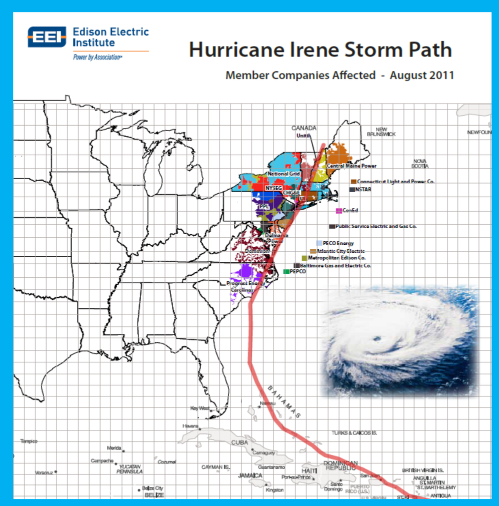
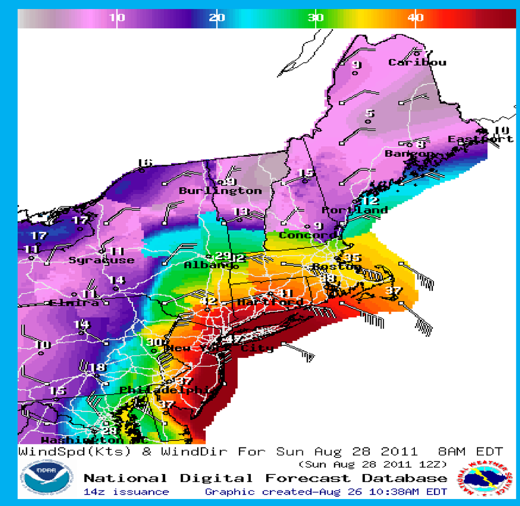
Weathering the Storm: Using Predictive Analytics to Minimize Utility Outages



Mark Konya, P.E., Ameren, St. Louis, MO

Kathy Ball, SAS, Cary, NC



Abstract

In order to meet ever-increasing customer service expectations, electric utilities must continuously improve the reliability of their electric distribution systems. Over the last decade, utilities have invested in digital technologies that give them near-real time readings on the health of their electric grid. This data is incredibly useful during major storm outages, but the flood of data pouring in from transformers and meters can quickly overwhelm even the most seasoned Distribution Engineer. Without analytical technologies, engineers cannot respond quickly enough to prevent additional outages and improve restoration times.

Distribution Optimization for storm management equips utility engineers and dispatchers to predict which assets will be affected by storms while optimizing the placement of crews, thus decreasing outage restoration times. Combining geospatial visualization with predictive analytics, the predictive enterprise utility can shorten outages from weather events and identify weak points in the electrical distribution system thus preventing future outages.

Introduction

The days immediately preceding a storm are a critical decision period for electric utility distribution company. The actions a company takes with respect to monitoring weather forecasts for an upcoming storm, predicting damage from that event according to its Emergency Response Plans (ERPs), and obtaining joint service agreements to obtain work crews will determine how well a utility can respond to customer outages when a storm hits. Then, a utility meets its second critical obstacle of determining the best method to restore power to its customers given safety, crew, and system constraints.

Preparing for the Storm

- Traditional analytics and advanced visual analytics
  - Utility visualizes Predicted assets impacted
  - Based on given storm forecast path
  - Detect system grid weaknesses real-time
- Holistic damage assessment
  - Combine historical and projected system
  - Predict damage using reliability analysis.

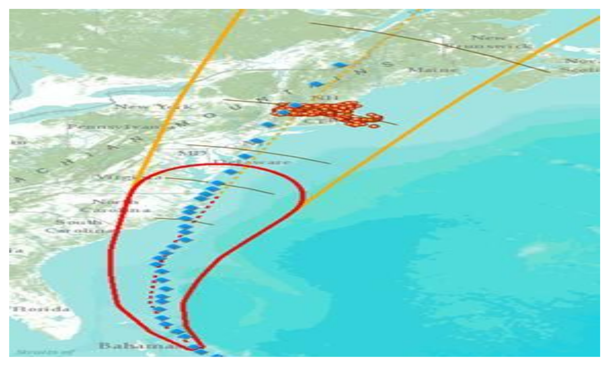


Figure 1. Current Method
(Source: ESRI Storm Archives)

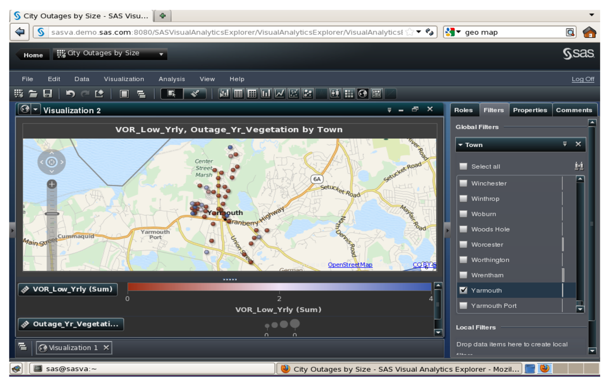


Figure 2. Advanced Method
(Source: SAS® Visual Analytics)

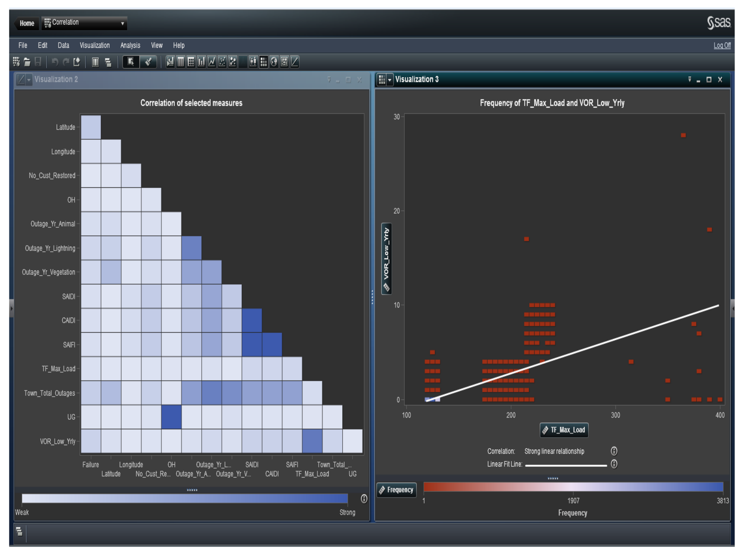


Figure 3. Correlate Variables to for Outage Model
(Source: SAS® Visual Analytics)

Modeling Asset Failure

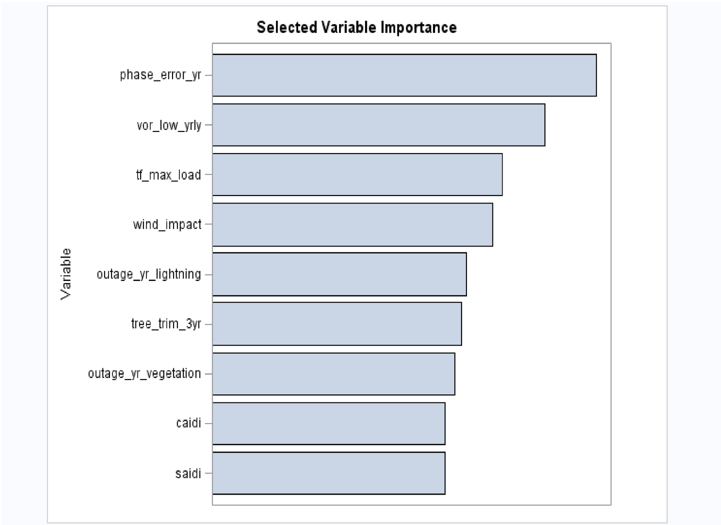


Figure 4 Advanced Modeling To Predict Outages
(Source: SAS® Enterprise Guide)

During the Storm

Integrating data from social media, a utility can better pinpoint outages in real-time from sources such as Twitter and can incorporate this information into real time forecasting including optimization analytics. In Figure 5, real-time outage information is viewable in an analytical format.

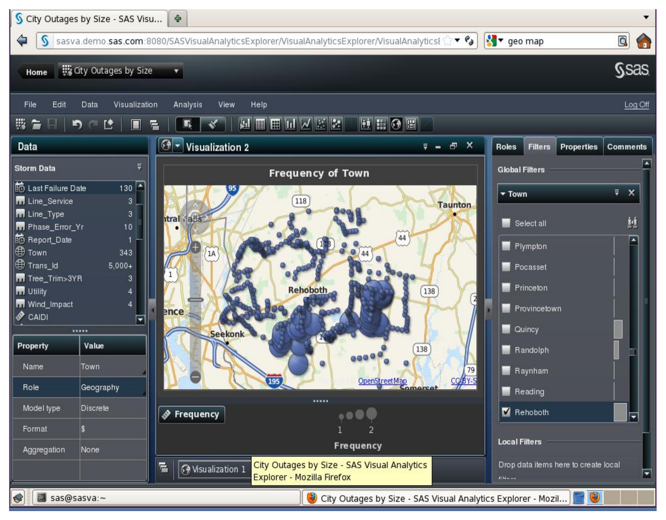


Figure 5. Hurricane Irene Outages by City – 9/1/2011
Real-time outage information leads to greater communications with customers and regulators.
(Source: SAS® Visual Analytics)

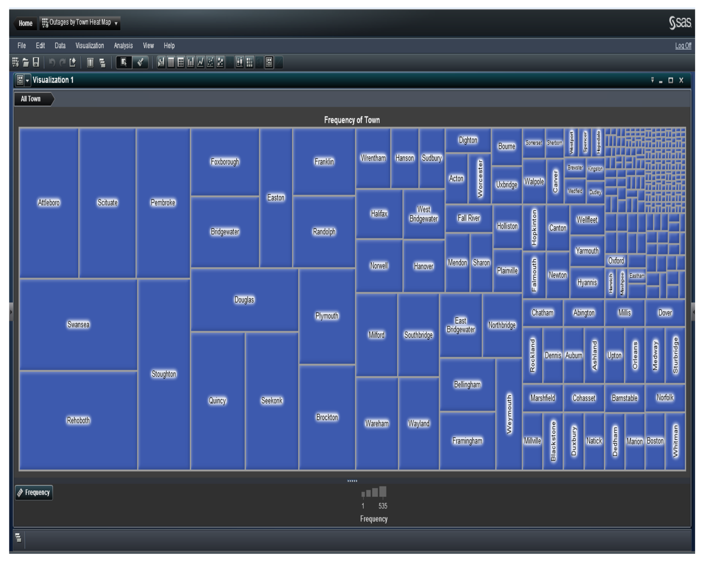
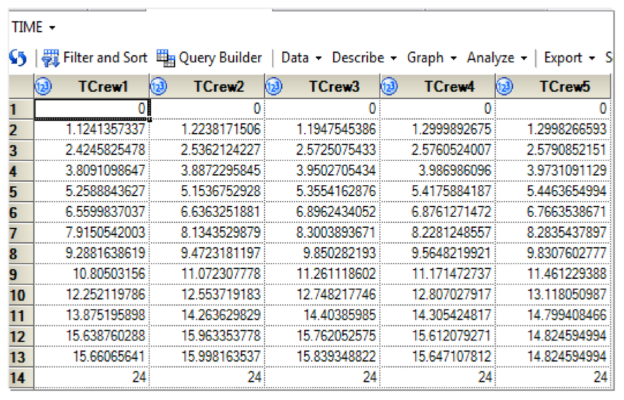


Figure 6. With millions of outages, a distribution engineer can tell at a glance where the majority of outages are located.
(Source: SAS® Visual Analytics)

After the Storm

- Objective: Restore the most customers while the work crews are covering the least distance given skill set, labor, and vehicle constraints
- In this poster, we will examine the optimal method for restoring power using an enhancement to an optimization technique known as Capacitated Vehicle Routing Problem using SAS® OR.

  - *STEP ONE: TRAVEL TIME CALCULATION FOR MODEL PREPARATION*



TIME

	TCrew1	TCrew2	TCrew3	TCrew4	TCrew5
1	0	0	0	0	0
2	1.1241357337	1.2238171506	1.1947545386	1.2999892675	1.2998266593
3	2.4245825478	2.5362124227	2.5725075433	2.5760524007	2.5790852151
4	3.8091098647	3.8872295845	3.9502705434	3.986986096	3.9731091129
5	5.2588843627	5.1536752928	5.3554162876	5.4175884187	5.4463654994
6	6.5599837037	6.6363251881	6.8962434052	6.8761271472	6.7663538671
7	7.9150542003	8.1343529879	8.3003893671	8.2281248557	8.2835437897
8	9.2881638619	9.4723181197	9.850282193	9.5648219921	9.8307602777
9	10.80503156	11.072307778	11.261118602	11.171472737	11.461229388
10	12.252119786	12.553719183	12.748217746	12.807027917	13.118050987
11	13.875195898	14.263629829	14.40385985	14.305424817	14.799408466
12	15.638760288	15.963353778	15.762052575	15.612079271	14.824594994
13	15.66065641	15.998163537	15.839348822	15.647107812	14.824594994
14	24	24	24	24	24

Figure 7. Time Calculation using PROC Geodist
(Source: SAS® Enterprise Guide)

  - *STEP TWO: MODIFY MIXED INTEGER LINEAR PROGRAMMING (MILP) FRAMEWORK FOR CUSTOMER RESTORATION CONSTRAINTS*

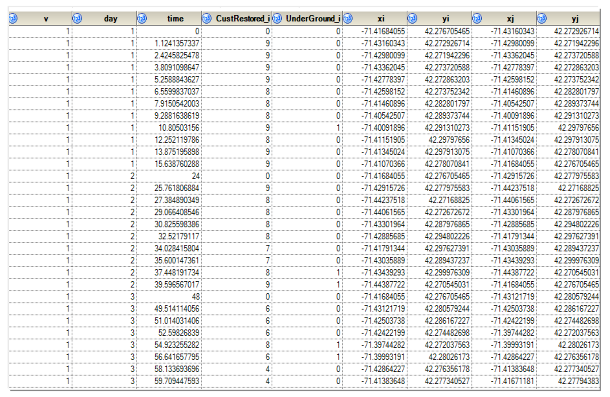


Figure 8. Vehicle and Skillset Calculations
(Source: SAS® OR and SAS® IML)

  - *STEP THREE: MILP SOLVER TO CREATE OPTIMAL SOLUTIONS VERSUS STANDARD UTILITY ROUTING*

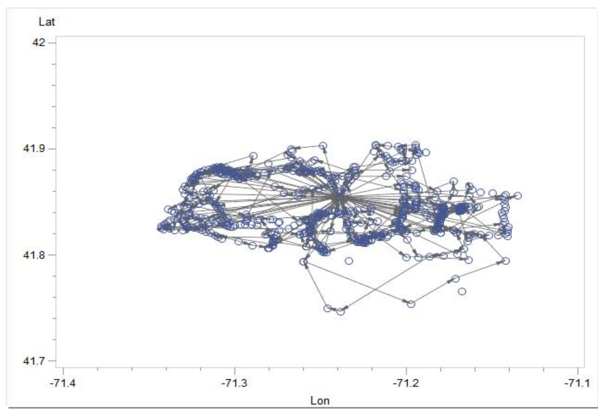


Figure 9. Dynamic crew scheduling
Sample Town: Fall River Massachusetts outages from Hurricane Irene 2011
(Source: SAS® OR and SAS® IML)

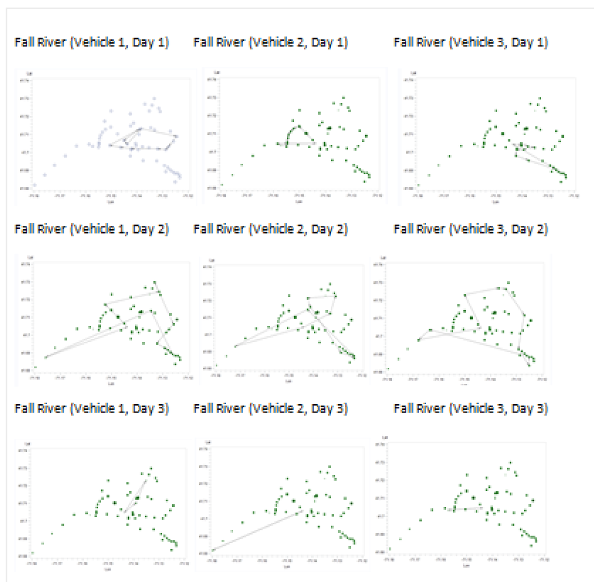


Figure 10. Dynamic crew scheduling
(Source: SAS® OR and SAS® IML)

Conclusions

BEFORE THE STORM RESULTS

- Predictive and visual analytics play a key role in pinpointing transformer outages in a proactive versus reactive manner.
- The methods used in this paper such as storm transformer outage prediction combined with geospatial modeling helps a utility better plan for assistance, materials, and potential storm impact.
- While the accuracy results in this simulated dataset were higher than should be expected at 98% over existing techniques, additional studies with real storm data could be beneficial for all.
- This could lead to timelier outage restoration, improved system reliability, and better communications with governmental and regulatory bodies.

AFTER THE STORM RESULTS

- Results from the Constrained Customer Restoration Optimization varied in this simulated dataset from no change to a 22% improvement in outage restoration time for optimized routes from non-optimized routes.
- On average, towns were able to have customers restored 13.8% faster than the present heuristic restoration technique.
- Variables contributing to the greatest gains include dynamic crew scheduling capability, distances between outages, number of underground outages, with crew and vehicle capabilities playing a role as well.

References

- Massachusetts Government information from the Department of Public Utilities, Storm Orders regarding Hurricane Irene. Available at http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/dpu/storm-orders.html
- "S.P. Anbuudayasankar, Amrita University, K. Ganesh, K. Mohandas, Amrita University, " Mixed Integer Linear Programming for Vehicle Routing Problem with Simultaneous Delivery and Pick-Up with Maximum Route-Length", International Journal of Applied Management and Technology, Vol. 6, Number 1

Acknowledgments

- Albert Hopping, SAS® Institute, Operations Research Optimization Modeling
- Jim Duarte, SAS® Institute, Survival Analysis Modeling

Contact Information

Your comments and questions are valued and encouraged.
Contact the author at:

Name: Kathy Ball
Company: SAS Institute

Name: Mark Konya, P.E.
Company: Ameren Missouri

SAS GLOBAL FORUM