Technische Universität München

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**Assessment of the PhD thesis of Ondřej Nývlt:**

**Risk Management Methods for Industrial Systems**

*Content of the thesis*

The thesis of Mr. Nývlt deals with classical methods for risk analysis of engineering systems. In the first part of the thesis, an example case is presented, and thereafter a novel method for engineering risk analysis is presented, which is based on Petri nets (PN). PN is a mathematical modeling formalism that is applied in multiple areas of technology and science to model dynamic system behavior. PNs have been used for risk analysis purposes since the 1990s, but, as correctly pointed out in the thesis, have received limited attention in theory and practice. The thesis further develops selected aspects of the PN application to risk analysis, presents a new general approach to the modeling, and illustrates the applications through a series of examples.

The main body of the thesis consists of three papers, of which Mr. Nývlt is the first author. All three papers appeared in leading journals in the respective fields.

The first paper presents an overview of risk analysis methods and illustrates their application to the case of the Strahov tunnel, specifically of the fire safety system in the tunnel under operation. The main contribution is the case study, which is a nice illustrative example of an engineering risk analysis in practice, demonstrating the questions asked by such an analysis, and the challenges faced in answering these questions. The classical methods, such as fault tree, event tree and sensitivity analysis are demonstrated. It remains a bit unclear what exactly the "proposed PRA method" is, respectively how it differs from existing methods used in many industries today. However, the paper contributes towards the application of more systematic risk analysis approaches in the field of tunneling, and shows quite impressively how the methodology can lead to significant savings and more efficient risk management solutions.

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The second paper introduces the use of Petri nets as an alternative to the classical methods in risk analysis. PNs facilitate the consideration of dependencies in the analysis, and potentially also dynamic effects (this is not further demonstrated however). The paper nicely introduces the PNs and shows how the structure function of a system is developed based on the PNs. This works well. The computational bottleneck is the calculation of the system reliability based on the so developed structure function, which is difficult to achieve for larger systems. This effect is in analogy to other methods of developing the structure function. Of course, Monte Carlo analysis is always possible. The paper demonstrates the application of the method on simple examples taken from the Strahov case study of paper 1.

The third paper focuses on the application of PNs to larger applications, presenting a formal concept that makes use of blocks for modeling reliability problems with PNs. The block concept is related to ideas found in object-oriented programing, and for this reason is well-suited to model larger systems. Because the general structure for modeling the risks is hierarchical, the resulting models do not become excessively complex. Besides proposing this structure, the authors also summarize the steps needed in the analysis. Numerical examples related to offshore engineering are included in the paper. The proposed theoretical concept is first illustrated on a simple example, which enables the reader to understand the theory. It is thereafter applied to a larger case study with dynamic components, in which the PN has advantages over classical methods.

The thesis ends with a brief Conclusion section. The recommended future work is mainly associated with improving the readability and access of the models for non-experts.

*Assessment of the thesis*

Overall, the thesis does present interesting case studies and contributes towards the development of an alternative methodology for risk analysis, which has potential. The three papers included in the thesis address relevant questions and are well written. It is hoped that the work started in this thesis is continued by others.

The thesis clearly demonstrates that Mr. Nývlt has gained a deep insight into risk analysis methods. The proposed methodologies are original and their application to different case studies gives them credibility.

The title of the thesis should be reconsidered. At present, it suggests a broad treatise of risk management in industrial systems. However, the papers are necessarily focused on specific aspects, and the introduction parts of the thesis are very short and do not provide the overview that one would expect from a thesis with such a title

While, the thesis is generally well written and reads nicely, the use of the English language in the Introduction (and to a lesser degree the Conclusion) of the thesis should be revised. These parts seem to have been prepared with limited effort

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and care, which is in contrast to the overall good quality of the papers included in the thesis.

Overall, with his thesis work, Mr. Nývlt shows that he is capable of performing scientific work at an internationally recognized level and is contributing to the state of the art.

In conclusion, the author of the thesis provided proved to have the ability to perform research and to achieve scientific results. I do recommend the thesis for presentation with the aim of granting the Degree of Ph.D.

Sincerely,

Prof. Dr. Daniel Straub