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SCADA Data processing for wind turbine reliability analysis

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Abstracts

This research project discusses the life-cycle analysis of wind turbines through the processing of operational data (SCADA, Alarm logs and Maintenance logs) from three modern onshore European wind farms. A methodology for SCADA data processing has been developed combining previous research findings and in-house experience followed by statistical analysis of the results. The goal of this research project is to perform reliability analysis of the wind turbines using SCADA data and the relevant Alarm logs.

An algorithm has been developed in VBA using the SCADA counters in order to define the downtime events of the wind turbine and the Alarm logs to identify which wind turbine assembly initiated the downtime event. The analysis was performed by dividing the wind turbine into assemblies and the failures events in severity categories. Depending on the failure severity category a different statistical methodology was applied, examining the reliability growth and the applicability of the “bathtub curve” concept for wind turbine reliability analysis. Finally, a methodology for adapting the results of the statistical analysis to site-specific environmental conditions is proposed. The methodology is based on recent findings of other researchers on the impact of wind speed on wind turbine reliability.

Objectives

The main objectives of this research project are to:

- Identify downtime events through SCADA Data processing
- Categorize failure events according to their severity
- Apply a different statistical approach to different failure categories
- Verify the applicability of the “bathtub curve” concept
- Suggest a methodology for taking into consideration the impact of wind speed on wind turbine reliability prediction

Methods

Failure detection & categorization

For the downtime events detection a Visual Basic algorithm was developed mainly using the SCADA counters (Turbine OK, Service ON, Alarm ON). The total downtime for each event is separated into response time and service time and the failure events are separated according to the service duration (Table 1), combining the methodologies developed for the Reliawind project [1] (where failures were separated according to their impact) and WMEP [2] (failure division into minor and major depending on the total downtime).

	Service Time
Manual Restart	≤ 1 hour
Minor Repair	1 hour ≤ Service Time ≤ 8 hours
Major Repair	≥ 8 hours

Table 1. Failure Categorization

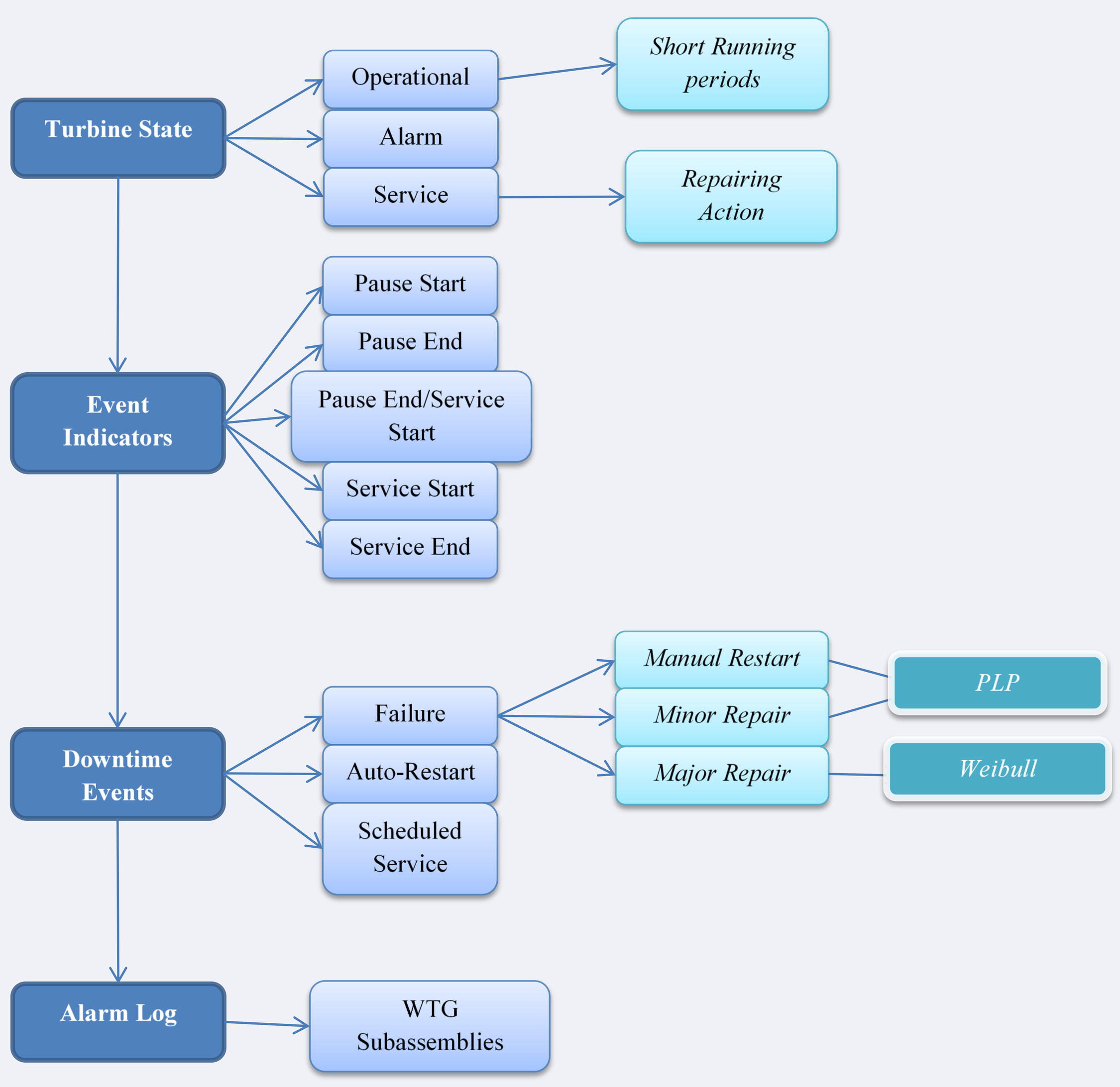

Figure 1. SCADA processing methodology overview

Statistical approach

Most of the previous research projects on wind turbine reliability ([1], [2], [3]) have adopted the “bathtub curve” concept, assuming a constant failure rate in time during the useful lifetime of the wind turbine. Recently, the applicability of the constant failure rate assumption was doubted [4]. Efforts have been made, to estimate more accurately the reliability growth of wind turbine assemblies during the turbine’s lifetime [5]. In [5] the Power Law Process (a Non Homogenous Poisson Process) is used to monitor reliability growth and the Weibull distribution is proposed by [5] and [6]. As explained in [7], a point process is useful for modeling the inter-occurrence of failures assuming that the assembly was brought back to the condition it was before the failure. On the other hand, a probability distribution is useful for modeling one single lifetime of an assembly / system. Taking the previous into consideration, the Power Law Process was applied for the manual restarts and minor repairs whilst the Weibull distribution was used to model the major repairs, assuming that after a major repair the assembly was thoroughly repaired or fully replaced.

Effect of wind speed on reliability

The effect of environmental parameters has been examined by several researches. Wind speed is considered to be the most significant the most significant environmental factor [8]. The results of Wilkinson et al. [9] are used to correlate the failure results of a wind farm to make a reliability estimation for another. The estimation is performed by comparing the wind speed Weibull distributions of the two wind farms.

Results

Below are presented some indicative results of the above described methodology.

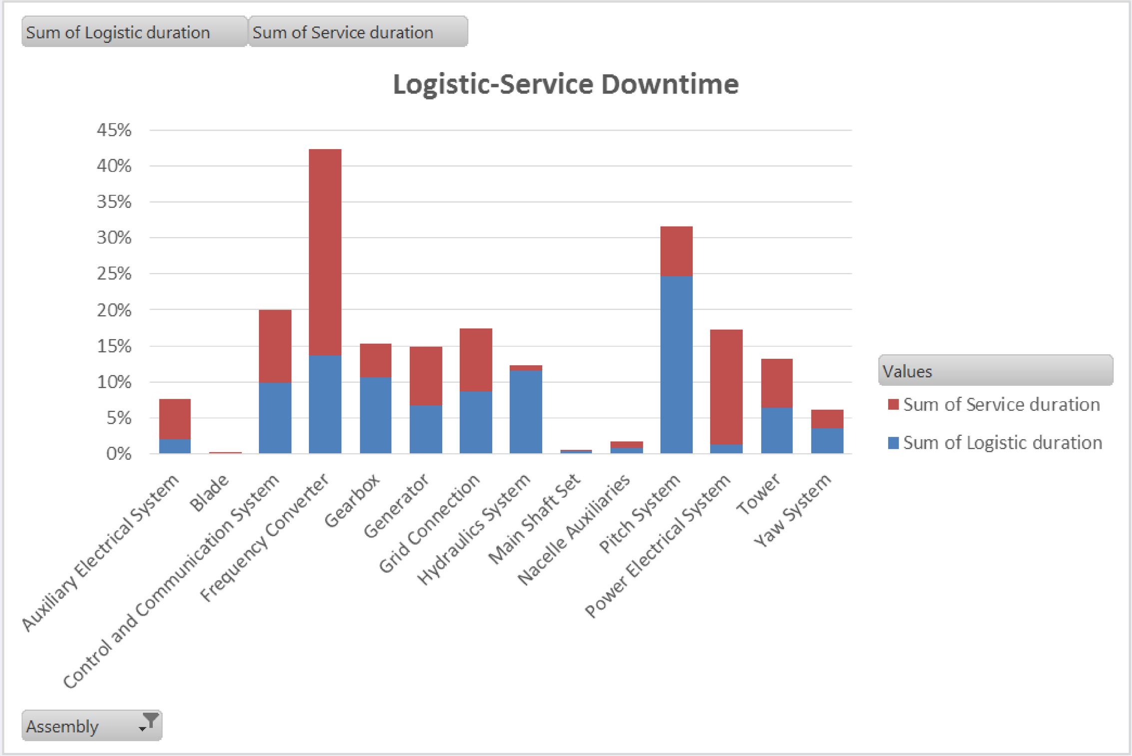

Figure 2. Downtime distinction

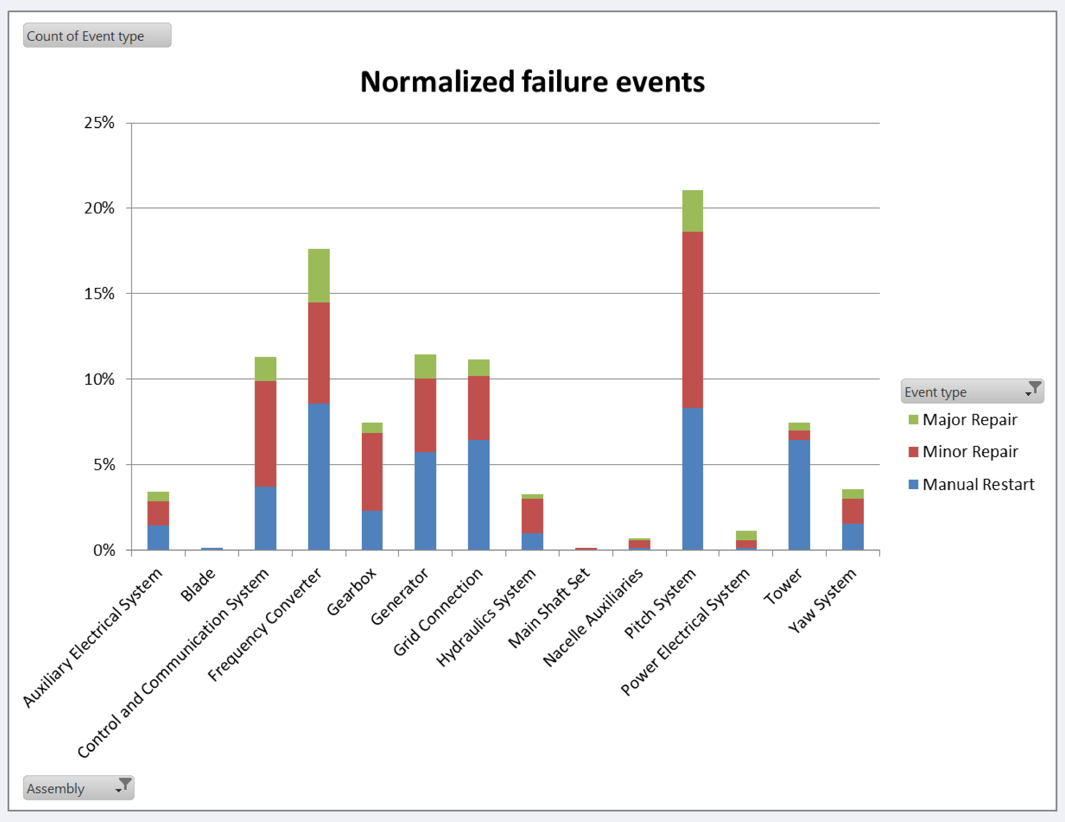

Figure 3. Normalized failure rate per assembly for 3 wind farms

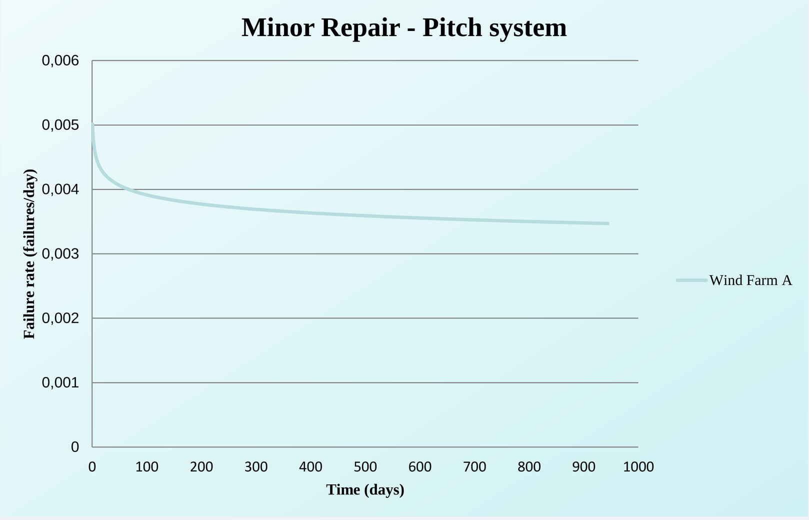

Figure 4. PLP example for Minor Repairs

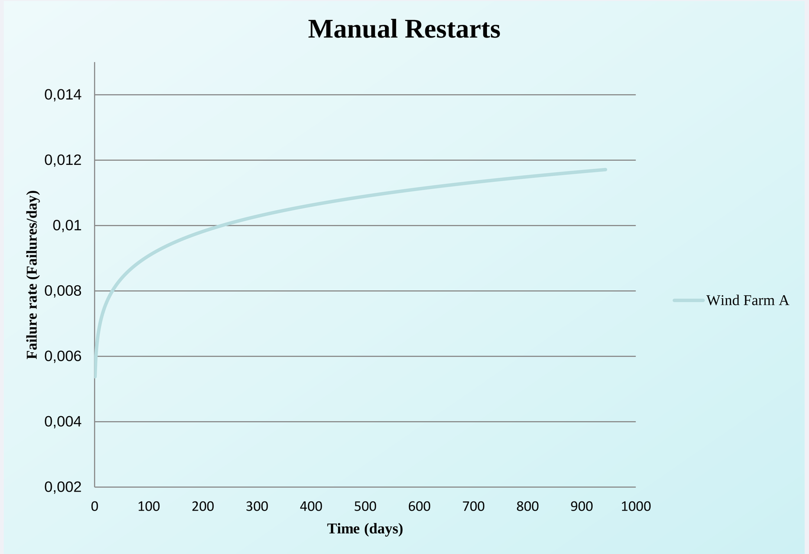

Figure 5. PLP example for Manual Restarts

Conclusions

The following conclusions can be derived:

- Processing SCADA data only (along with the alarms logs) can provide a sufficient description of the failure history. 83% of the failures were identified for the two wind farms examined in the project.
- Using the Weibull distribution and NHPP can model reliability more precisely and if the failure rate is constant it can be concluded (then we get an exponential distribution and HPP respectively)
- Grouping the data of several wind farms together is “hiding” information concerning the influence of environmental and other parameters on wind turbine reliability and can provide misleading results.

References

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