Some Thoughts on Extreme Events

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1. From an engineering perspective extreme events are rare events that are outside the expected operating conditions and that are "large" on some relevant axis. The axis may be related (indirectly) via a descriptor of the external 'cause' or input (e.g., a large wind speed or an intense earthquake ground shaking), or (directly) through a system response measure (such as an extreme structural displacement, a very long customer service time, or the number of injuries).

2. It is the engineer's objective to make sure that his system's design performs satisfactorily under expected (common) conditions and that its response to unexpected, less likely, rare, extreme, etc. events is not "disproportionate to the cause." This implies, for example, that we anticipate that a small subset of all buildings and their contents will suffer economic damage in their lifetimes due to (somewhat unlikely) earthquake shaking, because it is more economical to suffer such losses in a few buildings than to expend more resources initially in all buildings to avoid them (or make them less likely). But the behavior under such (moderately extreme, moderately rare, but not "surprising") events should not lead to collapse or severe life loss. Under "extremely rare" events, however, such behavior may not always be avoided.[1] It follows that for engineering system design an "extreme event" is defined relative to the system itself.

3. Consequently the extreme event problem in engineering becomes not one of defining what "extreme" is but one of attempting (1) to identify all such events and their spectrum of levels, (2) to estimate their likelihoods (e.g., mean annual frequencies), and, given the difficulty of doing that in the case of rare events, (3) to quantify the uncertainty in those estimates. Each of these three elements poses challenges. The first can suffer from lack of completeness ("none of the above"). Certain extreme events many not have revealed themselves in our experience base as yet; here we must depend upon the predictive powers of science and engineering to anticipate extreme behavior of both natural and manmade systems. Engineering risk analysis is one tool that builds on these technical bases to estimate likelihoods of not only rarely seen but also as yet unseen events and "accidents." I am sure the workshop will spend significant effort on the second two elements.

[1] Although I won't pursue it here we can discuss how such limits are or should be established, e.g., societal economics: "the benefits society will derive from the new system outweigh the costs, making an increment in the occupants' individual mortality rate of x tolerable"; effective public safety resource allocation: "there are cheaper ways to increase life safety"; equity; "no one should be exposed by a construct of society to an incremental mortality rate greater than 10^{-y} per annum, no matter what the benefit to society of the new system."