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Comment: Expert Elicitation for Reliable System Design

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The paper "Expert Elicitation for Reliable System Design" by Bedford, Quigley and Walls is timely and significant for three reasons:

1. It addresses the importance of expert elicitation in systems design and the statistical and practical challenges faced when trying to use expert judgements in a way that is consistent with established approaches based on statistical reliability testing.
2. It rightly focuses our attention on the need for a holistic approach to reliability evaluation that goes beyond analysis of single projects to also include information from "softer" sources such as design and operational use.
3. It recognizes the emerging importance of Bayesian methods in providing the "uncertainty calculus" to combine evidence from experts with statistical reliability data in such a way that system reliability assessments and forecasts can grow and evolve as a system changes throughout its life.

Our own research and experience support many of the key thrusts of the authors' ideas. For the last ten years we have been applying Bayesian methods—more specifically, Bayesian networks (which the authors refer to in Section 4.2.3)—to a wide variety of problem areas (see, e.g., Neil, Malcolm and Shaw, 2003, and Fenton et al., 2004). This includes system dependability evaluation, of which the best known example is the Transport Reliability Assessment Calculation System (TRACS) (Neil, Fenton, Forey and Harris, 2001); this is an early exemplar of the meta modeling frameworks cited by the authors in Section 4.1. We have found Bayesian methods to be most beneficial to the types of problems mentioned by the authors, including the issue of making trade-offs between reliability and other system objectives like functionality and cost (something we examined in detail for software systems in Fenton et al., 2004).

We have a number of additional observations to make about the paper:

Very often reliability assessments are carried out by a client (rather than the design authority) or by a procurement agency on behalf of the client. In this case, the expert is not the designer but a customer, and the impact of this is more general than the authors appear to suggest in Table 1. Such customers may have relevant operational reliability experience gained from use of similar products from this or different suppliers and will, quite correctly, want to use this experience to best effect either to reduce testing effort or to select suppliers at the procurement stage. Other situations spring to mind where a different perspective would give rise to additional problems and challenges, such as COTS (commercial off the shelf systems).

There can be a paucity of empirical data for mission and safety critical systems simply because the systems may be novel or the top events may be rare. Probabilistic risk assessment methods aside, this problem often forces practitioners to borrow or adopt data from different sources, some of uncertain provenance, to help make a reliability claim based on some structured (or often unstructured) argument. Where data do exist, they may only be partially relevant for a number of reasons. For example, the data may be sourced from heterogeneous systems or may have been collected under different or uncontrolled conditions. Detailed statistical modeling is practically and economically infeasible in such "messy" situations, but nevertheless judgements have to be made. In practice these decisions can be a black art, involving opaque assumptions and unchecked subjectivity, but in our experience Bayesian methods can help bring some rigor and structure. More importantly, they also encourage transparency and allow uncertainties and assumptions to be modeled explicitly.

In TRACS (Neil, Fenton, Forey and Harris, 2001) we built a system that partially or wholly addresses

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