical elements. ArcMap, the map component of ArcView, produces high quality maps that are easily read. ArcMap export feature can create a small 2 megabyte file size Adobe Acrobat Portable Document Format file of the regional power system restoration drill map. Adobe Acrobat is a free and widely used program that is easy to use and configure. ArcCatalog, the database component of ArcView, directly reads files from Microsoft's desktop database program Access. Access is part of Microsoft's Office Suite that is widely used by organizations.

Power System Restoration Drill Process

In 2005 the Midwest ISO built an integrated process around ArcView using standard desktop applications. This process is used to communicate restoration efforts by all power system restoration drill participants. This process uses ESRI's ArcView, Microsoft's Access, Excel, and Outlook.

To facilitate communication, the Midwest ISO created a standardized Microsoft Excel spreadsheet form (Restoration Tracking Form) for each drill participant. The drill participants can automatically e-mail the Restoration Tracking Form to the Midwest ISO by clicking on a command button that attaches the Restoration Tracking Form to an e-mail and sends it to a Midwest ISO drill facilitator. If the Internet or e-mail was unavailable for a time period in the drill scenario the updates could be read from the form and phoned (land line, cellular, or satellite) into the Midwest ISO drill participants or the form could be printed and faxed to the Midwest ISO drill participants. Creating the Restoration Tracking Form met the Midwest ISO's criteria of comprehensives, clarity, and communicability.

The Midwest ISO transferred the flat vector based Midwest ISO Map of Operations from an AutoCAD drawing file into an ArcView based shape or layer file. The AutoCAD file required minimal manual tweaking to align geographic features to a standard coordinate

and projection system because it was drawn to the Albers Equal Area Conic projection. The AutoCAD drawing was scaled to actual size for the appropriate units. Measurements were then taken to create a world file to convert the flat AutoCAD file into an ArcView layer file. Once the layer file was created a geodatabase was created for the drill to store all relevant base map, CAD, attribute, and ancillary tables. ArcView creates geodatabases for each project, these databases are in Microsoft Access format and are easily opened, viewed, and manipulated with Microsoft Access. Attribute groups were created in the geodatabase to organize geographic information, lines, points, areas, shapes, and text. The corresponding layer information was assigned to the attribute group. Once the geodatabase was complete the unique object identifier, the handle, and the Transmission Line Voltage information was exported into a spreadsheet for easy navigation and distribution.

A manual effort was undertaken to identify each of the unique handles with the corresponding transmission line common name. Files and plots were sent to temporary employees, interns, shift workers and other staff. All transmission lines were identified by their common name by comparing the Transmission Line common name on the Midwest ISO Map of Operations with the Transmission line unique identifier handle. These were compiled over four weeks and reviewed and corrected over one week. The Midwest ISO then had the Restoration Tracking Form, Restoration Sub Regions Maps, and a common key to link one to the other.

At this stage the Midwest ISO integrated the tools into a process to distribute and collect Restoration Tracking Forms, update the Restoration Sub Region Maps, and distribute the updated Sub Region Maps. This process was achieved using Microsoft Excel, Access, Visual Basic, Outlook, ESRI's ArcView, and Adobe Portable Document Format.

The restoration tracking forms were created unique for each drill participant. Each drill participant's form was populated with only his or her company's transmission line information and then had their companies NERC acronym added to the end of the file name. During the drill when a line switched from in service to out of service or from out of service to in service they would select the transmission line from a drop down list and then select the change of status from another drop down list. The Midwest ISO then asked participants to send the updates to the Restoration Tracking Form to drill facilitators at the Midwest ISO. The Midwest ISO automated this step for participants by adding a command button to the excel form that automatically e-mailed the Restoration Tracking Form to Midwest ISO drill facilitators, when clicked.

After the Restoration Tracking Form was e-mailed to Midwest ISO drill facilitators it would be sent as an e-mail attachment to the Midwest ISO drill facilitators Inbox in Microsoft Outlook. A visual basic script automatically saved any attachments that came in with a name containing "restoration tracking form" to a specific folder on the desktops local hard drive. Every 15 minutes a Midwest ISO drill facilitator would run a Microsoft Access Module that would automatically update (compile) a Microsoft Access Table with all the restoration information in the Restoration Tracking Forms saved on the local desktop and then delete the Restoration Tracking Forms it had updated to the Microsoft

Access Table. This table would then update (bind) on a one to one basis to another Microsoft Access Table and then delete itself. Once this module finished running the directory on the local hard disk did not contain any Restoration Tracking Forms, the Microsoft Access Table used to compile the restoration information was empty, and the final Microsoft Access Table was bound with all the current Transmission Line statuses as reported by drill participants.

The Midwest ISO drill facilitators had linked the Transmission line objects in the geodatabase to the bound Microsoft Access Table using the ESRI ArcMap program, which is part of ArcView. After the Microsoft Access Module completed the Microsoft Access Database was closed. Midwest ISO drill facilitators then opened an ArcView Restoration Sub Region Map. This map when opened automatically linked to the new attributes in the bound Microsoft Access Table and changed the Transmission line attributes according to what was reported by drill participants. The ArcView map was then exported as an Adobe Portable Document Format to a specific drive on the Midwest ISO network. Once the Restoration Sub Region Map was saved to the drive it was automatically posted to a secure site on the Midwest ISO Extranet for download by drill participants. Each Sub Region Map was updated and posted for distribution.

Conclusion and Lessons Learned

The Midwest ISO's project to create a cost effective process and tool to communicate and display restoration efforts across the region was a success. The process takes as little as 2 minutes and as many as 6 minutes. The Midwest ISO was able to distribute high quality maps of restoration efforts with a maximum delay of 21-minutes from the time an operator modified the Restoration Tracking Form. The file size was below 3 megabytes for each regional power system restoration drill map. The process received praise from drill participants for the quality and speed for which maps were available during the restoration drill. The Midwest ISO plans to improve upon the process by automating more of the manual tasks, using better CAD to GIS drawing standards, and moving toward internet data collection instead of e-mail. The process is currently under study for use as a tertiary off line back up to online systems during any future transmission restoration event. The Midwest ISO was also able to purchase and design the files and process for the power system restoration drill more quickly because the lower price of the desk top GIS solution did not have to go through a time consuming capital budget process. The Midwest ISO realized significant cost savings by using a desktop-based GIS instead of a server-based GIS.

The Midwest ISO could further improve update frequency and data collection by implementing an Enterprise GIS solution. Enterprise GIS uses ArcInfo instead of ArcView, servers instead of desktops and provides comprehensive GIS capabilities to support a broad range of server GIS requirements. The software price difference between a desktop GIS solution and an enterprise GIS solution is significant. The enterprise GIS also requires Information Technology staff support, additional server hardware, a greater level of user expertise, and would require a longer time to integrate. The desktop GIS Approach was less than \$3000 and the enterprise GIS approach could easily had been

more than \$200,000 more expensive. The Midwest ISO could have completed the project earlier with fewer staff linking handles and common names if we had implemented ArcInfo and ArcGIS Schematics for a slightly higher price tag. ArcGIS Schematics can automatically generate schematics from complex networks. The Midwest ISO may move to a server-based GIS in the future and the modular design of ESRI's products will allow the Midwest ISO to continue to use its desktop GIS.

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