Research Update:

Development of a Business Case for Scheduling Utility Vegetation Management on a Preventive vs. Corrective Maintenance Basis

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The Utility Arborist Association (UAA) has identified the need to develop a means of assessing preventive maintenance cycle periods as a top research priority. BioCompliance's proposal in response to UAA's RFP focusing on this topic was selected, and work on the project began earlier this year. The project, *Development of a Business Case for Scheduling Utility Vegetation Management (UVM) on a Preventive vs. Corrective Maintenance Basis* is on track to be completed in time for presentation at the UAA's annual meeting in August in Toronto. Progress on the project has included completion of a comprehensive review of the literature related to maintenance as a means of managing risk, and selection of an economic risk model (probability bow-tie analysis) that will be used to complete the second phase of the project. What follows is a general discussion of the observations made while working on the project thus far.

Maintenance and risk management

Utility vegetation management programs exist, and maintenance practices are performed, in an effort to reduce risk to a system. As risk can never be completely removed, it is important to understand the relationship between risk reduction, maintenance efficacy, and economic outlay. An important factor of maintenance optimization, as defined by UAA, is the relationship between the relative costs of preventive vs. corrective maintenance and the relative efficacy of each strategy in reducing risk to acceptable levels.

Risk management is an important topic that affects most industries. For municipalities and utilities, one of the primary management objectives is to reduce risk associated with large populations of trees in urban and utility forests. For example, there is the risk of lost service revenue, asset damage, or liability exposure from trees affecting overhead distribution and transmission systems. Maintenance activities typically represent a significant expense to both municipalities and utilities interested in reducing risks associated with tree failures.

Vegetation managers face a challenge common to maintenance management in general, that being how to maximize performance with limited resources. For vegetation managers, this has typically involved attempting to achieve an appropriate balance between investments in preventive tasks and the cost of corrective actions. As financial resources become increasingly scarce, an optimal balance can be achieved by optimizing cost, system performance, and levels of service.

In the case of most engineered systems, such as oil refining, a great deal is known about the performance and failure rates of critical system components, making it possible to conduct in-depth quantitative analysis. In contrast, Utility Vegetation Management (UVM) analysis is complicated by the current lack of quantitative data, and by the fact that a major component of any analysis involves a biological system. Additionally, information related to economic considerations for vegetation management is generally qualitative in nature. The quantitative cost and efficacy data for failure mitigation activities that do exist tend to be dated, and do not represent many of the contemporary approaches that are found in the industry today.

The intent of the UAA's RFP was to support development of a framework to help utilities and other managers of tree populations identify cost-effective maintenance resource allocations and cycle times. The UAA realized that this was a very substantial undertaking, so the intent of this initial investigation is to lay the groundwork for more comprehensive investigation into the relationship between costs (direct and indirect), performance (safety and reliability) and customer satisfaction.

Approaches used in the UVM industry to determining VM resource allocation

Findings from a review of the literature served as foundational reference information establishing the current state of practice. More than one hundred articles were reviewed, and fifty were deemed sufficiently important to warrant develop of project-specific abstracts for each article and to include in a narrative summary of findings.

Perhaps most importantly, the review of the literature and discussion with industry thought leaders identified five different approaches that have been used in efforts to determine appropriate vegetation maintenance cycle periods and preventive maintenance funding requirements. Each of the five vegetation maintenance models is briefly described below:

Clearance Model: Three factors are considered in the clearance-driven approach to determining an appropriate cycle: the amount of line clearance achieved at the time of preventive maintenance, the re-growth response rate of the tree being maintained, and the tolerance for incidental tree-conductor contact. Once the frequency of maintenance is established, the budgetary resource requirements are then calculated. This approach has been widely applied by Environmental Consultants, Inc., (ECI) as a core element of vegetation maintenance assessments that have been performed for nearly 100 utilities.

Cost of Deferral Model: This approach to determining appropriate preventive maintenance cycle period is based on the work of Browning and Wiant. This oft-cited work funded by the ISA Research Trust (now TREE Fund) focuses on the cost premium incurred when the preventive maintenance interval extends to the point where conductors are fully enveloped within the canopy of trees. In that respect it is related to the clearance model. The difference is that this approach is based on determining the inflection point where the cost of work increases dramatically due to an increases in the amount of time it takes to prune trees as crews are working in close proximity to conductors, and also due to increasing biomass requiring pruning, removal and disposal.

Reliability Model: This approach is based on the relationship between preventive maintenance cycle period and the frequency of tree-caused outages. There are at least two variations on this model. One approach has been to identify an inflection point in the reliability over time curve and establish a preventive maintenance interval just short of the point where tree-caused interruptions increase markedly. Another approach considers economics using a metric such as Customer Minutes Interrupted (CMI). In this approach, a relationship between preventive maintenance (cost) and CMI is defined. Once the relationship has been established, the utility determines how much to "invest" in preventive maintenance in an effort to buy down CMI.

Annual Increment Model: This approach borrows from traditional forestry. This emerging concept championed by Guggenmoos considers two factors: the annual increase in biomass as trees grow, and annual mortality rates. Equilibrium is achieved when the amount of vegetation maintenance work being funded and completed is in balance with the annual increase in biomass due to growth and any increase in the hazard tree population due to mortality.

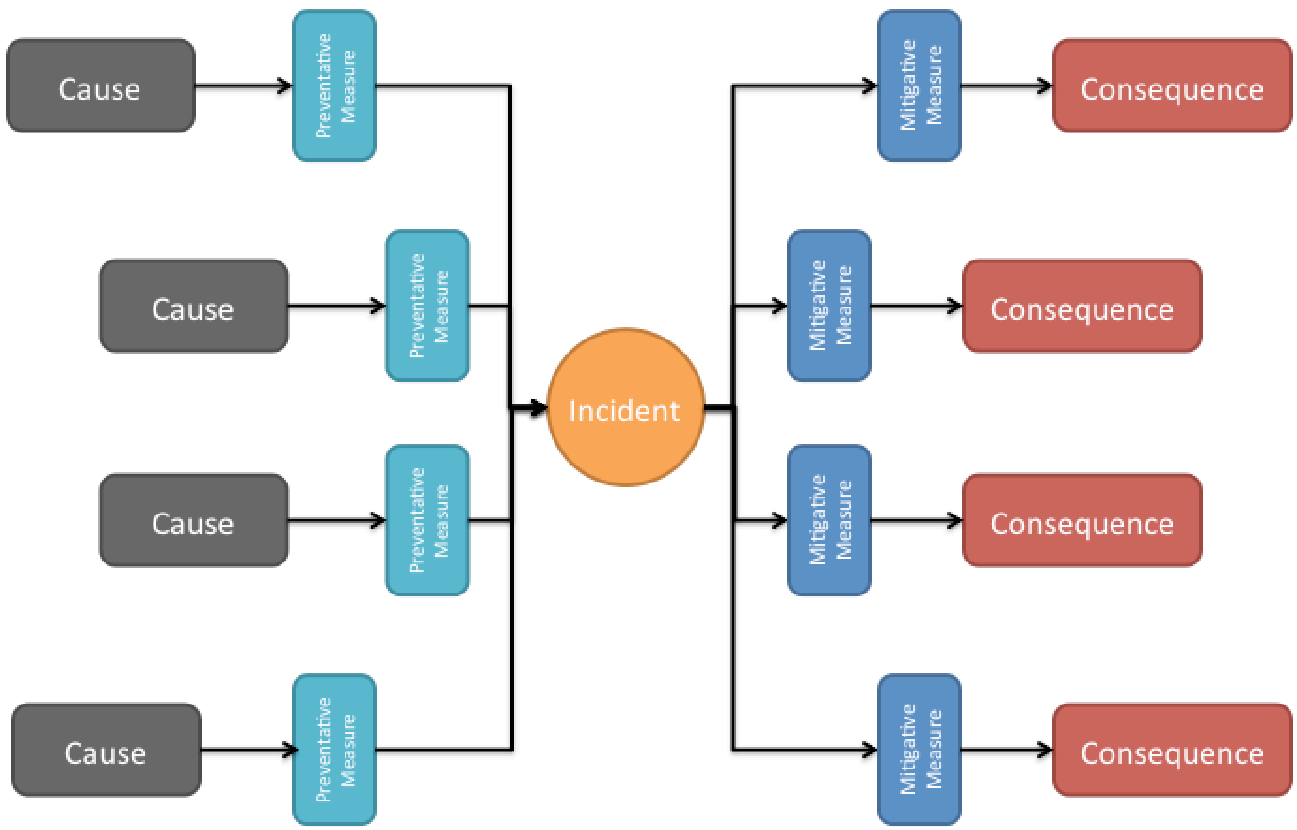
Regulatory Mandate: An alternative approach to preventive maintenance cycle period is based on regulatory requirements. Obviously this is not a "model" but mandate. Several states have either adopted or are considering adopting mandatory vegetation maintenance cycle periods. In these cases, since a fixed-interval cycle is a requirement, attention turns to the amount of work to be performed when preventive maintenance is required. As a result, the decision as to funding level is based on the relationship between works intensity (e.g., clearance obtained, hazard trees removed) and risk of tree-caused interruptions. A variation on this mandate is to establish minimum tree-conductor clearance requirements.

Interestingly, none of the models described an application of the classical approach to determining optimal preventive maintenance cycle period. This approach compares the cost of preventive maintenance and corrective maintenance over time, in what is often described as a "bathtub curve" where the optimal time interval is the point at which the combined cost of preventive and corrective maintenance is the lowest. One barrier to adoption of this model could be the need for quantitative data that may be hard to come by. Another reason that this approach has not gained favor may be due to the relatively low cost of corrective maintenance. The industry's default definition of corrective maintenance is what is commonly referred to as "hot spotting". This describes the assignment of tree crews to "problem" trees and sites on an unplanned basis, diverging resources from scheduled preventive maintenance work. With few exceptions, the costs of tree-initiated outages to the utility and utility customers have not been included in assessments of preventive vegetation maintenance requirements.

There are clear differences in the approach taken and complexity between Distribution Vegetation Management (DVM) and Transmission Vegetation Management (TVM). A fundamental difference is that DVM accepts some level of risk and tolerates tree-initiated interruptions, where as TVM faces regulatory mandates. That said, the basic constructs and assessment model that is being developed should be durable enough to support an assessment of both VM requirements on T&D systems.

Next Steps

As previously mentioned, Bow-tie analysis has been selected as the method to be used in completing this project. It has been used in a wide range of high-risk industries such as medicine, petrochemicals, and nuclear power. The advantage of the Bow-tie method is that it provides a relatively simple means of characterizing the risk equation using a diagram resembling a "bow-tie" that depicts the relationship between causes and consequences. The final result of a bow-tie analysis is linkage of causes and effects for an incident of interest. In this case of course the causes of interest are tree-initiated faults and the consequences of interest are interruptions and outages, along with the concomitant results.



Bow-tie Analysis

This project will address the relationship between costs (direct and indirect), performance (safety and reliability) and customer satisfaction as related to UVM. We expect the project to be completed in July 2013. The presentation in Toronto will include a summary of findings from the literature review, a business model framework identifying the most important variables to be considered in a complete analysis, and a description of the methodology that would be necessary to establish the value of all variables in the economic model. The intent of this study is to lay the foundation for a more rigorous analytical approach to determining optimal vegetation management spend and cycle times.