Overcoming the Challenges in Implementing Emerging Maneuver Concepts

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In January 2012, we published an article introducing the concept of MANeuver in N-dimensional terrain (MAN^N), which is synchronized maneuver across multidimensional terrain that is not limited to only the dimensions of space and time. MAN^N masses all battlefield effects toward a central concept of operation.[1] Since then, other concepts on maneuver in the contemporary operational environment have emerged, notably the *multi-domain battle concept* and *cognitive maneuver*. These concepts share the premise that influencing people and populations to act in a way that supports U.S. interests is fundamental to the achievement of enduring success. The common aim is to impose multiple forms of contact on our opponents to gain a position of advantage in order to mass physical and nonphysical effects, limit enemy responses, seize the initiative, maintain momentum, consolidate gains, and achieve a lasting victory. In this article, we discuss the convergence between new concepts on maneuver and MAN^N, challenges in their implementation, and the implications for information technology development needed to operationalize these concepts, particularly at the tactical level.

The Operational Environment

Continuous competition, often violent, below the level of armed conflict is a dominant feature of the operational environment today and is expected to persist into the future. This competition is fraught with ambiguity, underlying causes of conflict that are difficult to discern, and nonlinear solutions.[2] At the same time, the potential for nation-state conventional combat cannot be discounted. In reflecting on this future and the conduct of operations since the 2003 invasion of Iraq, we recognize the need for new approaches to account for the nature of contemporary conflict and new methods to achieve an advantage. One of these methods is an expanded concept of maneuver. While the basis of a broader concept of maneuver is familiar, what is new is the generally accepted need for wider application of maneuver in an integrated manner.

Emerging Maneuver Concepts

Two emerging concepts stressing the importance of broader maneuver are found in the United States Army-Marine Corps white paper titled "Multi-Domain Battle: Combined Arms for the 21st Century" and the United States Army Special Operations Command white papers titled "Expanding Maneuver in the Early 21st Century Security Environment" and "Cognitive Maneuver for the Contemporary and Future Strategic Operating Environment."[3] These concepts share a vision of the future operational environment as complex, where conventional military advantages the United States once enjoyed are now less decisive. They also share the view that nonphysical, cognitive domains must be included in the concept of maneuver and campaign design.[4] Emphasis is placed on sophisticated understanding of the operational environment, on the ability to influence populations and opposing decision-makers through the combined effects of the physical and nonphysical domains, and through simultaneous and sequential actions that create windows of opportunity for the decisive application of combat power.[5] Applied in this way, the United States can gain and keep the initiative, maintain momentum, consolidate gains, and achieve enduring success. These concepts are consistent with our concept of MAN^N.

MANeuver in N-Dimensional Terrain

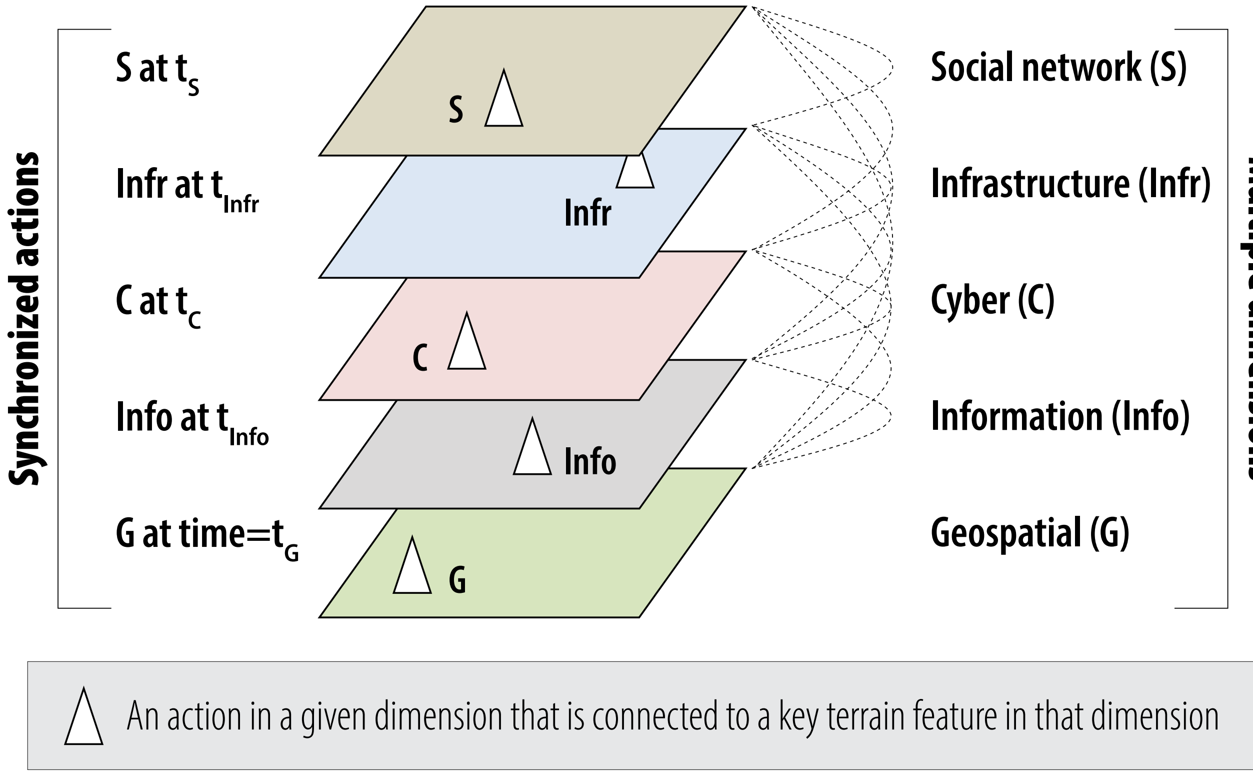
MAN^N is synchronized maneuver operations in a multidimensional terrain, achieving a position of advantage in order to mass effects. MAN^N generalizes spatio-temporal-centric maneuver terms and forms of contact so that maneuver extends broadly across the operational environment, including the political, military, economic, information, infrastructure, physical, and social dimensions. MAN^N is complex, dynamic, adaptive, and distributed.

Like traditional maneuver, MAN^N operates at the strategic, operational, and tactical levels of war. It is employed in all phases of conflict, from deterrence to post-hostilities. While the three coordinates of position (x, y, and z) and the coordinate of time (t) describe traditional geospatial maneuver, MAN^N covers more than these four coordinates since it operates in a multidimensional terrain that spans human institutions and interactions. The challenge is identifying the MAN^N coordinates unique to a specific operational area and using them in a similar manner as x, y, z, and time for geospatial maneuver.

A "multidimensional chessboard" analogy is useful in visualizing how MAN^N operates. The figure (on page 86) presents MAN^N within this construct, which is continually changing as actions occur. Readers will see the similarity to the center of gravity analysis process. The commander develops an N-dimensional concept (where N is greater than the dimensions of space and time) to achieve a position of advantage in order to attain a given objective.

In the context of the "chessboard" in the figure, this concept could include movement in the geospatial dimension (Action G at time = t_G), an information operation in the information dimen-

(Graphic developed by Arin Burgess, Army University Press. Original elements designed by brgfx/Freepik, https://www.freepik.com)



(Figure by authors)

Figure. Example of a Multidimensional "Chessboard" for MAN^N

sion (Action Info at time = t_{Info}), a cyber operation in the cyber dimension (Action C at time = t_C), an infrastructure building effort in the infrastructure dimension (Actions Infr at time = t_{Infr}), and changes in the social network dimension (Action S at time = t_S). The dashed lines connecting the different dimensions (or planes) in the figure represent interactions between actions in these dimensions. The key is that the actions are synchronized in space and time for greatest effect. In MAN^N, any of the dimensions could be the decisive operation (the operation that accomplishes the mission) or a shaping operation (an operation that establishes conditions for the decisive operation through effects on the enemy, other actors, and the terrain).[6]

MAN^N is consistent with multi-domain battle (MDB) and expanded/cognitive maneuver. The aim is to combine military activities into a concept of operation and a scheme of maneuver that gains physical and nonphysical positions of advantage over competing groups, defeating the enemy while protecting and winning the support of the population. The value of these concepts is clear. Implementing them—translating theory into action—has to address some challenges to conceptualizing, synchronizing, executing, and adapting sophisticated maneuver concepts.

Challenges

The sophistication and multidimensionality of MAN^N, MDB, or cognitive maneuver pose a number of challenges. We have chronic planning shortfalls that make highly sophisticated maneuver problematic, but information technology can help overcome these challenges. The primary challenges are (a) understanding the users in context, (b) planning sophisticated multidimensional maneuver, (c) achieving "near native" understanding of the operational environment, and (d) developing and analyzing courses of action (COAs) that includes enemy COAs (ECOAs).

Understanding the users in context. It is critical to understand the people who will plan, prepare, and execute advanced, sophisticated multidimensional maneuver. This is important because of a misperception that these concepts are already being done:

> A common counter argument from many organizations and participants with regard to existing processes is "Well, we do that already." Yes they do, but no they do not. People within different disciplines do separate aspects of cognitive maneuver … They all do a function related to maneuver, but are they united by a common purpose? Are they synchronized within an organizing framework to achieve operational objectives or a sequence of operational objectives? The short answer to that question is no. There has been a real struggle to orchestrate information related capabilities in a coherent manner toward a synchronized objective.[7]

This statement shows that members of the force understand the concept of combining the effects of physical and nonphysical actions. Their challenge is in translating that understanding into action. So, it is important to objectively look at who are the planning teams.

Planning sophisticated multidimensional maneuver. There are two major factors that impact the composition, experience, and stability of planning teams: peacetime manning levels and personnel rotation policies. Furthermore, time constraints and network bandwidth limitations impede these teams from adequately generating robust, integrated plans. This article does not propose any changes to these factors but seeks to qualify their impact on planning performance.

Peacetime manning levels are always lower than what is needed in wartime, which results in the wartime planning team being essentially a new one with little collective planning competence. This is particularly true for low-density specialties that have some of the critical nonphysical domain expertise. Similarly, normal service personnel turnover, where key personnel change at least once a year (more often in some cases), again results in planning teams that struggle to gain and maintain collective planning competence.[8] This is particularly challenging at tactical levels of command where the level of training and experience is lower but will have to meet the expectation that the advanced maneuver concepts will be used by widely-dispersed tactical formations.[9] To make any advanced maneuver concept a reality, automated decision tools are a necessity.[10] Unaided by information technology, the tendency is to conduct abbreviated planning processes that often fail to achieve even basic levels of understanding of the operational environment and warfighting function synchronization.

Time constraints are a common feature of nearly every planning effort. The pressure of deployment, current operations, enemy activity, and effects of higher headquarters activities combine to shorten the time available for planning. Studies on joint task force operations show that there is usually five weeks from alert to commitment.[11] Organizational adaptations (e.g., working groups) can gain efficiencies but often lead to stovepiped analysis and planning.[12] Under these conditions, despite the best efforts to use rapid decision-making techniques, shortcuts lead to incomplete analysis of the situation, fewer options considered, and abbreviated analysis.[13]

In regard to restrictions on bandwidth, current planning tools and technologies place demands on the communication systems that are supporting the headquarters as a whole. Naturally, this creates competing demands between planning and execution, which may restrict network access for the planning teams.[14] Planners will need capabilities that allow them to continue to work offline and then rapidly update their estimates and

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analyses when they have network access. This condition of intermittent access to "reachback" networks is explicitly recognized in the MDB concept.[15]

Achieving "near native" understanding of the operational environment.

> Arguably, mission analysis is the most critical step in the process. However, many BCTs [brigade combat teams] struggle to properly capture key inputs and outputs during this step.[16]

A major challenge of mission analysis is achieving a "near native" understanding of the operational environment. The lack of a truly integrated intelligence preparation of the battlefield (IPB) is a long-standing problem that continues to hamper our ability to gain a sophisticated understanding of the operational environment.[17] The tendency to stovepipe analysis has an effect on this task, where a common technique is to break the IPB into two parts, one kinetic, the other nonkinetic/PMESII (political, military, economic, social, infrastructure, information)/ASCOPE (areas, structures, capabilities, organizations, people, and events), without complete integration.[18] Achieving understanding builds upon knowledge, information, and data.

It is a daunting task to collect and analyze the data and information needed for intelligence preparation of the operational environment. Although we have spent nearly two decades in Iraq and Afghanistan collecting and analyzing data in breadth and depth, it is likely we would still have significant information and knowledge gaps across the many dimensions that would be needed to execute MAN^N/expanded maneuver in the fullest sense. Recall the description of the users in context and consider this:

> If you substitute Civil Engineering for Infrastructure, all of the PMESII domains are independent academic disciplines which, when staffed in a university … a typical department has dozens of faculty with expertise in a variety of areas. IPB might be the place this problem gets "solved" doctrinally, but the truth is that no IPB of PMESII domains will EVER provide the sort of clarity that one hopes for from IPB for a force-on-force engagement. Even THAT is messy and prone to error.[19]

Currently, our ability to analyze data and translate this analysis into action cannot keep up with the collection of data. To compound the problem, the multidimensional data requires continuous updates, a task that challenges operations today.[20] The data challenge poses a number of questions: How do we leverage modeling approaches to assist in mapping the multidimensional terrain and in reasoning about it? How do we identify the decisive points for each dimension and for the interactive connections between them? What are the multidimensional equivalents of "high ground" and its converse? Tools exist today for this analysis, but the state of the art requires expert technical support to set up, run, and interpret the results, and this takes too much time. Answering these questions, aided by information technology that is useable directly by the planners on their timeline, is the objective (see below). Collection and analysis of this information to understand the operational environment is just the beginning, with the commander needing sophisticated capabilities to plan and execute advanced maneuver. A degraded understanding of the operational environment leads to the next challenge, estimating what the enemy is going to do.

Developing and analyzing courses of action. All the preceding challenges impinge on the planning team's development of courses of action. It takes substantial detailed knowledge to do a good job planning for effects in all of these "new" nonkinetic domains. Just having the knowledge is not enough; it has to be made available to planners so that they can use it to plan. Even if the planners have near-native knowledge of the domain, skillful planning is still hard, and tools are needed that help with the mechanics of developing COAs. Producing multiple meaningfully different COAs and predicting their effects are the desired goals.[21]

In the case of enemy actions, time-constrained planning techniques result in the development of two ECOAs, most likely and most dangerous, which are typically developed with only a conventional combat focus. The ECOAs for the other hostile and nonhostile groups in the area of operations are developed and presented to the commander in a separate brief.[22] This leads to an incomplete estimate of the threat, where the physical and nonphysical activities are not visualized as a whole and where supporting and complementary effects are not fully understood. Our adversaries are developing integrated, multidimensional COAs, as seen in the Crimea, Ukraine, and the South China Sea, which should drive us to expand our planning representations. This process continues in the next step of developing, analyzing, and synchronizing courses of action by friendly forces.

> Commander's planning guidance observed at the NTC [National Training Center] typically takes the form of a single directed COA, normally as a result of the assessed lack of time for the staff to develop multiple options based on several unique enemy COAs. This single-directed COA often is not supported by a sufficient understanding of the enemy or tactical situation and fails to take into account the capabilities of a near-peer threat.[23]

At the tactical level, friendly COA development, like ECOA development, is routinely abbreviated for sake of efficiency. Most often, the commander directs the staff to develop a single COA based on his guidance, rather than a set of alternative COAs with unique concepts of operation that imagine a varied range of potential enemy actions.[24] The commander is the most experienced officer in the unit and has collaborated with the subordinate commanders on his COA. However, the directed COA is unlikely to fully cover all dimensions and will not experience the creativity and imagination provided by the collective staff. Information technology offers the potential to allow the commander and staff to develop a range of integrated COAs (both physical and nonphysical activities) that are distinguishable by type and form of maneuver, task organization, and other factors. Range of COAs for analysis gets to the next challenge.

As noted in an August 2017 bulletin published by the Center for Army Lessons Learned, "Many BCTs are inexperienced at COA analysis, or wargaming, missing necessary outputs of this step. The war game is a critical area that often determines success or failure at the BCT level."[25] Course of action analysis at the tactical level is currently a manual process. It is a collective skill that requires preparation, training, and discipline to be effective. Unfortunately, COA analysis is poorly done when done at all. Units struggle with the process overall and lack tools to make the objective estimate of effects needed to analyze the overall effectiveness of the COA.[26] The analysis of integrated COAs is even more difficult, given the need to synchronize the combined effects of physical and nonphysical domains to evaluate the integrated, complementary effects the COA is trying to achieve. One example of the analytical challenge is understanding potential effects that have different time factors: when effects take hold, how long they last, and their resilience to countermeasures. Advances in information technology can support sophisticated wargaming and red-teaming analysis that incorporate multidimensional information and capabilities. This includes the multidimensional maneuver aspects of penetration, frontal attack, infiltration, envelopment, turning movement, blocking, fixing, and disruption. This technology needs to operate during mission execution, as changing conditions across the dimensions are assessed in real-time in order to seize and maintain the initiative. A significant challenge is building these tools to conduct MAN^N/expanded maneuver at the tactical level, as well as the operational and strategic levels.

Overcoming the Challenges

There are lessons learned that should inform new technology development projects to enable advanced maneuver concepts. The most important lesson is the first of the challenges in this article—understanding the users in context. Technology developers have to understand the complexity of modern operations, the nature of the asymmetric fight, and the broad spectrum of actions that military units face. The developers have to see the people at work to better understand the process, the tools in use, and the expected outcomes. Partnership with an operational unit and potentially deployment with that unit to an active theater can help lead to effective technology objectives.

For example, the Defense Advanced Research Projects Agency (DARPA) funded a Small Business

Innovative Research project that established a partnership with a brigade combat team during its preparation for and deployment to Iraq.[27] While engagement with the users is important, it has to be tempered with understanding their perspective of wanting something quick and easy to get the job done. As a result, someone has to make an evaluation of their proficiency at their tasks, noting that every user will have different levels of training and experience that affects their performance. A guide is usually needed to point out how the tasks should be performed, and what that means to the technology development. Doctrine should be the baseline guide for development, which takes real discipline and judgment. This is important because doctrine is the common language of the force and prevents the technology development from becoming a reflection of how one unit performs the task.

Finally, the technology team has to have knowledge of the technology state of the art in order to know how to expand the technology's contribution without becoming captive to the perspective of the user. They have to be able to show the users the range of what is possible given the state of the art. Guided, sustained exposure to the intended end user will provide an important sanity check on technology concepts. In summary, essential to transition success is the practice of development operations, also known as DevOps, which unifies technology development with its operation.

In regard to analyzing the nonphysical dimensions in MAN^N, there has been significant investment in the development of human, social, cultural, behavioral sciences (HSCB) models. DARPA's Causal Exploration program aims to leverage this investment in the development of planning tools for expanded maneuver:

> Causal Exploration seeks to develop a modeling platform to aid military planners in understanding and addressing underlying causal factors that drive complex conflict situations. The technologies embodied in the Causal Exploration platform will enable users to rapidly create, maintain, and interact with a causal model that has been tailored for the operational environment they are facing. Interaction with the model will allow users to explore the causal dynamics driving the conflict, and gain in-depth understanding of the operational environment to support and inform their planning efforts. While this capability will have broad applicability, the program will focus on hybrid or irregular conflicts, which are dominated by complex human dynamics with intertwining political, territorial, economic, ethnic, and/or religious tensions.[28]

Another DARPA program worth noting here is Active Interpretation of Disparate Alternatives (AIDA).[29] This program seeks to make sense of complex events, situations, and trends of interest by overcoming the noisy, conflicting, and potentially deceptive nature of today's data environment. AIDA aims to create technologies for aggregating and mapping different pieces of information derived automatically from multiple sources into a common semantic representation, or storyline, and then generating and exploring multiple hypotheses about the true nature of events, situations and trends of interest. The program also hopes to determine a level of confidence for each piece of information and for each hypothesis that is generated. AIDA does not take the human out of the sensemaking loop, but augments the ability of a human to keep track of multiple interpretations, thereby avoiding the trap of a single interpretation that could be wrong or influenced by disinformation.

An example of an existing modeling technology is ATHENA, developed by the Jet Propulsion Laboratory. The U.S. Army Training and Doctrine Command G27 Operational Environment Training Support Center has used ATHENA to support training and operations. The ATHENA simulation "enables decision makers to anticipate the impacts of social, economic, and political dynamics on a region by evaluating the full range of Political, Military, Economic, Social, Infrastructure, Information-Physical Environment and Time (PMESII-PT) Variables."[30] And, there are commercial technologies that are gaining attention and use in planning. The Senturian system is one example.[31] These capabilities are particularly important for advanced maneuver concepts, but all need further development to gain acceptance by the intended users. Critical to the use of technology in planning is to ensure the output of the technology is presented in a way that is meaningful to the user, in the factors that a commander and staff care about for decision-making.[32] Relevance to the user points to another lesson learned—optimizing the symbiosis of human and machine.

A symbiosis that harnesses the complementary powers of human and machine for effective planning of advanced maneuver concepts is crucial. The machine generally excels in data, information, and knowledge processing tasks, freeing the human to concentrate on understanding and making decisions. Course of action analysis, or wargaming, is a good example of this human-machine symbiosis. The action-reaction-counteraction sequence in a wargame introduces points where the human and machine interact; the machine presents the results for the human to review, understand, and intervene as appropriate.[33] This ensures that the human user sees the "how" and "why," gaining the in-depth knowledge of the COAs and the range of possible outcomes that informs and improves decision-making. This is true for the physics-based outcomes but equally important for the HSCB model results. Technology for the planning of advanced maneuver concepts will advance with the evolution of human-machine symbiosis, where machines will not just be tools that execute pre-programmed instructions, but will function more as partners.

Conclusion

The challenges we have outlined are intended to encourage an objective assessment of the factors at work in tactical-level planning of maneuver concepts like MAN^N. This assessment can inform information technology development that will make real the potential in MAN^N, multi-domain battle, and cognitive maneuver.

Warfare continues its inexorable evolution as the tools used in its conduct continue their equally unstoppable growth. Widespread availability of militarily relevant technologies empowers nearly any group. As history makes clear, humans will continue to fight as groups on land, and will operate in multiple spheres that include human-centric dimensions in addition to space and time.[34] Our armed forces have adapted to this evolution well over the last decade plus of war. However, the experience of our forces will change over time, and new concepts like MAN^N, multi-domain battle, and cognitive maneuver will help provide continuity and an operational advantage in sustaining the ability to synchronize operations in all dimensions to defeat our adversaries. ■

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Notes

1. Brian M. Pierce and Col. (Ret.) James E. Zanol, "MANeuver in N-Dimensional Terrain (MAN^N): A Full Spectrum Maneuver Concept," Small Wars Journal, 24 January 2012, http://smallwarsjournal.com/jrnl/art/maneuver-in-n-dimensional-terrain-mann.

2. Joint Chiefs of Staff, *Joint Operating Environment 2035: The Joint Force in a Contested and Disordered World* (Washington, DC: Department of Defense, 14 July 2016), 4.

3. "Multi-Domain Battle: Combined Arms for the 21st Century" (white paper, U.S. Army and U.S. Marine Corps, 18 January 2017), accessed 27 February 2018, https://ccc.amedd.army.mil/PolicyPositions/Multi-Domain%20Battle%20-%20Combined%20Arms%20for%20the%2021st%20Century.pdf; "Cognitive Maneuver For the Contemporary and Future Strategic Operating Environment" (white paper, U.S. Army Special Operations Command [USASOC], 31 May 2016); "Expanding Maneuver in the Early 21st Century Security Environment" (white paper, USASOC, 12 January 2017), accessed 27 February 2018, http://www.soc.mil/USASOCTalks/Expandingmaneuver21Century.html.

4. "Cognitive Maneuver," USASOC white paper, 3. "Cognitive forms of maneuver are distinct combinations of shaping and influence actions with a unique set of characteristics that differ primarily in the relationship the maneuvering force has with actors in the environment. As with campaigns in physical domains, cognitive campaigns feature the combination of these same forms of maneuver but with an emphasis on the cognitive outcome relative to time."; "Multi-Domain Battle," U.S. Army and Marine Corps white paper, 6. Cognitive forms of maneuver are distinct combinations of shaping and influence actions with a unique set of characteristics that differ primarily in the relationship the maneuvering force has with actors in the environment. As with campaigns in physical domains, cognitive campaigns feature the combination of these same forms of maneuver but with an emphasis on the cognitive outcome relative to time.

5. "Multi-Domain Battle," U.S. Army and Marine Corps white paper, 6.

6. Army Doctrine Reference Publication 3-0, *Operations* (Washington, DC: U.S. Government Publishing Office [GPO], 11 November 2016), 4-6.

7. "Expanding Maneuver," USASOC white paper, 8.

8. Authors' notes, meeting with members of the Joint Planning Support Element, J7, Norfolk Naval Station, 11 April 2017; "MDMP (Military Decision Making Process) Study" (unpublished, 2015). Conducted in support of Defense Advanced Research Projects Agency (DARPA) program manager research, Brigade

Staff Operations, Leader Training Program, National Training Center, Fort Irwin, California. Observing six active brigades, the average time in position for executive officers was 5.75 months, for operations officers it was 2.67 months, and for intelligence officers it was 11 months.

9. "Multi-Domain Battle," U.S. Army and Marine Corps white paper, 9. Ultimately, Army formations and Marine air-ground task forces will be task organized to the lowest practical level with capabilities that enable multi-domain distributed or semi-independent operations minimizing the need for enablers from higher echelons of command.

10. Ibid., 11. Automated decision tools resident in command and control systems will analyze, filter, and report information helping commanders make informed decisions faster.

11. Susan K. Woodward, *Standing Up a More Capable Joint Task Force Headquarters* (Santa Monica, CA: RAND Corporation, 2011), 1.

12. "Expanding Maneuver," USASOC white paper, 8. "Many ideas have already been recognized. Some include organizational changes akin to a Directorate of Understanding or a dedicated center for cognitive maneuver operations. Some include institutional adaptations like reorganizing operations centers to function as a team of teams—physical maneuver team and cognitive maneuver team. Other ideas center on a recasting of operational design, to more deliberately layer in cognitive objectives as part of the schema for operational maneuvers."; "Joint Headquarters Organization, Staff Integration, and Battle Rhythm, Second Edition" (focus paper, Deployable Training Team, Joint Staff J7, July 2013), 2, 5, accessed 27 February 2018, www.jcs.mil/Portals/36/Documents/Doctrine/fp/fp_jthq_org.pdf. This document describes the use of boards, bureaus, centers, cells, and working groups and operational planning teams as effective organization techniques to overcome "stovepipes."

13. "MDMP Study" (unpublished). Observing six active brigades, standard abbreviated procedures included a commander-directed friendly course of action (COA), and most likely and most dangerous enemy COAs.

14. Authors' notes, meeting with members of the Joint Planning Support Element, J7.

15. Sydney J. Freeberg Jr., "Miserable, Disobedient & Victorious: Gen. Milley's Future U.S. Soldier," Breaking Defense, 5 October 2016, accessed 27 February 2018, https://breakingdefense.com/2016/10/miserable-disobedient-victorious-gen-milleys-future-us-soldier/. "Not only will units often be cut off physically, Milley said, but electronically as well. At times combat troops will be able to access satellite data, upload reports to their superiors, and call in precision strikes from Army missile batteries, Air Force planes, or Navy warships hundreds of miles away. At other times, however, thanks to hostile jamming and hacking, the airwaves will go dead and the screens will go dark—but soldiers can't hole up and wait for orders. Initiative, always an American strength, will take on a new importance."

16. Center for Army Lessons Learned (CALL), "Ten Fundamental Brigade Combat Team Skills Required to Win the First Fight," *CALL Newsletter 17-19*, August 2017, 4.

17. CALL, "Mission Command Training in Unified Land Operations, FY 16 Key Observations," *CALL Bulletin 17-05*, February 2017, 20.

18. "MDMP Study" (unpublished).

19. Robert Kohout (former DARPA program manager), comments, 13 July 2017.

20. *CALL Bulletin 17-05*, 6.

21. Kohout, review comments.

22. "MDMP Study" (unpublished).

23. *CALL Newsletter 17-19*, 5.

24. "MDMP Study" (unpublished). One brigade developed more than one course of action of the six brigades in the study.

25. *CALL Newsletter 17-19*, 7.

26. "MDMP Study" (unpublished). Of the six active brigades in the study, one conducted an effective wargame, evaluated by criteria listed in Field Manual 6-0, *Commander and Staff Organization and Operations* (Washington, DC: U.S. GPO, May 2014).

27. Elan Freedy et al., *Decision Infrastructure for Counterinsurgency Operational Planning (DICOP)* (Arlington, VA: Perceptronics Solutions, February 2011), accessed 27 February 2018, https://pdfs.semanticscholar.org/28ca/81273780c305972b255bccdd0e9991f9d3f6.pdf.

28. Steve Jameson, "Causal Exploration of Complex Operational Environments," DARPA (website), accessed 27 February 2018, http://www.darpa.mil/program/causal-exploration.

29. Boyan Onyshkevych, "Active Interpretation of Disparate Alternatives (AIDA)," Defense Advanced Research Projects Agency, accessed 16 March 2018, https://www.darpa.mil/program/active-interpretation-of-disparate-alternatives.

30. "ATHENA: Decision Support Tool for the Operational Environment," G-27 OE Training Support Center, U.S. Army Training and Doctrine Command (website), accessed 27 February 2018, http://oetsc.tradoc.army.mil/#224.

31. "Senturian," Acertas (website), accessed 16 Jun 2017, http://www.acertas-analytics.com/senturion/.

32. James McDonough, systems engineer, BAE Corps, email to author, 17 May 2017. McDonough was the systems engineer for the DARPA Deep Green program.

33. Ibid.

34. H. R. McMaster, "Strategy, Policy and History," interview by Mark Moyar, *FPI Forum,* The Foreign Policy Initiative, 30 November 2016, 3, 6, accessed 27 February 2018, http://foreignpolicyi.org/2016forum/mcmaster.