



# **Stellingen**

behorende bij het proefschrift

## **Maintenance models for systems subject to measurable deterioration**

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## I

Gamma process models are to be preferred over Brownian motion models for the statistical inference of continuous measurable deterioration, especially if the temporal uncertainty associated with deterioration is high.

*Chapters 2 and 4 of this thesis*

## II

Theoretically, white-box models are powerful tools for the statistical inference and prediction of measurable deterioration, because they can capture structural insights of the underlying physical process. In practice, their application has always been rather limited due to the mathematical intractability of these models. A framework that is based on well-known tools such as discrete-event simulation, density estimation and stochastic approximation, facilitates the analysis of these models considerably. Hence there is no excuse anymore, perhaps except for lack of computational power, for not applying white-box models. Moreover, this framework should be compulsory subject matter in advanced courses on simulation.

*Chapter 3 of this thesis*

## III

Adding randomness to a mathematical problem sometimes simplifies its analysis. Whereas the probability distribution of the first time a standard gamma process exceeds a fixed threshold cannot be expressed in elementary mathematical functions, the first time such a process exceeds an exponentially distributed threshold with parameter  $\rho > 0$  has itself an exponential distribution with parameter  $1 / \log(1 + \rho)$ . A direct consequence is that the first time a gamma process with mean proportional to a power of time exceeds an exponentially distributed threshold is Weibull distributed.

*Chapter 5 of this thesis*

## IV

The probability distribution of the first time a gamma process exceeds a random threshold can be approximated accurately and efficiently by linear interpolation of the exact distribution at integer time points.

*Chapter 5 of this thesis*

## V

Maintenance optimization is about doing the right maintenance action at the right time. Whether a maintenance action is the right one is a trade-off between the cost of the action, the lifetime extension due to the action and the length of the planning horizon. The lifetime extension again depends on both the reduction in condition as well as the structural change in the deterioration process due to the action. Whereas on longer horizons the action with the lowest “cost - lifetime extension” ratio is the right one, the cheapest action is often the right one on shorter horizons.

*Chapter 6 of this thesis*

## VI

The quality of the solution found by Response Surface Methodology algorithms for stochastic optimization problems depends heavily on the chosen starting point. Even if the starting point is located nearby the optimal solution, the probability that a good solution is found can be quite low. An extended algorithm that combines strict stopping rules and a restarting mechanism increases this probability significantly.

*Nicolai & Dekker (2005)*

## VII

Proposition XII attached to the thesis of dr. R.E. Wildeman is incorrect. In the Dutch language the correct abbreviation of the university degree ‘doctor’ is not ‘dr’ but ‘dr.’.

## VIII

PhD students are a professor’s main assets.

## IX

Talent seems to be given at one’s birth, but we will only speak of talent if one has had enough good fortune, opportunity and perseverance to demonstrate it.

## X

Although many tennis commentators still make us believe that the seventh game in a set is very important, it is certainly not more important than other games.

*Magnus & Klaassen (1996)*

## XI

The use of doping may be unhealthy, but so is riding the Tour de France without doping.