ADVANCED ASSET HEALTH MANAGEMENT FOR EFFECTIVE MAINTENANCE AND ASSET REPLACEMENT PLANNING

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ABSTRACT

This paper presents a case study about an Asset Management project, implementing the decision process for maintenance and asset replacement in a distribution network. It describes the principles used to produce an assessment of the health of the entire fleet of assets, together with the concepts retained to prioritize the interventions on the distribution network equipment.
The paper goes through the actual steps taken for the preparation and execution mode of the overall project. It covers the following project phases:

- *Definition of the problem & business objectives*
- *Process definition and preparation tasks*
- *Presentation of Solutions*
- *Execution phase*

.The project being still in the implementation phase, the conclusions are preliminary but already demonstrate concrete and tangible benefits.

INTRODUCTION: PROBLEM & BUSINESS OBJECTIVE

This project has been established by the Utility with the main business objective to maintain high level of reliability and enhance personnel & equipment safety. To reach this goal, the Utility decided to define and implement a company-wide set of process and tools, capable of supporting decisions and setting priorities for condition-based maintenance and repair actions.

To produce meaningful and effective results, this set of process and tools has to operate on reliable data. For this, it was decided to:
- carry out a comprehensive condition monitoring program of the 11kV Distribution Network in live condition (in service condition) to get a current &complete condition of the equipment,
- establish a central system hosting asset identification with all condition data, in order to further capitalize information and centralize decisions.

The overall scope consists in more than 11,000 secondary substations (MV/LV) to be visited and assessed in 3 years. These include MV switchgear with various isolation techniques (Vacuum, Oil, SF6), Oil immersed and dry MV/LV Power Transformers, and LV panels.

As many as 18 switchgear manufacturers, 40 Transformer manufacturers, and 17 manufacturers of Distribution Feeder Pillars are used today.

PREPARATION TASKS AND DEFINITION OF PROCESSES

The Utility specification document describes the main business objective, the concerned assets, the measurement techniques, and the expected results. From there, the first action was to articulate the process to be followed to implement such a large undertaking. This was split in 2 main areas:

- The data collection and analysis process, to make sure that the business goals will be met
- The team mobilization process, to setup quickly the proper organization to cover such a large task

Process for Data Collection and Analysis

A number of steps have been taken to define the process to be followed, setup the corresponding tools, the IT systems and their interactions.

Definition of Analytics

The first step is the definition of the expected results and how to get there. The main business objectives are (1) to define maintenance priorities and (2) to make decisions for replacement when asset condition is such that maintenance or repair actions are not practical or not economical.
This overall objective has been implemented through a strong methodology supported by a number of key analytics, provided by ALSTOM Grid **e-terra***assetcare* software product. These include:

- The Asset Health Index AHI, a representation of the residual life of each asset, targeted at asset replacement analysis
- The Asset Maintenance Index AMI, indication of the distance to the next maintenance action
- Probability of Failure POF, relying on statistical analysis to evaluate the exposure to major failure

- Additional key information, such as Estimated Residual Life ERL, an estimation of the number of years till practical end of life

Then a Criticality analysis (Asset Criticality Index ACI) is attached on each asset to evaluate the consequences of a major failure on the Utility business. Combined with the Probability of Failure, it provides an estimation of the risk incurred by the Utility (Asset Risk Index).

Together, these indices constitute the set of key analytics retained to assess the situation of the distribution assets and support the decision process.

Finally, a process for monitoring information, managing alerts, and defining Remedial Measures is implemented to take and manage the corrective actions.

Measurement techniques

All the above analytics cannot provide any meaningful results without solid data on assets. As per Utility innovative and visionary requirements, comprehensive and consistent sets of measurements were required to be taken for all assets when visiting the substations. These are grouped in the main categories below:

- Visual inspections: the visits include a systematic review of all key control points, such as oil leakages, gas pressures, status of gauges, environment status, corrosion, civil condition, abnormal noise, and so forth
- Thermal analysis: via temperature measurements, but also Infra-Red analysis, the field inspection teams collect a thermal image of the assets. This is used to detect any anomalous behavior or hotspots that could generate damage to the equipment, or are the sign of a degradation of the asset itself
- Partial Discharge: evaluation of the level of PD around each piece of equipment helps detecting abnormal situations, locating anomalies and defining corrective actions.
- Oil analysis for Oil immersed Transformers is done in a systematic manner, providing DGA analysis, Oil Quality, and also analysis of Furans to help in the overall evaluation of the ageing of the asset.
- For dry transformers, Vibration analysis replaces Oil analysis.

Alstom Health Model

Wherever applicable, Alstom has brought its existing practices and past experience. An example is the Alstom Health Model for Transformers, which is an agreement between all stakeholders in Alstom Grid about the parameters required to assess the health of a Power Transformer. Using these parameters has significantly reduced the time needed to create the model for the Health Index, by combining Alstom expertise, Utility experience and recommendations from standards such as CIGRE A2.34 WG for Transformer maintenance, IEEE C57.104 and IEC 60599 for DGA analysis, CIGRE TB 227 for Transformer condition.

A total of 12 different asset types have been created to represent the various assets in the grid, sized for approximately 150,000 assets; each asset type having its own Health Model, made of an average of about 50 condition parameters.

Tools for Data Management

For such a large number of assets and data elements to be created, a strong data management has been put in place. This starts with a proper definitions of data, grouped in key documents such as the Data Dictionary and the glossary of terms, essential to allow people from different business domains to communicate toward one single objective.

A second element key for success was the strict definition of the data management flow, from the field to the final reports, broken down in smaller, manageable functional units connected via proper interfaces, and allowing the creation of independent tasks executed in parallel.

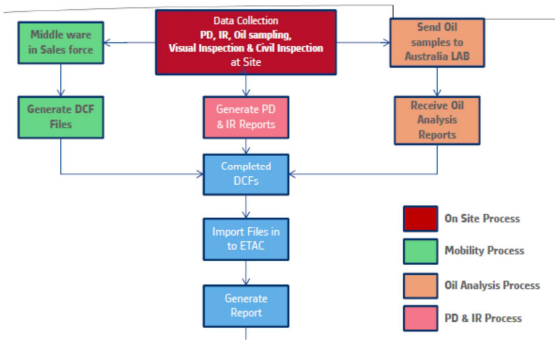


Figure 1: *a simple view of the data management flow, defined for an effective delivery mechanism of the reports to the Utility*

Team Mobilisation

The goal was to mobilize rapidly the proper set of experts in the various measurement techniques, define common tooling & methods, get the teams certified for technical expertise and compliance to safety regulation requirements. Both Utility and ALSTOM Grid safety

regulations are enforced.

Figure 2: *PD measurement on switchgear with anti-arc flashing clothing*

This strict process has been fully defined upfront and actually verified by site audits.

ALSTOM GRID SOLUTIONS

For this project, ALSTOM Grid has mobilized expertise and resources coming from multiple parts of the organization, including:

- The Service business line
- The Network Management business line
- The Equipment manufacturing business line
- The Asset management activity

All these skills are working together to fully cover the business objectives, as highlighted in the paper [2].

In addition to these skills and set of processes, this project is supported by 2 key ALSTOM Grid products:

- The **e-terra***assetcare* software product for asset health management
- The Alstom Grid Field Mobility suite, ranging from tablet-based applications for data entry on site, up to automatic integration into the health model of **e-terra***assetcare*

The e-terra*assetcare* product

e-terra*assetcare* is Alstom Grid solution to effectively support advanced strategies in the field of asset maintenance, asset replacement, and risk-aware grid operation. These strategies can move from time-based, to usage-based, to condition-based and to reliability-based by considering the criticality index of each piece of equipment.
e-terra*assetcare* provides interfaces to consolidate all asset related data, coming from manual records, inspection reports, on-line condition monitoring devices and also usage data from real-time systems such as the SCADA/EMS/DMS.
Assets are then analyzed through flexible health models, which encompass ALSTOM knowledge as equipment manufacturer along relevant CIGRE/IEC/IEEE standards. These models are fully adaptable to integrate Utility specific conditions and internal expertise.
All these data are combined to produce advanced, synthetic indices such as the Asset Health Index AHI representing the effective age of each piece of equipment.
In a subsequent step, the criticality index of each piece of equipment can be added to combine the health information with the business impact of a potential failure of this piece of equipment.

Presented in comprehensive dashboards, this information can be used to issue alerts for maintenance actions and even trigger work orders in the Computerized Maintenance Management System (CMMS) of the Utility.

Figure 3*: a typical dashboard from* e-terra*assetcare, with the asset navigation tree, geo-referenced displays, analytics presented in synthetic charts for effective decision support.*

In short, this product helps Utilities to define optimum maintenance schedule and asset replacement plan. No longer based on time & budget constraints only, these plans will take into account the actual condition and criticality of each piece of equipment, thus optimizing overall expenses with a risk-aware view of the situation.

The high level vision implemented by this product is introduced in book [1] “Smart Grids”, where the section on Asset Management has been produced by the author of this paper.

The Field Mobility suite

Alstom Grid has consolidated its large field experience in servicing power equipment with the well-structured methodology created by ALSTOM experts into a suite of mobility applications running on tablets and integrated with the overall Utility IT/OT architecture.

On one single mobile platform runs an integrated set of features, ranging from work orders management, collection of field data including pictures, safety processes, documentation management, up to time sheets for cost tracking.

Many benefits are obtained from this new, integrated set of tools:

- Standardization of practices: all field personnel will implement the same practices and will follow a consistent methodology. Implemented in the tool from ALSTOM experience, it can be adapted to each Utility situation
- Data collection is streamlined, made systematic, checked immediately and sent automatically to the Enterprise level for immediate action. As an examples, site pictures can easily be captured and integrated in the information structure
- Help for users: Documentation is readily available, synchronized with the actual task being performed
- Cost & time Reduction: fastest reaction times, reduced errors, well defined & integrated processes, all this result in significant reduction of site costs, and time saving for scarce power equipment experts.

Figure 4: *The tablet application from Alstom Mobility suite is used for capturing field data on the condition of the equipment, together with correcting static data on the equipment model whenever needed*

EXECUTION PHASE

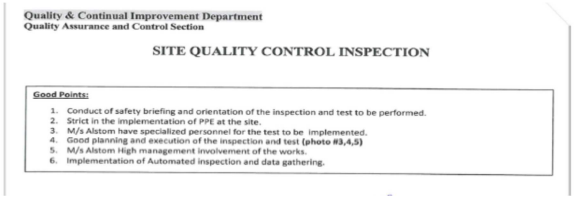
Given that the project is still in execution, only partial results are available at this time. However, benefits are already visible as show below.

Team Mobilisation

Addressing such a large scope in this time constraint was a real challenge. Actually, the multiple inspection teams have been mobilized with a small variance only vs the schedule, not impacting the results nor the overall timeline.
Mobilisation has reached the targeted inspection rate and will likely exceed the plan, thanks to the tablet-based mobility tools and a strict project management process.

Results

In addition to a timely execution, quality is a key focus, so that information and then decision can be built on reliable data. First results are quite positive in this regards.


Quality & Continual Improvement Department
Quality Assurance and Control Section

SITE QUALITY CONTROL INSPECTION

Good Points:

1. Conduct of safety briefing and orientation of the inspection and test to be performed.
2. Strict in the implementation of PPE at the site.
3. M/s Alstom have specialized personnel for the test to be implemented.
4. Good planning and execution of the inspection and test (photo #3,4,5)
5. M/s Alstom High management involvement of the works.
6. Implementation of Automated inspection and data gathering.

Figure 5: *The quality of the execution is demonstrated by the quality audits and certificates by Utility*

Upon inspection, data collection files are loaded into the **e-terra***assetcare* software, where analytics are computed, completed by analyst diagnostics and decisions, and then exported to build the management reports.

Reporting consists in fleet analysis charts, comments, and anomaly reports summarizing the abnormal situations detected together with the recommended corrective actions. A few examples of these charts are highlighted below

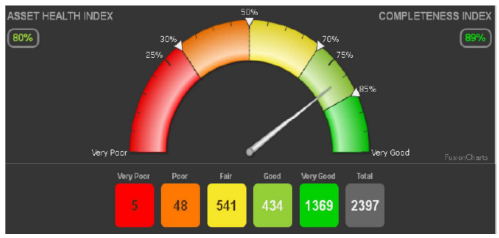


Figure 6: *an overall fleet assessment for a part of the grid, showing the split of assets by health zones, immediately highlighting the areas of concern*

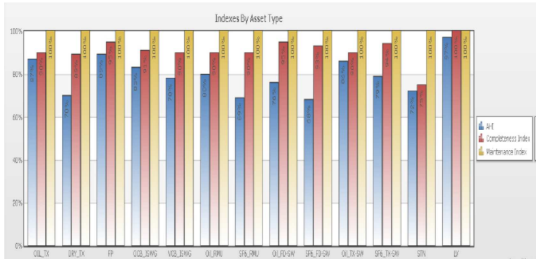


Figure 7:*the summary of key indices per asset type pvovide a quick comparison and sanity check*

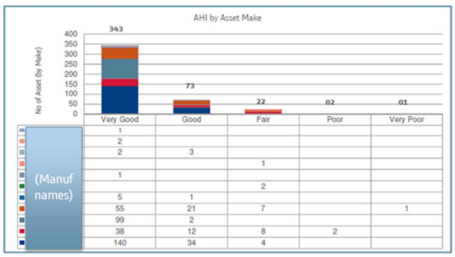


Figure 8*: for one asset type, health index per Make for one given inspection period focuses on potential issues*

Outcome - Decision support

Finally, the management report provides a summary of all recommended actions, with an Urgency level, leading in some cases to assets replacements.

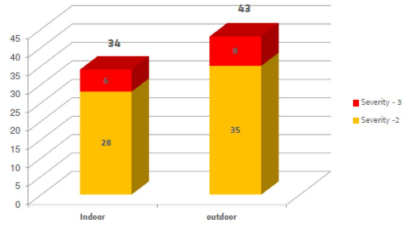


Figure 9*: required interventions, by urgency level*

Only a few months after the project initialization, all these actions have translated in well identified avoided failures in the grid, demonstrating the concrete benefits for the Utility.

CONCLUSION

As evidenced by the recent issuance of ISO55000 standards, Asset Management is the next area for efficiency improvement at asset-intensive industries like electrical utilities.

Products are now available, so that implementation risks are minimal for utilities.
First findings such as the ones obtained from the innovative project introduced in this paper demonstrate that benefits can be rapidly recognized in the definition of maintenance priorities and decisions for asset replacement.

However, this requires a well-structured approach and methodology, to avoid being lost in the Big Data syndrome, and lose the business perspective. The key ingredients to be required from solutions suppliers are:

- Experience and detailed knowledge in power equipment design and service
- Flexible models to cope with various equipment types and situations
- Well-designed business processes
- Actual products, in order to reduce the time and development risks
- Cooperation and teamwork with skills ranging from electrical knowledge, data management, IT deployment & integration, Utility processes, grid operation and maintenance experience.

REFERENCES

[1] Nouredine HADJSAID & Jean-Claude SABONNADIERE (editors), 2012, *Smart Grids*, published by Wiley, chapter on Energy Management by Jean-Louis COULLON, pages 99-102.

http://eu.wiley.com/WileyCDA/WileyTitle/productCd-1848212615.html

[2] Paul GUY, 2013, "Optimized Asset Management", *Transmission and Distribution.* June/July 2013,

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