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Comment: Expert Elicitation for Reliable System Design

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This article successfully identifies and addresses some of the most important challenges in the use of elicitation as part of engineered systems analysis. The authors make two key advances to the field. The first is that they perform an exhaustive synthesis of the probability elicitation literature relevant to the engineered systems context. The second advance to the field offered by this paper is that it reframes the elicitation literature around the limits, possibilities and actual constraints posed by systems engineering practice. This latter point is no small contribution—the authors have successfully opened a much needed discussion as to why system elicitation differs fundamentally from cultural ethnography methods, and why risk estimation and "systems ethnography" (elicitation of system dependencies and evolving uncertainties) are only partially informed by methods developed for identified and stable single distribution elicitation.

I like the overview of the systems engineering (SE) life cycle and the link made to reliability through the $r = r(d, p, u, m, c)$ relationship. In a follow-up paper or discussion it would be interesting to learn more about the types of systems the authors have studied. In thinking about how to elicit system information over a complete range of engineering efforts, it quickly becomes apparent how hard it is to characterize the elicitation effort (and why this article is such a notable exception to the general lack of disciplined study of this qualitative field). Because the elicitation problem varies greatly depending on the specific form of a technical system, as well as local analytic and decision-making realities, perhaps what this article has accomplished is to identify a core set of considerations for reliability elicitation. One could imagine additions to the core set of issues developed in this paper that could lead to a kind of technical system elicitation taxonomy.

Much of the article discusses systems characterized by a "closed loop" or "spiral" type of systems engineering process. In many cases, such as systems manufactured in multiple batches, this closed-loop model is accurate. In some cases, however, the SE process is not closed loop in form and while the basic building blocks of the elicitation task identified in this article remain valid, additional challenges can emerge. The bulk of my exposure to the use of elicitation methods as part of reliability prediction has involved either weapon or long lead facility construction systems. These systems have traditionally either been developed using a "waterfall" SE model or been deployed for a sufficiently long time that design and fabrication of new versions have ended. In the case of waterfall system engineering projects, there can be a great divide between design and operational life cycle phases, and often relatively little system knowledge (especially tacit knowledge) is transferred between the communities involved with each phase. By the time these kinds of systems are deployed, it is not uncommon that the design team has largely been scattered, downsized or otherwise dispersed. Because validation information generated during the operation of such systems cannot be passed back to the entity responsible for design, perhaps a valid extension of the authors' elicitation closed loop to the waterfall case taxonomy might include two additional types of expert knowledge:

1. System reliability predictions, associated uncertainties and estimates for component behavior may be dependent on changes in expertise and team composition between life cycle phases, in system models used by operators, in operational constraint shifts or in system program importance. For example, the military may transfer an operational, but no longer produced, weapon from front-line troops to support units, and this may entirely change the nature of reliability concerns, the amount of testing performed or the nature of operational evaluation. This lack of continuity in expertise over a waterfall system's life cycle implies it may be necessary to understand how system knowledge is changing between system engineering life cycle time periods.

2. A divide between design and operational stages may also make it necessary to understand whether the system's operational history has been disrupted by

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