Afstudeerproject bij SBM Schiedam B.V.

Non-linear probability distributions for roll motions

Motivation:
It is common industry practice to calculate the most-probably-maximum (MPM) based on linear transfer functions, assuming that the waves are Rayleigh distributed. This implies that the system response is as well Rayleigh distributed, and standard techniques can be applied. This is typically done for a 3 hour duration sea state (described by time constant statistical parameters). First order motions are however non-linear in higher and steeper sea states and linear transformation is not accurate anymore. As well, for many physical parameters the wave crest distribution is more important than the wave height distributions. The crest deviates from the Rayleigh distribution for moderate sea states.
The question for the thesis is: How to predict the extreme statistics of the offshore unit given the above non-linear parameter.

Scope of Work:

- The main question of the thesis is: is it possible to predict the probability distribution of first-order vessel motions given the fact that the wave input statistics are known (non-Rayleigh) and the vessel response characteristics are described by non-linear motion equations.
- There is a large amount of model test data available to benchmark the findings. FPSO vessels in a soft-mooring system will be subject of the study.
- Part of the non-linearity is addressed to the non-Rayleigh wave crest distributions (e.g. Foristall distributions). These wave statistics can be benchmarked (described) through existing theory or through empirical distributions from model tests (ShortCrest JIP, MARIN).
- The motion equations will be described by a mass-spring-damping system with non-linear damping. The system properties are known. In addition, simulation software (AQWA time domain) can be used.
- The focus is first order motions; second order responses (due to the mooring system) will be neglected.
- The roll non-linear response distribution is considered to be a function of the level of non-linear damping. Is it possible to derive the mathematical consequence of this?

Result: A better prediction of the roll MPM value. A tool to predict the non-linear response of the first-order vessel motions, other than through direct simulation.

Capabilities: Highly mathematical thesis; Math student; understanding wave physics and non-Rayleigh distributions, extreme value statistics