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Bayesian Network Methods for Risk-Based Decision Making for Wind Turbines

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1 Introduction

This paper presents recent contributions to the Marie Skłodowska-Curie Innovative Training Network titled INFRASTAR (Innovation and Networking for Fatigue and Reliability Analysis of Structures - Training for Assessment of Risk) to the field of reliability- and risk-based approaches for decision-making in wind turbine and bridges (http://infrastar.eu/). The subject of this paper is risk analysis and risk assessment which has become an important area in research, development, and applications in recent years, and is considered and applied at different levels in industry. Nowadays, by the fast development of new technologies many and new risks should be taken in to account. Risk is introduced as a measure of the expected potential loss occurring due to natural or human activities. Wind turbines are subject to climatic conditions and other environmental impacts, which decrease their life cycle performance and imply increased risk of failure of their components. For instance, in order to ensure acceptable risk levels of wind turbines throughout the whole lifetime, different operation and maintenance (O&M) strategies can be applied. To prevent wind turbine failures, and to account for the consequences, a rational and comprehensive method for assessing the risk exposure to the structures is required. Thus, in order to obtain a reduction in the risk level, it is important to be able to make rational decisions reducing the risk. The objective of this paper is to give an overview of risk-based methodologies for risk assessment for design and operation of wind turbines and present Bayesian network tools for risk-based decision making related to O&M.

2 Risk-Based Planning of Operation and Maintenance

An overall framework for risk-based planning of O&M for offshore wind turbines is described in [1], where Bayesian statistical theory is used as a theoretical basis. A comprehensive literature study is conducted by [2] focusing on maintenance optimization of wind energy assets. In [3] and [4] an overview of existing offshore wind O&M cost models is given. The use of Bayesian statistics allows investigating deterioration of wind turbines support structures, including how by inspections to obtain new information from sensors and condition monitoring.
A Bayesian statistical methodology to be utilized for system reliability analysis is described in [5]. The use of Bayesian networks, as a basis for decision-making, is described in [6] where a damage model with the possibility to update it with inspection information is proposed. In [7] different types of O&M strategies are investigated using the previously mentioned methods with emphasis on wind turbines. In the [8] by using discrete Bayesian networks, a computational framework for risk-based planning of inspections, maintenance, and condition monitoring is proposed.

3 Bayesian networks as a tool for risk-based decision making

Bayesian network allows development of the damage over time. Bayesian network with Markovian process can fully define a damage process dynamically. Where damage of any node at any given time step is dependent on calculated damage at previous time step and damage models based on fracture mechanics or/and S-N Curves. When no inspection is available for node at given time step then it is simply based on previous time step and prior distributions, but when any inspection data with some observation is available then same can be included as evidence and posterior distribution can be found for parameters and damage size [6].
In the [8] dynamic Bayesian network (dBN) is used as a framework for risk-based planning, the proposed dBN is illustrated in Figure 1 which is one of the comprehensive tools for risk assessment.

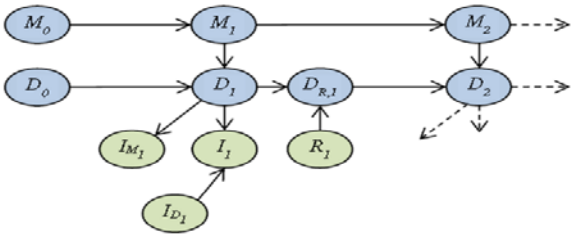

Figure 1. dBN framework for risk-based planning [8]

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