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# Component Life Assessment Using Incomplete Failure Datasets

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## Abstract

Premature failure of the main wind turbine sub-systems such as generators, gearboxes or transformers can result in prolonged downtime, production losses and expensive repairs. The implications of such failures for fleet owners and operators can become extremely significant, as the overall financial liability is potentially high.

Decisions concerning the choice of service contract, preferred service provider, level of insurance, required spare parts and tooling, or whether to extend the operational life of the turbine are all strongly influenced by expectations of the future reliability of the turbines. Therefore, the capability to project failure rates over relatively long time periods ranging from one to ten years becomes extremely important.

Classical reliability theory is readily available for addressing such problems, including well proven techniques such as MTTF (Mean-Time-To-Failure) assessment and Weibull modelling. However, the practical application of such techniques is often limited due to the high effort required to prepare well classified historical failure datasets, or even a complete absence of such failure data.

In this poster we demonstrate a method that has been developed to deals with such limitations in a pragmatic manner, allowing component failure risk to be calculated with quantified level of uncertainty. The method has been successfully implemented for an aging fleet of around 100 turbines and the results are used to provide decision support for centralised maintenance management.

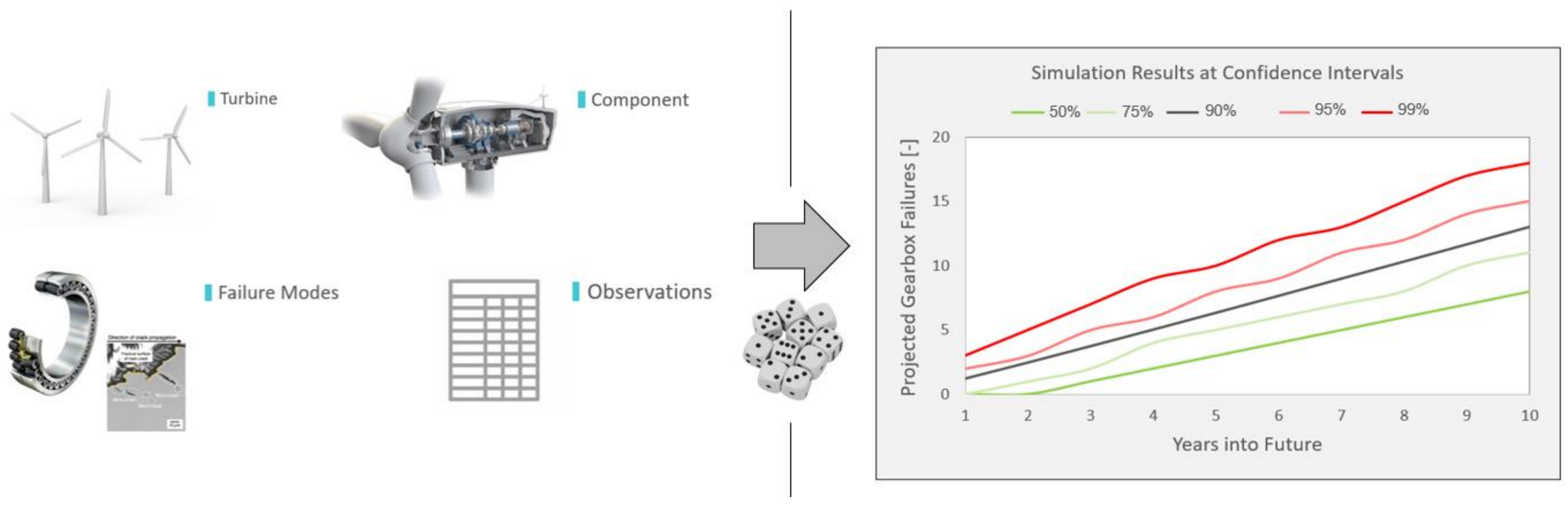
## Objectives

- Demonstrate how relatively small sets of failure data can be used to predict long term failure rates with defined levels of uncertainty.
- Integrate the results into a logistics management system to allow an operator to project spare parts requirements and financial risk

## Methods

Master data was gathered for a portfolio of around 100 turbines, all from the same manufacturer and type. Priority systems were selected including gearbox, generator, transformer, blades and blade bearings.

Service records for all turbines were examined and a database was compiled including all major failure events leading to complete repair or replacement of the priority systems. A statistical model was then developed capable of calculating the overall failure probability for each priority system, for a time period of up to ten years into the future. The method allows taxonomy to be defined with varying levels of detail, is tolerant to small input datasets and is adaptive, increasing in accuracy with the addition of any future failure events.

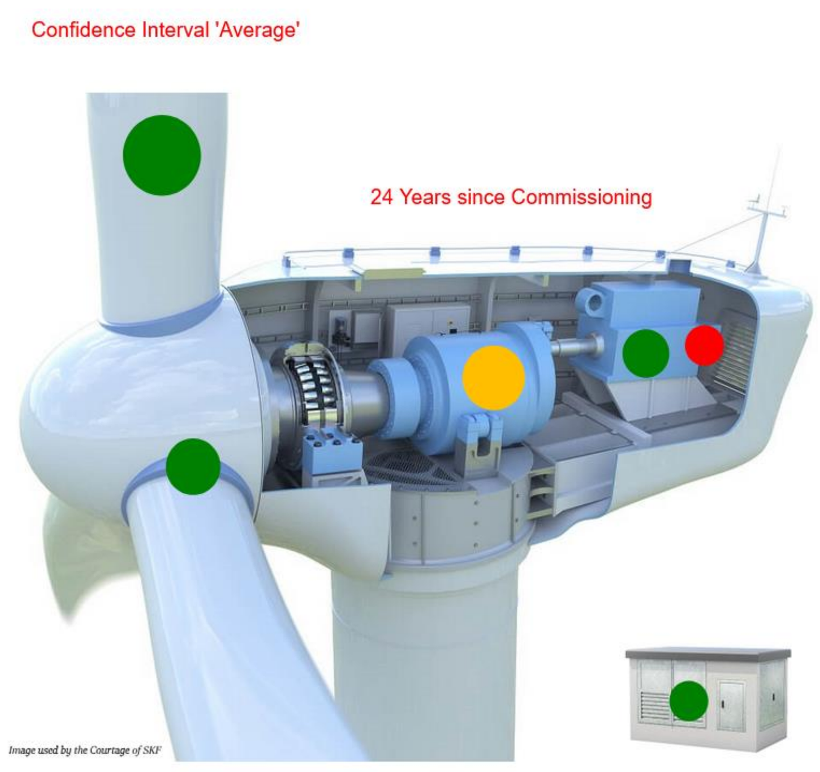



## Results

By relaxing typically strict requirements concerning taxonomy and failure mode classification, a solution was developed that could be deployed productively within a relatively short timescale. Limitations in the quality and quantity of available input data were accepted and considered in failure rate predictions, by stating the confidence intervals associated with all results.

As input data quality improves over time, these confidence intervals improve incrementally. Furthermore, as understanding of specific failure mechanisms improve, the data classification may be progressively updated for increasing results accuracy.

The resulting methodology has been embedded in an operational software system and is used to provide fleet level reliability projections that are updated on a monthly basis. This provides the fleet operator with valuable intelligence that is used for strategical decision support.




<25% Chance of Failure
25%-50% Chance of Failure
>50% Chance of Failure
High Percentage of Total
Low Percentage of Total

| | Age | Costs of Replacement (incl. Logistics, Crane etc.) | Prorated Costs of Total | Total Projected Reserve Costs for Selected Year |
|---|---|---|---|---|
| Transformer | 22 | 30,000.00 € | 5% | |
| Converter | 24 | 60,000.00 € | 9% | |
| Generator | 24 | 70,000.00 € | 11% | |
| Gearbox | 24 | 130,000.00 € | 20% | |
| Blade Bearings | 24 | 80,000.00 € | 12% | |
| Rotor Blades | 24 | 275,000.00 € | 43% | |
| | | | | 125,000.00 € |

## Conclusions

Wind turbine failure rate analysis and reliability projection has been the subject of research for many years in the wind industry, with several well know large scale funded projects aiming to advance the capability in this field. However, a fundamental barrier has always been a lack of high quality input data.

Nevertheless, the strategical and financial importance of this subject area is extremely high, and a pragmatic application of fundamental reliability theory can lead to huge improvements in O&M strategy and significant cost savings at many levels of the value chain. The developed approach is tolerant to imperfections in data quality, can be rolled out quickly and with low cost, and has been proven to provide immediate value in a practical use case.

## References

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