(Disentangling Classical and Bayesian Approaches to Uncertainty Analysis
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The rationale for uncertainty analysis does not seem to be well known or well understood by many users of the analysis, even some metrologists. Certainly the school-days explanation that "uncertainty is important because it measures the quality of the measurement", is not especially helpful as it provides no guidance of what uncertainty means in practice or how to evaluate it. Like many measurement practices, clarity can often be found by looking at how uncertainties are used.

Consider a biscuit manufacturer who states on the packets that the net weight of biscuits in the packets is 200 g. In New Zealand and many other countries, the practical meaning of such a statement is tied to consumer protection regulations and to the Average Quantity System (AQS), which requires the manufacturer to ensure that no packet is grossly under-filled and that the frequency of minor under-fills is below some prescribed percentage. Ideally, the manufacturer understands that his measurements of gross and net weight are subject to error processes that lead to both variability and bias. To be sure of compliance with the AQS and to be confident that, say, 95% of the packets exceed the required net weight, the accept-reject criterion imposed on product leaving the production line is increased above 200 g to account for the measurement errors. This situation is shown graphically in Figure 1 where we have characterised the measurement errors by a zero-mean (for simplicity) normal distribution. The shaded area represents the probability that a packet with a true net weight of 199 g would be measured to have a net weight exceeding 200 g and be accepted for sale. The addition of the guard band reduces the chance of accepting this underweight packet.

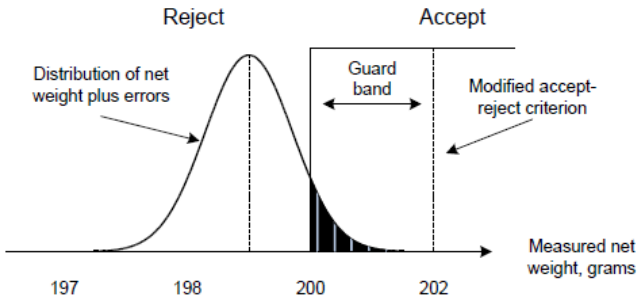

Figure 1: In order to avoid shipping underweight packets, the manufacturer includes a guard band to account for the errors in the calculated net weights.

When guard bands are used, there is often a compromise between two different risks or costs. In the case of the biscuits, the risk to the manufacturer is possible prosecution and bad publicity associated with selling underweight goods. The cost is the small excess of product added to every packet to ensure compliance with the AQS. The cost-risk compromise occurs with almost all measurement-based decisions. Other examples include pasteurisation processes where microbial kill rate is traded for food quality, and petrochemical plants where productivity at high temperatures is traded against plant life and reliability.

Effective cost-risk compromises can only be reached if those making the decisions have realistic (i.e., not 'optimistic' or 'conservative') estimates of the uncertainties in the measurements on which the decisions are based. For example, a conservative uncertainty reported for the readings of the balance weighing the biscuit packets at the end of the production line would cause the manufacturer to unnecessarily increase the overfilling of the packets. Similarly, an optimistic report of uncertainty would expose the manufacturer to prosecution.

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