Operational Assessment

So How *Are* We Doing?

Lt Col James S. Welshans, EdD, USAF, Retired
Lt Col Charles Owen, PhD, USAF, Retired
Dr. Alice M. Mulvehill
Col Calvin W. Hickey, USAF, Retired
Robert J. Farrell Jr., DAF, DR-III

We couldn't afford distorted assessments: too much optimism could prompt us to launch the ground war too soon, at the cost of many lives; too much pessimism could cause us to sit wringing our hands and moaning that the enemy was still too strong.

—Gen H. Norman Schwarzkopf

Introduction

Throughout history, operational commanders have asked the question, how are we doing? In the 1972 epic *Patton*, actor George C. Scott overlooks a great tank battle in North Africa through his binoculars. The famous commander takes in this expansive view of tanks and close air support on the battlefield, making his personal assessment of the situation.

Modern commanders can no longer conduct effective assessments without advanced sensor capabilities that demand information-management technologies. This situation became apparent during Operation Desert Storm and persists in current global irregular-warfare conflicts. As the appetite for assessment data intensified at an exponential pace over the past 25 years, today's commanders drown in increasingly complex volumes of data.[1] Starting with national and strategic objectives and deriving operational objectives and tactical tasks, commanders must stay attuned to myriad layers of requirements and inputs that frame an overall operational picture of the situation. Today's commanders rely on staff officers and noncommissioned officers (who rely on a variety of distributed and collaborative processes, work flows, and information technologies) to identify relevant data and provide synthesized assessments. The commander must then generate a holistic understanding of the operating environment and fuse it with interpretations and operational assessments (i.e., individualized, cognitive, and low-tech sense making) to render effective and timely decisions.

Modern operational assessment (OA) presents a combined data-management and analytical challenge. The greatest concern for the US military within the context of this dual-faceted challenge is the need for an agile OA framework that can support a human operator who is generally regarded as the critical element (grey matter) and the potential single point of failure in assessment. Although human intellect is the keystone of assessment, it does not preclude or diminish the need for existing and future technologies to support the process. Technologies designed to collect, screen, correlate, represent, visualize, and predictively model the battlespace can significantly expand and enrich the reach and complexity of human analytical thinking. Today's assessment teams must compile, synthesize, and analyze information, ultimately evaluating and estimating operational progress. The rapid advances of information and intelligence, surveillance, and reconnaissance (ISR) technologies have enabled assessors and commanders to better understand and make decisions involving nearly every facet of an operation. However, the complexity and overwhelming volume of incoming data have greatly complicated this critical task.

This article reviews foundational aspects of today's assessment paradigm, focusing on frameworks, research designs, and measurement types. An exploration of ambiguity and uncertainty culminates with a discussion of epistemological nuances. The article advocates a new foundation for assessment anchored in emerging technological innovations, revised OA epistemology, and adaptable representation systems.

US Doctrine and Operational Assessment

One of the greatest challenges facing airmen remains that of assessment: how do we know if we are achieving our objectives? The problem has haunted airmen for decades, but seems little closer to solution than it was in World War II.

—Col Phillip S. Meilinger, USAF

Simply stated, assessment measures the progress of the joint force toward mission accomplishment. Assessment continually compares forecast outcomes with empirically observed action-events to determine overall mission effectiveness with respect to attaining the desired end state, achieving objectives, or performing tasks. The focus is on measuring progress and delivering relevant, reliable feedback into the planning process to adjust operations during execution.

Although the official definition relates assessment to the *military end state*, all commanders and analysts understand that much more than the purely military consequences of an operation are monitored, evaluated, and understood in the assessment process. Carl von Clausewitz emphasized that military operations do not occur in a vacuum but are an outgrowth of a political process that operates according to larger objectives—through its set of actions—and before, during, and after the comparatively brief span of operations.[2] More importantly, military capability is only one of several elements of national power employed to achieve and protect vital national interests and is often not even the most important or the most effective means of exercising a nation's might. When viewed from this perspective, military operations are often shown to be less effective and thus less supportive of a nation's interests than the political, economic, social, and informational *soft power* elements.

Ideally, military force should be applied to operate synergistically with the other soft power elements, but because military action almost always involves either the implicit or explicit application of violence, it is the *bluntest instrument* of national power. Unfortunately, history provides unending examples of nations overreaching in their reliance on military force, often to disastrous ends. As a result, effective and judicious use of military engagement demands a means to ensure it is being applied at times and places and in ways that are most efficacious while minimizing downside risks. OA is the feedback that permits the commander to adjust to changing conditions in an appropriate and effective way to achieve mission goals and objectives. Without assessment, a commander operates blindly and relies on good fortune rather than skill and planning to accomplish the mission.

An effective assessment process must begin at the outset of deliberate military operations analysis and planning—long before (and even if) an actual crisis arises in the particular geographic area of operational responsibility. At this point, commanders and staffs must consider "what to measure and how to measure it to determine progress toward accomplishing a task, creating an effect, or achieving an objective."[3] In addition to the aspects of military operations more traditionally associated with assessment, planners must take into account a wide array of outside factors that may affect planning and execution to assess the impact on progress toward achieving objectives. Consequently, the commander and staff often collaborate (and as necessary, fully integrate) with various nonmilitary governmental agencies and nongovernmental organizations to better detect, analyze, and measure the impact of "friendly, adversary, and neutral diplomatic, informational, and economic actions applied in the operational environment."[4]

Operational Design and Research Design

> *First, anything we study in international security—an event in history, current crisis, speculative future engagement—is almost always more complex than it seems at first glance. Understanding complex national security events requires simplification, and that simplification has become a routine part of how we assess a strategic situation.*
>
> —Andrew L. Stigler
> "Assessing Causality in a Complex Security Environment"

Today's approach to operational planning and assessment is grounded in *operational design* or the "conception and construction of the framework that underpins a campaign or major operation plan and its subsequent execution."[5] Focusing more on generating a deep understanding of operational and environmental complexities than problem solving, this foundational activity helps commanders "visualize the operational environment, understand the problem that must be solved, and develop a broad operational approach that can create the desired end state."[6]

Operational design includes several well-established mechanisms to conduct effective OA. Developed early in the design process, the collection plan offers "a systematic scheme to optimize the employment of all available collection capabilities and associated processing, exploitation, and dissemination resources to satisfy specific information requirements."[7] Further, the OA collection plan identifies all of the commander's critical information requirements, which are "linked to the assessment process by the commander's need for timely information and recommendations to make decisions. The process helps staffs by identifying key aspects of the operation that the commander is interested in closely monitoring and where the commander wants to make decisions."[8]

Evolving beyond current, established processes and products can better align OA with operational design. Taking a broader perspective, one sees that the core of OA is effectively a matter of research, discovery, and interpretive sense making, grounded in rigorous, scientific, and adaptive research designs. Normally, these designs involve hypothesis testing across an effect or outcome-based framework (i.e., if action, then effect/outcome) or an independent variable = > treatment = > dependent variable design. Jennifer Mason anchors research design into three broad questions. First, what is my research about, or what phenomenon is to be investigated? Second, what is the strategy or proposed research hypothesis that would link research questions, methods, and evidence? Finally, how will the proposed research take account of relevant ethical, political, and moral concerns?[9] Research designs, therefore, combine "theoretical claims [hypotheses] and empirical evidence [indicator data] to produce an argument that answers the research question or problem that the study examines."[10] Today's operations analysts use routine office-product software or other specialized software (e.g., maps or scheduling tools) to support their investigation. Analysts then generate evidential data to answer the questions of who, what, when, where, and how of what was executed against the why that drove the planning in order to determine what, if anything, should be done next.

If the world stayed still, this process would be rather simple. But change over time is inevitable, and military operations involve motivated adversaries intent on achieving their objective(s) while simultaneously preventing us from attaining ours. Therefore, OA research designs must be flexible and adaptive. Emergent design addresses these concerns, "allowing for and anticipating changes in [assessment] strategies; procedures; questions to be asked; ways of generating data, and so on."[11] Emergent design processes, focused on innovative discovery and continuous adaptation, almost evoke a biological model in which

> the actual analysis would be less like a pre-specified process of testing and verification and more like discovery. Analysis unfolds in an iterative fashion through the interaction of the processes of generating data, examining preliminary focusing questions, and considering theoretical assumptions. Analysis thus becomes a process of elaborating a version of, or perspective, on the phenomenon in question; revising that version or perspective as additional data are generated and new questions asked; elaborating another version; revisiting that version or perspective, and so on.[12]

Instead of organizing findings in prescriptive and static knowledge category bins, emergent design anticipates and accommodates necessary interactions between the analyst and the data to generate fresh new frameworks and perspectives. It is not the evidential data that informs here but the cognitive meanings generated by and adapted from the myriad relationships among the data elements. Essentially, emergent design delivers the foundation for learning.

Measurement

> *On a cautionary note, do not try to link Measures of Performance (MOPs) with Measures of Effectiveness (MOEs). Doing things right does not necessarily mean you are doing the right things. MOPs and MOEs look at different things. MOEs and their supporting indicators measure the operational environment without regard for the MOPs and tasks. Within the assessment process, MOEs and MOPs are only looked at together during deficiency analysis. Lessons learned indicate that trying to build a linkage between MOP and MOE is a proven waste of time for staffs.*
>
> *—Commander's Handbook for Assessment Planning and Execution*

Data (relevant indicators applicable to the phenomenon of interest) are the sources for measurement and the outcomes of measurement. The act of measurement imbues data with two qualities: *accuracy* and *precision.* Unfortunately, these two concepts are often misunderstood and are used interchangeably or, worse, in a context where being precise is to be considered better than merely being accurate.

The accuracy that pertains to data obtained through measurement is defined as the "closeness of agreement between a measured quantity value and a true quantity value of a measurand."[13] This definition expresses the first critically important quality of measurement-derived data: the *measurand* is the quantity or object intended to be measured, but because all measurement is never free of error, no matter how exactingly it is performed, there is always some variance between the resulting data and (the epistemologically unknowable) ground truth. Furthermore, the concept of measurement accuracy is not a quantity and therefore is not given a numerical quantity value. Instead, a measurement is said to be more accurate when it offers a smaller measurement error. Measurement accuracy should not be confused with measurement trueness or the closeness of agreement between the average of an infinite number of replicate measured quantity values and a reference quantity value.

Data precision refers to the "closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions."[14] This definition introduces the second critically important quality of measurement-derived data, the *exactness* (i.e., repeatability) of the measurement act itself and the resulting agreement (or lack thereof) between data derived from repeated measurements. The specified conditions can be repeatability conditions of measurement, intermediate precision conditions of measurement, or reproducibility conditions of measurement. As a statistically derived term, measurement precision is usually expressed numerically (i.e., standard deviation, variance, or coefficient of variation). When applied in the OA context, measurements must, therefore, address these critical aspects of accuracy and precision, not only to generate assessments regarding how closely our executed operations achieve desired outcomes but also to make reasonable estimates of our success (or lack thereof) in achieving objectives.

Representing Precision and Accuracy in Indicators

An indicator is defined as a "specific piece of information that shows the condition, state, or existence of something, and provides a reliable means to measure performance or effectiveness."[15] Furthermore, "indicators are developed by identifying the data needed to answer intelligence and information requirements. Operation assessment is an iterative process that depends on accessible data sources and professional military judgment. Judging effectiveness and the degree of progress often depends on establishing trend lines for particular indicators in context with appropriate outcomes."[16]

Precision is achieved in indicators by stating the degree of specificity required in the data derived from the resulting measurement. Accuracy can be enhanced by obtaining data through means and sources most sensitive or closely attuned to those changes in enemy behaviors that an analyst is expecting to observe—especially if the analyst employs multiple means and sources rather than relies on a single or a few favorites.

Careful representation of data will incorporate a combination of numeric and textual qualifiers that reveal the information's precision and estimates of its accuracy; however, the exact form of conveying the precision and accuracy of the data will depend on the exact nature of the data being represented. For example, the intended and actual impact points of a weapon may be conveyed through a three-dimensional geographic coordinate in which the precision is expressed as the significant digits employed in the horizontal and vertical measurement. The accuracy is expressed as an estimate of the circular (horizontal plane) and linear (vertical plane) error. In the case of nonquantitative assessment data such as a poststrike mission report, however, precision is a direct function of the specificity of detail included in the report text. Furthermore, accuracy is dependent upon the extent to which any of those details can be corroborated by other sources, such as an onboard sensor video, the observations of other aircrews involved in the attack, and poststrike ISR reporting. Nevertheless, if data are to be used to maximum effectiveness for OA, the information must be represented in ways that properly reflect its level of precision and estimate of accuracy. Even more importantly, to make use of the data, OA team members must be thoroughly conversant with the principles underlying these qualities.

Representation of the data also involves bias—expressed as the human's natural tendency to seek consistency and orderliness in the natural world. In short, we seldom perceive the world as it is, unconsciously opting instead to see the world as we wish it to be. Thus, the implication for OA is to evaluate data populations or samples, gravitating toward measures of central tendency and normal (i.e., Gaussian) distributions as the taken-for-granted standard approach. Perhaps an objective and critical analysis of these human tendencies would reject center-of-mass outcomes, instead actively exploring outliers (i.e., Black Swan events), given their proclivity for greater significance and severity of consequences.[17]

That said, what data sources will provide the best answers about indicators and measures associated with the attainment of one or more objectives? Most assessors find that "there is a tendency to overstate the number of measures and indicators needed, thus generating huge data collection requirements . . . [even though] lessons learned indicate that more information does not necessarily translate into a better assessment."[18]

Uncertainty and Ambiguity

> *Uncertainty is fundamental in nature, rather than just a residual insufficiency of information. Truth is not buried in the data, information does not bring about knowledge, and the best answer is not normally within reach even in principle.*
>
> —Darryn J. Reid and Lt Col Ralph E. Giffin
> "A Woven Web of Guesses, Canto Three"

The measures and indicators developed during mission analysis are likely to be incomplete. Generating a list of possible measures and indicators for each desired objective serves as a starting point at which the responsibilities for measurement are assigned to available resources. Additionally, assessment is made difficult by two pitfalls that are part of the process: the asymmetry of human perception and the ambiguity that infects all data.

Asymmetry of perception arises from the fact that no two people will arrive at exactly the same conclusions regarding observed events or circumstances. We all tend to look at everyone and everything through a complex and often subtle interpretive framework. This framework is built over a lifetime of acquired experiences and learning (i.e., wisdom), and it functions as an essential device that enables us to make sense of our world. This interpretive framework is a direct consequence of the uniquely human attribute of self-awareness. Nevertheless, we also need to recognize that this framework tends to become entrenched over time as we collect experiences.

The result is a feedback effect that causes us to develop set interpretations of objects and events that seem to bear some sufficient level of similarity with these past experiences. In no small measure, this interpretive typing is attributable to the second pitfall for assessment—the inherent ambiguity that infects all data. Even the most objectively analytical people must admit to the influence of subjectivity and inherent bias. Also, the effect of asymmetric perceptions needs to be considered in light of the fact that the same pitfall afflicts our enemy when he experiences our offensive and defensive operations and when he plans, executes, and assesses operations against us.

Although asymmetric perceptions and ambiguity are closely linked and both conspire to complicate assessment, data ambiguity is a profoundly more intractable problem than our inability to objectively discern how things fit together. This difficulty arises because it is impossible to obtain every detail on any matter; there are always known and unknown issues associated with every element of information we receive. Given the complexity of modern warfare, the sophistication of our capabilities, and the expectations of our political leaders, this reality is almost ironic for the assessment process.

Moreover, the increasingly lopsided emphasis on technical intelligence and ISR in recent decades, as well as the stunning detail often revealed by these capabilities, often leads to unwarranted expectations for their truthfulness. For example, a sensor can see only what is in its field of regard and whatever is in the slice of the spectrum in which it is designed to observe and collect, but it is incapable of making a value judgment as to the veracity or meaning of what it is observing. In the case of the cited example of the a priori assessment of the Iraqi Air Force, the fact that Saddam possessed this relatively modern and rather sizeable military capability extended to an unwarranted presumption that he would employ it in the same manner as our own.

Iraq's Air Force in Desert Storm

Before Operation Desert Storm, judged on quantitative and qualitative measures, Iraq possessed one of the most advanced and formidable air forces in the region. However, once combat commenced, the Iraqi air force was rarely employed and never posed a meaningful threat to coalition air or ground operations.

The asymmetry that drove the ineffective use of Iraq's air force had nothing to do with qualitative or quantitative assessments of capabilities; the asymmetry existed in Saddam Hussein's worldview and colored his decision making. He always kept his air force under close watch and on a short leash; he had good reason to be wary. Including some of the most advanced and foreign-educated members of the Iraqi military, the air force was a traditional source of conspirators at the center of previous coups against Iraqi leaders and was even involved in repeated attempts to depose Saddam himself. Thus, when the time finally came when Iraq's air forces could have been employed to far greater effect against the coalition, Saddam's asymmetric perspective toward his air arm dictated a course of events that seemed paradoxical to our thinking about how to best use a modern air force. Therefore, the targeting of much of his air force proved to be of little or no consequence to the actual course of the war, particularly considering that within the first weeks of the war, more than 125 aircraft and a substantial number of pilots fled to Iran.

For more information on this subject, see 1st Lt Matthew M. Hurley, USAF, "Saddam Hussein and Iraqi Air Power: Just Having an Air Force Isn't Enough," *Airpower Journal* 6, no. 4 (Winter 1992): 4–16.

Try as we might, the attainment of explicit knowledge is a complex and elusive endeavor. As a result, assessment is itself a representation problem because of the constant struggle to get around our human inability to see things for what they truly are (perception) and to mitigate to the maximum practical extent our inevitably incomplete knowledge of the facts (cognition). This struggle requires analytical methodologies, processes, and technologies that demonstrate the potential to reduce or minimize the impact of perceptual asymmetry and ambiguity while at the same time recognize that their influence can never be completely eliminated.

Epistemology and the Operational Assessment Process

> *Leaving causal assumptions unstated raises the risk of taking action in the strategic realm that is founded on inaccurate expectations of causal relationships. Exploring potential vulnerabilities in our causal reasoning is by no means a guaranteed bulwark against error, but the complexity of today's strategic environment demands it.*
>
> —Andrew L. Stigler
> "Assessing Causality in a Complex Security Environment"

Many rich theories describe alternative approaches to epistemology or the study of knowledge and justification. Although not exclusive to folks from Missouri, empiricists would anchor our understanding of the world in authentic, primary sense experience. For example, viewing fresh poststrike imagery of a severely damaged building would suffice as credible evidence of positive mission outcomes. Rationalists build on this empirical framework, adding reason as a logical extension to our sensory perceptions. Here, a simple cause-and-effect logical premise (i.e., *strike mission activity* = > *damaged building*) would then complete the knowledge model. When these foundationalist perspectives "seek permanent, indisputable criteria for knowledge . . . and a preoccupation with establishing correspondence between idea and object, concept and observation," they represent today's dominant approach to OA.[19] Dr. James S. Welshans points out that

> despite our best efforts at objectivity, human observation and analysis are fundamentally a subjective enterprise. Each objective measurement is only as precise as the subjectively established (i.e., culturally dominant and accepted) threshold. The researcher does not simply find data which already exists in a collectable state but instead must create viable frameworks for how to best generate and represent data from the chosen sources. Therefore, the data generation and representation processes involve activities that are intellectual, analytical, and interpretive.[20]

In addition to being the foundation of what we already know, knowledge is the framework for evaluating and incorporating new experiences and information. Our existing knowledge is used to create new knowledge. New events, experiences, and information interact with a priori observations, interpretive patterns, implicit assumptions, and beliefs. The expertise, insight, experience, and judgment of the experienced assessor cannot be easily codified, nor can it be easily shared as information. Consequently, the linchpin to making such knowledge more productive is to create or provide a sound methodology for thinking and to place enhanced emphasis on the relationships and networks between war fighters to enable knowledge to proliferate, be tested, and used most effectively. We propose a broader and more intellectually inclusive epistemology for OA that will shift our focus from exclusive notions of causality to accommodate notions of meaning. This approach should blend philosophical elements of critical social science and standpoint theory to offer a more intellectual, analytical, and interpretive environment for effective OA.

Critical social science seeks to integrate theory and practice to develop awareness of "contradictions and distortions in belief systems and social practices . . . [that] do not measure up to their own standards and are internally inconsistent, hypocritical, incoherent, and hence comprise a false consciousness."[21] We need to redefine our OA approaches with a healthy skepticism and understanding of the limits of empirical evidence and rational judgment. Today's OA analyst never truly interacts with primary evidence, but secondary (and nth order) artifacts—whether imagery, mission reports, or intelligence summaries. Whether taken individually or collectively, our text-based data elements are at best representative models of reality, as evidenced by alternative approaches offered from a research culture perspective (e.g., database structures or semantic ontologies). Mediated by the imperfections of human language, our information objects absolutely deserve a critical eye. Yet, this same symbols-based language framework adds the nuanced richness of tacit knowledge and authentic human experiences that enables sense making, learning, and shared understanding.

Standpoint epistemologies also criticize universal and objective interpretations of knowledge as unauthentic, ineffective, and incomplete. Knowing must begin with broad exposure to the experiences, interests, and values of diverse stakeholder groups and continually adapt by challenging the taken-for-granted and deconstructing the dominant perspective in active learning. *Views from everywhere* replace the outsider-observer view from nowhere to frame the analytical space, and, as such, it is "impossible to imagine uniting them into a single complete or collective view of what knowledge is."[22] The best we can hope for is the mosaic picture, the dot-matrix printout, and the highly qualified analytical text. Knowledge is ever incomplete; humans live with uncertainty and contradictions while generating informed assumptions.

Conclusion

Once in a while you get shown the light

In the strangest of places if you look at it right.

—Robert Hunter and Jerry Garcia
"Scarlet Begonias"

The best assessment practices tell us that "predicting outcomes in complex environments is problematic at best. Conditions change, adversaries adapt, missions shift, and objectives evolve. . . . As environmental conditions, political considerations, and operational realities collectively influence the successful accomplishment of developed objectives, the commander and staff must review the underlying assumptions and conditions that provided the foundation for their assessment."[23]

The commander who is unable to accurately and rapidly assess ongoing operations and relevant nonoperational events is a commander who is failing and unable to accurately make the necessary resource-allocation and operational-adaptation decisions. While crude mechanisms exist to work this analysis, they are inadequate to the challenge and overly reliant on the input of a very small number of humans. Furthermore, they currently lack a credible data foundation to ensure reasonable accuracy in both analysis and projection while accounting for innate and systemic biases and ambiguities.

Assessment is clearly more art than science. The artfulness of reasoning is the only thing that enables humans to intuit their way through the ambiguity and asymmetric perceptions that are the inextricable consequences of living life, but modern science also has a big part to play. Experienced analysts generally find that effective assessment requires significant measurements and that often the most important data are missing. Additionally, a high likelihood exists that the most likely times and places where data are missing coincide with the times and places where data are most critical. Although operational planning and execution are not deterministic, a good analyst or planner can generally estimate—with a high degree of confidence—how causes, effects, and consequences will unfold.

Clearly, what is needed is a way to both accumulate and organize the massive amounts of information required to support effective OA, enabled by means that allow operational analysts to visualize and represent those data in an intuitive and easily managed format to assist the commander in making decisions based on that information without overwhelming him or her with unnecessary or not immediately relevant detail. Note that some progress is already being made to support the data volume, velocity, variety, and veracity issues faced by the OA analyst with programs supported by agencies like the Defense Advanced Research Projects Agency.

That agency is heavily focused on programs to analyze and manage big data, with investments directed at advancing such areas as algorithms, analytics, and data fusion—and growing from just under $97 million in fiscal year 2014 to more than $164 million in fiscal year 2016.[24] If representational languages and automated reasoning technology can lift some of this fog shrouding OA analysts from key insights as they sift through voluminous data, that capability would be of enormous value. The Air Force Research Laboratory is leveraging this work in its pursuit of improving synchronized planning and execution across and within the air, space, and cyber mission elements to achieve decisive unities of effort within heavily contested environments. Effective, efficient OA grounded in an agile framework is paramount to doing so. ✪

Notes

1. Lt Gen David A. Deptula, USAF, Retired, "A New Era for Command and Control of Aerospace Operations," *Air and Space Power Journal* 28, no. 4 (July–August 2014): 5–16.

2. Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 75–99.

3. Joint Publication (JP) 3-31, *Command and Control for Joint Land Operations*, 24 February 2014, III-14.

4. JP 5-0, *Joint Operation Planning*, 11 August 2011, Appendix D, "Assessment," D-2.

5. JP 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 8 November 2010 (as amended through 15 February 2016), 175.

6. Joint Chiefs of Staff, J-7 Joint and Coalition Warfighting Division, *Planner's Handbook for Operational Design*, version 1.0 (Suffolk, VA: Joint Chiefs of Staff, J-7 Joint and Coalition Warfighting Division, 7 October 2011), I-2.

7. JP 1-02, *Department of Defense Dictionary*, 36.

8. JP 3-31, *Joint Land Operations*, III-14.

9. Jennifer Mason, *Qualitative Researching*, 2nd ed. (London: Sage Publications, 2002), 27.

10. Thomas A. Schwandt, *Dictionary of Qualitative Inquiry*, 2nd ed. (Thousand Oaks, CA: Sage Publications, 2001), 229.

11. Ibid., 63.

12. Ibid., 64–65.

13. *International Vocabulary of Metrology—Basic and General Concepts and Associated Terms* (*VIM*), 3rd ed. (Paris: Joint Committee for Guides in Metrology, 2008), 21.

14. Ibid., 22.

15. Joint Doctrine Note (JDN) 1-15, *Operation Assessment*, 15 January 2015, GL-4.

16. Ibid., A-5.

17. "A black swan is an event or occurrence that deviates beyond what is normally expected of a situation and is extremely difficult to predict; the term was popularized by Nassim Nicholas Taleb, a finance professor, writer and former Wall Street trader. Black swan events are typically random and are unexpected." "Black Swan," *Investopedia*, accessed 20 September 2016, http://www.investopedia.com/terms/b/blackswan.asp.

18. JDN 1-15, *Operation Assessment,* I-11.

19. Schwandt, *Dictionary of Qualitative Inquiry*, 71.

20. Dr. James S. Welshans, "Truths, Torments, and Togas," *ITEA Journal* 34, no. 3 (September 2013): 220.

21. Schwandt, *Dictionary of Qualitative Inquiry*, 45.

22. Ibid., 239.

23. JDN 1-15, *Operation Assessment*, I-5.

24. Jonathan Lutton, "DARPA Is Spending Big on Big Data," *FCW: The Business of Federal Technology*, 15 April 2015, http://fcw.com/articles/2015/04/15/snapshot-data-programs.aspx.

Lt Col James S. Welshans, EdD, USAF, Retired

Dr. Welshans (USAFA; MS, Troy State University; EdD, University of West Florida) is a former active duty Air Force fighter pilot, instructor, and war planner. Currently president and chief operating officer with LectricSix Solutions, Inc., he advises the Air Force Research Laboratory on military command and control projects and technology transition. A founding member of the Air Force Operational Command Training Program, Dr. Welshans taught strategy and operational assessment to senior military officers worldwide during major command and control exercises. He has five years of experience teaching at the collegiate level and is a member of the adjunct faculty at Air University and the US Marine Corps University.

Lt Col Charles Owen, PhD, USAF, Retired

Dr. Owen (MBA, Louisiana Tech University; PhD, Louisiana State University) is a senior training and intelligence consultant with PatchPlus Consulting, Inc. He provides training, intelligence, and policy subject-matter expertise to Department of Defense and intelligence community customers. His areas of expertise include training development, targeting, and intelligence analysis. Dr. Owen served for 20 years on active duty as an Air Force intelligence officer, deploying to four contingencies: Operations Desert Storm, Southern Watch, Allied Force, and Enduring Freedom. He has five years of experience teaching at the collegiate level and is a member of the adjunct faculty at Indiana Wesleyan University.

Dr. Alice M. Mulvehill

Dr. Mulvehill (BS, MS, PhD, University of Pittsburgh) is a research scientist and consultant with extensive experience in the design and development of mixed-initiative, knowledge-based decision-support systems. She participated in several Defense Advanced Research Projects Agency and US Air Force research programs focused on providing advanced computing technology to military planners in support of course-of-action development, air campaign planning and execution, logistics planning, and adaptive model development. Currently, Dr. Mulvehill is president and chief operating officer of Memory Based Research, LLC.

Col Calvin W. Hickey, USAF, Retired

Colonel Hickey (BS, University of Akron; MS, Golden Gate University) retired after a 30-year career in the Air Force's regular and reserve components. He was commissioned through AFROTC in 1970 and entered the Air Force as a mapping, charting, and geodesy officer. He spent 12 years on active duty, primarily involved in operational targeting, the geospatial sciences associated with weapons and weapon system development, and associated issues related to operational planning. In 1982 Colonel Hickey left active duty to begin a career in Civil Service. From 1987 until his retirement in 2008, he served as a Department of Defense civilian working in the targeting discipline and related geospatial intelligence sciences. Among other accomplishments during his military and civilian careers, he has taught targeting, been involved in the development of modeling and simulation for weapon-effects estimation, and advised on geospatial data dependencies of weapons and weapon systems. Colonel Hickey continues to apply his particular blend of subject-matter expertise to national security issues in semiretirement as a consultant.

Robert J. Farrell Jr., DAF, DR-III

Mr. Farrell (BS, MS, Pennsylvania State University) is a senior software program engineer, Resilient Synchronized Systems Branch, Information Systems Division, Air Force Research Laboratory, Air Force Materiel Command, Rome, New York. He leads the discovery, development, and integration of innovative computer-automated decision-support technologies that give resilient command and control capabilities to Air Force and joint decision makers. These capabilities enable synchronized planning and execution across and within the air, space, and cyber mission elements to achieve decisive unities of effort, all within heavily contested environments. Mr. Farrell has 34 years of experience keeping the US Air Force the best in the world.

Let us know what you think! Leave a comment!

Distribution A: Approved for public release; distribution unlimited.

http://www.airpower.au.af.mil