SOFWERX hosts Cyber Capability Expo at its newest facility in Tampa, Florida, to identify cyber technologies to meet current and future Special Operations Forces requirements, October 19, 2017 (U.S. Air Force/Barry Loo)

Multidomain Battle

Time for a Campaign of Joint Experimentation

By Kevin M. Woods and Thomas C. Greenwood

The term *multidomain* has reached beyond mainstream military parlance to dominate defense-related discussions, concept papers, and op-eds. While the idea of operating across warfighting domains is hardly original, the rapid growth of capabilities tied to the newly minted space and cyber domains is forcing a re-examination of all previous military concepts and doctrine. This article explores the debate around multidomain battle (MDB). Developing a new warfighting concept (as opposed to a slogan or bumper sticker) is difficult because new concepts need to demonstrate that they are sufficiently better than the status quo at addressing the challenges and opportunities in order to justify the disruptive effects of the change. This, as it should be, is a high bar.

The desks of the Pentagon are littered with "transformative" joint warfighting concepts that have appeared with great fanfare only to fall into obscurity. Despite serving as a vehicle to explore ideas, in the end, concepts like Rapid Decisive Operations and Air-Sea Battle failed to move beyond the nascent stage. Some of this can be attributed to a natural resistance to top-down joint concepts, the difficulty of exploring future concepts while maintaining readiness, the lack of coherent institutional processes for examining concepts across organizational boundaries, and, ultimately, the lack of patience for what can be an intellectual slog. As a result, many such efforts were never sufficiently examined so as to generate compelling evidence to drive more than cosmetic changes across the force.

Dr. Kevin M. Woods is Deputy Director of the Joint Advanced Warfighting Division at the Institute for Defense Analyses (IDA). Colonel Thomas C. Greenwood, USMC (Ret.), is a Researcher at IDA.

This article advocates two approaches to exploring MDB. The first is to link the MDB concept to the existing body of available evidence. The second is to generate new evidence through experimentation. These approaches are offered not because Service concept developers have not already begun this process—as evidenced by the MDB draft concepts and plans for U.S. Army MDB experimentation in 2018 and 2019. Rather, this article argues that in addition to the bottom-up development of what could arguably be deemed a joint concept, there should also be a parallel effort to explore the top-down or explicit joint, theater-level implications of MDB.

The term multidomain itself is most often used as a modifier for a particular application of military force, such as (multidomain) battles, (multidomain) operations, or (cross or multidomain) fires; however, more substantially, MDB promises more fluid, adaptive, and effective operations simultaneously across five domains (land, sea, air, space, and cyber). Although operations are conducted in and occasionally across these five domains, the promise of a concept that makes domain integration the norm and not the exception is a tall order. Extraordinary claims require extraordinary evidence.

The logic of MDB's underlying tenets is widely accepted, but that is not the same as demonstrating the concept's viability. Will the application of a multidomain approach enable the Department of Defense (DOD) to overcome current warfighting challenges? Will it allow the Services to seize new opportunities? Or, instead, will MDB distract the Services from restoring atrophied conventional warfighting capabilities? Perhaps more importantly, can MDB serve as a unifying concept that DOD business processes can be organized around for the development of future concepts and capabilities?

MDB is a future concept (perhaps near-future, but future nonetheless). As such, it "must be stated explicitly in order to be understood, debated and tested to influence the development process."[1] The maturation of a concept is a critical first step in the birth of any capability. Concepts are narrative descriptions of suppositions formulated from historical and contemporary experiences; however, as debatable propositions, they must be validated before they transition from concept to capability. This requires settling the debatable elements. This article thus argues that concepts on the scale of MDB require a campaign of experimentation that provides compelling evidence for the concept by fleshing out its operational and institutional contexts.[2]

The State of the Debate

Proponents of the emerging MDB concept make the case that the joint force must adapt to the times, or, as one author put it, "multi-domain battle . . . doctrine is being developed to address the interconnected, Omni domain battlespace of the 21st Century."[3] One of MDB's strongest proponents, Admiral Harry Harris, commander of U.S. Pacific Command, argues that "MDB conceptualizes bringing jointness further down to the tactical level [by] allowing smaller echelons to communicate and coordinate directly while fighting in a decentralized manner."[4] Regardless of the operating theater and specific mission, tactical-level MDB operations, noted U.S. Army Pacific Commander General Robert Brown, will drive the Services to "change their distinct Service cultures to a culture of inclusion and openness, focusing on a purple (or joint) first mentality."[5] Rhetorically, at least, the emerging MDB concept is progressing from the often stated but little realized goal of Service deconfliction to increasing interdependency and, in the optimistic version of MDB, seamlessly integrated operations across domains.[6]

MDB critics dismiss its significance by arguing that it is old wine in a new bottle.[7] Even proponents agree that the "idea and desire for cross-domain effects is not new" but contend the traditional Service-domain alignments are inadequate for coping with the new security environment.[8] A more fundamental challenge is made by those arguing that the categorization of future war by domain—especially but not limited to the cyber domain—is neither logical nor practical. As one observer notes, "the word [domain] contains some built-in assumptions regarding how we view warfare that can limit our thinking . . . [and] could actually pose an intractable conceptual threat to an integrated joint force."[9]

Joining the critics are the cynics, some of whom see MDB's real purpose as programmatic: a ploy to restore or preserve force structure by returning land power to the tip of the spear in joint operations.[10] Others see the concept as requiring deep institutional reforms that are simply unattainable.[11] As one pessimist argued, "without consistently organizing, training, and equipping as a joint team, the Services will be ill-prepared to provide multi-domain capable forces to combatant commanders, continuing history's trend of falling short of the vision of jointness."[12] The institutional questions loom large here. At one end of the spectrum there are calls to form separate Services for the space and cyber domains.[13] At the other end, one MDB proponent provides fodder for the cynics by arguing that the only way to implement MDB is to create a single force and eliminate the independent Services.[14]

Running parallel to the ongoing MDB debate are distinct theater versions of the concept. Because practice trumps theory in the application of military force, how the MDB concept evolves will be strongly influenced by how the operating theaters find a way to employ its promise.

In the Pacific, where much of the initial energy behind the cross-domain idea began, MDB has been described as:

ground-based batteries of anti-aircraft, anti-missile, and anti-ship weapons, supported by long-range sensors and jammers, that can strike targets well out to sea. Islands defended by such Army batteries (or Marine Corps outposts) could serve as unsinkable anvils, with the Navy and the Air Force as the highly mobile hammers.[15]

In support of developing MDB, the Army has recently established a Multi-Domain Task Force in U.S. Army Pacific to accelerate the process of overcoming the tactical and technical challenges

associated with reincarnating the Army's capability to "sink ships."[16] This bottom-up approach to building a joint capability, as one commentator noted, has the potential to simultaneously work toward joint interoperability, interdependence, and integration. But this may fall short of answering how the Services can organize, train, and equip themselves to sustain the readiness required to operate as an MDB capable force.[17]

Meanwhile in Europe, the Army is offering MDB as a conceptual solution to a different, but in many ways familiar, problem set. The Russian army is no longer the colossus of the Cold War era, but it still presents the challenge of mass. Whereas the Russia's army does not boast a raw-troop-strength advantage over the North Atlantic Treaty Organization (NATO), it is threatening a multidomain equivalence in long-range missiles, rockets, drones, sophisticated cyber attacks, jamming, and an integrated information campaign.[18] The solution, argues the commander of the U.S. Army's Training and Doctrine Command, is to take the multidomain fight to the adversary:

AirLand Battle started developing the concept of "extended battlefield." This concept noted that different commanders had different views of the battlefield in geographical terms. [MDB] *continues the concept of extended battlefield but now with a focus on the extension across domains and time. . . .* [MDB] *endeavors to integrate capabilities in such a way that to counteract one, the enemy must become more vulnerable to another, creating and exploiting temporary windows of advantage.*[19]

This NATO-centric version of the MDB development process explicitly argues that, just as the earlier Soviet threat drove large-scale change in the U.S. military's warfighting doctrines, the new Russian threat will drive long-overdue updates to Army force structure and critical warfighting capabilities, especially in the areas of long-range fires and cyber/electronic warfare.[20]

It is clear, then, that there are multiple lenses through which one can view the emerging MDB concept. Each perspective brings a unique set of operational and institutional contexts to the process of concept development. Having a unique perspective can be a healthy part of a robust debate, but progress requires an agreed-upon set of facts, or, in the case of an emerging concept, a common basis of evidence. The concept development challenge is to generate credible evidence that is relevant to decisionmakers from across the tactical-operational and conceptual-institutional divides.

The Emerging MDB Concept

According to a new Army–Marine Corps white paper, the MDB concept "describes how U.S. and partner forces organize and employ capabilities to project and apply power across domains, environments, and function over time and physical space to contest adversaries in relative 'peace' and, when required, defeat them in 'war.'"[21] The white paper posits three key tenets or "interrelated components of the solution," as they are so labeled in the document.

First, MDB requires appropriate *force posture* for the "calibration of forward presence, expeditionary forces, and integration of partner capabilities to deter the adversary and, when necessary, defeat the enemy's fait accompli campaign." The latter is defined as an enemy campaign that seeks to rapidly achieve military and political objectives before an allied response can be generated. Next, MDB will be executed by *resilient forces* that "can operate semi-independently in the expanded operational area while projecting power into or accessing all domains." Headquarters elements will use a mission command philosophy to integrate operations with advanced capabilities. Finally, *converging* joint force capabilities will "detect and create physical, virtual, and cognitive windows of advantage" during the three phases of an MDB campaign: competition, defeat the enemy in armed conflict, and return to competition. The white paper concludes by offering that the MDB concept

allows U.S. forces to outmaneuver adversaries physically, virtually, and cognitively, applying combined arms in and across all domains. It provides a flexible means to present multiple dilemmas to an enemy by converging capabilities from multiple domains to create windows of advantage enabling friendly forces to seize, retain, and exploit the initiative to defeat enemies and achieve campaign objectives. Employing the ideas in this concept, the Joint Force can credibly deter adversary aggression, defeat actions short of armed conflict, deny the enemy freedom of action, overcome enemy defenses, control terrain, compel outcomes, and consolidate gains for sustainable results.

While these three tenets establish a useful framework for institutional considerations of the concept, they do not capture some of the explicit and tacit implications of MDB's potential utility in a theater or joint campaign. To that end, this article offers the following four attributes, derived from the current MDB concept, as potentially useful in developing a joint campaign of experimentation to better understand the concept and to develop evidence for or against its military utility in the joint force.

First, despite the *battle* suffix, MDB may have more to do with campaigns than tactical actions. The battle aspects required to create windows of advantage are a necessary precondition to creating decisive overmatch.[22] However, various descriptions point to an operational-level concept designed to maneuver friendly forces—and direct their kinetic and nonkinetic fires or effects—simultaneously across five domains.

Second, overmatch in one domain may trigger cross-domain multiplier effects that theater commanders can leverage to bypass, unhinge, and defeat an enemy. This, of course, works in both directions, which is why failing to adequately defend the force across multiple domains may have an outsize impact on war termination.[23]

Third, cyber and space domains may become tomorrow's most valued battlespace given U.S. force dependence on the electromagnetic spectrum and satellite-enabled intelligence and communications. The continued development of

sophisticated cyber weapons and employment means—as well as the direct and indirect weaponization of space—could exacerbate this trend.

Fourth, MDB implies the need to reexamine our approach to joint command and control. The authorities needed by geographic combatant commanders charged with planning, coordinating, integrating, deploying, and employing forces (and their effects) simultaneously across five domains will increasingly challenge the very concept of boundaries and the traditional relationships used to conduct joint campaigns.

The MDB concept remains more aspirational than practical at this point. To overcome the cognitive challenges and bureaucratic inertia described earlier, the concept needs to demonstrate that it is both more than the sum of its parts and sufficiently better than the status quo.

Operational Antecedents: Two Case Studies

Historical case studies aid the concept development process by contextualizing the problem. As critics and proponents alike have noted, "cross-domain" or combined arms operations stretch back into antiquity. The following case studies offer two examples of multidomain operations. Like any case study, some imagination is required to place the perceptions of the past into a future context. These cases provide some insights for how cross-domain capabilities, applied primarily at the tactical level, can have outsize operational implications.

Guadalcanal. The conceptual assumption in MDB is that the joint force commander must leverage the interdependencies occurring between diverse operational activities simultaneously across multiple domains. It is not enough just to manage, coordinate, deconflict, and integrate. In his 1987 article "Thinking About Warfare," Lieutenant General Phillip D. Shutler, USMC (Ret.), used the 1942 South Pacific campaign to highlight the three strategic pathways (primarily air, sea, and undersea) that U.S. forces had to successfully transit during World War II before they could project combat power overseas. Although he labeled the strategic pathways *regimes* instead of *domains*, the underlying concept remains the same.

Shutler observed that once enemy airfield construction on Guadalcanal was completed, Japanese land-based aircraft were capable of attacking U.S. planes stationed 500 miles to the southeast on Espiritu Santo—threatening the supply lines connecting the United States with Australia and New Zealand. Accordingly, the Marines were ordered to seize the airfield on Guadalcanal to deny its use to the Japanese. In other words, U.S. land forces, in effect, were directed to create an antiair warfare shield at Guadalcanal to protect Espiritu Santo. But as the operational campaign progressed, the Marines' (and later the Army's) mission shifted from antiair warfare to enabling U.S. land-based aircraft to support subsequent island-hopping battles to the north and the eventual reduction of the Japanese strongpoint on Rabaul.

Initial success, however, required the United States to prevent Japanese ground forces from reinforcing Guadalcanal. A successful landing would have turned the battle into yet another symmetrical and protracted, single-domain, attritional fight between opposing land forces—both of whom sought to control the airfield. As Shutler noted, accomplishing this required U.S. submarines, surface ships, and naval aviation to establish maritime and aviation "shields" (that is, anti-submarine, anti-surface, antiair defenses) that the Japanese had to penetrate before their ground reinforcements could reach Guadalcanal.[24]

During the critical phases of the campaign, Japanese forces were unable to effectively penetrate the "multidomain" defensive shields, and the Marines were able to preserve their tactical overmatch ashore on Guadalcanal (approximately 11,000 Marines against 2,000 entrenched Japanese, many of whom were civilian laborers). The tipping point occurred on November 14, 1942, when U.S. naval forces attacked and sank seven Japanese troop transports that were carrying approximately 7,000 embarked Japanese troops trying to reinforce Guadalcanal.[25] Although the Japanese did partially penetrate the U.S. shields during the campaign, they were unable to do so with sufficient combat power to alter the battle's outcome.

Once U.S. air operations began at Guadalcanal's Henderson Field, a multiplier effect occurred because the Japanese fleet was largely restricted to conducting night operations. This was due in part to additive U.S. airpower projected from ashore and concomitant flexibility gained from an untethered U.S. fleet that could inflict serious losses on Japanese shipping during daylight hours. This reduced Japanese flexibility and freedom of maneuver with implications well beyond the tactical area of operations and marked the start of the U.S. island-hopping campaign.

Like many similar operations in the Pacific theater, Guadalcanal had only marginal tactical utility as an island except for its value to the air domain. The airfield was the operational lynchpin that was denied to the enemy by adroit integration of multidomain activities on the land, sea, and in the air. This further enabled U.S. land-based airpower to support the drive from the Solomon Islands northward into the Central Pacific and eventually to the Japanese homeland.[26]

Falkland Islands. Almost 40 years after Guadalcanal, we can observe the same multiplier effect in a more modern campaign—the 1982 Battle of the Falklands—that revolved around a centuries-old territorial dispute between the United Kingdom and Argentina over the Falkland (Malvinas) Islands.[27] Like the U.S. fleet in the Solomon's Campaign, the United Kingdom established maritime and antiair shields around the Falklands in order to isolate the objective area, protect Royal Navy/Marines amphibious operations, and deny Buenos Aires the ability to reinforce its forces.

Multidomain actions in the Falklands campaign were numerous, and the multiplier effects these actions had on the campaign's outcome were significant. The sinking of the 13,500-ton Argentine cruiser *General Belgrano* (armed with 15 6-inch guns and 8 5-inch guns) by three conventional torpedoes fired from the

Airman aboard KC-135 Stratotanker participates in Red Flag 16-3, one of four Red Flag exercises that focuses on multidomain operations in air, space, and cyberspace, at Nellis Air Force Base, Nevada, July 18, 2016 (U.S. Air Force/David Salanitri)

British nuclear submarine *Conqueror* took the lives of 323 Argentine sailors (slightly more than half of their total casualties suffered during the war). But more importantly, this action had a cross-domain effect that forced the Argentine surface navy to remain inside its territorial waters for the duration of the campaign.[28] Additionally, the sinking of the *Belgrano* dramatically relieved naval surface pressure on Great Britain's fleet operating in the Falkland littorals, which in turn allowed Royal Navy vessels on picket duty more time to visually detect Argentine aircraft being launched from the mainland and alert the British Task Force.[29]

The multiplier effect continued when British special operations forces, supported by naval gunfire, conducted an amphibious raid on Pebble Island to further reduce the Argentine air threat. The raid destroyed 11 forward-based Argentine aircraft. While Argentine helicopters and light aircraft were subsequently dispersed around the islands, the raid forced Argentina to withdraw most of its high-performance aircraft 400 miles back to the mainland.[30] Thus, Argentine aircraft were required to fight at their maximum operating radius, which greatly reduced their time on station (Argentina had only limited aerial refueling capability). This was a major advantage for Great Britain's amphibious fleet and embarked ground forces, who were worried they would not have air superiority during the amphibious landing.

Dismissing the Falklands as nothing more than a creative use of limited assets under extreme conditions risks overlooking key multidomain insights that contributed to operational success. If the notion of achieving dominance in one or more warfighting domains is a thing of the past, then learning to leverage a broader but perhaps relatively less robust toolkit is necessary. To modify a quotation often attributed to Winston Churchill, "Gentlemen we are out of overwhelming resources; Now we must think."[31]

It might be easy to dismiss military case studies of the previous century as irrelevant to the challenges faced when looking forward into the current one. But it is worth considering how these multiple domains were integrated in the first place. The process (including technical, conceptual, and instructional efforts) of integrating new-fangled flying machines into the traditional warfighting domains of the land and sea began decades before a mature concept. It was not a straight line or a preordained outcome. The associated technologies and tactical concepts were leavened by decades of peacetime "experimentation" and wartime adaptation. The resulting capabilities for presenting an adversary with multiple,

simultaneous dilemmas across domains changed the way the United States fights at both the tactical and operational levels of war.

Developing Evidence

The second source of evidence with which to examine the viability of the MDB concept is to look at it from operational perspectives and across a range of contexts. To do this, DOD should subject the MDB concept and its supporting tenets to a rigorous campaign of joint experimentation—even as the specific capabilities are still being developed. *Joint experimentation* in this context is an inclusive phrase meant to indicate the exploration of ideas, assumptions, and crucial elements of nascent MDB capabilities. To be clear, joint experimentation covers a wide range of activities (from structured seminars, virtual and constructive environments, to field events) and should be seen as complementary or undertaken in parallel with the development of specific capabilities or tactical employment concepts.

We employ the term *campaign* in association with joint experimentation to indicate that no single event can generate the quality or variety of necessary data. Moreover, only an experimentation campaign utilizing iterative activities with learning feedback loops (including workshops, wargames, constructive and virtual simulation, and live field events) can generate sufficient evidence to genuinely assess what it will take to realize, adapt, or abandon the MDB idea.

In terms of military experimentation, no single method has ever worked. The complex nature of military problems, and especially ones with interactions across five domains, argues for diverse forms of "discovery experimentation" to introduce novel systems, concepts, organizational structures, and technologies into settings where their use can be observed and Red Teamed.[32] The results of such a comprehensive assessment will help identify MDB similarities and differences between the theaters, and will inform future doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy initiatives that must be addressed before MDB can become a deployable set of capabilities.

One of the most complex challenges in debates about future joint concepts is not the concept per se; it is the nature of *jointness* as practiced in a post–U.S. Joint Forces Command (USJFCOM) environment. Without digressing too far into the history of USJFCOM's role in joint concept development and experimentation, it is worth contrasting the contexts. Formed in 1999, USJFCOM developed a generally top-down approach to joint concept development and experimentation. While this approach had some advantages, it often resulted in excessively large experiments, with the Services playing a limited or marginally productive role. When USJFCOM was disestablished in 2011, joint concept development reverted to the Joint Staff J7, whose time and resources for experimentation was more limited.[33] More recently, Service or multi-Service–led efforts to develop and experiment with new joint concepts are increasing. This can be seen as a bottom-up, collaborative effort. While this approach has many practical advantages over the top-down approach, it is not without challenges—a key one being that the longer joint stakeholders (that is, combatant commands and prospective joint force commanders) remain spectators to the Service-dominated joint experimentation process, the less likely MDB's theater-wide and strategic-level implications will be subjected to a full examination by the customer.

Under Joint Staff policy for concept development, experimentation begins *after* concept development. This may be adequate for narrow concepts or mission/domain capabilities where one Service has the lead. But this approach seems ill-suited for complex and multifaceted warfighting concepts such as MDB. As the two case studies indicate, cross-domain overmatch and multiplier effects are often discovered and subsequently leveraged in the course of operations. Early discovery experimentation with some level of joint analysis and sponsorship is essential. Not only will such early experiments increase the capacity to do joint experimentation, but they can also help co-develop Service concepts within a joint context.

As noted at the outset of this article, the MDB debate at this stage is a useful set of thought experiments, but it is not producing tangible evidence. Such evidence would shift the debate from a primarily subjective one to a more balanced and objective conversation. However, the recent history of joint concept development and the very nature of institutional jointness as practiced in DOD are not encouraging. According to the Joint Staff, joint concepts are assessed "using various analytical methods; the joint concept community evaluates both developing and approved concepts to determine whether they are feasible and promote informed decisions on developing new joint capabilities."[34]

One potentially more lucrative approach would be to embark on a series of parallel joint discovery experiments designed to identify the specific characteristics, demands, and challenges associated with assessing the feasibility of MDB transcending theater-specific applications to serve as a more universal warfighting concept. Such a joint discovery experiment has historically been at the heart of military experimentation.[35]

The objective of discovery experiments is to learn, so it is useful to begin with a set of well-defined conceptual and operational conditions. One does not seek a well-defined "concept," rather a statement of the military problem and a clear understanding of the initial military context. The discovery experimentation approach, supported by an initial data collection plan, is designed to tinker with the variables, modify the conditions, and challenge the assumptions and constraints in a way that dynamically helps refine a nascent concept and identify the kinds of capabilities worth considering. This notion of progressive learning through experimentation generates feedback that enables concept framing, definition, and refinement to occur dynamically.

The ability to use experimentation to explore the utility of emerging technologies and concepts is a force multiplier. Technology cannot be optimized until

its impact on warfighting concepts and doctrine is fully appreciated. According to the National Academy of Sciences in a study done for the Navy:

By simulating future systems, [military commanders] *can also learn how those systems will work in simulated combat environments and how to use forces equipped with such proposed systems. By such means they can explore new ideas and concepts for the use of variously composed and equipped forces against diverse anticipated threats, and they can learn how to integrate such forces on a large scale in the joint and combined force environment.*[36]

One major challenge in calling for more joint experimentation is the large gap between the operating environment envisioned in the MDB concept and the availability of validated models and simulations. Earlier efforts to support joint analyses (both constructive and human-in-the-loop) with custom designed joint models "amounted to a costly failure with little or no resulting joint analysis capability gain for the Department."[37] Nevertheless, progress in MDB will require some capability to integrate space, cyber, and electromagnetic effects into models designed to explore the interaction of new capabilities and human decisionmaking. Any effort to explore MDB in a joint context must include an effort to integrate existing Service modeling and simulation tools (in the same bottom-up approach discussed here). This will help the Services to operate across new domains in support of specific joint priorities instead of attempting to create a standalone, top-down modeling and simulation solution.

Discovery experimentation is not a free-for-all, but a deliberately crafted and planned approach for addressing an issue long before it becomes a pressing problem. It allows operators to interact with new or potential concepts and capabilities to explore their military utility—something that is not often supported through traditional studies or hypothesis-based experiments. It requires careful attention to the specification and collection of data that will provide solid evidence for the conclusions reached by conducting experiments. If all these constraints are observed, discovery experimentation could be a valuable tool and a useful "way of weeding out ideas that simply do not work, forcing the community to ask rigorous questions about the benefits being sought and the dynamics involved in implementing the idea, or specifying the limiting conditions."[38]

It is time to subject the MDB concept to discovery experimentation. To modify slightly Sir Michael Howard's admonition about future doctrine, it is the "task of military science in the age of peace to prevent new capabilities from being too badly wrong" when the next war starts.[39] **JFQ**

Notes

[1] John F. Schmitt, *A Practical Guide for Developing and Writing Military Concepts*, Defense Adaptive Red Team Working Paper #02-4 (McLean, VA: Hicks & Associates, December 2002), 4, available at <www.au.af.mil/au/awc/awcgate/writing/dart_paper_writing_mil_concepts.pdf>.

[2] An *experiment campaign* consists of "a set of experiments, complementary analyses, and synthesis activities . . . conceived, orchestrated, and harvested" in order to better understand the complex issues associated with a warfighting concept. See David S. Alberts and Richard E. Hayes, *Campaigns of Experimentation: Pathways to Transformation* (Washington, DC: Department of Defense, 2005), 4.

[3] Amos C. Fox, "Multi-Domain Battle: A Perspective on the Salient Features of an Emerging Operational Doctrine," *Small Wars Journal*, May 21, 2017.

[4] Senate Armed Services Committee, Statement of Admiral Harry B. Harris, Jr., USN, Commander, U.S. Pacific Command, on U.S. Pacific Command Posture, April 27, 2017, 19.

[5] Robert B. Brown, "The Indo-Asia Pacific and the Multi-Domain Battle Concept," March 20, 2017, available at <www.army.mil/article/184551/the_indo_asia_pacific_and_the_multi_domain_battle_concept>.

[6] For example, see Joint Staff–issued concept papers *Capstone Concept for Joint Operations* (CCJO) (Washington, DC: The Joint Staff, 2012), *Joint Operational Access Concept* (Washington, DC: The Joint Staff, 2012), and *Joint Concept for Rapid Aggregation* (Washington, DC: The Joint Staff, 2015).

[7] Richard Hart Sinnreich, "Multi-Domain Battle: Old Wine in a New Bottle," *The Lawton Constitution*, October 30, 2016.

[8] Brown.

[9] Erik Heftye, "Multi-Domain Confusion: All Domains Are Not Created Equal," *Real Clear Defense*, May 26, 2017, available at <www.realcleardefense.com/articles/2017/05/26/multi-domain_confusion_all_domains_are_not_created_equal_111463.html>. For an early related argument, see Martin C. Libicki, "Cyberspace Is Not a Warfighting Domain," *I/S: A Journal of Law and Policy for the Information Society* 8, no. 2 (2012).

[10] Mike Pietrucha, "No End in Sight to the Army's Dependence on Airpower," *War on the Rocks*, December 13, 2016, available at <https://warontherocks.com/2016/12/no-end-in-sight-to-the-armys-dependence-on-airpower/>.

[11] A.J. Shattuck, "The Pipe Dream of (Effective) Multi-Domain Battle," Modern War Institute at West Point, March 28, 2017, available at <https://mwi.usma.edu/pipe-dream-effective-multi-domain-battle/>.

[12] Mike Benitez, "Multi-Domain Battle: Does It End the Never-Ending Quest for Joint Readiness?" *Over the Horizon*, May 2, 2017, available at <https://overthehorizonmdos.com/2017/05/02/mdb-joint-readiness/>.

[13] See James Stavridis and David Weinstein, "Time for a U.S. Cyber Force," U.S. Naval Institute *Proceedings* 140, no. 1 (January 2014). The House Armed Services Committee mark of the 2018 National Defense Authorization Act calls for the creation of a separate Space Corps.

[14] Michael C. Davies, "Multi-domain Battle and the Masks of War," *Small Wars Journal*, May 11, 2017, available at <http://smallwarsjournal.com/blog/multi-domain-battle-and-the-masks-of-war-why-it's-time-to-eliminate-the-independent-services>.

[15] Sydney J. Freedberg, Jr., "Army Must Be Ready for Multi-Domain Battle in Pacific 'Tomorrow,'" *Breaking Defense*, January 31, 2017, available at <https://breakingdefense.com/2017/01/army-must-ready-for-multi-domain-battle-in-pacific-tomorrow/>.

[16] Megan Eckstein, "Army Set to Sink Ship in 2018 as PACOM Operationalizes Multi-Domain Battle Concept," *USNI News*, May 30, 2017. The Army had a standing mission to "sink ships" in the form of the Coast Artillery Corps from 1901 to 1950.

[17] Benitez.

[18] Sydney J. Freedberg, Jr., "Army's Multi-Domain Battle Gains Traction Across Services: The Face of Future War," *Breaking Defense*, March 13, 2017, available at <https://breakingdefense.com/2017/03/armys-multi-domain-battle-gains-traction-across-services/>.

[19] David G. Perkins, "Multi-Domain Battle: Joint Combined Arms Concept for the 21st Century," Association of the United States Army, November 2016, available at <www.ausa.org/articles/multi-domain-battle-joint-combined-arms-concept-21st-century>. The notion of extended battle dates to General Don Starry and the development of the AirLand Battle

Concept in the early 1980s. See Don Starry, "Extending the Battlefield," *Military Review* 61, no. 3 (March 1981), 31–50.

[20] J.P. Clark, "In Defense of a Big Idea for Joint Warfighting" *War on the Rocks*, December 22, 2016, available at <https://warontherocks.com/2016/12/in-defense-of-a-big-idea-for-joint-warfighting/>. Kevin Benson, "Extending the Second Offset and Multi-Domain Battle," *Real Clear Defense*, November 29, 2016, available at <www.realcleardefense.com/articles/2016/11/30/extending_the_second_offset_and_multi-domain_battle_110411.html>.

[21] U.S. Army–Marine Corps White Paper, "Multi-Doman Battle: Evolution of Combined Arms for the 21st Century," September 30, 2017, available at <www.tradoc.army.mil/multidomainbattle/docs/DRAFT_MD-Bconcept.pdf>. The Air Force is developing a related Multi-Domain Operations concept that combines Air Force theater contributions into a unified air-space-cyberspace capability set in support of the joint force. See "Multi-Domain Command and Control: The Air Force Perspective with Brigadier General B. Chance Saltzman" (Part 1 of 2), *Over the Horizon*, April 3, 2017, available at <https://overthehorizonmdos.com/2017/04/03/multi-domain-command-and-control-the-air-force-perspective-with-brigadier-general-b-chance-saltzman-part-1-of-2/>. Saltzman makes the distinction with traditional combined arms by arguing, "[combined arms] is using the assets you have, in some cases from different functions or different domains. Whether it's artillery, armor, infantry, aviation, those are the traditional arms we're talking because a lot of times we talk about combined arms in terms of the Army sense of things."

[22] *Overmatch* is defined as "the application of capabilities or unique tactics either directly or indirectly, with the intent to prevent or mitigate opposing forces from using their current or projected equipment or tactics." See U.S. Army–Marine Corps White Paper, 13, 17, 55, 61, 73.

[23] In the context of a specific campaign, all domains are not of equal value. Even opponents in the same battle may, for a host of reasons, not share the same view of a domain's value.

[24] Phillip D. Shutler, "Thinking About Warfare," *Marine Corps Gazette*, November 1987, 20, 23–25.

[25] J.J. Edson, "The Asymmetrical Ace," *Marine Corps Gazette*, April 1988, 51.

[26] Guadalcanal was a pivotal battle in the larger Solomon's campaign but a closely contested fight to the bitter end. The United States suffered a terrible naval defeat in the Battle of Savo Island, August 8–9, 1942, which reduced Allied heavy cruiser strength in the Pacific by more than 33 percent and compelled Navy transport and supply ships to depart the objective area prematurely. Command relationships between senior Marine Corps and Navy commanders were also overly complex, which led to unnecessary friction. For a more detailed account, see Jeter A. Isley and Philip A. Crowl, *The U.S. Marines and Amphibious War: Its Theory and Its Practice in the Pacific* (Princeton: Princeton University Press, 1951), 130, 153–162.

[27] The proximate cause, however, was a textbook case of two serious and mutually reinforcing misjudgments. These misjudgments, as one scholar put it, stemmed from "the belief in London that Argentina would not invade the Falkland Islands and the expectation in Buenos Aires that Britain would accommodate itself to a military takeover of the islands." See Richard Ned Nebow, "Miscalculation in the South Atlantic: The Origins of the Falkland War," *Journal of Strategic Studies* 6, no. 1 (1983), 5.

[28] Sandy Woodward, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander* (Annapolis, MD: U.S. Naval Institute Press, 1992), 246.

[29] In an effort to isolate the islands and limit the scope of the campaign, Great Britain declared a 200-mile radius Total Exclusion Zone around the Falkland Islands. This declaration had the tacit effect of making the Argentinian home waters a bastion for the Argentine navy.

[30] Sir Lawrence Freedman, *The Official History of the Falklands, Volume II: War and Diplomacy* (New York: Routledge, 2005), 431. Freedman wrote, "This was a remarkably successful raid, depriving the garrison of a number of aircraft and undermining morale, by demonstrating the capacity of special forces to mount operations on the Islands against units that were detached from the main forces." That said, Argentine aircraft remaining in the Falklands after the raid were assessed to be three Shyvan light transports, two navy Tracker early warning aircraft, nine Pucara counterinsurgency aircraft, four Chinooks, three Puma, and one Agusta 109. Although none of these aircraft threatened the overall outcome of the campaign, they remained a major concern throughout it.

[31] The most common original Churchill version is "Gentlemen, we have run out of money: Now we must think." Some evidence suggests Churchill borrowed the phrase from famed physicist Sir Ernest Rutherford.

[32] The other two major types of experiments are hypothesis tests and demonstrations. Both could play a role in narrow aspects of the campaign but could not serve as a description of the overall experimentation effort.

[33] *Joint operating concepts* (JOCs) "broadly describe how the joint force may execute military operations within a specific mission area in accordance with defense strategic guidance and the CCJO. Collectively, JOCs describe joint capabilities required to operate across the range of military operations and encourage further examination through wargaming, joint training, and a variety of studies, experimentation, and analyses." See Chairman of the Joint Chiefs of Staff Instruction 3010.02E, *Guidance for Developing and Implementing Joint Concepts* (Washington, DC: The Joint Staff, August 17, 2016), A-10.

[34] Ibid., A-1.

[35] Examples include the Navy's Fleet Problem series in the 1920s and 1930s that integrated fledgling naval airpower into fleet operations, Brigadier General Billy Mitchell's Project B experiments on the use of airpower against shipping, or the Marine Corps' Fleet Landing Exercises in the 1930s leading to the validation of Major Earl Hancock "Pete" Ellis's amphibious concepts. See Williamson Murray, *Experimentation in the Period Between the Two World Wars: Lessons for the Twenty-First Century* (Alexandria, VA: Institute for Defense Analyses, November 2000).

[36] National Research Council, *The Role of Experimentation in Building Future Naval Forces* (Washington, DC: National Academies Press, 2004), available at <www.nap.edu/catalog/11125/the-role-of-experimentation-in-building-future-naval-forces>.

[37] The failure of the Joint Warfare System, Joint Simulation System, and Joint Modeling and Simulation System programs stemmed from not only the efforts' complex and high-risk technical natures but also some of the same integration and development issues that challenge the development of joint capabilities. For a summary of the issues and lessons, see Robert Lutz et al., *Factors Influencing Modeling and Simulation to Inform OSD Acquisition Decisions* (Alexandria, VA: Institute for Defense Analyses and Johns Hopkins University, April 2017).

[38] The authors are indebted to our colleague Dr. Sue Numrich for input on discovery experimentation. See also David S. Alberts, ed., *Code of Best Practice: Experimentation* (Washington, DC: Department of Defense, July 2002), 21.

[39] Michael Howard, "Military Science in an Age of Peace," *RUSI Journal* 119, no. 1 (1974), 2.