Information about robustness, reliability and safety in early design phases

This thesis is motivated by the need for support in considerations of robustness, reliability and safety during early design phases. The thesis deals with the question of how to codify and communicate failures and hazards, and devises measures against these. Current methods to robustness, reliability and safety reviewed have shortcomings including the complexity of using them and dependence on expert input for mitigating uncertainty and ambiguity among solution alternatives. This research is carried out using case studies: a pilot case to assess information requirements from reliability methods, and an industrial case to assess how the use of information about robustness, reliability and safety as practised by current methods influences concept development. Current methods cannot be used in early design phases due to their dependence on detailed design information for the identification of attributes of robustness, reliability and safety. The uncertainty and ambiguity that are inherent to concept development impede the evaluation and improvement of attributes of robustness, reliability and safety in early design. A taxonomy was therefore developed to assess the information about these attributes that current methods require, and to address the need for clarity about design issues that result in risks. The concept development phase fosters ambiguity on how to satisfy requirements of robustness, reliability and safety, which is exacerbated by complexity in the individual solution alternatives. This prompts designers to reuse working principles that are inherently flawed, as they are liable to disturbances, failures and hazards. To address this issue, an approach based upon individual records of early design issues consists of comparing failures and benefits from prior working principles, before making a decision, and improving the more suitable alternatives through this feedback. Workshops were conducted with design practitioners to evaluate the potential of the approach and to simulate decision-making and gain feedback on a proof-of-concept basis. The evaluation has demonstrated that the use of individual records on failures and benefits of solution alternatives successfully averted the repeated use of flawed working principles and identified the effective design solutions of the outstanding issues.

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