TABLE I

Comparison of the Estimates for the Frequency of Core Melts

Distribution	Comments	5th Percentile	Mode	Median	Mean	95th Percentile
Prior ($\alpha = 0.12, \beta = 120$)	Apostolakis and Mosleh prior	7.4×10^{-14}	---	1.6×10^{5}	1.0×10^{-3}	5.8×10^{-3}
WASH-1400	WASH-1400 results	8.3×10^{-6}	1.5×10^{-5}	5.0×10^{-5}	9.0×10^{-5}	3.0×10^{-4}
Posterior ($\alpha = 1.12, \beta = 6787$)	Apostolakis and Mosleh posterior	1.0×10^{-5}	1.8×10^{-5}	1.2×10^{-4}	1.7×10^{-4}	5.0×10^{-4}
Prior–case 1 ($\alpha = 1.125, \beta = 9177$)	Gamma prior fitted to 5th, 95th percentiles of unmodified WASH-1400 results	8.3×10^{-6}	1.4×10^{-5}	8.9×10^{-5}	1.2×10^{-4}	3.5×10^{-4}
Posterior–case 2 ($\alpha = 0.80, \beta = 10\,310$)	Based on case 2 prior and Poisson data (zero meltdowns in 310 reactor years) in the likelihood	2.1×10^{-6}	---	4.9×10^{-5}	7.8×10^{-5}	2.5×10^{-4}
Prior–case 2 ($\alpha = 0.80, \beta = 10^4$)	Gamma prior fitted to 50th, 95th percentiles of unmodified WASH-1400 results	2.2×10^{-6}	---	5.0×10^{-5}	8.0×10^{-5}	2.6×10^{-4}
Posterior–case 1 ($\alpha = 1.125, \beta = 9177$)	Based on case 1 prior and Poisson data (zero meltdowns in 310 reactor years) in the likelihood	8.0×10^{-6}	1.3×10^{-5}	8.6×10^{-5}	1.2×10^{-4}	3.4×10^{-4}
"Prior" ($\alpha_0 = 2, \beta_0 = 6667$)	Modification gamma "prior" based on critics' views of WASH-1400 results	5.3×10^{-5}	1.5×10^{-4}	2.5×10^{-4}	3.0×10^{-4}	7.1×10^{-4}
Posterior ($\alpha' = 2, \beta' = 12\,667$)	Based on modified WASH-1400 results used to fit a gamma prior (using Apostolakis and Mosleh data) and observed Poisson data (zero meltdowns in 310 reactor years) in the likelihood function	2.8×10^{-5}	7.9×10^{-5}	1.3×10^{-4}	1.5×10^{-4}	3.7×10^{-4}

than their posterior estimate, the median estimate is 8% larger than theirs, while the 95th percentile estimate is 26% smaller than their estimate. However, the important difference is that the subjectivity is now in the proper place in the analysis (in the prior), while the sampling data are in their proper place (in the likelihood). This is in conformance with a proper Bayesian approach. Also, a different interpretation of the critics' views would most likely lead to significantly different results. Table I summarizes all of the above estimates, including the authors' estimates, for ease in making rapid comparisons.

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Reply to "On the Correct Use of the Bayesian Method for Reactor Core Melt Frequency"

The basic contention of Martz[1] that the approach of our paper[2] is a misapplication of "proper" Bayesian methods is without foundation. Bayes' theorem is the fundamental tool that allows us to coherently incorporate in our knowledge new evidence, which does not have to be statistical. In fact, we believe that for rare events, such as reactor core meltdowns, the new evidence will almost always come as experts' opinions.

[1]H. F. MARTZ, Jr., *Nucl. Sci. Eng.*, **72**, 368 (1979).

[2]G. APOSTOLAKIS and A. MOSLEH, *Nucl. Sci. Eng.*, **70**, 135 (1979).

For example, it would be inappropriate to treat the Three Mile Island (TMI) accident as just another statistical point. If we wished to modify the distribution of the frequency of core melts to account for TMI, we would be wise to seek the new beliefs of the experts to form our likelihood.

A more striking example, which shows that the characterization of statistical evidence as "objective" is inappropriate, is the disagreement between the U.S. Nuclear Regulatory Commission[3] (NRC) and the Electric Power Research Institute[4] (EPRI) concerning the scram experience with light water reactors. Looking at the same experience, the NRC concludes that there has been one failure in 7908 trials, whereas EPRI gives several interpretations to the evidence, one of which is zero failures in 114 332 tests. The conclusion is that subjective judgment is essential, even in the assessment of the likelihood (except in trivial cases).

It is true that in some applications, especially when numerous data are available or anticipated, we prefer to put all subjective judgments into the prior distribution. This way, the data eventually will dominate. However, there is nothing in the theory itself that mandates such practice. It is improper to call it proper.

Martz claims that our likelihood, Eq. (22) of our paper, can be decomposed as the product of a Poisson distribution with $x = 0$ and $T = 6000$, and a gamma distribution with $\alpha_0 = 2$ and $\beta_0 = 6667$. We obtain the following:

Poisson distribution: $\exp(-6000\lambda)$;

Gamma distribution: $\frac{(6667)^2}{\Gamma(2)} \lambda \exp(-6667\lambda)$;

Product: $\frac{(6667)^2}{\Gamma(2)} \lambda \exp(-12\,667\lambda)$.

This product is not our likelihood, as Martz claims, and all his subsequent conclusions are meaningless.

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[3] "Anticipated Transients Without Scram for Light Water Reactors," NUREG-0460, Vols. I and II, U.S. Nuclear Regulatory Commission (1978).

[4] "ATWS: A Reappraisal, Part II. Evaluation of Societal Risks due to Reactor Protection System Failure," NP-265, Vols. I and II, Electric Power Research Institute (1976).