OPERATIONALIZING THE DEFINITION OF RISK AS VARIABILITY[1]

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Maintaining safety requires acknowledging risk. However, one's definition of risk can depend on whether the word is being used in everyday conversation or by safety practitioners or by domain experts. Not having a commonly agreed-upon definition poses problems for those charged with identifying, reducing, and communicating about risk. In an effort to standardize the definition, the International Organization for Standardization defined risk simply as the effect of uncertainty on objectives. Still, this general definition lacks enough specificity to describe uncertainty's positive or negative effects. Relevant information can reduce uncertainty's potential effects if it's not ambiguous, unreliable, incomplete, or unavailable.

The global aviation community strives to continually increase the level of safety and relies on a highly procedural system of systems to maintain flight safety.Rules and regulations for all airspace users specify procedures for executing safe operations. For example, specific words distinguish required performance: must, must not, shall, shall not.[i] For example, "At tower-controlled airports where radar coverage does not exist to within 1/2 mile of the end of the runway, arriving aircraft must be informed when radar service is terminated" (FAA, 2012). This mandatory procedure is executed to reduce risk. If 10 out of 100 arriving aircraft are not informed, then there is variation from the required standard.

Maintaining safety requires acknowledging risk. However, "risk" is used as a very plastic concept. One's definition can depend on whether the word is being used in everyday conversation or by safety practitioners or by statistical experts. Not having a generally agreed-upon definition can pose problems for those charged with identifying, reducing, and communicating about risk. As either noun or verb, it can be used to characterize a variety of situations. Aviation safety professionals seem to have developed an unspoken requirement to use "risk" concepts in every document.

Variability and Risk

In aviation, risk characterizes a future when consequences are unknown. "In general, risk considers uncertain and undesired future occurrences and it is typically assessed by combining probability and severity levels of future occurrences. Note that there is no risk involved in runway incursion events as such, since they did occur and their consequences are known" (Stroeve, S., van Doorn, B., Bakker, B., & Som, P. 2015).

The opinions expressed in this paper are those of the authors and do not reflect FAA policies or positions.

Efforts to identify future safety risks typically rely on stochastic methods but the complexity of situations may disguise risk, making its prediction difficult. Jaeger (2000) proposed that prediction methods may reveal financial risk but not describe the nature of it and too much reliance on quantitative forecasting tools can lead to trouble. For example, financial risk industries predict price volatility but risk is uncertainty, not volatility. Jaeger believed that difficulty measuring risk could lead to improvements in one's ability to manage risk. To quantitatively oriented financial experts, variance is a commonly used substitute for risk. (Chang, Lin, & Zhu, 2008).

"Given the ubiquity of risk in almost every human activity, it is surprising how little consensus there is about how to define risk" (Damodaran, A. 2008). In an effort to standardize the definition, the International Organization for Standardization (ISO) defined risk simply as the effect of uncertainty on objectives (ISO 31000, 2009; ISO Guide 73). Uncertainty is generally viewed as undesirable vagueness, or ambiguity, that is unintended and to be avoided. An overview how uncertainty relates to variability was discussed in Davis et al, (2015).

We discuss variability as a simple solution for the complex problem of defining, identifying, measuring and mitigating safety risks by defining risk as unintended variation. This can be operationally useful when defined using recognized indicators of deviation from a standard. We hypothesize that safety can be supported by recoginzing and reducing sources of unintended variation.

Rather than trying to forecast potential adverse events, a method we examine to address these considerations is to re-conceptualize uncertainty, risk and outcome in terms of variability. We are examining methods from other areas as means to operationalize, measure, and mitigate current safety hazards. Early detection and mitigation of hazards can block risk in future operations.

Variability and Safety Controls

The concept of variability is not new. This definition can be tested using methods to measure variance that are familiar to most safety professionals. Reducing variation is a standard manufacturing tool for improving consistency in production. However, to our knowledge it has not been used to re-conceptualize uncertainty. This definition can be tested using methods to measure variance that are familiar to most safety professionals using frequencies distributions. We don't presume that this is a predictive, stochastic method for forecasting outcome, only that it is a way of identifying deviation from an expected standard.

Safety compliance with the appropriate standards is required to control known risks.

- Variability that is known to the controlling organization and permitted is classified as "intended" and thus is an acceptable uncertainty that the controlling organization has judged does not need to be controlled.
- Variability that is known to the controlling organization and not permitted is classified as "unintended" and thus is unacceptable uncertainty that the controlling organization has judged needs to be controlled.

Risk management with appropriate mitigations in place as controls is needed to control unknown risks.

- Variability that is unknown to the controlling organization but could be present is classified as "unintended but discoverable." Because it is unknown to the controlling organization, it is classified as "unintended."
- Variability that is unknown to the controlling organization and cannot be imagined is classified as "unintended and unimagined." This type is difficult to discover and control, if needed, because it *is* unimagined.

By using present variability instead of estimated future states, this approach can describe how and when known and unknown variability occurs, whether it is intended or unintended, what influences it, whether a mitigation reduces it, etc. In short, using this approach can provide an objective method for managers of safety organizations in government and industry to address the present potential for future risk by recognizing the hazard of unintended variability.

To explore the implications of this, we used the metaphor of an iceberg metaphor, with intended safe outcomes at its top (Figure 1). Whatever the desired performance (e.g., an accurately executed procedure), the organization's safety controls can reduce variability and increase the potential of a process achieving its intended outcome (i.e., to maintain separation) or objective (e.g., safety). Moreover, any practitioner will recognize that there are situations when variability occurs as expected; but in some cases, variability occurs and is unexpected.

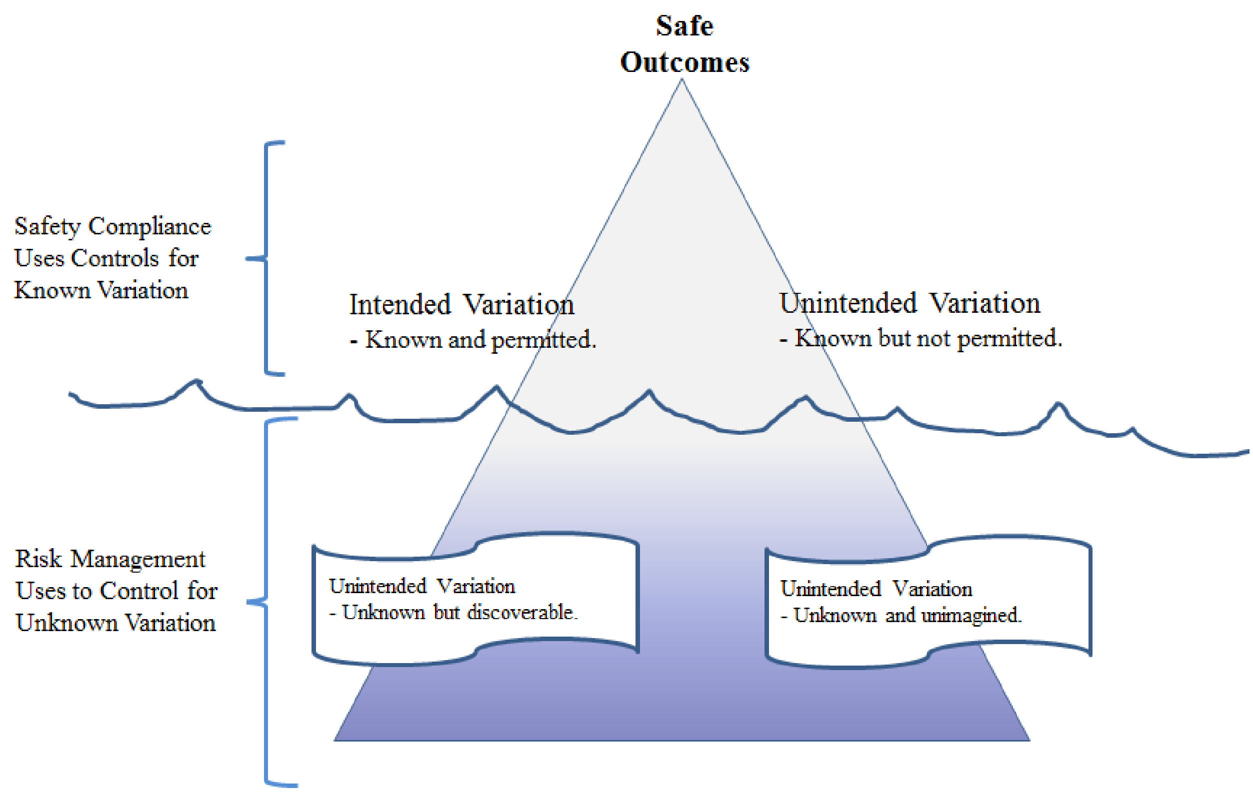

Figure 1. Types of intended and unintended variation in safety compliance and risk management.

This approach can be used to recognize how and when variability occurs, what influences it, if a mitigation is effective in reducing it, etc. In short, using this approach provides an objective, measurable method for safety practitioners to address potential risk.

References

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[i] In FAA documents the practice of using directives such as "shall" and "shall not" is changing to forms such as "must" and "must not."