ASPJ
Air & Space Power Journal

Vol. 34, Issue 1

Spring 2020

ASPJ Air & Space Power Journal

Air & Space Power Journal
600 Chennault Circle
Maxwell AFB AL 36112-6010
e-mail: aspj@us.af.mil

Visit *Air & Space Power Journal* online at https://www.airuniversity.af.edu/ASPJ/.

The *Air & Space Power Journal* (ISSN 1554-2505), Air Force Recurring Publication 10-1, published quarterly in both online and printed editions, is the professional journal of the United States Air Force. It is designed to serve as an open forum for the presentation and stimulation of innovative thinking on military doctrine, strategy, force structure, readiness, and other matters of national defense. The views and opinions expressed or implied in the *Journal* are those of the authors and should not be construed as carrying the official sanction of the Department of Defense, Air Force, Air Education and Training Command, Air University, or other agencies or departments of the US government.

https://www.af.mil/ https://www.aetc.af.mil/ https://www.airuniversity.af.edu/

VOL. 34 NO. 1 SPRING 2020

BOOK REVIEWS

Air & Space Power Journal Reviewers

Christian F. Anrig, PhD
Swiss Air Force

Filomeno Arenas, PhD
USAF Air Command and Staff College

Bruce Bechtol, PhD
Angelo State University

Kendall K. Brown, PhD
NASA Marshall Space Flight Center

Anthony C. Cain, PhD
Wetumpka, AL

Norman C. Capshaw, PhD
Military Sealift Command Washington Navy Yard, District of Columbia

Christopher T. Colliver, PhD
Wright-Patterson AFB, Ohio

Chad Dacus, PhD
USAF Cyber College

Maj Gen Charles J. Dunlap Jr., USAF, Retired
Duke University

Sandra L. Edwards, PhD
Thomas N. Barnes Center for Enlisted Education

Lt Col Derrill T. Goldizen, PhD, USAF, Retired
Naval War College

Col Mike Guillot, USAF, Retired
Editor, Strategic Studies Quarterly

Col Dale L. Hayden, PhD, USAF, Retired
Birmingham, AL

Brig Gen S. Clinton Hinote, USAF
Air Force Warfighting Integration Capability HAF/AJA, Pentagon

Thomas Hughes, PhD
USAF School of Advanced Air and Space Studies

Lt Col J. P. Hunerwadel, USAF, Retired
Curtis E. LeMay Center for Doctrine Development and Education

Tom Keaney, PhD
Senior Fellow, Merrill Center at the School of Advanced International Studies

Col Merrick E. Krause, USAF, Retired
Executive Director, Resource Management and Planning Board of Veterans' Appeals, Veteran's Affairs

Col Chris J. Krisinger, USAF, Retired
Burke, Virginia

Benjamin S. Lambeth, PhD
Center for Strategic and Budgetary Assessments

Rémy M. Mauduit
Editor, Forum of European, Middle Eastern, and African Affairs

Col Phillip S. Meilinger, USAF, Retired
West Chicago, Illinois

Richard R. Muller, PhD
USAF School of Advanced Air and Space Studies

Lt Col Jason M. Newcomer, DBA, USAF
USAF Air Command and Staff College

Col Robert Owen, USAF, Retired
Embry-Riddle Aeronautical University

Lt Col Brian S. Pinkston, USAF, MC, SFS
Air Force Review Board Agency

Maj Gen John E. Shaw, USAF
Headquarters Air Force Space Command A5/8/9 Peterson AFB, Colorado

Col Richard Szafranski, USAF, Retired
Isle of Palms, South Carolina

Lt Col Michael Tate, USAF, Retired
USAF Air University

Lt Col Edward B. Tomme, PhD, USAF, Retired
CyberSpace Operations Consulting

Lt Col David A. Umphress, PhD, USAFR, Retired
Auburn University

Xiaoming Zhang, PhD
USAF Air War College

CMSgt Michael J. Young, USAF, Retired
Montgomery, Alabama

FEATURE

First Sergeant

Weak-Tie of the Air Force Leadership Triad

CMSgt Josh Lackey, USAF

Introduction to the Problem of Practice

The intent of this article is to discuss the role of the Air Force first sergeant through the lens of a theoretical investigation based on an in-depth literature review, empirical observation, and experiential knowledge. It is worth declaring early that as of the initial writing of this article, the author was assigned as a command first sergeant. Consequently, limitations for the impact of this biased perspective were constructed by introducing peer review to validate the trustworthiness and credibility of the methods and conclusions.

To provide the greatest level of accessibility, the author formatted this article to improve information consumption and increase contextual applications into operational environments. The initial discussion begins with the role and elements of the Air Force leadership triad, followed by an analysis of the role of the first sergeant. Next, the article moves to the unique characteristics of the first sergeant in the triad, specifically that they work outside their Air Force Specialty Code (AFSC). Then, the article describes the elements of diversity, the causative factors, effects, and the social network subset of weak-ties. These weak-tie networks are reviewed in terms of the leadership triad and the overall network effect on the unit and the Air Force. Finally, the article incorporates a brief look into Utility

Theory and the constraints to diversity and weak-tie networks to form the analysis to demonstrate the scope of the theoretical framework. The overall construction of the research and theoretical investigation has been approached through the Socratic model: (1) what point of view is or should be present; (2) what is the purpose of the line of thinking; (3) what is the underlying question at hand; (4) what is the relevant evidence; (5) what assumptions are being made; (6) what guiding concepts, theories, or laws exist; (7) what can be inferred or implied from the existing evidence; and (8) what consequences or implications are present.

Leadership Triad

The squadron is the "beating heart of the Air Force" as described by the current Air Force chief of staff, Gen David L. Goldfein, and he put enough emphasis behind that belief to make it the number one priority for his tenure—to "revitalize the squadrons." In that vein, it is important for all Airmen of every grade and AFSC to understand the leadership triad that is central to the successful operation of a squadron.

The Air Force leadership triad is a dynamic team composed of the commander, chief, and first sergeant, who fill the roles of decision maker, subject-matter expert, and human resources advisor, respectively. The first two components—the commander and chief—have a relatively constant relationship and performance expectations irrespective of the unit of assignment. Although the specific mission of the unit varies between squadrons, the commander makes the decisions. The chief, as the pinnacle of enlisted development and resident expert on available mission resources, has a relatively constant role across squadrons in the superintendent role.

The first sergeant, however, can come from any other AFSC as a senior noncommissioned officer (SNCO) and fills the leadership requirement on a range of topics from health, morale, welfare, training, readiness, mentorship, and discipline. The needs of the unit and commander determine how loosely or strictly defined each of those broad categories can be interpreted.

As the focal point for readiness in the squadron charged with providing the commander a mission-ready force,[1] the first sergeant interacts with key leaders across the installation on behalf of the commander. The first sergeant must attend and serve as the commander's proxy at the Commander's Review Board, Sexual Assault Review Board, Community Action and Information Brief, Status of Discipline, Arming and Use of Force, Installation Staff Meeting, and Alcohol, Drug and Treatment Program treatment team meetings, among other decision-making meetings. The first sergeant works hand-in-hand with the Chaplain Corps, Airmen and family readiness center, mental health, housing, civil engineers, security forces, family advocacy program, medical treatment facility, urinalysis program manager, base honor guard, Office of Special Investigations, inspector general, equal opportunity office, military equal opportunity office, public affairs, and many other agencies internal to the Air Force and outside support entities like Child Protective Services, Department of Corrections, Chamber of Commerce, United Way, and Red Cross. The duties of first sergeants take them across disparate resources as they attempt to uphold the belief: My business is people; everyone is my business.

The first sergeant position can reasonably by construed as important across the enterprise based on the breadth, depth, and flexibility of the scope of responsibility. Why then would the Air Force place such trust and authority integral to mission success in the office of an SNCO with little experience in the operating environment specialty code? Why would the third component of the triad not be a member of the unit who speaks the same language, shares a common developmental background, and has a similar mental map of unit needs? What is the reason for bringing in the outsider? The proposed answer of this article is in the social network utility of weak-ties and cultural cross-pollination.

First, for clarity: a weak-tie is not a pejorative. Second, this is a theoretical exploration of a deeper contextual understanding to the purpose and implications to the member, unit, and Air Force of first sergeants operating outside their career field. Unlike the Air Force model, the Army imbeds first sergeants within units derived of their primary military occupation specialty (MOS). Should the Air Force adopt the Army system? Is the current system elucidated by the complex-adaptive service culture of the Air Force?

Diversity and Weak-Ties

As in the classic "Sesame Street" song, "One of These Things Is Not Like the Others," the first sergeant is the unmatched item. What does this mismatch mean in terms of differentiation and diversity? What is diversity, and does the first sergeant meet the criteria for adding diversity to the leadership triad? What is the effect to the member, the triad, the unit, and the Air Force? To uncover the answers to these questions, it is necessary to understand diversity and its role in the interdependent behaviors between entities.

Diversity in Context

As described by social scientist and University of Michigan complexity science professor Scott Page in his 2011 book *Diversity and Complexity*, whether in reference to biology, economy, ecology, or organizations, diversity is the "differences across types."[2] In the case of the triad, both the commander and chief are derived from a similar background based on functional expertise. Since the first sergeant is not, there is differentiation across the type, and it can be viewed as diversity within this context. Although the sample size of a single individual is small, the overall impact to the three-person triad is one-third composition by diversity index. How can that diversity be measured, and what is the impact of this additive element within the triad if the first sergeant does represent a diverse element?

In complex-adaptive systems, such as the Air Force, the individual entities, rather than whole organizations, adapt to changing situations. Thus, a higher degree of heterogeneity translates into increased potential for adaptation. This predisposition toward maximum individual adaptability is expressed in the Air Force mission-command model of empowering to the lowest possible level and subscribing to centralized command with decentralized execution. The evolutionary potential for the adaptation of organizations and organisms follows similar patterns so measurement can be quantified through standard mechanisms—variation, entropy, distance, attributes, and population composition.[3]

In terms of the first sergeant within the triad, the most appropriate determination of differentiation is attribute measure. The commander and chief share commonalities derived from a shared developmental background and the associated cultural setting, so the differentiating factor is the first sergeant's attributes outside of those shared, experientially-driven attributes. These typological attribute measures are useful for capturing differences between ecosystems, economies, organizations, networks, and other complex-adaptive systems.[4] As the parameters of this article are restricted to a theoretical investigation, the application of attribute diversity indexing will be left for future researchers in this field.

In what ways does diversity impact the evolution of an organization? Evolutionary adaptation occurs through mutation, crossover, inversion, transfer, recombination, and representational diversity.[5] There are differences between purely evolutionary systems like biology and creative processes such as organizations. The latter include intention and intelligence in the selection process that removes an element of chaos and provides a more stabilized approach. Additionally, the levels of diversity depend on the network structure, rates of adaptation, and interactions, which drive the specialization and synergistic effects of diversity.[6]

According to Scott Page, there are two specialization effects of diversity—responsiveness and competitiveness. There are also at least five synergistic effects of diversity—collective knowledge, redundancy, degeneracy, modularity, and cross-cutting cleavage. This article will address the specialization effects as well as the synergistic effects of collective knowledge, redundancy, and modularity as they are the most relevant to the discussion of the first sergeant's role in the triad.

Specialization is the increased specific ability common to complex systems. In organizational context, this means that since the rate of return on training decreases over time, the easiest tasks are learned early. More difficult tasks take longer and constitute a small segment of a job, and specialization allows individuals to become increasingly focused on the smaller segments of the tasks so as to increase overall skill. The law of requisite variety states that the level of diversity must equal the level of perturbations to maintain organizational stability. To meet that expectation, specialization in potential areas of disturbance must be developed. Since the unknown future problems will require unknown levels of diversity, such diversity must be creatively inserted into the organization intelligently with intent to mitigate those potentials. In the Air Force, this is modeled by introducing a first sergeant to the leadership triad with a dissimilar AFSC background from the other two members.

Benefits of Diversity: Resilience, Plasticity, Point of View, and Cross-Pollination

The Air Force, like any other organization, must remain responsive to internal and external environmental factors to remain dominant. As originally stated by Italian Air Force strategist Gen Giulio Douhet and subsequently adopted by the US Air Force, flexibility is the key to airpower. Continuous organizational innovation, frequently aligned with continuous process improvement, is necessary for longevity and success. Problem sets, challenges, and barriers do not remain static, nor should solutions.

Diverse entities that interact in a network or contact structure are interdependent and can stabilize and adapt resulting in a more dynamically stable organization robust to perturbations since variation moderates the effects of shocks.[7] *Robustness*, like resilience in social constructs, is the ability of a system to maintain functionality in the face of some change or disturbance. *Stability* is the tendency of a system to return to an equilibrium given a dynamic environment.

Diversity strengthens the resiliency of an organization to negative stimuli. Diversity enhances responsiveness, the ability of the system to respond to disturbances.[8] This capability is an extension of the law of requisite variety—the need for specific skill sets to be available to respond to the specific type of disturbance. The potential responses must be proportionate to the diversity of disturbances so the organization can remain resilient and ready.[9] The military uses exercises and theater campaign plans to test and execute the validity of our responsiveness to multivariate opponents across a wide spectrum of domains. To sense and meet these emerging factors and requirements, some levels of redundancy are necessary.

Redundancy and diversity are interrelated as diversity provides unique levels of redundancy rather than duplication. Consider the coverage provided by using two security alarms—one that detects motion and the other physical access. The capacity to detect an actual breach is increased based on the specialization and sensitivity of each detector so that if either fails, the other offsets the lapse to meet the intrusion disturbance. In this way, diversity-driven redundancy decreases institutional fragility and enhances robustness. This antifragility, so-called by Nassim Taleb in his economic research in the 2007 book *The Black Swan*, is an organizational reflection of the social concept of resiliency. Antifragility, as expressed through diversity in response to positive internal or external stimuli, increases the probability of emergent innovation and in response to negative internal or external stimuli, diversity increases the probability of stabilization and robustness of the organization.[10] In what ways does the first sergeant's diversity in the triad specifically alter the organization of assignment?

Point of view. The individual capacity to process information is limited and is shaped by perspective and bias that sculpt how reality is partitioned and interpreted.[11] As stated by Scott Page, "Cultural blindness limits the ability to see how information in one context can be useful in an alternate context for a different purpose."[12] Adding a diversity element to increase group heterogeneity, such as the first sergeant within the triad, increases the partitions by adding a new perspective and bias which allows for recombinations of existing ideas in unique ways. These recombinations are a source of evolutionary innovation and organizational adaptation.

In 1998, Martin Weitzman demonstrated in his research that recombinant growth relies on the fact that even a relatively modest number of ideas produces many combinations.[13] If even a fraction of those combinations bear fruit, then an organization can continue to innovate and grow. Thus, the injection of a single individual such as a first sergeant, into a highly interdependent structure like the triad can produce unexpected growth and innovation.

There is a limit to the effectiveness of adding elements of diversity, and it is described by *Utility Theory*. The theory defines the decreasing return on each additional differentiation element. Having an engineer on a train is important. Having two is helpful. Having 17 is unnecessary. Utility Theory asserts that the initial differentiation has more utility than the second. In common terminology, "more is better but increasingly less so."[14] There is an optimal level of variation in a complex system, and the deciding factor is the organizational growth stage: exploration or exploitation?

Exploration and exploitation. Innovation and growth are based on exploration and exploitation described in James March's 1991 organizational behavior model, which depicts organizations as being in one of the two information leveraging states. During exploration, research and experimentation are high whereas in exploitation, the information derived is leveraged to benefit the organization.

Organizations must explore until it is time to exploit the innovations, and in order to explore, it is imperative the widest array of diversity is available for probing of future exploitation. Failure to adapt in this manner exemplifies an organizational brittleness antithetical to resilience. In the Air Force, the inclusion of the first sergeant adds elements of diversity, flexibility, and resilience to counteract potential organizational brittleness. One of the unique characteristics of having an imbedded first sergeant is the transfer of their skills to the triad and the reverse. In fact, upon the execution of the reverse, the first sergeant can then transfer those skills across functional barriers to their previous functional alignment and work as a cross-pollination of ideas throughout the Air Force.

Cross-pollination. Do not compare apples and oranges, mix them. In ecology and organizations, some attributes from individuals and units are transferable and separable in their functions. The separability of the attributes refers to the ability of those attributes to be used in areas outside the original functional area. The sequence of attribute information being transferred to another entity as a favorable attribute strengthens the diversity of the network and improves the potential for survivability. In the context of the triad, this would be demonstrated by a first sergeant from an outside career field utilizing attributes from their previous work to meet the new functional area of the triad.

There are a multitude of unique cultures and mission-specific leadership practices and perspectives across the Air Force. These are evolutionary products of generations of Airmen honing these professional adaptations to their particular operating environments and expectations. As described in the above segment on diversity, innovation and adaptation comes through the introduction of new information. First sergeants have the opportunity to carry information from their primary AFSC to the new unit and pollinate the unit with the tools and techniques. Reciprocally, once imbedded on a series of tours outside their AFSC, when they return to their original functional assignment, first sergeants have been exposed to the tools and techniques of the host units and can carry them, like antibodies, to their primary AFSC for a better coverage of lessons-learned and best practices across the enterprise. In this way, first sergeants can act as the enlisted version of a residency program by adopting and cross-pollinating both leadership and management skills and techniques.

This is beneficial to the squadron by leveraging a new perspective at an intermediary leadership level. Mission-command, or centralized control and decentralized execution, is hinged upon the principle of delegation to act. As such, Airmen are empowered to handle problems at the lowest possible level. So, by the time an issue reaches the squadron level, it has been iteratively addressed through increasingly expert solutions common to that unit by practitioners from front-line journeymen to seasoned flight chiefs. When it arrives at the triad then, the base can provide the decision maker with the deepest, most innovative, and nuanced solution sets. On one leg of the base is the chief, the expert in all aspects of the functionalities of the unit. On the other side, the first sergeant with a vastly different background and perspective divorced from the common bond tying the commander and chief. This level of individualized variance across types can only be reached with the flexibility to explore, innovate, and depart from expected.[15]

These examples, rationale, theory, and conclusions are not intended to indicate that first sergeants are the only, or even the largest progenitor, of innovation. They are a highly susceptible source for such ideas based on position and experience. The mutually beneficial exchange of information and cultural norms between individuals, units, and AFSCs described herein as cross-pollination was termed *symbiogenesis* by the ecologist Lynn Margulis in her 1967 paper.[16] *Symbiogenesis* is the symbiotic envelopment of one microorganism by another whereby each one retains its integrity through a radical interdependence that enhances the functioning of both. The key terminology is *radical interdependence*, which implies a trusting relationship of vulnerability that allows each component to rely on the other in a way that improves the operations for both entities. In terms of the leadership triad, this translates to the inculcation of the first sergeant's background and experience into the new team as well as the resulting transformation achieved by the first sergeant from absorbing components of the triad's culture. Diversity then provides a significant adaptive benefit to organizations through evolutionary mechanisms, which can be scaled for utility at the triad level. Although diversity broadly describes the benefit of differentiation within an organization, this conceptual model lacks contextual specificity that incorporates the social network of the leadership triad. In order to increase the granularity of this theoretical investigation, relevant social networking models, concepts, and laws must be applied to the specific scenario of the cross-functionally aligned first sergeant operating in a trusted leadership role within the squadron triad.

Weak-Ties

Organizations are networks of interconnected people moving toward the same goal. Strong-ties are those relationships built between like-minded people of similar background with a common, shared perspective. These relationships are wrapped around a shared language, cultural norms, expectations, and perspectives.[17] The strong-ties are closely knit together because of the array of similarities that bind them together. These strong-ties, so-called by Mark Granovetter because of the density and intensity of the connection points and bonds within a social network, create a tapestry of commonalities across the unit.[18] Personnel within the group identify with a key characteristic of the unit, such as the Air Force ammunitions culture: "if you ain't ammo, you ain't…" These shared identification beliefs become ingrained in the membership and are reverberated throughout the unit to build a culture. These strong-ties are important, integral even to the construction of the focused culture of a unit toward mission success around a resolute drive and cohesive bond.[19] There are significant correlations between sense-of-belonging and these social network strong-ties; however, these will not be addressed in the scope of this article.

Weak-tie relationships are those competent, confident colleagues who have infrequent interaction but have access to important information, resources, and perspectives.[20] In his seminal work, *The Strength of Weak-Ties*, Granovetter asked Boston West-Enders about the manner in which they secured their current employment. The findings, since replicated and in numerous domains, showed that the vast majority of people were hired based on information from people outside of their close network. These weak-tie relationships had the benefit of different knowledge, in this case alternative employment opportunities, which benefited the study participants. Since weak-ties are not beholden to the same common thought process ingrained from a shared background, weak-ties present new information or unique ways of perceiving the same information based on their differentiation.

In order to be accepted as a competent, trusted colleague despite an absence of background commonality, a visible indication distinguishing the bearer as having a special position with unique qualities can be helpful. The Air Force has made specific allowance for this potential. The French lozenge, or diamond, one of only three devices affixed to enlisted rank insignia, differentiates the first sergeant as such a trusted advisor irrespective of background.

Beyond pure innovation, what then is the benefit to diversity and a weak-tie within a social network such as the leadership triad of a unit? First sergeants, as integral members of the leadership triad of the Air Force's top priority population segment, assert unique perspective and influence through leveraging the diversity principles of their weak-tie affiliation. What is the benefit to the triad, unit, Air Force, and first sergeants of this weak-tie relationship? The next section explores the positive attributes of weak-ties though the lens of individual, team, unit, and network effects.

Combating Groupthink

Unit cohesion, lack of internal conflict, and smooth operations all seem like inherently good qualities and goals every unit should strive to achieve. While they are admirable qualities in moderation, too far down the scale produces a single-mindedness within a group termed *groupthink* by Irving Janis in 1971.[21] His original research conducted to uncover the reason why intelligent, rationale individuals failed to exercise their critical thinking skills or even indicate awareness of alternatives in highly homogenous, cohesive groups led to the discovery of the social phenomena of groupthink.

All interactions have positive and negative attributes, and organizational characteristics are not immune to this balancing effect. While highly cohesive groups of similar individuals can add predictability to responses and stabilize the actions within an organization, those same groups tend towards groupthink because new information is discounted in favor of a single prevailing mental map.[22] The desire to be part of the group and be perceived as fitting in overrides internal objections among members and at times can obscure the possibility of alternatives. The failure to recognize the presence of an alternative position is the hallmark of groupthink. This is true across many industries and is irrespective of educational background, socioeconomic status, political affiliation, or any other social differentiating factor. In healthcare, employees are empowered to request a "time-out" to highlight anything that seems amiss, to protect patients. After several highly-publicized medical procedure errors, including the errant amputation of the wrong leg of a patient in 2007, these processes were instituted as an acknowledgment of the power of groupthink.

The limiting parameter to groupthink in organizations is the nature of complex, diverse systems to become adaptive through natural departures from norms.[23] Diversity, such as introduced by weak-tie relationships, does not synchronize with the commonality of the perspectives and assumptions of homogeneous group members. As such, they provide impedance to the sheep mentality of unquestioned agreement since they are uniquely positioned to observe the incongruences within a system. This vision further adds innovative capacity to the system in the form of a competent, trusted colleague which forces the group to acknowledge the presence of an alternative. This aspect is in direct contradiction to groupthink and serves to inoculate the organization from the negative aspects by amplifying differences rather than balancing them.

Units without the capacity to see alternative pathways risk stagnation since change requires new information or new perspectives. Adaptation can occur from the addition, subtraction, or recombination of materials and information to produce differing results. In the case of natural sciences, the change in number and combination of cells alters the created organism from human to rabbit. The determinant factor is the manner in which the cells are combined. In terms of organizational characteristics, creating an ecology of innovation requires access to new information or mechanisms to combine existing information in new ways. Even in an appropriately primed environment, for innovation to occur the success is largely dependent on the quality of interactive resonance between the strong and weak-ties of the triad. Interactive resonance is the reverberation, in this instance an idea, across functional components and the increasing intensity of the reverberation based on resonance. This is representative of the grinding of two tectonic plates together and the resultant structural movement that is amplified by the height of a structure, such as a hotel, during an earthquake. Developing a high degree of interactive resonance requires individuals with very different backgrounds and very different experiences interact in meaningful ways. These prerequisites for interactive resonance are achieved in the Air Force through imbedding personnel with different background AFSCs in the core leadership triad of the fundamental unit of the Air Force.

Can We Get an Expert Opinion?

If the leadership triad is important, and the first sergeant plays a critical role in the triad where weak-ties leverage diversity principles, and diversity enhances innovation, what is the role of expertise? If the first sergeant does not understand the operations as well as an indigenous SNCO, would that asset be a better addition to the triad? This thought process underscores the Army integration of first sergeants operating within their primary MOS.

The Air Force first sergeant is required to understand the unit mission well enough to recognize the implications of any recommendations or advice they provide regarding unit members and the impact to the mission.[24] That rationale only addresses the requirement for first sergeants to maintain a moderate level of operational understanding. It does not adequately respond to the question of an expert SNCO in the role instead of a weak-tie. In answering that position, the following December 2017 interview response by Evan Apfelbaum, a Massachusetts Institute of Technology Sloan School of Business professor, is particularly relevant, "difference trumps higher skill levels in homogenous teams, creating better performance as well as more accurate prediction of trends."[25] In social network studies, it has been determined that groups of diverse individuals outperform higher intelligence individuals and homogenous groups of higher intelligence people on complex tasks. If the task is mechanical in nature and can be relegated to algorithmic logic without sophisticated problem-solving or critical thinking skills, greater intelligence and experience win. If the problem requires a solution beyond rote mechanistic ability, then diversity surpasses intelligence for complex task completion. This was notably captured in the Duncker Candle Test, originally performed in 1945 and subsequently reproduced at a variety of universities. In the course of the test, individuals with a high IQ were given a problem to solve that required analytic and critical thinking skills. Separately, a group of average to below average IQ individuals with moderate levels of emotional intelligence and diversity were presented the same problem. In the majority of instances, the solution time of the second group was much faster than the highly intelligent group.

If diversity has such a profound impact, then should we inject the highest degree of diversity into the unit in order to maximize innovative potential? In order for any of the positive attributes of innovation to take effect, there has to be parameters to contain and focus the ideas. Chiefs act in this capacity to assess the feasibility of the ideas through the lens of their deep knowledge and network inter-cohesion for social, mental models, resource, and practices. The chiefs act as the counterbalance in the triad to the first sergeants by determining the practicality of the recombinations, additions, and subtractions due to their deep expertise in the field.

Network Effect

If first sergeants are operating as weak-ties within the triad as agents for diversity and innovation, what is the network effect to the unit and Air Force? Is the relevance a linear ratio, or does it conform to exponential power laws? To better understand the impact of the first sergeant weak-tie application and whether it is extended across the Air Force enterprise, consideration must be given to the principles governing networks.

In the early 1980s, Robert Metcalfe presented the original idea behind what later became known as Metcalfe's Law of Network Utility while working to understand the connectivity within the Ethernet. Metcalfe originally posited the rate at which networks related to the number of nodes increased. Over the course of several decades in research, this was determined as the power law describing network utility. The law has come to describe the exponential increase in social network utility as well as machine-based utility functions. Metcalfe's Law governs the addition of a node within the network. The nodes, in the instance of social networks, are representative of the interconnections between personnel.

As the homogeneity of a unit increases, the number of repetitious interconnections increases. However, with the introduction of a weak-tie, a new set of unrelated nodes are connected to the network. The relationship of this new nodal interconnectivity and the resultant utility of the network does not have a correlational linear relation. Instead, the new nodes, because they have a series of unfathomable interconnections beyond the superficial introduction to the weak-tie network, bears exponential characteristics based on power laws. Specifically, the square of the new node is the increase in utility value to the overall network or as described by Beckstrom's Law of Network Theory, "the value of a network equals the net value added to each user's transactions conducted through that networked, summed over all users." Thus, incorporating the first sergeant as a weak-tie within the leadership triad exponentially increases their network utility through the unit's access to unique, new connections.

Synthesis

The intent of this article is not prescriptive in nature but rather as a facilitation for understanding the underlying potential of existing organizational structures unique to the Air Force. The conclusion of the theoretical investigation is that the squadron is an important component of the Air Force and the leadership team—the triad—impacts the direction of the squadron. The first sergeant is an integral part of the squadron triad with an intentionally different background, suggesting creative intelligence in the structure of the triad and lends elements of diversity as measured through attributes. Diversity positively impacts the innovation and robustness of the squadron by increasing specializations for responsiveness and competitiveness as well as synergies. The first sergeant, as a unique network subset of diversity in social mediums referred to as weak-ties, leverages the diversity principles through application of exploration and exploitation, point of view partition differentiation, recombination, and attribute transference through cross-pollination at the individual, organizational, and functional levels of the Air Force.

First sergeants, as weak-ties in one network and strong-ties in another, apply experiences and perspectives in both their temporary and permanent environments to affect adaptation through interactive resonance that impacts the cultural capacity and innovative disposition of both units. Although they are not the only source of new ideas and do not necessarily generate them at all, the potential for creating such an environment by imbedding them in the leadership team increases. These innovations can come in the form of alternative approaches to persistent issues, resource recombination for organizational change, disciplinary assessment adjustments, or other mechanisms. First sergeants can affect these changes by using weak-tie network strengths and diversity principles through interactive resonance, exponentially increasing the information and connectivity of their assignment. Additionally, returning first sergeants to their career fields allows that acquired knowledge from the squadrons they were assigned to be cross-pollinated throughout new career fields, so the impact is broadened. In this way, it is possible for first sergeants to increase the lethality of the force, revitalize the squadrons, and enhance readiness within their spheres of influence and beyond. ✪

CMSgt Josh Lackey, USAF

Chief Master Sergeant Lackey (EdD, University of Southern California; MHA, Saint Joseph's University) is the superintendent of the 96th Medical Operations Squadron, Eglin AFB, Florida.

Notes

1. Air Force Instruction (AFI) 36-2113, *The First Sergeant*, 19 December 2007, https://static.e-publishing.af.mil/; and AFI 36-2618, *The Enlisted Force Structure*, 5 July 2018, https://static.e-publishing.af.mil/.
2. Scott Page, *Diversity and Complexity* (Princeton, NJ: Princeton University Press), 2011.
3. C. S. Holling, "Resilience and Stability of Ecological Systems," *Annual Review of Ecology and Systematics* (1973), 4, https://www.annualreviews.org/.
4. RH Bradbury, JD Van Der Laan, and DG Green, "The Idea of Complexity in Ecology," *Senchkenbergiana Maritima* 27, no. 3–6 (1996): 89–96.
5. Scott Page, *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies* (Princeton, NJ: Princeton University Press), 2007.
6. Page, *Diversity and Complexity*.
7. Albert-László Barabási and Jennifer Frangos, *Linked: The New Science of Networks* (Cambridge, MA: Perseus Books), 2002.
8. Martin Ruef, "Strong Ties, Weak Ties and Islands: Structural and Cultural Predictors of Organizational Innovation," *Industrial and Corporate Change* 11, no. 3 (2002): 427–49, https://academic.oup.com/.
9. Peter Csermely, "Strong Links Are Important, but Weak Links Stabilize Them," *Trends in Biochemical Sciences* 29, no. 7 (2004): 331–34, https://www.sciencedirect.com/.
10. Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable* (New York: Random House), 2007.
11. Barabasi, *Linked: The New Science*.
12. Page, *Diversity and Complexity*, 126.
13. Martin Weitzman, "Recombinant Growth," *Quarterly Journal of Economics* 113, no. 2 (1998): 331–60, https://scholar.harvard.edu/.
14. Page, *How the Power of Diversity*, 158.
15. Bradbury, "The Idea of Complexity in Biology."
16. Lynn Margulis, "On the Origin of Mitosing Cells," *Journal of Theoretical Biology* 14, no. 3 (1967): 255–74.
17. Peter V. Marsden and Karen E. Campbell, "Measuring Tie Strength," *Social Forces* 63, no. 2 (1984): 482–501, https://academic.oup.com/.
18. Mark S. Granovetter, "The Strength of Weak Ties," *American Journal of Sociology* 78, no. 6 (1973): 1360–80, http://www.jstor.org/.
19. Noah E. Friedkin, "Information Flow through Strong and Weak Ties in Intraorganizational Social Networks," *Social Networks* 3, no. 4 (1982): 273–85, https://www.sciencedirect.com/.

20. Daniel Z. Levin and Rob Cross, "The Strength of Weak Ties You Can Trust: The Mediating Role of Trust in Effective Knowledge Transfer," *Management Science* 50, no. 11 (November 2004): 1477–90, https://pubsonline.informs.org/.

21. Irving Lester Janis, *Victims of Groupthink: A Psychological Study of Foreign-Policy Decisions and Fiascoes* (Boston: Houghton-Mifflin Company, 1972), 9; and David Waltner-Toews, James Kay, and Nina-Marie Lister, *The Ecosystem Approach: Complexity, Uncertainty, and Managing for Sustainability (Complexity in Ecological Systems)* (New York: Columbia University Press, 2008).

22. Janis, *Victims of Groupthink*, 9.

23. Page, *Diversity and Complexity*.

24. AFI 36-2113, *The Enlisted Force Structure*.

25. Martha E. Mangelsdorf, "The Trouble with Homogenous Teams: Interview with Evan Apfelbaum," *MITSloan Management Review*, 2018, http://ilp.mit.edu/.

FEATURE

Air and Space Power with Chinese Characteristics

China's Military Revolution

Lt Col Thomas R. McCabe, USAFR, Retired*

China's Strategic Revolution

A quarter-century ago, China's air force and its naval air arm—the People's Liberation Army Air Force (PLAAF) and the People's Liberation Army Navy Air Force (PLANAF)—were largely composed of, at best, short-range aircraft of an obsolescent design with minimal offensive capability. China had no aircraft carriers, and its conventional missile force was largely short-ranged and inaccurate. Its nuclear force was small and composed primarily of unsophisticated land-based missiles. These forces were largely suited for a poor country with a military strategy primarily concentrated on territorial defense and deterrence of attack on the Chinese homeland.[1]

*Editor's note: Significant portions of this article are based on material previously published in Lt Col Thomas R. McCabe's *China's Air and Space Revolutions*, Mitchell Institute for Aerospace Studies, 2013, https://secure.afa.org/; and McCabe's *Keeping A2/AD at Bay: The Imperative for Base Defense in the Western Pacific*, Mitchell Forum for Aerospace Studies, 2018, http://www.mitchellaerospacepowerorg/. Reprinted with permission.

Those days are largely gone, and the days of Western military superiority over China are ending if not already over. China has become a partially modernized economic superpower, and while their announced military strategy defines itself as strategically defensive, it proclaims itself to be operationally and tactically offensive.[2] China has conducted a massive—and continuing—program of military modernization, which has deployed much more capable systems that provide vastly more offensive capability against targets in neighboring states. Functionally speaking, this program translates to a goal of military dominance of the Western Pacific (WestPac) in what must be considered a strategic revolution in the region.

Offensive Air and Space Power with Chinese Characteristics

The Chinese have exhaustively studied the American way of war. They have concluded that it is immensely powerful but potentially brittle, meaning it has a variety of key vulnerabilities that, if attacked, could severely cripple or even collapse the entire system.[3] They have heavily concentrated their strategy and systems to target these vulnerabilities. Since American military strategy is critically dependent on air, space, and naval power, the central requirement of Chinese wartime military strategy will undoubtedly be the neutralization of that power. We can expect the Chinese efforts to do this to have several overlapping aspects of both offense and defense that—together at a minimum—call for more and more ambitious defense in depth (commonly called *antiaccess/area denial*) of the Chinese mainland.[4] This strategy will be done by:

- neutralizing forward-based deployed forces
- denying access to reinforcing forces
- defeating power projection against China
- neutralizing American and allied command, control, communications, computers, and intelligence, surveillance, and reconnaissance (ISR), especially space systems

Not surprisingly, they are preparing to do this their way, emphasizing asymmetric means, and have increasingly developed what this author will call *offensive air and space power with Chinese characteristics*. In particular, these characteristics involve the following:

- dependence on large numbers of increasingly long-range and accurate conventional ballistic and cruise missiles for power projection
- the deployment of large numbers of modern combat aircraft
- the development and deployment of a major unmanned air system capability

- the deployment of an integrated air defense system (IADS) that can reach far offshore
- the development of antisatellite (ASAT) capability
- minimal reliance on nuclear weapons

Also, they are probably laying the basis for a major extra-regional intervention/deployment capability.

This article will examine each of the characteristics in turn.

Long-Range, Accurate Conventional Ballistic and Cruise Missile Deployment

Due to the geography of WestPac, almost all American and allied bases in the region are close to China, few in number, and mostly unhardened. Further, even hardened facilities are not necessarily proof against modern precision-guided munitions,[5] and usually lightly defended, especially against ballistic missile strikes. Due to the dense population of most of the region, there are only a few potential dispersal bases, and, as a rule, these dispersal bases face similar problems. All this makes them especially vulnerable to a short-warning (i.e., missile) attack. The Chinese have targeted this vulnerability, and one of the defining characteristics of Chinese offensive air and space power is the centrality of conventional missiles. China has deployed a large force of conventional tactical ballistic and cruise missiles, mostly under the People's Liberation Army Rocket Force, for use against land targets and, increasingly, ships. When deployed in sufficient numbers in at most the not very distant future,[6] this force could give them the potential capability to stage a comprehensive, integrated conventional surprise attack against American and allied air and naval bases in WestPac.

Land Attack Ballistic Missiles

As noted, China has deployed a large force of conventional tactical ballistic and cruise missiles. They have steadily expanded the capabilities of this force with precision-guided systems. (As early as 2011, the DF-15C reportedly had a terminally-guided warhead for use against fixed targets.)[7]

The Chinese have a force of up to 1,500 conventional short-range ballistic missiles (SRBM), with a range up to 1,000 km), although evidently, their force of launchers is significantly smaller (250 launchers).[8] Historically, these missiles have been unguided and short-ranged—most could reach Taiwan but not Okinawa.[9] However, China is now deploying upgraded missiles with longer range and precision guidance that from coastal launch sites can reach not only Okinawa but also most of Kyushu and much of Luzon.[10] In addition to SRBMs, the Chinese were reported to have deployed up to 450 medium-range ballistic missiles (MRBM) in 2019, with a range of between 1,000–3,000 km,[11] on 150 launchers.[12] Up to 40 of these launchers and up to 80 missiles may have nuclear warheads.[13] Further, the Chinese are deploying a version of the longer-range DF-26 intermediate-range ballistic missile (IRBM) that can reach Guam.[14] China announced the commissioning of a brigade with at least 22 launchers in April 2018,[15] and in 2019 were reported to have up to 160 of them on 80 launchers.[16] In 2017, they were reportedly practicing missile strikes against mockups of Pacific air and naval facilities.[17]

Also, the PLA (the Chinese land force, not the rocket force) has deployed the B-611, an artillery rocket with a half-ton warhead intended for tactical use.[18] It has a range of up to 250 kilometers,[19] which would put much of Taiwan, especially northwestern Taiwan, within range if launched from coastal sites. If equipped with a satellite navigation system, the B-611's accuracy would be as good as 30 meters.[20] No information is available as to the number deployed, but if deployed in any numbers, it could obviously be employed to supplement any rocket-force SRBM operations against Taiwan.

Long-Range Land Attack Cruise Missiles

China has currently deployed a force of up to 540 CJ-10/DH-10 and DH-10A long-range (up to 2,000 km) ground-launched land attack cruise missiles (LACM) on 90 launchers, although the launchers carry multiple missiles.[21]

Recently, the Chinese have started deploying long-range air-launched CJ-20 cruise missiles (the air-launched version of the DH-10) on their H-6K bombers,[22] the upgraded Chinese version of the Russian-designed Tu-16 Badger. They are reported to currently have 36 such bombers in the PLAAF inventory, each of which can carry up to six CJ-20s.[23]

China may also be developing a next-generation ground-launched cruise missile.[24] The HN-2000 is supposed to be stealthy, equipped with advanced sensors (millimeter-wave radar, imaging infrared, laser radar, and synthetic-aperture radar), and use a guidance system based on the Chinese Beidou satellite navigation system. It is also reported to have a supersonic terminal flight phase and an expected range of 4,000 kilometers.[25] China is starting to deploy a large new cruise missile,[26] but so far, there is no way to tell if this is the HN-2000.

Other Launch Platforms

Beyond these platforms, we must expect additional LACMs can be launched from other aircraft, PLA Navy submarines, surface ships, and forward island bases, potentially from containers on civilian ships,[27] and especially from tactical combat aircraft.

Other Long-Range Land Attack Cruise Missiles

In addition to the long-range LACMs previously discussed, China has deployed shorter-range tactical LACMs, in particular, the KD-88 air-to-surface LACM, with a range of 180–200 km (108–120 miles).[28]

Targeting Ships

In addition to conventional ballistic missiles aimed at land targets, the Chinese are deploying antiship ballistic missiles (ASBM). The primary ship targets for the immediate future will undoubtedly be US aircraft carriers at sea. However, if and when the US Navy expands its concept of distributed lethality to include land attack, it may drastically complicate and increase Chinese targeting requirements.[29]

Part (portion unknown) of the Chinese deployments of MRBMs include the DF-21D ASBM, and part of IRBMs includes the DF-26 ASBM. Press reporting indicates they have deployed "… at least a dozen" launchers for ASBM DF-26s at an inland base.[30] They have started testing these systems against targets in the South China Sea.[31]

Finally, the Chinese have bought and/or developed a variety of antiship cruise missiles (ASCM). Among others, these include the YJ-12 supersonic radar-guided ASCM with a range of up to 400 km and a speed of up to Mach 4 (4,900 km/3,000 mph),[32] as well as the shorter-range supposedly hypersonic CM-401.[33] These missiles can be launched from land, sea, or air platforms.

We must expect the Chinese missile threat will only increase over time, especially from ballistic missiles, since the missiles and the launchers cost less than the measures necessary to counter them. While the PLAAF is currently reported to have only a small supply of tactical air-to-surface missiles,[34] it is reasonable to expect the Chinese will deploy these in much larger numbers.

Deployment of Large Numbers of Modern Combat Aircraft

Until fairly recently, the PLAAF and the PLANAF were largely equipped with Chinese-built variants of unsophisticated, short-range, single-role second- or third-generation Soviet designs, such as the F-6 (MiG-19) and the F-7 (MiG-21), mostly intended for air defense. This started changing in the 1990s when the Chinese began to acquire Russian fourth-generation Su-27 Flanker-family fighters. It has recently changed rapidly with the Chinese development and production of large numbers of their versions of Su-27/Su-30/Su-33 designs and their fourth-generation designs. These are at least roughly equivalent, if not better than, the F-15s, F-16s, and F-18s that will predominate in the USAF, USN, USMC, and allied inventories for the foreseeable future and give China both a vastly improved defensive capability and a vastly improved offensive capability. In producing these versions, China has reached past cloning foreign (especially Russian) aircraft, and they now design and build modified or new military aircraft, systems, and aircraft weapons with limited or no foreign assistance. They have done this with the following:

J-11 Flanker family. These versions are derived from the Russian Su-27 design (and its Su-30 and Su-33 derivatives). When combined with Su-27s and Su-30s acquired and Su-35s being acquired from Russia, the total force is more than 400 aircraft.[35] The Chinese are producing several of their own redesigned versions, which carry Chinese weapons, most significantly the KD-88 ASCM and possibly the YJ-12 ASCM. With a reported combat radius of approximately 1,400 km,[36] these aircraft can potentially reach all targets on Taiwan, the Republic of Korea (ROK), Okinawa, much of mainland Japan, and Luzon from Chinese coastal bases, and most of Japan from Manchurian bases, even without aerial refueling or using the missiles. While it should be noted that many of these aircraft are not necessarily well-equipped or their crews trained for ground or antiship attack, by serving as launch platforms for such missiles, they could still be a threat.

J-10 Firebird family. Often compared to the F-16, the Chinese have produced multiple versions of this dual-role aircraft. As of early 2017, they were estimated to have produced as many as 400 of them.[37] They have a reported combat radius of up to 1,000 km.[38] That radius would put bases in Taiwan, Okinawa, the ROK, and much of Luzon in range from coastal bases, potentially most of Japan if they overfly North Korea from Manchurian bases, and more of Japan and the Philippines if they served as a launch platform for KD-88 LACMs or YJ-12 ASCMs.

In addition to the fourth-generation aircraft, China is continuing to deploy other combat aircraft. These aircraft include the JH-7/7A Flounder fighter-bomber. As of 2017, the Chinese had at least 246 JH-7/7As, divided between the PLAAF (30–40 aircraft) and the PLANAF, with 216.[39] With a reported combat radius of more than 1,600 kilometers,[40] China can potentially reach all bases in the ROK, southern Japan, and Luzon from Chinese coastal bases even without aerial refueling or ASMs. The JH-7 can also carry the KD-88 and the YJ-12.[41] Also, the Chinese are continuing to deploy and upgrade the H-6 medium bomber. The Chinese intend these as missile carriers; the PLAAF H-6K can carry up to six LACMs,[42] and some reports indicate the PLANAF H-6Js, the latest H-6 version, can carry as many as seven YJ-12s.[43]

China is working on combat aircraft with stealth characteristics. They may have recently started the initial production of the J-20, an aircraft larger than the F-22 with at least limited stealth.[44] While reports on its performance are fragmentary, some reports estimate its combat radius as over 1,800 km.[45] Also, the Chinese are testing (and offering for foreign sales) a second, smaller, stealth fighter—the J-31—which is reported to have a similar combat radius.[46] The intended role of these aircraft is as of yet uncertain, but prudence demands we assume they will be dual-role and capable of carrying at least tactical LACMs and ASCMs. The Chinese are also developing a stealth strategic bomber, called the H-20, and a next-generation fighter-bomber, presumably stealthy.[47] Both bombers can be expected to carry LACMs, and, for the fighter-bomber, at least ASCMs.

The Chinese still have a large force of obsolescent F-7 and F-8 fighters and a substantial number of obsolescent Q-5 ground attack aircraft. We should expect them to be replaced with modern aircraft over time—the Chinese are building more than 100 fighters per year.[48] As part of this procurement, the Chinese may intend to procure up to 500 J-20 fifth-generation aircraft.[49] China also reportedly has two air-launched ballistic missiles in development, one of which may be nuclear-capable.[50] If and when deployed, they can be expected to functionally increase the capability of their launch aircraft.

Major Effort to Develop and Deploy Unmanned Air Systems

The Chinese have made a major development effort in unmanned air systems (UAS), and they have established a potentially impressive UAS technology and production base.[51] (They have even sold UASs to American allies such as Jordan, Saudi Arabia, and the United Arab Emirates and have also provided armed drones to Iraq.[52]) Publicly available information about the actual number of Chinese military UASs currently deployed is very fragmented and limited,[53] and vary widely. (While the PLA was reported to have 280 UASs in service in mid-2011, a 2014 estimate gave them at least 1,000 medium and large UASs, which, if true, would have indicated a huge buildup.[54]) They are reportedly intending a massive procurement of UASs, with the *2015 Annual Report to Congress* indicating that China possibly plans to produce more than 41,800 land- and sea-based unmanned systems, worth about $10.5 billion, between 2014 and 2023. However, the report did not provide specifics as to their possible role and capability, especially their potential armament.[55]

ISR Unmanned Air Systems

Much of the Chinese UAS effort is in ISR systems. These systems include at least two reported analogs to the American high-altitude long-endurance Global Hawk—the Divine Eagle and the Xianglong/Soaring Dragon, both of which have entered production.[56] Also, they are developing a large unmanned airship and several systems for the medium-altitude, long-endurance (MALE) UAS role.[57] The most widely reported MALE systems are the Yilong/Wing-loong and the BZK-005, roughly similar to or larger than the American Predator, and the CH-5, roughly equivalent to the American Reaper.[58] The MALE systems, like their American counterparts, also can carry bombs and missiles.[59] Further, they also have deployed the WJ-600 (35 reported produced as of mid-2019.[60]) It has been advertised in an ocean-reconnaissance role, supposedly intended to hunt US aircraft carriers, but has also been reported to have a ground-attack capability.[61]

Unmanned Combat Air Vehicles

The Chinese program includes the development of unmanned combat air vehicles (UCAV). Some reports indicate that in the "near [timeframe unspecified] future," the PLAAF could have at least five UCAV regiments, each with at least 100 attack UCAVs.[62] The PLAAF is reportedly working on at least three stealthy UCAVs, although as of mid-2019, there are no public indications that any have started operational deployment. One of these is the supersonic Anjian (Dark Sword).[63] First reported several years ago, unconfirmed reports indicate it may have started testing in 2014.[64] The second stealth UCAV design, the Lijian (Sharp Sword), may have started testing in 2013.[65] The third design is the CH-7, which may make its first flight in 2019.[66]

Finally, in the past, China may have converted at least 200 of their retired J-6 (Chinese-manufactured MiG-19) and some J-7 (Chinese-manufactured MiG-21) fighters into drones or UASs,[67] with the obvious potential of being used as decoys to drain supplies of defensive systems.

"Beetle Bomb" Threat—Small Unmanned Combat Air Vehicles

The Beetle Bomb threat—more correctly the low, slow, and small (LSS) threat—is a rapidly emerging but only partially recognized threat that the Chinese are working to exploit.[68] While the danger to operations at airports posed by small, cheap drones ('hobby drones') is widely recognized (the Federal Aviation Administration has established a 30-mile radius, no-drone zone around Reagan National Airport south of Washington, DC),[69] the threat posed by swarms of such drones to air bases has only gradually been recognized. While the potential danger of such drones to airports that has so far drawn the most attention is the possibility of collisions with aircraft, the dangers they pose to air operations at military air bases are potentially far more comprehensive. Along with the possibility of a collision with aircraft, these dangers are:

- LSS could, literally, be beetle bombs—small flying bombs sent against air base facilities, aircraft, and personnel. They could employ a variety of tactics—fly the beetle bombs directly into targets, or have them drop undetonated explosives and then crash. The explosives would be the equivalent of unexploded bombs needing to be removed or disarmed. At the same time, the crashed mini-UAVs would have to be removed before pieces get sucked into an engine—a small piece of junk can ruin a very expensive engine and ground a plane.
- By having weapons and cameras installed, they could be used to target personnel and aircraft.
- Even if they aren't used as bombs, by crashing or just scattering scrap on runways, they could disrupt operations until cleared. Further, since this doesn't directly kill anybody, this tactic could also be used against reinforcing bases (and for that matter, civilian airfields) in the US while minimizing the risk of escalation.

Of equal significance, these aren't necessarily one-time threats. By preparing in advance and taking advantage of Chinese economic penetration of its neighbors and/or the US, they could release individual beetle bombs or swarms of them at intervals from garages in a nearby town, from prepositioned containers, or a ship in a nearby harbor) as a harassment tactic. More ambitiously, they might be locally produced using three-dimensional printers.

Finally, if they have significant range and flight time, beetle bombs could be released from one or multiple points and programmed with a variety of courses as a multidirectional threat.

Regarding the future of the Chinese UAS threat, while the deployments so far look rather modest, clearly, the Chinese recognize the immense potential of these systems, and they obviously intend to develop and harvest that potential over time. They are also reportedly pursuing developments in new directions, including a manned-unmanned teaming UAS.[70]

Deployment of an Integrated Air Defense System that Can Reach Far Offshore

As a rule, air defenses are not considered part of offensive air and space power. However, depending on their range and location, they could potentially be used in that role, which is the case here. The Chinese are deploying an IADS, based especially on modern, long-range surface-to-air missiles (SAM). When deployed along the Chinese coast or on ships or offshore islands,[71] these SAMs have the potential to reach up to several hundred kilometers beyond their coastlines. This missile deployment could potentially deny, or at least disrupt, friendly operations within their range, in particular at bases on Taiwan. Especially vulnerable would be the large support aircraft like tankers and airborne early warning and control system (AWACS) that act as major force multipliers.

Along with being one of the major buyers of advanced Russian SAMs, including SA-20s and S-400s/SA-21s, China is currently producing at least four advanced long-range SAMs based on Russian designs:

- the HQ-9 Chinese-built SA-10, which the PLAAF has claimed has a range of 200 kilometers and a speed of over Mach 4.
- the HHQ-9 (the naval version of the HQ-9)
- the HQ-15 (upgraded SA-10)
- HQ-18 (Chinese-built SA-12, which presumably means the Chinese have a tactical BMD capability)[72]

They are also building the FT-2000 missile system, which uses an antiradar seeker intended to target airborne warning aircraft and electronic warfare aircraft.[73] The FT-2000 has also been reported as having the ability to intercept tactical ballistic missiles.

Parallel to this, the Chinese Navy is steadily deploying modern ships carrying advanced SAMs, including a class of at least eight (so far) 055 guided missile cruisers, with 112 vertical launch tubes for HHQ-9s each.[74] Further, their Type 052D air defense destroyers, which the Chinese are mass producing (as many as 20 were deployed or being fitted out as of May 2019, and they may intend to deploy a class of 24) carry up to 88 HHQ-9 missiles in vertical launch cells.[75] If the Chinese deploy these ships within the land-based SAM envelope as a forward line of defense and can integrate the SAM systems of these ships with the IADS (admittedly a major assumption), it will potentially extend the reach of the IADS even further offshore.

Reinforcing the SAM threat is a long-range air-to-air missile (AAM) capability the Chinese are working to build. The PL-15 may have a maximum range of up to

200 kilometers, especially against large nonmaneuvering targets such as AWACS and especially the tankers that US tactical aircraft need because of their short ranges, and the Chinese may be developing an AAM with a range of up to 400 km.[76] Further, they are developing ramjet engines that could drastically increase the range and further increase the speed of existing shorter-range missile designs.[77]

We must expect the SAM threat to continue to increase as the Chinese buy and/or duplicate the capability of the advanced SAM systems the Russians are building. (The Chinese technological base has got to the point where we must assume that they can duplicate anything the Russians can build.) The 40N6 missile of the Russian S-400 system has been tested to a range of up to 250 miles, and a missile from the Russian S-500 system, currently in development, has reportedly intercepted a target 299 miles away.[78] It will further increase if/when the Chinese deploy fighter aircraft with long-range AAMs.

Development of Antisatellite Capability

The Chinese have viewed space systems as a critical American asset and a major potential US vulnerability for many years.[79] Therefore, in addition to cyber attack and jamming,[80] they are developing a wide variety of ASAT systems and dual-use technology with ASAT potential, and their ASAT capability probably already exceeds that of the USSR in the Cold War.

Beginning in 2005–07, China launched multiple tests of the SC-19, a ground-based direct-ascent ASAT missile capable of reaching low-earth orbit, at least one of which was successful against an aging Chinese weather satellite.[81] They are also reportedly working on additional direct-ascent systems, the DN-2 and the DN-3, capable of attacking satellites in higher orbits, possibly including geosynchronous orbit.[82]

In past years, both American and French satellites were hit with dazzle lasers from China. (Such incidents have been reported at least as far back as 2006.[83]) No permanent damage was reported, although the Chinese claim they blinded a satellite in 2005 using a 50–100 kilowatt laser,[84] but it must be taken as an indication that the Chinese are experimenting with ASAT lasers and can be expected to develop more powerful ones.[85] Some reports indicate the Chinese may have as many as five directed-energy weapon ASAT sites.[86]

The Chinese have been testing satellite rendezvous techniques, starting in 2008 with the BX-1, and then with the unmanned Shenzhou 8 mission in November 2011, which rendezvoused with the Tiangong-1 orbiting laboratory.[87] While both of these tests were performed over a considerable period of time as the maneuvers for the 2010 rendezvous took several weeks,[88] the basic technology has obvious ASAT development potential. More recently, in late 2016, they launched the SJ-

17 experimental satellite, which conducted extensive maneuvering, including approaching to within "a couple of hundred meters" of a supposedly dead Chinese communications satellite.[89]

The Chinese may be developing a multistage spacecraft launch system mounted on a version of the H-6. While the spacecraft to be launched are reportedly small (50 kg), this technology also has obvious ASAT development potential.[90]

Limited Reliance on Nuclear Weapons

China's declared nuclear strategy is that its nuclear weapons are to deter the use of nuclear coercion or nuclear weapons against China, and China will not use them first or threaten to use them against nonnuclear weapon states or nuclear weapon free zones.[91] However, there is some uncertainty as to what the Chinese will consider a threshold triggering retaliation: Chinese officials have privately said attacks on Chinese nuclear forces with conventional weapons will provoke a nuclear response.[92] Also, there have been reports in the past that the Chinese may have started deploying nuclear electromagnetic pulse warheads on some of their missiles.[93] If true, this would mean the use of nuclear weapons in a nonstrategic role, further calling into question the Chinese commitment to no-first-use.[94]

Historically, Chinese strategic forces have consisted primarily of a monad of land-based missiles, ambiguously supplemented with a small force of nuclear weapons carried by bombers. China is currently estimated to have a modest force of land-based nuclear ballistic missiles. The core is a force of approximately 90 ICBMs, which means the size of the ICBM force has not changed much in recent years, since in 2016 it was estimated at 75–100 ICBMs.[95] Also, China has a force of 80–100 shorter-ranged land-based nuclear missiles.[96]

More recently, China has expanded its strategic nuclear forces to a dyad, with the building of six Type 094 JIN-class missile submarines (SSBNs), each with 12 JL-2 submarine-launched ballistic missiles.[97] Four of the SSBNs are operational, with two more fitting out.[98]

The Chinese are continuing to gradually modernize and modestly enlarge their strategic nuclear force, with the following programs ongoing:

- Developing and deploying mobile, solid-fuel ICBMs with multiple independently targeted reentry vehicle warhead capability. For example, the DF-41 ICBM may be able to carry as many as 10 warheads.[99]
- They reportedly intend to start the construction of a new class of SSBN—the Type 096—with longer-range JL-3 missiles, in the 2020s. Public reports vary as to the number intended with public estimates ranging from four to six boats.[100]

- As previously noted, the Chinese are developing the H-20 strategic bomber, which must be assumed to have a potential nuclear role. Also, China reportedly has experimented with the H6K as an airborne launcher for the DF-21 MRBM missile.[101] Presumably, this is intended for a nuclear role since, while this would provide a much longer range for the missile, it is an extremely inefficient method for deploying conventional missiles.

Increase in Power Projection Capability

This aspect of offensive air and space power, especially at long distances from the Chinese homeland, has historically been something of an afterthought with the Chinese. That is changing rapidly, however, with the Chinese undertaking major improvements in support aircraft and aircraft carriers.

Improvement in Support Aircraft

Until very recently, the Chinese have had a very modest airlift capability, centered mostly around a small number) of Il-76s purchased from the Russians.[102] They attempted to buy a larger batch (38 aircraft) of Il-76 transports and Il-78 tankers from Russia, but the deal died due to problems on the Russian end.[103] Also, they have had a very small force of tankers.

They may be in the early stages of change, in particular with the development and deployment of the Y-20 transport, an aircraft roughly comparable in size to the US C-17, although its range and carrying capacity are currently somewhat less.[104] While the Chinese government has not announced the number to be procured, in 2014, the PLA National Defense University issued a report saying that China might require up to 400 such aircraft.[105] An aviation industry spokesman called for the production of more than 1000, which may include procurement for other roles, such as an airborne tanker version that has reportedly started testing.[106] Other sources claim the Chinese may only procure about a hundred and then procure a larger, more capable transport.[107]

Also, China has reportedly reached an agreement with Ukraine to resume production of the very heavy AN-225 transport. China expected to receive the first one "by 2019."[108] Some reports indicate the planes are being built in China.[109]

Finally, the Y-9, intended to be a C-130J equivalent, has also entered production.[110] They may be testing a redesigned version with new engines and a glass cockpit,[111] although this may be additional information on the previous design. The Y-9 also serves as the platform for the KJ-500 AWACS.[112]

We must expect the Chinese are in the early stages of a major increase in their air transport force, which will, over the longer term, greatly increase their mobility/

intervention capability both regionally and at longer ranges. For the longer term, we must also note that China has declared the intention to build a world-class commercial aviation industry. However, so far, they are having trouble producing even a small world-class-quality airliner. Although they are (with the Russians) working on the CR929, a four-engine widebody transport the size of a Boeing 767, the largest aircraft currently near production is the C919, equivalent in size to a Boeing 737 or an Airbus 320, which probably makes it unsuited to be anything but a niche military platform. Currently in-flight testing, it is several years behind schedule and, like the rest of the Chinese civil aviation industry,[113] is currently heavily dependent on foreign suppliers for subsystems. Its design is a generation behind the upgraded 737 and 320 designs now in production. However, a huge domestic Chinese market (along with a presumed Chinese government order for Chinese airlines to buy Chinese-made aircraft whether they want to or not) can be expected to eventually give the Chinese at least a modest foot in the door of civil aircraft production. The market will also provide a basis to build on, and, over time, potentially to build a Chinese equivalent to the American Civil Reserve Air Fleet, where civilian airliners can be mobilized for military support. We should note that, as in the Soviet/Russian example, problems with civilian production will by no means prevent them from producing world-class military equipment.

An Aircraft Carrier Force

The PLAN is in the early stages of deploying an aircraft carrier force. Although the role of the force is currently ambiguous, a large force of carriers must be considered inherently offensive.[114] The Chinese Navy has announced it intends to shift its focus to "open seas protection."[115] They have reconditioned the former Russian VARYAG, commissioned it into the fleet as the LIAONING,[116] and have built a similar carrier, currently undergoing sea trials.[117] They are also building a second conventionally-powered aircraft carrier that, unlike the previous two, is being equipped with a catapult rather than a ski-jump for launching aircraft.[118] As previously noted, they have deployed and are continuing to build a large force of the types of ships, especially guided missile cruisers and air defense destroyers (at least eight Type 055 guided-missile cruisers and up to 20 Type 052D air defense destroyers so far) that would logically be used for the defense of the task forces that would be built around such carriers. They are also building the aircraft force for a carrier navy, including the J-15, (based on the Su-33, the carrier version of the Su-27), the KJ-600 radar plane, and reportedly a drone.[119] A variant of the J-31 may also be intended for carrier use.[120]

Plans for the future of the carrier force are still unknown, in particular, whether China will build another conventionally-powered carrier or move directly to constructing nuclear-powered ships. Also uncertain is the number of carriers to be built and how fast China will build them—some estimates expect a force of four nuclear carriers by 2035, with the first nuclear carrier to be launched as early as 2022.[121]

Conclusions and Implications

Even though China has only partially modernized, it must already be considered an economic superpower, and it is emerging as a military superpower. Most important for this analysis, when the size, increasing capability, and modernity of its air, missile, and space forces and the increasing potential of its technology and production base are considered, it must also be considered an emerging air and space superpower. The comprehensive and continuing modernization of its offensive air and space power potential that China has undertaken and is continuing to undertake has what must be considered revolutionary implications for the Indo-Pacific region and ultimately for the world. China obviously intends to change the security architecture in the region and establish itself as the dominant military power there. Chinese economic and military power is reaching, if it has not already reached, the point where it must be considered a peer competitor of the United States, at least in the WestPac region.

These deployments are clearly intended to prevent the United States from using its preferred post-Cold War military strategy of overwhelming its enemies with its superior military and technological might. To an ominous degree, they have succeeded, and the days of Western military superiority over China are ending, if not already over. China's deployment of large numbers of ballistic missiles, modern aircraft, and cruise missiles means our bases and the oceans in WestPac are no longer sanctuaries.[122] If integrated with modern C4ISR systems (C4IKSR to the Chinese, who include "kill" in the mix[123]) and used effectively—admittedly very big 'ifs'—this should be more than adequate to overwhelm any air defenses Taiwan can plausibly mount. All too plausibly, they will be enough to overwhelm American and Japanese base defenses in the region, including on Okinawa. A significant Chinese antiship ballistic missile deployment will pose a major threat to surface ships operating within the First Island Chain in the Yellow Sea, Taiwan Strait, East China Sea, and at least much of the South China Sea. They will also pose an increasingly dangerous threat to American or Allied bases as far away as Guam, and require that any American military counteraction to a regional Chinese military move will risk a major war.

And given the will and resources, the Chinese have no obvious reason to stop their deployments. While they may not yet have the global reach, alliance networks, and basing structure of the United States, their investments in power projection (including their investments in amphibious capability which this article didn't discuss) and their plans for the Belt and Road Initiative, where they plan to at least acquire access and influence in much of Eurasia and Africa, if not buy themselves an empire,[124] should probably be considered strategic warning that they intend to acquire them.

The Chinese have made clear that they intend to become a scientific and technological superpower. How fast they can do this is uncertain. While much is made about the huge numbers of engineers and scientists they are supposedly training, the Soviets made similar claims back in the 1960s, which turned out to be very overstated.[125] Nevertheless, the Chinese are making great investments in growing their scientific and technological base at a time when substantial portions of American opinion are skeptical of science if not openly hostile to it. We should not take their efforts lightly. We can no longer assume technological superiority—the technical sophistication of many or most of their weapons and aircraft may be at least as good as ours. Further, the Chinese science and technology base is becoming advanced enough in at least some areas, such as, for instance, hypersonics and artificial intelligence,[126] that we cannot rule out the possibility of technological surprise. Beyond that, we should remember that even a comparatively have-not nation can develop and spring nasty technological surprises, as the Japanese did with the Mitsubishi A6M Zero Fighter and the Type 93 "Long Lance" torpedo at the start of World War II.

Finally, we must note that all that has been done so far has been done without crash programs on an economy significantly smaller than that of the US and without imposing a crushing burden on the Chinese economy. What will they be able to do if and when the size of their economy matches or surpasses that of the US in the next decade or so, and their military spending matches or surpasses that of the US without having to pay American military manpower costs?

In conclusion, the days when the US could take its status as the world's leading superpower and premier air and space technology superpower for granted may not be over. But it clearly *is* time to realize that our status cannot be taken for granted and to keep a very close eye on the competition. Above all, we need to recognize that our military strategy against China, and, in fact, our entire way of war, may be dangerously obsolete, and a comprehensive rethinking and a new strategy, one aimed at exploiting China's strategic vulnerabilities in an environment where we are not militarily or technologically dominant, is now a critical necessity. ✪

Lt Col Thomas R. McCabe, USAFR, Retired

Lieutenant Colonel McCabe (BA, West Chester State College; MA, Georgetown University; MS, Defense Intelligence College) is a retired career analyst for the Department of Defense.

Notes

1. For a good overview of the evolution of Chinese strategy, see M. Taylor Fravel, *Active Defense* (Princeton, NJ, Princeton University Press, 2019).

2. The State Council Information Office of the People's Republic of China, "China's National Defense in the New Era" (Chinese 2019 White Paper), 25 July 2019, http://www.xinhuanet.com/.

3. For a useful summary of the potential problems, see Christopher M. Dougherty, "Why America Needs a New Way of War," *Center for a New American Security,* June 2019, https://s3.amazonaws.com/.

4. A term that has been declared politically incorrect in the Navy. In 2016, Chief of Naval Operations Richardson banned the use of the term by the Navy. Sam LaGrone, "CNO Richardson: Navy Shelving A2/AD Acronym," *USNI News*, 3 October 2016, https://news.usni.org/.

5. Eric Heginbotham et al., *The U.S.-China Military Scorecard: Forces, Geography, and the Evolving Balance of Power 1996–2017* (Santa Monica, CA: RAND Corporation, 2016), 63, https://www.rand.org/.

6. As discussed in ch. 9 of Roger Cliff, *China's Military Power*. Cliff assesses that it would take a barrage of 45 missiles with submunitions to destroy more than 80 percent of the aircraft at an unhardened base (he used Iwakuni in Japan as the example). See Cliff, *China's Military Power* (New York: Cambridge, 2015), 197.

7. See Ron Christman, "Conventional Missions for China's Second Artillery Corps," Andrew Erickson and Lyle Goldstein (eds), *Chinese Aerospace Power* (Annapolis, MD: Naval Institute Press, 2011) 309.

8. The 2019 estimate given was 750–1,500. Office of the Secretary of Defense, *Annual Report to Congress*, *Military and Security Developments Involving the People's Republic of China 2019*, (*Annual Report to Congress, 2019*), May 2019, 47, https://news.usni.org/. In 2015, the US-China Economic and Security Review Commission estimated at least 1,200. US-China Economic and Security Review Commission, *2015 Report to Congress of the U.S.-China Economic and Security Review Commission*, (*2015 Report to Congress*), 23 November 2015, 351, http://news.usni.org/; and "Sphere of Impact," *Defense News* 34, no. 10, 3 June 2019, 11.

9. In 2010, 700–750 were DF-11/11A, with a range of up to 530 km, while 250–400 were DF-15/15As, with a range of up to 800 km. Jacob L. Heim, "The Iranian Missile Threat to Air Bases," *Air & Space Power Journal*, July–August 2015, 27, https://www.airuniversity.af.edu/aspj/.

10. The DF-11 is being replaced by the DF-16 with a range of up to 1,000 km, which would put Okinawa and most of Kyushu potentially within range. The DF-15/15As are being replaced with the DF-15B with a range of up to 800 km that would put Okinawa within range. See David Xia, "A Comprehensive Analysis of Chinese Ballistic Missile Systems Displayed on Victory Day Parade," *IndraStra Global*, 20 September 2015, https://www.indrastra.com/. Some variants of the DF-16 may have a range greater than 1000 km. See the *2015 Annual Report to Congress*, 352.

11. *2019 Annual Report to Congress,* 47. The low end of the estimate range was 150 missiles.

12. "Sphere of Impact," *Defense News*, 11.

13. Hans Kristensen, "Chinese Nuclear Forces 2018," *Federation of American Scientists Nuclear Notebook*, 25 June 2018, https://www.tandfonline.com/.

14. See Wendell Minnick, "China's Parade Puts US Navy on Notice," *Defense News*, 3 September 2015, http://www.defensenews.com/; and Jordan Wilson, "China's Expanding Ability to Conduct Conventional Missile Strikes on Guam," *U.S.-China Economic and Security Review Commission*, 10 May 2016, https://www.uscc.gov/.

15. Ankit Panda, "China Announces Commissioning of DF-26 Intermediate-Range Ballistic Missile Brigade," *Diplomat*, 17 April 2018, https://thediplomat.com/. The report did not specify whether the DF-26 missiles deployed were land attack or antiship missiles or whether they were conventional or nuclear.

16. The low end of the range was 80 missiles. See "Sphere of Impact," *Defense News*. Some of these are nuclear. *2019 Annual Report to Congress,* 47.

17. Thomas Shugart, "Has China Been Practicing Preemptive Missile Strikes Against U.S. Bases?," *War on the Rocks*, 6 February 2017, https://warontherocks.com/.

18. "B-611/BP-12A/Toros/Yildirim," *Global Security*, accessed 17 May 2019, https://www.globalsecurity.org/.

19. "B-611/BP-12A/Toros/Yildirim," *Global Security.*

20. "B-611/BP-12A/Toros/Yildirim," *Global Security.*

21. *2019 Annual Report to Congress,* 47. The low end of the estimate range was 270 missiles. "Sphere of Impact," *Defense News*, 11. CJ-10 transporter/erector/launchers carry three missiles. See Jeffrey Lin and P. W. Singer, "China's New Mystery Missile and Launcher," *Popular Science*, 11 August 2015, https://www.popsci.com/, It is reasonable to assume they have deployed additional launchers since then.

22. Dennis M. Gormley, Andrew S. Erickson, and Jingdong Yuan, "A Potent Vector: Assessing Chinese Cruise Missile Developments," *Joint Force Quarterly* 75, 30 September 2014, 104, http://ndupress.ndu.edu/.

23. Franz-Stefan Gady, "China's Air Force Can Now Launch Long-Range, Precision Strikes," *Diplomat*, 15 October 2015, http://thediplomat.com/; and *2015 Annual Report to Congress,* 12. Some sources say they can carry up to seven missiles each. See Jeffrey Lin and P. W. Singer, "China Shows Off Its Deadly New Cruise Missiles," *Popular Science*, 10 March 2015, http://www.popsci.com/.

24. Ian Easton, "The Assassin Under the Radar: China's DH-10 Cruise Missile Program," *Project 2049 Institute*, 1 October 2009, https://project2049.net/. Evidently, there is some uncertainty as to the current status of the program. Gormley, Erickson, and Yuan did not mention an HN-2000, although they did describe a "possible DH-2000," a submarine-launched 500 km-range LACM. See Gormley, Erickson, and Yuan, "A Potent Vector," 102.

25. "Key Element in the Taiwan Straits Military Situation" (Taihai junshi taishi de guanjian), 36, quoted in Easton, "The Assassin Under the Radar."

26. It carries two missiles on a larger TEL. Lin and Singer, "China's New Mystery Missile."

27. Bill Gertz, "China Building Long-Range Cruise Missile Launched From Ship Container," *Jackson Press*, 30 March 2019, http://thejacksonpress.org/.

28. Gormley, Erickson, and Yuan, "A Potent Vector," 102.

29. Distributed lethality is a concept for increasing the offensive and defensive firepower of US Navy ships—"if it floats, it fights." See Vice Adm Thomas Rowden, Rear Adm Peter Gumataotao, and Rear Adm Peter Fanta, US Navy, "Distributed Lethality," *Naval Institute Proceedings* 141, no. 1 (January 2015): 1,343, https://www.usni.org/, for background on the concept. However, the original concept concentrated on sea control (fighting a war at sea), not an attack of land targets.

30. David Axe, "China Just Deployed Its Deadly DF-26 'Carrier-Killer' Missiles in A Very Slick Way," *National Interest*, 14 January 2019, https://nationalinterest.org/.

31. James Holmes, "China Likely Tested Missiles That Can Kill Aircraft Carriers in the South China Sea," *National Interest*, 6 July 2019, https://nationalinterest.org/.

32. Mark Episkopos, "Does the U.S. Navy Have Another Carrier-Killer Missile to Worry About?," *National Interest,* 29 December 2018, https://nationalinterest.org/.

33. Ryan Pickrell, "China Has a New Hypersonic Anti-Ship Missile That It Claims Could Destroy a US Warship in One Hit," *Business Insider*, 7 November 2018, https://www.business insider.com/.

34. *Annual Report to Congress*, 2019, 47.

35. Author's estimate for the combined total of PLAAF and PLANAF aircraft, derived from *Military Technology Special Issue—World Defense Almanac 2018,* 268*;* Bradley Perrett, "Flanker Fixation," *Aviation Week and Space Technology* (*Aviation Week*) 179, no. 4, 20 February–5 March 2017, 50; and Eric Hegenbotham, *The US-China Military Scorecard: Forces, Geography, and the Evolving Balance of Power 1996–2017* (Santa Monica, CA: Rand, 2015), 76. It should be noted that not all these aircraft are regularly deployed in coastal areas.

36. 750 nautical miles. Reported in Kelley Sayler, "Red Alert: The Growing Threat to U.S. Aircraft Carriers," *Center for a New American Security*, February 2016, https://s3.amazonaws.com/, 6. No specifics were provided as to the flight profile used in the calculation.

37. Richard D. Fisher Jr., "PLANAF J-10 Lost in Crash," *IHS Janes Defense Weekly*, 20 December 2015, http://www.janes.com/(site discontinued).

38. 540 nautical miles. Reported in Kelley Sayler, "Red Alert," 4.

39. *Military Technology Special Issue—World Defense Almanac 2018,* 268.

40. Greg Goebel, "Chinese Jet Fighters: JH-7, J-10, & J-20."

41. Wendell Minnick, "China Reveals New Missiles at Singapore Airshow," *Defense News*, 16 February 2016, https://www.defensenews.com/.

42. Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018*, (2018 *Annual Report to Congress*), 16 May 2018, 34, https://media.defense.gov/2018/Aug/16/2001955282/-1/-1/1/2018-CHINA-MILITARY-POWER-REPORT.PDF.

43. Franz-Stefan Gady, "China's Navy Deploys New H-6J Anti-Ship Cruise Missile-Carrying Bombers," *Diplomat,* 12 October 2018, https://thediplomat.com/.

44. For information on the J-20, see Jeffrey Lin and P. W. Singer, "Chinese Stealth Fighter J-20 Starts Production," *Popular Science*, 28 December 2015, http://www.popsci.com/; and Cavin Dsouza, "Comparing Chengdu J-20 with F-22, F-35 and Su-PAK FA or T-50," *Defence Aviation*, 4 January 2011, http://www.defenceaviation.com/.

45. "Expected to have a combat radius of over 1000 nm." Sayler, "Red Alert," 6.

46. Richard D. Fisher and Gabriel Dominguez, "China's Second FC-31 Fighter Prototype Makes Maiden Flight," *IHS Jane's Defence Weekly*, 28 December 2016, http://www.janes.com/(site discontinued); and Sayler, "Red Alert," 6.

47. Andreas Rupprecht, "Xi'an H-20; China's Stealth Bomber," *Combat Aircraft* 20, no. 1, January 2019, 22–23; and Defense Intelligence Agency, *China Military Power: Modernizing a Force to Fight and Win,* January 2019, (*China Military Power* 2019) https://admin.govexec.com/, 88.

48. Liu Zhen, "China's Air Force in Recruitment Drive for J-20 Stealth Fighter Pilots," *South China Morning Post*, 5 January 2019, https://www.scmp.com/.

49. Richard D. Fisher, "Chinese Resurgence," *Aviation Week* 179, no. 25 (25 December 2017–January 2018): 56.

50. 2018 *Annual Report to Congress,* 34.

51. See Jeffrey Lin and P. W. Singer, "China Shows Off Its Growing Drone Fleet," *Popular Science*, 14 November 2014, http://www.popsci.com/.

52. For sales to Jordan, see Rep. Duncan Hunter, "Hunter: Why is Obama Letting China Beat the US at Global Drone Sales?" Press Release, 7 December 2015, https://hunter.house.gov/(site discontinued). For sales to the Saudis and the UAE, see Jeremy Binnie, "UAE, Saudi Arabia operating Chinese UAVs over Yemen," *IHS Jane's Defence Weekly*, 17 December 2015, http://www.janes.com/(site discontinued). For sales to the Iraqis, see "Iraq Receives Chinese Armed Drone," *Combat Aircraft* 16, no. 12, December 2015, 18.

53. One of the best available sources admitted piecemeal that most reports on the operational use of Chinese UAVs are unconfirmed. See Ian M. Easton and L.C. Russell Hsiao, *The Chinese People's Liberation Army's Unmanned Aerial Vehicle Project: Organizational Capacities and Operational Capabilities*, 11 March 2013, https://project2049.net/. A more recent source was similarly hedged. See Elsa Kania and Kenneth Allen, "The Human and Organizational Dimensions of the PLA's Unmanned Aerial Vehicle Systems," *Jamestown Foundation China Brief* 16, no. 8, 11 May 2016, https://www.jamestown.org/.

54. For the 280 figure, see Easton and Hsiao, *The Chinese People's Liberation Army's Unmanned Aerial Vehicle Project*, 11. For the 1,000 figure, see Kania and Allen, "The Human and Organizational Dimensions."

55. 2015 *Annual Report to Congress,* 36. This figure would give the UASs an average price of about $250,000 each, so this does not include any small drones they may be planning to acquire.

56. For the Divine Eagle in production, see Dylan Malyasov, "Huge Unmanned Aerial Vehicle Spotted at Chinese Production Facility," *Aviation News*, 5 January 2018, https://defence-blog.com/news/huge-unmanned-aerial-vehicle-spotted-at-chinese-production-facility.html. For the Xianglong having been deployed, see Kristin Huang, "The Drones That Have Become Part of China's Military Strategy," *South China Morning Post*, 26 August 2018, https://www.scmp.com/.

57. Jeffrey Lin and P. W. Singer, "China Tests Its Largest Airship," *Popular Science*, 26 October 2015, http://www.popsci.com/.

58. For Wing Loong, see "Wing Loong Unmanned Aerial Vehicle (UAV)," *Air Force Technology*, accessed 24 June 2017, https://www.airforce-technology.com/. For the BZK-005, see "The Drone Index: Harbin BZK-005," *21st Century Asian Arms Race*, 16 May 2017, https://21stcenturyasianarmsrace.com/ and Center for Strategic and International Studies, "Is China at the Forefront of Drone Technology?," *ChinaPower*, June 2018, https://chinapower.csis.org/.

59. For armament on the Yilong/Wing Loong, see "Wing Loong Unmanned Aerial Vehicle (UAV)." For armament on the CH-5, see Adam Rawnsley, "Meet China's Killer Drones," *Foreign Policy*, 14 January 2016, http://foreignpolicy.com/.

60. "CASIC WJ-600," *Military Factory*, accessed 26 June 2019, https://www.militaryfactory.com/

61. Lin and Singer, "China Shows Off Its Growing Drone Fleet;" Wendell Minnick, "Zhuhai Airshow Goes Unmanned," *Defense News*, 16 November 2010, http://minnickarticles.blogspot.com/; and "CASIC WJ-600," *Military Factory*.

62. Kania and Allen, "The Human and Organizational Dimensions."

63. "Anjian (Dark Sword)—Unmanned Aerial Vehicle (UAV) Specifications," accessed 15 January 2012, http://www.unmanned.co.uk/(site discontinued).

64. Sarah Griffiths and Mark Prigg, "Does China have a SUPERSONIC drone? Claims Secret 'Dark Sword' Project May Already Have Flown," *Daily Mail,* 24 November 2014, http://www.dailymail.co.uk/.

65. Jeffrey Lin and P. W. Singer, "Meet China's Sharp Sword, a Stealth Drone that Can Likely Carry 2 Tons of Bombs," *Popular Science*, 18 January 2017, https://www.popsci.com/.

66. Patrick Tucker, "China's Beating the US to Market on Combat Drones, By Copying US Technology," *Defense One*, 6 November 2018, https://www.defenseone.com/.

67. Richard Fisher, *Chinese Military Modernization* (Stanford, CA: Stanford University Press, 2010), 85. See also "As Highlighted on This Site as a Threat for Years: China's Converted Surplus Fighter Drone Force Eyeballed from Space," *Aviationintel.com*, 16 January 2013, http://aviationintel.com/.

68. Joseph Trevithick, "China Is Hard At Work Developing Swarms Of Small Drones With Big Military Applications," *Drive War Zone*, 16 January 2018, http://www.thedrive.com/.

69. Matthew Cox, "Army Testing New Weapons to Combat Weaponized Drones," *Military.com*, 29 January 2016, http://www.military.com/.

70. Kristin Huang, "China's Sky Hawk Stealth Drone Has Capability to 'Talk' to Fighter Pilots, Developer Says," *South China Morning Post*, 11 January 2019, https://www.scmp.com/.

71. Amanda Macias, "China Quietly Installed Missile Systems on Strategic Spratly Islands in Hotly Contested South China Sea," *CNBC*, 2 May 2018, https://www.cnbc.com/.

72. Dmitry Solovyov, "China Buys Air Defense Systems from Russia," *Reuters*, 2 April 2010, https://www.reuters.com/; Dave Majumdar, "Russia's Dangerous S-400 Air Defense System is Headed to China (And Maybe Turkey)," *National Interest*, 3 April 2018, http://nationalinterest.org/; Carlo Kopp, "CPMIEC HQ-9/HHQ-9/FD-2000/FT-2000 Self Propelled Air Defence System," Technical Report APA-TR-2009-1103, November 2009, http://www.ausairpower.net/; Richard Fisher and Carlo Kopp, "Game Changers," *Aviation Week Defense Technology International*, December 2009, 32; Kopp, "CPMIEC HQ-9/HHQ-9/FD-2000/FT-2000"; Missile Defense Advocacy Alliance, "HQ-15," 20 June 2018, http://missiledefenseadvocacy.org/; and Missile Defense Advocacy Alliance, "HQ-18," 20 June 2018, http://missiledefenseadvocacy.org/. The Russians used the SA-12 as a tactical antiballistic missile system.

73. Global Security, "FT-2000," accessed 2 June 2018, https://www.globalsecurity.org/.

74. Laura Zhou and Minnie Chan, "China Makes Turbine Blade Breakthrough that Could Give Type 055 Guided-Missile Destroyers an Edge," *South China Morning Post*, 26 December 2018, https://www.scmp.com/news/; and Rick Joe, "All You Need to Know about China's New Stealth Destroyer," *Diplomat*, 8 June 2018, https://thediplomat.com/.

75. Minnie Chan, "China Launches Two New Type 052D Destroyers as It Continues Drive to Strengthen Naval Force," *South China Morning Post*, 14 May 2019, https://www.scmp.com/; Rick Joe, "Predicting the Chinese Navy of 2030," *Diplomat*, 15 February 2019, https://thediplomat.com/; and "The Type 055 Isn't the Only Chinese Destroyer America Fears; Newly Inducted Type 052D Warships Key to Facilitating Primacy at Sea," *Military Watch*, 13 August 2018, https://militarywatchmagazine.com/.

76. Douglas Barrie, "It's Not Your Father's PLAAF: China's Push to Develop Domestic Air-to-Air Missiles," *War on the Rocks*, 21 February 2018, https://warontherocks.com/; and "China May Be Developing New Long-Range Air-to-Air Missile," *Reuters*, 26 January 2017, https://www.reuters.com/.

77. Jeffrey Lin and P. W. Singer, "This New Ramjet Engine Could Triple the Range of Chinese Missiles," *Popular Science*, 12 June, 2017, https://www.popsci.com/.

78. Tamir Eshel, "Russia to Introduce Prometheus, a Successor to S-400 in 2020," *Defense Update*, 1 January 2018, http://defense-update.com/; and Amanda Macias, "Russia Quietly Con-

ducted the World's Longest Surface-to-Air Missile Test," *CNBC*, 25 May 2018, https://www.cnbc.com/.

79. Ashley J. Tellis, "Punching the U.S. Military's "Soft Ribs": China's Antisatellite Weapon Test in Strategic Perspective," Carnegie Endowment Policy Brief No. 51, June 2007, http://carnegieendowment.org/.

80. For cyber attacks, see Tim Starks, "Chinese Hackers Targeting Satellite and Defense Firms, Researchers Find," *Politico*, 19 June 2018, https://www.politico.com/. For jamming of satellite communications, see Todd Harrison, Kaitlyn Johnson, and Thomas Roberts, *Space Threat Assessment 2019, Center for Strategic & International Studies*, April 2019, 14, https://aerospace.csis.org/.

81. Leonard David, "China's Anti-Satellite Test: Worrisome Debris Cloud Circles Earth," *Space.com*, 2 February 2007, https://www.space.com/. There have been additional tests since then. See US-China Economic and Security Review Commission, *2015 Report to Congress of the US-China Economic and Security Review Commission*, 294, accessed 21 December 2015, https://www.uscc.gov/.

82. For the DN-2, see the *2015 Annual Report to Congress*, 294. For the DN-3, see Bill Gertz, "China ASAT Test Part of Growing Space War Threat," *Washington Free Beacon*, 23 February 2018, https://freebeacon.com/national-security/.

83. Vago Muradian, "China Tried to Blind U.S. Sats with Laser," *Defense News*, 25 September 2006, 1.

84. Bill Gertz, "Satellite Photos Show Chinese Anti-Satellite Laser Base," *Free Beacon*, 1 April 2019, https://freebeacon.com/.

85. "Endangered Birds," *Economist*, 11 December 2010, http://www.economist.com/.

86. Gertz, "Satellite Photos Show Chinese Anti-Satellite Laser Base."

87. Information Office of the State Council of the People's Republic of China, "China's Space Activities in 2011," http://china.org.cn/, accessed 22 January 2012.

88. William Matthews, "Chinese Puzzle," *Defense News*, 6 September 2010.

89. Colin Clark, "China Satellite SJ-17, Friendly Wanderer?," *Breaking Defense*, 18 April 2018, https://breakingdefense.com/.

90. Andreas Rupprecht, "The Dragon's Wings," *Combat Aircraft* 13, no. 2 (February 2012): 61.

91. Chinese 2019 White Paper.

92. Hans M. Kristensen and Matt Korda, "Chinese Nuclear Forces, 2019," *Bulletin of the Atomic Scientists Nuclear Notebook*, 28 June 2019, https://www.tandfonline.com/.

93. See Bill Gertz, "Report: China Building Electromagnetic Pulse Weapons for Use against U.S. Carriers," *Washington Times*, 21 July 2011, https://www.washingtontimes.com/.

94. There are some indications the Chinese may be reconsidering their no-first-use policy. See Toshi Yoshihara and Jack Bianchi, "Chinese Nuclear Weapons Strategy—Leaning Towards a More Proactive Posture? Part II: External Drivers of Potential Change—Technical-Military Developments and Perceptions of Credibility," *Jamestown Foundation China Brief* 19, no. 13, 16 July 2019, https://jamestown.org/.

95. 2019 *Annual Report to Congress,* 66; and Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2016*, 26 April 2016, https://dod.defense.gov/.

96. Kristensen and Korda, "Chinese Nuclear Forces, 2019."

97. 2019 *Annual Report to Congress,* 66.

98. 2019 *Annual Report to Congress,* 66.

99. Kristensen and Korda, "Chinese Nuclear Forces, 2019."

100. The four boats estimate is from Kristensen and Korda, "Chinese Nuclear Forces, 2019." The estimate of six boats is from James E. Fanell, "China's Global Naval Strategy and Expanding Force Structure," *Naval War College Review* 72, no. 1 (2019): 43, https://digital-commons.usnwc.edu/.

101. Tyler Rogoway, "Is This China's DF-21D Air Launched Anti-Ship Ballistic Missile Toting Bomber?," *Drive*, 15 August 2017, http://www.thedrive.com/. While this would provide much longer range, it is an extremely inefficient method for deploying conventional missiles.

102. Sebastien Roblin, "Forget About China's Stealth Fighter or Aircraft Carriers. This Is the Plane America Needs to Worry About," *National Interest*, 15 September 2018, https://nationalinterest.org/.

103. Gordon and Komissarov, *Chinese Air Power*, 164–71.

104. It can carry a maximum load of 72.5 tons, less than the C-17's 85.5 tons. See Roblin, "Forget About China's Stealth Fighter or Aircraft Carriers."

105. Richard D. Fisher, "China Needs 'More Than 1,000' Xian Y-20 Transport Aircraft," *IHS Jane's Defence Weekly*, 7 June 2016, reprinted in https://thaimilitaryandasianregion (site discontinued), accessed 25 June 2018.

106. Fisher, "China Needs 'More Than 1,000' Xian Y-20"; and Craig Caffrey and Andrew Tate, "Possible Y-20 Tanker Variant Spotted," *Jane's Defence Weekly*, 21 November 2018, https://m.kaskus.co.id/.

107. Roblin, "Forget About China's Stealth Fighter."

108. *China Military Power*, 2019, 34.

109. Brian Wang, "China Completing More Copies of the World Largest Cargo Plane," *Next Big Picture*, 17 January 2019, https://www.nextbigfuture.com/.

110. Dylan Malyasov, "Fourteen New Shaanxi Y-9 Military Transport Aircraft Spotted in China," *Defense Blog*, 3 August 2016, https://defence-blog.com/.

111. Wendell Minnick, "China Expanding Air Mobile Capabilities," *Defense News*, 31 October 2011, 14.

112. "Shaanxi KJ-500 Airborne Early Warning and Control (AEW&C)," *Military Factory*, accessed 22 June 2019, https://militaryfactory.com/.

113. Maxim Pyadushkin and Bradley Perrett, "CR929 Has 'Soft Orders;' Delivery Due In 2025–27," *Aviation Week*, 26 June 2019, https://atwonline.com/, accessed 30 June 2019. The first flight is tentatively scheduled (i.e., hoped for) for 2023–25. Bradley Perrett, "Comac C919 Testing Needs to Accelerate," *Aviation Week* 180, no. 23, 26 November–9 December 2018, 24; and Roger Cliff, Chad J. R. Ohlandt, and David Yang, *Ready for Takeoff: China's Advancing Aerospace Industry* (Santa Monica, CA: RAND, 2011).

114. Sam Roggeveen, "China's New Carrier Shows Beijing Is Done Playing Defense," *Foreign Policy*, 10 May 2019, https://foreignpolicy.com/.

115. Huang Panyue, "PLA Navy to Have at Least 5 Carriers: Experts," *Global Times*, 6 December 2018, http://english.chinamil.com.cn/.

116. Rick Joe, "A Mid-2019 Guide to Chinese Aircraft Carriers," *Diplomat*, 18 June 2019, https://thediplomat.com/.

117. Joe, "A Mid-2019 Guide to Chinese Aircraft Carriers."

118. Joe, "A Mid-2019 Guide to Chinese Aircraft Carriers." The first two carriers had ski jumps for takeoff rather than catapults, which limits the weight of the aircraft taking off.

119. Wendell Minnick, "Are U.S. Defense Experts Getting China Wrong? Yes on Everything," *Defense News*, 1 December 2012, https://engineeringevil.com/; Global Security, "KLC-7/KJ-600/

Air Police 600 Carrier—Based Airborne Early Warning (AEW)," accessed 12 August 2019, https://www.globalsecurity.org/; and David Axe, "China's Carrier Drone Breaks Cover," *Combat Aircraft* 20, no. 1 (January 2019): 94.

120. "China's Medium-Sized Stealth Fighter Jet FC-31 May Be Deployed on Future Aircraft Carriers: Sources," *Global Times*, 2 January 2019, http://en.people.cn/.

121. Minnie Chan and Guo Rui, "China Will Build 4 Nuclear Aircraft Carriers in Drive to Catch US Navy, Experts Say," *South China Morning Post*, 6 February 2019, https://www.scmp.com/; and Panyue, "PLA Navy to Have at Least 5 Carriers."

122. For a detailed study of this subject, see Lt Col Thomas R. McCabe, USAFR, Retired, "Keeping A2/AD at Bay: The Imperative for Base Defense in the Western Pacific," *Mitchell Forum for Aerospace Studies*, January 2018.

123. Fisher, *China's Military Modernization*, 112.

124. Keith Johnson and Dan De Luce, "One Belt, One Road, One Happy Chinese Navy," *Foreign Policy*, 17 April 2018, https://foreignpolicy.com/.

125. Many of the Soviet engineers were very narrowly trained and were actually more technicians than engineers. The education level for a "sizeable percentage" of Chinese "engineering students" is reportedly "significantly less" than for their Western counterparts. Eric Hagt, "Emerging Grand Strategy in China's Defense Industry Reform," in Roy Kamphausen, David Lai, and Andrew Scobell, *The PLA at Home and Abroad: Assessing the Operational Capabilities of China's Military* (Carlisle, PA: US Army Strategic Studies Institute, 2010), 512.

126. Sydney J. Freedberg Jr., "US Must Hustle On Hypersonics, EW, AI: VCJCS Selva & Work," *Breaking Defense*, 21 June 2018, https://breakingdefense.com/.

VIEW

An Argument against Satellite Resiliency

Simplicity in the Face of Modern Satellite Design

Capt Dax Linville, USAF
Maj Robert A. Bettinger, USAF, PhD

Introduction

"I watch what our adversaries do. I see them moving quickly into the space domain; they are moving very fast, and I see our country not moving fast, and that causes me concern," US Strategic Command Commander Gen John E. Hyten told the Halifax International Security Forum in November 2017.[1]

The US Air Force and the wider US government rely heavily on space-based capabilities in various orbital regimes to project national security and sovereignty. However, these capabilities are enabled by the design, launch, and operation of satellites produced with a design methodology that favors large, monolithic, and technologically exquisite space systems. Despite the ability for these satellites to provide enduring and resilient capabilities, they suffer from a woefully long acquisition process that debilitates any prospect of rapid satellite reconstitution in the event of a space war.

Classically, the satellite design process has focused on hardening and protecting spacecraft from the hostile natural space environment. Now the emphasis has shifted to address man-made and counterspace threats in a broader context of securing spacecraft survivability in space as a war-fighting domain within which to operate. The most prevalent, nonhostile man-made threat comes from the generation of space debris resulting from on-orbit satellite breakups and collisions. Most notably, debris resulting from breakup events such as the Chinese antisatellite (ASAT) test in 2007, the collision of Cosmos 2251 and Iridium 33 in 2009, and the more-recent Indian ASAT test in 2019 have prompted an increasing awareness of the contested and congested nature of space operations.[2] The cause of debris-generating events in 2007 and 2019, kinetic ASATs, and the broader spectrum of counterspace weapons constitute a progressively pressing belligerent threat to the US Space Enterprise.

A new satellite design methodology is advocated to counter the increasingly hostile space environment and ensure the continued benefits of US space-based capabilities. Its design focuses on a disaggregated architecture comprised of smaller, less capable spacecraft that collectively work together to perform the same task or mission. In 2013, Air Force Space Command (AFSPC) responded to the events described above and proposed the implementation of disaggregated space architecture. This article serves as a complement to the earlier AFSPC study and will discuss the benefits of a US space systems engineering posture that focuses on simplicity rather than resiliency. Such a paradigm shift in satellite design is proffered as a means of national security space enterprise force reconstitution in the event of counterspace hostilities. This shift would ensure continued US access to space capabilities necessary for the execution of national strategy. In terms of structure, this article will examine the thesis by first outlining the role of resiliency in modern space systems engineering as specifically related to satellite design, reliability, and architectures. Next, the argument for satellite simplicity will be presented with an analysis of the advantages and disadvantages of such a design implementation.

Resiliency and Modern Space Systems Engineering

Since the dawn of the Space Age, emerging space-faring nations have recognized that space is a harsh environment for the operation of both manned and unmanned systems. Also, the inability to perform on-orbit repairs makes space an increasingly challenging environment for which to design satellites. Ionizing radiation from celestial bodies wreaks havoc on sensitive electronics with such radiation causing frequent microscopic damage that can lead to unexpected system restarts, and in some cases, completely circuit burnout. Also, as previously introduced, the rise in spacecraft ASAT tests and other collisions increases the amount of debris that will remain on-orbit for the foreseeable future. The debris generated from these types of collisions can create fragments of millimeters in diameter, which, despite their size, can still pose an incredible danger to spacecraft. For example, an extremely small piece of space debris, "likely no bigger than a few thousandths of a millimeter across," caused a 7 millimeter diameter chip in one of the International Space Station's glass windows,[3] an exterior surface specifically designed for such a collision. In addition to space debris, satellites must also resist adversarial counterspace threats exploiting a diverse array of disruptive, degrading, and destructive capabilities that seek to interfere with and obstruct satellite mission execution. Each of these factors—environmental, man-made, and counterspace threats—should be balanced within spacecraft design. Collectively, they can be thought of as a Venn diagram where the optimal design strikes a balance at addressing each design factor while also meeting cost, schedule, and performance goals, as shown in the accompanying figure.

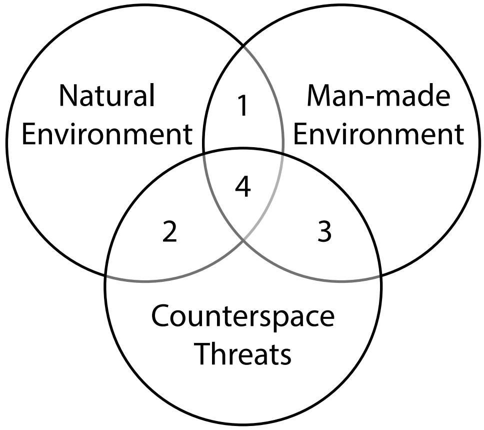


Figure. Venn Diagram illustrating the key focus areas in spacecraft resiliency

By their fundamental nature, spacecraft are products of processes and methodologies. The underpinning philosophy of current spacecraft design is the concept of resiliency, which can be broken down into three main categories: design, reliability, and architecture. Current spacecraft designs accomplish resiliency in single-satellite systems by maximizing the on-orbit lifespan through the use of highly optimized components that result in an aggregated highly reliable design. In other words, the expenditure of both significant program funding and schedule will more than likely produce satellites that feature a high design-based level of reliability. Given the historically high costs associated with both satellite component/system design and space launch, it is understandable how cost-saving techniques would dictate that the architecture be monolithic because a requirement for a single launch minimizes total launch costs. Thus, a given single-satellite architecture, paired with a high demand for system capability, often necessitates a highly complex design solution. This design, born out of a peaceful use of space ideology, has been proven to work quite well in providing capability that resists the natural and man-made environment. However, as the political landscape changes and counterspace threats are increasingly considered, our idea of spacecraft design must also evolve.

As a counterpoint to spacecraft resiliency, the term *spacecraft system simplicity* is proposed, which is best described as the movement in the Venn diagram in the preceding figure from Region 1 to Region 4. Historically, when spacecraft were designed with only the natural and man-made environment in mind, the resulting optimal design naturally became a compromise between the two design factors based on the requirements of a given mission. The core idea of spacecraft simplicity can be thought of as a series of changes to "recenter" the spacecraft design methodology. These changes would adequately address the inclusion of the third design factor (counterspace threats) that had not previously been seriously considered because of the reigning peaceful use of space ideology. It is proposed that one of these recentering changes address counterspace threats be in the form of evolving the contemporary architectural paradigm of single-satellite systems to multiple satellite systems. Such a shift would enable the design for each satellite to be less complex, less expensive, and more capable of resisting counterspace threats by relying on a strength-in-numbers approach rather than providing a tailored system defensive response.

Dividing a given space capability across multiple smaller satellite constellations can be accomplished in a variety of different ways. As part of a Defense Advanced Research Projects Agency study from the late 2000s, O. Brown shows a possible future where smaller satellites are organized in a fractionated architecture where individual spacecraft subsystems are broken down into separately flown modules connected via wireless encryption.[4] Fractionated architectures theoretically allow easier system modification and provide the capability of replacing damaged subsystems without having to replace the entire system. To illustrate this idea, Brown provides an example where an on-orbit communication satellite can gain additional uplink/downlink capability by simply launching more communication modules into the midst of the total collection. However, to effectively carry out a fractionated architecture, the US would need to completely rethink how spacecraft are designed and built, which may be too aggressive a move in the short-term for not only for the government but also for the space industry. In light of this obstacle, a disaggregated architecture is proposed.

A disaggregated architecture splits the total capability across smaller, less capable, near-identical platforms. While the individual spacecraft would be inferior in terms of performance compared to contemporary monolithic single-satellite systems, the sum of all capability delivered by the disaggregated architecture can be shown to have significant advantages in terms of overall performance, reliability, and robustness to counterspace threats. In essence, the idea of spacecraft simplicity revolves around the notion of abandoning high levels of individual satellite reliability in favor of a "strength-in-numbers" approach. By abandoning the need to make each satellite highly reliable, the cost and complexity of each satellite can be substantially reduced. As a result, economies of scale can be utilized to quickly and cheaply make higher quantities of these "less resilient" satellites. When cost savings from development and production are paired with the increasingly cheaper access to space, a cost and schedule advantage can be made over the typical single resilient spacecraft paradigm.[5] Furthermore, abandoning redundant components included for extending mission lifetime, reinforced environmental shielding, and other resiliency measures allow the overall size envelope of the satellite to shrink, thus further reducing material costs. These cost and schedule savings have the potential to make responsive space feasible, which would be necessary to rapidly replenish failed or destroyed satellites on-orbit.

In the context of a "congested, contested, and competitive" space environment,[6] another strength that the simplicity model has over the traditional resilient model is the concept of swarming, which can provide both offensive and defensive benefits. Examples of swarm tactics used in nature, namely how wolves hunt, illustrate the benefits of offensive swarming. Overall, a lone wolf is relatively easy to dispatch and poses little threat to a larger prey; however, a pack of wolves makes even the most massive prey extremely cautious. Therefore, as demonstrated by this one example in nature, a large number of weaker attackers can easily overwhelm the defenses of a larger defender, especially when the defender is optimized for countering only one enemy at a time.[7] When this concept is applied to space, a similar effect could be gained from a team of smaller, less capable spacecraft. Faced with space as a war-fighting domain, the concept of spacecraft simplicity results in spacecraft swarms that could provide an edge against the historically strong, single-satellite.

The concept of swarming also carries defensive benefits primarily in the form of improving attribution of hostile action and dissuasion from attack. A swarm is inherently difficult to eliminate, because it requires a persistent show of force to eradicate each member in the swarm. This show of force is much more substantial than a single strike against a single-satellite, and, therefore, is more directly attributable to hostile action. Alternatively, the failure of one satellite can easily be attributed to the natural space environment, or a faulty component or system. Rendleman states that this lack of attribution in today's space environment makes it difficult to enforce existing and future space policies due to plausible deniability.[8] Furthermore, a swarm can operate through an adversarial attack, although at degraded performance, and can be repaired after the attack to full capability with subsequent reconstitution space launches.[9] This idea of repairing damaged system capability is completely infeasible with the current monolithic architecture because repairing any lost capability involves spending millions to even billions of dollars on an entirely new system. This reparability aspect of the simplicity model further illustrates Rendleman's idea of *benefit denial*. This term describes when a potential adversary realizes little gain in attacking the swarm architecture as it is continually reconstituted to the point where no lasting capability was lost or even temporarily placed offline. It is hoped that a logical adversary would conclude such an attack is pointless, thus reinforcing the idea of deterrence from hostile actions that is gained from a swarm architecture over the existing single-satellite alternative.

Simplicity as a Counter to Satellite Resiliency

The current methodology of achieving architectural resiliency can be vastly improved by the simplicity model. Instead of making an already complex system last longer through the use of adding more redundant components, a better strategy would be to utilize a disaggregated architecture comprised of less complex spacecraft that boast higher reliability both as individual systems and when integrated as an architecture. This strategy is achievable with the spacecraft simplicity model, which allows for less complex designs through the reduction in overall form factor by eliminating or reducing system components such as certain redundant modules and bulky shielding. While the individual spacecraft may seem logically less resilient as a result, the reliability actually increases. In a study conducted by G. F. Dubos, J. F. Castet, and J. H. Saleh, the overall reliability for medium-sized satellites (500–2,500 kilograms) was shown to be actually higher than any other size category, thereby reducing the likelihood of failure when compared to the larger exquisite systems (>2,500 kilograms).[10] This increase can primarily be attributed to the observed trend that medium-sized satellites enjoy the "best of both worlds" in terms of reduced complexity (when compared to larger satellites), and higher quality of components (than those used in smaller satellites).[11] By having a disaggregated architecture, the maintaining organization now can replace worn-out spacecraft individually without replacing the entire architecture. In a way, this can be seen as reserving spares to act as redundancies and deploying them only when needed. This practice is statistically optimal and more resource-efficient as redundancy is used only when needed and can be done without taking the system capability offline. Thus, research shows that reliability statistically favors medium-sized satellites, making a disaggregated architecture all the more appealing when compared to monolithic, single-satellite systems.

The concept of simplicity also opens new doors to the expanded use of commercial-off-the-shelf (COTS) and government-off-the-shelf (GOTS) components in the satellite design process. The need for contemporary satellite systems to be highly capable and resilient requires a highly optimized solution. This solution often excludes the use of COTS/GOTS simply because either a tailored solution is required to meet required system specifications or that the COTS/GOTS solution lacks the on-orbit heritage of legacy space-tested components and systems. With a shift toward simplicity, the use of these readily available components could substantially reduce the system hardware and development costs, while also decreasing production timelines required for larger satellite formations to be viable. The use of more standardized parts enables research and development efforts to be diverted from focusing on developing highly specialized parts for one particular spacecraft toward the development of new components that can be used in a variety of different space systems, independent of the mission. In other words, instead of spending time reworking current technology into a highly optimized part for a particular satellite mission set, development could instead work toward inventing new technology and/or evolving current technologies for incorporation into future component designs. Doing so spurs the development of new technology, which, along with the shorter design life of spacecraft in the simplicity model, allows a greater technology refresh cycle to be realized. Finally, the on-average faster production time observed for less complex satellites within the simplistic model means newer generation spacecraft incorporating better technology can be more quickly fielded to outpace current monolithic satellite systems that are still operating with technology likely developed in the preceding 10–20 years. The result is the capability to respond, adapt, and incorporate the impact of new technology that current monolithic satellite design architectures cannot maintain the pace.

Counterarguments for Simplicity

The concept of simplicity brings several challenges that would hamper its implementation. First, the introduction of more satellites requires an increased launch tempo, as well as an increased integration complexity of payload stacks on the launch vehicle to ensure maximum usage of launch capability. While cheaper access to space could theoretically allow more launch vehicles to be purchased (thereby increasing launch tempo), the nation's launch infrastructure would also have to be expanded to handle the extra launches. The proposed strategy for increasing launch capability (while current launch infrastructure is built up), is to utilize rideshare to ensure maximum efficiency in the current use of launch capacity. Offices such as the DOD's Space Test Program (STP) can help overcome the logistical and programmatic challenges inherent in rideshare if their lessons learned and expertise were incorporated into mainstream system program office activities. Ultimately, this change in launch tempo is necessary to replace failed or decommissioned spacecraft within the disaggregated architecture since the individual satellite lifetimes would be shorter than those observed with most contemporary space missions. Finally, controlling a dynamic constellation of satellites in space requires the state-of-the-art guidance, navigation, and control (GNC) algorithms to precisely perform rendezvous and proximity operations (RPO) without the risk of inadvertent collisions. These topics are discussed in more detail below to illustrate how these required advancements do not represent insurmountable obstacles to the concept of simplicity.

The need to increase the launch tempo is evident for spacecraft simplicity to be fully realized since more spacecraft would be required to operate on-orbit with shorter total lifetimes compared to those currently in operation today. The current market price per kilogram to space has recently begun to drop from an average of \$18,500 from 1970–2000 to \$2,700 in 2010 with the debut of the Falcon 9.[12] This considerable reduction results from the expansion of launch vehicle options, as well as the introduction of commercial entities such as SpaceX into the launch vehicle market. From an interview in 2012, SpaceX CEO Elon Musk stated that the secret to the company's success "stems from one core principle: simplicity enables both reliability and cost. Think of cars, is a Ferrari more reliable than a Toyota Corolla or a Honda Civic?"[13] Thus, SpaceX has demonstrated the effective use of simplicity regarding launch vehicles, thereby demonstrating the idea works and also taking the first steps toward increasing the launch tempo that is required for the spacecraft simplicity model to work. By reducing the costs of the exquisite traditional monolithic spacecraft to cheaper simplistic spacecraft, and by leveraging increasingly cheaper access to space, the idea of spacecraft simplicity takes steps toward an executable plan that is cheaper than traditional models if the current cost trends continue.

An increase in integration complexity is evident if launch capabilities are to be fully utilized. Ensuring that each launch vehicle is launched with a full payload complement (to prevent a waste of launch capability) is the specialty of STP, which has been launching primarily smaller research payloads for various government and university customers for the last 50 years.[14] At STP, commonplace is the negotiation of different organization's operational requirements as payloads from all types of communities are manifested onto a single launch vehicle. The logistics of multiorganization, multiobjective missions are sorted out by matching procured launch capability to forecasted and prioritized needs through a variety of rideshare mechanisms such as the Space Experiment Review Board process. For the concept of simplicity to be effective, expertise within the STP process needs to be applied to mainstream operational satellite processes to both prioritize launches to replace degrading architectures and to ensure each launch is full to effectively use each launch vehicle. The USAF is taking a step in the right direction by recently standing up organizations such as the Space & Missile's System Center's Multi-Mission Manifest Office.[15] This new organization's creation shows that the US is starting to take practices utilized by STP to mainstream operational mission sets. The expertise provided by these organizations will be critical to the idea of simplicity since there will be a need to effectively manage how architecture replenishment should be prioritized and how each launch vehicle should be filled to meet the increased demand.

In terms of on-orbit operation, if the idea of spacecraft simplicity was implemented now without the required advancement of GNC for RPO, then the current cadre of spacecraft operators would certainly find themselves overwhelmed in controlling the disaggregated architecture against the unpredictable space environment. For example, Earth's oblateness causes gravitational effects that disperse spacecraft formations under natural uncontrolled motion.[16] Thus, controlling a spacecraft formation requires constant maintenance, which is added on top of normal mission operations. Managing the architecture instead of managing the mission would undoubtedly call for an increased shift burden to an already undermanned career field without the use of autonomous or semiautonomous GNC for RPO. This type of autonomy could help keep formation integrity, prevent accidental spacecraft collisions with other members in the architecture, and reduce the number of commands to be sent from the ground stations (thus reducing the operational workload). Ultimately, these advancements in autonomous station and formation keeping are needed to ensure spacecraft operators can focus on the mission and not on tasks such as orbit maintenance, formation integrity, and other mundane tasks.

Conclusion

Since the end of the twentieth century, the US has examined the disaggregation of space resources in response to new emerging counterspace threats but has yet to act as evidenced by the continued development of monolithic satellite architectures. The concept of spacecraft simplicity provides a way to realize the shift to disaggregated architectures because it utilizes multiple less capable satellites to fulfill the role historically taken by exquisite high-value, flagship space systems. The idea of a multiple satellite swarm enhances the combat effectiveness and ability to attribute hostile action, both of which is assessed to deter a potential adversary from conducting counterspace operations against existing space-based resources. Finally, satellites that supplant the notion of complicated resiliency schemes in favor of a "strength-by-numbers" approach reduces their technical complexity (i.e., cheaper to produce) and makes them lighter, smaller in mass, and reduced in form factor (i.e., easier to launch on a responsive scale and more reliable). All of these factors point together to form an effective argument against today's idea of spacecraft resiliency toward tomorrow's idea of how spacecraft resiliency methodologies should evolve. ✪

Capt Dax Linville, USAF

Captain Linville (Student, Air Force Institute of Technology) is pursuing a master's degree in astrodynamics with a specialty in space control.

Maj Robert A. Bettinger, USAF, PhD

Major Bettinger (PhD, Air Force Institute of Technology [AFIT]) is an assistant professor of Astronautical Engineering and the Curriculum Chair for the Astronautical Engineering degree program in the AFIT Department of Aeronautics & Astronautics, Wright-Patterson AFB, Ohio.

Notes

1. Sandra Erwin, "STRATCOM Chief Hyten: 'I Will Not Support Buying Big Satellites That Make Juicy Targets,'" *Space News*, 19 November 2018, https://spacenews.com/.
2. T. S. Kelso, "Analysis of the 2007 Chinese ASAT Test and the Impact of its Debris on the Space Environment" (paper presented at the 8th Advanced Maui Optical and Space Surveillance Technologies Conference, Maui, HI, 2007): 1–10, https://celestrak.com/; A. Tan, T. X. Zhang, and M. Dokhanian, "Analysis of the Iridium 33 and Cosmos 2251 Collision using Velocity Perturbations of the Fragments," *Advances in Aerospace Science and Applications*, Vol. 3, no. 1 (2013): 13–25, https://www.ripublication.com/; and Caleb Henry, "India ASAT Debris Spotted above 2,200 Kilometers, Will Remain a Year or More in Orbit," *Space News*, 9 April 2019, https://spacenews.com/.
3. Derek Richardson, "Survey Shows 'Hundreds of Impacts' on ESA's Columbus Module," *Spaceflight Insider*, 8 February 2019, https://www.spaceflightinsider.com/.
4. O. Brown and P. Eremenko, *Fractionated Space Architectures: A Vision for Responsive Space* (Arlington, VA: Defense Advanced Research Projects Agency, 2008): 1–15, https://apps.dtic.mil/.
5. J. D. Rendleman, "A Strategy for Space Assurance," *Astropolitics* 1, no. 1 (2010): 249.
6. DOD, *National Security Space Strategy* (Washington, DC: DOD, January 2011), https://www.hsdl.org/?view&did=10828.
7. Håkan Sand et al., "Effects of Hunting Group Size, Snow Depth and Age on the Success of Wolves Hunting Moose," *Animal Behaviour* 72 (2006): 781–89, https://www.researchgate.net/.
8. Rendleman, "A Strategy for Space Assurance," 230–32.
9. Air Force Space Command, "Resiliency and Disaggregated Space Architectures," white paper, 2013, https://www.afspc.af.mil/.
10. G. F. Dubos, J. F. Castet, and J. H. Saleh, "Statistical Reliability Analysis of Satellites by Mass Category: Does Spacecraft Size Matter?" *Acta Astronautica* 67 (2010): 584–95.
11. Dubos, Castet, and Saleh, "Statistical Reliability Analysis of Satellites," 584–95.
12. H. W. Jones, "The Recent Large Reduction in Space Launch Cost" (paper presented at the 48th International Conference on Environmental Systems, Albuquerque, NM, 2018): 2–3, 8.
13. Andrew Chaikin, "Is SpaceX Changing the Rocket Equation?," *Air & Space Magazine*, 2012, https://www.airspacemag.com/.
14. Barbara Braun et al., "Breaking (Space) Barriers for 50 Years: The Past, Present, and Future of the DoD Space Test Program" (paper presented at the 31st Annual AIAA/USU Conference on Small Satellites, Logan, UT, 2017): 1–11, https://docplayer.net/.

15. Lt Col Colleen Kroeker, "Launch Enterprise Systems Directorate Uses SMC 2.0 Initiatives to Streamline," *SMC Public Affairs*, 2018, https://www.losangeles.af.mil/.

16. S. A. Schweighart and R. J. Raymond, "High-Fidelity Linearized J2 Model for Satellite Formation Flight," *Journal of Guidance, Control, and Dynamics* 25, no. 6 (2002): 1073–80.

VIEW

Quiet Giant

The TITAN Cloud and the Future of DOD Artificial Intelligence

Maj William Giannetti, USAFR

The DOD's new artificial intelligence (AI) strategy is a treasure trove of ideas.[1] Unveiled during a February 2019 press conference, it is (to put it mildly) an ambitious document, and its implications are far-reaching. In a departure from hard-coded "garbage-in, garbage-out" programs that burp out specific output, algorithm writers will craft code that learns on its own. Neural networks modeled after biological systems might one day roam the gray areas of human thought. With time and considerable training, AI will discern tanks from trucks or MiGs from run-of-the-mill airplanes. Autonomous vehicles will transport troops to the frontlines, and someday pilotless aircraft might transport cargo and refuel fighters. Developmental Air Force AI already enables semiautonomous "loyal" wingmen, guided by pilots, to carry out preprogrammed missions from the relative safety of their cockpits.[2] Later, faulty parts imbued with AI would speak out when their replacement comes due, making maintenance schedules more efficient and less costly. Military doctors might recommend an early biopsy after an AI-assisted ultrasound detects disease, thus improving prognoses so that all Americans might live longer, fuller lives.

Air Force generals presently envision a world where AI rapidly transforms data into knowledge that accurately informs a human-led decision-making process.[3] "We need our analysts to harmonize the data-to-decision quality at speed," said Air Force Director of Intelligence Lt Gen VeraLinn "Dash" Jamieson during an interview at Goodfellow AFB, Texas in 2017. "We must build the next generation ISR enterprise capable of possessing decision advantage across the entire spectrum of conflict."[4] But to get there, developers require a preaccredited, flexible cloud to cultivate the AI strategy's ideas, lest they die an untimely death on the policy vine. Another must is a secure DOD cloud that stores the considerable quantity of data that would fuel the nation's AI and machine learning algorithms. Skeptics say the piles of servers and processors it would take cost billions. But a partnership between Lt Gen John N. T. (Jack) Shanahan's new Joint Artificial Intelligence Center (JAIC) and a little-known Air Force cloud service called TITAN (Technology for Innovation and Testing on Accredited Networks) could bring value while making everyone's AI dreams come true for a fraction of the cost. First, let's put cloud computing in context by looking at its costs and the role it plays in managing the Pentagon's IT.

Cloud City

According to the Government Accountability Office, the federal government invests more than $90 billion annually in the development, implementation, and maintenance of IT infrastructure.[5] To offset this cost, the Office of Management and Budget debuted its Cloud First Strategy, which mandated agencies pool IT resources in secure, efficient, and cost-effective ways.[6] Cloud computing eliminates storing data on bare metal, stand-alone hard drives and shifts the burden to groupings of software and high-capacity storage servers. A cloud's elasticity allows administrators to add (or subtract) storage and computing power while public and private user groups lend it scalability.

The DOD went all in with the cloud, investing $2.7 billion between 2015–18. Its subordinate organizations operate an estimated 500 clouds, and as of 2019, the Pentagon racked up 88 cloud investments out of 2,735 for IT overall.[7] The sheer number of clouds managed by multiple vendors poses a growing administrative headache. The Joint Enterprise Defense Infrastructure (JEDI) initiative, with its estimated $10 billion price tag over 10 years, seemed to be the cure. Businesses from across the tech community flocked to Washington with their proposals. Microsoft, a decades-long mainstay of government IT, recommended Azure for JEDI. Amazon Web Services (AWS), a relative upstart, offered its seemingly infinite storage capacity.

AWS was a favorite to win because it gained the government's confidence in storing sensitive information and programs.[8] Engineers from the private and government sectors use AWS' SageMaker to create machine-learning algorithms with drag-and-drop ease. Clouds would consolidate under JEDI's umbrella and lessen confusion as the department transferred its oldest legacies into it.[9] One set of tools and standards for AI (or other software development for that matter) affords engineers a shared environment to discover information and create algorithms. Traditional computer firms, like IBM and other Silicon Valley players like Oracle, have lodged complaints. They claimed awarding JEDI to a single company unfairly stifles competition and makes the military's cloud especially vulnerable to Russian and Chinese cyberattacks.[10] The arguments soon intensified and took a more personal turn. President Donald Trump's feud with Amazon CEO Jeff Bezos spilled into public view, and in a surprise ruling Microsoft was granted the huge contract. In its appeal to a U.S. federal court, *Amazon says "political influence"* tipped the Pentagon's decision, and that procurements should be administered "objectively."[11]

A Clear Choice

Meanwhile, as corporate and government lawyers do battle, an average-looking industrial building sits tucked into the scrub pines and dogwood trees of Fort Belvoir, Virginia. Inside one of its air-cooled rooms, chilled to 65 degrees Fahrenheit, are dozens of repurposed computer servers quietly whirring away. To the average onlooker, the sight might seem unimpressive, but this is TITAN, a government-owned, contractor-operated cloud worth $18 million—a veritable shoestring compared to JEDI. The US Air Force's ISR Innovations Directorate founded TITAN in 2016. It is funded entirely by Headquarters Air Force's ISR chief information officer and maintained by a handful of defense workers. TITAN is unique because it is a hybrid cloud, a place where engineers rapidly prototype and deploy their software or custom applications. At 7.6 petabytes, it is modestly sized and ideal for the JAIC's specialized work. To the layman, a petabyte might not seem like much, but it's a very sizable chunk of data. Back in 2013, the Air Force's Distributed Common Ground System was processing 1.3 petabytes per month, which equates to about 1,000 hours of full-motion video per day.[12] By comparison, in 2014, Facebook's massive 1.2 billion user base was generating four new petabytes of content per day.[13]

A hybrid cloud combines the best of private and public clouds. Public clouds' combination of hardware, software, and storage services are managed by a third party while private clouds are sequestered from the public and protected by a firewall. "Combining public services with private clouds and the data center as a hybrid is the new definition of corporate computing," says Judith Hurwitz of Hurwitz and Associates, an IT consulting firm. "Not all companies that use some public and some private cloud services have a hybrid cloud. Rather, a hybrid cloud is an environment where the private and public services are used together to create value."[14] Top cloud competitors AWS and Microsoft Azure offer a combination of physical and virtual suites, too. They bill their customers on a monthly pay-as-you-go basis. While AWS typically charges customers by the hour, Microsoft Azure and its Machine Learning Service charge by the minute. The attraction to AWS stems from its unalloyed computing power. Depending upon the customer, it can increase scale to thousands of machines and weave neural nets that far exceed TITAN's limit. Azure, on the other hand, is less hardware intensive. Customers can have as many virtual machines as they like. Simple to use cookie-cutter software loads make start-up easy. And both firms enable the fast-paced development-to-operations (DevOps) culture that pervades software development and AI today.

But AWS and Microsoft Azure create vendor lock-in, which eventually commits (or locks) customers into using their specific proprietary tools indefinitely. Not TITAN. Its value to the JAIC comes from its agnostic nature, where users are in control. They can choose either the Microsoft or Linux operating systems for DevOps, at no monthly or daily expense, and with zero strings attached. And, unlike the typical government 1990s-style data center where IT support occurs in-house (or, on-premises), TITAN is managed off-premises. Its servers are separate from the Pentagon but kept secure and effectively reachable by all its customers. TITAN's almost two dozen customer agencies can access 430 data feeds via virtual machines worldwide and develop custom software without purchasing additional equipment. Portability is a plus, too, because administrators can log in almost anywhere to diagnose problems, upload software patches, make updates themselves, or automate the tasks. As an added benefit, like AWS and Microsoft Azure, TITAN has authorities to operate on the DOD's unclassified and classified systems, an essential requirement for clouds, according to former Deputy Secretary Patrick Shanahan's Cloud Executive Steering Group.[15] With a flexible, preaccredited cloud that provides developers value and relative cost savings to the taxpayer, the JAIC's choice is clear. A TITAN partnership will help the Pentagon discover the AI advances of tomorrow to improve America's security and quality of life today. ✪

Maj William Giannetti, USAFR

Major Giannetti (MS, St. Joseph's University) is a reserve officer assigned to the Headquarters Air Force staff at the Pentagon.

Notes

1. "Summary of the 2018 Department of Defense Artificial Intelligence Strategy: Harnessing AI to Advance Our Security and Prosperity," 12 February 2019, https://media.defense.gov/.

2. Andrew Liptak, " 'Skyborg' Could Let F-35 and F-15 Fighter Jets Control Their Own Companion Drones," *Verge*, 22 May 2019, https://www.theverge.com/.

3. *Air Superiority 2030 Flight Plan: Enterprise Capability Collaboration Team*, May 2016, https://www.af.mil/.

4. Oriana Pawlyk, "China Leaving US Behind on Artificial Intelligence: Air Force General," *Military.com*, 30 July 2018, https://www.military.com/.

5. US Government Accountability Office (GAO), "Cloud Computing: Agencies Have Increased Usage and Realized Benefits, but Cost and Savings Need to Be Better Tracked," Report to Congressional Requesters, April 2019, https://www.gao.gov/.

6. Federal Cloud Computing Strategy, "From Cloud First to Cloud Smart," accessed 24 October 2019, https://cloud.cio.gov/.

7. "DoD Cloud Update," Deputy Secretary of Defense, 22 June 2018, https://federalnews network.com/. See also GAO, "Cloud Computing: Agencies Have Increased Usage and Realized Benefits, but Cost and Savings Need to Be Better Tracked," Report to Congressional Requesters, April 2019, https://www.gao.gov/.

8. Frank Konkel, "Tech Firms Ask Congress to Intervene on Pentagon JEDI Contract," *Next-Gov*, 30 April 2018, https://www.nextgov.com/.

9. Jack Moore, "Here Are 10 of the Oldest IT Systems in the Federal Government," *NextGov*, 25 May 2016, https://www.nextgov.com/.

10. GAO, "Decision in the Matter of International Business Machines Corporation," 11 December 2018, https://www.gao.gov/. See also GAO, "Decision in the Matter of Oracle America, Inc.," 14 November 2018, https://www.gao.gov/.

11. Aaron Gregg and Jay Greene, "Fierce Backlash Against Amazon Paved the Way For Microsoft's Stunning Pentagon Cloud Win," *Washington Post,* 30 October 2019, https://www.washingtonpost.com/. See also Jared Serbu, "Amazon to Protest DoD's JEDI Cloud Contract," *Federal News Network*, 14 November 2019, https://federalnewsnetwork.com/.

12. Marc V. Schanz, "ISR After Afghanistan," *Air Force Magazine*, January 2013, http://www.airforcemag.com/.

13. Janet Wiener and Nathan Bronson, "Facebook's Top Open Data Problems," *Facebook Research*, 22 October 2014, https://research.fb.com/.

14. Judith Hurwitz et al., "What is Hybrid Cloud Computing?" *Dummies*, https://www.dummies.com/.

15. DOD, "Accelerating Enterprise Cloud Adoption," 15 February 2018, https://dod.defense.gov/.

COMMENTARY

Getting out of Our Tactical Comfort Zone

Leveraging the Joint Planning Process to Prepare Airmen for Joint Duty

Col Frederick "Trey" Coleman, USAF

I wasn't thrilled when I received my initial assignment notification to US Central Command (CENTCOM) Strategy, Plans, and Policy (J5) after graduating from National Defense University. Like many of us, I wasn't looking forward to staff work, much less in the infamous "SADCOM" headquarters. Three years later, I'm here to confess that my time in the CENTCOM J5 was one of the most defining assignments in my professional career. My time at CENTCOM J5 presented the opportunity to plan and negotiate operations at the international level and to make an impact well beyond that which I could make in an operational assignment. Simply put, my time on the CENTCOM staff made me a better officer and senior leader. In many ways, the skills and habits I learned as an Airman helped prepare me for joint staff work, but I believe there are several things we can do better to prepare officers for joint staff duty. What follows are three lessons that I took from my time on the CENTCOM J5 planning staff. After each lesson learned, I will identify some opportunities to better prepare Airmen to serve on a joint staff. I will also identify some competitive advantages that Airmen bring to any joint staff position.

First, good staff officers (not just those on planning staffs) use the Joint Planning Process to plan and communicate. The joint planning process (JPP) works. It gives us a model to organize and communicate our thoughts. It is a proven framework that provides a step-by-step approach to problem solving. One of the greatest strengths of the JPP is that it begins by defining the desired end state. It requires the planner to first identify a discernible, achievable, and measurable end state, and then build objectives and tasks to meet that desired end state. If we don't align our tasks and objectives with the end state, we may find ourselves executing tactical operations flawlessly without ever achieving our operational or strategic goals while creating unnecessary risks for our Airmen and aircraft. Just as important, the JPP works because it is the commonly understood joint operational language. Combatant commanders understand operational design and are fluent in terms like *assumptions*, *risks*, *limitations*, and *tasks*. Similar to USAF operational brevity codewords, planning terminology has very nuanced meaning—every term means something and has implications and relationships with other planning terms. If staff officers don't speak this language, their words too often fall on deaf ears.

By increasing our emphasis on the JPP and thereby teaching Airmen to speak the planning language fluently, we can build and prepare better joint staff officers. As it stands, the JPP is a bit of an afterthought in the Air Force—although it is taught at different levels of professional military education, we don't apply it to daily Air Force operations. In contrast, other services apply it to everything they do, from logistics to operations; Army, Marine, and Naval officers grow up using the JPP. Frankly, emphasizing the joint planning process in the Air Force isn't an education problem; it's an application problem. The most effective way to build better joint planners is to use the JPP in regular, everyday Air Force operations. If we planned our daily operations using the JPP model, including flying operations, we would grow better joint officers from the ground up.

Second, good joint staff officers get out of their tactical comfort zone and build vast networks of subject matter experts. No good joint staff officer works alone. Instead, he or she builds a team of professionals throughout the enterprise with whom he or she shares ideas, checks for redundancies and accuracy, and gains buy-in before formal staffing. An operational planning team lead does not need to be a subject matter expert in any single domain or system. In fact, it is often best if the lead planner isn't a tactical subject matter expert at all but instead is an expert at facilitating and organizing information in accordance with the JPP. Often, if the lead planner is a tactical subject matter expert, he or she becomes naturally predisposed to focusing too much on his or her system, platform, or domain as a solution, instead of exploring several courses of action to achieve an end state. If staff officers aren't able to get out of their tactical comfort zones and instead are too reliant on their own system or domain, their proposals and projects will often fail to gain traction in the joint community.

The natural tendency to focus on tactics is perhaps the greatest challenge for an Airman on a joint staff, and one of the most important paradigm shifts we can make if we want to build better joint qualified officers. Airmen, by our very nature, are subject matter experts in our highly technical systems and platforms—we are born and raised to be tactical. For this reason, we tend to gravitate to staff positions in Operations Directorates (J3) where we can remain in our tactical comfort zone, and we steer away from planning positions that don't necessarily require or leverage our technical subject matter expertise. This gravitational pull toward operations, in turn, causes senior Air Force leaders and the Air Force personnel system to prioritize J3 (operations) assignments over J5 (strategy and planning) assignments. If we placed greater emphasis on joint staff planning assignments (J5) as well as on the schools that prepare officers to become joint planners, we would grow better joint officers, and the Air Force would be better represented on joint staffs.

The third lesson I learned on the CENTCOM staff was that on a joint staff, product is king, and the written word (not PowerPoint) is gold. Good ideas are not easily communicated using PowerPoint; they are best constructed and communicated using sentences formed around a logical argument. The written word stands alone, and it doesn't require a briefer or an explanation. It can certainly be supported by charts, graphs, or images, but the product itself must be whole, complete, comprehensive, and, most importantly, produced. Written products can take many forms—white papers, talking papers, night orders, or fragmentary orders, to name a few. But what is important is that an idea is presented, supported, and communicated in a way that can be easily understood and shared throughout a distributed enterprise. Good ideas poorly communicated are like hundred-dollar bills stuffed in a mattress—they don't grow in value, and you can't spend them.

As Airmen, we grow up planning on whiteboards and maps, and we tend to present our plans using PowerPoint slides. From my personal experience, I can't remember a single instance of writing a paper as a company grade officer (CGO) (other than for Squadron Officer School), and I hadn't heard of a night order or fragmentary order until I was a lieutenant colonel at CENTCOM. While PowerPoint may be effective for flying exercises like Red Flag, it doesn't effectively communicate to higher headquarters, the Joint Staff, the DOD, or other government departments or agencies. Moreover, because most Air Force officers don't generally practice writing as a CGO, we don't develop good writing habit patterns, and we continue to default to PowerPoint instead of the written word to communicate. By placing greater emphasis on the written word at all levels of the Air Force, we can better prepare our officers for joint staff duty.

Although there are several steps we can do better to prepare Airmen for joint assignments, I found that Airmen bring a unique set of skills to a joint staff that gives them a distinct competitive advantage. Through experience in planning, briefing, and executing flying operations, particularly during large exercises like Red Flag, we learn the fundamental organizational and briefing skills that are critical to organizational leadership. Skills like task delegation, information management, and public speaking are foundational requirements for success on a joint staff, and these skills are chiseled into Airmen in any career field. Our challenge is simply parlaying these foundational skills into processes and products that are relevant on a joint staff.

After leaving CENTCOM in the summer of 2019, I took command of the 609th Combined Air Operations Center (CAOC). This transition is fortuitous as I am now in a position to oversee the execution of many of the plans I helped write while at CENTCOM. I also have the opportunity to impress upon our CAOC planners the value of the joint planning process, the imperative of getting out of our tactical comfort zones, and the superiority of communication using the written word instead of PowerPoint. Using these tools, the CAOC is writing plans that communicate well at the combatant command level and are approved for execution, thereby turning words into ordnance. And along the way, we are building and preparing future joint staff officers. ✪

Col Frederick "Trey" Coleman, USAF

Colonel Coleman is the 609th Air Operations Center commander at Al Udeid AB, Qatar. Before this assignment, he served for three years on the US Central Command staff as the Levant branch chief in the Strategy, Plans, and Policy Strategic Plans Division.

SCHRIEVER ESSAY AWARD

On Implementing a Space War-Fighting Construct

A Treatise on Applied Frameworks from Other Domains

Lt Col Brandon Davenport, USAF*

Space is a warfighting domain."[1] This statement, made by the president and the new commander of US Space Command (USSPACECOM) Gen John W. Raymond, is now unequivocally the position of the United States. This "war-fighting domain" implication drastically changes how the US military views and plans for conflict in space. At the national-strategic level, the US should recognize it is the nation with the most to lose in a space war. Perhaps more importantly: war in space is tied to war on Earth.[2] In a peer conflict, the US must always cast a wary eye toward escalation when warring with nuclear-armed states. As such, the US policy toward space conflict should be one of limited aims and defensively postured. The US should not seek war in space, but our adversaries should know that if pressed into battle, we intend to win. As the war-fighting major command responsible for the organization, training, and equipping of USAF Space Forces, Air Force Space Command (AFSPC) must build a war-fighting culture to employ space forces in pursuit of national objectives. To do so, AFSPC must craft new *strategy*, *doctrine*, and *tactics* that allow space operators to apply fundamental war-fighting concepts to the space domain while achieving US policy goals of winning a limited war in space.

On Space Strategy

For AFSPC, as a service component to USSPACECOM and the USAF's core functional lead for space, strategy can run the gambit from grand strategy to inform national policy, acquisitions strategies, talent management strategies, and finally operational strategies in support of war plans.[3] AFSPC needs strategies for each of these in turn. However, we shall focus on strategy linked to command of the domain. Within that context, a study of other domains' theorists can help shape our views.

* Editor's note: This article was written before the signing of the FY2020 National Defense Authorization Act establishing the US Space Force (USSF) as the sixth branch of the Armed Forces. As such, references to Air Force Space Command and its associated major command functions will now need to be applied to the future USSF organizational structure currently being established.

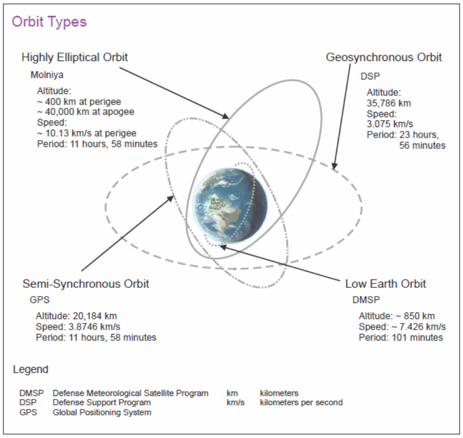
At the core of a potential space strategy are the applicable truths identified by historical theorists. These truths stretch into recorded history, and on to the standard-bearers for any discussion on military strategy: Thucydides and Clausewitz. As the first history text states, nations act out of fear, honor, and interest and often react to a perceived security dilemma.[4] These actions can lead to open war to achieve geopolitical objectives.[5] Importantly, actions in space for the foreseeable future will be undertaken by Earth-bound nations with terrestrial concerns. These nations will be required to act in a physical "space," as Colin S. Gray and John B. Sheldon point out.[6] This space would be one that is unforgiving, difficult to reach, tough to refit/service, and minimally populated as of this writing. The physical properties of operating in the space domain result in national assets of fair cost, exquisite engineering, and high military value. What these points tell us is that conflict will likely follow humanity into orbit. Here nations will use counterspace capabilities to dissuade, coerce, or compel others to bend to their political will.[7] Conflict on-orbit will most often be done by remote, and under the ultimate Clausewitzian "fog of war," the vastness of dark space. Clausewitz also highlighted that while the *nature* of war never varies, its *character* often changes its tune. This adage holds true for orbital warfare too, where space forces will march to the melody of Kepler, as well as Clausewitz.

What piece does AFSPC play here? Firstly, it must set out the objectives it wishes to achieve to meet US policy goals, then craft a strategy that accomplishes those objectives. I propose a space strategy that, at its core, is purposely restricted in scope, or as Clausewitz would say—a limited war strategy. The main objective should be to protect and defend US and Allied interests in space. Secondary objectives should include (1) the ability to negate especially critical adversary space systems that place joint and coalition forces at extreme risk during terrestrial operations; (2) the ability to reconstitute or build resiliency into space architecture; and (3) to continue supporting the joint terrestrial force with war-winning, space-based enabling capabilities such as the Global Positioning System, missile warning, and satellite communications.

The US is the space-dependent nation when it comes to military operations. This imbalance in the need for space capabilities will likely not shift much in the next few decades, primarily because the US is the expeditionary power, not our rivals. AFSPC should protect and defend US, Allied, and where appropriate, commercial, and civil space systems that allow expeditionary forces to operate far from home. AFSPC's strategy should focus on deterrence by the denial of adversary objectives, both in space and terrestrially. This deterrence can be enabled by both offensive and defensive capabilities, but their openly stated purpose should be to negate adversary counterspace systems. The Space Mitchells and Douhets—who clamor for offensive space supremacy—do so without the context of today's reality.

Two significant points undercut the rationality of the large-scale destruction of adversary space capabilities. First, in all likelihood, any large-scale space conflict the US would find itself embroiled in with space systems under dire threat would be set with nuclear-armed opponents. Thus, both sides are incentivized to limit escalation and miscalculation as outlined by earlier nuclear-war theorists like Bernard Brodie.[8] The wholesale destruction of space early-warning systems, dual-use nuclear command and control (C2), or the fielding of persistent on-orbit precision strike capabilities could run the risk of tripping nuclear red lines. Second, likely hotspots such as the Baltic States, the South and East China Seas, Straits of Malacca, and North Korea are all within our adversary's regional spheres of influence. Therefore, they can augment most space-based capabilities with local terrestrial equivalents like high-altitude long-endurance drones, pseudolites for position, navigation, and timing (PNT), terrestrial radios, fiber lines, or commercial intelligence, surveillance, and reconnaissance (ISR) capabilities. Today's advocates for offensive space supremacy are likely guilty of mirroring US requirements for space capabilities to our potential adversaries. We ought not to fall victim to the oft-warned trap. A strategy of the limited objective to protect and defend our valuable space assets will focus attention on enabling a true deterrence-by-denial strategy. This strategy may convince a would-be space aggressor that the attack would likely not succeed and consequently choose not to execute it. With a limited war objective established, where then to place assets or invest in capabilities?

Here, AFSPC should strive to embody the teachings of Corbett and, with a caveat, the contemporary writings of Dr. Everett C. Dolman.[9] Strategic lines of communication (LOC), specific orbital regimes, and LaGrange points will become the equivalent of the Straits of Malacca or Gibraltar. Albeit, these nodes and LOCs are spread over an incredibly vast region of space. Thus, Corbett's idea of fast, relatively cheap, and plentiful cruisers to defend critical assets and space LOCs holds more weight than historical maritime strategist Adm Alfred Thayer Mahan's quest for heavy battleships engaged in decisive battle.[10] As John Klein points out in his work *Corbett in Orbit*, "cruisers" in a space context may be an even more fiscally conservative than Corbett's initial work. Here, "cruisers" are best characterized as small, maneuverable satellites able to escort high-value systems cheaply and in-depth.[11] Additionally, these conceptual systems could defend vital orbital regimes or points in space, such as Molynia orbits, certain sections of the geosynchronous belt, cislunar and lunar orbits, and earth-moon LaGrange points. Of note, the low-Earth orbit (LEO) belt is excluded from this list. This primarily deals with the orbital mechanics in play. LEO orbits are too numerous and inclinations too varied to actively defend with "cruisers," except for perhaps some sun-synchronous orbits. Within the rest of LEO, defenses on-board the high-value asset seem best suited to that orbital regime. Representative orbits are shown in figure 1 below, and the complexity of the LEO regime is shown in figure 2.



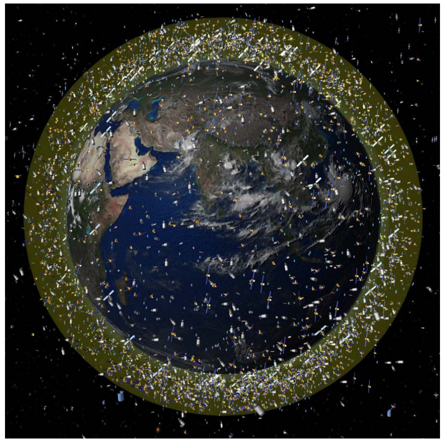


Figure 1. Representative orbit examples. Source: Joint Staff, JP 3-14, *Space Operations*, DOD, 29 May 2013

Figure 2. ESA view of orbit. Source: "Space Junk Explainer," *National Geographic*, 25 April 2019

A vitally important piece of a "protect and defend" strategy is openness, detectability, and strategic messaging. One nation's defensive weapon is another nation's security dilemma. These systems and their underlying technology are clearly dual use between offensive and defensive postures. To attempt to limit an arms race in space, the US should publicly and verifiably place these systems defensively next to high-value systems and work to minimize any overtly provocative actions that could be perceived as offensively oriented. To this point, systems placed in key orbital points may need only to be armed with reversible effects like blocking, jamming, or dazzling. Additionally, the US would need to submit to inspection by adversary craft to build trust and confidence that the systems are what they portend to be. These defensive systems should be only one line of effort within the AFSPC deterrence strategy.

The second line of effort aligns to proliferate and disaggregate. The defense of expensive, exquisite systems always runs the risk of an adversary cost/benefit calculation that tilts toward launching an attack. Additional deterrence measures are warranted to flip the cost/benefit equation against an attacker. Here, Mahan's point regarding a nation's power comes into play. He measured national power by its ability to produce ships, its standing navy, its commercial shipping capabilities, and its network of strategic bases.[12] Today, contemporary space theorists call for the US to invest in the commercial industry as a means to stake out economic ecosystems in a new space-based mercantilist model.[13] These themes fit nicely with Mahan and can be applied to AFSPC acquisitions strategies to make use of a commercial space renaissance to broaden the industrial base as a means to further US national power within the space domain. Using this expansion in national capability, AFSPC should proliferate its space-enabling capabilities into smaller, cheaper, less-capable satellites that would be less worthy of an attack. Additionally, it should leverage a responsive space launch architecture to reconstitute degraded systems after attack. Lastly, by proliferating launch sites, ground architecture, and running common software, AFSPC can blunt the impact of physical or cyber-attacks against any one node on the ground. Altogether, US resiliency in space will rely on a broad capability base and the resultant proliferation of ground and space architecture in multiple orbital regimes. Some of this is already in motion, as shown by today's Space Defense Agency (SDA) notional architecture, as depicted in figure 3.

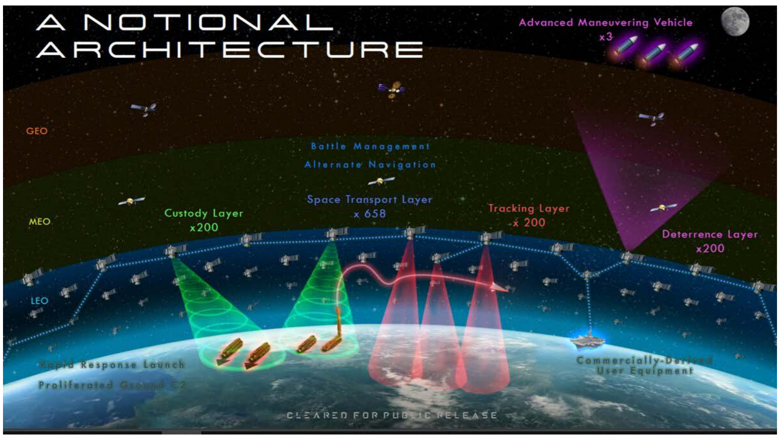


Figure 3. US DOD Notional Future Architecture. Source: Aaron Mehta, "4 Questions with the Space Development Agency's Acting Director," *Defense News*, 26 September 2019, https://www.defensenews.com/.

In summary, US policy and subordinate AFSPC strategy should have a core objective to dissuade an attack against US and allied interests, and if necessary, ensure the US can fight and win on-orbit. Winning means protecting and defending our space assets during conflict so that our terrestrial forces are provided space-based enabling capabilities. A secondary objective could include the offensive negation of select "red" satellites or systems, but only if warranted, within the bounds of acceptable escalation risk, and if meaningfully impactful on adversary terrestrial operations. A strategy of *offensive space supremacy* sweeping the skies of adversary systems should be rejected. To execute a "protect and defend" strategy, AFSPC should acquire space-based defenders to blunt or deny adversary counterspace systems from achieving objectives. To further deter adversary aggression in space, AFSPC should set an acquisitions strategy that broadens our industrial base and builds layers of resiliency into our space architecture, to the point that the cost/risk/reward equation tilts toward not bothering to attack at all. With the strategy in place, one must now formulate an operational framework for forces to operate. In other words, we need doctrine.

On Space Doctrine

Implementing a deterrence-by-denial strategy will require heavy modification to existing doctrine. USAF Space Doctrine, captured in Annex 3-14 *Counterspace Operations*, does an adequate job describing the terms around space operations, as well as key effects provided by space forces. Joint Publication (JP) 3-14 similarly describes systems, how space supports joint functions, and high-level C2 and planning considerations. Compared to equivalent air, maritime, and land domain doctrine, space doctrine is severely lacking in the specifics on how to fight in the domain. After the establishment of USSPACECOM and its associated area of responsibility (AOR), the other combatant commands (CCMD) and associated services will need to work out details on a joint operating concept for space. Within the AOR, USSPACECOM will need associated Joint Doctrine to execute space domain control. JP 3-14 touches on the topic, defining the terms associated with space control, but what is needed is an operational framework akin to what is housed in JP 3-30, *C2 of Joint Air Operations*. AFSPC should work with partners, including the Curtis E. LeMay Center for Doctrine Development and Education and the Joint Staff, to update this cohort of documents.

The best corollary appears to be a space version of the Theater Air Control System (TACS). A Space TACS, or Space Defense Control System (SDCS), would incorporate applicable constructs such as an area air defense commander, repurposed as the area space defense commander (ASDC). This role would be given to the commander of USSPACECOM's Joint Task Force Space Defense (JTF-SD). Additionally, CDR JTF-SD would be given space control authority (SCA) to establish a space control plan and establish sector battle management areas akin to what TACS has. SCA here is different than today's space coordinating authority in JP 3-14 and Annex 3-14. SCA would be the capability to *direct* forces akin to the Airspace Control Authority. See figure 4 below for notional TACS sectors, and figure 5 for recommended SDCS sectors. See table 1 for the overall correlation between roles and authorities.

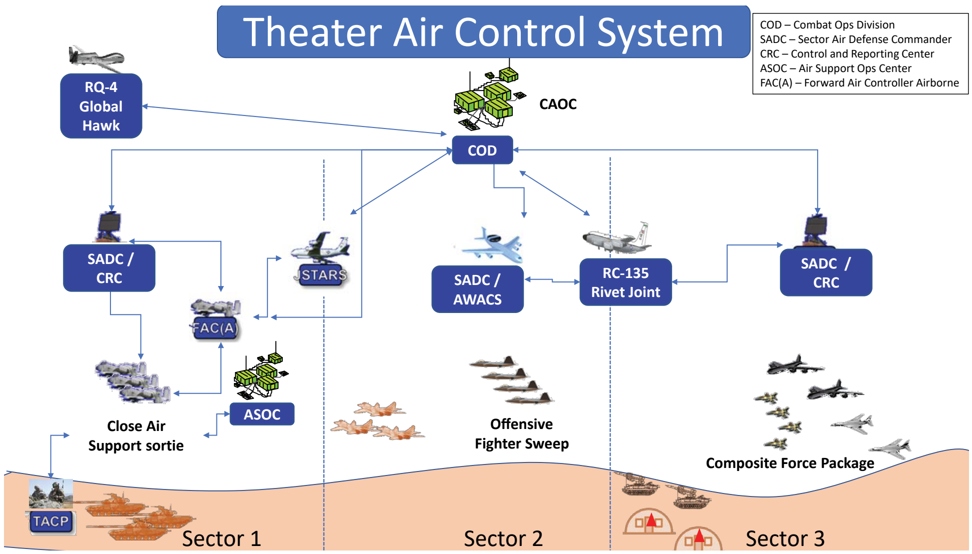


Figure 4. Notional Theater Air Control System. Source: Brandon Davenport, *Beyond the Air Domain: Battle Management in Space Operations* (Maxwell AFB, AL: School of Advanced Air and Space Studies, June 2018), 33

The creation of the SDCS would allow for clear authorities, purposeful planning, and the doctrinal underpinnings to allow JTF-SD to refine space war-fighting concepts. Overall, this framework implements an executable C2 structure to credibly defend US and allied interests, thereby increasing the likelihood of deterring aggression in space.[14]

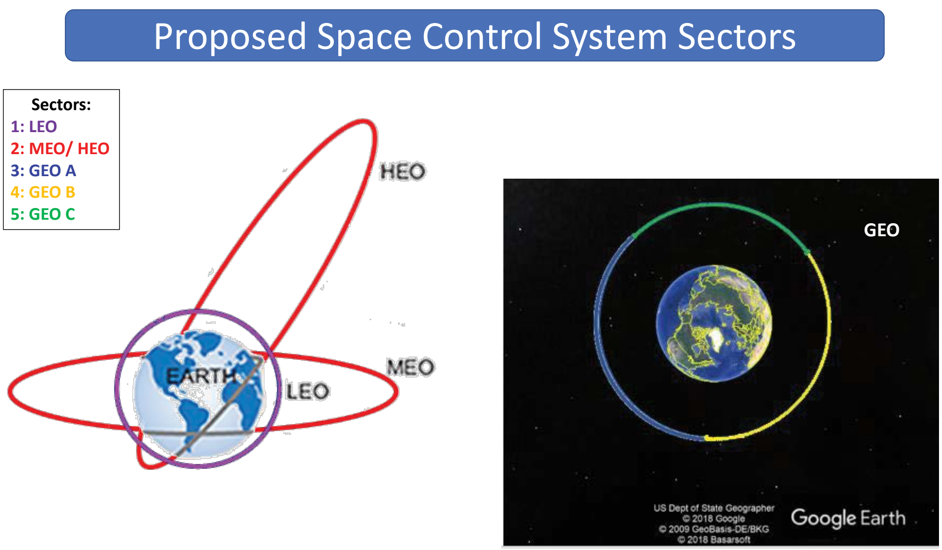


Figure 5. Proposed Space Control Sectors. Source: Davenport, *Beyond the Air Domain*, 70

Table 1. Comparison of Air and Proposed Space Doctrine

Commander	Joint Functional Air Component Commander	Commander Joint Task Force–Space Defense
Role	**Area Air Defense Commander**	**Area Space Defense Commander**
Product	Area Air Defense Plan —Defense CONOPS —Critical Asset List/Defended Asset List —Special Instructions —Rules of Engagement —Combat ID —Threat matrix —Air Defense Warning (Red, Yellow, White)	Space Defense Plan —Defense CONOPS —On-Orbit Critical Asset List/ Defended Asset List —Special Instructions —Rules of Engagement —Combat ID —Threat matrix —Space Defense Warning (Red, Yellow, White)
Role	**Airspace Control Authority**	**Space Control Authority**
Product	Airspace Control Plan —Air Control Order —Airspace Deconfliction —Airspace Control Measures —Airspace Coordinating Measures	Space Control Plan —Space Control Order —Orbital Deconfliction —Space Control Measures —Space Coordinating Measures (on-orbit)
Control System	**Theater Air Control System (TACS)**	**Space Defense Control System (SDCS)**
C2 Structure	Air Ops Center (AOC) —Sector Controllers —Tactical Engagement Controllers/ Battle Managers	National Space Defense Center (NSDC) —Sector Controllers —Space Battle Managers

Doctrine must also be modified to accommodate the creation of USSPACECOM and its subordinate commands. Current Air Force Doctrine Document 3-14 *Counterspace Operations* outlines SCA, as does JP 3-14. SCA, in its current form, is no longer efficient within the new structure. A new term, *theater space support coordinating authority* (TSSCA), should take its place. This authority should continue to be housed at the combatant commander level and then delegated to the joint force air component commander (JFACC) in theater, if warranted. The TSSCA would no longer facilitate terrestrial or on-orbit counterspace targeting into the joint targeting process, nor would they be responsible for facilitating space-language into CCMD operational plans. Targeting will now fall upon the USSPACECOM staff, coordinated through its integrated planning elements (IPE) embedded into geographic CCMD staffs. These same IPEs, modeled after US Cyber Command's similarly named teams, will ensure space planning integration across the CCMDs.[15]

Within USSPACECOM, the global space support coordinating authority (GSSCA) should be delegated to the combined force space component commander (CFSCC). The CFSCC's role is currently assigned to the commander of the 14th Air Force at Vandenberg AFB, California. The CFSCC, with the GSSCA, will primarily be responsible for "planning and conducting global space operations and [to] deliver space capabilities to combatant commanders and allies."[16] The CFSCC will continue to liaise directly with theater JFACCs and is responsible for ensuring PNT, satellite communications, missile warning, space situational awareness, space-weather, ground-based electronic warfare, and title-10 space-based ISR is appropriately supporting the geographic CCMDs.

A realignment and growth within space doctrine, both within USAF AFDD series, as well as JP 3-14, will better posture both AFSPC and USSPACECOM to field forces both to protect and defend on-orbit. The doctrine will also enable both commands to continue the track record of almost 30 years of excellence in providing space-based enabling capabilities to US and allied war fighters worldwide.[17] The establishment of C2 and space control doctrine will clearly align authorities under one commander—CDR JTF-SD—and allow for the creation of a SDCS analogous to the TACS utilized by JFACCs around the world. Redefining SCA will help doctrine incorporate the reestablishment of USSPACECOM. Clear doctrine will pay dividends as the USAF looks to new tactics, techniques and procedures (TTP) to fight and win a war in space as doctrine often forms the basis for tactics development.

On Space Tactics, Techniques, and Procedures

New space TTPs are difficult to discuss in an unclassified setting. As such, this last section will be purposely vague and short on details. Nonetheless, the creation of a SDCS will open up a new world for synergistic creation of new TTPs for space operations crews. Using air battle management (ABM) as a model, TTPs will build from battle management core competencies. See table 2 for distinctive ABM competencies that a space battle manager (SBM) would want to emulate. Beyond the SBM, satellite operations center commanders at locations like the 2nd Space Operations Squadron, 2nd Space Warning Squadron, 4th Satellite Operations Squadron, among others, would want to interface with SBMs, filling the role of the mission commander shown in table 2 below.

Table 2. ABM distinctive core competencies

Defensive counterair

Function	*ABM*	*Mission commander*	*Package CC*	*Flight lead*
Command and control	X	X	X	X
Force management	X	–	X	–
Integrated surveillance and identification	X	–	–	–
Continuum of control	X	–	–	–
Information management	X	X	X	X

Source: Maj Jonathan Watson and Maj Kendrick Carroll, *Air Battle Management: Establishing A Common Thread for Integrating Cross-Domain Operations in the 21st Century* (Air University Press: Maxwell AFB, AL, 2014), 33.

Each core competency, or function, requires TTPs to implement. For example, an ABM will execute surveillance and identification for assigned assets with a clear call-out on the radio, such as "Eagle 21, Barnyard, track 2322 hostile, Bullseye 194 for 42, angels 32." In that radio call, the ABM (barnyard) is telling a flight of F-15s that Link-16 track number 2322 is cleared to engage, and that it is 194 degrees from a pre-established point (bullseye) and 42 nautical miles away, at 32,000 feet. Space tacticians are working to formalize a similar set of procedures for space. C2 direction would follow, where ABMs would attempt to place the F-15 in a position of advantage to take a shot. This would rely on both the SBM and Eagle flight to have common understandings of tactics available to the fighters.

ABMs have a core competency requirement to execute force management of assigned assets. They must resource actions based on factors such as the location of forces, fuel, weapons, sensors, and the tactical capabilities of the systems under their control.[18] Additionally, they must be steeped in JFACC objectives and tasks to make tactical decisions. SBMs will need to build comparative skills within their domain. With SBMs tasked to manage forces, tactics will undoubtedly follow as the teams look to collectively solve problems via mission planning and debrief. One key technique provided by ABMs is the threat callout and subsequent direction to "slide" to modify the route or "scram" to clear the area for high-value air assets. Here again, SBMs will likely provide clarity to space forces who currently have little situational awareness of the environment around their satellites. With the authority of the ASDC and the associated Space Defense Plan, SBMs can help develop and execute techniques to maneuver high-value satellites out of harm's way, if possible.

Further TTPs will be required to normalize space operators' responses for combat identification, orbital deconfliction, and reaction to Space Defense Warning declarations. Each, ensconced in doctrine, will require iterative steps at establishing acceptable TTPs to meet the needs of the new SDCS framework. Each operational-level TTP will better help the National Space Defense Center, SBMs, and satellite operators collectively operate at the same level as a war-fighting CAOC and its associated TACS.

At the unit-level, whether a high-value asset like the Space-Based IR System or an as of yet-notional "cruiser" defender system, operators will begin to work out package-level TTPs, contracts, and common language to allow interoperability up and down the command chain, as well as among the orbital regimes AFSPC operates in. The doctrinal framework of the SDCS will enable clarity of purpose, authorities, and terms among the collective crews. The empowered SBMs and crews will furnish the horsepower, in venues such as Space Flag, to further advance TTP development.

Conclusion

AFSPC will need to work with USSPACECOM, the Joint Chiefs of Staff, Office of the Secretary of Defense, and other key space enterprise stakeholders such as the intelligence community to establish a national policy for a potential war in space. That policy, grounded in the same peer-conflict reality our other war-fighting major commands like US Air Forces in Europe, and Pacific Air Forces operate under, will drive a national objective of winning a limited space war centered around protecting and defending US and allied interests. The resultant AFSPC strategy will be one of dissuading adversaries from attacking on-orbit assets due to a combination of "cruisers" deployed as escorts or along strategic LOCs in the domain, as well as a proliferated space and ground architecture that limits the value of any one node in the system. Updated doctrine will evolve to include the establishment of USSPACECOM, as well as create a C2 framework, known as the Space Defense Control System, that is defensively postured akin to the roles and responsibilities an area air defense commander executes in theater. TTP development will build upon that doctrinal framework to enable young space battle managers, high-value satellite, and defender satellite operators to work collectively within that system to come up with innovative non-material solutions to thwart adversary counterspace systems. As a result, AFSPC will be better postured to instill a space war-fighting construct implementing a new evolution of strategy, doctrine, and tactics. ✪

Lt Col Brandon Davenport, USAF

Lieutenant Colonel Brandon Davenport (BS, Saint Louis University; MS, Embry-Riddle; MAS, Air University; MAS, Air University) is the commander of the 2nd Space Warning Squadron, Buckley AFB, Colorado.

Notes

1. Lucy Bierer, "The New Warfighting Frontier," *Defense One*, accessed 28 September 2019, https://www.defenseone.com/.

2. Steve Hirsch, "There Is No 'War in Space,'" *Air Force Magazine*, 29 May 2018, http://www.airforcemag.com/.

3. US Air Force, *USAF Strategic Master Plan* (Arlington, VA: USAF, May 2015), http://www.af.mil/.

4. Thucydides, Robert B. Strassler, and Richard Crawley, *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian War* (New York: Free Press, 1996).

5. Carl von Clausewitz, Michael Howard, and Peter Paret, *On War* (Princeton, NJ: Princeton University Press, 1984).

6. Charles D. Lutes and Peter L. Hays, eds., *Toward a Theory of Spacepower: Selected Essays* (Washington, DC: Government Printing Office, 2011), 300.

7. Jim Sciutto, "US Military Prepares for the Next Frontier: Space War," *CNN*, 29 November 2016, https://www.cnn.com/.

8. Bernard Brodie, *Strategy in the Missile Age*, New RAND ed. (Santa Monica, CA: Rand Corp, 2007).

9. Julian Stafford Corbett, *Some Principles of Maritime Strategy*, Classics of Sea Power (Annapolis, MD: Naval Institute Press, 1988), publisher description, http://www.loc.gov/; and Everett C. Dolman, *Astropolitik: Classical Geopolitics in the Space Age* (New York: Routledge, 2005).

10. John Klein, "Corbett in Orbit: A Maritime Model for Strategic Space Theory," 2004, 68, https://apps.dtic.mil/.

11. Klein, "Corbett in Orbit," 69.

12. A. T. Mahan, *The Influence of Sea Power upon History, 1660–1783* (New York: Dover Publications, 1987), publisher description, http://www.loc.gov/.

13. Dolman, *Astropolitik: Classical Geopolitics*.

14. Theresa Hitchens, "Raymond's First SPACECOM Move: Two New Subcommands and Their Leaders," *Breaking Defense* (blog), 30 August 2019, https://breakingdefense.com/.

15. Joint Staff, JP3–12, *Cyberspace Operations*, 8 June 2018, III-6, https://www.jcs.mil/.

16. Sandra Erwin, "Army General to Run One of USSPACECOM's Subordinate Commands," *SpaceNews*, 1 September 2019, https://spacenews.com/.

17. Larry Greenemeier, "GPS and the World's First 'Space War,' " 8 February 2016, https://www.scientificamerican.com/.

18. Watson and Carroll, "Air Battle Management," 4.

SCHRIEVER ESSAY AWARD

A Culture of Military Spacepower

Maj Kenneth Grosselin, USAF

During a May 2019 exit interview with the national media, outgoing Secretary of the Air Force Heather Wilson identified the development of a war-fighting culture as the most pressing challenge confronting the Air Force space mission.[1] This challenge persists despite a range of recent and historical Air Force initiatives aimed at developing and strengthening an independent space war-fighting culture. In 2001, the US Space Commission recommended the Air Force strengthen its military space culture through focused career development, education, and training.[2] This recommendation was the foundation of the Air Force Space Command's (AFSPC) Space Professional Development Program and the Space100, -200, and -300 professional military education sequence.[3] In 2002, the Air Force eliminated the phrase *aerospace power* from its institutional lexicon, replacing it with the phrase *air and space power*. When defending this decision, Gen John P. Jumper, the 17th USAF chief of staff, stated, "[the Air Force] will respect the fact that space is its own culture, and that space has its own principles."[4] In 2005, Gen Lance W. Lord, the 12th AFSPC commander, authorized the wear of a space badge to "unify our USAF credentialed space professional community under a single space badge—a recognizable, distinctive symbol of the unique and challenging space mission and those who execute it."[5] Most recently, Acting Secretary of the Air Force Matthew P. Donovan advocated that a separate US Space Force within the Department of the Air Force (DAF) would forge the unique culture required to unleash the power of space in an age of great-power competition.[6] While important, all of these initiatives fail to address the foundational impediment restraining the development of a space war-fighting culture within the Air Force. The first step toward establishing a space war-fighting culture is enshrining the purpose and identity of Air Force space forces within basic doctrine centered around an independent and authoritative formulation of military spacepower.

This article presents why and how the Air Force should use basic doctrine to shape the purpose, identity, and culture of Air Force space forces. A brief survey of organizational culture theory is followed by a discussion on how doctrinal theories of military power shape the purpose, identity, and culture of land, maritime, and air forces. Next, this article will show how military spacepower doctrine remains underdeveloped within Air Force basic doctrine. Finally, this article will present the cornerstone principles of an independent framework for military spacepower—national space interests, joint interdependence, and unique space expertise—designed to set the conditions for a space war-fighting culture to develop and thrive. These recommendations are independent of any Congressional action to reorganize US military space forces. Whether the AFSPC remains in the Air Force or becomes the foundation of a separate military service, incorporating the three principles described here into capstone service doctrine is a critical element in the development of a space war-fighting culture.

Shifting from a Servicing Culture to a War-Fighting Culture

The foundations of the space servicing culture are well-documented.[7] In brief, this culture arose to minimize disruptions to space services in the absence of a credible threat to US space superiority following the end of the Cold War. The uninterrupted delivery of space capabilities, such as missile warning and precision navigation and timing (PNT), is so critical to the Joint Force that even the slightest disruption may result in mission failure. Without a credible threat to organize against, the space community adopted a servicing culture similar to commercial information service providers. Human error—not a thinking adversary—presented the largest and most probable threat to service delivery. In this environment, Air Force space operations were routinized to minimize the human element and maximize service reliability. National policy reinforced this culture, declaring space a sanctuary from attack and curtailing the culture required to protect and defend space assets against a thinking adversary.[8]

The servicing culture is no longer appropriate for military space operations. Emerging threats to US space superiority have invalidated the assumptions of the space community's servicing culture. The most recent *National Security Strategy* formally and authoritatively declares space a war-fighting domain and recognizes the existence of credible threats to US space superiority.[9] Building on this declaration, Space Policy Directive-4 makes clear the organization, policies, doctrine, and capabilities of the national security space community must evolve to defeat these threats.[10] The culture of Air Force space forces must also evolve, synchronized with the guidance, intent, and policy directives of our national leadership.

Scrutinizing the academic definition of *organizational culture* demonstrates why shifting from a space servicing culture to a space war-fighting culture is an operational imperative for the Air Force. *Organizational culture* is defined as a group's shared approach to external adaption and internal integration problems.[11] Culture captures a group's shared and accepted approach to the challenges of uncertainty, problem solving, and innovation. In the interest of precision, it is worth noting that organizational culture and organizational climate are different concepts. While organizational culture defines an organization's values when taking action, the term *organizational climate* captures the shared experience of group members based on accepted norms of behavior.[12] While both culture and climate are important, this article focuses on the development of a space war-fighting culture.

Servicing cultures are system-centric. These cultures approach the problems of adaption and integration seeking to optimize the availability of a static system. Human error and system reliability are the dominant sources of uncertainty that servicing cultures coalesce to solve. A servicing culture values fault management, standardization, and centralization as acceptable approaches to problem solving and innovation. To minimize human error, dynamic decision making is discouraged in favor of routinized procedures and centralized tactical decision making.

War-fighting cultures are adversary-centric. Problems of external adaption are defined by a thinking, competent, and lethal adversary who threatens American interests. Problems of internal integration focus on the perpetual pursuit of combat readiness. Problem solving starts with the assumption of a competent and lethal adversary, and innovation seeks a relative advantage over that adversary. Victory and defeat—not system availability—are the most important measures of effectiveness. A war-fighting culture fights through uncertainty in a dynamic environment by seizing the initiative through decentralized execution and the principles of mission command. Shifting from a servicing culture to a war-fighting culture (fig. 1) implies certain behavior changes. Technicians become tacticians, schedulers become mission planners, and system watch officers become battle managers.[13] In a war-fighting culture, the imperative for victory engenders a tenacious fighting spirit and the unbreakable resolve to outmaneuver and dominate an adversary.

	Servicing Culture	Warfighting Culture
Organizational Focus	System centric	Adversary centric
Organizational Objective	Maximize availability of a static system	Deter and defeat a thinking, competent, and lethal adversary
Handling Uncertainty	Preserve system health, status, and reliability through centralization	Seize the initiative through decentralized execution and the principles of mission command
Pursuing Innovation	Fault management, routinized procedures, and standardization	Endless pursuit of a military advantage over adversaries
Key Roles	Technician Schedulers System Watch Officers	Tacticians Mission Planners Battle Managers
Measure of Success	System availability	Winning amidst a competitive environment

Figure 1. Air Force space forces must shift from a servicing culture to a war-fighting culture

Purpose Shapes Identity; Identity Shapes Culture

With these definitions in mind, how should the Air Force proceed in developing a war-fighting culture within its space community? The study of organizational culture theory reveals that a unifying culture can only emerge after a group's purpose and identity are clearly understood and broadly accepted.[14] *Purpose* captures the existential tasks a group is chartered to accomplish while *identity* captures how group members view their group relative to other groups. Stable cultures emerge when a unifying purpose and group identity are broadly recognized and understood. Thus, the connection between purpose, identity, and culture can be condensed into an axiomatic relationship: purpose shapes identity, and identity drives culture (fig. 2).

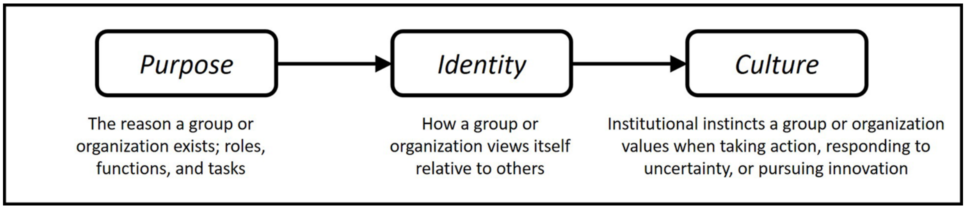


Figure 2. Organizational purpose shapes identity, and identity drives culture

Across the US military, capstone doctrine—that is, basic doctrine in Air Force parlance—provides the authoritative formulation of purpose and identity for military forces. This authority makes capstone doctrine the most important encapsulation of the beliefs, values, and assumptions that underpin military culture within each branch of the armed forces. Army Doctrine Publication 1, *The Army,* champions the primacy of land power, delineates the Army's contribution to national security, and describes a professional warrior ethos rooted in seven common values.[15] The Air Force's *Volume I, Basic Doctrine* espouses the independence of airpower and the air-mindedness expertise unique to Airmen.[16] Naval Doctrine Publication (NDP) 1, *Naval Warfare*, anchors the purpose, identity, and core values of US naval forces to the importance of American sea power.[17] Marine Corps Doctrine Publication (MCDP) 1-0, *Marine Corps Operations,* builds upon NDP 1 by emphasizing how maneuver warfare, mission command, and an enduring relationship with the Navy defines the rapid and expeditionary nature of Marines Corps operations.[18] Capstone doctrine is not culture. However, by authoritatively defining service purpose, capstone doctrine shapes institutional identity, and hence, culture. Furthermore, war fighters in every domain connect their purpose and identity to an independent theory of military power: land power, airpower, and sea power. A review of the history and evolution of Air Force basic doctrine reveals that Air Force space forces lack a unified, independent, and authoritative formulation of military spacepower from which to derive purpose and identity (fig. 3).

Doctrine	Purpose	Identity
	*"Seapower has been and will continue to be the critical foundation of national power and prosperity and international prestige for the United States of America.:*	*"We are the United States Navy and United States Marine Corps, our Nation's seapower—ready guardians of peace, victorious in war."*
	*"Landpower enables the Nation's leaders to respond to security challenges in definitive and decisive ways... Landpower protects our national interests, brings order to chaos, and protects populations."*	*"Our Soldiers make the Army the most capable land force in the world, which in turn maintains U.S. credibility and security."*
	*"Through airpower, the Air Force provides the versatile, wide-ranging means towards achieving national objectives with the ability to deter and respond immediately to crises anywhere in the world."*	*"Air Force doctrine presents airpower as a unitary construct. The Air Force acknowledges the importance of the space and cyberspace domains. However, Air Force doctrine should address what unifies Airmen."*

Figure 3. Capstone doctrine sets conditions for organizational culture by providing the authoritative formulation of the purpose and identity of military forces. Source: NDP-1, *Naval Warfare*, March 2010; *A Cooperative Strategy for 21st Century Seapower* (Washington, DC: Department of the Navy, 2015); ADP-1, *The Army*, July 2017; and ADP 3-0, *Operations*, Vol. I, *Basic Doctrine*, July 2017)

The Evolution of Spacepower Theory in Air Force Doctrine

The idea that airpower and spacepower are one and the same is almost as old as the US space program itself. Gen Thomas D. White, the fourth chief of staff of the Air Force, first expressed this idea in 1958, declaring "air and space are indivisible" just one month after the first successful launch of a US satellite.[19] The term *aerospace power* consolidated airpower and space operations into a single framework and became official Air Force doctrine in 1959 with the publication of Air Force Manual (AFM) 1-2, *United States Air Force Basic Doctrine.* [20] For the next 47 years, Air Force basic doctrine would continue to use a unitary definition of aerospace power, though small changes would be introduced. For example, the Air Force introduced the term *space force enhancement* in 1979 and *counterspace* in 1982.[21] Despite small changes and evolutions, during this period Air Force basic doctrine viewed space operations as an element of aerospace power. Air Force senior leaders succinctly expressed the unitary theory of aerospace power in a 2000 white paper. "Our Service views the flight domains of air and space as a seamless operational medium. The environmental differences between air and space do not separate the employment of aerospace power within them."[22]

The aerospace power formulation lasted until 2002 when General Jumper replaced the term *aerospace power* with *air and space power*, noting that the legacy term did not "give the proper respect to the culture and to the physical differences that abide between the environment of air and the environment of space."[23] For the first time in Air Force institutional history, airpower and spacepower were viewed as separate theories of military power. Following this split, the Air Force published Air Force Doctrine Document 2-2, *Space Operations,* in 2006. While this served as the first full Air Force treatment of spacepower doctrine, the AFDD 2-2 framework still constrained spacepower as an enabler and force multiplier to combat operations in other domains.[24]

Air Force spacepower doctrine would be short-lived. The Air Force abandoned spacepower doctrine and returned to a unitary definition of airpower in 2011, again placing space operations as part of the larger airpower framework.[25] Today, Air Force doctrine defines *airpower* as "the ability to project military power or influence through the control and exploitation of air, space, and cyberspace to achieve strategic, operational, or tactical objectives."[26] Conversely, Air Force doctrine does not include a formal theory of military spacepower in any official publication. *Air Force Doctrine Annex 3-14* provides operational-level doctrine for Air Force space operations but does not include an independent formulation of military spacepower and makes no attempt to deliberately shape the purpose and identity of Air Force space forces.

In the absence of credible threats to US space superiority, the airpower-centric approach to space operations was an overwhelming success. This partnership ignited an unprecedented level of cross-domain synergies between air and space capabilities. Space-based PNT enabled the joint direct attack munition and transformed the accuracy and lethality of joint fires. The integration of wideband satellite communication onto air platforms permitted the development of a globally integrated intelligence, surveillance and reconnaissance architecture. Persistent missile warning impacts strategic deterrence in every domain. In short, the airpower-centric approach to space operations that has been codified in Air Force doctrine since 1959 has fundamentally transformed every joint function. This transformation persists across the range of military operations and the entire spectrum of conflict.

Despite these unprecedented synergies, interweaving space operations within airpower doctrine reinforces three false equivalencies. First, a unitary approach to airpower reinforces the false assumption that airpower and spacepower impact national policy objectives through shared ways and means. Second, connecting space operations as a subset of airpower falsely assumes that the same principles guide the application of airpower and spacepower in a military context. Third, this approach presupposes that the airmindedness perspective of military power is the optimal perspective for military space forces. These assumptions are more than semantic. They underpin the very purpose and identity of military space forces. Accepting these assumptions without an independent theory of spacepower undermines the formation of purpose, identity, and culture within Air Force space forces and unnecessarily inhibits the impact military space operations can have on national policy objectives. Because of the strong connection between purpose, identity, and culture, Air Force efforts to cultivate a space war-fighting culture must start with the acceptance and publication of an authoritative formulation of independent military spacepower doctrine.

A War Fighter's Conception of Military Spacepower

While the Air Force lacks an institutional theory of military spacepower, a multitude of proposed spacepower frameworks exist. These theories date back to 1958 when Donald Cox and Michael Stoiko published the book *Spacepower: What it Means to You*.[27] Since this initial publication, David E. Lupton, Peter L. Hays, Brig Gen Simon P. Worden and Maj John E. Shaw, James E. Oberg, M. V. Smith, Everett C. Dolman, and John J. Klein have all made important contributions. [28] The Air Force can draw heavily on these sources when formulating an institutional theory of military spacepower within its basic doctrine; however, the final formulation must accentuate three themes to set conditions for a space war-fighting culture. These themes are: vital national space interests, joint interdependence, and unique space expertise. Taken together, these three principles would be institutional recognition that Air Force space forces are expert practitioners of an independent discipline of military power unique to the space domain. This purpose, in turn, shapes the identity of Air Force space forces as coequals with the war fighters responsible for military power in the air, maritime and land domains.

Theme 1: Space is vital to national power and prosperity. First, Air Force doctrine must differentiate between national spacepower and military spacepower in a way that captures the vital role military space forces play in securing national interests. Maritime doctrine provides an appropriate analogy for this distinction. While the term *naval power* represents military power at sea, *sea power* describes the totality of a nation's use of the maritime domain in pursuit of national power and prosperity.[29] Borrowing this construct, *national spacepower* is defined here as the totality of a nation's use of the space domain in pursuit of national power and prosperity. This construct recognizes that space is a conduit of national power through which diplomatic power, economic power, information power, and military power can be generated, applied, and exploited. In this regard, space is no different than the land, maritime, air, and cyberspace domains. Thus, national spacepower includes political, economic, information, and military elements. As one element of national spacepower, *military spacepower* is defined here as a nation's ability to accomplish military objectives through the control and exploitation of the space domain.

Distinguishing between national spacepower and military spacepower recognizes that a grand space strategy amplifies all four instruments of national power: diplomacy, economy, information, and military. Space exploration strengthens diplomatic power by conferring national prestige and generating opportunities for peaceful multinational cooperation. The commercial space industry is a rapidly growing segment of the US economy with limitless potential. Information derived from space-based remote sensing is the core of US global information dominance. Because the elements of national spacepower are mutually reinforcing, unified action with civil, commercial, and intelligence community space programs is an important attribute of the proper employment of military spacepower. US military spacepower must reflect the nation's political, economic, information, and military interests. To solidify purpose and identity, Air Force space forces must appreciate these other elements of national spacepower and understand military spacepower's unique role securing vital national interests in the space domain.

Theme 2: Military space forces are an interdependent element of the Joint Force. Military space forces are the practitioners of military spacepower. Security, deterrence, and violent competition are the hallmarks of a war-fighting force. Military space forces are no different. They shape the security environment, deter aggression, and apply lethal and nonlethal force in space, from space, and through space. They perform these tasks as an interdependent element of the joint team.

Joint Publication 1 defines *joint interdependence* as "the purposeful reliance by one Service on another Service's capabilities to maximize complementary and reinforcing effects of both."[30] Joint interdependence implies that space operations are no longer an auxiliary adjunct to air, land, maritime, and cyberspace operations. Military spacepower is an obligatory component of modern Information Age warfare. Capabilities as fundamental as precision attack, maneuver warfare, strategic warning, and global power projection presuppose the Joint Force's ability to control and exploit the space domain. Without access to space capabilities, joint operations would devolve into the Industrial Age warfare of the early twentieth century, characterized by the mass concentration of force-on-force violence and indiscriminate destruction.[31] Military spacepower doctrine must recognize this distinction and elevate terminology that reflects the indispensable role space plays in joint operations. For example, the doctrinal term *space force enhancement* connotes an incremental improvement in capability while *space support to operations* does not capture the true interdependencies between space and the war-fighting forces in other domains. Such terms cast space as an auxiliary adjunct to joint operations. Instead, the term *global information mobility* should replace these legacy terms as a more accurate description of the vital interdependent effects capabilities like satellite communications and PNT provide to the Joint Force.

At the same time, joint interdependence implies that operations in the air, land, maritime, and cyberspace domains are critical to gaining and maintaining space superiority. Space systems consist of three segments: ground, link, and space. This makes military spacepower inherently multidomain and necessitates support from military forces in the other domains to secure space superiority. For example, maritime standoff strike capabilities can support space superiority by neutralizing adversary satellite command and control nodes. In pursuit of true joint interdependence, military spacepower doctrine must prepare space forces to operate side-by-side with war fighters in other domains in both supporting and supported roles. Thus, emphasizing joint interdependence reinforces a coequal identity with war fighters in the other domains.

Theme 3: Military spacepower demands a unique expertise. This third theme emphasizes that military spacepower is a unique form of military power. Because military operations in the space domain are distinct from operations in other domains, the successful application of military spacepower demands war fighters with an intuitive understanding of the domain. Referred to as *space mastery*, this intuition must encompass the entire space environment. [32] In addition to the physics and engineering of space flight, space mastery also includes a predictive understanding of the interests and behaviors of civil, commercial, and foreign space actors. The unique nature of the space domain demands war fighters with space mastery who are deliberately developed in the conduct and application of military spacepower.

An intuitive understanding of the domain is an important component of a war-fighting culture. MCDP 1, *Warfighting,* pinpoints speed and focus as universal determinants of combat power.[33] Based on Col John Boyd's Observe, Orient, Decide, and Act (OODA) loop, under this formulation *speed* represents the rapidity of action while *focus* represents the convergence of effects on an objective.[34] Space domain intuition enhances the speed and focus of military spacepower by allowing space war fighters to observe, orient, and decide faster than their adversaries. Developing space war fighters with an intuitive understanding of the domain requires deliberate professional development over time. Air Force basic doctrine must recognize this imperative by formally acknowledging the distinctions between airpower expertise and military spacepower expertise.

Conclusion

The widespread acceptance of a new idea in an organization takes time. But the process always benefits from an authoritative formulation that defines the shape, structure, and implied values of the new idea. Publishing a new idea through formal organizational channels advances the permanence of a concept and provides a point of departure for future innovations.

Publishing an independent theory of military spacepower as formal Air Force basic doctrine is the first step toward ensuring military spacepower is broadly understood and accepted across the DAF. Doctrine is not culture. But by publishing and adhering to an authoritative theory of military spacepower, the Air Force can set the conditions for a space war-fighting culture to develop. Under the framework for military spacepower presented here, Air Force space forces are practitioners of an independent discipline of military power unique to the space domain. This purpose, in turn, shapes their identity as coequals with the other war fighters responsible for military power in the air, maritime, and land domains. With purpose and identity solidified, other initiatives aimed at cultivating a space war-fighting culture will take root and flourish. ✪

Maj Kenneth Grosselin, USAF

Major Grosselin (BS, USAFA; PhD, Pardee RAND Graduate School) is a space weapons officer and an Air Force Fellow assigned to Georgetown University for Intermediate Developmental Education.

Notes

1. Oriana Pawlyk, "Outgoing SecAF Worries About Developing Service Culture at New Space Force," *Military.com*, 16 May 2019, https://www.military.com/.
2. Rumsfeld et al., *Commission to Assess United States National Security Space Management and Organization* (Washington DC: Central Intelligence Agency Printing and Photography Group, 2001), 42.
3. Trisha Schmalz, "Space Professional Development Program Readies Better Space Cadre," *Air Force Space Command*, 15 September 2006, https://www.afspc.af.mil/.
4. Gen John P. Jumper, "A Word from the Chief: Why 'Air and Space'?," *Air & Space Power Journal* (*ASPJ*) XVI, no. 3 (Fall 2002): 5, https://www.airuniversity.af.edu/aspj/.
5. TSgt Jennifer Thibault, "New Space Badge Wear Begins Today," *Air Force Space Command*, 1 November 2005, https://archive.is/.
6. Acting Secretary of the Air Force Matthew P. Donovan, "Unleashing the Power of Space: The Case for a Separate U.S. Space Force," *War on the Rocks*, 1 August 2019, https://warontherocks.com/.
7. Miller et al., *Space Cadre Personnel Review Report: Developing our Space Cadre for a Warfighting Domain*, 15 August 2018.

8. Peter L. Hays, *Struggling Towards Space Doctrine: U.S. Military Space Plans, Programs, and Perspectives During the Cold War*, thesis presented to the faculty of the Fletcher School of Law and Diplomacy, May 1994, 212.

9. *National Security Strategy of the United States of America*, December 2017, 27, https://www.whitehouse.gov/.

10. Office of the Press Secretary, The Office of the President of the United States, Space Policy Directive—4, "Establishment of the United States Space Force," 19 February 2019.

11. Office of the Press Secretary, "Establishment of the United States Space Force."

12. Andrew Neal, Mark A. Griffin, and Peter M. Hart, "The Impact of Organizational Climate on Safety Climate and Individual Behavior," *Safety Science* 34, no. 1–3 (2000): 99–109.

13. Lt Col Casey Beard, *Transforming Technicians into Tacticians*, Air Force Public Affairs, 13 September 2019, https://www.schriever.af.mil/.

14. Edgar H. Schein with Peter Schein, *Organizational Culture and Leadership* (Hoboken, NJ: Wiley, 2017), 127.

15. United States Army Training and Doctrine Command, Army Doctrine Publication 1, *The Army*, July 2019, v.

16. Curtis E. LeMay Center for Doctrine Development and Education, Volume I, *Basic Doctrine*, 14 October 2011, https://doctrine.af.mil/.

17. Department of the Navy, Naval Doctrine Publication 1, *Naval Warfare*, March 2010.

18. United States Marine Corps, Marine Corps Doctrine Publication 1-0, *Marine Corps Operations*, 26 July 2017.

19. Gen Thomas D. White, "Air and Space are Indivisible," *Air Force Magazine*, September 2008, http://www.airforcemag.com/.

20. Air Force Manual 1-2, *United States Air Force Basic Doctrine*, 1 December 1959, 6.

21. Air Force Manual 1-1, *USAF Basic Doctrine*, 1979 and Air Force Manual 1-6, *Military Space Doctrine*, 15 October 1982.

22. Department of the Air Force, *The Aerospace Force: Defending America in the 21st Century* (Washington, DC: Headquarters United States Air Force, 2000), 1.

23. Gen Jumper, "A Word from the Chief," *ASPJ*, 5.

24. Air Force Doctrine Document 2-2, *Space Operations*, 27 November 2006.

25. Air Force Public Affairs, "Air Force Updates Doctrine Documents," *Air Force News Service*, 16 November 2011, https://www.af.mil/.

26. Curtis E. LeMay Center for Doctrine Development and Education, Volume I, *Basic Doctrine*, 27 February 2015, 22, https://www.doctrine.af.mil/.

27. Donald Cox and Michael Stoiko, *Spacepower: What it Means to You* (Philadelphia, PA: John C. Winston Company, 1958).

28. David E. Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, AL: Air University Press [AUP], June 1988); Peter L. Hays et al., eds., *Spacepower for a New Millennium: Space and US National Security* (New York, NY: McGraw-Hill, 2000); Maj John E. Shaw and Brig Gen Simon P. Worden, *Whither Space Power? Forging a Strategy for the New Century* (Maxwell AFB, AL: AUP, 2002); James E. Oberg, *Space Power Theory* (Maxwell AFB, AL: AUP, 2002); M. V. Smith, *Ten Propositions Regarding Spacepower* (Maxwell AFB, AL: AUP, 2002); Everett C. Dolman, *Astropolitik* (New York, NY: Frank Cass Publishers, 2002); and John J. Klein, *Space Warfare: Strategy, Principles, and Policy* (New York, NY: Routeledge, 2006).

29. Milan N. Vego, "On Naval Power," *Joint Force Quarterly* 50, no. 3 (2008): 8.

30. Vego, "On Naval Power," I-2.

31. Casey Beard, *Information Control: Preserving the Advantage* (Maxwell AFB, AL: Air University, 2015), 43–60.

32. Beard, *Information Control: Preserving the Advantage* (Maxwell AFB, AL: Air University, 2015), 43–60 and; Miller et al., *Space Cadre Personnel Review Report*, 26.

33. Department of the Navy, Marine Corps Doctrine Publication 1, *Warfighting*, 4 April 2018, 2–19, https://www.marines.mil/.

34. Department of the Navy, Marine Corps Doctrine Publication 1, *Warfighting*.

Autonomous Horizons: The Way Forward by Dr. Greg L. Zacharias. Air University Press, 2019, 326 pp.

As automation sweeps across every sector of industry, defense officials must constantly update the road map for dominance in a digital future. In particular, the proliferation of autonomous systems (AS) within defense requires new ways of thinking to fully leverage new capabilities. *Autonomous Horizons: The Way Forward* provides the needed reference text to map the future of AS. The text is a widely sourced reference guide with hundreds of authoritative citations for further research. The book's multidisciplinary approach provides new thinking for both novice and advanced practitioners because it covers the numerous disciplines involved in AS's design and employment. It also provides numerous lessons learned from previously deployed AS.

Autonomous Horizons details the leading edge of AS, associated technologies, and solutions for human-system integration. Also, the text sequences numerous past paradigms on the subject to delineate the evolution among the varying schools of thought within research communities. The authors recognize the importance of common definitions and reach across government, industry, and academia to present a unified lexicon. Common definitions are critical to accommodating the convergence of six key professional communities: robotics, cybernetics, cognitive psychology, neuroscience, hard artificial intelligence (AI), and soft AI. The book correctly highlights the most important issues to remember when designing for autonomy: how do the AS interact with humans, and which human capabilities does the system augment?

At a minimum, the six identified professional disciplines are critical stakeholders within AS development. Engineering, computer sciences, and neurosciences all contribute to the necessary body of knowledge. Because the development of AS involves such a broad array of practitioners with extremely different backgrounds, the book provides a calibration mechanism for diverse teams looking to unify development and deployment strategies. To drive efficiencies and collapse development timelines, these groups must agree on common definitions, ethical priorities, and developmental frameworks. *Autonomous Horizons* effectively identifies theoretical advances, practical advances, and opportunities for collaboration between the diverse disciples. The collaborative approach enables the development of the needed capabilities without unintended or unethical design flaws.

Autonomous Horizons defines three key dimensions for autonomous system design: proficiency, trust, and flexibility. These three aspects earned a critical designation because they all present human-systems integration issues that must be resolved to field effective AS. In particular, the text identifies how artificial intelligence and machine learning can be technically and organizationally implemented across systems of systems.

If implemented to their full potential, AS could shift military operations and acquisition strategies from a platform-centric model to an information-centric model. At present, the platform-centric model of military systems divides and subdivides resources by mission: sensor platforms, attack platforms, support platforms, and others. Further, national assets such as space and cyber capabilities present parallel resource bases that require significant coordination across agencies. *Autonomous Horizons* envisions an architecture where information flow integrates across all platforms. In the same way that the worldwide web operates agnostically across a diverse array of hardware, an information-centric military will yield enhanced capabilities and improved proficiency. To deliver on these large promises, AS developers will focus on identified challenge problems, developmental processes, and organizational structures.

In addition to identifying critical human systems integration elements, *Autonomous Horizons* highlights the importance of designing "flexible autonomy" that enables task, peer, and cognitive flexibility. Inherent flexibility enables a system to rapidly and transparently reorient its relationship with human team members between subordinate, peer-to-peer, and supervisory roles. For example, an unmanned aerial vehicle (UAV) autonomously flies to a designated target. Once in range, the UAV pilot assumes control of weapons employment tasks while the UAV maintains basic flight control functions. In addition to moving vertically within organizational hierarchies, system architecture and organizational structure must easily shift horizontally between one-to-one, one-to-many, and many-to-one relationships to best integrate human and autonomous system resources. Expanding the previous example, a human signals intelligence analyst designates threat parameters to a fleet of orbiting UAVs (one-to-many). The squadron of UAVs autonomously searches for the designated signals and promote matches to a human targeteer (many-to-one). The human targeteer approves the proposed target and passes the target to a UAV pilot for weapons engagement (one-to-one). A third dimension for scale is achievable by integrating sensor networks across manned and unmanned platforms in all domains.

Reviewer's Recommendations

Autonomous Horizons envisions a total system redesign of warfare platforms and employment but fails to explicitly link this redesign to combat efficiency. Core arguments for fundamental changes in military acquisition programs must articulate their value in relation to their ability to accomplish items on the Joint Task List (JTL). To overcome the inertia of legacy, platform-oriented programs, product evangelists must explain how AS can fulfill JTL requirements faster, better, cheaper, or more safely to justify the switching cost.

Also, early in the text *Autonomous Horizons* predicts that implementing AS will "reduce manning requirements" while increasing system performance. Historically, highly technical acquisition programs have a mixed record of delivering on such promises, so these advertisements will likely be met with skepticism. Instead, autonomy advocates should seek to unitize return on investment through discrete, comparable metrics such as reconnaissance flight hour per pilot or cost of delivered weapons payload. Ideally, the unitized variable of comparison would be the most valuable or scarce commodity needed to achieve the JTL effect.

As a final criticism, the architecture strategy proposed by *Autonomous Horizons* uses analogies from popular platform business models like Amazon and Uber to illustrate deployment strategies for AS. These technology companies provide valuable lessons for computing intensive organizations like the Defense Intelligence Systems Agency and cyber-oriented commands that benefit from scale and commercially available hardware, but enterprise similarities drop significantly upon departure from the computing realm. Amazon and Uber's genius involved leveraging existing infrastructure and spare capacity like the postal service and personal automobiles. However, the economy lacks few commercial options or suitable infrastructure for inherently military capabilities such as long-range strike in a contested environment. As previously mentioned, architecture redesign must begin and end with defined JTL requirements to ensure the delivery of needed military capabilities.

LCDR James M. Landreth, USN

The Future of Extended Deterrence: The United States, NATO, and Beyond edited by Stéfanie von Hlatky and Andreas Wenger. Georgetown University Press, 2015, 259 pp.

This edited collection draws on the analysis of workshop participants brought together by the work's editors to discuss the complex relationship between the US and its European allies in the context of deterrence. *The Future of Extended Deterrence* contains seven individual contributions organized into three sections: "New Thinking on Deterrence," "the North Atlantic Treaty Organization's (NATO) Nuclear Weapons Policy," and "The Politics of Missile Defense." The contributors range from professors and think-tank experts to policy makers representing Western nations including the US, Canada, and European countries. The contributors emphasize the critical importance of reassessing deterrence from a broader lens in light of post-Cold War developments.

More specifically, this collection's impetus derives from a number of developments that have occurred in the last decade, including the Obama administration's *US National Security Strategy* (2010) and NATO's *Deterrence and Defense Posture Review* (2012).

Extended deterrence refers to the protection the US offers its allies to deter an attack or other coercive action by a third party. The benefits of extended deterrence to the US, it is argued, include the ability to treat war as an "away game" and the reduction of "adventurism" by other nuclear powers (pp. 44–45). If deterrence fails, however, the US response need not involve the use of nuclear weapons. Indeed, it is likely that the US would use conventional weapons to respond (p. 47). This owes much to the improvement in US conventional capabilities, which has been somewhat destabilizing because it provides the nation with an asymmetric advantage over Russia. This "high-precision deterrence" rests, not only on conventional weaponry, but also on advanced cyber and space capabilities (p. 205). By contrast, Russia remains invested in an approach that stresses its nuclear capabilities (p. 184), and these competing visions have stalled negotiations between NATO and Russia, among other factors. Also, as the deterrence weapons have changed for some parties, so, too, have ideas about the purpose of deterrence. Increasingly, Western policymakers view deterrence as a flexible tool that can achieve many aims, including the "protect[ion] of global norms" and the maintenance of the liberal international order (p. 21).

Most of the work addresses extended deterrence in Europe to evaluate the changes NATO previously has considered making, with the purpose of helping NATO arrive at a more decisive solution the next time it engages in similar talks. Russian aggression in Ukraine had helped stimulate this round of discussion, as did concerns about a wider array of threats, including Iran. But the expansion of NATO makes consensus-building even more challenging because its members have such wide-ranging interests and national security concerns. At the same time, it is the very strength of this alliance that is as important to deterrence's success as the alliance's military capabilities. Yet NATO's 2012 *Deterrence and Defense Posture Review* only resulted in the "paper[ing] over" of key areas of disagreement (p. 19). In particular, members cannot agree on whether or not the US should continue to maintain nonstrategic nuclear weapons (NSNW) in Europe. Although they constitute less than 2 percent of the earth's nuclear weapons (p. 107) and are of questionable military utility given the alliance's conventional capabilities, they occupy a significant portion of the debate for a variety of reasons, including their high classification level (p. 112–13). Also, of great importance to NATO is missile defense, which has received increased emphasis since the end of the Cold War. In the context of deterrence, this represents a shift away from relying solely on offensive capabilities for deterrence to using defensive ones as well.

Different issues are at play in Asia, where the US relies on bilateral agreements and does not maintain NSNW. The work includes some scattered disagreement over the applicability of the Asian model to Europe (pp. 62, 208). Unfortunately, despite the title promising to cover deterrence "beyond" NATO, the collection lacks a chapter focused solely on Asia, not to mention other regions of the world, to provide more detailed and systematic comparative insights. Such a chapter might also reduce some of the monotony that comes from repetitive background information about Europe.

As mentioned, the book stresses the increased complexity and changing understandings of deterrence, which are both strengths and weaknesses. In some ways, the book rests on the assumption that today's political climate is more challenging than in previous times, but these kinds of assessments come with the benefit of hindsight. It is potentially shortsighted to claim, as one contributor does, that the changes occurring today are far more profound than those that occurred with the Cold War's ending (p. 34). Elsewhere, though, the collection's emphasis on breadth results in the incorporation of many facets of NATO members' concerns ranging from individual nations' strategic cultures to trends in popular opinion.

This work also occupies a somewhat uncomfortable position in terms of its target audience. The work is neither a primer on deterrence for those interested in national security nor an argumentative work with ground-breaking insights to offer. Rather, it is a broad, yet nuanced, treatment that touches on and explores multiple aspects of deterrence. As such, this book should be most helpful to policy makers given the work's wide coverage. But they will have to draw some of their own conclusions regarding the best path forward. In a lengthy and detailed conclusion, for example, the authors offer as one of their "Final Thoughts" that NATO members "cannot afford to shy away from tough policy trade-offs (p. 221)." Despite not having to compromise like NATO members, the contributors themselves resist setting forth a compelling vision for the future of extended deterrence in Europe, instead relying more on offering readers a variety of alternatives and explanation for consideration.

Dr. Heather Venable

Space Wars: The First Six Hours of World War III, a War Game Scenario by Michael J. Coumatos, William B. Scott, and William J. Birnes. Macmillian Books, 2007, 400 pp.

In the techno-thriller *Space Wars: The First Six Hours of World War III, a War Game Scenario*, authors Michael J. Coumatos, William B. Scott, and William J. Birnes paint the picture of America's national security with destroyed and degraded intelligence capabilities. The authors draw on their personal experiences and specializations to place the reader inside the cockpit, the war planning center, and into the middle of a national security nightmare. Coumatos is a former Navy aviator and spent years as a test pilot where he was exposed to the military's most futuristic air capabilities. Scott also served as an Air Force test pilot and was the bureau chief for *Aviation Week and Space Technology International* magazine. Their expertise, paired with Birnes's storytelling skills, create a convincing crisis with global implications and a chilling warning.

The book begins with the US losing some key space assets—both commercial and military—that give it the power to have an updated, 24/7, global intelligence picture. The loss of these key space capabilities suddenly exposes the Achilles heel of the technologically reliant national defense. It soon becomes clear that with degraded intelligence from space, the nation is vulnerable. Malicious actors worldwide recognize the blind spots caused by the loss of overhead assets and attempt to take advantage of the superpower. Everyone, including Columbian cartels, state-sponsored hackers, Iranian revolutionaries, Middle Eastern terrorists, and Russian defectors, converge, preying upon a weakened, blind America. Trying to stay one step ahead of the nation's enemies are a few elite members of the US national security team. They use their years of analytical experience, a predictive artificial intelligence machine, war-gaming exercises, and a futuristic space spy plane to help the country recover its global position.

I appreciate that this book describes the complex, often incomplete, pieces of intelligence provided by dozens of agencies that go into the national security decision-making process. The story combines open-source, signals, human, and geographical intelligence in a balanced manner that lets the reader and the characters simultaneously analyze the situation and conjure "what's next?" Although the story revisits key characters multiple times, I never got to the point of investing in one set of characters or one piece of the puzzle. Instead, the situation is compelling and takes center stage.

At some points, it is noticeable that the book is written by three authors, and there are occasional abrupt transitions between scenes within chapters. Additionally, the characters, particularly the women, are underdeveloped and tend to rely on stereotypical archetypes. Notwithstanding, I enjoyed the book and found that it presented a believable chronology of events. I recommend it to anyone interested in national security, decision making during a crisis, and a futuristic fiction that may be more factual than we know.

1st Lt Erika Volino, USAF

Above and Beyond: John F. Kennedy and America's Most Dangerous Cold War Spy Mission by Casey Sherman and Michael J. Touglas. PublicAffairs, 2018, 330 pp.

Above and Beyond is the latest book about the Cuban Missile Crisis (CMC), the perilous 13 days in October 1962 that threatened to turn the Cold War red-hot as America and the Soviet Union were on the brink of a nuclear war. Casey Sherman and Michael J. Touglas are award-winning journalists and respected public speakers who teamed on award-winning nonfiction books such as *The Finest Hours: The True Story of the U.S. Coast Guard's Most Daring Sea Rescue* and *Boston Strong: A City's Triumph Over Tragedy*, which were turned into motion pictures. The CMC is one of the most written about events in modern history so the lead author (Sherman) looked for a differentiating theme. With the thought that war was more about the individuals in power than the state entities, he chose to explore the effects of human persona such as President John F. Kennedy's (JFK) life experiences on his decision making during the crisis. The authors extended their personification of participants to the largely unheralded USAF U-2 Dragon Lady spy plane pilots who risked all in flying reconnaissance missions high over the secretly emplaced nuclear missiles in support of those crucial presidential decisions.

Those 11 pilots were epitomized by Maj Rudolph Anderson Jr., the lone casualty of the crisis and posthumous recipient of the first Air Force Cross after he was shot down by a Russian surface-to-air (SAM) missile on his sixth mission. It was Anderson's death that led to ending the 13-day crisis just 24 hours later. Surprisingly, the authors raised another U-2 pilot, Capt Charles Maultsby, to near-equal status by relating a harrowing but errant mission over Soviet territory near the North Pole that had nothing to do with Cuba but contributed to the crisis. (This is not meant to take away from Maultsby, a former Thunderbird who retired as a lieutenant colonel after an extraordinary career spanning the Korean War [where he was shot down and became a prisoner of war], the Cold War and Vietnam.)

With the theme set, the authors went about pulling together the background stories on the main participants leading up to their role in the CMC. They devoted four chapters to JFK, beginning with his heroic efforts to save the crew of his PT boat after it was sunk during World War II. The authors then recapped JFK's political career, which brought him to the White House as a young man still dealing with near-debilitating back problems. The seeds of the CMC were sown early in JFK's presidency as he was held accountable for the ill-fated attempt to overthrow Fidel Castro with Central Intelligence Agency (CIA)-backed Cuban expatriates at the Bay of Pigs. That debacle led to the June 1961 summit in Vienna where Soviet Union Chairman Nikita Khrushchev sized him up as being weak and risk-adverse.

The authors rightfully addressed the amazing story of the rapid development of the U-2 and its all-important camera system in 1955 in some detail. They gave appropriate attributions to Richard M. Bissell Jr., the CIA lead for the project dubbed "Dragon Lady," and to Lockheed Martin's Skunk Works, led by the renowned Kelly Johnson who developed the first article in just eight months. The authors interviewed 97-year-old retired Col Richard S. Leghorn, a legendary World War II and Korean War photo pilot and one of the visionaries of the new spy plane. Leghorn was a consultant on the camera system and involved in the selection of the first pilots.

Above and Beyond relates the story of the initial deployments of the CIA U-2s and the first operational missions over the Soviet Union and its satellites in June and July 1956, noting the aircraft was tracked to some extent by Soviet radars. The revelation that his most secret strategic weaponry was exposed by the US spy plane led Khrushchev to direct an urgent development of the SA-2 SAM system to take down the high-flying U-2,which it ultimately did on 1 May 1960. The pilot was Gary Powers, who miraculously survived but was captured and later tried as a spy, which spelled trouble on the world stage for President Dwight D. Eisenhower. At the time, he was castigated for presumed misconduct by many, including Colonel Leghorn who said, "He should have killed himself," a quote best left out by the authors. After being exchanged for a Soviet spy, Powers was fully exonerated by Congress and the CIA, who gave him its coveted Intelligence Star. Somehow missed by the authors was the fact that he was awarded the CIA Directors Medal and the USAF's Silver Star, both posthumously.

Up to this point, I credit the authors for successfully setting the stage for the delivery of their "new" material to be added to the existing body of work as portended by the book's title. Inexplicably, in my opinion, the wherewith to make good on their goals was there for the taking, but the authors failed to take advantage of it.

It's said that you can't judge a book by its cover, but here's an exception. It has a modern-era U-2S on the front that bears little resemblance to the U-2A/C/F variants flown over Cuba, and a review on the back calling it "an adventure yarn worthy of a spy novelist!" The variant oversight was carried forward to a chapter 1 first-page reference to the much longer wingspan of the late-generation U-2S on an aircraft being readied for flight in 1962!

The readers will find few new revelations about the crisis or the U-2 beyond those detailed by investigative journalist Michael Dobbs in his 2008 book, *One Minute to Midnight*, and U-2 author/historian Chris Pocock's *50 Years of the U-2: The Complete Illustrated History of the Dragon Lady*. The authors compiled an extensive bibliography of relevant books, reports, and websites but conspicuous by their absence is the long declassified and very detailed Strategic Air Command (SAC) operations and intelligence histories of the crisis. This was a puzzling research oversight because SAC's 4080th Strategic Wing (SW) conducted the USAF U-2 operations during the crisis from its forward Operating Location-X at McCoy AFB in Orlando, Florida.

More troubling was the fact that the authors conducted just 10 interviews, and only two of those individuals had contemporary knowledge of the crisis! Inexplicably, the authors didn't interview several available veterans of the 4080th SW who have in-depth knowledge of the aircraft, participants, and mission execution during the crisis. Instead, they relied too heavily on the recollections of one surviving CMC pilot, apparently without even a cursory review of his manuscript by someone with a military aviation background. The result is a book that is replete with errors in easily verifiable information on U-2 pilot training and service records, as well as aircraft configurations and mission details. For example, Anderson's first operational tour in the Far East in 1953–55 was tied to the Korean War although the war was over months before he arrived, and he flew top-secret reconnaissance missions from Japan, not South Korea (p. 30). Anderson transitioned to the U-2A at Laughlin AFB, Texas; yet the book describes he and Maultsby, who followed him, undergoing training at the CIA's Area 51 at Groom Lake, Nevada (p. 73). Maultsby is reported to have followed the money to become a CIA pilot but in fact never left the USAF (p. 72).

One glaring omission is any mention of low-level photo missions by USAF RF-101 Voodoo pilots that complemented the high-flying U-2s while Navy RF-8A pilots were glamorized in that role. In so doing, the authors missed an opportunity to interview Carl Overstreet, who flew the first operational CIA U-2 mission over Poland and East Germany before rejoining the USAF and flying a first day RF-101 mission over Cuba. Another missed story was that one of the two RF-101 squadrons overflying Cuba was led by the legendary World War II and Korean War photo pilot, Lt Col Clyde East, a double ace with 13 kills!

Despite claims of conducting deep research, the authors bought into one version an often repeated but uncorroborated story by the aging CMC pilot that he was fired on by the Russian SAM site that downed Major Anderson two days later near Banes, Cuba. The pilot complained of not receiving an alert from his SAM warning device, but it was not installed on any U-2 aircraft until after the CMC! Then a captain, the pilot recalls being confronted by an unnamed three-star general from Washington the morning after his mission telling him he was wrong, and his intelligence debrief report was being torn up. It was not, and the SAC operational history of the CMC references the mission, stating the pilot reported no coverage of targets in northwest Cuba (more than 300 miles from Banes) due to a solid undercast, with no mention of a SAM engagement.

Instead of doing due diligence to corroborate this questionable story, the authors seized on it and ran it in vivid detail as the first chapter of their book!

Unbelievably, the authors preceded to use this alleged cover-up as the basis of a supposition that either Gen Curtis LeMay, the USAF chief of staff, wanted a U-2 to be shot down as a pretext for launching an air attack he had been pushing (p. 252), or that SAC commander Gen Thomas Power, along with LeMay and perhaps Gen Maxwell Taylor, chairman of the Joint Chiefs of Staff, conspired to cover up the incident to prevent JFK from cancelling U-2 overflights (pp. 251–52, 58). In either case, the inference was these iconic leaders contributed to Major Anderson's loss as a matter of mission over man.

Most damning is an unsubstantiated assertion in the epilogue that the Anderson family was ordered out of base housing at Laughlin AFB almost immediately after his death, stating this cold treatment was "customary on all military bases" as the presence of a lost pilot's family was thought to lower morale!

In summary, this book brings into question whether the mainstream media's adoption of fake news and alternate facts has spilled over into nonfiction works to sell more books.

COL H. Wayne Whitten, USMC, Retired

A Complete History of U.S. Combat Aircraft Fly-Off Competitions: Winners, Losers, and What Might Have Been by Erik Simonsen. Specialty Press, 2016, 228 pp.

What is better than a fly-off? The premise of two new designs, fully formed and performing to their utmost, all in the hopes of big procurement contracts, is behind aviation historian and photographer Erik Simonsen's *A Complete History of U.S. Combat Aircraft Fly-Off Competitions*. The author reviews 10 post-World War II competitions, providing details of each plane, the goal of the competition, and the long-term consequences of the decision.

The technological developments in America, but especially Germany, are used to set the stage for the vast expansion of aircraft development after the war. From there, Simonsen evaluates the 10 postwar competitions, starting with the B-45 Tornado versus the B-47 Stratojet medium-bomber competition, on through the Vietnam era with the F8U-3 Crusader III versus the F4H-1 Phantom II, and finally to the present-day Joint Strike Fighter (JSF) competition. In all, he provides a thorough review of the subject as it evolved through the last half-century.

Simonson gives each aircraft its due, describing its origins, evolution, and winning or losing traits. It is easy to see why the winners triumphed and the losers were scrapped, although in a few cases, he makes a strong case for the loser as a better airplane if not the better choice. Take, for example, the F-105 Thunderchief against the F-107A. The F-107A was the more sophisticated and daring design evolution but not the politically correct choice for an Air Force needing a multirole fighter-bomber to justify the cost. Simonson laments the demise of the faster and more innovative F-107A in the way any true aviation enthusiast does—like the loss of what might have been.

It is in this quest for what might have been that the book strikes its real gold. Using a technique he developed, Simonsen integrates 3D models, actual aircraft, and aerial photographs to give the reader images of what the losing aircraft would have looked like operationally. These pictures run the spectrum from the mundane operational scenarios—like the Convair YB-60 in Southeast Asia camouflage headed to targets in Vietnam—to renderings of what the Boeing X-32 JSF would have looked like in its production configuration. These images open a world of possibilities by putting into tangible terms the planes that never were and giving context to the missions they would have performed. He also includes pictures of proposed derivatives of each aircraft that were offered by manufacturers but failed to find a market. The one criticism of the technique is its overuse on planes that were placed into production. The author is credited with embellishing the color and background of many pictures in the book, projecting the production aircraft with the same fanciful image that its ghostly competitors deserve.

An important aspect of this book is the scope it covers, dealing with the entire postwar procurement period. To see how the decision-making process has changed, yet stayed the same, gives the reader a better understanding of why we have the airplanes we do. The changes in technology in the postwar period, notably the jet engine and swept wings, drove the requirements for capabilities and design. The B-47 won the medium-bomber competition hands down because of its swept wings making it faster than its competitors. Likewise, the use of these new design concepts from the get-go made the B-52 the obvious choice over the YB-60, which had the features added to the ungainly B-36 fuselage. Often, though, a healthy dose of political maneuvering and salesmanship were required to sell a plane. The YF-105 could call itself a bomber when money was available for a bomber, and Lockheed presented the X-35 as a member of the services before the competition ended, making the plane appear as the customer and the public wanted it to be.

The politics of the decisions creates the book's one major shortcoming—editorializing. The more recent competitions elicit some strong opinions from the author, who is obviously no fan of the F-35. Whether it be the idea that the A-10 Thunderbolt II could be replaced by the JSF, or the reduction in F-22 Raptor production to accommodate the newer plane's cost-overruns, Simonson does not miss a chance to lament the JSF's shortcomings and impacts on the military services. The criticism even stretches to editorializing on executive administration policy decisions as they impact the use of these aircraft. I suppose it is not surprising that a politically driven subject would elicit strong opinions, but they should be kept out of an objective history. Too many readers today will be turned off by the political content they disagree with and ignore the interesting and valuable information the book provides.

Overall, this is an enjoyable book that consolidates into one place all the snippets of information on the planes that never were and then puts them in context. It is a must for any aviation enthusiast's bookshelf and a good read for those in the aviation industry. For 70 years, there have been fly-off competitions, and in a cost-conscious world, there is no reason to believe those head-to-head showdowns will stop, so grab your helmet bag and enjoy this ride.

Daniel Schwabe

Always at War: Organizational Culture in Strategic Air Command, 1946–62 (Transforming War) by Melvin G. Deaile. Naval Institute Press, 328 pp.

Always at War examines the creation and formation of culture in the best-known command in the Cold War US Air Force: Strategic Air Command (SAC). Melvin G. Deaile, a retired USAF bomber pilot, argues that SAC's culture stemmed from a shared World War II experience and prioritized standardization, centralization of authority, and specialization. The work, Deaile's revised 2007 University of North Carolina dissertation, relies on Air Force archival records, the personal papers of senior USAF officers, and some oral history interviews conducted with SAC veterans. Drawing upon the work of Edgar Schein on organizational culture, Deaile uses a foundationalist perspective that emphasizes the influence of group leaders in forming culture. In particular, he focuses on Gen Curtis E. LeMay and Gen Thomas S. Power, who together commanded SAC for 16 years beginning in 1948.

The book begins by examining pilot culture in the Army Air Corps before World War II. Pilots tended to view themselves as a separate, superior group compared to other officers due to several factors: they received extra pay, the high attrition rate due to accidents, and the difficulty of passing the physical entrance exams. Within the pilot community, officer standing depended on physical characteristics such as flying skill and hand-eye coordination. SAC imported this pilot culture and consequently prized flying skill as the principal characteristic of leaders. The second chapter traces the shared experience of SAC's leaders in World War II. LeMay's initial experiences with the bombing campaign against Germany taught him the value of standardized training that eliminated individual squadron or wing eccentricities. Furthermore, a successful mission required all members of a bomber's crew to focus on performing their specialized tasks. SAC reflected this World War II-inspired emphasis on specialization. Finally, LeMay insisted on realistic training for his bomber crews, which, in turn, led to a culture that prized constant readiness. LeMay carried these priorities with him when he went to the Pacific to direct the strategic bombing campaign against Japan based in the Mariana Islands. The Navy's struggle to keep his bombers fully supplied with incendiary weapons shaped SAC's reluctance to depend on the other services or branches of the Air Force. LeMay's Pacific command stood outside the theater command structure and reported directly to the Joint Chiefs of Staff, another model that SAC followed.

SAC's first commander, Gen George C. Kenney (1946–48), struggled to bring his squadrons up to combat readiness in the midst of postwar demobilization. While the US alone held the atomic bomb, the problems with SAC's bomber squadrons meant that America's atomic capability provided a relatively hollow deterrent, as historian John M. Curatola noted in *Bigger Bombs for a Brighter Tomorrow* (2015).

LeMay took command of SAC in 1948 and began to turn the force around. He instituted standardized procedures, required realistic training, and worked to provide better housing for SAC personnel, believing that improved housing would attract better people. He also brought the reconnaissance, weather, and transport aircraft required to execute a bombing campaign against the Soviet Union into SAC. LeMay believed that just as bomber crews needed to focus on their specialized task—strategic bombing—so, too, these supporting units needed to focus on their specialized task of making the bombing campaign possible. This approach not only helped integrate SAC's various constituent parts but expanded SAC's influence within the larger Air Force. Under LeMay, standardization and constant evaluation became the hallmarks of SAC culture, along with an emphasis on operating on a permanent wartime footing. LeMay left his mark on SAC, which came to prize independent, self-sufficient operations. The Korean War showed one potential downside to this approach in that SAC formations in Korea insisted that other units in the Far East Air Forces adjust their routines to fit SAC's methods, rather than the other way around.

By the mid-1950s, the development of longer-range bombers allowed SAC to end rotational deployments to overseas locations. The newer aircraft could reach the Soviet Union with aerial refueling, reducing the need to operate from bases in the United Kingdom or Morocco. SAC's leaders welcomed this shift as theater commanders such as the US European Command commander would no longer be able to exert authority over SAC units deployed into their area of operations. This redeployment corresponded with massive growth in the size of SAC. By 1956, the command had more than 60 wings of aircraft with more assets than the largest corporation in America.

SAC's operations exacted a heavy toll on its personnel. Deaile describes the experience of spending hours on alert and flying long bomber missions. Long working hours impacted spouses and children, straining marriages and relationships. SAC's leaders sought to alleviate this pressure through auto hobby clubs, wives' groups, and sporting shooting organizations. Like everything else in SAC, the participation in these groups was monitored and recorded.

By the late 1950s, the ongoing development of ballistic missiles introduced a new subculture into SAC: the missileers. The crews who manned the launch control centers for intercontinental ballistic missiles (ICBM) formed a distinct group within SAC, although pilot culture remained dominant. In contrast to pilots, who prized physical skills such as hand-eye coordination, the missile field emphasized technical education. General Powers, who did not have a college degree, stood in contrast to the missileers who generally held bachelor's degrees. The introduction of ICBMs also added an element of fear to SAC's culture as the force sought to prevent Soviet missiles from destroying America's bombers on the ground.

Deaile's book joins a growing number of works on America's early Cold War nuclear force. *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (2009), Neil Sheehan's biography of ICBM pioneer Gen Bernard A. Schriever, is likely the most widely read. In 2012, Francis J. Gavin published *Nuclear Statecraft: History and Strategy in America's Atomic Age*, a revisionist account of US nuclear history, challenging much of the received wisdom. More recently Curatola highlighted the Truman administration's struggle to develop an efficient nuclear deterrent in the late 1940s in *Bigger Bombs for a Brighter Tomorrow: The Strategic Air Command and American War Plans at the Dawn of the Atomic Age, 1945-1950*. In *To Kill Nations: American Strategy in the Air-Atomic Age and the Rise of Mutually Assured Destruction*, Edward Kaplan examined the development of Air Force nuclear strategy and thinking in the same period covered by Deaile. Gavin, Curatola, Kaplan, and Deaile all benefited from recently declassified sources that only now allow historians to thoroughly examine the nuclear history of the early Cold War using primary sources.

Deaile's book makes a significant contribution to this growing subfield of Cold War military history. His use of organizational culture theory is illuminating without being overly dense. He clearly demonstrates the strong connections between the experience of World War II and choices made in the early Cold War, a link too often ignored. The historical and bureaucratic context during which SAC came into existence exerted powerful influences on the new command. As a well-written account of this important Air Force organization, *Always at War* is recommended for general readers interested in aviation history as well as specialist scholars.

Dr. Corbin Williamson

Wild Blue Yonder (ISSN 2689-6478) is Air University Press's new online journal and forum focused on airpower thought and dialogue. The journal seeks to foster discussion and debate among air, space, and cyberspace practitioners. We want to hear your ideas on how to reshape the way we think about air, space, and cyberspace. Our articles bridge the gap between academic thought and practical operational experience.

Articles submitted to the journal must be unclassified, nonsensitive, and releasable to the public. The length and depth of articles can vary significantly, and we strive for a good balance between pieces of scholarly rigor and operational perspective. Submit all manuscripts to WildBlueYonder@hqau.af.edu.

Wild Blue Yonder
600 Chennault Circle, Building 1405, Room 143
Maxwell AFB, AL 36112-6026
Tel (334) 953-5560 Fax (334) 953-1451
https://www.airuniversity.af.edu/Wild-Blue-Yonder/

Visit our social media:
https://www.facebook.com/WBYjournal/
https://twitter.com/WBY_Journal
https://www.linkedin.com/company/wild-blue-yonder-digital-journal/