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# Risk assessment for structural design criteria of FPSO systems. Part I: Generic models and acceptance criteria

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ABSTRACT

A generic framework for consequence assessment and risk analysis of FPSO systems for the purpose of establishing structural design criteria is introduced, taking basis in recent work by the Joint Committee on Structural Safety (JCSS) addressing the issue of system representation through exposure events, direct and indirect failure consequences. The scenarios considered for risk-based calibration of a design code safety format for FPSO systems are outlined. It is shown how these scenarios may be represented in a generic risk assessment model using Bayesian Probabilistic Networks (BPNs). Risk acceptance criteria related to consequences to humans are determined based on the Life Quality Index (LQI), which is outlined and discussed in this paper. The generic risk framework and acceptance criteria are then applied in a companion paper [1] to build consequence models and to determine target reliability indices for structural design of FPSO components.



## 1. Introduction

Risk assessment is considered an appropriate tool for the development of structural design criteria and guidelines for FPSO systems that are consistent with the relevant natural hazards, mainly meteorological and oceanographic site conditions, as well as operating conditions, production volumes and

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economics, and inspection/maintenance practices and philosophies. For that purpose, the risk assessment provides the basis for determining the optimal level of structural reliability for design; the corresponding design criteria for all relevant failure modes should be determined by consideration of the possible consequences of failures. The assessment of failure should consider all relevant causes of structural failures due to environmental extreme loading, degradation processes, accidental load events and operational errors.

Taking basis in a discussion of best practices and more recent developments on systems risks, the present paper introduces a generic framework for consequence assessment and risk analysis of FPSO systems. Thereafter, the scenarios considered for the risk-based calibration of a design code safety format for the design of FPSO facilities are outlined. Furthermore, it is shown how these scenarios may be represented in a generic risk assessment model greatly enhanced by the utilization of hierarchical risk modeling procedures such as Bayesian Probabilistic Networks (BPNs). BPNs have several advantages when compared to traditional risk assessment tools. Foremost, the risk assessment methodology becomes more transparent because the considered events and their causal interrelations are represented graphically, which strongly facilitates communication of the model. Experts in design and operation of FPSOs with limited experiences in risk assessment techniques are able to contribute directly to the basis of the risk assessment. BPNs are used to assess expected consequences of failure, which along with risk acceptance criteria, provide the basis for determining optimal target reliabilities for structural design. Furthermore, BPNs may be developed generically such that they are valid for a given FPSO design concept (for example disconnectable or non-disconnectable turret, single or double hull, etc.). Information regarding specific design choices for any FPSO of the given concept type may then be introduced in the risk assessment through the nodes of the BPNs and the corresponding consequences and risk are immediately obtained without any further efforts. Finally, the BPNs greatly facilitate the identification of the weak spots in a given concept by allowing the identification of the most probable causes of adverse events leading to consequences. This can provide insightful information on how risks may be better reduced by optimization of the design parameters.

In addition, to account for societal acceptance criteria of the risk associated with the operation of FPSOs, it is necessary to establish the optimal and acceptable level of reliability of the individual components of the FPSOs. A short outline and discussion of best practices in regard to risk acceptance criteria (RAC) and the more recent concept of the Life Quality Index (LQI) as a practically applicable means to determine how much should be invested into life saving activities, are therefore provided. The process of design optimization may then be efficiently facilitated by use of the developed risk models, the BPNs and the concept of the LQI. Applications of the generic risk assessment framework and the RAC to decision making on target reliability indices for structural design of components of FPSOs are presented in a companion paper [1].

## 2. On best practice risk assessment

Most regulated risk assessments are built up around procedures such as the ones defined e.g. in the Australian New Zealand Standard AS/NZS 4360 [2], but also in the recently developed AS/NZS ISO 31000 standard [3] on “General principles on risk assessment for structures”. Following these procedures, risk analysis may be represented in a generic format, which is largely independent from the application, e.g., independent from whether risk analysis is performed in order to document that risks associated with a given activity are acceptable or whether it is performed to serve as a basis for management decision making. Reviews of present practice on engineering risk assessments and risk-informed decision making may be found in [4–8]. It is not within the scope of the present paper to outline best practice risk assessments in any detail. Instead, some of the more recent insights derived from practical applications as well as from research in the area of risk assessment are presented and discussed in the following. This discussion will then form part of the basis for the formulation of a risk assessment framework for FPSOs presented in this paper and its application to decision making on target reliability indices for structural design which is shown in a companion paper [1].