

UNCERTAINTY-ORIENTED APPROACH FOR NUCLEAR SAFETY ASSESSMENT

Calabourdin A.V.¹, Radchenko R.V.¹

¹ Ural Federal University, Yekaterinburg, Russia

E-mail: a.calabourdin@gmail.com

In the framework of “rare events” problem, the probabilistic approaches tend to be ineffective. Therefore, we can't reliably estimate risks from fat tail/Black Swans events for nuclear power plants with typically used methods. We examine alternative approach to mitigate this issue.

In the context of nuclear safety, we often have to deal with frequentist probabilities like $10^{-4} - 10^{-6}$ a year. And there is a lot of uncertainty in such estimates, which is costly, since nuclear accidents have relatively significant impact so that safety is often claimed as of highest priority by the industry professionals.

There are multiple factors of uncertainty in risk estimates, for example lack of experimental data and fat tails problem. Often risk models deflate risk estimates because in reality such events follow fat-tailed distributions and therefore, in practice are more probable & can cause more damage than the model tells us – a seemingly local nuclear accident can have potential to contaminate large areas, severely damage economy of whole states or affect global communities in other ways, as we've already seen.

Traditional classical method of Reliability theory is widely used within the PSA, but leads to deadlock schemes when trying to estimate risks of rare events. Thus, lies the need to create safety evaluation and management systems based on determining the level of safety by comparing the estimated risks with acceptable levels, which, unlike PSA, would be applicable for rare events problems. In other words – account for uncertainty (preferably better than the current approaches).

In alternative, expert-system like approach measure of the safety level of a system is evaluated via a set of “Risk Categories”. In cases where the probability of a risk event is almost zero or unknown, unreliable or cannot be calculated on the basis of statistics or system properties, a measure of risk as a degree of damage from an event will objectively mean the real measurable risk. In these cases, for calculating risks of events occurring with probability of almost zero, become relevant, as an alternative to PSA, the methods of Fuzzy Sets and Fuzzy Logic theory.

1. N. R., «The future role of risk assessment in nuclear safety,» IAEA Bull., т. 25, № 4, pp. 30-36, 1983.
2. K. A. M. S. Toshiro Terano, APPLIED FUZZY SYSTEMS, Tokyo, Japan: Ohmsha, Ltd, 1989.
3. I. A. E. AGENCY, «Technical Approach to Probabilistic Safety Assessment for Multiple Reactor Units, Safety Reports Series No. 96, » IAEA, Vienna, 2019.