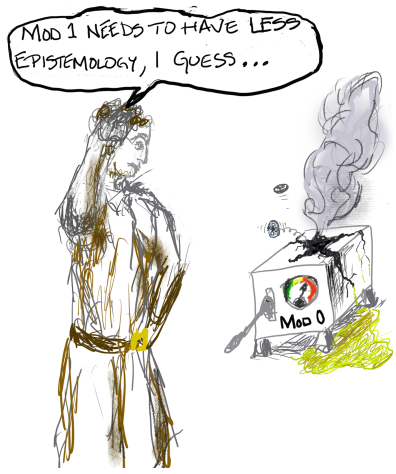
Epistemic or Aleatoric?

> *Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns–the ones we don't know we don't know.*
> (Donald Rumsfeld, 2002)

Assessment of aleatoric and epistemic uncertainties has been asked for in new US Nuclear Regulatory Commission regulations under Title 10 of the Code of Federal Regulations in Part 53, a new Part; a regulatory setting requires clear understanding or definition in the language of engineering what is meant by these terms.[1] The regulations, as requested in the Nuclear Energy Innovation and Modernization Act (NEIMA), recently approved by Congress and Executive branches for a "risk-informed, performance-based framework", are the Commission's response. Importantly, the legislation and regulations flowing from it applies to "advanced reactors"



A practicing engineer is unlikely to think about root cause as aleatoric or epistemic uncertainty when addressing a break down in the next design.

Engineers are well aware that any device or collection of devices can break down unexpectedly; the concept of root cause analysis is used to isolate the immediate cause for the break down. They are even more acutely aware that a substantial departure from familiar designs that have have break downs arising from "known unknowns" is likely to invite break downs due from "unknown unknowns."

Engineers who are good at root cause analysis can determine if a break down arose from a physical cause, that is, something that can be assigned to physics, or improper operation or maintenance. At the time a break down occurs, the engineer digs into the physics, it is unlikely the divvy between aleatoric and epistemic uncertainty is reviewed as such; it seems incongruous to imagine an engineer wondering about a break down as depicted in here. Similarly, the engineer is unlikely to think about classifying uncertainties in designs this way although it has been pointed out to me the ASCE Standard, ASCE/SEI 7-16 does ask for consideration of epistemology.[2]

Thinking about the US Nuclear Regulatory Commission's development of regulation for new reactors engineers in the industry and the Commission would certainly wonder how they can be sure a future accident can be avoided in an advanced reactor. The concepts of safety margin, defense in depth are most likely in the forefront of engineers' thinking when considering such dangerous process designs. Engineers use logic structures, such as Failure Modes and Effects Analysis (FMEA), fault trees, and event trees, to reveal where a single failures could lead to consequential accidents; they attempt to add backup where they find exposures to single failure. If a single failure event can not be avoided, they are reluctant to accept the design unless the failure of the device has been tested thoroughly and includes substantial safety margin. They will want to require regular inspections of the device in order to ensure the design remains fully intact and the safety margin remains in effect over the device service life.

In this engineer's opinion, introduction of terms from the philosophical domain into regulation of engineered protections adds unnecessary confusion in the engineering domain where the risk assessment is based on physics, service experience, test, and principles of reliability and safety engineering have been used successfully for many years. This is not to say that epistemology is of no concern; serious scientists wrestle with the philosophical foundations under their assertions. But engineers, as "end users" of scientific principles they use in design analysis, necessarily accept the science that produced the physical principles upon which they base their designs. So too, regulations must assume the scientific foundations of engineering physics are settled.

What are your thoughts? Let's talk!
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Send your feedback/thoughts on this or any reliability subject to me at erniekee@illinois.edu.

[1] Their meaning is not a simple matter. Epistemology, for example see https://plato.stanford.edu/entries/epistemology/. Accessed 28 December 2020.

[2] Personal communication, Farshadmanesh and Kee, 23 December 2020.