Uncertainty: The Forgotten Factor in Joint Planning?

A Monograph

by

Col Jürgen Prandtner
German Army

School of Advanced Military Studies
US Army Command and General Staff College
Fort Leavenworth, KS

2019

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
23-05-2019	Master's Thesis	June 2018-May 2019

4. TITLE AND SUBTITLE
Uncertainty: The Forgotten Factor in Joint Planning?

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
COL Jürgen Prandtner

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Command and General Staff College
ATTN: ATZL-SWD-GD
Fort Leavenworth, KS 66027-2301

8. PERFORMING ORG REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Advanced Strategic Leadership Studies Program

10. SPONSOR/MONITOR'S ACRONYM(S)
CGSC

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

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

13. SUPPLEMENTARY NOTES

14. ABSTRACT

There is always uncertainty in military planning. Military analysts have to analyze large amounts of data from multiple sources, data that might be unclear, ambiguous, or even contradictory. There is a difference between uncertainty and risk because risk is characterized by having identified outcomes with the probability that those outcomes would occur. This monograph analyzed how the United States (US) military 2017 Joint Planning Process (2017 JPP) addresses uncertainty. This research examined almost two decades of unclassified US strategic security documents and US military joint doctrine, focusing on the 2017 JPP and how it did or did not approach uncertainty. It was surprising that uncertainty plays a subordinate role or is even nonexistent in the 2017 JPP. The strategic security documents also do not consider uncertainty adequately. Although uncertainty is discussed in the military intelligence domain, the 2017 JPP does not demand that a planner pay due consideration to the topic of uncertainty and therefore provides no tools for the planner to deal with uncertainty. This monograph examined tools to improve the handling of uncertainty. There is an example of a fallacy (base rate) that illustrates the need for education/training for uncertainty. A standardized communication of probability is required. The decision tree model helps to visualize areas where insufficient or no information is available. The concepts of robustness offer an approach of how to improve resilience against surprises. The model ''robust-decision-making'' focuses on planning against the worst-case scenario, and the info-gap model emphasizes on defining an outcome that is vital to achieving. The priority is to have a satisfying solution rather than the best solution. This monograph recommends taking available tools and developing a standardized framework to improve the consideration of uncertainty to ensure that it is treated adequately in the 2017 JPP. Such an approach would not necessarily provide a flawless forecast, but it would increase transparency in the planning process, improve ways of thinking about otherwise overlooked courses of action, and develop possibilities into opportunities.

15. SUBJECT TERMS
Joint planning process; Joint publication (JP) 5-0; info-gap theory; robust decision making; uncertainty; risk;

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. PHONE NUMBER** *(include area code)*
(U)	(U)	(U)	(U)	46	913 758-3300

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

Monograph Approval Page

Name of Candidate: Col Jürgen Prandtner

Monograph Title: Uncertainty: The Forgotten Factor in Joint Planning?

Approved by:

_____, Monograph Director
Melissa A. Thomas, JD, PhD

_____, ASLSP Director
Barry M. Stentiford, PhD

_____, Director, School of Advanced Military Studies
Kirk C. Dorr, COL

Accepted this 24th day of May 2019 by:

_____, Director, Graduate Degree Programs
Robert F. Baumann, PhD

Abstract

Uncertainty: The Forgotten Factor in Joint Planning? by Col Jürgen Prandtner, German Army, 42 pages.

There is always uncertainty in military planning. Military analysts have to analyze large amounts of data from multiple sources, data that might be unclear, ambiguous, or even contradictory. There is a difference between uncertainty and risk because risk is characterized by having identified outcomes with the probability that those outcomes would occur. This monograph analyzed how the US military 2017 Joint Planning Process (2017 JPP) addresses uncertainty. This research examined almost two decades of unclassified US strategic security documents and US military joint doctrine, focusing on the 2017 JPP and how it did or did not approach uncertainty. It was surprising that uncertainty plays a subordinate role or is even nonexistent in the 2017 JPP. The strategic security documents also do not consider uncertainty adequately. Although uncertainty is discussed in the military intelligence domain, the 2017 JPP does not demand that a planner pay due consideration to the topic of uncertainty and therefore provides no tools for the planner to deal with uncertainty. This monograph examined tools to improve the handling of uncertainty. There is an example of a fallacy (base rate) that illustrates the need for education/training for uncertainty. A standardized communication of probability is required. The decision tree model helps to visualize areas where insufficient or no information is available. The concepts of robustness offer an approach of how to improve resilience against surprises. The model "robust-decision-making" focuses on planning against the worst-case scenario, and the info-gap model emphasizes on defining an outcome that is vital to achieving. The priority is to have a satisfying solution rather than the best solution. This monograph recommends taking available tools and developing a standardized framework to improve the consideration of uncertainty to ensure that it is treated adequately in the 2017 JPP. Such an approach would not necessarily provide a flawless forecast, but it would increase transparency in the planning process, improve ways of thinking about otherwise overlooked courses of action, and develop possibilities into opportunities.

Contents

Acknowledgments

I would also like to thank the faculty of the School of Advanced Military Studies, notably Dr. Thomas for her mentorship in helping me write this monograph.

Acronyms

ADP	Army Doctrine Publication
CJCSM	Chairman of the Joint Chiefs of Staff Manual
COA	Course of Action
DOD	Department of Defense
JIPOE	Joint Intelligence Preparation of the Operational Environment
JP	Joint Publication
JRA	Joint Risk Analysis
JRAM	Joint Risk Analysis Methodology
NDS	National Defense Strategy
NMS	National Military Strategy
NSS	National Security Strategy
OE	Operational Environment
RDM	Robust Decision Making
US	United States

Illustrations

Tables

Introduction

> The Quadrennial Defense Review was undertaken during a crucial time of transition to a new era. Even before the attack of September 11, 2001, the senior leaders of the Defense Department set out to establish a new strategy for America's defense that would embrace uncertainty and contend with surprise, a strategy premised on the idea that to be effective abroad, America must be safe at home.
>
> — Donald H. Rumsfeld, *Quadrennial Defense Review 2001*

There is always uncertainty in military planning. Military analysts have to analyze large amounts of data from multiple sources, data that might be unclear, ambiguous, or even contradictory and short-lived. "Uncertainty is prevalent due to, for example, the unpredictability of the behavior of the threats as well as due to the imperfection of the information sources available."[1] Almost 200 years ago, in his definition of "friction," Clausewitz stated that "uncertainty, ignorance, confusion, fatigue, error, and countless other imponderables—all interfered with the effective application of force." Furthermore, "in war everything is uncertain, and calculations have to be made with variable quantities."[2] Today, the security environment remains uncertain. In 2017, the Director of National Intelligence, Daniel Oats, stated during his swearing-in ceremony that "these are clearly uncertain times."[3] Further, in 2018, NATO Secretary General Jens Stoltenberg demanded a strong NATO alliance to handle "these uncertain times."[4] Future strategies will depend "on assumptions regarding the campaigns the United States

---

[1] Tove Helldin et al., "Transparency of Military Threat Evaluation through Visualizing Uncertainty and System Rationale," International Conference on Engineering Psychology and Cognitive Ergonomics, in *Engineering Psychology and Cognitive Ergonomics*, ed. Don Harris (Berlin: Springer, 2013), 3, accessed January 12, 2019, https://doi.org/10.1007/978-3-642-39354-9_29.

[2] Carl von Clausewitz, *On War*, ed. Michael Eliot Howard and Peter Paret (Princeton: Princeton University Press, 1984), 119, 16, 147.

[3] "Remarks by the Vice President and Director of National Intelligence Daniel Coats at a Swearing-in Ceremony," The White House, March 16, 2017, accessed January 12, 2019, https://www.whitehouse.gov/briefings-statements/remarks-vice-president-director-national-intelligence-dan-coats-swearing-ceremony/.

[4] "Remarks by President Donald Trump and NATO Secretary General Jens Stoltenberg before Expanded Bilateral Meeting," The White House, May 17, 2018, accessed January 12, 2019, https://www.whitehouse.gov/briefings-statements/remarks-president-trump-nato-secretary-general-stoltenberg-expanded-bilateral-meeting/.

is called on to wage, the capabilities of adversaries, the progress of technology, and the strategies and tactics used. But many of these factors are intrinsically hard to predict."[5]

Despite the Quadrennial Defense Review's policy guidance from 2001 embracing uncertainty, the development of the joint planning process (JPP) did not put much emphasis on uncertainty. In contrast, intelligence assessments, which are one key input of the mission analysis step in the JPP, consider uncertainty. However, uncertainty is a challenge for the whole JPP. This research focuses on the strategic level of the US military planning and examines the JPP, defined in the US military *Joint Publication 5-0, Joint Planning* (JP 5-0). The 2017 JPP is "a logical process to approach a problem and determine a solution."[6] During this process, the military planner requires key inputs to analyze the problem set and to develop a plan. All these inputs have a degree of uncertainty, which becomes even more relevant in modern warfare that is influenced by the cyber and information domains.

While this research paper will neither delve into the debate related to how uncertain the world is nor focus on predicting the future, it will examine whether uncertainty might be a forgotten factor in the 2017 JPP and what kind of tools and methods could support decisionmakers, analysts, and planners so they can better handle uncertainty. It analyzes unclassified official documents endorsed by the US government.

The first section describes the characteristics of uncertainty and concludes that uncertainty and risk are different concepts. Therefore, the available tool of joint risk assessment is insufficient to handle uncertainty. The second section examines joint military planning and concludes that there is inadequate consideration of uncertainty. It also reveals that while the military intelligence domain does consider uncertainty, there is no standardized framework to

---

[5] Robert J. Lempert et al., *Defense Resource Planning Under Uncertainty* (Santa Monica: RAND Corporation, 2016), 7.

[6] US Department of Defense, Joint Staff, *Joint Publication (JP) 5-0, Joint Planning* (Washington, DC: Government Printing Office, June 16, 2017), V-1.

convey the uncertainty of the intelligence estimates in the planning product. This section also analyzes why uncertainty might be a forgotten factor in the 2017 JPP and provides an overview of possible shortcomings in consideration of uncertainty. The following section analyzes available tools and methods to support the 2017 JPP and the military intelligence domain in better handling uncertainty. Furthermore, this section introduces the "concepts of robustness" in which the goal of achieving optimum solutions by considering uncertainty in planning is replaced with the goal of achieving resilience against surprises. The final section summarizes the findings and provides recommendations of how the 2017 JPP can adequately address uncertainty, which in turn could improve the reliability of recommendations from analysts and planners, thereby positively impacting decisionmaker performance.

Characteristics of Uncertainty

Uncertainty and risk are different concepts, which require different handling. The subsection "Knightian Uncertainty" examines the theory of Frank Knight, an economist, who distinguished between risk and uncertainty. His definition of uncertainty, also named "Knightian uncertainty," is based on the assumption that only risk can be measured by probability. Based on "Knightian uncertainty," several models are developed describing uncertainty in more detail. The subsection "Four-Component Model of Uncertainty" examines a model of uncertainty and illustrates that components of uncertainty can be accommodated, although probabilistic methods could not apply.

Knightian Uncertainty

In the early 1920s, Knight developed a model that distinguished between "uncertainty" and "risk." He stated that "[i]t is a world of change in which we live and a world of uncertainty. We live only by knowing something about the future; while the problems of life, or conduct at least, arise from the fact that we know so little. This is as true of business as of other spheres of activity." This incomplete or even nonexistent knowledge could not be handled with the tools of

risk assessment. His book "represents an attempt to state the essential principles of the conventional economic doctrine more accurately." Knight was one of the first social scientists to develop a theory about the relationship between risk, uncertainty, and profit.[7] This research examines only the relationship between uncertainty and risk, and the implications for military planning, because the element of profit relates to the economic domain.

A risk is "characterized by known probability distributions with observable outcomes."[8] For Knight, a decision setting was risky when decisionmakers did not know with certainty what a decision outcome would be, but did know the possible outcomes associated with a decision, along with the probability that those outcomes would occur, at the time of the decision. The following example illustrates Knight's understanding of risk: "Risk means future events occur with measurable probability. Risk can be quantified, either on *a priori* grounds (a flipped coin will come up heads 50 percent of the time) or by empirical observation (14 percent of all automobile deaths involve young drivers)."[9] Based on Knight's definition, there is a definition of risk that "means possible unfavorable outcomes."[10] This definition does not focus on all possible outcomes and is used in the US military joint risk analysis.

Uncertainty is "characterized by a decision-making context in which probability distributions on outcomes were not or could not be known with assurance at the time of choice."[11] According to Knight, "the practical difference between the two categories, risk and uncertainty, is

---

[7] Frank Knight, *Risk, Uncertainty, and Profit* (Cambridge: Houghton Mifflin Company, The Riverside Press, 1921), 199, author's preface.

[8] Francis X. Diebold, Neil A. Doherty, and Richard J. Herring, *The Known, the Unknown, and the Unknowable in Financial Risk Management: Measurement and Theory Advancing Practice* (Princeton: Princeton University Press, 2010), 149.

[9] Emily Goldman, *Power in Uncertain Times: Strategy in the Fog of Peace* (Redwood City: Stanford University Press, 2014), 13.

[10] Stephan Ward and Chris Chapman, *How to Manage Project Opportunity and Risk: Why Uncertainty Management Can Be a Much Better Approach than Risk Management* (Hoboken: John Wiley & Sons, 2011), 3.

[11] Diebold, Doherty, and Herring, 149.

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, the reason being in general that it is impossible to form a group of instances, because the situation dealt with is in a high degree unique."[12]

Military planners face Knightian uncertainty resulting from surprises, deception, or biases. There is neither enough knowledge nor experience to handle surprises before they occur. Therefore, it is not possible to measure the probability of outcomes as in risk assessment.

Knight offered approaches to handle uncertainty, but these are particular to the economic domain and cannot support the 2017 JPP. "We may call the two fundamental methods of dealing with uncertainty, based respectively upon reduction by grouping and upon selection of men to 'bear' it, 'consolidation' and 'specialization,' respectively." Consolidation means "uncertainties are less in groups of cases than in single instances." Even "true uncertainties, show some tendency toward regularity when grouped on the basis of nearly any similarity or common element." Consolidation is possible when at least some information from similar events in the economic domain is available. Uncertainties in military planning are less likely to occur similarly in, for example, the environment, actors, and warfare. Specialization "takes place under pressure of the same problem, the anticipation of wants and control of production with reference to the future." [13] A specialization in production cannot be transferred as a method to handle uncertainty in military planning. Knight defined these tools in addition to available tools for risk assessment and concluded that uncertainty could not be assessed with the same instruments as risk. This research will later examine the available tool for risk analysis in the 2017 JPP.

Knight saw uncertainty positively as a chance for the entrepreneur to make a profit. "It is this *true uncertainty* which by preventing the theoretically perfect outworking of the tendencies of competition gives the characteristic form of 'enterprise' to economic organization as a whole

[12] Knight, 133.

[13] Knight, 239, 238, 239, 244.

and accounts for the peculiar income of the entrepreneur."[14] Business organizations had developed techniques to handle risk with its supposed consequence, not looking further at uncertainty. Knight saw here the opportunity for the entrepreneur to explore new options. Military planning could use this approach to enhance risk assessment by examining the uncertain aspects of a plan.

Four-Component Model of Uncertainty

The four-component model is one model to distinguish between different components of uncertainty. In the context of project management, a model of uncertainty suggests that there are four different components: "ambiguity, inherent variability, event uncertainty, and systemic uncertainty" in order to get a better understanding of uncertainty. Two of the four components are relevant to military planning. "Ambiguity uncertainty" involves "lack of complete/perfect knowledge like a lack of definition of project objectives, … unpredictable behavior of relevant project players, …lack of specification of what has to be done in design or planning terms, lack of clarity about proactive or reactive responses if plans do not work." Probability or statistics cannot solve problems of ambiguity uncertainty. "Event uncertainty" includes "events, conditions, circumstances or scenarios that may or may not happen plus associated specific responses—like a particularly important piece of equipment failing (or not) in a particular way and being repaired/replaced or not (referred to as 'risks' by many people)." Event uncertainty is relevant to the joint risk assessment, which will be examined in the section "Uncertainty and US Military Joint Planning." The four-component model illustrates that uncertainty can be characterized in more detail.[15]

---

[14] Knight, 232 (emphasis in the original).

[15] Stephan Ward and Chris Chapman, *How to Manage Project Opportunity and Risk: Why Uncertainty Management Can Be a Much Better Approach than Risk Management* (Hoboken: John Wiley & Sons, 2011), 3, 33, 34.

Uncertainty and US Military Joint Planning

Today, almost two decades after the US secretary of defense announced a new strategy to "to prepare for an uncertain future," the 2017 JPP does not provide an approach to handle uncertainty. Also, the US strategic documents, which are the overarching documents that guide the development of the 2017 JPP, do not emphasize uncertainty. In contrast, the intelligence domain provides approaches to consider the uncertainty of intelligence products.

The first subsection examines unclassified US strategic documents and US military joint doctrine. Among others, the research tried to answer the following question: Did the strategic concept "preparing for an uncertain future" change the JPP or did the considerations of uncertainty never make it into the JPP? The next subsection provides a few possible reasons why uncertainty might be a forgotten factor in the 2017 JPP. The last subsection presents possible reasons that the 2017 JPP does not adequately consider uncertainty.

The Term "Uncertainty" in US Security Documents and Military Joint Publications

There is no evidence that the announced strategy to "embrace uncertainty" from 2001 found recognition in the development of the JPP. Also, there no details of this strategy were found in either joint doctrine or the strategic documents from the last two decades. However, the military intelligence domain has methods to consider uncertainty and has tools available which have the potential to be enhanced for handling uncertainty.

The 2017 *Joint Publication (JP) 5-0, Joint Planning* (2017 JP 5-0) does not consider methods to handle uncertainty, although it describes the strategic environment as uncertain.[16] The 2017 JP 5-0 is the bridging document between strategies and operational execution. The 2017 JP 5-0 defines the 2017 JPP and provides "commanders with processes that allow for…flexibility and the ability to plan and develop plans for an uncertain and challenging environment."[17] It is

[16] US Department of Defense, Joint Staff, *Joint Publication (JP) 5-0, Joint Planning* (Washington, DC: Government Printing Office, June 16, 2017), I-1.

[17] JP 5-0, 2017, foreword.

not specified in what kind of context flexibility is provided. Previous versions of the 2017 JP 5-0 were more specific about the responsibility to handle uncertainty. In the 2011 JP 5-0, the task of the commander and staff was to reduce uncertainty: "joint operation planning fosters understanding, allowing commanders and their staffs to provide adequate order to ill-defined problems, reduce uncertainty, and enable further detailed planning.“[18]

In the 2006 JP 5-0, “joint operation planning” distinguished between two categories of planning: contingency and crisis action planning. “These categories differ primarily in the level of uncertainty." Furthermore, “while contingency planning normally is conducted in anticipation of future events, crisis action planning is based on circumstances that exist at the time planning occurs.” [19] Without further explanation, the 2017 JP 5-0 recommended removing “crisis action planning” from the *Joint Publication (JP) 1-02, DOD Dictionary of Military and Associated Terms* (the “DOD dictionary”).[20]

The versions of JP 5-0 from 2006, 2011, and 2017 do not consider the term “uncertainty,” although the 2006 and 2011 versions appreciate uncertainty as a characteristic of the operational environment. Later on, this research will show that a similar development occurs in the US strategic documents.

The 2017 JP 5-0 provides four analytical tools, “operational art and design,” “flexible response option” (FRO), “flexible deterrent option” (FDO), and “joint risk management,” to support the decisionmakers and planners in their planning efforts.

“Operational art and design” do not guide the user in how to think about uncertainty. The 2017 JP 5-0 states that “operational art is the application of creative imagination by commanders

---

[18] US Department of Defense, Joint Staff, *Joint Publication (JP) 5-0, Joint Operation Planning* (Washington, DC: Government Printing Office, August 11, 2011), I-1.

[19] 2006 US Department of Defense, Joint Staff*, Joint Publication (JP) 5-0, Joint Operation Planning* (Washington, DC: Government Printing Office, December 26, 2006), xi.

[20] JP 5-0, 2017, GL-7.

and staffs—supported by their skill, knowledge, and experience—to design strategies, campaigns, and major operations and organize and employ military forces." Furthermore, "operational art helps the JFC [joint forces commander] overcome the ambiguity and uncertainty of a complex operational environment." There is no explanation of what the terms "ambiguity" and "uncertainty" mean and how operational art helps. The 2017 JP 5-0 describes "operational design" as one tool to help "commanders and staff to understand the uncertainty in a complex operational environment (OE)." Without going into detail, "operational design" is a nine-step method. In step seven, "identify decisions and decision points," commanders must inform their senior leadership "of the decisions that will need to be made, when they will have to be made, and the uncertainty and risk accompanying decisions and delay." This statement is remarkable in the sense that it is the only time JP 5-0 differentiates between uncertainty and risk. However, the commander, who is the central figure in operational design, receives no further guidance on how to assess and describe uncertainty in order to inform superiors.[21]

FRO and FDO are also not planning tools to prepare for and respond to uncertainty. The 2017 JP 5-0 defines FRO, which is "used for response to terrorist actions or threats," and FDOs, which are "preplanned, deterrence-oriented actions … established to deter actions before or during a crisis." Both FRO and FDO are adaptive military options for the secretary of defense or the president to respond to the uncertainty of a crisis. In contrast to FDOs, FROs are "operations that are first and foremost designed to preempt enemy attacks, but also provide DOD the necessary planning framework to fast-track requisite authorities and approvals necessary to address dynamic and evolving threats." FRO is not a planning tool to prepare for and respond to uncertainty; it is more a reaction to an existing, known threat using available capabilities and resources.[22]

[21] JP 5-0, 2017, IV-1, IV-6, IV-17, IV-2.

[22] JP 5-0, 2017, F-1, F-2, F-5.

The fourth tool is joint risk analysis (JRA), which also does not consider uncertainty. JRA, described in the *Chairman of the Joint Chiefs of Staff* (CJCS) *Manual 3105.01, Joint Risk Analysis*, is a tool for planners for risk assessment as part of mission analysis. The 2016 JRA establishes the joint risk analysis methodology (2016 JRAM) which identifies, assesses and manages risk. It enables the CJCS to make consistent, timely risk assessments and provides "the best military advice based on risk management in support of title 10 responsibilities, most notably, the National Military Strategy (NMS)."[23] Title 10 defines the role of armed forces and provides the legal basis for the roles, missions, and organization of the US military. Two excerpts of the 2016 JRAM illustrate that uncertainty is not considered. First, there are three major challenges to successful risk analysis—complexity, ambiguity, and uncertainty—"because human knowledge is inherently incomplete, and assessments require assumptions." Uncertainty is presented as a challenge to risk analysis, but no guidance is offered on how to handle it. Second, the manual defines risk as "the probability and consequence of an event causing harm to something valued." All these definitions and descriptions could lead to the assumption that joint doctrine follows the traditional Knightian definition, with the focus of possible bad outcome, described earlier in "Characteristics of Uncertainty."[24]

The previous version of the 2017 JP 5-0 defined the tool "crisis planning" which may also have the potential to handle uncertainty. Versions of JP 5-0 from 2000-2006 stated that two types of planning exist: "deliberate and crisis planning," distinguished by whether the probability of occurrence is known. Furthermore, "while deliberate planning is conducted in anticipation of future events, there are always situations arising in the present… and sometimes they will be

[23] US Department of Defense, Chairman of the Joint Chiefs of Staff, *CJCSM 3105.01, Joint Risk Analysis* (Washington, DC: Government Printing Office, October 14, 2016), foreword.

[24] CJCSM 3105.01, *Joint Risk Analysis*, B-6, GL-4.

completely unanticipated."[25] This research sees in "crisis planning" a possible method to enhance the 2017 JPP in handling uncertainty.

Not only is there no guidance in the 2017 JP 5-0, but the *Joint Publication (JP) 1 Doctrine for the Armed Forces of the United States* (JP 1) does not provide guidance on uncertainty either. In the joint document hierarchy, JP 1 is superior to JP 5-0. The 2017 JP 1 is the "capstone publication for all joint doctrine, presenting fundamental principles and overarching guidance for the employment of the Armed Forces of the United States," and only alludes to uncertainty through a reference to Clausewitz, saying that "the conduct of war combines friction, chance, and uncertainty" which "remain[s] true today." Even though the 2017 JP 1 "represents the evolution in our warfighting guidance and military theory that forms the core of joint warfighting doctrine," [26] the research reveals no evidence that the 2017 JP 1 considers uncertainty adequately to influence the development of joint doctrine.

Because the 2017 JP 5-0 and the 2017 JP 1 do not consider uncertainty adequately, this research examined the DOD dictionary, which is the source for definitions in the joint doctrine domain. It does not describe the term "uncertainty" either. The DOD dictionary "sets forth standard US military and associated terminology to encompass the joint activity of the Armed Forces of the United States." The DOD dictionary does mention the term "uncertainty" twice. First, it states that an "uncertain environment is an operational environment in which host government forces, …do not have totally effective control of the territory and population in the intended operational area." There is no further explanation of how this uncertainty could be determined. Second, the DOD dictionary mentions the analytical method of intelligence preparation of the battlespace (IPB) or joint intelligence preparation of the operational

[25] US Department of Defense, Joint Staff, *Joint Publication (JP) 5-00.1, Joint Doctrine for Campaign Planning* (Washington, DC: Government Printing Office, January 25, 2002), III-1, IV-1.

[26] US Department of Defense, Joint Staff, *Joint Publication (JP) 1, Doctrine for the Armed Forces of the United States*. (Washington, DC: Government Printing Office, July 12, 2017), foreword, I-3, foreword.

environment (JIPOE) which should help the "services or joint force component commands to reduce uncertainties concerning the enemy, environment, time, and terrain." [27] Later, this research examines how IPB/JIPOE could help to handle uncertainty.

JIPOE is defined in the 2014 Joint Publication (JP) 2-01.3, Joint Intelligence Preparation of the Operational Environment (2014 JP 2-01.3) and part of the 2013 Joint Publication (JP) 2-0, Joint Intelligence (2013 JP 2-0) which provides approaches to consider uncertainty in intelligence analysis and products. The military joint intelligence domain recognizes uncertainty as a factor that has an impact on outcomes and the audience of intelligence analysis. The 2013 JP 2-0 states that "the commander cannot be left with uncertainty regarding what is fact, what is opinion, and what is unknown," and that "intelligence is not an exact science; intelligence analysts will have some uncertainty, as should the commander and staff as they plan and execute operations." [28] The following four examples describe considerations of uncertainty in the 2013 JP 2-0. First, uncertainty is a factor in intelligence planning. The planning of intelligence operations requires "considering all of the identified intelligence gaps relevant to the planning effort and recognizing the uncertainties in analytical conclusions." In contrast, the 2017 JPP does not consider a step for recognizing uncertainty. Second, there is no certainty about the accuracy of the collected information. "The intelligence staff must ensure that the commander is aware of this shortcoming and that the future contains much uncertainty." The 2017 JPP does not demand such an analysis. Third, analysts are required to clarify or resolve uncertainties: "The value of information or intelligence is tied to the decision which it supports and the amount of uncertainty it clarifies or resolves." The 2017 JPP lacks a definition of the value of information. Lastly, the intelligence analyst has in the 2014 JIPOE a tool to support predictive analysis. The 2014 JIPOE "provides an

[27] US Department of Defense, Joint Staff, *Joint Publication (JP) 1-02, Department of Defense Dictionary of Military and Associated Terms* (Washington, DC: Government Printing Office, November 2018), i, 243,117.

[28] US Department of Defense, Joint Staff, *Joint Publication (JP) 2-0, Joint Intelligence* (Washington, DC: Government Printing Office, October 22, 2013), II-4, I-3.

excellent methodology for assessing adversary intentions and predicting the relative probability of enemy courses of action," thus reducing uncertainty.[29]

Predictive intelligence analysis uses different levels of probability (high, medium, low) than the 2017 JPP, which relies on the 2016 *Joint Risk Analyses* (highly unlikely, improbable, probable, very likely). The intelligence analyst has to communicate the level of uncertainty in the intelligence products. Commanders "must understand that intelligence predictions are only estimates and they accept a certain amount of risk in formulating plans based only on the intelligence assessment of the adversary's most probable courses of action (COA)."[30] The results of predictive analysis support the 2016 JRA. However, the two tools use different ways of communicating levels of probability. This lack of standardization in the communication of probability levels is potentially a cause for friction and misunderstanding for the decisionmakers, planners, and intelligence analysts.

As US joint doctrine does not provide approaches to handle uncertainty, the next step in the research is to examine the unclassified US strategic documents that are in the document hierarchy above joint publications and guide military doctrine development. The 2017 *National Security Strategy of the United States of America* (2017 NSS), similar to its 2015 predecessor, does not mention the term "uncertainty." There is no evidence that the 2017 NSS followed the 2000 NSS which published a "strategy of engagement" with the element "preparing for an uncertain future."[31] Unlike previous NSSs from 1999-2006, the 2010, 2015 NSS and 2017 NSS neither state that there is an "uncertain environment" nor uncertainties about the future. There is no evidence that the US government deliberately omitted the term "uncertainty," but it is of note that before the three most recent NSSs (2017 and 2015), the documents mentioned the terms

[29] JP 2-0, 2013, IV-6, II-9, I-22, II-10;

[30] JP 2-0, 2013, II-10.

[31] US President, *A National Security Strategy for a Global Age* (Washington, DC: The White House, December 2000), 3.

"uncertainty" or "uncertain environment." However, there are several mentions of the term "risk." First, the 2017 NSS states that "to improve the security and resilience of our critical infrastructure, we will assess risk across six key areas." Further on, the 2017 NSS states that the US government "will improve its ability to assess the threats and hazards that pose the greatest risks," and finally, it refers to "nuclear force structure that meets our current needs and addresses unanticipated risks." [32] None of these mentions provide guidance on how to calculate the probability of each risk and to handle the inherent uncertainty either.

Older national security strategies do address uncertainty. In the fallout of the bombings of the US embassies in Nairobi and Dar es Salaam, the US government published a new "strategy in engagement" in the 1999 NSS. Furthermore, the 1999 NSS stated that "[t]he security environment in which we live is dynamic and uncertain, replete with a host of threats and challenges that have the potential to grow deadlier," and described a strategy with three components: "shaping the international security environment, responding to threats and crises, and preparing for an uncertain future." [33] The 2000 NSS stated that one strategic concept of the "strategy of engagement" was "preparing for an uncertain future." [34] The strategy demanded that "we must prepare for an uncertain future even as we address today's security problems… preparing for an uncertain future also means that we must have a strong, competitive, technologically superior, innovative and responsive industrial and research and development base."[35] The 2000 NSS defined "preparing for an uncertain future" as one of three strategic concepts and described measures to hedge against future uncertainties stating that "[t]ogether with other security, critical

[32] US President, *National Security Strategy of the United States of America* (Washington, DC: The White House, December 2017), 13, 14, 30.

[33] US President, *A National Security Strategy for a New Century*, 1999, 3, 2, 5.

[34] US President, *A National Security Strategy for a Global Age* (Washington, DC: The White House, December 2000), 3.

[35] US President, *A National Security Strategy for a New Century*, 1999, 20.

infrastructure protection, and counterterrorism programs, Continuity of Government and Continuity of Operations programs remain an important hedge against current and emerging threats, and future uncertainties."[36] The US military had to conduct a transformation "to shape and respond today, modernizing to protect the long-term readiness of the force, and transforming [its] unparalleled capabilities to ensure [that it] can effectively shape and respond in the future."[37]

The 2002 and 2006 NSS did not continue with the "strategy of engagement" and the strategic concept of "preparing for an uncertain future." Both documents had no noteworthy statements on an "uncertain future." The 2002 NSS stated that "today, the United States enjoys a position of unparalleled military strength and great economic and political influence…Enemies in the past needed great armies and great industrial capabilities to endanger America….The gravest danger our Nation faces lies at the crossroads of radicalism and technology." The document did mention the term "uncertainty" in the context of forward positioning of forces, but there were no references to uncertainties about the future. [38] The 2006 NSS stated that the global situation had deteriorated as seen in the brevity of the statements, "America is at war. This is a wartime national security strategy."[39] This document also did not mention anything about uncertainties in the future. This concludes the research on the NSS of 1999, 2000, 2002, 2006, 2010, 2015, and 2017. The strategic concept of "preparing for an uncertain future" from 1999 does not exist in the 2017 NSS anymore.

While the NSS provides the guidelines for the whole government, the National Defense Strategy (NDS), published by the US secretary of defense, is the subordinate strategy to the NSS

---

[36] US President, *A National Security Strategy for a Global Age*, 2000, 3, 25.

[37] US President, *A National Security Strategy for a New Century*, 1999, 20.

[38] US President, *The National Security Strategy of the United States of America* (Washington, DC: The White House, September 2002), foreword, 22.

[39] US President, *The National Security Strategy of the United States of America* (Washington, DC: The White House, March 2006), foreword.

and outlines how the US military will contribute to achieving the NSS objectives. Since 2008, NDSs tended to focus on certainties, although there is insufficient information to judge how these documents specifically influenced the development of the JPP. The 2008 NDS stated that "whenever possible, the Department will position itself both to respond to and reduce uncertainty. This means we must continue to improve our understanding of trends, their interaction, and the range of risks the Department may be called upon to respond to or manage."[40] Risk assessment is presented as a way to reduce uncertainty. In the 2012 NDS, the task of the Joint Force is "ensuring that [it] can meet any future threats," which is less specific. However, there is still the task of providing the "ability to regenerate capabilities which might be needed to meet future, unforeseen demands."[41] The 2018 NDS demands a "lethal, agile, and resilient force posture to account for the uncertainty that exists" but the term "uncertainty" overall does not appear as a dominant consideration for the future. [42] There is no evidence that the 2018 NDS continues the approach of using risk assessment to reduce uncertainty.

The 2018 NDS is followed by the 2015 National Military Strategy (NMS) which is the subordinate strategy to the 2018 NDS. The unclassified 2015 NMS "describes how [the US military] will employ [US] military forces to protect and advance [US] national interests." It is remarkable that no other strategic document above the 2015 NMS tasked the senior military leadership with handling uncertainty. The 2015 NMS is the first document above US joint doctrine that puts the demand on the "joint leader to anticipate and adapt to surprise, uncertainty,

[40] US Department of Defense, Secretary of Defense, *National Defense Strategy* (Washington, DC: Government Printing Office, June 2008), 5.

[41] US Department of Defense, Secretary of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Washington, DC: Government Printing Office, January 2012), foreword.

[42] US Department of Defense, Secretary of Defense, *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge* (Washington, DC: Government Printing Office, 2018), 7.

and chaos." However, the 2015 NMS does not provide further guidance on how the joint leader should anticipate and adapt to uncertainty.[43]

Why Might Uncertainty Be a Forgotten Factor in Joint Planning?

The 2017 JPP leads the decisionmaker to view uncertainty in a binary way. In order to find the most likely outcome, the 2017 JPP focuses on certain factors and seeks to make predictions, but uncertain events are unpredictable. Consequently, it is possible that planners underestimate uncertainty in order to make a compelling case for their "certain" plans. Also, the US budget system creates demands for precise threat assessments. Risk-averse decisionmakers are most likely to avoid decisions in an uncertain environment. Therefore, planners provide a planning product based on known facts and risks. In the worst case, uncertainty forces the planner to stop planning, because the 2017 JPP does not provide guidance on handling uncertainty.

A planner does not like to present planning products with an element of uncertainty. "The planner may feel that he or she will be perceived to be a failure as a professional if the products are presented with degrees of uncertainty."[44] The 2017 JP 5-0 stated that "joint planning provides a realistic assessment of the application of forces, given current readiness, availability, location" and "planning provides decision makers an honest assessment of the costs and potential consequences of military actions."[45] Part of this capability-based analysis is the demand for a "realistic assessment" and the "potential consequences," which limits the options for expressing areas of uncertainty and emphasizes more certain factors. Intelligence analysts use both, predictive and capability analysis. In predicting the future development of possible enemy operations, the analyst could be wrong. "Predictive analysis is riskier than capabilities analysis

---

[43] US Department of Defense, Chairman Joint Chiefs of Staff, *National Military Strategy 2015* (Washington, DC: Government Printing Office, June 2015), i, 14.

[44] Kenneth H. Reckhow, "Importance of Scientific Uncertainty in Decision Making," *Environmental Management* 18, no. 2 (New York: Springer-Verlag, 1994): 161.

[45] JP 5-0, 2017, xii.

because it deals more extensively with dynamic adversary characteristics…Therefore, the chances of analytic failure are greater. As a consequence, there may be a tendency among overly cautious intelligence personnel to avoid predictive analysis."[46]

Uncertainty is unpredictable, and therefore it is difficult to allocate resources against it. The US Congress decides the military budget. "Without a clear threat, it becomes difficult to convince wary politicians and publics of the importance of peace-time defense spending." Even when threats are known but assessed as very unlikely, the discussion about resources will probably shift away from funding military projects. "When threats subside, financial risks are perceived to overwhelm military risks, and strategic insurance appears to depend disproportionately on economic strength at the expense of military strength." This rationale would support planners' hesitation to look for long-term objectives with high uncertainty and their preferences to focus instead on short-term, tangible risks with a calculable certainty to bolster arguments for military spending. The US military budgeting planning system may not be capable of integrating uncertainty, which may lead security policy papers and joint doctrine to deemphasize uncertainty.[47]

There is no evidence that the 2017 JPP requires considering uncertainty. One could argue with respect to the 2017 JPP that "despite the uncertainties, the decisions or designs implemented may be still satisfactory."[48] Because of the classification, this research could not examine cases to find evidence of failure. Also, it seems easier to find examples where the intelligence estimate did not provide the required and correct information. "Military research has generally focused on strategic surprise attacks while paying less attention to technological and doctrinal surprise, although the latter's importance is constantly increasing. Traditional research states that the main

[46] JP 2-0, 2013, II-10.

[47] Goldman, 17, 17.

[48] Reckhow, 161.

solution for a surprise attack lies in improving the intelligence layout."[49] There also may be the wrong perception that with long term planning—"think of the 30-year-plus lifetimes of major military platforms—[one] can acquire the belief that [one is] constructing [his/her] future.… It does mean that we would be well-advised not to use the all-too-familiar phrase, 'the foreseeable future.' The future is not foreseeable, at least not in a very useful sense. The challenge is to cope with uncertainty, not try to diminish it."[50]

Uncertainty provides an argument for not planning because it is impossible to plan for unpredictable events. In 2003, Deputy Secretary of Defense Paul Wolfowitz stated during a defense budget hearing that "in short, we do not know what the requirements will be….Fundamentally, we have no idea what is needed unless and until we get there on the ground."[51] The focus on uncertainties turned into "a rationale for rigidity in planning rather than flexibility."[52] Emphasis on the unpredictable future may become an argument not to conduct predictive planning, replaced by hope for the ability to handle surprises with flexibility.

What Are the Shortcomings in the JPP's Consideration of Uncertainty?

The 2017 JPP falls short in five areas with respect to handling uncertainty. First, the 2017 JPP has no confidence levels for analytic judgment, although the 2013 JP 2-0 defines them. Second, there is no standardization of the communication of probability levels between planning products and intelligence estimates. The 2016 JRAM, which is part of the 2017 JPP, and the 2014

---

[49] Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield* (Redwood City: Stanford University Press, 2011), 1.

[50] Colin Gray, "21st Century Security Environment and the Future of War," *Parameters* (Winter 2008-2009): 15.

[51] US Congress, *Department of Defense Budget Priorities for Fiscal Year 2004: Hearing before the Committee on the Budget House of Representatives* (Washington, DC: Government Printing Office, February 27, 2003), 10, accessed January 1, 2019, https://www.govinfo.gov/content/pkg/CHRG-108hhrg85421/pdf/CHRG-108hhrg85421.pdf.

[52] Michael Fitzsimmons, "The Problem of Uncertainty in Strategic Planning," *Survival* 48, no. 4 (Winter 2006-2007): 141, accessed January 1, 2019, https://doi.org/10.1080/00396330601062808.

JIPOE use different criteria to assess probability levels. Third, the 2017 JPP does not provide methods for assessing non-probabilistic problems characterized by uncertainty. Forth, the 2017 JPP does not consider analytic biases which could lead to errors in planning. Finally, the 2017 JPP starts with the receipt of a directive or order to identify COAs for a known threat. The directive should also initiate considerations about the uncertainty inherent in the planning.

The lack of incorporation of confidence levels in the 2017 JPP prevents the commander from fully understanding risks and uncertainty. There is no standardization between the 2017 JPP and the intelligence products regarding the use of confidence levels of analytic judgment. To support the commander in his decisionmaking process, the 2013 JP 2-0 "defines the confidence level in an analytic judgment based on three factors: number of key assumptions required, the credibility and diversity of sourcing in the knowledge base, and the strength of argumentation."[53] This confidence level helps to ensure that the commander understands the uncertainty of intelligence assessments. Uncertainty is not limited to intelligence analysis. The 2013 JP 2-0 also states that "intelligence analysts will have some uncertainty as they assess the operational environment, as should the commander and staff as they plan and execute operations."[54] Therefore the 2017 JPP should also validate planning products and use the same methodology to assess confidence levels as the 2013 JP 2-0. With a growing cyber threat, it is even more important to introduce confidence levels to the 2017 JPP analysis. A confidence level will also provide more transparency on uncertainty in the analysis because it could help to identify uncertain elements of the analysis.

Similarly, there is no standardized way to communicate probability. The 2017 JPP has in mission analysis a step for "risk assessment." *Joint Risk Analysis* defines "probability" as "[a] simple four-level table [that] helps the assessor designate level of probability of an event

[53] JP 2-0, 2013, A-2.

[54] JP 2-0, 2013, I-2.

occurring or an objective being met."[55] The table below shows the details followed by a brief explanation.

Table 1. Probability Levels in the Joint Risk Analysis Methodology (JRAM)

Probability of Event (P)
Highly Unlikely (~0-20%)
Improbable (~21-50%)
Probable (~51-80%)
Very Likely (~81-100%)

Source: US Department of Defense, Chairman of the Joint Chiefs of Staff, *CJCSM 3105.01, Joint Risk Analysis* (Washington, DC: Government Printing Office, October 14, 2016), B-2.

"The categories 'Highly Unlikely' and 'Very Likely' are assigned smaller intervals to ensure these two categories are reserved for more certain events (i.e.[,] more certain to happen or not to happen). The Probable and Improbable categories capture the less certain outcomes." [56] In the 2013 JP 2-0, intelligence analysis uses the 2014 JIPOE to identify "courses of action by probability." [57] There are few hints as to what that probability means. "Estimative Intelligence analyzes known factors using techniques such as pattern analysis, inference, and statistical probability to address unresolved variables."[58] However, there is no guidance on how to calculate the probability. Without further explanation, only one example mentioned the three different categories of probability: low, medium, high.[59] These are different categories of probability than in joint risk analysis. Both categories and the way how to communicate should be standardized.

[55] CJCSM 3105.01, *Joint Risk Analysis,* 2016, B-2.

[56] CJCSM 3105.01, *Joint Risk Analysis,* 2016, B-2.

[57] JP 2-0, 2013, I-17.

[58] JP 2-0, 2013, I-20.

[59] US Department of Defense, Joint Staff, *Joint Publication (JP) 2-01.3, Joint Intelligence Preparation of the Operational Environment* (Washington, DC: Government Printing Office, May 21, 2014), B-23.

The 2016 JRAM and the 2014 JIPOE do not provide methods for assessing non-probabilistic problems characterized by uncertainty. The 2016 JRAM defines levels of probability for "an event occurring or an objective being met."[60] Furthermore, how should unknown or events that do not provide enough knowledge for probabilistic methods be addressed? The same question applies to the 2014 JIPOE.

"The Intelligence Community has long struggled with the need for analysts to overcome analytic biases."[61] Because of the human inability to process all available information, people often unconsciously use mental shortcuts, also known as "heuristic rules." These mental shortcuts are often used in uncertain conditions and in response to surprises. As a result, this leads to assumptions, named "biases," which then could result in errors. There are many different biases documented, such as the "anchoring bias," which means that partial information influences the mindset. This bias "causes pre-loaded and determined tunnel vision and influences final decision making."[62] A military example is: "[I]n assessing an enemy's behavior, a decisionmaker will often rely on the most available model for decision-making—his own plans and intentions. Britain based its pre–World War II estimates of the Luftwaffe's size on the basis that the "best criteria for judging Germany's rate of expansion were those that governed the rate at which the RAF could itself form efficient units."[63] The "authority bias," in this case, is "favoring authority figure opinions ideas within … teams. This means that innovative ideas coming from senior team members trump or better all others, even if other concepts, ideas, and inputs could be more

[60] CJCSM 3105.01, *Joint Risk Analysis,* 2016, B-2.

[61] JP 2-0, 2013, II-9.

[62] Mike Pinder, "16 cognitive biases that can kill your decision making," *Board of Innovation* (blog), January 13, 2019, accessed January 13, 2019, https://www.boardofinnovation.com/blog/16-cognitive-biases-that-kill-innovative-thinking/.

[63] Paul K. Davis, Johnathan Kulick, and Michael Egner, *Implications of Modern Decision Science for Military Decision-Support Systems* (Santa Monica: RAND Corporation, 2005), 10.

creative and relevant to problem-solving."[64] The 2013 JP 2-0 cautions: "The methodology, production, and use of intelligence should not be directed or manipulated to conform to the desired result; institutional position; preconceptions of a situation or an adversary; or predetermined objective, operation, or method of operations."[65] However, the 2017 JP 5-0 does not provide similar guidance and should, as a planning document, advise on how to recognize and handle the possible impact of biases on planning.

The 2017 JPP requires a trigger to start the planning cycle. "Planning usually starts with the assignment of a planning task through a directive, order, or cyclical strategic guidance."[66] A disadvantage of traditional planning is that it starts when the threat or enemy is known; there is no planning for uncertainty beforehand. "When threats are unclear, traditional planning procedures are of limited utility because the underlying assumption—the identity of the enemy—has been overturned."[67] The 2017 JP 5-0 states that the commander and the staff have to conduct "operation assessments…to identify and analyze changes in the operational environment ('OE') and to determine the progress of the operation."[68] These operations assessments do support the commander in analyzing changes in the OE, but they do not identify areas of uncertainty. The 2017 JPP does not consider unknown threats or an unknown OE in the planning process.

Tools to Handle Uncertainty

There are tools available to support the 2017 JPP and the 2014 JIPOE to handle uncertainty better. The first subsection examines mathematical models from probability and statistics to improve the understanding and quality of use of probability and statistics in order not

---

[64] Pinder, "16 cognitive biases that can kill your decision making," *board of innovation* (blog), January 13, 2019.

[65] JP 2-0, 2013, II-3.

[66] JP 5-0, 2017, IV-7.

[67] Goldman, 162.

[68] JP 5-0, 2017, VI-1.

to add uncertainty to the assessment. The subsection "Heuristics" researches how mental shortcuts could impact the planning process and concludes that an understanding of heuristics is required to improve the awareness of decisionmaker of biases because planning under conditions of uncertainty favors the use of mental shortcuts with the possible disadvantage of errors. The decision tree model provides an approach to visualize uncertainties in the analysis. It helps to understand the development of COAs better and visualize the areas where there is insufficient or no information. The concepts of robustness focus on the outcome of the planning process. This research describes the model of robust-decision-making (RDM) which focuses on planning against the possible worst scenario, and the info-gap model which focuses on the outcome which must be achieved regardless of surprises. These tools do not require additions or changes to the 2017 JPP, but they could supplement the analysis of the objectives of the 2017 JPP and the 2014 JIPOE.

Mathematical Models

The use of mathematical models from probability and statistics will lead to more informed and confident decisions. The 2016 JRAM and the 2014 JIPOE use probabilities without explaining how to calculate the probability. Without guidance, it is up to the analysts to determine how they calculate the probability, and the results of different analysts are then even harder to compare. This could result in increased uncertainty about the reliability of the planning and intelligence products. Two examples illustrate the benefits of statistics and probability calculus in the analysis.

Statistical methods could improve the intelligence assessment and help to reduce the uncertainty about the reliability of information. Intelligence analysts have to "communicate the degree of confidence they have in their analytic conclusions."[69] The 2014 JIPOE does not specify what kind of mathematical method the analyst should use to determine the confidence level. The

[69] JP 2-0, 2013, I-2.

following example illustrates possible differences between "guessing" an estimate and using statistical methods to analyze available information. During World War II, British statisticians were very close with their estimates of the German tank production in World War II. "It turned out that the statisticians had done really well and outclassed the estimates obtained by British and American intelligence." For a period from 1940 to 1942, the comparison of statistics versus intelligence estimates versus actual production numbers illustrates the value of using statistics. In 1940, intelligence analysts estimated 1000 tanks versus 169 calculated by statisticians versus 122 produced. There were similar assessments in 1941: the intelligence estimate was 1,550 versus 244 using statistics versus 271 actual numbers. Moreover, the numbers in 1942 proved the quality of the statisticians' estimates: the intelligence estimate was 1,550 tanks versus 327 by statisticians, and 342 produced.[70]

Probabilistic methods support the assessment process but require training for users and receivers of probabilistic statements. The 2016 JRAM defines four categories of probability including 'highly unlikely' (probability level:~0-20%) and 'very likely' (probability level: ~81-100%).[71] However, the 2016 JRAM does not provide guidance on how to calculate these probabilities. The following fictitious adapted example shows how different probability results could be and emphasizes the need to provide standardized training on the use of probability. It also is an example of "base rate fallacy," a form of bias. It illustrates that intuitive understanding of probability may be flawed and could increase the uncertainty about the assessment. The example takes place at airport security.

> [T]his x-ray test [for luggage] is not perfect, so when there IS a bomb, it gets detected 98% of the time, and when there ISN'T a bomb, the staff will think they see one about 1% of the time. Let's also acknowledge that only 1 person in a million actually DOES have a bomb in their bag… a bag down the line in front of you comes up positive with this test (the staff believe they see a bomb). What's the probability that the bag ACTUALLY contains a bomb? Intuitively, you probably think the chance is pretty high.

[70] Peter Olofsson, *Probabilities: The Little Numbers That Rule Our Lives*, 2nd ed. (New York: John Wiley & Sons, 2015), 447.

[71] CJCSM 3105.01, *Joint Risk Analysis*, 2016, B-2.

> You might think to yourself, "Well the test catches almost all of the bombs (98 out of 100), and it has a very low rate of false positives (only 1 in 100), so if that test is here must be a very high probability that there is, in fact, a bomb in that bag." Sounds pretty reasonable, right? Well, it turns out you're wrong. There is approximately a 0.01% chance that the bag actually contains a bomb. And the reason you're wrong is because it's very hard to take into account the one-in-a-million base rate: how likely is it that anyone has a bomb, whether the test is positive or not?....[T]here are 100,000,000 people and 100 of them actually have bombs in their bags (that works out to one in a million). Now, out of those 100 people with bombs, 98 get caught in this test but 2 of them get away (reflecting the 98% accuracy). [Earlier it was mentioned] that 1% of the time the test comes up positive for people who don't have bombs…[that amounts to] 999,999 people, which represents 1% of the 99,999,900 people who don't have bombs….[using] the Bayes' rule to estimate the likelihood that a positive test result actually catches a bomb…[calculates for] 0.000098 bomb threat. [72]

Probabilistic methods are a tool to support the analysis of risk. However, these methods require a clear understanding of how to determine probability and how to interpret the results. "The inability to apply the logic of probability correctly and to analyze statistics is alleged to be a main source of irrational behavior."[73]

Heuristics

Decisions are not always done on rational analysis but are also impacted by mental shortcuts known as cognitive biases or heuristics. "The reliance on heuristics and the presence of common biases are characteristics of intuitive judgments under uncertainty."[74] Heuristics are "adaptive tools that ignore information (or do not have the information) to make fast and frugal decisions that are accurate and robust under conditions of uncertainty."[75] Although heuristics could apply in many situations and not only under conditions of uncertainty, sometimes there is

---

[72] Emma H. Geller, "Psychology in Action: Bayes' Rule and Bomb Threats," *Psychology in Action* (blog), October 22, 2012, accessed January 1, 2019, https://www.psychologyinaction.org/psychology-in-action-1/2012/10/22/bayes-rule-and-bomb-threats.

[73] Herbert I. Weisberg, *Willful Ignorance: The Mismeasure of Uncertainty* (Hoboken: John Wiley & Sons, 2014), 321.

[74] Amos Tversky and Daniel Kahneman, Judgement under Uncertainty: Heuristics and Biases, *Oregon Research Institute Research Bulletin* 13, no. 1 (Springfield, VA: US Department of Commerce, National Technical Information Service, August 1973): 27, accessed February 9, 2019, https://apps.dtic.mil/dtic/tr/fulltext/u2/767426.pdf.

[75] Shabnam Mousavi and Gerd Gigerenzer, "Heuristics are Tools for Uncertainty," *Homo Oeconomicus* 34 (2017): 367, accessed February 9, 2019, https://doi.org/10.1007/s41412-017-0058-z.

no other option than to use mental shortcuts. However, they come with a cost. A lack of accuracy and bypassing the planning system could cause errors. Therefore, it is important to be aware of the effects of heuristics.

Human thinking could be described as comprising two systems: "System-1 operates automatically and quickly, with little or no effort and no sense of conscious control. System-2 allocates attention to the effortful mental activities that demand it, including complex computations."[76] "System-1" thinking uses heuristics to make decisions under uncertainty. "On a daily basis, people make both important and inconsequential decisions under uncertainty, often under time pressure with limited information and cognitive resources."[77] "Sytem-1" thinking results in intuitive reactions which decisionmakers, planners, and analysts need to be aware of.

Heuristics could help to solve a problem but at the same cause errors in the planning process. "The simplicity of heuristics is the very reason for their robustness; it avoids finetuning of parameters that can cause large estimation error under uncertainty, and particularly under changing environmental conditions."[78] In a planning environment with a high degree of uncertainty, decisionmakers could be forced to rely more heavily on their prior experiences and expertise than on rational analysis. In this sense, heuristics could improve the planning and decision process because they will save time and resources. However, these processes are less consciously controlled and often happen unconsciously. Heuristics carry the danger that important information would not be considered, and the wrong assessment produced because heuristics "allow" the decisionmaker to shortcut the analytic processes. It is necessary for the decisionmaker and planner to be aware of heuristics and the possible errors caused by heuristics.

---

[76] Daniel Kahneman, *Thinking Fast and Slow* (New York: Farrar, Straus and Giroux, 2011), 20.

[77] Mousavi and Gigerenzer, 367.

[78] Mousavi and Gigerenzer, 368.

The example of the "availability heuristic" illustrates the benefit and challenge of heuristics. The availability heuristic describes a situation where "newer" information is considered in priority and "older" information is not because it is not as present as "newer" information. Decisionmakers may judge the quality of an intelligence report based on information that was recently in the reports. This mental shortcut is based on the assumption that if new information can be recalled, it must be important. The following example illustrates the availability heuristic:

> In the aftermath of the horrendous killings of over 30 people at Virginia Tech (VT) in 2007, parents, students, faculty, and staff at the nation's more than 4,200 colleges and universities sharply revised their estimates of the probabilities of a similarly deranged killer's assault on their own campuses. Campus security increased, counseling centers received more funding, legislators held hearings at the state and national levels, and campus authorities updated emergency plans and conducted readiness drills. Although these might have been good things to do, resources are finite. Were these the most urgent things for a campus to do, given all the other risks and threats out there? Probably not. Fire preparedness, weather disaster preparedness, theft detection and prevention, rape and assault protection, food poisoning prevention, and flu epidemic preparedness are just a few projects that address tragically lethal and somewhat more probable eventualities. But all the attention was on the VT situation. It was vividly in mind for administrators, students, parents, and the media. Those other more likely dangers were not on their minds right then. Hence, the disproportionate allocation of time, money, and attention.[79]

The value of heuristics is controversial. The research on heuristics could identify at least two groups with controversial opinions. One group emphasizes the possible harmful outcomes (biases) and labels heuristics with predicates like unreasonable, illogical, or irrational. The other group sees the advantage and positive results, especially in situations with uncertainty, time pressure, or complexity. Heuristics are not rational, and their impact relies on individuals and the circumstances.

Decision Tree - Visualization of Uncertainty

A decision tree helps to visualize areas of uncertainty in the comparison of COAs. "The most common technique for COA comparison is the weighted numerical comparison, which uses

[79] Peter Facione and Carol Ann Gittens, *Think Critically,* 3rd ed. (Boston, MA: Pearson Education, Inc., 2015), 202.

evaluation criteria to determine the preferred COA based upon the wargame."[80] The following is a fictitious scenario:

> The US commander receives the mission to develop COAs to defend the partner country B against a possible attack of country A. The military objective is to maintain and if necessary, to restore the sovereignty of the territory of country B.

According to the procedures of the 2017 JPP, the staff provides three COAs (see Figure 1), and the commander must now decide.

Military objective: Maintain/restore territorial sovereignty of country B

evaluation criteria	COA 1	COA 2	COA 3
	US lead large scale defense operation	US lead small scale defense operation	military assistance of country B
criteria 1	-	-	+
criteria 2	++	-	+
criteria 3	+	+	+
criteria 4	+	-	--
overall ranking	1.	3.	2.

Figure 1. Weighted numerical COAs comparison. Adapted from US Department of Defense, Joint Staff, *Joint Publication 5-0, Joint Planning*, June 16, 2017, G-3.

Uncertainty is not considered as a planning factor in COA development. The commander cannot see how these COAs were developed nor does it show areas for further options, risks, or uncertainty. The presentation of COAs with this technique provides an incomplete picture. The commander now faces two challenges: The process of COA development is not transparent (probably due to time pressure). What did the staff consider in the development of the COAs, and what did they not or what is uncertain? How did the staff come up with these options? Which options did the planners not present? What will happen if country A does not attack? A decision tree model could help the commander to visualize the possible answers. For example, there is one common assumption in all three COAs: Country A will attack country B. What are the options if the attack does not happen at all? Figure 2 shows a different approach to using a decision tree.

[80] JP 5-0, 2017, G-1.

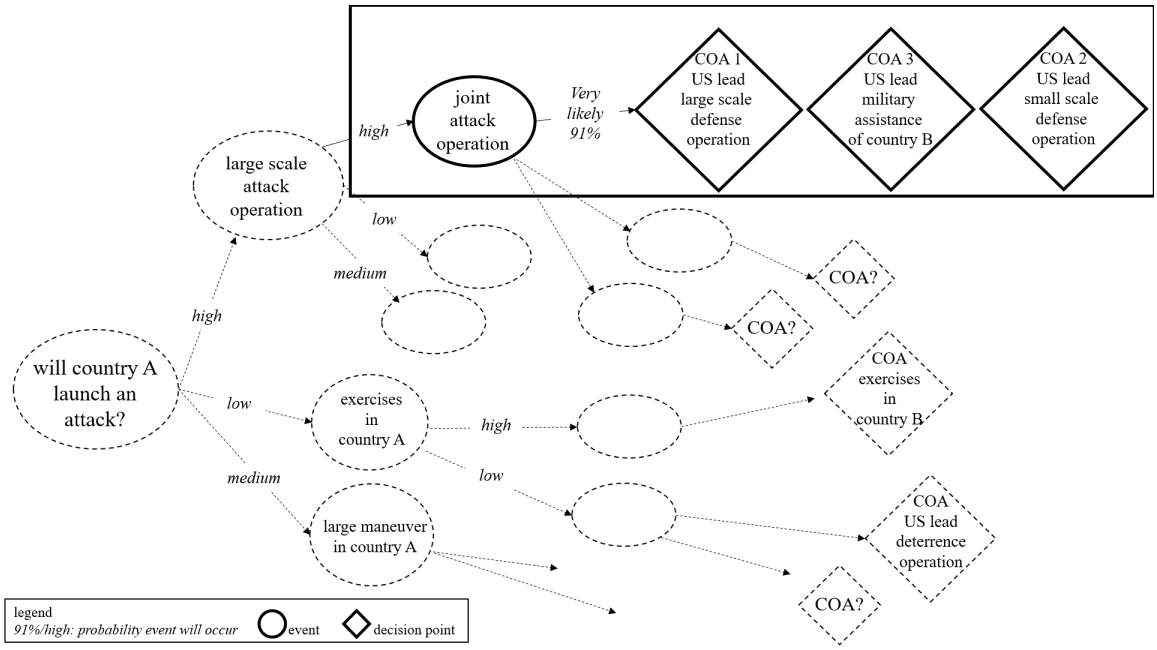

Figure 2. Decision tree model. Created by author.

The box on the top right corner presents the three COAs from the previous fictitious example. It shows the assumption that an attack is "very likely" (91% probability level; using the categories of probability of the 2016 JRAM) and the intelligence estimate with "high" probability (using the categories of probability of the 2014 JIPOE). The fact that there are two different ways of categorizing probability for the same event illustrates the challenge of using nonstandardized ways of communicating probabilities. The values and information of figure 2 are represented inside the box. Outside of this box, the decisionmaker now sees how the staff developed the COAs, which options the staff rejected, and the areas where no or not enough knowledge is available. This method could help to visualize the areas of uncertainty (dotted, blank circles), to support the commander in the assessment of the COAs, and also improve the transparency of the development of COAs.

Concepts of Robustness to Uncertainty

The JPP focuses on best-estimate predictions of the future, which requires an environment with a low degree of uncertainty. "[M]uch quantitative risk and decision analysis (in

particular, DoD's planning) typically uses a *predict-then-act approach*. Analysts assemble available evidence into best-estimate predictions of the future and then use models and tools to suggest the best strategy given these predictions."[81] The approach of optimizing the outcome works well when the predictions are accurate and not controversial. This monograph examines two alternative approaches to outcome-optimization. First, the Robust-Decision-Making (RDM) methodology focuses on minimizing the worst outcomes. Second, by using Info-Gap theory, a planner aims to achieve an outcome that is good enough. "Neither requires knowledge of probabilities. The overarching principle behind these two approaches is to find strategies that are robust to a range of different contingencies."[82]

RDM methodology provides insurance against the worst anticipated outcome. The concept of RDM is to identify those future conditions where the strategy or plan will perform well and poorly. A strategy or plan will then be designed to minimize the maximally bad outcome. "The appeal of this technique is that it provides insurance against the worst anticipated outcome."[83] The planner runs models with different sets of assumptions to describe how plans perform in many plausible futures. This serves as a "stress-test of strategies and helps decision makers identify 'robust' strategies—those that perform reasonably well regardless of what the future brings—and identify the key tradeoffs among potential robust strategies."[84] RDM requires more time for planning than the best-estimate approach. It also requires more resources to run through as many models as possible to find the worst outcome for a plan. This makes it unnecessarily costly because the worst may happen rarely or not even occur. On the other side,

---

[81] Robert J. Lempert et al., *Defense Resource Planning Under Uncertainty* (Santa Monica: RAND Corporation, 2016), 7 (emphasis in the original).

[82] Yakov Ben-Haim and Maria Demertzis, "Decision Making in Times of Knightian Uncertainty: An Info-Gap Perspective," *Economics*, no. 2015-42 (2015): 4, accessed February 10, 2019, http://www.economics-ejournal.org/economics/journalarticles/2016-23.

[83] Ben-Haim and Demertzis, 4.

[84] Lempert et al., 7.

RDM helps to identify vulnerabilities by examining a wide range of futures and designing plans that reduce those vulnerabilities.

Professor Yakov Ben-Haim initiated the info-gap theory for modeling and managing severe uncertainty. He is a professor of mechanical engineering and holds the Yitzhak Moda'i Chair in Technology and Economics at the Technion–Israel Institute of Technology. "Info-gap theory has impacted the fundamental understanding of uncertainty in human affairs, and is applied by scholars and practitioners around the world in engineering, biological conservation, economics, national security, project management, climate change, natural hazard response, medicine, and other areas." [85] The info-gap theory relies on the principle of robust satisficing. The principle of satisficing is one in which the planner is not aiming at best outcomes or minimizing worst outcomes; instead, the goal is to achieve an outcome that is good enough.

> Three components make up an information-gap robust-satisfying decision. The first component is our information, understanding, and insight about relevant situations, what we are calling our knowledge. Second, we specify the goals that must be achieved, without which the outcome is not acceptable or good enough or not distinctly survivable. Third, we identify those aspects of the first two elements–the knowledge and the goals–that are uncertain, about which we might be wrong or ignorant…
>
> The question being asked is not "how wrong are we?" but rather "how large an error can we tolerate?"…Furthermore, the question is not "what is the best possible outcome?" but rather "what is the most robust plan for achieving our goals?"[86]

Strategic planners must "identify critical goals–outcomes that must be achieved, without which the result would be unacceptable–and then choose a decision that will achieve those goals over the widest range of surprise."[87]

---

[85] Yakov Ben-Haim, "Info-Gap Theory and Its Application," Professor Yakov Ben-Haim, Yitzhak Moda'i Chair in Technology and Economics, accessed February 10, 2019, https://yakovbh.net.technion.ac.il/.

[86] Yakov Ben-Haim, "Thinking Strategically: Dealing with Uncertainty in Strategic Decision-making," *Parameters*, 45, no. 3 (Autumn 2015): 66, 67, accessed February 10, 2019, http://strategicstudiesinstitute.army.mil/pubs/parameters/issues/Autumn_2015/9_Ben-Haim.pdf.

[87] Ben-Haim, "Thinking Strategically: Dealing with Uncertainty in Strategic Decision-making," 72.

Conclusion

It is surprising that uncertainty plays a subordinate role or is even nonexistent in the 2017 JPP. The following four examples illustrate that uncertainties are inherent in all facets of military planning from the very beginning:

> Unlike other organizations, military forces in peacetime must innovate and prepare for a war 1) that will occur at some indeterminate point in the future, 2) against an opponent who may not yet be identified, 3) in political conditions which one cannot accurately predict, and 4) in an arena of brutality and violence which one cannot replicate.[88]

However, the 2017 JPP does not provide guidance and tools to handle uncertainty. Furthermore, related strategic documents do not task the military leadership with developing concepts to handle uncertainty, except the 2015 NMS, which demands that the joint leader adapts to uncertainty and surprise, without providing any further details. With the assumption that this task is still valid in the current classified NMS, US joint doctrine should address the given task to educate joint leaders about anticipating uncertainty. In contrast, current military intelligence documents put the demand on the intelligence analyst to consider uncertainty in intelligence assessments and products. This monograph recommends examining the intelligence approaches to uncertainty, then standardizing the understanding, and developing a concept of how and what kind of tools joint leaders should use to adapt to uncertainty.

The research could not find differences between the 2017 JPP and previous versions with respect to the topic of uncertainty. The "concept of preparing for an uncertain future"[89] in the 1999 NSS did not find a foothold in the development of joint planning. The reason that uncertainty is a forgotten factor in the 2017 JPP could be that the main effort of military planning in the last two decades was on asymmetric warfare against terror. Factors like planning time horizon or response to threat are different at the strategic, operational, and tactical levels. By

[88] Williamson R. Murray, and Allan R. Millett, *Military Innovation in the Interwar Period* (New York: Cambridge University Press, 1996), 301.

[89] US President, *A National Security Strategy for a New Century*, 1999, 5.

nature, asymmetric warfare is less strategic and at the operational level actually occurs through tactical engagements. These circumstances could require fewer planning activities at the strategic level. The shift from the Cold War scenario (planning on operation with large formation) to asymmetric warfare could be the reason the JPP was not fully exercised as intended, and only marginal changes to the process occurred. This monograph recommends examining the concept of "preparing for an uncertain future" and adapting the 2017 JPP to handle uncertainty.

The 2017 JP 5-0 no longer has a section on "crisis planning" and, for unknown reasons, the term "crisis planning" was removed from the DOD dictionary. This monograph recommends examining the elements of "crisis planning" in order to adapt elements in the 2017 JPP to improve flexibility in reacting to surprises.

The 2016 JRAM and the 2014 JIPOE are two tools available to help planners and analysts better advise decisionmakers about facts and risks. This research could find neither evidence of standardization of the tools nor an overall framework where both tools are integrated. The 2016 JRAM assumes a probability of the occurrence of an event. It is not clear what kind of calculation method is behind the "simple four-step" grading. The 2014 JIPOE uses a different system to grade analytic judgment and the intelligence products for the commander. The two systems are not linked. This monograph recommends standardizing the tools and defining a general framework for all tools that include mathematical models. Also, all planners should complete standardized training, so they are able to make the products coherent and transparent for the decisionmaker. This would also help to mitigate the inherent uncertainty of analyses.

The decision tree model could support the decisionmaker in a better understanding of risks and uncertainties. In addition to the 2016 JRAM, the visualization of areas with insufficient or no information helps to understand COAs development better. This monograph recommends adding decision tree methodology to the 2017 JPP.

Decisionmakers, planners, and analysts should improve awareness of heuristics because planning under conditions of uncertainty favors the use of mental shortcuts with the possible

disadvantage of errors. This awareness will help to improve the quality of the 2017 JPP because it helps to understand better how assumptions may be made based on insufficient information. This monograph recommends providing education on heuristics to learn how to minimize possible negative impacts.

Concepts of robustness focus on the output of the planning process. This monograph examined the RDM and info-gap model, which focus on the resilience of a plan against surprises. The RDM model recommends developing a plan that is robust enough to handle the worst scenario. The Info-gap model recommends identifying objectives and tasks that could be realistically achieved under circumstances of uncertainty. "Instead of maximizing utility or minimizing worst outcomes, the planner aims to achieve an outcome that is good enough."[90] Advocates of concepts of robustness do not recommend changing the 2017 JPP but focusing on robust instead of optimal solutions. The underlying assumption is that uncertainties remain an element of the operational environment and cannot be neglected in the planning process. The challenge is in reacting rapidly to surprise if all resources have been allocated to the "best" and most certain solution. This monograph recommends examining how concepts of robustness could supplement to the 2017 JPP and support the testing of robustness.

Uncertainty offers new opportunities. "The strategy for the discoverers and entrepreneurs is to rely less on top-down planning and focus on maximum tinkering and recognizing opportunities when they present themselves."[91] Should military leaders and planners focus more on uncertainties to gain an advantage in planning? This research revealed a tendency towards risk-avoidance vice pursuing opportunities. "Perhaps we are somehow conditioned always to look for order and regularity, which makes us overlook and misinterpret many phenomena of

[90] Ben-Haim and Demertzis, 4.

[91] Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable* (New York, NY: Random House, 2007), 18.

chance."[92] The following example supports this argument. "The French, after the Great War, built a wall along the previous German invasion route to prevent reinvasion—Hitler just (almost) effortlessly went around it. The French had been excellent students of history; they just learned with too much precision. They were too practical and exceedingly focused for their own safety."[93] This monograph recommends that the military consider creating a planning climate conducive to exploring uncertainties.

The 2017 JPP does not consider uncertainty. Unlike the military intelligence domain, the 2017 JPP neither demands that a planner consider uncertainty during analysis nor does it provide tools to handle uncertainty. In 2010, General James Mattis, as the commander of US Joint Force Command, stated that "we will likely not call the future exactly right, but we must think through the nature of continuity and change in strategic trends to discern their military implications to avoid being completely wrong." Further on, military planning has to consider uncertainty, because "[t]here is a strong note of urgency in our efforts to balance the force for the uncertainties that lie ahead."[94] This monograph recommends taking the available tools from the intelligence domain, developing a standardized framework, and improving the mathematical models in use. Such an approach would not necessarily provide a more accurate forecast for the future, but more transparency in the planning process and improved resilience to future unknown challenges without losing sight possible opportunities.

[92] Olofsson, 149.

[93] Taleb, 18.

[94] US Joint Forces Command, Joint Future Group (J59), *The Joint Operating Environment* (Suffolk: USJFCOM Public Affairs, February 2010), foreword.

Bibliography

Ben-Haim, Yakov. "Thinking Strategically: Dealing with Uncertainty in Strategic Decision-Making." *Parameters* 45, no. 3 (2015): 63-73. Accessed February 10, 2019. http://strategicstudiesinstitute.army.mil/pubs/parameters/issues/Autumn_2015/9_Ben-Haim.pdf.

_____. "Info-Gap Theory and Its Application." Professor Yakov Ben-Haim, Yitzhak Moda'i Chair in Technology and Economics. Accessed February 10, 2019. https://yakovbh.net.technion.ac.il/.

Ben-Haim, Yakov, and Maria Demertzis. "Decision Making in Times of Knightian Uncertainty: An Info-Gap Perspective." *Economics*, no. 2015-42 (2015): 1-18. Accessed February 10, 2019. http://www.economics-ejournal.org/economics/journalarticles/2016-23.

Clausewitz, Carl von. *On War.* Edited by Michael Eliot Howard and Peter Paret. Princeton: Princeton University Press, 1984.

Davis, Paul K., Jonathan Kulick, and Michael Egner. *Implications of Modern Decision Science for Military Decision-Support Systems.* Santa Monica: RAND Corporation, 2005.

Diebold, Francis X., Neil A. Doherty, and Richard J. Herring. *The Known, the Unknown, and the Unknowable in Financial Risk Management: Measurement and Theory Advancing Practice*. Princeton: Princeton University Press, 2010.

Facione, Peter, and Carol Ann Gittens. *Think Critically.* 3rd ed. Boston, MA: Pearson Education, Inc., 2015.

Finkel, Meir. *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield.* Redwood City: Stanford University Press, 2014.

Fitzsimmons, Michael. "The Problem of Uncertainty in Strategic Planning." *Survival* 48, no. 4 (Winter 2006/2007): 131–46. Accessed January 1, 2019. https://doi.org/10.1080/00396330601062808.

Geller, Emma. "Psychology in Action: Bayes' Rule and Bomb Threats." *Psychology in Action* (blog), October 22, 2012. Accessed January 1, 2019. https://www.psychologyinaction.org/psychology-in-action-1/2012/10/22/bayes-rule-and-bomb-threats.

Goldman, Emily. *Power in Uncertain Times: Strategy in the Fog of Peace.* Redwood City: Stanford University Press, 2014.

Gray, Colin. "21st Century Security Environment and the Future of War." *Parameters* (Winter 2008-2009): 14-26.

Helldin, Tove, Göran Falkman, Maria Riveiro, and Anders Dahlbom. "Transparency of Military Threat Evaluation through Visualizing Uncertainty and System Rationale, International Conference on Engineering Psychology and Cognitive Ergonomics." In *Engineering Psychology and Cognitive Ergonomics,* edited by Don Harris*,* no. 3*,* (2013), Berlin: Springer Verlag, 2013. Accessed January 12, 2019. https://doi.org/10.1007/978-3-642-39354-9_29.

Kahneman, Daniel. *Thinking Fast and Slow*. New York: Farrar, Straus and Giroux, 2011.

Knight, Frank H. *Risk, Uncertainty and Profit*. Chicago: University of Chicago Press, 1971.

Lempert, Robert J., Drake Warren, Ryan Henry, Robert W. Button, Jonathan Klenk, and Kate Giglio, *Defense Resource Planning Under Uncertainty.* Santa Monica: RAND Corporation, 2016.

Mousavi, Shabnam, and Gerd Gigerenzer. "Heuristics are Tools for Uncertainty." *Homo Oeconomicus* 34 (2017): 361–379. Accessed February 9, 2019. https://doi.org/10.1007/s41412-017-0058-z.

Murray, Williamson R., and Allan R. Millett. *Military Innovation in the Interwar Period*. New York: Cambridge University Press, 1996.

Olofsson, Peter. *Probabilities: The Little Numbers That Rule Our Lives.* 2nd ed. New York: John Wiley & Sons, Incorporated, 2015.

Pinder, Mike. "16 cognitive biases that can kill your decision making," *Board of Innovation* (blog). January 13, 2019. Accessed January 13, 2019. https://www.boardofinnovation.com/blog/16-cognitive-biases-that-kill-innovative-thinking/.

Reckhow, Kenneth H. "Importance of Scientific Uncertainty in Decision Making." *Environmental Management* 18, no. 2 (March 1994): 161-166.

Taleb, Nassim Nicholas. *The Black Swan: The Impact of the Highly Improbable.* New York, NY: Random House, 2007.

Tversky, Amos, and Daniel Kahneman. Judgment under Uncertainty: Heuristics and Biases. *Oregon Research Institute Research Bulletin* 13, no. 1. Springfield, VA: US Department of Commerce, National Technical Information Service, 1973. Accessed February 9, 2019. https://apps.dtic.mil/dtic/tr/fulltext/u2/767426.pdf.

US Department of Defense, Chairman Joint Chiefs of Staff. *National Military Strategy 2015*. Washington, DC: Government Printing Office, 2015.

_____. (*CJCSM) 3105.01, Joint Risk Analysis.* Washington, DC: Government Printing Office, 2016.

US Department of Defense, Joint Staff. *Joint Publication (JP)* 1, *Doctrine for the Armed Forces of the United States*. Washington, DC: Government Printing Office, 2013, with change 1, July 2017.

_____. *Joint Publication (JP) 1-02, Department of Defense Dictionary of Military and Associated Terms.* Washington, DC: Government Printing Office, November 2018.

_____. *Joint Publication (JP) 2-0, Joint Intelligence*. Washington, DC: Government Printing Office, 2013.

_____. *Joint Publication (JP) 2-01.3, Joint Intelligence Preparation of the Operational Environment*. Washington, DC: Government Printing Office, 2014.

_____. *Joint Publication (JP) 5-0, Joint Planning*. Washington, DC: Government Printing Office, 2017.

_____. *Joint Publication (JP) 5-0, Joint Operation Planning*. Washington, DC: Government Printing Office, 2006.

_____. *Joint Publication (JP) 5-0, Joint Operation Planning*. Washington, DC: Government Printing Office, 2011.

_____. *Joint Publication (JP) 5-00.1, Joint Doctrine for Campaign* Planning. Washington, DC: Government Printing Office, 2002.

US Secretary of Defense. *Defense Quadrennial Defense Review Report 2001.* Washington, DC: Government Printing Office, 2001.

_____. *National Defense Strategy*. Washington, DC: Government Printing Office, 2008.

_____. *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense*. Washington, DC: Government Printing Office, 2012.

_____. *Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military's Competitive Edge*. Washington, DC: Government Printing Office, 2018.

US Joint Forces Command, Joint Future Group (J59). *The Joint Operating Environment.* Suffolk: USJFCOM Public Affairs, 2010.

US President. *A National Security Strategy for a Global Age*. Washington, DC: The White House, 2000.

_____. *A National Security Strategy for a New Century*. Washington, DC: The White House, 1999.

_____. *National Security Strategy*. Washington, DC: The White House, 2010.

_____. *National Security Strategy of the United States of America*. Washington, DC: The White House, 2015.

_____. *National Security Strategy of the United States of America*. Washington, DC: The White House, 2017.

_____. *The National Security Strategy of the United States of America*. Washington, DC: The White House, 2002.

_____. *The National Security Strategy of the United States of America.* Washington, DC: The White House, 2006.

The White House. "Remarks by President Trump and NATO Secretary General Stoltenberg Before Expanded Bilateral Meeting." May 2017, 2018. Accessed January 12, 2019. https://www.whitehouse.gov/briefings-statements/remarks-president-trump-nato-secretary-general-stoltenberg-expanded-bilateral-meeting/.

_____. "Remarks by the Vice President and Director of National Intelligence Daniel Coats at a Swearing-in Ceremony." March 16, 2017. Accessed January 12, 2019. https://www.whitehouse.gov/briefings-statements/remarks-vice-president-director-national-intelligence-dan-coats-swearing-ceremony/.

Ward, Stephen, and Chris Chapman. *How to Manage Project Opportunity and Risk: Why Uncertainty Management Can be a Much Better Approach than Risk Management.* Hoboken: Wiley, 2011.

Weisberg, Herbert I. *Willful Ignorance: The Mismeasure of Uncertainty*. Hoboken: John Wiley & Sons, 2014.