# Modeling of Technical, Human and Organizational Factors and Barriers in Marine Systems Failure Risk

## – Modeling of stability operations on a semi-submersible unit with the use of bayesian belief networks


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## Objectives

1. Conduct a literature survey to determine the current research frontier, and to explore similar modeling cases in related fields.
2. Describe the basic concepts of stability theory, and systems used in stability operations.
3. Describe and explain the theory and use of bayesian belief networks (BBN) in order to have a foundation for using this theory to model stability operations on semi-submersibles.
4. Investigate incidents and accidents where stability or buoyancy was lost or uncontrolled.
5. Identify the most common risk influencing factors (RIF) that influences the risk of loosing stability.
6. Develop a BBN network with the identified RIFs.
7. Evaluate the model, results and applicability of this model.

## Introduction

- During the last 25 years there have not been any extensive research or work on risk analysis of marine systems. RNNP [3] states that it is necessary to increase the attention to marine systems, and there is also a general consensus about this in the industry. This thesis suggests a model that can be applied to stability risk modeling, and it considers a root cause perspective, as opposed to the more common barrier perspective.
- The model is based on a bayesian belief network (BBN). The strengths of using BBN, in contrast to traditional models such as fault and event trees, is that a BBN can handle uncertainty, non-deterministic factors and non-sequential failures. It is therefore well suited to model human and organizational factors.

## Quantification of BBN

- The drawback of using a BBN is that it requires an extensive amount of conditional probabilities in order to produce a quantitative result. Each node in the BBN must be assigned a conditional probability table (CPT). The amount of probabilities required depends on the possible states the node can be in, and it increases exponentially with the amount of parents (arrows pointing towards the node in question).
- To overcome this challenge, a semi-mechanized algorithm is used. This method was developed by Røed et. al. (2009) [2]. Each node is given a state **a** — **f**, where **a** is the best, and **f** is the worst state. The stats are awarded on the basis as compared to the average in the industry. The assumption behind this method is that the probability of a RIF being in a state that differs considerably from its parents' state should be smaller compared to a state equal to its parents' state [2].
  - The "distance" between the RIF and its parent is calculated using equation (1), where $\mathbf{Z_j}$ is a weighted "distance" measure, $\mathbf{Z_{ij}}$ is the number of states between the parent **i** and the RIF we are considering, and $\mathbf{w_i}$ is the normalized weight of parent **i** compared to the other parents.

$$Z_j = \sum_{i=1}^{n} |Z_{ij}| w_i \qquad Z_j \in [0,6] \tag{1}$$

  - The probability of the node being in state **j** is then calculated by using equation (2), where R is an outcome distribution index.

$$P_j = \frac{e^{-RZ_j}}{\sum_{j=a}^{f} e^{-RZ_j}} \qquad P_j \in [0,1] \tag{2}$$

  - To determine a binary outcome, or a probability of an event, the equation (3) is used, where $\mathbf{Q_{ik}}$ is an adjustment factor, and $\mathbf{P_{ik}}$ is the probability of parent **i** being in state **k**.

$$P_j = P_{basis} \sum_{i=1}^{n} w_i \sum_{k=a}^{f} P_{ik} Q_{ik} \qquad P_j \in [0,1] \tag{3}$$

This method simplifies the quantification process. The only input to the calculation is the $\mathbf{w_i}$ and **R**, these are decided by expert judgment.

## Results: Risk analysis using the BBN model

- The completed model is illustrated in figure 1, and this also shows how evidence is inserted to perform a risk analysis of a scenario illustrated by an offshore worker in an interview conducted during the work with the RNNP report [3].
- By using equation 3 the risk of loosing stability can be determined, based on a basis probability found by [1] $\mathbf{P_{basis} = 27 \cdot 10^{-4}}$ per platform year. With the given evidence the probability of loosing stability is determined to be $\mathbf{P_{loss\ of\ stability} = 2.85 \cdot P_{basis} = 7.70 \cdot 10^{-3}}$ per platform year.

## Results: Graphical BBN model

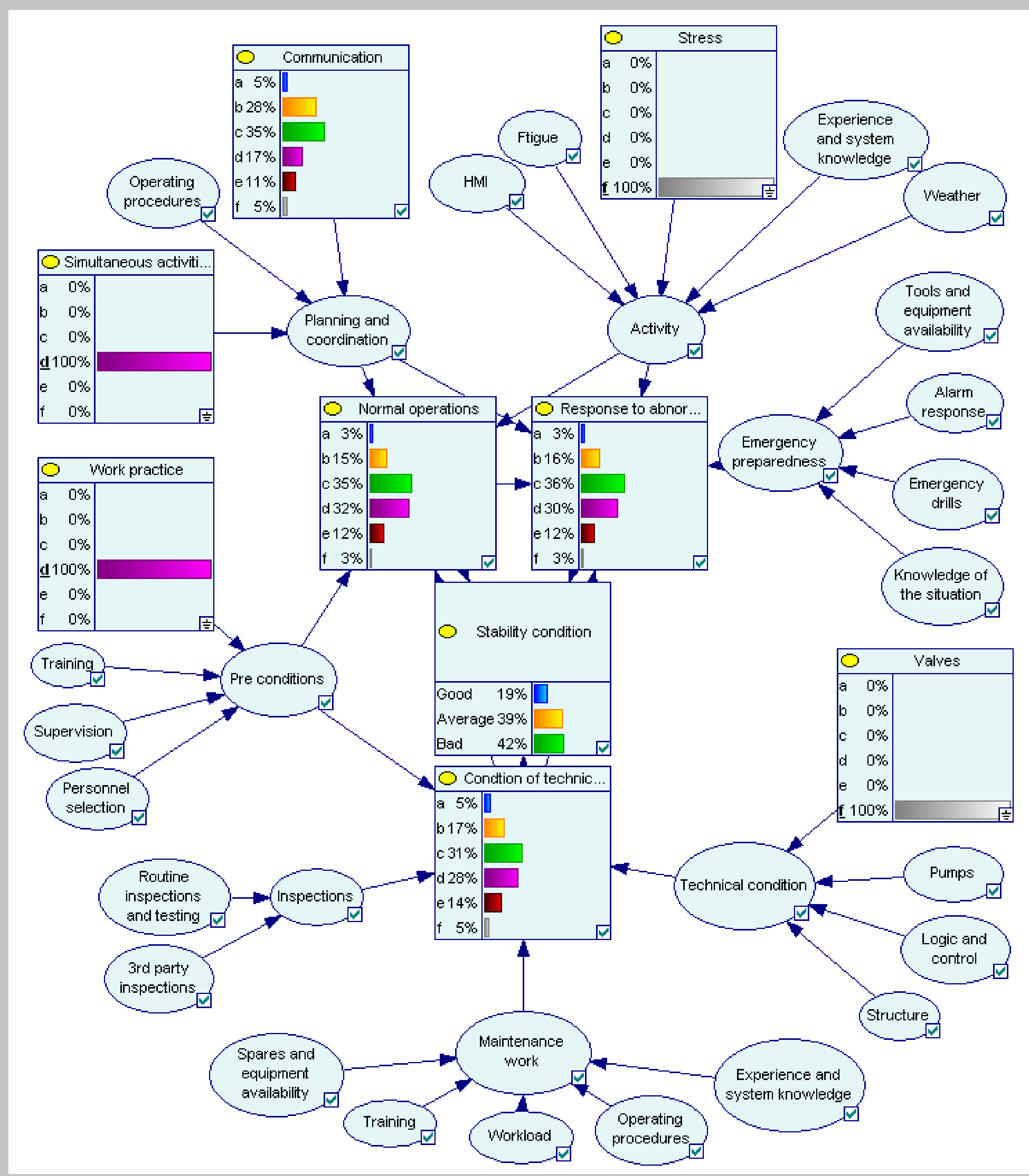


Figure 1: BBN model of case study

## Conclusion

- BBN is a very well suited method for analyzing risks involving human and organizational factors.
- This model do, however, contain some limitations due to the quantification algorithm. This is to a limited degree based on real data, hence difficult to argue that the results are applicable.
- The model can be used for monitoring developments of risk levels, rather than to determine a specific risk.
- This model is suggested as a starting point for further research in the area of marine systems, and specifically in stability risks for semi-submersibles.

## References


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