2018 Award Winner
USAWC Student Awards Program

Selected for publication

Understanding Uncertainty: Incorporating the Unknown Into Military Estimates

by

Lieutenant Colonel Robert E. Croft
United States Army

Under the Direction of:
Colonel Robert Bradford

United States Army War College
Class of 2018

DISTRIBUTION STATEMENT: A
Approved for Public Release
Distribution is Unlimited

REPORT DOCUMENTATION PAGE

Form Approved--OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
01-04-2018	STRATEGY RESEARCH PROJECT	

4. TITLE AND SUBTITLE
Understanding Uncertainty: Incorporating the Unknown Into Military Estimates

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Lieutenant Colonel Robert E. Croft
United States Army

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Colonel Robert Bradford

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army War College, 122 Forbes Avenue, Carlisle, PA 17013

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution A: Approved for Public Release. Distribution is Unlimited.

13. SUPPLEMENTARY NOTES
Word Count: 5897

14. ABSTRACT
Strategic leaders make decisions in uncertain environments. Uncertainty has several possible definitions, but does not have a widely accepted definition and has little impact on the military planning or decision-making processes. Assumption-based planning and risk assessment are key components of military planning culture from the tactical to the strategic level. Failure to account for concepts of uncertainty impacts the efficacy of these procedures. This paper examines uncertainty in detail and introduces a taxonomy labeled Analytic Uncertainty. It includes five components that are important for understanding in the context of military estimates. Analytic Uncertainty facilitates both theoretical thinking and analytic thinking about uncertain environments and uncertain quantities. Unifying definitions are provided for uncertainty, risk, opportunity, and measurement. The paper also explores the relationship between uncertainty and risk. Finally, the concepts of Analytic Uncertainty are applied to the Risk Assessment provided by the Chairman of the Joint Chiefs of Staff to determine its limitations.

15. SUBJECT TERMS
Risk, Estimation, Estimates, Assessment, Opportunity, Measurement, Planning

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(w/ area code)*
UU	UU	UU	UU	31	

Understanding Uncertainty: Incorporating the Unknown Into Military Estimates

(5897 words)

Abstract

Strategic leaders make decisions in uncertain environments. Uncertainty has several possible definitions, but does not have a widely accepted definition and has little impact on the military planning or decision-making processes. Assumption-based planning and risk assessment are key components of military planning culture from the tactical to the strategic level. Failure to account for concepts of uncertainty impacts the efficacy of these procedures. This paper examines uncertainty in detail and introduces a taxonomy labeled Analytic Uncertainty. It includes five components that are important for understanding in the context of military estimates. Analytic Uncertainty facilitates both theoretical thinking and analytic thinking about uncertain environments and uncertain quantities. Unifying definitions are provided for uncertainty, risk, opportunity, and measurement. The paper also explores the relationship between uncertainty and risk. Finally, the concepts of Analytic Uncertainty are applied to the Risk Assessment provided by the Chairman of the Joint Chiefs of Staff to determine its limitations.

Understanding Uncertainty: Incorporating the Unknown Into Military Estimates

> Best efforts are essential. Unfortunately, best efforts, people charging this way and that without guidance of principles, can do a lot of damage.
>
> —W. Edwards Deming[1]

From 1980 until 2013, Mike Morell served in United States' Central Intelligence Agency (CIA).[2] He spent his early career as an analyst and his final three years as the CIA's Deputy Director, including two stints as the acting Director.[3] In late 2010, Morell participated in highly sensitive updates to President Obama about an unusual compound in Abbottabad, Pakistan.[4] His discussion about Osama Bin Laden's suspected location provided a remarkable symmetry. In the first year of the Bush administration, Morell travelled with the President and gave the daily intelligence briefing.[5] In the immediate wake of the September 11th attacks and before any official intelligence could be assembled, President Bush asked him to step beyond the customary caveats and voice his personal belief as a career intelligence officer about the source of the attack. Morell replied, "I would bet my children's future that the trail would lead to the doorstep of Osama bin Ladin and al Qa'ida."[6]

In the discussion a decade later about whether the Abbottabad compound contained the actual doorstep of the nation's long-hunted enemy, Morell was not so unequivocal. "Mr. President, if we had a human source who had told us directly that Bin Laden was living in that compound, I still wouldn't be above 60%."[7] To make his confidence level clear, he contrasted Abbottabad with 2002 intelligence estimates of Iraq's weapons of mass destruction of which he had seen thirteen analytical drafts. He told President Obama, "The case for WMDs [weapons of mass destruction] wasn't just stronger, it was much stronger."[8] In Morell's three estimates—the origin of the

September 11th attacks, the status of Iraq's WMD program, and the occupants of the Abbottabad compound—we find uncertainty in the presence of analysis and decision.

Leaders and analysts recognize that unknown facts and unsure causal relationships are inherent to the decision-making environment. Leaders can still be successful, according to the Army's Strategic Leadership Primer, if they "determine which elements of their environment are most important… and focus their attention and efforts there."[9] If leaders interpret this to mean focusing on what they understand then their decisions are in jeopardy. Supporting this interpretation, one investigation found that "[r]ather than face uncertainty or environmental complexity, the [decision maker] keys on only a few relevant variables in its environment" and "turns to a standard repertoire of activities in search of something that works reasonably well."[10] The standard repertoire of activities, as we will see, leaves valuable information in the shadows. Uncertainty, contrary to one accepted definition, is not an absence of knowledge. When grasped properly, strategic leaders will seek to incorporate uncertainty rather than merely tolerate it. This paper will present Analytic Uncertainty, a new taxonomy, as a form of knowledge with discernable components that leads to better understanding, better communication, better models, and better decisions.

Uncertainty and its more popular counterpart, risk, cover so many concepts, often incongruent, no definitions will suffice at the outset. Using an indirect approach, a tactical staff estimate illuminates uncertainty concepts and exposes the false simplifications planners employ in service to analytic tradition. The Analytic Uncertainty taxonomy includes two surface components and three deep components to frame proper analysis. Understanding these components leads to clear definitions for uncertainty, risk, opportunity, and measurement. Lastly, this paper evaluates the Risk Assessment the Chairman of the Joint Chiefs of Staff uses to communicate to civilian oversight. Elements of that methodology are problematic when viewed through the lenses of Analytic Uncertainty.

Military Estimates

The Decision-Making Environment

The phrase "making decisions under conditions of uncertainty" litters not only military writings but also those of business and social science. Much of life's texture involves decision making without access to all the facts, particularly those that only time can reveal. A currently accepted model for the military strategic leadership environment uses the acronym VUCA: Volatility, Uncertainty, Complexity, and Ambiguity.[11] Volatility, which we will later capture within the term "nonlinearity," concerns rate of change. The narrow definition of Uncertainty in this construct is "the inability to know everything about a situation." More helpful is the immediate conclusion that uncertainty "drives the need for intelligent risk management." Planners need to understand the relationship between uncertainty and risk to be clear about both. Complexity appropriately refers to "the difficulty of understanding the interactions of multiple parts." And ambiguity concerns differences of interpretation.[12] The VUCA model demonstrates the difficulty inherent in strategic decisions. A routine tactical estimate can provide an opportunity to show why the "U" definition of "inability to know" will not suffice.

Wargames and Assumptions

Consider a staff during a wargame analysis involving a large force conducting a river crossing using a temporary military bridge. The Commander previously expressed concern about operational tempo and directed more analysis of how long the unit will need to complete the crossing. The Engineer, no stranger to gap crossings or calculation, performs the assessment. First, she acknowledges some construction risk and logs an assumption that the bridge will not prematurely fail. More assumptions follow including availability of adequate staging areas, an organized call-forward plan, lack of enemy interdiction, and the rate of march across the bridge. She produces a number defensible with her expertise: 7.5 hours.

Military planners are so familiar with this process that nothing here appears objectionable. There are, however, several details which require careful treatment. In a first attempt to untangle uncertainty from risk, planners should distinguish between the discrete and the continuous. A bridge failure is a discrete event. Because failure will produce an unambiguously negative impact, the likelihood of failure represents risk. Other variables, such as rate of march, are continuous. If the Engineer applies her expertise to estimate the highest and lowest conceivable rates of march, she can make a clear statement about how much uncertainty exists around the 7.5 hour central estimate. This demonstrates why defining uncertainty as "an inability to know everything" is limiting. The planner does have knowledge about the degree of uncertainty. Ignoring this knowledge prematurely terminates a story that is just beginning.

Employing assumptions frequently sets conditions for disappointment. Experience and intuition tells us this wargame's assumptions taken together incline toward success and result in something like a best-case scenario. In the passage leading to his famous comment on the friction of war, Carl von Clausewitz articulates this intuition saying, "Countless minor incidents—the kind you can never really foresee—combine to lower the general level of performance so that one always falls short of the intended goal."[13] A doctrinally trained planner might protest by claiming the assumptions were "necessary… to complete an estimate of the situation."[14] Like fish troubling to understanding the concept of water, staff may have difficulty recognizing their analytic culture promulgates widely accepted techniques at odds with their own field experience. Assumptions are one of the "standard repertoire of activities" which seeks to avoid uncertainty. Sam Savage states that plans created in this way fall victim to "The Flaw of Averages" which states: "Plans based on *average* assumptions are wrong on *average*."[15] As with military acquisition programs and family vacation budgets, estimates which ignore uncertainty prove fragile to reality. Decision makers require better approaches.

Incorporating Uncertainty and Distributions

To produce a robust plan, the staff must incorporate uncertainty rather than assume it away. The Engineer should provide the Commander a likely range of outcomes. A pessimistic upper bound, still based on her expertise, suggests 9.5 hours for the crossing, while an optimistic but conceivable lower bound is 6.5 hours. A Commander comfortable with uncertainty should welcome an answer of "between 6.5 and 9.5 hours" and not seek a point estimate. The staff can then use knowledge of that range to design flexible measures to maintain the desired operational tempo.

This method of uncertainty planning is untaught and untrained. Field Grade Officers steeped in assumption-based planning will likely rebut the idea stating that planning time is finite, and ranges makes this too complicated. They may also argue "no plan survives first contact" as a cynical way of avoiding a more rigorous planning approach. The blind spot in both perspectives is that staffs increase the fragility—the inability to “survive first contact”—of plans based on averages rather than bounded ranges. Given limited time, a staff will better serve the Commander and the unit by making a best estimation of all real possibilities than by hanging all expectations on an assumed one.

When planners take this real-world approach, they will naturally think about the situation in terms of a "distribution" or numeric shape of all the possible outcomes. Figure 1 depicts four common distributions with marked averages. One example is the normal distribution (Figure 1: item a), a “bell curve” which applies to many natural phenomena such as the distribution of individual weights or a shot pattern around a target.

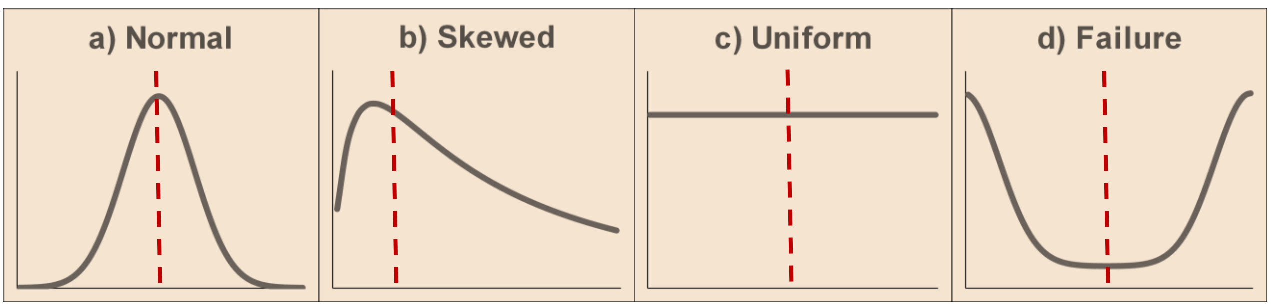

Figure 1. Distributions with Marked Averages[16]

Determining an appropriate distribution can be complicated, and Operations Research and System Analysts can provide the staff expertise and training where appropriate. In most military planning scenarios however, mathematical precision is secondary to the illumination that draws out the planner’s experience and intuition. The Engineer may, for the bridge crossing estimate, inductively reason the time to traverse the bridge is not normal but likely skews to one side (Figure 1: item b) reflective of Clausewitz’ sentiment that most sources of uncertainty will play against the operation. Moreover, she understands that the average of 7.5 hours, even if mathematically justified by multiple simulated crossings, has little value in describing likely outcomes. The arrival of units to the staging area may take on a uniform distribution (Figure 1: item c). Like the roll of a die, a specific arrival time is as likely as another. And the "bathtub curve" (Figure 1: item d) represents the failure probability of many mechanical components including military bridges. If the bridge doesn't fail soon after being placed into service, it is likely to last until excessive wear and environmental factors aggregate at the end of its lifespan. In comparison with point estimates or averages, these distributions yield far better understanding.

Planners should consolidate four points from this primer. Firstly, assumptions and averages frequently remove valuable information and oversimplify the system. Second, risk is most clear when viewed as a discrete negative event, while uncertainty better describes a range of continuous outcomes. How risk and uncertainty are related will be expanded later. Third, estimated uncertainty is more likely to capture the future truth than a prediction. Uncertainty frames a probabilistic view of the world and produces forecasts of *what may happen*. Predictions, in contrast with forecasts, derive from a deterministic approach which presumes that available facts can determine *what will happen*. Returning to Mike Morell's examples, his intuitive prediction of the September 11th perpetrators was correct. Those in his agency who predicted, after considerable effort, Iraq had WMDs were incorrect. Predictions may be right or wrong, but they are not robust to uncertainty. Finally, accepting uncertainty as a lack of knowledge is a self-limiting idea. If leaders must render judgment in conditions of uncertainty, then uncertainty-based planning will best allow them to understand and influence the dynamic aspects of the system. Planners require a complete taxonomy to think and communicate clearly about uncertainty.

Understanding Uncertainty

Historical Background

Epistemology, the theory of knowledge, is one of four branches of philosophy. From this perspective, uncertainty as an epistemological concept is as old as philosophy itself. Nicolas Nassim Taleb, who popularized the concept of black swans, primarily employs philosophy and human behavior research to allege human proclivity to underestimate the improbable.[17] His arguments certainly bear on strategic estimation problems. They also lead to some considerations than distract from this paper's focus on uncertainty in military planning contexts.

Frank Knight provided one of the first modern attempts to untangle uncertainly from commonly understood risk.[18] In his 1921 book *Risk, Uncertainty, and Profit*, he made this distinction: "The practical difference between the two categories, risk and uncertainty, is that in the former the distribution of the outcome in a group of instances is known… while in the case of uncertainty this is not true."[19] From his context in the world of finance, he noted that repeatable events like bond defaults have observable distribution patterns for calculating risk. Knightian Uncertainty, as it is now called, exists where the distribution is unknown, foiling calculation, and most applies when "the situation is in a high degree unique."[20] Such is the case with military estimates. The following taxonomy will identify and relate the required components.

Analytic Uncertainty

Uncertainty, as is now apparent, is a single word to which are attached multiple concepts and definitions. Clear understanding comes through careful use of labels and nesting concepts. This paper introduces the term Analytic Uncertainty to encompass a set of five components useful for military planning and assessments. Table 1 divides these components into the two categories of deep uncertainty and surface uncertainty. Deep uncertainty components are "unknowable" in the sense that even hindsight or repetition will not completely illuminate the system's behavior. For example, observations of combat, political elections, or international relations do not end debates about which factors best describe or influence outcomes. Deep uncertainty can only inform theory on which decision makers establish beliefs. Surface uncertainty, in contrast, contains mere "unknowns" which, as with the bridge crossing, inform specific planning considerations. Planners must understand all components to organize their thinking and analysis.

Table 1. Analytic Uncertainty[21]

ANALYTIC UNCERTAINTY	
Deep Uncertainty (Unknowables)	**Surface Uncertainty (Unknowns)**
Complexity	Factual Uncertainty
Nonlinearity	Precision Uncertainty
Adaptivity	

The first component of deep uncertainty is complexity. The U.S. Army Training and Doctrine Command's Commanders Appreciation Guide distinguishes two kinds of complexity, only one of which is helpful. The guide classifies systems as structurally complex if they involve many parts. It uses the term interactively complex to describe uncertain interactions.[22] Systems with many parts are better described with the word “complicated,” alleviating the need for “complex” to serve both purposes which have different implications. Modern passenger jets have a huge number of parts, but passengers are safe because aviation engineers understand these parts’ limits and interactions very well. When military professionals use the term complex, they should be referring to fundamentally uncertain relationships between elements even if the number is few. Complexity also includes Knightian Uncertainty as described in the historical background. Particularly at the strategic level, Knight’s insight of unknowable distributions is the norm. “Establishing security and stabilizing insecure areas has raised questions about acceptable levels of violence,” states one unsurprising 2014 commentary on Afghanistan.[23] Complexity in the relationship of security, stability, and levels of violence can only be considered as part of a theory about the operational environment. There is no expectation of teasing forth distributions in a complex system.

The second component of deep uncertainty is nonlinearity. This term is not common outside of technical circles and is, in a strict sense, a type of complexity as just described. But the concept that the ratio of input to output can vary over time and conditions should be a deliberate consideration in military and strategic environments. The “rapid change” in the volatility term of VUCA is one type of nonlinear reaction. While planners might view volatility as a negative attribute, they should approach nonlinearity as a neutral term that also facilitates positive leverage and opportunity. William Upshur, Jonathan Roginski, and David Kilcullen stated that an assessment plan for counterinsurgencies needed to “capture nonlinearity in the environment” so that “the commander could make more informed decisions about the allocation of resources in the battlespace.”[24] Headlines of Clausewitzian thought frequently include fog, friction, and complexity. But Alan Beyerchen's detailed analysis demonstrates Clausewitz repeatedly focused on nonlinearity as a separate and important idea.[25] "War is a pulsation of violence, variable in strength and therefore variable in speed with which it explodes and discharges its energy."[26] This is not a comment on fog but the nonlinearity of interactions between competing formations.

Finally, adaptation exists when humans or, increasingly, artificial intelligence are present. Actors or organizations in a system may change their objectives, adopt new rules, develop new resources, find novel ways to employ current resources, or change the boundaries of the system. Over time, system parameters themselves can appear or disappear.[27] This inability to understand an adapting system's temporal attributes places the capstone on deep uncertainty.

The remedy that analysts must employ in the face of complexity, nonlinearity, and adaptation is theory. Theories, by their nature, are uncertain, and planners in early stage operational design work must again avoid the assumption trap. As epistemologist Karl Popper warned, "Whenever a theory appears to you as the only possible one, take this as a sign that you have neither understood the theory nor the problem which it was intended to solve."[28] By engaging with deep uncertainty, planners take on the challenge of building multiple worldviews as possible explanations of system behavior and change both during and after conflict.

In contrast with the unknowables of deep uncertainty, the two unknowns of surface uncertainty are far easier to grasp. The first unknown is factual uncertainty, sometimes expressed as "known unknowns."[29] The limited definition in the VUCA model, the inability to know everything, is covered by this component. Former Secretary of State Colin Powell and Amazon CEO Jeff Bezos both hold that the best decision threshold is about 70% of the desired information. Waiting longer means the decision maker is "probably being slow" and may "lose an opportunity."[30] As Bezos explains, "If you're good at course correcting, being wrong may be less costly than you think, whereas being slow is going to be expensive for sure."[31] By highlighting course correction, Bezos echoes the position that flexible plans with acknowledged unknowns are superior to rigid ones with assumed knowns.

The second unknown is precision uncertainty. As previously discussed, diligent analysts use their expertise to generate a likely range of values for uncertain quantities. Development of these analytical procedures requires a separate treatment. Douglas Hubbard shows how an adoption of range-based estimates is both possible and, in conjunction with analyst training, considerably improves decision quality.[32] Hubbard has done significant work on this topic and provides us with the best definitions to unify these concepts.

Defining Uncertainty, Risk, Opportunity and Measurement

With the five components of Analytic Uncertainty established, we can adopt these general definitions for uncertainty, risk, opportunity, and measurement. Proposed in his book How to Measure Anything, Hubbard provides three of these definitions to support understanding and follow-on analysis through measurement.

> Uncertainty: The lack of complete certainty, that is, the existence of more than one possibility. The "true" outcome/state/result/value is not known.[33]

Hubbard's definition usefully addresses all earlier observations in two ways. First it emphasizes not a lack of facts in the present, but of *complete certainty about the outcome*. This shift is critical if we want to leverage available information and expert inferences. Second is the simple idea of “more than one possibility.” Multiple possibilities encourage specific descriptions and probabilistic thinking. Clausewitz states “judgment … can only be based on the phenomena of the real world and the laws of probability.”[34] This definition derives from facing real-world outcomes rather than a priori assessments.

> Risk: A state of uncertainty where some of the possibilities involve a loss, catastrophe, or other undesired outcome.[35]

In contrast with Knight’s approach which separated uncertainty and risk into different categories, Hubbard’s definitions make risk a subset of uncertainty. This resolves the issue of how to evaluate risk involving a continuous variable. If analysts know the point on the distribution that constitutes the “undesired outcome,” then that point serves as the discrete change which makes risk assessment is possible. Returning to the bridge crossing, the Commander may request the risk of the crossing taking more than 9 hours. Informed by analysis of precision uncertainty, the Commander is providing a discrete point for further consideration of risk. This is true commander-staff dialog and, importantly, illuminates an analytic continuity. Risk analysis should not be a separately contained event but a refinement of uncertainty analysis and probabilistic thinking infused from mission analysis onward.

> Opportunity: A state of uncertainty where some of the possibilities involve a favorable advance in effect, time to achievement, or other desired outcome if facilitated by decision, engagement, or resources.[36]

Commanders seek to capitalize on opportunities. This definition by the author augments Hubbard’s first two definitions and provides symmetry to the definition of risk with one notable difference. A favorable outcome that happens purely as a matter of chance is called luck. What distinguishes opportunity is the possibility of committing resources to further increase the odds. Whether the resource commitment achieves the desired exploitation is a separate matter of chance. Planners enable opportunities by identifying decision windows and the decision or resource required for exploitation.

> Measurement: A quantitatively expressed reduction in uncertainty based on one or more observations.[37]

Hubbard's definition of measurement allows that any information—not just "metrics"—can serve as a measure. Returning to the time estimate in the bridge crossing example, the Engineer's staff might watch a river crossing exercise or conduct analysis of the staging areas to better inform their judgment. These "observations" serve to measure the previous confidence levels and aid in refining the estimate.

An orientation on uncertainty reduction is not new or unique to Hubbard. A 1958 RAND study on materiel development states, "Research and development is a way of progressively reducing uncertainty by buying information."[38] Morell defines his profession when he says, "Intelligence is all about reducing uncertainty for decision makers on national security and foreign policy." And by adding "...you reduce that uncertainty, but you cannot eliminate it" he further implies the decision maker must accept the remaining uncertainty.[39] Military planning at all levels concludes with risk assessment and the underwriting of residual risk. As with planning, risk management without incorporating uncertainty also proves fragile to reality.

Applying Analytic Uncertainty to Strategic Risk Assessment

Analytic Uncertainty appears logical and justified for tactical contexts. A better test is whether it helps in understanding strategic planning models. An often cited maxim by George Box is "all models are wrong but some are useful."[40] Those who invoke this quote are usually acknowledging a lack of fidelity in a particular model while implying better-than-nothing usefulness. This misses Box's point on both counts. Simplification in a model is necessary—in fact, definitional—to see through a system's complication and complexity. What matters, Box is saying, is whether the model produces a better understanding of reality *including* the complexities. To this end, we will apply the lenses of Analytic Uncertainty to evaluate the model used for the Chairman's Risk Assessment.

The Joint Risk Assessment Methodology (JRAM)

Congress mandates under Title 10 that the Chairman of the Joint Chiefs of Staff annually produce a risk assessment to support the *National Military Strategy*.[41] The Chairman's Risk Assessment (CRA) itself is not the focus here as the product is classified and proper investigation requires full evaluation of the report's historical forecasts. Instead, the unclassified JRAM which guides production of the CRA will serve as the target for exploration.

If risk is contained within uncertainty, applying the wider lens of Analytic Uncertainty should illuminate any limitations of the JRAM. This investigation makes two critiques. The first, supported by academic literature, is a misapplication of financial risk models which cannot translate to strategic risk calculation. The second is a misapplication of safety risk models which do not adequately capture the dynamics of complex strategic environments. Both result in degraded clarity of communication and decision.

Misapplying the Financial Risk Model

The JRAM defines risk as "the probability and consequence of an event causing harm to something valued."[42] Figure 2 shows these two factors as the "Generic Risk Contour Graph" along with single dimension risk output definitions.

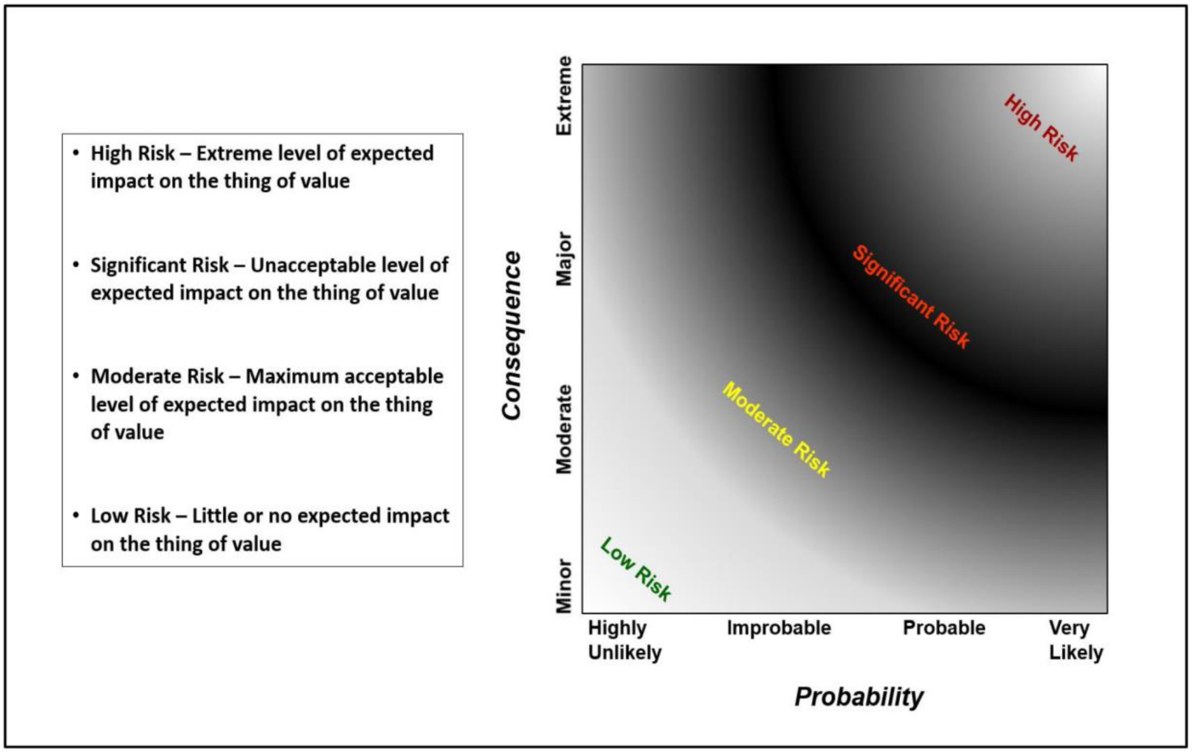

Figure 2. The JRAM's "Generic Risk Contour Graph"[43]

A 2017 U.S. Army War College paper finding is among the latest of academic critiques. La Rock states, "Although a risk matrix is a convenient way to represent the interaction of probability and severity, its ambiguous probability, severity, and risk scales can cause both miscommunication and estimation error."[44] The JRAM attempts to mitigate the matrix issue by using smooth contour lines rather than the more commonly seen matrix like the one shown in Table 2. But the attempt falls short because the problem, as La Rock noted, is not the matrix boxes (which merit their own critiques) but the scales. An understanding of scale data explains why.

Table 2. U.S. Army Risk Assessment Matrix[45]

		Probability (expected frequency)				
		Frequent: Continuous, regular, or inevitable occurrences	**Likely:** Several or numerous occurrences	**Occasional:** Sporadic or intermittent occurrences	**Seldom:** Infrequent occurrences	**Unlikely:** Possible occurrences but improbable
Severity (expected consequence)		**A**	**B**	**C**	**D**	**E**
Catastrophic: Death, unacceptable loss or damage, mission failure, or unit readiness eliminated	**I**	**EH**	**EH**	**H**	**H**	**M**
Critical: Severe injury, illness, loss, or damage; significantly degraded unit readiness or mission capability	**II**	**EH**	**H**	**H**	**M**	**L**
Moderate: Minor injury, illness, loss, or damage; degraded unit readiness or mission capability	**III**	**H**	**M**	**M**	**L**	**L**
Negligible: Minimal injury, loss, or damage; little or no impact to unit readiness or mission capability	**IV**	**M**	**L**	**L**	**L**	**L**
Legend EH – extremely high risk H – high risk L – low risk M – medium risk						

In financial risk analysis, both probability and consequence use the same type of scale data. That scale type, known as ratio data, facilitates multiplication.[46] For example, a financial analyst computes a 10% chance of a $10,000 dollar loss as an expected risk of a $1,000 loss. Decision makers can weigh this against the 90% expected gain to make a rational decision. The scale type on both consequence axes shown above, however, is ordinal data. Examples of ordinal data include the star rating of a hotel or the degrees of a skin burn. The order (hence, ordinal) of categories is clear. But, as a statistics text explains, ordinal scales are not like "a ruler" which can "quantify how great the distance between categories is."[47] Four nights in a one-star hotel cannot be stated, mathematically or qualitatively, as the same as one night in a four-star hotel. In short, ordinal data cannot be used, even conceptually, in an addition or multiplication process.[48] Any attempt to do so will result in warped estimates and biased decisions.

The Joint Risk Analysis Manual provides the following anecdote about a portion of a CRA contributed by the Commander of U.S. Pacific Command:

> He assessed military risk to the defense of a Treaty Ally as "High"; that is, in event that [Operational Plan] X was executed it was unlikely that the Plan would achieve its objectives. However, he assessed the strategic risk of the actual attack as "Low"; very unlikely to occur. He concluded that his overall risk was "Moderate"; giving equal weight to the strategic risk probability and military consequence.[49]

The Pacific Command (PACOM) Commander's theory about the deep uncertainty factors in the region supported a low probability of conflict. The problem begins with "giving equal weight" which indicates a weighted matrix approach like a financial risk manager but without an understanding of the interval between minor and extreme consequence. Whether an extreme consequence is 4 times, 10 times, or 100 times worse than a minor consequence should play heavily. A Naval Postgraduate School paper states, "Risk cannot be…described until we know how much the decision maker desires to avoid the various outcomes representing loss."[50] Congressional recipients of the CRA must underwrite the risk, but the methodology does not include their preferences.

The PACOM Commander's "moderate risk" estimate produces the strategic equivalent of using an average to describe the bathtub-shaped failure curve distribution in Figure 1: item d. Applying Hubbard's definitions clears the fog. Uncertainty is described by the set of two outcomes. The risk, marked by the discrete event of an attack, is a low probability of presumably existential consequences for our ally. The real world will not present a moderate outcome.

A defense of the PACOM risk assessment would have to cling to the importance of the JRAM's single dimension output (high risk to low risk) over what we are trying to understand about reality. This is what Box warns us about. Hubbard and Evans explain that the weighted scoring method is easy to teach and, therefore, has spread across industries.[51] It has become another of the standard repertoire of activities that Hubbard maintains only provides a "strong placebo effect" of managing risk.[52] A proper statement of risk that civilian leadership must underwrite might be, "The current strategy includes a risk as high as a 5% that Operational Plan X will be executed but will not meet its objectives." A model that compresses two divergent outcomes avoids a meaningful dialog about what the future may hold.

The academic critiques are decades old. Kahneman and Tversky revealed the issues of inconsistent decision maker risk preferences in their seminal work on Prospect Theory in 1979.[53] Kastenberg, McKone, and Okrent found in a 1976 study that "risk assessments are as a rule extremely sensitive to how outliers (unusual observations) are treated. Thus whether or not one takes unusual events seriously may greatly influence the decisions one reaches."[54] The most important items of national security involve the remote possibility of unusual and dire events. By misapplying financial risk models, the JRAM ignores these sensitivities leading to constructed and unrealistic assessments.

Misapplying the Safety Risk Model

The difference between systems requiring safety risk mitigation and those requiring strategic risk mitigation leads to a second type of distortion. The Joint Risk

Framework in Figure 3 shows the JRAM process. Step 2 shows the identification and assessment of threats and hazards which is standard in many accident-avoidance risk processes. Typical processes follow with implementation of controls to reduce or eliminate the hazards.[55] Some elements of the strategic environment, such as adversary threats, fit within this hazard-based approach. Other strategic decisions have a different nature, and these are ill-served by a process for avoiding accidents.

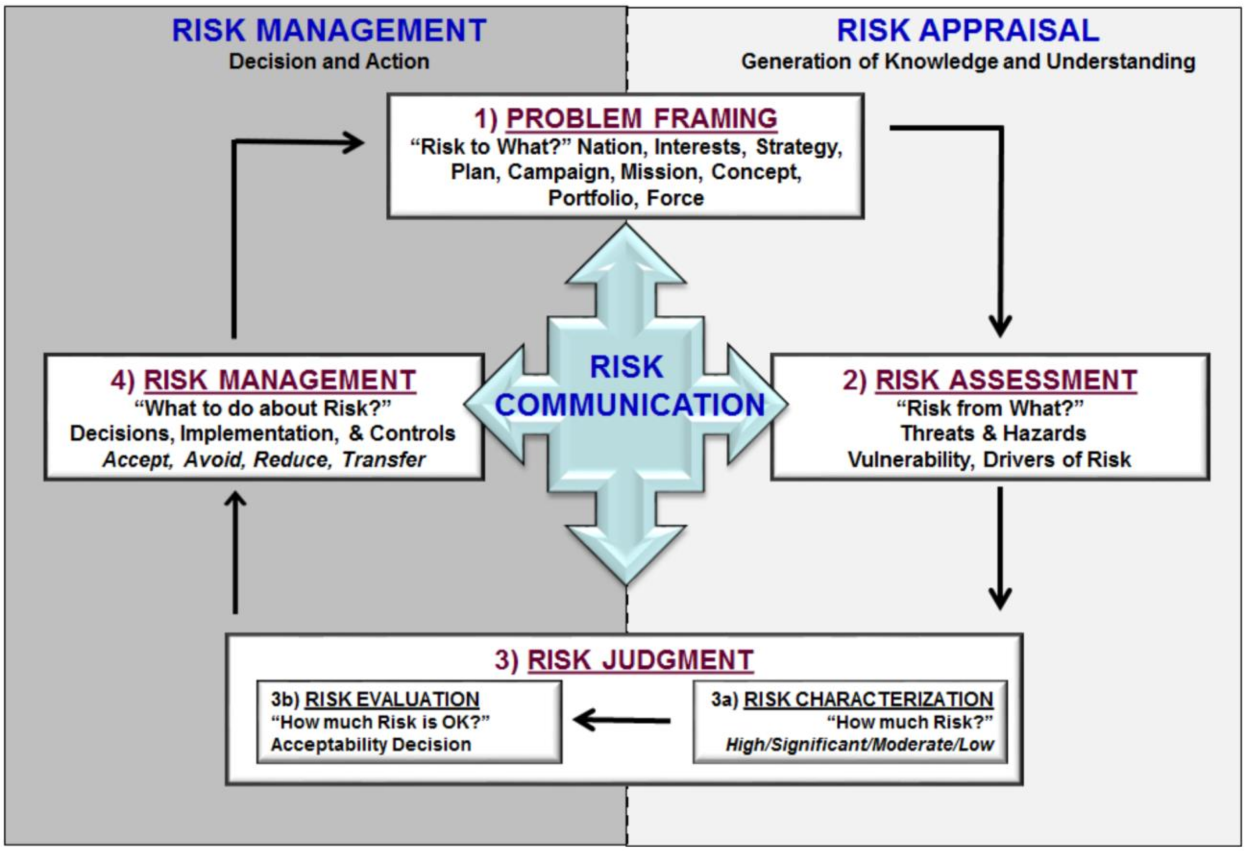

Figure 3. The Joint Risk Framework[56]

The manual provides this anecdote from 2009 where, in accordance with Step 4, the President chose to transfer risk:

> Military and Strategic risk in Iraq had decreased…while Military and Strategic risk in Afghanistan were elevated and rising. Based upon this collective assessment…the Chairman recommended the "Afghan Surge." The President considered the risks and shifted priority to Afghanistan. The

> surge required 40,000 more Soldiers and Marines—which increased military risk-to-force but was necessary to decrease military risk-to-mission…[57]

This scenario displays the needed discussion of inherent trade-offs between resourcing horizons. The President transferred the risk from the risk-to-mission horizon of two years out to the risk-to-force horizon of seven years.[58] But the framework limits the scope of the system and therefore its effectiveness in describing decision impacts.

Applying uncertainty fundamentals reveals a fuller and more meaningful context. The Services are charged with "maintaining, equipping, and training the forces of their respective departments."[59] Insufficient resources at any horizons is, according to Step 2, a "driver of risk." But if risk was only transferred to the far horizon, then there was also still some probability of long-term success. This is unlikely. The problem is twofold. First, the concept of non-linearity exposes the inference that risk is transferred on a one-to-one basis. It is not clear the methodology might account for disproportionate long-term impacts. Second, resourcing is a continuous variable problem. The only discrete point demarking risk is the original resource analysis. Inadequate long-term resourcing guaranteed that all possible outcomes were unfavorable. There is no risk without favorable outcomes. An uncertainty approach would have begged what damage would be done instead of offering the placebo of managing risk.

Civilian leadership requires detailed and sober forecasts to properly underwrite the impact of decisions. In 2017 a U.S. Congressman summarized, "In recent years, Congress has received repeated warnings from senior military officials across every service, testifying to the readiness crisis facing our military."[60] The sources of current readiness deficiencies extend, of course, far beyond the 2009 surge decision. Notably, the 2011 sequestration and ongoing budget instability continue to compound force management issues ranging from pilot retention to, allegedly, ship collisions.[61] The true test of the JRAM's efficacy is if the CRA forecasts in recent years were as direct and dire as the testimony to Congress is today.

Broadly speaking, accident prevention frameworks for risk management are unhelpful at strategic levels where deep uncertainty reigns. Strategic level systems are primarily continuous variables of resourcing fraught with complex and nonlinear interactions. To its credit, aspects of the JRAM indicate modification over time to better suit its strategic purpose. Where the risk definition in Joint Publication 1-02 focusses only on "hazards," the JRAM adds "drivers of risk" to incorporate internal risk sources like resource deprivation.[62] And Step 3b asking "How much risk is OK?" partly addresses the problem with discrete risk points.[63] Maximizing the probability of strategic success under deep uncertainty, however, should take a different theoretical approach than minimizing safety hazards in environments where success is the default state. The Chairman's Risk Assessment could be more effective if framed according to the larger considerations of Analytic Uncertainty.

Recommendations and Conclusion

Models that provide descriptions of real outcomes will better serve decision makers at all levels.[64] The concepts and definitions of Analytic Uncertainty provide multiple lenses with which planners can develop better protocols for analysis and communication. Overcoming the inertia of current analytic culture will take time. Adopting these three recommendations can begin the process.

1) The next update to Joint Publication 1-02 should adopt Hubbard's definitions for uncertainty, risk, and measurement along with the author's complimentary definition of opportunity. Currently, JP 1-02 provides no definition of uncertainty or opportunity. Hubbard's definition of risk is slightly more expansive and not incongruent with the current definition of "probability and severity of loss linked to

hazards."[65] The change, therefore, will not disrupt or constrain risk as defined for safety-oriented best practices.

2) These definitions and the Analytic Uncertainty taxonomy should be introduced in the joint force in programs of instruction that teach planning and staff estimates.

3) Proponents of strategic level models, not only risk models like the JRAM, should reevaluate current practices. They should purge processes computing ordinal consequence scales into single dimensional scores in accordance with four decades of academic research. Other models exist. Cost-benefit analysis may provide a better framework for resource allocation decisions. Strategic planners can also portray strategic risk as a gap in end-ways-means alignment.[66] Finally, any model which makes forecasts should, as a matter of protocol, evaluate previous forecasts for continuous model improvement.

Military professionals must harness uncertainty in pursuit of better decisions. Uncertainty has attributes that can be identified, assessed, visualized, communicated, and measured. Developing theories to account for deep uncertainty and conducting the technical exploration of surface uncertainty will serve to illuminate potential future states of the real world. Decision makers require this expansion of the theoretical and the technical from their planners and analysts.

President Obama's decision about the compound in Abbottabad followed six months of discussion of both deep and surface uncertainty. Risk was omnipresent, but the team did not use a risk framework. They instead proffered multiple theories to explain the odd construction of and behavior inside the facility. As facts and observations came in, they updated their theories. They measured the uncertainty regarding the outcomes of air or ground operations. Planners laid out flexible responses to tactical and strategic contingencies.[67] Mike Morell's agency was applying the reforms that came, in part, from the lessons following the intelligence estimate on Iraq's WMD program.[68] The Abbottabad team reduced the uncertainty as far as national assets and world class analysis would allow. "One of the things you learn as president is you're always dealing with probabilities.… Because if people were absolutely certain then it would have been decided by somebody else."[69] President Obama finally gave his own confidence for the group whose individual confidences ranged from 40% to 90%. "This is fifty-fifty.… I can't base this decision on the notion that we have any greater confidence than that."[70] Then he made a decision. Those who take estimates seriously must understand Analytic Uncertainty and engage it head on.

Endnotes

[1] W. E. Deming, *Out of the Crisis* (Cambridge, MA: Massachusetts Institute of Technology, Center for Advanced Engineering Study, 1986), 19.

[2] Beacon Global Strategies, "Michel Morell Senior Counselor," https://bgsdc.com/team/michael-j-morell/ (accessed December 6, 2017).

[3] Susan B. Glasser, "Ex-Spy Chief: Russia's Election Hacking Was An 'Intelligence Failure,'" December 11, 2017, https://www.politico.com/magazine/story/2017/12/11/the-full-transcript-michael-morell-216061 (accessed December 18, 2017).

[4] Michael Morell, *The Great War of Our Time: The CIA's Fight Against Terrorism—From al Qa'ida to ISIS* (New York: Twelve, 2015), 150.

[5] Ibid., 27.

[6] Ibid., 54.

[7] Mark Bowden, *The Finish: The Killing of Osama Bin Laden* (New York: *Atlantic Monthly Press*, 2012), 161.

[8] Ibid.

[9] Stephen J. Gerras, *Strategic Leadership Primer, 3rd ed*. (Carlisle Barracks, PA: U.S. Army War College, 2010), 11.

[10] Thjomas L. McNaugher, *The M16 Controversies: Military Organizations and Weapons Acquisition* (New York: Praeger Publishers, 1984), 6.

[11] Gerras, *Strategic Leadership Primer*, 11.

[12] Ibid., 11-12.

[13] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 119.

[14] U.S. Department of Defense, *Dictionary of Military and Associated Terms*, Joint Publication 1-02 (Washington, DC: U.S. Department of Defense, February 15, 2016), 17.

[15] Sam L. Savage, *The Flaw of Averages: Why We Underestimate Risk in the Face of Uncertainty* (Hoboken, NJ: John Wiley & Sons, Inc., 2009), 11.

[16] Developed by author.

[17] Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable* (New York: Random House, 2007).

[18] Tim Rakow, "Risk, uncertainty and prophet: The psychological insights of Frank H. Knight," *Judgment and Decision Making Online* 5, no. 6 (October 2010): 458-466, http://journal.sjdm.org/10/10625a/jdm10625a.html (accessed January 12, 2018).

[19] Frank H. Knight, "Structures and Methods for Meeting Uncertainty," in *Risk, Uncertainty, and Profit* (Boston: Hart, Schaffner & Marx - Houghton Mifflin Co., 1921), http://www.econlib.org/library/Knight/knRUP7.html#Pt.III,Ch.VIII (accessed December 3, 2017).

[20] Ibid.

[21] Developed by author.

[22] U.S. Department of the Army, *Commander's Appreciation and Campaign Design,* TRADOC Pamphlet 525-5-500 (Washington, DC: U.S. Department of the Army, January 28, 2008), 5.

[23] Chuck Thiessen, *Local Ownership of Peacebuilding in Afghanistan: Shouldering Responsibility for Sustainable Peace and Development* (Lanhan, MD: Lexington Books, 2014), 103.

[24] William Upshur, Jonathan Roginski, and David Kilcullen, "Recognizing Systems in Afghanistan: Lessons Learned and New Approaches to Operational Assessments," *Prism* 3, no. 3 (June, 2012): 98.

[25] Alan D. Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," *International Security* 17, no. 3 (Winter, 1992): 59-90.

[26] Clausewitz, *On War*, 87.2

[27] Andrew Hill, "Systems Thinking," lecture, U.S. Army War College, Carlisle Barracks, PA, September 26, 2017.

[28] Karl Popper, *Objective Knowledge: An Evolutionary Approach* (Oxford, UK: Oxford University Press, 1979), 266.

[29] Donald Rumsfeld, "DoD News Briefing – Secretary Rumsfeld and Gen. Myers," February 12, 2002, linked from the *U.S. Department of Defense Home Page* at "News Transcripts,"

http://archive.defense.gov/Transcripts/Transcript.aspx?TranscriptID=2636 (accessed February 8, 2018).

[30] Jeffrey P. Bezos, "2016 Letter to Shareholders," April 12, 2017, https://www.amazon.com/p/feature/z6o9g6sysxur57t (accessed November 13, 2017); Colin Powell, "Interview with General Colin Powell," interview by John Grumbar, *EgonZehnder,* January 1, 2017, https://www.egonzehnder.com/the-focus-magazine/leaders-dialogue/other/politics-and-society/interview-with-general-colin-powell.html (accessed January 10, 2018).

[31] Bezos, "2016 Letter to Shareholders."

[32] Douglas Hubbard, *How to Measure Anything: Finding the Value of "Intangibles" in Business* (Hoboken, NJ: John Wiley & Sons, Inc., 2010), 181-186.

[33] Ibid., 50.

[34] Clausewitz, *On War*, 80.

[35] Hubbard, *How to Measure Anything*, 50.

[36] Developed by author.

[37] A "quantitative" reduction in uncertainty does not mean that the observation has to be numerical, only that the ensuing reduction can be stated in quantitative terms. For example, if a reconnaissance of the bridge crossing staging areas reveal ample nearby locations, the estimated range of 3 hours (6.5 to 9.5 hours total) may be reduced to 2.5 hours (6.5 to 9 hours). This reconnaissance serves as a "measure" for the expert judgment which led to a 16.7% reduction (0.5 hours / 3 hours) in uncertainty. When staff search for "metrics" by which they hope to objectively measure a problem, they may fail to seek non-numeric information that can be of subjective value to experts;

Hubbard, *How to Measure Anything*, 23.

[38] McNaugher, *The M16 Controversies*, 3.

[39] James F. Smith, "Spotlight: Michael Morell," Spring 2014, linked from the *Harvard Kennedy Scholl Belfar Center Home Page at Newsletter Article,"* https://www.belfercenter.org/publication/spotlight-michael-morell (accessed December 6, 2017).

[40] G .E. P. Box, *Robustness in the Strategy of Scientific Model Building* (Madison, WI: University of Wisconsin-Madison Mathematics Research Center, May 1979), 2.

[41] USCODE Title-10-Armed Forces (2011), I, section 151-156, http://uscode.house.gov/view.xhtml?path=/prelim@title10/subtitleA/part1/chapter5&edition=prelim (accessed January 12, 2017), §153(b)(2).

[42] U.S. Department of Defense, *Joint Risk Analysis*, Chairman of the Joint Chiefs of Staff Manual 3105.01 (Washington, DC: U.S. Department of Defense, October 14, 2016), B-1.

[43] Ibid., B-5.

[44] Harold L. La Rock II, *Improving Strategic Risk Assessment and Communication* (Carlisle Barracks, PA: U.S. Army War College, March 1, 2017), 5.

[45] U.S. Department of the Army, *Risk Management*, Army Techniques Publication (ATP) 5-19 (Washington, DC: U.S. Department of the Army, April 14, 2014), 1-7.

[46] Sarah Boslaugh and Paul Andrew Watters, *Statistics in a Nutshell: A Desktop Quick Reference* (Sebastopol, CA: O'Reilly Media, Inc., 2008), 4.

[47] Ibid., 3.

[48] Market Research Guy, "Types of Data & Measurement Scales: Nominal, Ordinal, Interval, and Ratio," linked from the *My Market Research Methods Home Page*, http://www.mymarketresearchmethods.com/types-of-data-nominal-ordinal-interval-ratio/ (accessed January 16, 2018).

[49] U.S. Department of Defense, *Joint Risk Analysis*, C-15.

[50] Kent D. Wall, *The Trouble With Risk Matrices* (Monterrey, CA: Naval Postgraduate School, August 18, 2001), 8.

[51] Douglass Hubbard and Dylan Evans, "Problems With Scoring Methods And Ordinal Scales In Risk Assessment," *IBM Journal of Research and Development* (May 2010): 2:2.

[52] Hubbard, *How to Measure Anything*, 82.

[53] Daniel Kahneman and Amos Tversky, "Prospect Theory: An Analysis of Decision Under Risk," *Econometrica* 47, no. 2 (March 1979): 263.

[54] Baruch Fischhoff et al., *Acceptable Risk* (Cambridge: Cambridge University Press, 1981), 38.

[55] U.S. Department of the Army, *Risk Management*, 1-3.

[56] U.S. Department of Defense, *Joint Risk Analysis*, B-2.

[57] Ibid., C-15.

[58] Ibid., C-9.

[59] U.S. Department of Defense, *Functions of the Department of Defense and Its Major Components*, DoD Directive 5100.01 (Washington DC: U.S. Department of Defense, December 21, 2010), 26.

[60] Brad Wenstrup, "U.S. military readiness crisis: a call to action for Congress," *The Hill*, blog entry posted April 4, 2017, http://thehill.com/blogs/congress-blog/politics/327087-us-military-readiness-crisis-a-call-to-action-for-congress (accessed January 12, 2018.)

[61] Jeremy Herb and Dianne Gallagher, "Many warnings of readiness 'crisis' before latest ship accidents," August 25, 2017, linked from the *CNN Home Page* at "Politics," https://www.cnn.com/2017/08/24/politics/navy-readiness-crisis-military/index.html (accessed January 27, 2018).

[62] U.S. Department of Defense, *Dictionary of Military and Associated Terms*, 206; U.S. Department of Defense, *Joint Risk Analysis*, B-2.

[63] U.S. Department of Defense, *Joint Risk Analysis*, B-2.

[64] Wall, *The Trouble With Risk Matrices,* 18.

[65] U.S. Department of Defense, *Dictionary of Military and Associated Terms*, 206.

[66] Arthur F. Lykee, "Defining Military Strategy," *Military Review*, May 1989, 6.

[67] Bowden, *The Finish*, 142-175.

[68] Smith, "Spotlight: Michael Morell."

[69] Bowden, *The Finish*, 161-162.

[70] Ibid., 163.