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Development of a software tool to implement reliability assessment of developing technologies

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The reliability assessment of under development O&G equipment is a critical matter to the industry and has been increasingly pursuit by the stakeholders. In this context, it is essential to aggregate information from different taxonomical levels and from different development phases, which consists in a challenge to the traditional reliability tools. The use of a multilevel reliability model, in conjunction with the Bayesian approach, is one of the possible pathways to estimate reliability of developing technology. However, given the large amount of data and the hermetic knowledge needed to apply Bayesian methods, it is fundamental to have a reliability computational tool to implement the reliability estimation. In this work, a reliability software developed to deal with multilevel Bayesian reliability models specifically developed for the O&G industry is presented. The software tool allows the user to input equipment information and characteristics, and provide the reliability estimation all over the development process, giving the decision-makers the means to use the reliability as a key decision variable in the developing technology pathway.

Keywords: reliability analysis, O&G industry, software applications, developing technologies.

1. Reliability Estimation Methodology

Recently, a methodology for reliability estimation of developing equipment has been established, which considers the details of the development process (Azevedo et al., 2022; Maior et al., 2022). This considers the evolution of technologies according to the TRL scale, ranging from TRL 1 to TRL 9. In each phase of the process, different data sources and qualification testing are available. The methodology aggregates all these information data in a single reliability estimate in each TRL, as shown in Fig. 1. It begins in requirements planning and scope definition analysis. Next, the technology begins in TRLs 1-3, where the expert elicitation is used to estimate basic events probabilities. The following TRLs use multilevel reliability model and Bayesian methods to update the reliability estimation.

2. Software Tool

The reliability estimation steps of the MRM methodology were implemented as a software tool, aiming to enable users to access its functionality and perform robust analyses without worrying about the theoretical knowledge required to understand the MRM in its entirety.

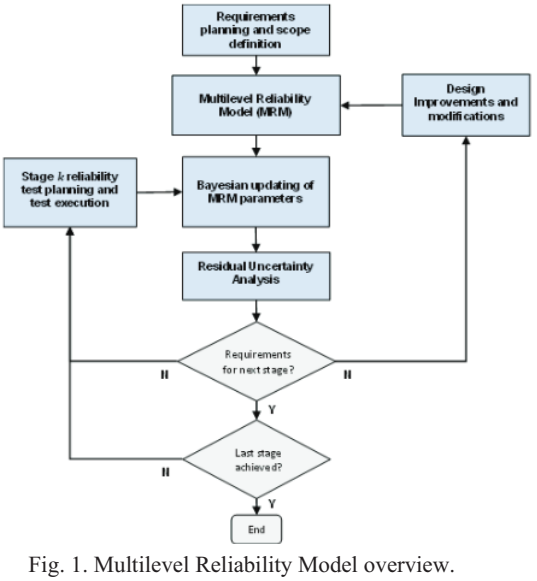

Fig. 1. Multilevel Reliability Model overview.

Fig. 2 shows a summary of the software tool, where the main implemented components can be seen, as well as their relationship in the methodology process. These elements will be further explained in the following sections.

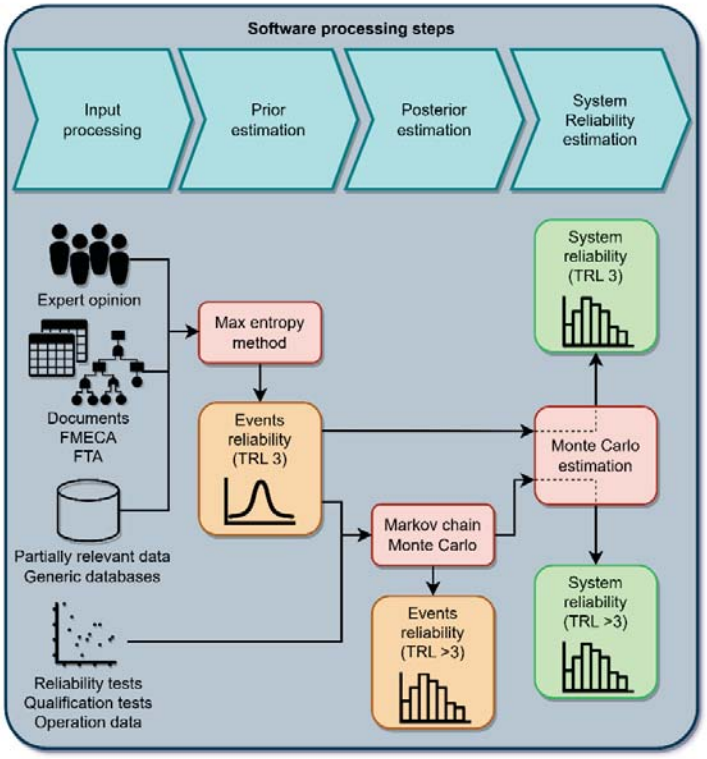

Fig. 1. Multilevel Reliability Model overview.

2.1. *Processing steps*

In order to perform the steps that compose the MRM methodology, several processing modules were implemented. The current software modules are listed below:

i) A maximum entropy method implementation is used to estimate the prior distributions for each undesired event.
ii) Markov Chain Monte Carlo (MCMC) is used to perform a Bayesian update for each event.
iii) A Monte Carlo method is used to sample the nonparametric posterior distributions of all undesired events, forming an estimate for the system reliability.

These modules largely cover the portion of the MRM methodology represented by the three central blocks in Fig. 1: "Multilevel Reliability Model (MRM)", "Bayesian Update of MRM Parameters", and "Residual Uncertainty Analysis".

2.2 *Inputs and Outputs*

In order to estimate the prior distributions, several data sources are used, such as partially relevant data (from similar technologies and/or previous design iterations), document sources (e.g., risk assessment documents, PRA, FMECA, etc) as well as expert opinion. Failure tree analysis (FTA) can be used to identify the basic failure events. Each basic event is analyzed independently, so that there is at least one prior distribution for each basic event.

For the Bayesian update procedure, the prior distributions are used along testing data, which will be used to build likelihood functions for the events.

Finally, for estimating system reliability, the resulting nonparametric posterior distributions for each basic event are used. A Monte Carlo approach allows estimating system behavior, based on the FTA relationship.

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