SYM-AM-22-053

Excerpt from the Proceedings of the Nineteenth Annual Acquisition Research Symposium

Acquisition Research: Creating Synergy for Informed Change

May 11–12, 2022

Published: May 2, 2022

Prepared for the Naval Postgraduate School, Monterey, CA 93943.

Acquisition Research Program
Department of Defense Management
Naval Postgraduate School

The research presented in this report was supported by the Acquisition Research Program at the Naval Postgraduate School.

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Resourcing a Mosaic Force: Lesions from an Acquisition Wargame

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Abstract

DARPA has an ambitious vision for Mosaic Warfare, conceived by its Strategic Technology Office (STO) leadership as both a warfighting concept and a means to greatly accelerate capability development and fielding. Although the success of Mosaic depends on DARPA advancing multiple technologies, the Mosaic vision is inherently more challenging to "transition" than is a program or technology. Anticipating this challenge, DARPA sponsored RAND to examine the opportunities and challenges associated with developing and fielding a Mosaic force under existing or alternative governance models and management processes, as would be required for the vision to move from DARPA to widespread acceptance by DoD. To this end, RAND designed and executed a policy game that immersed participants in the task of fielding a Mosaic and required them to operate within the authorities, responsibilities, and constraints of the existing and an alternative governance model. This article presents select findings on the capacity of the existing acquisition resourcing system (i.e., the Planning, Programming, Budgeting, and Execution [or PPBE] process) to exploit STO's vision of Mosaic Warfare.

Preface

This research was sponsored by the DARPA's Strategic Technology Office and conducted within the Acquisition and Technology Policy Center of the RAND National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Navy, the Marine Corps, the defense agencies, and the defense Intelligence Community. For more information on the RAND Acquisition and Technology Policy Center, see www.rand.org/nsrd/ndri/centers/atp or contact the director (contact information is provided on the webpage).

Introduction

DARPA has an ambitious vision for Mosaic Warfare, conceived by DARPA's Strategic Technology Office (STO) leadership as both a warfighting concept and a means to greatly accelerate capability development and fielding. Although the success of Mosaic Warfare depends on DARPA advancing multiple technologies (Clark et al., 2020), STO's Mosaic vision is inherently more challenging to "transition" than is a program or technology. Anticipating this challenge, DARPA sponsored RAND to examine the opportunities and challenges associated with developing and fielding a Mosaic force under existing or alternative governance models and management processes, as would be required for the vision to move from DARPA to widespread acceptance by the DoD.

This article focuses on a subset of the results of a larger study on the "big A" acquisition implications of Mosaic Warfare.[1] Specifically, this article focuses on the intersection of the status quo resourcing system (i.e., the Planning, Programming, Budgeting, and Execution [or PPBE] process) and Mosaic Warfare. Given the recent attention on defense resourcing reform and the importance of the PPBE-based barriers to acquiring a Mosaic force that were identified during the larger study, we believe this to be an opportune time to highlight this set of our larger findings.

Conceptualizing Mosaic Warfare

A complete survey of Mosaic as a warfighting concept is beyond the scope of this report but can be found in other sources (Clark et al., 2020; Deptula et al., 2019; Grana et al., 2021; Grayson, 2018; O'Donoughue et al., 2021). Briefly, Mosaic Warfare is conceived by STO leadership as both a warfighting concept and a means to greatly accelerate capability development and fielding. With regard to warfighting, Mosaic Warfare entails a more fractionated, heterogenous force that can be dynamically composed on tactical timelines into unique force packages to surprise and overwhelm an adversary. As such, Mosaic Warfare entails shifting away from a focus on monolithic platforms, which are slow-to-develop and slow-to-field, to focus on simpler force elements that can be developed and fielded quickly and integrated at mission execution.

At the top level, the Mosaic concept envisions a U.S. Force characterized by three properties.

Fractionation. Fractionation refers to the extent to which the capabilities of a military force are concentrated on particular weapons platforms. A monolithic or non-fractionated force locates a large number of capabilities on one platform; the F-35 is perhaps the canonical example of a monolithic platform, with the capabilities of a sensor, shooter, command control node, electronic warfare, and others all integrated on a single platform. In contrast, a fractionated force spreads such functions and capabilities across an array of platforms. Mosaic Warfare envisions a more fractionated U.S. force.

Heterogeneity. Heterogeneity refers to the extent to which the platforms in a military force possess distinct capability sets. In a homogeneous force, platforms have a high degree of capability overlap. As the DoD transitions away from legacy fourth generation fighters to the F-35, by definition the U.S. TACAIR fleet will grow more homogenous, notwithstanding differences between F-35 variants and what will be an ever-evolving series of incremental capability upgrades. In a heterogeneous force, platform capabilities will have less commonality and more diversity; for example, the same electronic warfare effect might be delivered by a UAV, an aerostat, or a low-cost cruise missile. Mosaic Warfare envisions a more heterogeneous U.S. Force.

Composability. Composability refers to the extent to which force elements can be dynamically combined in different ways to deliver an operational effect. A highly non-composable force would be constrained to fixed, pre-specified kill chains embodied by a codified system architecture; the Ballistic Missile Defense system represents an archetype. A highly composable force eliminates the concept of an architecture, allowing kill chains to be created dynamically from the force elements available at the time of mission execution. Mosaic Warfare envisions a more composable force, where an AI-

[1] The full report is available open access and can be found at the following link: https://www.rand.org/pubs/research_reports/RRA458-3.html

enabled decision aid will facilitate the force package composition function at the time of mission execution.

For purposes of this report, we will assume that a force with these properties is militarily advantageous and technically feasible. However, let us briefly comment on the operational and acquisition-related advantages of Mosaic Warfare as conceived by DARPA.

In terms of operations, Mosaic Warfare proponents expect that a fractionated, heterogeneous, and composable force will increase the adaptability, scalability, and unpredictability of the U.S. Force. The current force, it is argued, comprises force packages that are self-contained or part of fixed system-of-systems architectures and thus limited in terms of the distinct force presentation permutations available. In contrast, a Mosaic force will decompose force packages into a larger number of more varied elements, thereby increasing the number, resiliency, and ultimately the effectiveness of force packages available for employment by U.S. Commanders. Clark et al. (2020, p. 27) succinctly characterize some of the hypothesized warfighting advantages of Mosaic Warfare, stating:

> The central idea of the Mosaic Warfare concept is to create adaptability and flexibility for U.S. Forces and complexity or uncertainty for an enemy through the rapid composition and recomposition of more disaggregated U.S. Forces using human command and machine control.

DARPA also anticipates that Mosaic Warfare may accelerate the weapons system acquisition and fielding process. The development of complex multi-mission platforms is slow and expensive. Much of the cost and schedule expended in the development of these platforms stems from a requirements system that attempts to forecast general purpose requirements, which tend to prescribe costly, complex solutions embodied by monolithic solutions. By fractionating systems–and therein decreasing the average complexity of systems in the acquisition pipeline, Mosaic Warfare is anticipated by DARPA to entail individually simpler systems that are subject to less cost, schedule, and performance risk; defer integration challenges to the mission-level; and result in a flexible, modular force that can be continually upgraded over time. Deptula et al. (2019) explain that the functional effect of transitioning to a Mosaic force composition on acquisition and fielding may be to realize the benefits sought during the many recent rounds of acquisition reform, affirming,

> Incrementally migrating the current force to a system of disaggregated capabilities is an approach that could finally achieve the goals that many of DoD's previous attempts at acquisition reform have sought.

The elements of a Mosaic force also can be expected to be more autonomous, expendable, and short-lived than the technologies comprising today's force. These traits may positively reinforce the core Mosaic concepts of fractionation, heterogeneity, and composability. For example, autonomous systems may hasten the anticipated speedup in fielding by eliminating certain portions of the operator training cycle. Expendable systems can be expected to eliminate time-intensive sustainment processes such as repair, maintenance, and upgrading. Shorter weapon system lifespans may obviate the cost and schedule implications of a requirement to maintain long (e.g., 30 year) service lifetimes.

To be sure, this is an abbreviated if not incomplete description of DARPA's vision for Mosaic Warfare. However, it suits our purpose of introducing Mosaic Warfare in sufficient detail to motivate several assumptions. We refer the reader to references cited within the preceding discussion for further information on Mosaic Warfare.

In the following section, we briefly describe the acquisition policy game designed to explore the consequences of acquiring a Mosaic force within the current and an alternative governance models.

Game Design

For the purposes of the larger study on which this article draws, we were principally interested in the implications of Mosaic Warfare for requirements, resourcing, and acquisition. In that context, two hypotheses frame our research.

1. DARPA's vision of Mosaic Warfare can enable orders of magnitude reduction in time for the transition from idea to effect, allowing force development on operational if not tactical timescales.
2. Mosaic Warfare may be necessary but will not be sufficient to achieve such increased throughput—it must be complemented with new approaches to setting requirements, resourcing, and acquisition.

Based on the two hypotheses, we distill two research questions.

1. Are the DoD's existing requirements, resourcing, and acquisition structures and processes compatible with fielding DARPA's vision of Mosaic Warfare? Are those management systems compatible with the envisioned increases in time-effectiveness?
2. If the DoD's current governance systems are not adequate to handle the increased time effectiveness, what are viable alternative governance models and management systems for acquiring a Mosaic force? What are the opportunities, challenges and risks associated with them?

To answer these questions, we reviewed existing studies, spoke to experts, and designed and executed the *Acquiring a Mosaic Force Policy Game* to immerse DARPA representatives and RAND researchers in the task of fielding a Mosaic force and required them to operate with the authorities, responsibilities, and constraints provided to them under existing or alternative governance models and management constructs. In total, we executed two internal (RAND only) play-tests of the policy game while hypotheses and the game design were still in formation and one "capstone" game with combined DARPA-RAND participation once these hypotheses were firmer.

In order to better understand how the current and an alternative governance models would work in conjunction with Mosaic Warfare, we developed a three-part activity, depicted visually in Figure 1. Each activity took the form of a virtual, half-day session conducted. The activities were exercised two times internally, and once with a mixed group of RAND and DAPRA personnel. As detailed above, the activities posited that Mosaic Warfare was technically feasible, was accepted by the DoD, and that an initial suite of capabilities had been successfully fielded. From this starting point, we asked players to consider how the acquisition of both individual capabilities and the Mosaic enterprise as a whole might be managed.

	Half Day 1: Mosaic in Today's System	Half Days 2&3: Mosaic in an Alternative Model
Goal of exercise	Identify conditions under which today's requirements, resourcing & acquisition systems support a Mosaic model	Exercise an alternative to today's management systems to assess viability & identify improvements
Role of participants	Experienced professionals and analysts	Role playing DoD stakeholders

Figure 1. Structure of Three Half-Day Virtual Event

Day 1 focused on how the current acquisition system could accommodate both individual tiles (i.e., specific Mosaic enabler technologies) and a Mosaic force as a whole. This activity was designed to explore the shortfalls of the current system by working to identify "pain points." To do this, we used a format based on previous a RAND game to assessing C2 structures (Alkire et al., 2018). Drawing on the principles of Assumptions Based Planning (Dewar et al., 1993), we provided players with a set of vignettes (two of which are included in Tables 1 and 2 below) describing instances of successful Mosaic acquisition, including descriptions of requirements, resourcing, contractor selection and management, testing and evaluation, fielding, and maintenance and sustainment. Players were then asked to describe what assumptions would have to hold true in today's system for the vignette to play out as described. A facilitator then led a discussion regarding the reasonableness of those assumptions. This process allowed players to grapple with the difficulty of making Mosaic Warfare work under the current rules and processes, adding to our understanding of the barriers to acquiring a Mosaic force.

The second two activities changed the focus from examining Mosaic under the current system to exploring Mosaic acquisition under an alternative system. While these activities drew on lessons from past work on acquisition policy gaming (Bartels et al., 2020), the activities that were used during days two and three was designed specifically for exploring acquisition under a Mosaic Warfare construct. This allowed us to explore the interaction between a pipeline of Mosaic capabilities and an alternative acquisition system designed to accommodate Mosaic acquisition.

Entering days two and three, the research team presented the Joint Mission Office (JMO)-centered acquisition model (the details of the JMO as played are described in the full report [Predd et al., 2021].) Activity two focused on how enterprise-level acquisition management might occur under the JMO-centered model. Activity three focused on tile-level decisions under the same model.

In both activities, players were divided into two teams. One team was comprised of players representing the Anti-Surface Warfare (ASuW) JMO. The other team was comprised of players representing traditional institutional players: the Services, COCOMs, and the Office of the Secretary of Defense. A more detailed breakdown of roles is visualized in Figure 2. Players were assigned to roles that mirrored their past expertise. These roles are shown to be seated around the proverbial table in Figure 3. Using experienced players allowed us to depend on participants' mental models of institutional equities, authorities, and processes to bring additional realism and surface concerns about which the RAND design team may not have been

aware. Thus, our players added greater fidelity to the representation of the interactions between the JMO and institutional roles.

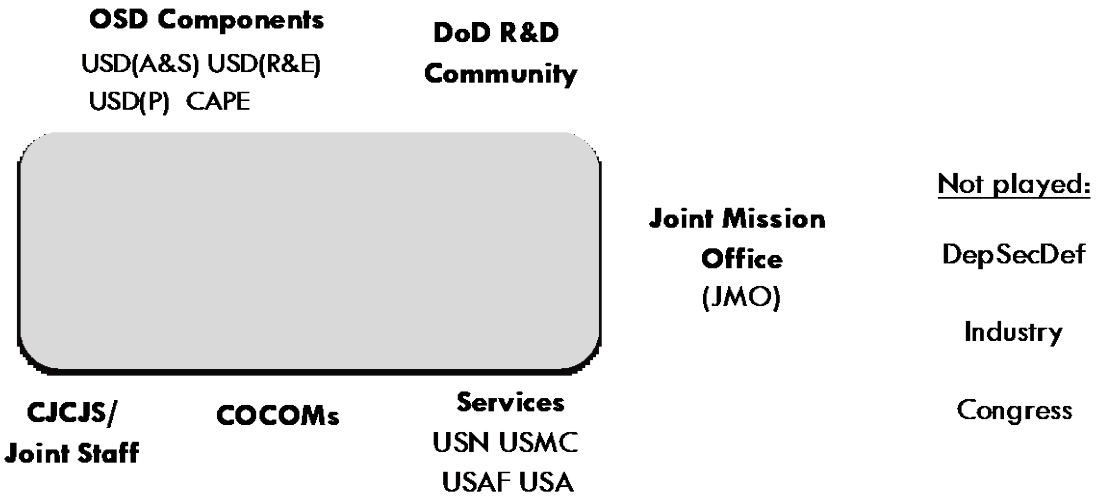

Figure 2. Players Inhabit the Roles of DoD Decision Makers

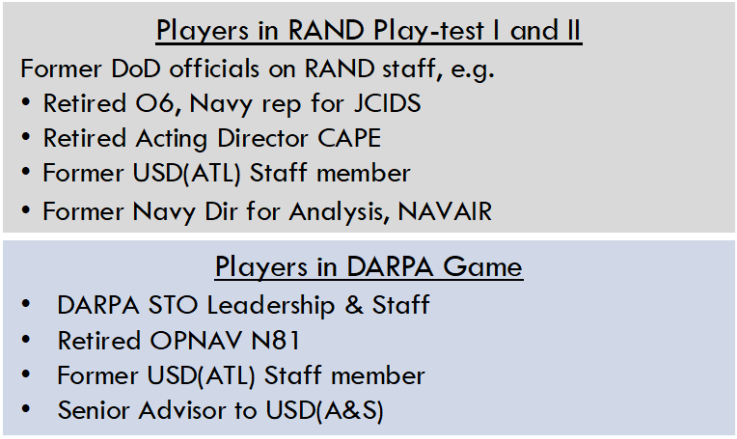

Figure 3. Players' Backgrounds Reflect Assigned Roles

In activity two, players were provided with a portfolio of contrived Mosaic programs (i.e., Mosaic tiles) and a budget and asked to make decisions about what tiles to fully fund, which to keep warm for potential future investment, and which to terminate. For each tile, players were provided with a description of the system and data including estimates of cost, schedule, and anticipated gain in mission effectiveness. JMO players were asked to use these data to develop a strategy for acquisition, while institutional players acted as liaison officers to represent the concerns of their offices. After a first round of decisions, the RAND research team projected how the portfolio would perform the following year, with a specific eye to highlighting the tradeoffs identified in previous stages of research.

The third activity maintained the same general structure as the second: the JMO and institutional teams made sequences of decisions about the acquisition of Mosaic capabilities. However, during the third activity, decisions were made at the level of individual Mosaic tiles. In

this activity, we presented players with several key decision points, which sought to elicit potential points of tension between the JMO and institutional actors. The resultant discussion provided confirming evidence to support our preliminary hypotheses, unearthed additional tensions, and offered tension mitigation strategies.

Vignettes

The intersection of the Mosaic Warfare vision and acquisition is sufficiently uncertain and abstract that planners and policymakers may benefit from concrete representations of how Mosaic acquisition would manifest. One way of providing this tangibility is through vignettes, which illustrate possible manifestations in narrative form. The vignettes describe successful "instances" of Mosaic acquisition at the tile- and enterprise-level. The tile-level vignettes are comprised of a set of events associated with the acquisition of a new ELINT sensor, an EW payload, and XLUUV-launched loitering UUV munitions. The enterprise-level vignettes consider Mosaic acquisition at the level of the DoD enterprise. They describe the changes to the force structure, industrial base, and R&D pipeline associated with shifting a portion of acquisition from monolithic platforms to dozens of new short-lived, low-cost, Mosaic tiles (e.g., attrittable platforms, data links, C2 nodes, decision aids, sensors, loitering munitions, small satellites, and counter-UAS systems). The vignettes do not reference any specific acquisition governance model or management system. Instead, they provide generic descriptions of requirements, resourcing, vendor selection, testing and evaluation, fielding, maintenance, and sustainment events for the capabilities in question. In this article, two tile-level vignettes are used to highlight tensions between the PPBE process and Mosaic-style acquisitions.

The Resourcing Function

In the larger study, we conceived of "acquisition" in a very general sense, including the end-to-end timeline that begins with an idea on an engineer's whiteboard and culminates with an operational effect delivered on the battlefield. Today, DoD exercises management control over this process through three primary management systems sometimes referred to as the "Big A" acquisition system: the requirements system, manifested by JCIDS; the resourcing system, represented by PPBE; and the DAS, represented by DoDD 5000.01 and DoDI 5000.02, and more recently by the Adaptive Acquisition Framework.[2] In this article, we are concerned with the PPBE process.[3]

The PPBE process, instituted more than 60 years ago, is the DoD's primary resource allocation managements system. PPBE occurs annually and yields the DoD's contribution of the President's annual budget request. It is also used each year to update the DoD's Future Years Defense Program (FYDP).

At least two features of PPBE process have implications for the acquisition of Mosaic force. First, PPBE is a calendar-driven process involving a roughly two-year gap between the resource allocation decision and the date at which these resources are available for use. Second, PPBE is inflexible with regard to re-allocating funds. The implications of these features are manifold. The section to follow elaborates several of these implications for the prospect of acquiring a Mosaic force.

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[2] In fact, there are other relevant management systems in play, including the Global Force Management Process, which governs DoD posture and force allocation, and of course multiple operational planning processes. In the larger study we focus on those traditionally considered part of the big "A" acquisition process.

[3] We do not provide a comprehensive summary of the status quo resources system in this article. The current (as of March, 2021) DoD guidance on the PPBE Process is documented in DODD 7045.14 (effective date Aug 2017).

The Resourcing Function and Acquiring Mosaic Capabilities

A general finding from our analysis is that the PPBE process has limited flexibility to accommodate a warfighting concept that relies on agility in terms of what capabilities are pursued and by whom. Two features of the current PPBE process were identified by players to be particularly significant impediments to acquiring a Mosaic force. These features, along with their implications for fielding a Mosaic force, are elaborated below, and summarized in Table 3.

We arrived at these findings, in part, by considering how the incumbent resourcing system might accommodate a series of hypothetical acquisition events. These vignettes were provided to participants during day one of our "Acquiring a Mosaic Force" game. The vignettes are meant to be emblematic of the types of capability acquisitions envisioned by Mosaic Warfare. They are used here to highlight the interaction of the PPBE process and Mosaic-style acquisition.

PPBE is a Calendar-Driven Process Involving a Two-Year Gap Between Resource Allocation and Resource Availability

Under the current system, funding for a program must be requested approximately two years prior to the allocation of funds. This feature of the PPBE process has at least three consequences that are at odds with fielding a Mosaic force.

First, the planning-to-resourcing gap forestalls the ability to realize novel capabilities via unanticipated technology opportunities. Table 1 describes the events associated with "Capability Thread A," a technology-push acquisition of a new ELINT sensor. Within the same fiscal year, the decision is made to integrate the ELINT sensor onto fielded aerostats, a firm is put on contract, technology integration takes place, and the capability is tested during a live fire exercise. The PPBE process requires that funding used in a given year, be planned at least two years prior. In the events described in Table 1, the technology opportunity and the resource allocation occur within the same fiscal year. During the game, participants identified this inconsistency, observing that the while the traditional PPBE process may be able to handle such acquisitions on a small scale, the incumbent resourcing model could not likely accommodate the volume of such acquisitions that would be required to field a Mosaic force.

Table 1. Vignette (Capability "Thread") A—Leap Forward Sensor Tech

Events (all occur within a single year)
• A.1. A small firm demonstrates a promising new ELINT sensor on a medium rotary-wing UAS at White Sands.
• A.2. Analysis shows 20% improvement in mission (ASuW) effectiveness in 20% of scenarios analyzed with 80% probability if the sensor is integrated onto either a medium UAS or an aerostat.
• A.3. Analysis shows the sensor outperforms other fielded ELINT sensors as well as those already in the enterprise-wide development pipeline.
• A.4. An in-year decision is made to fund integration of the sensor onto a fielded aerostat.
• A.5. The small firm is put on contract to produce enough units of the sensor to achieve the net-mission effectiveness improvement as government furnished equipment (GFE) provided to the prime aerostat sustainment contractor for integration.
• A.6. The prime contractor delivers and installs an initial set of sensors onto aerostats assigned to a Naval task force ahead of a Pacific exercise, at an additional, unplanned cost representing 5% of the aerostat's program's yearly budget.
• A.7. The capability is demonstrated in live fire exercises as part of a kill chain that uses aerostats to cue land-based fires against naval SAMs.

The events described in Table 2 underscore another point of friction between Mosaic Warfare and PPBE: that of quickly resourcing a capability to respond to a change in the threat environment. Table 2 describes a series of hypothetical events whereby a threat (i.e., Chinese near-real-time situational awareness of U.S. movements via a long range UAS) is identified, a means of mitigating that threat is found, and funds are allocated to develop and integrate the new technology. Put plainly, Table 2 describes an acquisition system responding rapidly to a new threat. Again, participants in our game, indicated that the PPBE process was unlikely to accommodate such acquisitions *en masse* (as would be required by a Mosaic Force).

Table 2. Vignette (Capability "Thread") B—Emergent Critical Requirement Gap

Events (all occur within a single year)
• B.1. Intel reports a previously unknown Chinese long range UAS is being tested that is capable of providing near-real-time situational awareness of U.S. movements in potential future engagements.
• B.2. Analysis confirms that, unimpeded, the new UAS threat may degrade mission (ASuW) effectiveness by 20% in 30% of scenarios analyzed, representing a significant requirements gap.
• B.3. Analysis shows that fielding a previously prototyped yet never fielded Air Force-developed RF effector payload to Group 3 (< 1,320 MGTOW) UASs could function as an effective countermeasure to the Chinese UAS and largely mitigate net-mission effectiveness losses. Further, there is a potential force multiplication effect provided if this RF effector is fielded in concert with the sensor in Capability Thread A. Analysis suggests that if the RF effector and ELINT sensor are both fielded there is an 70% probability that anticipated mission (ASuW) effectiveness increase of as much as 30% in 35% of future scenarios analyzed.
• B.4 The Air Force contracts with multiple companies (totaling 4 years, $166,000,000) to ramp up on the mothballed payload, mature the technology, and explore its performance on seven different existing platforms, as well as consider adapting existing platforms not currently in DoD use.
• B.5. Field tests are conducted at the Air Force Test Center in California that reveal unforeseen challenges in integrating the RF effector payload onto existing Group 3 UAS.
• B.6. A decision is made to retire an U.S. Air Force R&D project to overcome integration challenges and expedite fielding of the system.

Third, the two-year resource allocation waiting period limits new- and non-traditional firm entry into DoD contracting. Mosaic Warfare requires a highly robust technology pipeline, and its advocates seek that this pipeline be populated in large part by technologies developed by non-traditional vendors. Non-traditional defense contractors such as startups or civilian-servicing firms often lack the resources or willingness to wait two years before receiving funding.

PPBE is Inflexible with Regard to Re-allocating Resources

Within the current resourcing system, the primary means of reallocating funds in the year of execution—reprogramming—is inflexible. For example, a PEO's below threshold reprogramming (BTR) for RDT&E is just 20% of the RDT&E cost or $10 million (whichever is lesser). For procurement, the PEO's BTR is 20% of procurement cost or $20 million (whichever is lesser). This gives PEOs very little flexibility to reallocate resources to adjust to novel threats or take advantages of emergent technology opportunities.

Above the threshold reprogramming (ATR) requires passing an arduous Congressional approval process. Besides slowing the process of funds reallocation, the need for Congressional approval requires the DoD to expend scarce political capital. When players explored the source of funding for Mosaic-type acquisitions as described in Tables 1 and 2, players commented on the impracticality of relying on reprogramming for capabilities of relatively low cost—put bluntly, the bureaucratic costs of securing congressional support outweighed the limited value of each individual Mosaic capability, and the value of the Mosaic force as a whole would get lost in the small-scale transactions required under the status quo.

Another effect of inflexible funding is technology lock-in. The technological approaches or components used within a program were selected based on estimates of technical maturity and rates of technological change made years prior to the point at which they are ready to be integrated into a given weapons system. At integration time, it is therefore possible that the chosen approach is not sufficiently mature or is no longer the best solution with respect to cost or performance. In such cases, switching to a different component may be warranted. However, the rigidity of the reprogramming function often precludes such switching, resulting in the use of a component technology that is no longer optimal for the system in question.

Table 3. PPBE Features, Consequences, and Contrast to Mosaic Warfare

Feature of Current Resourcing System	**Consequence**	**Mosaic Warfare Seeks**
PPBE is a calendar-driven process involving a two-year gap between resource allocation and resource availability	Limits ability to respond to unanticipated technology opportunities	Ability to rapidly incorporate new technology into force
	Limits responsiveness to threats	Responsiveness to a dynamic threat environment
	Limits new- and non-traditional firm entry into defense innovation marketplace	A defense innovation system comprised of a greater diversity of contributing organizations
PPBE is inflexible with regard to re-allocating resources	Limits ability to respond to unanticipated technology opportunities and threats	Ability to rapidly incorporate novel technology into force and respond to threats
	Encourages technology lock-in	Ability to rapidly switch technological approaches

Conclusion

The findings presented here are not necessarily novel; the ailments of the PPBE process have been observed by many.[4] However, the use of an acquisition policy game provides a novel source of evidence in assessing acquisition system performance. In addition, the policy game that we designed proved to be a useful way of experimenting with alternative governance models. Placing DoD representatives in the mode of decision makers operating within the Mosaic model allows for insights that would not be easily deduced from mere logic. While not reported here, a variety of lessons were learned that could improve subsequent games—thus continuing the iterative learning process of formulating refined hypotheses, adapting and

[4] Eric Lofgren of Acquisition Talk has compiled an excellent list of calls for budget reform from prominent sources. They can be found here: https://acquisitiontalk.com/budget-reform/

executing games, and so on. We suggest that DARPA and other defense agencies continue to experiment with alternative acquisition governance systems and management systems.

DARPA's vision of Mosaic Warfare is ambitious, compelling, and seemingly responsive to many attributes of the emerging technological and security environment. Transitioning this vision to widespread DoD acceptance may well require strong proponents across the DoD to create change within institutions that today may—given their accrued equity in longstanding governance structures—in certain cases view the status quo as an end rather than a means. We advise the proponents of Mosaic Warfare to be mindful of falling into the same trap by making Mosaic an end rather than a means. Like all emerging visions for the future of American warfighting, the ultimate test for Mosaic will be its contribution to the United States' ability to deter and defeat adversary aggression.

References

Alkire, B., Lingel, S., & Hanser, L. (2018). *A wargaming method for assessing risk and resilience of military command-and-control organizations.* RAND Corporation.

Clark, B., Patt, D., & Schramm, H. (2020). *Mosaic warfare exploiting artificial intelligence and autonomous systems to implement decision-centric operations.* CSBA, Center Strategic Budgetary Assessments. https://csbaonline.org/uploads/documents/Mosaic_Warfare_Web.pdf

Deptula, D. A., Penney, H. R., with Stutzriem, L. A., & Gunzinger, M. A. (2019, September). *Restoring America's military competitiveness: Mosaic warfare.* The Mitchell Institute for Aerospace Studies. http://docs.wixstatic.com/ugd/a2dd91_29e021b297f2492ca7f379d31466ad0c.pdf

Dewar, J. A., Builder, C. H., Hix, W. M., & Levin, M. H. (1993). *Assumption-based planning: A planning tool for very uncertain times* (MR-141-A). RAND Corporation.

Grana, J., Lamb, J. & O'Donoughue, N. A. (2020). *The benefits of fractionation in competitive resource allocation* (WR-1329). RAND Corporation. https://www.rand.org/pubs/working_papers/WR1329.html

Grayson, T. (2018, July 27). *Mosaic warfare*. https://www.darpa.mil/attachments/STO-MosaicDistro-A.pdf

Lempert, R. J., Popper, S. W., & Bankes, S. C. (2013). *Shaping the next one hundred years: New methods for quantitative, long-term policy Analysis* (MR-1626). RAND Corporation.

O'Donoughue, N. A., McBirney, S. & Persons, B. (2021). *Distributed kill Chains: Drawing insights for mosaic warfare from the immune system and from the Navy.* RAND Corporation. https://www.rand.org/pubs/research_reports/RRA573-1.html

Predd, J. B., Schmid, J., Bartels, E. M., Drezner, J. A., Wilson, B., Wirth, A. J., & McLane, L. (2021). *Acquiring a mosaic force: Issues, options, and trade-offs.* RAND Corporation. https://www.rand.org/pubs/research_reports/RRA458-3.html

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