On the Concept of RISK, UNCERTAINT

By Bruce K. Lyon and Georgi Popov

WHAT IS RISK? Depending upon the context or the individual involved, it can mean different things. Traditionally, risk is characterized as having the capacity to produce harm or loss and is measured in terms of likelihood of occurrence and severity of impact.

The term "risk" has its roots in an ancient Greek navigation term "rhizikon" or "rhiza," which was a metaphor for "difficulty to avoid in the sea" (Skjong, 2005). The word "risk" comes from the French word "risque" and the Italian word for danger, "risco" (Lyon & Popov, 2020). In the 16th century, "rysigo," a German term for business, was used meaning "to dare, to undertake, enterprise, hope for economic success" (Skjong, 2005).

Risk is found in all aspects of life. In the financial world, risk can be defined as the "possibility that an outcome will not be as expected," specifically in reference to returns on investment in finance. And within financial risk, there are many forms such as investment risk, market risk, inflation risk, credit risk, business risk, liquidity risk and others (Sraders, 2019).

At an organizational level, OSH practitioners view risk derived from hazards, while production and operational managers see risk coming from operations. At the senior-executive level, a much broader view is taken to include financial and strategic risks that threaten business objectives. This is commonly referred to as enterprise risk management (ERM).

Enterprise Risk Management

The concept of risk and its management have evolved over time. Traditionally, companies have managed risk in silos, separating departments from each other and from the financial and strategic decision-making process. Specifically, the OSH function has managed hazards and compliance, while the production and quality departments have managed operational issues, and the C-suite has dealt with financial and strategic concerns. This fragmented management style of managing risk has evolved to a more integrated approach known as ERM.

In this increasingly global economy, the world is getting smaller and less predictable. To adapt, organizations are removing silos and integrating ERM into their management systems, enabling them to be more agile and resilient in achieving their objectives. The days of operating in silos and hazard-based compliance are fading into the past. A new set of skills is required for today's OSH professional.

KEY TAKEAWAYS

- **Risk, depending upon the context, can have different meanings to different groups. At the organizational level, OSH practitioners view risk derived from hazards, while production and operational managers see risk coming from operations. At the senior-executive level, a much broader view is taken to include financial and strategic risks that threaten business objectives.**
- **These various perspectives have led to the development of many definitions for the term "risk," raising some confusion as to its universal meaning. Risk management and management systems standards have their own definitions of risk, while safety standards and dictionaries describe risk differently.**
- **For the benefit of those who manage risk, it may be time to reexamine the concept of risk and understand its true meaning. This article presents the authors' viewpoints on risk, uncertainty, opportunity and unique events known as black swans and grey rhinos.**

Defining Risk

Over roughly the past decade, the term "risk" has become a more controversial subject among consensus standards developers. Depending upon the context, various definitions can be found. In occupational safety, health and environmental standards, risk has generally been defined as the probability or likelihood of an occurrence, and its resulting severity of consequences. Note that "probability" is a mathematical term used when adequate statistical data exist, whereas "likelihood" is a more qualitative term used when statistical data are not available. The international guide, ISO/IEC Guide 51:2014, Safety Aspects—Guidelines for Their Inclusion in Standards, defines risk as a "combination of the probability of occurrence of harm and the severity of that harm." The ANSI/ASSP Z590.3-2021 prevention through design standard defines risk as "an estimate of the probability of a hazard-related incident or exposure occurring and the severity of harm or damage that could result." And a third example, ISO 11231:2019, Space Systems—Probabilistic Risk Assessment (PRA), defines risk as an "undesirable situation or circumstance that has both a likelihood of occurring and a potentially negative consequence on a project." These definitions tend to align with most common definitions found in various dictionaries.

In a broader context, ERM-related standards and guidelines such as ANSI/ASSP/ISO 31000-2018, ANSI/ASIS/RIMS RA.1-2015 and the Committee of Sponsoring Organizations of the Treadway Commission (COSO) define risk differently. In the ANSI/ASSP/ISO 31000 risk management family of standards, risk is defined as the "effect of uncertainty on objectives." The ANSI/ASSP/RIMS RA.1-2015 risk assessment standard defines it as "the effect of uncertainty on the achievement of strategic, tactical and operational objectives." And COSO (2004) defines it as "the possibility that an event will occur and adversely affect the achievement of objectives." Being framed in the context of ERM, these three definitions describe risk as affecting an organization's achievement of objectives and being organization-centric. However, ISO 31000 and ANSI RA.1 say risk is caused by uncertainty, while COSO indicates that risk is caused by an event.

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TY & BLACK SWANS

A third variation on the definition of risk is found among management systems standards including ISO 45001, Occupational Health and Safety Management Systems (OHSMS); ISO 14001, Environmental Management Systems; and ISO 9000, Quality Management Systems. These all define risk as the "effect of uncertainty," omitting the word "objectives." Based on the definitions, it appears that the management systems standards and the risk management standards consider uncertainty as the source of risk.

To add more confusion to the meaning of risk, some standards and guides suggest risk can be a good thing. For example, *A Guide to the Project Management Body of Knowledge*, by the Project Management Institute (PMI, 2017), defines individual project risk as "an uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective." And the British Standards Institution's BS 6079-1:2002, Guide to Project Management and BS 6079-2:2000, Project Management Vocabulary, define risk as a "combination of the probability or frequency of occurrence of a defined threat or opportunity and the magnitude of the consequences of the occurrence" (Hubbard, 2009).

In reviewing these various definitions of risk, several questions emerge: Should risk be limited to organizations and their objectives? What role does uncertainty play in risk? Can risk be a good thing? Is a more encompassing definition needed to unify and align standards regarding the meaning and usage of the term?

The answers may be found by taking note of what has been happening in the world recently. For example, the COVID-19 pandemic has clearly affected organizations and their achievement of objectives in negative ways. However, these negative effects have extended well beyond corporate boundaries to individuals and families, communities, countries, society, market trends, governmental policies and the overall environment. This suggests that risk is universal and not limited to organizations or their objectives.

Uncertainty plays a major role in risk management by increasing the potential for risk and influencing decisions and actions. However, current definitions in ISO and ANSI standards seem to indicate that uncertainty is not the source of risk, but rather a driver of risk. ISO defines "risk source" as an "element which alone or in combination has the intrinsic potential to give rise to risk" and a "risk driver" as a "factor that has a major influence on risk" (ANSI/ASSP/ISO, 2019; ISO, 2011). There must first be a risk source for a risk to exist. The level of uncertainty surrounding the risk can reduce or escalate the risk as a risk driver and influence decision-making. For example, consider a natural disaster type risk such as a hurricane. Based on history, the risk of hurricane landfall along the U.S. southeastern coast is highly certain. An organization considering locating a new facility in such areas would likely assess the degree of risk for wind and flood damage based on a location's weather patterns, flooding and wind damage history, elevation, proximity to coastal waters, and other risk factors. Risk sources can create uncertainty as well as risk, however, uncertainty alone does not create the risk.

Can risk be a good thing? This notion seems to confuse and conflate risk with opportunity. Risk and opportunity, while often conjoined, are two separate concepts. Risk by itself does not present "favorable outcomes," only harmful and unwanted effects. Opportunity, on the other hand, is a chance for gain or benefit. However, with opportunity comes risk. If given the choice between an opportunity with little downside risk and a high-risk opportunity, one would certainly select the opportunity with least risk. In dictionaries, risk is commonly defined as something that is undesired. Merriam-Webster defines "risk" as the "possibility of loss or injury" and the Cambridge Dictionary defines it as "the possibility of something bad happening."

With these differing definitions and applications, a final question is raised: Is there a need for a more universal definition of risk? The authors believe the answer is yes. In October 2021, a proposal submitted by ISO/TC 262 to establish a coordination committee on risk and associated concepts was accepted by the ISO Technical Management Board for that very purpose. The accepted proposal will involve a high-level committee of global experts with the goal of developing a consensus on meta-definitions (universal or base definitions) for risk and associated terms that would standardize their use in standards and reduce confusion to end users.

Risk

A fundamental meaning of risk that can be applied within any context should be clearly, concisely defined to help align standards. Such a definition must be applicable to all end users including individuals, organizations, public entities and society in general. When considering the fundamental meaning and available definitions, a meta-definition for risk might be the potential for adverse outcomes. A breakdown of the definition's words and descriptions of their meaning is provided in Figure 1 (p. 20).

In this definition, the phrase "adverse outcomes" not only addresses organizational objectives, but the entire risk universe—people, society and the environment. A simple test of the definition's validity can be performed by adding certain activities or actions that can cause risk to the end of the definition. For example, risk is the potential for adverse outcomes from operating a machine, performing elevated work, traveling abroad, acquiring a business, making an investment or building an addition. To help clarify and add meaning to a meta-definition for risk, the authors provide their observation regarding the characteristics and nature of risk as follows:

- Risk is a *state*, a situation or condition where there is a potential for adverse outcomes.

•Risk is a *negative* effect—the higher the risk, the greater the potential for adverse outcomes.
•Risk is always *present* in some degree—there is no such thing as risk free.
•Risk is *dynamic* and can be viewed as a continuum as described in ASSP TR 31010.
•Risk is an *estimate* of likelihood and severity.
•Risk encompasses its risk sources, risk drivers, exposures, causes and consequences.
•Risk is derived from hazards, operations, financial and strategic actions or inactions.

Opportunity

Opportunity and risk are conjoined but are on opposite sides of the same coin. Opportunity, as opposed to risk, is the chance for gain or benefit. According to Hubbard (2009), risk as opportunity itself (as opposed to something one is willing to accept in exchange for opportunity) contradicts the most established use of the word in the practical world of insurance as well as the theoretical world of decision theory.

In reviewing common dictionary definitions, Merriam-Webster defines "opportunity" as "a favorable juncture of circumstances." Interestingly, while ISO 14001:2015 defines "risk" as "effect of uncertainty," it also defines the two terms "risks" and "opportunities" together as meaning "potential adverse effects (threats) and potential beneficial effects (opportunities)."

As explained by COSO (2004), opportunities are "the possibility that an event will occur and positively affect the achievement of objectives, supporting value creation or preservation." Uncertainty presents both risk and opportunity, with the potential to erode or enhance value. ERM enables management to effectively deal with uncertainty

FIGURE 1
DEFINITION OF "RISK"

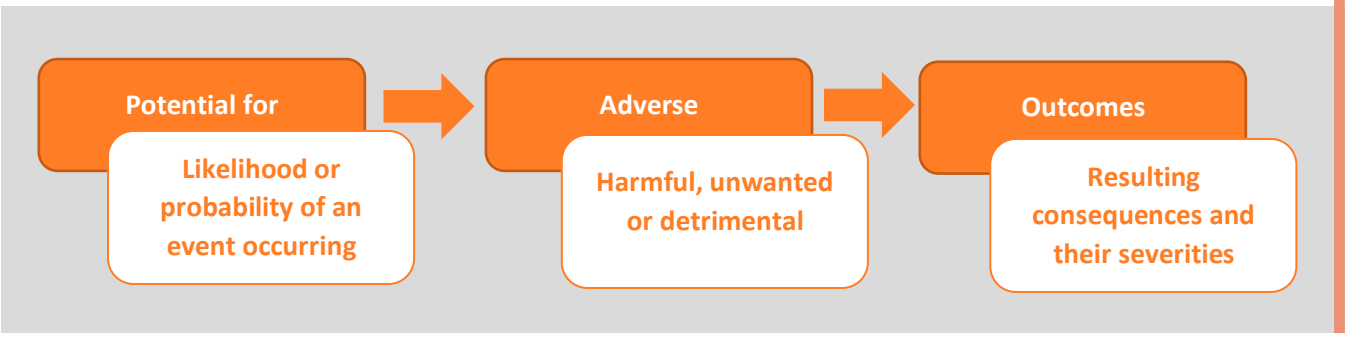
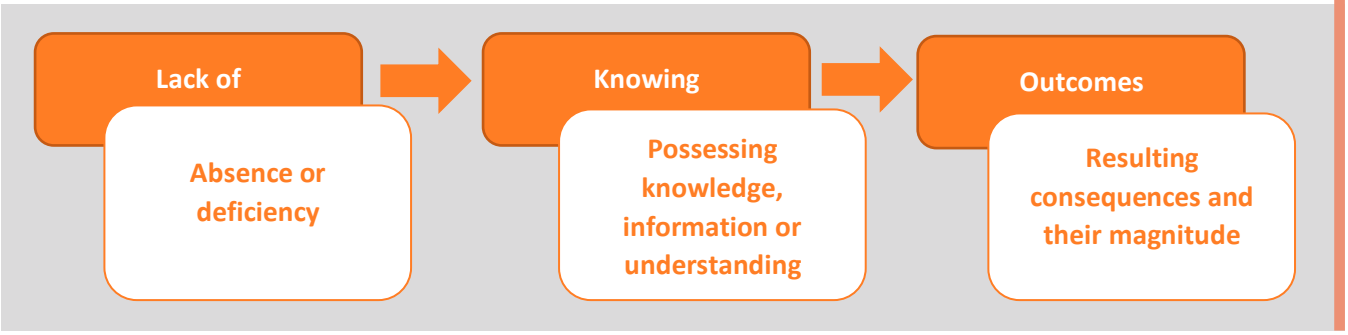


FIGURE 2
DEFINITION OF "OPPORTUNITY"

FIGURE 3
DEFINITION OF "UNCERTAINTY"



and associated risk and opportunity, enhancing the capacity to build value.

To mirror the risk definition, the following definition for "opportunity" could be considered: "Opportunity, the potential for favorable outcomes." Figure 2 provides a breakdown of the definition and its meaning.

Opportunity is a state in which there is a chance for desired outcomes. Like risk, opportunity is dynamic and fluid. Unlike risk, opportunity is considered positive, meaning the greater the opportunity, the greater the reward or desired outcomes. However, with opportunity, there is also risk. Opportunities such as adding a new product line, ending a partnership, expanding operations in a foreign country, or acquiring a business all have risk or a potential for adverse outcomes as well. Each can influence the other and can vary greatly.

For organizations, both pure risk (hazards and operations) and speculative risk (financial and strategic) must be considered and managed in pursuit of objectives. All risks are considered negative—the greater the risk, the greater the potential for loss—and measured from high (undesirable or unacceptable) to low (desirable or acceptable). For speculative type risks, a higher level of risk associated with an opportunity may make a higher return possible, but it also exposes one to potentially higher levels of loss. There is always a level of risk taken when pursuing opportunities, whether it is an organization achieving its business objectives or an individual making an investment; the key is managing the risk to a level that is acceptable.

Uncertainty

As former Secretary of Defense Donald Rumsfeld famously said:

> 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. (Profita, 2006)

All decisions are made either knowingly or unknowingly of the level of uncertainty involved. In the authors' opinion, the difference is that those decisions made with a better understanding of the uncertainties and risks are more likely to be successful.

Uncertainty is defined in ISO Guide 73 as the "state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood" (ANSI/ASSP Z690.1, 2011). A simplified meta-definition for uncertainty that could be applied universally is presented in Figure 3.

Uncertainty, strongly linked to probability or likelihood, can occur in four ways:

1. epistemic uncertainty: a condition where there is a lack of relevant knowledge of the system;
2. aleatoric uncertainty: a condition where a random, unpredictable nature exists surrounding the system;
3. linguistic uncertainty: a vagueness or ambiguity inherent in spoken languages; and
4. decision uncertainty: uncertainty associated with value systems, professional judgment, company values and societal norms (ANSI/ASSP/ISO, 2019; Lyon, 2022).

To some extent, uncertainty surrounding a decision can be reduced by effectively communicating relevant or needed risk-based information concerning a decision. Effective communication and consultation throughout the risk management process are needed to help facilitate risk oversight and reasoned decision-making.

Knowable Unknowns

Uncertainty is inherent in risk. A lack of information or insufficient understanding of the hazards and potential risk scenarios is referred to as epistemic uncertainty (Spiegelhalter & Riesch, 2011). "Epistemic" comes from the branch of philosophy called epistemology concerning the nature and scope of knowledge. Epistemic uncertainty can be caused by a lack of knowledge of the system or situation that is knowable with the right information. Typically, epistemic uncertainty can be reduced through investigation and assessment to acquire relevant risk-based information and knowledge of systems and to understand the risk and reveal the knowable unknowns.

To reduce uncertainty, relevant knowledge is required in respect to the quantities and qualities. "Knowable unknowns" may include uncertainty regarding the likelihood of an event, the consequences that may occur and the magnitude of the consequences. Other sources of epistemic uncertainty may include a lack of data, potential inaccuracies or lack of precision in measurements and inadequate historical data for calculating probabilities. By acquiring such information, epistemic uncertainty can be reduced although rarely eliminated.

Unknowable Unknowns

Another form of uncertainty is aleatory uncertainty, which comes from an unpredictable process such as flipping a coin and predicting either heads or tails. Aleatory uncertainty is caused by random variables that cannot be predicted with any certainty and are literally unknowable. The word "aleatoric" comes from the Latin word for dice, which is defined as being "characterized by chance or indeterminate elements," according to Merriam-Webster. Aleatory uncertainty is a statistical type of uncertainty derived from the natural variability of a risk, or inherent sensitivities (vulnerabilities) to a risk. Unlike epistemic uncertainty, it cannot be materially reduced, only identified and quantified. Where aleatory uncertainty or randomness is intrinsic to the risk, it may not be possible to reduce risk by further study; however, it can be represented by a statistical range of possible values (Gluckman, 2016).

Examples of events during which aleatory uncertainty might occur include volcanic eruptions, catastrophic earthquakes and individual reactions to chemicals or medicine. All of these contain inherently random factors making it nearly impossible to predict their occurrence or impact, leaving only a projected range of possibilities. Aleatory uncertainty and its lack of predictability make it impossible to know the outcome with complete certainty (Spiegelhalter & Riesch, 2011).

Black Swans & Gray Rhinos

Prior to the 1600s, Western Europeans assumed that all swans were white. This belief was based on their observations of swans in Europe until that time. Then, in 1697, Dutch explorers made the amazing discovery of large flocks of black swans in Australia, common to the area. Their long-held belief that all swans were white was immediately changed.

In 2007, Nassim Nicholas Taleb introduced the black swan theory in his book, *The Black Swan*. His theory refers to a catastrophic event that is unprecedented or unexpected in

human history at the time of its occurrence. Such events are largely unpredictable because there is no historical information or experience to rely upon. Black swan events are characterized as having a very low likelihood or probability but extremely high severity. Examples might include the Sept. 11, 2001, terrorist attacks in the U.S. or the global financial crisis of 2008 (Gluckman, 2016).

There is increasing awareness by organizations of black swan type events being possible and that exploration of such uncertainties is in order. Such events can be based on randomness, such as earthquakes, volcano eruptions or acts of nature that rarely occur, thus making it almost impossible to predict if and when it might occur. However, what-if type contingencies for such events can be considered and evaluated by organizations as they plan for business continuity and resilience.

While black swan events can result from a singular cause, they are more commonly triggered by a less severe event that cascades into a catastrophic event (e.g., the Three Mile Island nuclear incident). Such events can arise from a combination of interdependent or connected risk factors that develop into more complex factors and resulting multiple cascading impacts. Individually, single risk factors may not result in a major disaster, but when combined they can have a cumulative and catastrophic effect.

An example of a cumulation of events cascading into a catastrophic event is the Fukushima nuclear accident in 2011. It began with the Tōhoku undersea earthquake registering a magnitude of 9.1 in the Pacific Ocean. The force of the undersea earthquake caused a 45-ft-high tsunami that struck the plant 50 minutes later, over-topping the seawall, flooding the basements and disabling the emergency generator system. Without power to operate the pumps circulating coolant through the reactors' cores, the reactors overheated resulting in three nuclear meltdowns, several hydrogen explosions and the release of radioactive contamination (Lipscy et al., 2013). Like the Fukushima event, black swan type events tend to reveal vulnerabilities and weaknesses in systems that were not previously known or considered.

Gray rhinos are a known risk but not taken seriously. Although the financial press throws the term around more often than it should, black swan events are actually quite rare. But a crisis event that telegraphs danger signs in advance is not a black swan; it is a gray rhino. A gray rhino is a highly probable, high impact yet neglected threat, kin to both the elephant in the room and the improbable and unforeseeable black swan. Gray rhinos are not random surprises, but occur after a series of warnings and visible evidence. The bursting of the housing bubble in 2008, the devastating aftermath of Hurricane Katrina and other natural disasters, the new digital technologies that upended the media world, the fall of the Soviet Union—all were evident well in advance (Wucker, 2016).

TABLE 1
STRATEGIES FOR REDUCING UNCERTAINTY IN DECISION-MAKING

Strategy	Description
Reduce the size of the decision	Break it into smaller steps, reducing potential impact from a single decision.
Understand the options	Knowledge is power and the antidote to the unknown.
Defer the decision	Postpone making the decision until it is better understood.
Focus on one decision	Keep the focus on a single decision rather than combining risks from multiple decisions. Other risks and decisions that may impact the decision should be factored into the decision-making process.
Understand the credible worst case	Determine what the worst-case scenario could be that is credible, and define the potential outcomes.
Clarify potential outcomes	Estimate the consequences of the decision, both positive and negative, and the risk drivers that may influence the outcomes.
Understand the context	Know the reasons for the decision, the internal and external stakeholders, and the goals and values of the organization.
Be flexible and adaptable	Keep options open, and make adjustments as more is learned during the decision-making process.
Remain objective and unemotional	Remove emotions and maintain a calm, rational mindset.

Reducing Uncertainty

All decisions involve some level of risk, and few are made with absolute certainty. However, with adequate risk-based information, decision-makers can reduce uncertainty and risk in their decisions. Some fundamental strategies that can help reduce uncertainty in decision-making are presented in Table 1.

For situations where it is difficult to reduce uncertainty, it may be possible to better understand the nature and the potential implications of the uncertainty. Methods that can be used to gain an understanding of uncertainty include sensitivity analysis, scenario analysis and Monte Carlo simulation.

Sensitivity Analysis

Sensitivity analysis is a systematic way to understand how risk estimates and risk-based decisions are dependent upon variability and uncertainty in contributing risk factors (ANSI/ASIS/RIMS, 2015). ISO 31010 suggests that sensitivity analysis be used to help test, verify and validate results. The method is used to determine the degree of variations produced in the model by testing different input values. As different inputs are applied, the outcomes produced are compared and evaluated. The degree of uncertainty associated with each variation is then evaluated and ranked (ANSI/ASSP/ISO, 2019; ASSP, 2020).

Scenario Analysis

Scenario analysis is used to estimate risk levels and consequences of various alternative scenarios and their possible outcomes. Through brainstorming and extrapolation, plausible scenarios are identified and defined. Then, for each plausible scenario, the potential risks and consequences are explored

considering what might happen given various possible future developments (ANSI/ASSP/ISO, 2019; ASSP, 2020).

Monte Carlo Analysis

Monte Carlo analysis or simulation is a computer-based method that uses statistical sampling to obtain a probabilistic approximation to the solution of a problem. It is used to analyze uncertainty and variability, especially in more complex risks, and calculates the probability of outcomes by running multiple simulations using random variables. The analysis can be used for a specific model where the interactions of the various inputs can be mathematically defined. The inputs can be based upon a variety of distribution types according to the nature of the uncertainty they are intended to represent (ANSI/ASSP/ISO, 2019; ASSP, 2020).

Like risk, uncertainty can never be completely eliminated, only reduced and managed to an acceptable level.

Conclusion

Risk, opportunity and uncertainty are three inseparable variables that must be managed together as part of the risk management process and overall management system. The days of operating in silos and hazard-based compliance are fading into the past. To prove value to their organizations, OSH professionals must become actively and effectively engaged in the risk management process. This requires an understanding of these variables and their effects on the organization, as well as the world we live in. The art of assessing and treating risk requires skill and an inquisitive mind. As the authors have stated in previous work, proper modification and customization of methods are required to effectively manage risk. **PSJ**

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