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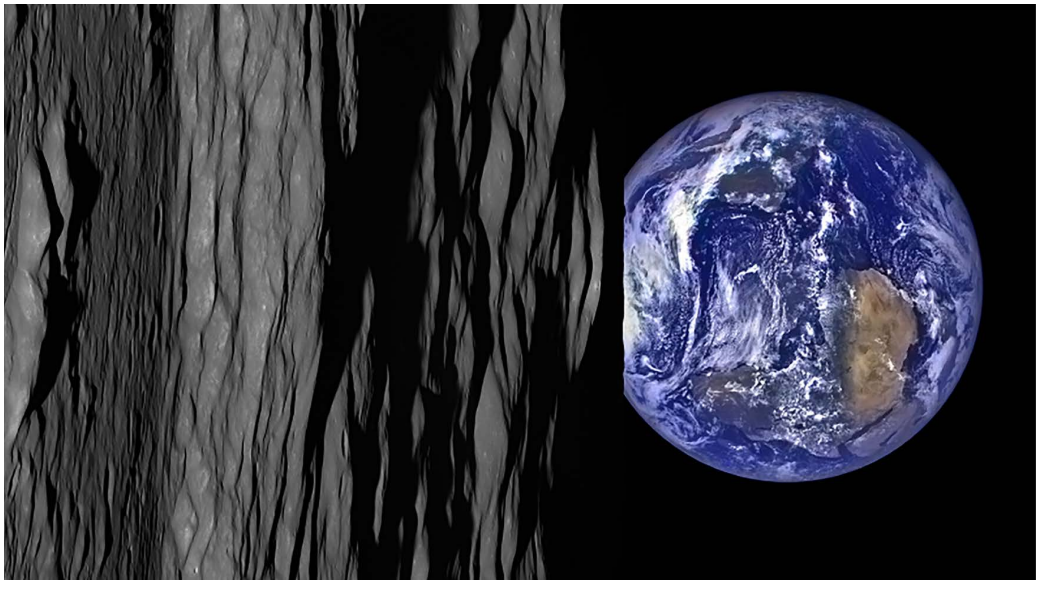
FEATURE

Black Space versus Blue Space

A Proposed Dichotomy of Future Space Operations

Capt Carl A. Poole, USSF
Maj Robert A. Bettinger, USAF, PhD



Introduction

As defined by the *National Defense Authorization Act (NDAA) for Fiscal Year 2020*, the purpose of the United States Space Force (USSF) is to "provide for freedom of operations in, from, and to the space domain for the United States" and shall include "both combat and combat-support functions to enable prompt and sustained offensive and defensive space operations and joint operations in all domains."[1] As part of the formal debut of the USSF after the signing of the NDAA into federal law, Chief of Space Operations Gen John Raymond stated the formation of the USSF serves to "[elevate] space commensurate with its importance to our national security and the security of our allies and our partners."[2]

Traditionally, Air Force space operations were ostensibly limited to near-Earth space with mission altitudes extending from low-Earth orbits (LEO) to geosynchronous (GEO) or highly-elliptical (HEO) orbits. During the 2010s, however, space operations began moving beyond this approximate altitude limit to encompass cislunar space with reinvigorated US initiatives to return to the Moon, planned commercial space projects, and cislunar injection trajectories for geosynchronous-

orbiting satellites. Additionally, an increase in projects from both near-peer and emerging spacefaring nations, such as China's Chang'e 4 lunar rover mission and accompanying Lagrange-point communications relay satellite (2018–19), and Israel's attempted lunar surface mission (2019),[3] has pushed US space domain awareness and space control considerations beyond near-Earth space.

The US and wider international space operations, moving beyond cislunar space extending to the Moon, are poised to extend to Mars and potentially asteroids. Recently, then President Donald J. Trump issued an executive order encouraging the recovery and use of natural resources in space, thereby sanctioning the commercial mining of asteroids and potentially other celestial bodies.[4] Considered by some to still be the realm of science fiction, the conceptualizing of realistic space operations beyond the Earth's gravitational sphere of influence within the next several decades has initiated around the world. Relevant to the US and the scope of this article, the (former) Air Force Space Command released a study in 2019 outlining the findings of its "Space Futures Workshop." This report, *The Future of Space 2060 and Implications for U.S. Strategy*, pushes the bounds of legacy space operations paradigms and maps potential realities for emerging space-based economies and alterations to the international order.[5]

Influenced by this preliminary US Air Force (USAF) planning initiative, the authors advocate a new way of classifying space operations within a dichotomous structure that focuses on the location where space operations are intended and conducted with respect to the Earth or other celestial bodies (e.g., the Moon). Similar to the legacy classification paradigms of "brown-water" and "blue-water" navies in the maritime domain and the differences between local/regional and global air forces in the air domain, this article proposes the creation of a "black-space" and "blue-space" structure for space operations. This new distinction enables the functional division of current and emerging USSF missions as national space operations begin to routinely transcend the Earth's gravitational sphere of influence and the formation of acquisition lines of effort to support expanding missions aligned with an equally expanding scope of national security and strategy. The proposed structure differs from contemporary analyses that posit terms such as *blue-water space* and *brown-water space* by instead creating a description of operations truly unique to the space domain.[6]

This article will examine the proposed space operations structure by first outlining the historical foundations for differences in maritime and air domain military capabilities, specifically brown-water versus blue-water navies, and "local/regional" versus "global" airpower. Next, the article will present the concept of black space and blue space in terms of an environment-specific definition, as well as an examination of the technical capability requirements, mission types, and

national prestige and geopolitical considerations underpinning the proposed operation types. Finally, the article will explore how the USSF might support future space exploration within the black-space and blue-space operations structure.

Historical Antecedent: Brown-Water Navy versus Blue-Water Navy

Space has always had a strong tie to the oceans—from the vast emptiness to the ever-present drifting of everything. This analogy makes the employment of naval and maritime references only natural as the venture into space begins to mirror humanity's mastery of the sea. This article seeks to use the capabilities and areas of influence developed for brown-water and blue-water navies as a foundational dichotomy for the space domain to further press upon the connection. The term *brown-water navy* refers to a coastal, littoral, or inland waterway naval defense force used to protect local interests and national assets. Similarly, a *blue-water navy* is an open-ocean or international naval defense force used for the protection of commerce and national interests through the projection of national instruments of power. The operational techniques for each type of navy and their respective area or "sphere" of influence are dependent on both technology implementation and evolving national security needs.[7]

Following the American Revolution, US naval attention was bifurcated into two modes. The first represented the maintenance of an emerging blue-water capability to protect US shipping and trade routes. For example, this capability was pivotal in defeating the Barbary pirates in the Tripolitanian War (or the First Barbary War; 1801–05) and sustaining a sea line of communication between the eastern seaboard and California before the transcontinental railroad.[8] The second mode, brown-water in orientation, is exemplified by the creation of the "Revenue Cutter service," known today as the US Coast Guard (USCG),[9] which was charged with coastal defense and maritime law enforcement. Auxiliary, yet temporary brown-water capabilities, were also forged by the US Navy (USN) to combat the British during the War of 1812 in the Great Lakes and Lake Champlain and later during the Civil War along the major inland rivers such as the Mississippi.[10] The end of the 1898 Spanish-American War solidified the need to create a viable US blue-water navy with the acquisition of former Spanish territories across the Pacific Ocean and in the Caribbean Sea.[11] Nineteenth-century naval progress enabled the US to secure "command of the sea" and control its commercial and military "maritime communications" during the twentieth and early twenty-first centuries.[12]

Whether it was the Portuguese and the Spanish during the fifteenth and sixteenth centuries, the English and French during the seventeenth and eighteenth centuries, or the English and Americans in the nineteenth century, the evolution in technology became a central component to the transformation of brown-water into blue-water naval capabilities. New ship designs, the introduction of a nautical chronometer for the measurement of longitude,[13] and the eventual transition from wind to steam and then to diesel power-produced potent naval forces that could predictably and reliably be used to project national power with both increasing speed and precision. The new forms of maritime propulsion, coupled with the ability for near-instantaneous communications brought about by the invention of the radio, allowed for national spheres of influence to realistically grow beyond littoral control, and the age of global naval power became technologically practical.

Enamored by the prestige of wielding a blue-water navy, some nations neglected to sustain a brown-water capability and, therefore, limit their naval power. As previously described, the US has had a long history of balancing coastal protection needs with the importance of international maritime power projection. During the Vietnam War, however, the USN had no means to conduct missions in littoral and inland waters against the North Vietnamese and insurgent Viet Cong. In its place, portions of the USCG were used until the USN could transition equipment and tactics for "riverine" missions.[14] This need emerged again during recent operations in the Persian Gulf because the USN had overlooked the need to maintain a brown-water capability.[15] As with the Vietnam War, the USCG again served a deployed function during Operation Iraqi Freedom and complemented USN operations by protecting Persian Gulf shipping, coastal petroleum refineries, and Gulf oil platforms.[16] Despite its lack of a true brown-water capability, the USN has come to use its "blue-water [aircraft] carrier[s]" as an effective tool in both "influence and power projection" to provide coverage between the blue-water and brown-water arenas of maritime warfare.[17]

Historical Antecedent: Local/Regional Versus Global Airpower

As with the maritime domain, there is an observable distinction in the air domain concerning the evolution and pursuance of local, regional, and global airpower. In the present research, the term *airpower* is restricted to its classical air-centric definition and does not include the cyber and space domains as reflected in current USAF doctrine.[18] Foundationally, local and regional airpower is projected by air capabilities technologically constrained in terms of spatial range due to airframe design and fuel storage capacity. Local and regional air forces (or

services) will typically operate within a radius that is intracontinental in scope without the need for aerial refueling capabilities for range enhancement. By extension, these technological constraints are a byproduct of and influenced by a given nation's geopolitical position and security considerations vis-à-vis its regional neighbors and international interests.

Historically, early aircraft were limited in range and operated within a radius measured in tens to hundreds of miles of airfields. This range continued to grow as operational requirements intensified during World War I. The British Handley Page V/1500 (HP 15) delivered a maximum range of approximately 1,300 miles (2,092 km) to bomb targets deep within Germany from Great Britain or France.[19] Aeronautical advances were rapid in the early days of aviation, with the first US transcontinental flight from New York to San Diego (approx. 2,700 mi, or 4,350 km) in 1923 in a Fokker T-2 and the first trans-Atlantic flight (approx. 3,600 mi, or 5,790 km) in 1927.[20] These advances, however, were only associated with smaller-scale aircraft featuring limitations in both weight and crew to maximize aerodynamic and engine efficiency. Commercial aviation and the record-breaking exploits during the Interwar period helped push the bounds of aeronautical engineering, with aircraft evolving in terms of maximum range, altitude, size, weight capacity, and design. The onset of World War II brought a new set of requirements, with the exigencies of global war again extending large aircraft range with B-29 bombers flying over 1,500 mi (2,410 km) sorties against targets in mainland Japan.[21] Even with such demonstrated strategic reach, Allied and Axis air forces remained fundamentally regional in reach, only approaching the prospect of "global reach" at the maximum extent of existing aircraft capabilities.

Intercontinental, global airpower originated after the end of World War II with the introduction of aerial refueling. Although tested and proven during the 1920s, aerial refueling became a defined and increasingly reliable capability within the nascent USAF with the debut of the KB-29M/P and KC-97, and later the KC-135.[22] This new capability reduced aircraft range and overall mission endurance dependencies of aircraft design and fuel storage capacity. As a supporting function of Air Force operations during the Cold War and post-Cold War environments, aerial refueling provided global reach to not only the strategic attack function, as embodied by aircraft like the B-52 and B-2, but also airlift and mobility. As a salient example of global airpower, consider the combined use of the B-2 and aerial refueling platforms to conduct long-range strikes from Whiteman AFB, Missouri, to locations such as Serbia (1999), Afghanistan (2001), and Libya (2011), with recovery back in the US.[23]

For the US, the maintenance of a global airpower capability advances, in part, the *National Defense Strategy* objectives of deterrence and the sustainment of

global Joint Force military advantages.[24] However, the realization of US global airpower arose due to technological innovation, capability evolution, and the requirements associated with advancing and protecting US national interests in the polar postwar order emerging after World War II. The establishment and sustainment of a global air force is not a requirement for all nations, and rather a capability ultimately influenced—similar to that of local/regional airpower—by the security considerations of a given nation. While nations such as the US and Russia maintain global airpower capabilities, they also maintain aircraft intended to function on the local/regional level for air defense, intratheater combat support, or regional power projection needs.

Competition has arisen with China's desire to enter the global airpower and naval arenas. Currently limited to regional operations in eastern Asia due to forward basing requirements and limited aerial refueling platforms, China seeks to develop longer-range bombers and tankers intended to deliver global reach for Beijing. The evolution of the People's Liberation Army Air Force aerial refueling capabilities is regarded as a "necessity to project power throughout the globe" and ensures parity with perceived Chinese geopolitical rivals.[25] By contrast, other nations do not seek global power projection and only persist in sustaining local/regional air forces to satisfy a desired regional defensive posture. Every continent now has air forces subject to limited local/regional access, such as Israel, Mexico, and Pakistan.

Proposed Space Operations Architecture

Since that fateful day in 1957 when Sputnik made its first orbit around the Earth, humanity has sought to further its operational presence in outer space. Terms describing orbital regimes, such as LEO, GEO, and HEO, have become common in both the space professional and laymen communities. Also, the global society is becoming increasingly linked to—and dependent on—space-based capabilities. As nations and commercial entities alike seek to transcend the limits of Earth's gravitational pull toward the Moon, asteroids, and beyond, a more universally accurate dichotomy is needed to classify and describe space operations. As the terms *brown-water navy* and *local/regional airpower* have developed to denote operations within "localized" terrestrial spheres of influence, the term *blue space* is proposed as a means to denote space operations within "celestial" gravitational spheres of influence associated with a given planet, moon, or planetoid.[26] More accurately, *blue space* will feature two definitions: (1) space operations occurring between the boundary of the sensible atmosphere to the outer boundary of the Earth's gravitational sphere of influence; and (2) space operations from the sur-

face/sensible atmospheric boundary to the edge of the gravitational sphere of influence for a celestial body (planet, moon, or planetoid).

Following the terrestrial example further, the terms *blue-water navy* and *global airpower* can be used as a basis to denote black-space operations occurring between local gravitational spheres of influence. As with blue space, the term *black space* will also feature multiple definitions: (1) space operations extending outside the Earth's gravitational sphere of influence; and (2) space operations occurring between local gravitational spheres of influence where the primary gravitational source is a star, such as the Sun; and (3) space operations occurring at the interstitial boundaries formed between two or more gravitational spheres of influence. The use of the second and third definitions of *black space* will become more important as future space missions begin to occur regularly beyond the Earth's gravitational sphere of influence.

The bulk of space operations are of the blue-space variety, except for black-space scientific exploration missions in the form of interplanetary probes, such as Voyager I and II or the more-recent Juno satellite, or lander and/or rover sojourns to celestial locales like the Moon and Mars. Due to the dual requirements of technological innovation and cost, few nations have historically pursued, developed, and maintained an active space launch capability. As the first and only spacefaring nations at the dawn of the Space Age, the US and Soviet Union conducted blue-space operations under the "big-sky" principle and governed by treaties, such as the Outer Space Treaty of 1967 and the Anti-Ballistic Missile treaty of 1972.[27] These early operations focused on the development of communication, navigation, and Earth-observation missions, all of which have a military support function. This focus meant that up until the creation of the USSF, these missions were considered an extension of the USAF's operation and acquisition processes and could be grouped under the blue-space umbrella.

Engineering/Technology Considerations. As the number of spacefaring nations grew, so did the type of blue-space operations and missions beyond near-Earth space into the black-space realm. During the 1960s, the race to the Moon introduced several new dimensions for space operations, each capable of being binned into the blue-space and black-space categories: (1) the reality of long-duration manned space flight to a different celestial body; (2) the need for a black-space rescue capability; and (3) the increased importance of material transportation to space. Unfortunately, since the Apollo missions, human spaceflight has been limited to the International Space Station (ISS) and other space stations located in LEO and, therefore, limited to blue space.

Entering into the 2020s, however, both national governments and commercial enterprises alike are seeking to end the nearly 50-year blue-space focus of human

spaceflight by returning to the Moon, visiting an asteroid, and venturing out to Mars. As human spaceflight endeavors to extend its reach beyond LEO, evolving propulsion capabilities will play a deciding role in increasing long-duration space missions and extending from "blue" to "black space." Propulsion accounts for the majority of mass during current space-lift operations, with payload mass ultimately limited by the necessities of carrying sufficient propellant to attain exoatmospheric flight and inject a given payload into a desired orbit or trajectory. Advances in propulsion technology will need to deliver higher-power densities to achieve a greater payload capacity while delivering high levels of efficient propulsive power. Even with higher efficiencies and power, future propulsion systems will still require some form of propellant management. In the same way that aerial refueling allowed for the shift from a local/regional to global airpower, orbital refueling will allow for the transition from blue to black-space operations. Once established, an orbital refueling capability will enable an expansion of space-lift capabilities to blue space and the required mission durations and speed for black-space missions, thereby ushering in an increased level of mission assurance, responsiveness, and agility.

Propulsion systems also have a role to play in spacecraft maneuverability. As spacecraft maneuverability is advanced to the point of the vehicle becoming a "free flyer," not tied to the limitations of Keplerian mechanics of motion, the ability to conduct black-space operations such as rescue and servicing will increase.[28] An extension of human spaceflight beyond the Earth's gravitational sphere of influence will necessitate the USSF to formulate doctrine and capabilities associated with the execution of rescue operations in both the blue and black-space environments. Each environment will require drastically different techniques due to the timing component of any rescue effort. In the same manner that customary international law recognizes the "affirmative obligation" of blue-water navies and general ocean-going to "render assistance to persons in distress at sea,"[29] Article V of the 1967 Outer Space Treaty[30] requires "all possible assistance" be given to astronauts in distress. In the event of a blue-space incident, such rescue missions can be conducted from a terrestrial location on Earth (or other celestial body) or a space station as long as a rescue launch is always on standby. These blue-space capabilities will resemble the current doctrine and operations conducted by the USCG, which patrols and renders aid within US littoral waters. The planning for rescue changes for the case of a black-space event, wherein such operations would require at least a vehicle or station capable of rendering assistance and aid. The time it would take to stage a terrestrial-based rescue would likely impede and negate the effectiveness of such efforts, thus making the capability of a space-based rescue increasingly relevant. Using the USN's blue-water doctrine as a

foundation for this arena, the USSF would need to maintain a controlling presence in black space. The importance of something like the Lunar Gateway being located on a gravitational interstice between the Earth and the Moon would be foundational in the area of rescue.[31]

A final engineering consideration for future operations deals with the exponentially increasing factor of material cost and transportation inherent in an Earth-centric logistic system. A move to on-orbit refinement and fabrication facilities will need to be pursued to enhance development, dependability, and sustainment. This consideration will have two far-reaching effects. First, it will eliminate the long and costly procurement times for materials and equipment associated with launch and transit from Earth. Second, it will limit the dependence on Earth if material transport becomes interrupted or too distant to be considered time effective. Similarly, orbital facilities will bolster "black space" operations; once outposts on the Moon and Mars have been established, the need will arise to create facilities capable of supporting local blue-space and surface operations. The new celestial-based facilities will also have the added effect of creating additional lines of logistics that can decrease material bottlenecks and further increase exploration capabilities.

National prestige/geopolitical considerations. The advancement of technological innovation and the pursuance of scientific exploration are often tied to national prestige and the enhancement of a nation's geopolitical standing. During the early Space Age, Cold War competition between the US and Soviet Union translated into a race of culture, economic ideology, and technology beyond near-Earth space. As the first into space with both an artificial satellite and a manned space capsule, the Soviet Union sought to extend its early Space Age prestige victories by sending interplanetary probes to Venus concurrent with its lunar exploration program. From its first successful Venusian landing with VENERA-3 in 1966 to the back-to-back landings with VENERA-5 and VENERA-6 in 1969, the Soviet Union sought to declare that it "clearly demonstrates the high perfection of Soviet space science and technology, [and] the high talent of its scientists, engineers, constructors, and workers."[32] Even though losing to the Americans in the race to the Moon, the Soviet Union persisted in maintaining its presence in space and incrementally developing its space lift and space-based capabilities with the Soyuz program and Salyut series of space stations—all within LEO and the blue-space realm of operations.[33]

Despite winning the race of the Moon, the US rapidly returned its focus to blue-space operations with the programs such as Skylab and the Space Shuttle, with only minor forays into black space with interplanetary probes to Mars and the Outer Planets. Presidents John F. Kennedy and Ronald Reagan both suggested the importance of having joint/cooperative governmental capabilities "to

explore the stars" while spreading the cost of such ventures.[34] This early concept of cooperation is the foundation that many spacefaring nations rely on at present. Amidst this environment of post-lunar space system development and exploration, the US became inextricably dependent on its space-based technologies for commercial, governmental, and military needs. This reliance forms the basis for an increase in US space control and defense considerations as embodied by the recent formation of the USSF. Although the US commercial space enterprise comprises the bulk of satellites in the American blue-space operations footprint, the continued use of and access to space by US stakeholders represent a matter of national security and interest. As the US pushes more into black-space operations, there will be attendant national security considerations that drive space system capability development and acquisition. This need is echoed in the recently released *Space Capstone* publication: "As the range of civil, commercial, national intelligence, and multinational space applications expands in scope and extends farther from Earth, military space forces must prepare to extend Space Security in support of these new US interests."[35]

After several decades of well-established cooperation between nations for space exploration and study, the early twenty-first century has witnessed a re-ignition of competition in space. Comparatively, new entrants into the space domain, China and India have set sights on missions to the Moon and Mars. Faced with China's LEO space station, recent and planned cislunar missions, and a planned mission to Mars in the early 2020s, as well as India's Chandrayaan-1 and Chandrayaan-2 (attempted) missions to the Moon and Mangalyaan mission orbiting Mars, the US has started to invigorate its own blue and black-space operations to expand its space presence vis-à-vis its geopolitical competitors.[36]

Additionally, missions to and operations on the International Space Station (ISS), along with evolving efforts at expanding spacecraft maneuverability and autonomy, represent a burgeoning foundation in future near-Earth blue-space area of operation for the USSF and allied space programs. The recent launch of the crewed SpaceX Dragon capsule to the ISS on 30 May 2020 adds a new dimension to blue-space operations with the potential for privately owned commercial flights. Coupled with plans for commercial space tourism and mining operations, the security of national interests in space will only increase, thus requiring a persistent US presence in both blue and black space. To this end, the Lunar Gateway "will uphold the US position as a leader in spaceflight and allow the United States to set "rules of [the] road" for activities in space."[37] The Lunar Gateway represents the natural foundation for the creation of black-space operations doctrine going forward. It will also set the tone for future US/allied acquisitions and security capabilities needed in the transit to Mars or deeper space mis-

sions. Though this has been described as an important issue for the newly formed USSF, even the newer spacefaring nations recognize that it "is conceivable that demands on logistics for this kind of [exploration] operation can only be met with multinational cooperative effort."[38]

Scenario: Space 2060. In the future, the USSF will continue to service blue-space operations and more than likely support interplanetary exploration in the same manner that the USN, USCG, and USAF currently support terrestrial exploration to remote areas such as Antarctica. Although the future remains unknown, a report such as *The Future of Space 2060 and Implications for U.S. Strategy* helps to provide at least a notional mooring point for scientific conjecture rather than embarking on pure science fiction.[39] In line with one of the "Positive Futures" contained in this report, the USSF by the year 2060 has effectively helped to establish a number of US/coalition-led outposts on both the lunar surface and Mars. Resupply spacecraft regularly travel between the successor to the Lunar Gateway and Mars, with a black-space station located at a Sun-Earth Lagrange point acting as a way-point and transportation depot during the multiweek interplanetary trek.[40] Onboard the resupply spacecraft, USSF personnel comprise critical crew functions to include command/control, navigation, engineering, and life support; at the Sun-Earth Lagrange station, the USSF maintains a rescue function to support interplanetary transit operations. Following the initial landings on Mars in the early 2030s, the USSF became responsible for the construction of the initial outpost. Such a mission was similar to the early days of lunar infrastructure development, and also relied on decades of lessons learned from similar USN and USAF forward-base construction and logistical operations in overseas austere locations. In addition to the infrastructure maintenance and planetary logistics, the current USSF blue-space footprint on Mars also includes operation of communications and imaging satellites in Martian orbit.

Although four decades in the future, this scenario illustrates—at least at a cursory level—the dual-use of blue and black-space operations within the context of human spaceflight between the Earth, Moon, and Mars. As black-space requirements expand to encompass more distant celestial bodies, the USSF may need to consider localized and more specialized blue-space zones. The creation of localized blue-space zones of operations is similar to air domain operations in which a local or regional airpower structure is created to support a wider military or humanitarian campaign in a geographically separated location. For example, a local or regional airpower capability was created to support combat operations in Serbia (1999) and Iraq (2003) with the basing of aircraft such as F-15s and F-16s within the area of operation. While the US maintains a global airpower capability, reliance on such a capability for all airpower operations is untenable and prevents the

execution of short-time duration or ad hoc mission taskings within the joint or coalition environment. Within the context of the 2060 Mars scenario, black-space operations would need to morph into blue space to provide the support functions necessary to Martian operations due to a dissonance of mission expertise, the tyranny of distance, and the likelihood for emergency operations.

Conclusion

While the Korean War and wider Cold War of the 1950s served as the crucible for the newly formed USAF, the 2020s will present an entirely new set of challenges for the developing USSF. In addition to facing geopolitical threats that seek to compete with and contest the US and its access to and use of space, the USSF must navigate an increasingly congested space environment with an emergent commercial space sector. Space operations are extending and will continue to extend deeper into space. As a result, the USSF must formulate doctrine that will address the realities of conducting security, support, and crew operations both near and far from the Earth. The dichotomy of black space and blue space provides the architecture for not only classifying space operations with respect to different gravitational spheres of influence but also the formulation of doctrine and the establishment of acquisition lines of effort to support expanding missions aligned with an evolving national security posture and strategy. The development and acquisition of new technologies, the potential for constrained budgets, and the expanding roster of emerging spacefaring nations represent only a few of the challenges for the USSF as it embarks on securing US space interests in near-Earth, cislunar, and eventually interplanetary space. Implementing the black-space and blue-space space operations architecture will help the USSF organize its needs and focus areas of concern for different planning time horizons and will ultimately assist the US to delineate and execute its current and future mission responsibilities in the space domain. ✪

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Notes

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Infrastructure Truths for Air, Space, and Cyberspace

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Introduction

The importance of the air base and the physical infrastructure that it contains to the success of air operations is not a new concept. There is a general acknowledgment in the Air Force today that the air base itself is a "weapons system." As former Secretary of the Air Force Dr. Heather Wilson stated with the release of the Infrastructure Investment Strategy (I2S), "in the Air Force, we fight from our bases. . . the places we call home are also the platforms from which we project combat power."[1] The Air Force major command (MAJCOM) commanders further stated that "the foundation of Air Force readiness and lethality is an integrated network of resilient installations that enable advanced-generation, multi-domain operations while also providing safe communities for our Airmen and families."[2] Nevertheless, budgets are tight, and it is often difficult to quantify the value provided to the mission through the investment in physical infrastructure or the risk to mission associated with neglecting infrastructure. To that end, this ar-

ticle describes a succinct set of "infrastructure truths," clear statements of the foundational principles of infrastructure management. Airmen and Guardians can use these principles to guide advocacy and funding decisions at all levels of leadership. To set the stage for these truths, this article includes a brief history of the important role that air base infrastructure has played in airpower employment with logical extensions to space and cyberspace and a brief review of current doctrine pertaining to infrastructure. Although infrastructure has a broader definition in some contexts, including industries and institutions, the focus of this work is on the physical infrastructure—the facilities, airfield pavement, and utilities that are integral components of mission success.

Infrastructure and Airpower—Historical Linkages

Although air bases looked much different in the early days of aviation than they do today, aviation pioneers recognized the importance of air base infrastructure to successful air operations. Airpower's reliance on physical infrastructure preceded the first powered flight. Photographs of the Wright brothers' first powered flights in December 1903 depict the Wright Flyer taking off from the first runway, a wooden monorail track, rather than asphalt or concrete-like modern runways. Given the modern reliance on concrete and asphalt runways, it is appropriate that this first flight launched from something other than an unimproved field or the bare sand at Kitty Hawk. The brothers' early photos also show two wooden buildings—the first aircraft maintenance shop and support building.

Likewise, in the first operational deployment of airpower, Maj Benjamin Foulois led the 1st Aero Squadron to support Brig Gen John J. Pershing's mission to locate and apprehend Pancho Villa in 1915. Operating from Columbus, New Mexico, the squadron conducted 548 flights.[3] Through the course of the mission, Major Foulois learned the seemingly obvious fact that air operations are inherently dependent on fixed bases when he remarked that "one or more aero squadrons operating in the field should have a base, conveniently located, from which all supplies, material, and personnel should be drawn."[4]

For many years, these first bases used grass fields or semiprepared strips since the combination of aircraft weight, tire pressure, and soil conditions required nothing more in the form of a runway. As aircraft became more technologically sophisticated and increased in weight, and the military leaders employing them demanded all-weather operations, the requirements for preparing runways and support facilities increased. The "airdrome" environment gradually evolved to a full-fledged air base with the standard training airfield design in World War I, consisting of 50 buildings to support 100 aircraft, 150 student pilots, and their instructors.[5]

Gen Henry H. "Hap" Arnold recognized the growing importance of the installation when he stated in 1941 that "air bases are a determining factor in the success of air operations. The two-legged stool of men and planes would topple over without this equally important third leg."[6] Campaigns in both Europe and the Pacific during World War II illustrated the importance of basing infrastructure. At the time, the Army Air Corps included more than 120,000 aviation engineers who built, improved, maintained, and operated airfield infrastructure. Aviation engineers from the IX Engineer Command constructed and opened the first landing strip on Utah Beach approximately 15 hours after the beginning of the D-Day invasion. What followed was best summarized by an aviation officer as he briefed the 834th Engineer Battalion: "you engineers have the vital job of paving the way for the air cover to back us up all the way to Berlin. Each base you build will be a steppingstone toward victory because the faster you move and work, the faster 'the air' moves and gets at the enemy—up close where it counts."[7] By V-E Day on 8 May 1945, the IX Engineer Command built or refurbished 241 airfields in France, Belgium, Holland, Luxembourg, and Germany with a peak production of opening a new airfield every 36 hours. In total, engineers built, improved, or maintained 1,435 airfields for the Army Air Forces in 67 countries during World War II.[8]

The end of World War II saw a significant reduction in the number of installations and infrastructure. The reduction in conventional capabilities was short-lived as the Cold War required the development of the nation's nuclear capability, along with infrastructure investment and expansion to support those new capabilities. The inventory of Air Force facilities grew from $3.1 billion in 1950 to $8.9 billion in 1958—an increase of approximately $51 billion in 2020 dollars in just eight years.[9] Despite this investment, Gen Curtis LeMay testified to Congress in 1956 that "the building of bases has lagged behind the production of airplanes to form wings; this has resulted in a shortage of bases and a crowding up of units and aircraft on bases."[10] LeMay and then Chief of Staff of the Air Force (CSAF) Gen Nathan Twining feared that overcrowding at installations provided the Soviet Union with easy targets and sought to disperse aircraft at new installations.

The Vietnam conflict required contingency buildups and bed-downs as the Department of Defense (DOD) executed what some have called the "largest military construction project in history" that entailed the construction of six new airfields in Vietnam, adding six more in Thailand, enlarging two French-constructed airfields, and constructing 100 smaller airfields and landing sites for helicopters and smaller aircraft, along with new ports and roads, around South Vietnam.[11] The DOD created Prime Base Engineer Emergency Force and Rapid Engineer Deployable Heavy Operational Repair Squadron Engineers units to

construct, operate, and maintain air installations with as many as 55,000 military engineers from all services present in Vietnam.[12]

The 1990 buildup to the Gulf War saw aircraft deployment to numerous locations in the Persian Gulf region. Perhaps the most important contribution pertaining to infrastructure and warfare came from the perspective of targeting the enemy's infrastructure as CNN and other news outlets played clips of precision munitions destroying Iraqi infrastructure with pinpoint accuracy. Although adversaries targeted infrastructure in conflicts dating back hundreds, if not thousands, of years, precision-guided munitions and the targeting strategy in Col John Warden's concentric ring theory made this historical period significant. In Warden's theory, physical infrastructure is a key component of the enemy's system as the third most critical ring, along with leadership, organic essentials, the population, and the fielded military.[13] Warden demonstrated that, in addition to understanding how protection of our critical infrastructure is a key component to sustain our mission, it is equally important to understand how disrupting the enemy's infrastructure can affect their ability to govern and wage war.

The end of the Cold War and drawdown after the 1991 Gulf War brought a reduction in budgets, force structure, and personnel. The inextricable linkage between infrastructure and force structure became readily apparent through the Base Realignment and Closure rounds in 1988, 1991, 1993, 1995, and 2005 as basing and infrastructure were reduced in accordance with the reductions in both personnel and weapons systems.[14] Since the end of the Gulf War, the Air Force had 60 percent fewer fighter squadrons and 40 percent fewer Airmen but surprisingly only 15 percent fewer CONUS installations with a current estimate of 24 percent excess infrastructure capacity.[15] Considering the Government Accountability Office has rated DOD support infrastructure management as "high-risk" since 1997, this complicates leaders' decision-making process when determining how to allocate precious resources among research and development of new capabilities, current operational capability, quality-of-life improvements, and infrastructure investment.[16]

Infrastructure and Current Doctrine

This brief historical review demonstrates the reliance of United States Air Force (USAF) combat power on the air base and the physical infrastructure it contains. Further, it underscores a fundamental tenant of Air Force doctrine that "[a]irpower results from the effective integration of capabilities, people, weapons, *bases, logistics, and all supporting infrastructure*."[17] Without the public and private infrastructure on both sides of the air base fence-line, the traditional weapons systems (e.g., aircraft, intercontinental ballistic missiles, satellites, etc.) are ineffective—airplanes need a runway and satellite control requires reliable power. Cyber and remotely piloted

aircraft (RPA) operations require facilities with resilient and reliable building systems (e.g., air conditioning to keep servers from overheating and reliable backup power). Airmen and space professionals operating across all domains require the services that physical infrastructure provides, such as clean drinking water, adequate sanitation, and suitable housing, whether at home station or deployed. All these infrastructure components are integrally linked to successful mission execution.

Air Force Basic Doctrine Volume 1 further states that "supporting bases with their people, systems, and facilities are essential to the launch, recovery, and sustainment of Air Force forces. . . the availability and operability of suitable bases can be the dominant factor in employment planning and execution."[18] Former CSAF Gen David Goldfein summarized this point succinctly when he stated, "we don't project power without the network of bases and infrastructure needed to execute multidomain operations."[19]

The 2018 *National Defense Strategy* (*NDS*) summary also makes it clear that air superiority is not an inherent right that US forces will always enjoy and that there are no sanctuaries from enemy attack. The future employment of airpower will require sufficient air base defense capabilities to protect the aircraft, people, and infrastructure therein, and may require "smaller, dispersed, resilient, adaptive basing that include active and passive defenses."[20] Recent publications have noted that air base defense can easily "fall between the cracks" between the Air Force, Army, and host nation support, leading to potential vulnerabilities to the mission, and that the base itself may be an "Achilles heel,"[21] as current doctrine fails to give requisite attention to the importance of the air base in airpower employment. Operations planning doctrine reinforces that developed basing infrastructure is a concern, particularly during contingency operations. Recently released doctrine on Joint All-Domain Operations states that operational units may not be able to rely on the level of infrastructure support that they enjoyed in recent history while directing units to question assumptions about the availability of logistics and infrastructure support.[22]

A careful reading of the *National Security Strategy* (*NSS*) and *NDS* summary reveals several important themes pertaining to physical infrastructure:

- The protection, resilience, and security of US critical infrastructure
- The use of infrastructure for malicious purposes by transnational criminal organizations
- Quality infrastructure as a mechanism to stimulate the US economic power
- Modernizing key defense infrastructure, particularly nuclear infrastructure
- Infrastructure investment by China and Russia across the globe to expand influence over other governments and gain access to natural resources

As shown in figure 1, the word *infrastructure* appears in these documents as often, if not more, than other terms commonly recognized as vital to the USAF and USSF missions—for example, nuclear, cyber, and space, as well as emerging technologies such as artificial intelligence and hypersonics. Further, energy is a fundamental component of infrastructure and a key theme in these documents.

Based on the foundation in the *NSS* and *NDS*, the Infrastructure Investment Strategy describes a strategic commitment to manage USAF infrastructure better and to fund it appropriately at an annual minimum of 2 percent of the plant replacement value, the capital cost in present dollars to replace the USAF's physical infrastructure.[23]

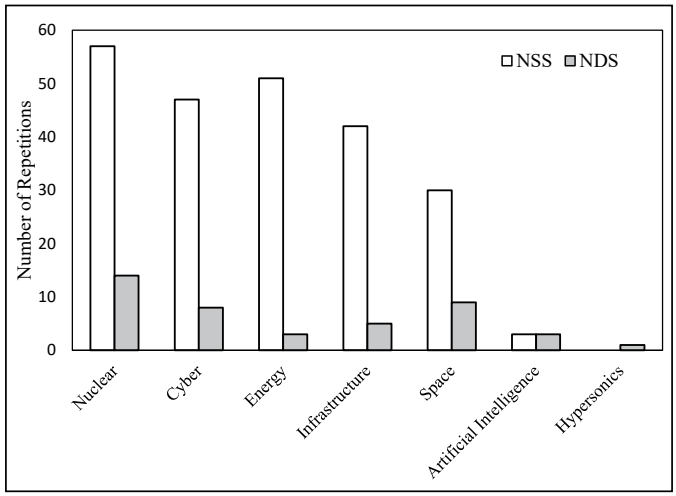

Figure 1. Repetitions of keywords in the 2017 *National Security Strategy* and 2018 *National Defense Strategy* Summary

Sources: *NDS* and *NSS*

Infrastructure Truths

Physical infrastructure will continue to play an ever more important role due to the increasingly complex requirements of current and future weapons systems and the reliance of these weapons systems on an infrastructure backbone of support. As such, it is helpful to have a common understanding of the role that infrastructure plays in executing air, space, and cyberspace operations. The special operations community defines five special operations force (SOF) truths to help military and civilian leaders understand the differences in employing SOF compared to conventional forces. As an analog, the following five "infrastructure truths" are proposed to develop a common understanding of infrastructure as a critical component of the mission and communicate the role that infrastructure plays in the Air and Space Forces' multidomain mission. Figure 2 shows the five infrastructure

truths, along with a brief description of each. The subsections that follow define each truth in further detail.

INFRASTRUCTURE TRUTHS

1. **Infrastructure is an integral component of air, space, and cyber operations.**
   Based on the lessons of history and the guidance of current doctrine, physical infrastructure inside and outside the air base fence-line is an integral component of success in air, space, and cyberspace.
2. **Quality infrastructure requires investment.**
   Quality infrastructure that enables the mission requires time and money to build, maintain, and protect.
3. **Critical infrastructure systems must be sustainable and resilient.**
   Infrastructure is a network of systems that must be sustainable and resilient, as problems at one node of the system can cause cascading effects elsewhere.
4. **Neglecting infrastructure puts the mission at risk.**
   If the infrastructure fails, the mission fails…and costs to repair and maintain physical infrastructure only compound with time.
5. **Infrastructure is for all leaders.**
   All leaders must be aware of the status and capabilities of infrastructure systems within their span of control, from military family housing to runways, maintenance facilities, and operations centers.

Figure 2. Infrastructure truths

1. Infrastructure Is an Integral Component of Air, Space, and Cyber Operations.

This statement naturally follows from the historical review of infrastructure and airpower, and the current doctrine outlined previously. The Air Force Infrastructure Investment Strategy begins: "Installations—both enduring and expeditionary—are foundational platforms from which the Air Force successfully executes its five core missions–air and space superiority; intelligence, surveillance, and reconnaissance (ISR); rapid global mobility; global strike; and command and control."[24] Put simply: without reliable infrastructure, our squadrons and wings cannot deliver the readiness or combat power that our nation requires.

Further, airpower is inherently different than combat operations on the ground or at sea due to the shorter duration that aircraft can be self-sustaining compared to Army mechanized or infantry units and Navy ships. Even with the benefit of aerial refueling, the time aircraft remain aloft is measured in minutes and hours compared to the weeks or months a nuclear-powered ship can remain at sea. Most weapons systems require air base infrastructure within close proximity to the mission objective and "up close where it counts," in the words of the World War II

briefing officer. In the case of manned and unmanned ISR platforms, the closer the better since finite fuel capacity makes the time-on-target inversely proportional to the transit time between the installation and the objective.

Although this historical review focuses primarily on airpower, reliable infrastructure is equally vital, if not more so, to space and cyber operations. Control of satellites and execution of offensive and defensive cyber operations require a network of military, public, and private systems. These systems must have highly reliable power and cooling systems, uninterrupted satellite and fiber-optic relays, and many other physical infrastructure components. The vast majority of these systems require redundancy for backup because a downtime of even a few seconds or minutes can be detrimental to mission success, which is one reason for executing "black-start" exercises emphasizing continuity of operations during outages.[25]

2. Quality Infrastructure Requires Investment.

Physical infrastructure that provides the robustness, redundancy, and reliability to execute the mission demands significant time, money, and effort to create and maintain. In short, managing infrastructure is resource-intensive and requires continued investment over time. Physical infrastructure systems consist of large-scale components made of steel, concrete, wood, copper, and custom-designed materials that require significant effort to design, install, and maintain. Technological advances that reduce the size of aerospace applications or computing power do not necessarily transfer to the built environment. In fact, advancements in air, space, and cyber platforms often drive the need for greater physical infrastructure, not less, as evidenced by the growing air base infrastructure support requirements described in the historical review.

Furthermore, physical infrastructure systems, such as runways or command centers, are typically designed for a 50-year lifespan to minimize life cycle and recapitalization costs. In most cases, providing these systems for this life span, at the level of service that the mission demands, is costly. The construction industry has long recognized the "iron triangle" of time, quality, and cost for physical infrastructure systems.[26] A benefit in one component comes at the expense of the others. For example, hastily constructed infrastructure may come with a less-expensive price tag, but quality is typically sacrificed in the process. The same is true for long-term infrastructure maintenance, as providing quality infrastructure requires adequate investment over a system's entire life cycle.

Another reason physical infrastructure is resource-intensive is due to the design-once, build-once nature of construction. Unlike the manufacturing industry that produces aircraft parts—for example, where a single product can be designed once, tested, refined, and produced thousands or millions of times—each

construction project is unique; it is designed once and then built once. Even with Air Force initiatives on standardized facility designs or standardized equipment, these "off-the-shelf" solutions still require engineered site adaptation and locally or regionally sourced construction crews each time they are built.[27]

Physical infrastructure is also highly regulated and involves compliance with numerous laws such as the National Environmental Policy Act, the Federal Acquisition Regulation, minor construction limits established in the National Defense Authorization Act, host nation requirements for overseas locations, and State Historic Preservation Office regulations at US installations. In a perfect scenario, leaders can incorporate these requirements into infrastructure project planning. Still these regulatory components often end up on the critical path of project completion, particularly when a project requirement arises on short notice, as in a contingency environment or an unforeseen surge requirement at the home station.

3. Critical Infrastructure Systems Must Be Sustainable and Resilient.

The term *critical infrastructure* was first defined in 1996 with Executive Order 13010,[28] and the term came into vogue after 9/11 with the recognition that our nation's critical infrastructure was vulnerable to attack from terrorist organizations. Such attacks could have a debilitating effect on our national defense and economic well-being. The United States established the critical infrastructure program through several additional legislative acts and Presidential directives (e.g., the Critical Infrastructures Protection Act of 2001 and Homeland Security Presidential Directive 7).[29] DOD Directive 3020.40 defines *infrastructure* as "the framework of interdependent physical and cyber-based systems comprising identifiable industries, institutions (including people and procedures), and distribution capabilities that provide a reliable flow of products and services essential to the defense and economic security of the United States, to the smooth function of government at all levels, and to society as a whole."[30]

The focus on infrastructure protection eventually broadened into the need for sustainability and resilience of physical infrastructure. Sustainable development entails meeting today's needs without compromising future needs.[31] Specifically for the USAF and USSF, this entails managing physical infrastructure in a way that meets the current mission without risking the mission in the future. Examples of this might include efficient use of water at Cannon AFB, New Mexico) to preserve the Ogallala Aquifer as a viable water source for the installation or the use of renewable energy sources to minimize the risk of a blackout.

Resilient infrastructure refers to infrastructure that can withstand a disturbance and still maintain its function and capacity. An example of this might be backup

generators in combination with an uninterruptible power supply at an RPA operations center. The concept of resilience entails risk management and acknowledges the technical and financial inability to protect all critical infrastructure against all threats.

Critical infrastructure resilience includes defending against enemy attacks in a national defense context, whether kinetic or nonkinetic cyber attacks. As stated earlier, this includes homeland installations. Although homeland air bases have largely been safe from aerial attack since Pearl Harbor, many of our expeditionary air bases in Iraq and Afghanistan have consistently been subject to indirect fire and more coordinated attacks such as the January 2020 Iranian missile attack on US personnel at Iraqi air bases. In addition to targeting personnel or aircraft, these attacks often affect air base infrastructure with lasting adverse effects to the mission, consistent with Warden's view of the enemy as a system and physical infrastructure being a critical component of that system.

"Attacks" via accidents and natural disasters can also limit the capability of infrastructure and, therefore, of mission accomplishment. Consider Hurricane Michael in 2018, which damaged F-22s housed in World War II-era hangars at Tyndall AFB, Florida, or the Joint Base Elmendorf-Richardson, Alaska earthquake in 2018, or Offutt AFB, Nebraska flooding in 2019, each of which resulted in degradation to the installations' respective missions. History shows that these are not anomalous events. A 1952 windstorm at Carswell AFB, Texas, damaged more than 70 B-36 Peacemakers and prompted Strategic Air Command Commander Gen Curtis LeMay to disperse aircraft to other sites. Homestead AFB, Florida, took direct hits from massive hurricanes in 1945 and 1992, causing years-long mission disruption in both cases and resulting in the redesignation of the base as an air reserve station.[32]

Furthermore, providing sustainable and resilient infrastructure systems is not simply about the ability to withstand large, one-time attacks or sudden shocks. It also includes "slow-onset impacts."[33] These could include the impact of routine weather or climate events, such as the impact of freeze and thaw cycles on building foundations, erosion caused by wind and rain, or corrosion caused by saltwater. It likewise extends to preparing our bases for the long-term effects of climate change, such as wildfires or flooding due to sea-level rise.[34] These slow-onset events are perhaps easier to ignore but can result in equally devastating mission impacts over the long-term.

Finally, providing reliable critical infrastructure requires partnership with other public and private entities. Many of our installations' utility services, such as electricity, natural gas, telecommunications, water, and wastewater services, are supplied from off-installation sources. As such, the mission infrastructure system is vulnerable to threats largely outside of the direct control of installation personnel. Consider an anecdote from one of the authors, whose base lost mission-critical

communications because a lawnmower cut a fiber-optic line located off the installation. Dealing with such vulnerabilities requires installation leaders to develop and maintain partnerships with the local community and consideration for on-base redundancy or backup capabilities when off-base sources fail.

4. Neglecting Infrastructure Puts the Mission at Risk.

Given its tie to the mission, its resource-intensive nature, and the requirement for resilience (truths 1–3), leaders cannot afford to neglect infrastructure investment. The Department of the Air Force (DAF) currently has a $33 billion backlog of infrastructure maintenance across its portfolio as the Air Force has taken a significant risk in deferred facility maintenance for the past several decades.[35] Annually, senior DAF leaders make difficult tradeoffs between new weapons systems, personnel costs, modernization, and other priorities. Each of these decisions carries its own risk, so communicating and understanding the infrastructure underinvestment risk to the mission is vital.

The principal of the time value of money dictates that a dollar wisely invested today yields better outcomes than the same dollar invested in the future. Delayed costs result in increased costs. Additionally, during that period of delay or neglect, infrastructure continues to degrade. Both effects, a dollar doing less in the future and infrastructure degrading with time, doubly compound the cost of repairs over time. Figure 3 provides a notional example of the additional costs incurred by delaying investment (e.g., delaying crack/joint sealing in a runway may result in a requirement for full-depth replacement of the pavement given its continued and accelerated deterioration over time). Degradation curves like the one in figure 3 were initially developed for pavement management, but the concept applies to other infrastructure systems as well. Note that failing to invest earlier in the life cycle of the system leads not only to more degradation but to more *rapid* degradation.[36]

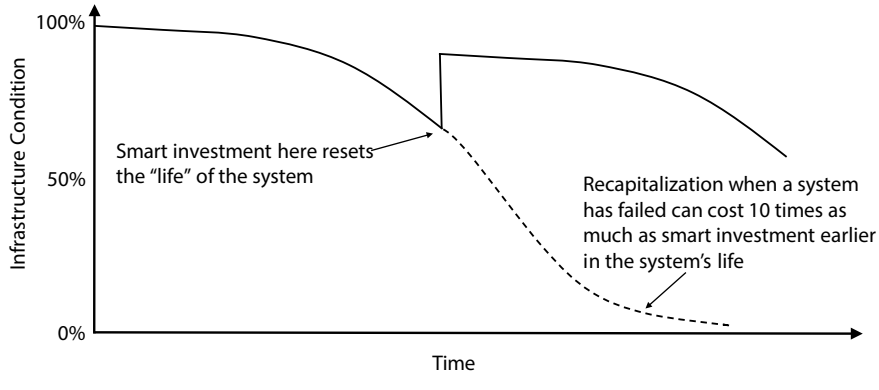

Figure 3. Infrastructure degradation with time showing the positive impact of timely maintenance and repair, along with the negative impacts of no investment

Historically, one of the challenges of infrastructure funding has been quantifying the risk of delaying infrastructure investment. Major weapon system program offices have done the research and maintained the documentation to determine when aircraft parts will fail.[37] This documentation enables an investment strategy and detailed life cycle maintenance plan to ensure the weapon system can continue to perform, in many cases beyond its originally intended life cycle. The data required to build failure-prediction algorithms are more easily obtained for mass-produced parts whose installation follows a well-documented technical order. In contrast, building systems are typically designed once and built once, as explained earlier, and are generally comprised of a nearly infinite number of components from a variety of manufacturers. Until recently, the Air Force had no such failure-prediction algorithms for built infrastructure. Without the historical asset management data that enables the ability to predict when a roof will leak, disable a critical server, a heating, ventilation, and air-conditioning system will malfunction, or runway concrete will spall, it becomes difficult to capture the risk of failure accurately.

Fortunately, in the last decade, Air Force civil engineers have improved their ability to quantify mission risk based on infrastructure requirements. The new approach implements asset management principles, including developing accurate inventories of infrastructure components at each installation down to the subfacility level (e.g., roofs, electrical systems, fire suppression, runway pavement, etc.); assessing the condition of each of these systems and components, and; forecasting, based on documentation and manufacturer recommendations when each system requires maintenance or replacement.[38] A second major development was implementing a risk assessment based on a facility's condition and its importance to the mission.[39] This assessment provides tools for leaders to plan maintenance, prioritize requirements, communicate risk, and advocate for investment. Figure 4 provides an example of these tools, showing current facility conditions and future conditions based on three different investment levels over a 30-year period. Facilities are shown by USAF MAJCOM and the USSF, with each pixel representing a facility. Green indicates a good "condition index" on a 0–100 scale, with yellow and red facilities having increasingly worse condition indices. Facilities with a higher mission dependency index (MDI)—a rating of the importance of the facility to mission execution—are on the left, with the lower MDI facilities on the right. Continuing to fund infrastructure investment at historical levels (figure 4b) is untenable, which is why the Infrastructure Investment Strategy commits to funding at a minimum of 2 percent of PRV. Even a modest increase of 0.3 percent PRV or an additional $350 million annually (figure 4d compared to 4c), results in a significant improvement in facility condition over the 30-year period. Based on the same database, the Air Force Installation and Mission Support Center

(AFIMSC) can also produce charts for the facilities at each installation or for the condition of a particular subfacility component (e.g., the condition of all runway pavement or roofs in the USAF and USSF).

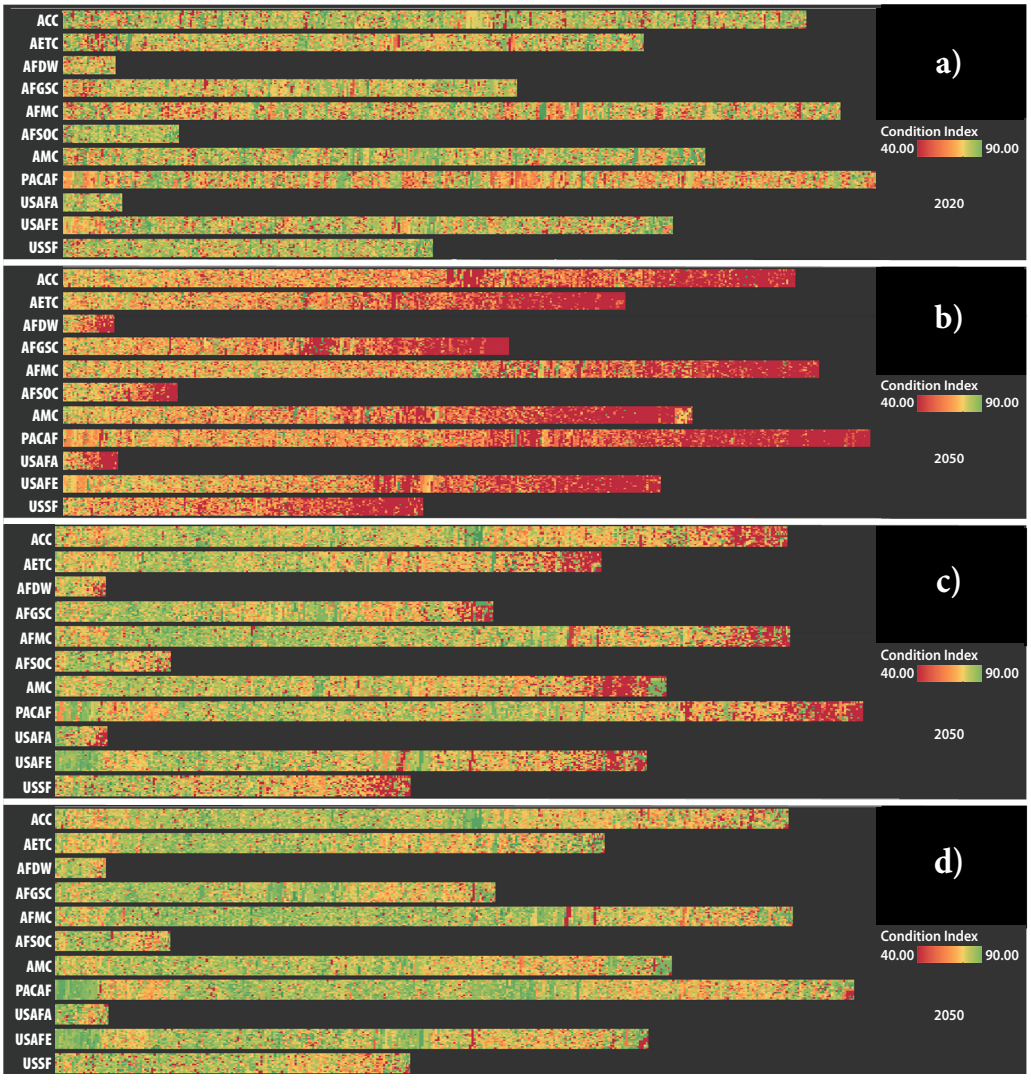

Figure 4. (a) The current condition of facilities by USAF MAJCOM and USSF, (b) condition of facilities in 2050 with pre-I2S funding, (c) condition of facilities in 2050 with an investment of 2.0 percent of PRV per year, and (d) condition of facilities in 2050 with an investment of 2.3 percent of PRV per year

Source: Figure courtesy of AFIMSC Expeditionary Support Directorate

Note: Since readers of the print edition will view figure 4 in black and white, and the authors refer to green, yellow, and red in the text, the lighter color (green in the online edition) indicates a good condition index on a 1-100 scale; darker colors (yellow and red online) refer to having increasingly worse condition indices.

5. Infrastructure Is for All Leaders.

Because of its essential role in executing the mission, infrastructure is a concern for every Air Force and Space Force leader.[40] The Air Force aircraft inventory has a replacement cost of $600 billion in 2018 dollars, and the plant replacement value of its facilities and utilities is $359 billion, which does not include the cost of its 8.5 million acres and the natural and cultural resources.[41] Thus, the value of the USAF's physical infrastructure is on the same order of magnitude as its aircraft—clearly, both natural and built infrastructure are valuable resources and important to executing the mission.

Because of the tendency to create functional stovepipes (e.g., the consolidation of infrastructure funding at AFIMSC), it could be tempting for MAJCOM staff officers, for example, to think that they can leave the infrastructure for AFIMSC or Air Force Civil Engineer Center to manage. Yet delivering and maintaining quality infrastructure requires support from a range of leaders at the wing, MAJCOM, and functional command levels. The installation commander makes most major infrastructure decisions at the installation level with informed support from various subordinates, only some of whom are technical experts. Commanders certainly have a diverse set of responsibilities, but a basic working knowledge of the requirements of infrastructure and investment can pay dividends in securing the future of the base's systems and in executing the mission within each commanders' span of control. A simple example might be educating the airfield owner (usually in an operations support squadron) of the need to shut down the airfield on occasion to perform needed repairs. On a larger scale, it may require cross-MAJCOM coordination to utilize resources when a critical facility is down for an extended period for repair or replacement. It may also include coordinating with civilian entities, such as the recent Offutt AFB runway replacement project, where installation leaders had to coordinate the transfer of operations to the municipal airport for up to a year. When an infrastructure issue arises, it is incumbent on leaders across functional areas to find a solution, up to and including our most senior leaders, as highlighted in the Service Secretaries and Chiefs' testimony to the Senate Armed Services Committee on military family housing problems.[42]

As noted earlier, infrastructure reductions have not paralleled the cuts in personnel and aircraft. The global coronavirus pandemic that started in 2019 may also provide an opportunity to reduce physical infrastructure needs. Although a reduction in operations and maintenance, command and control, or mission facilities is unlikely, there may be opportunities to reduce administrative spaces due to the anticipated increase in teleworking moving forward. Some have appropriately called for leaders to think differently about air bases to make them more

efficient and support multiple missions,[43] but the reality is that political ramifications are likely to limit the extent of future closures and consolidation if they happen. In the absence of future reductions, it is ever more likely that leaders will be forced to deal with difficult resource allocation decisions as the funding available is unlikely to maintain the portfolio of infrastructure at the quality that the mission requires. Such a condition requires all leaders to advocate for infrastructure funding and be cognizant of mission impacts due to infrastructure failures.

Conclusion

Given the lessons of history and current doctrine guidance, resilient air base infrastructure is an integral and inseparable component of air and space power. As the future of warfare evolves and new technologies emerge, infrastructure will only increase in importance as high-tech weapons systems require even more sophisticated and reliable physical infrastructure systems. Physical infrastructure requires significant investment in time and money to achieve the resiliency required for today's missions. The mission dependency and current state of infrastructure necessitate that all leaders be aware of the risk to mission associated with infrastructure failure. Leaders must also be prepared to advocate, along with functional experts, for the investment required to maintain the infrastructure within their span of control adequately. The infrastructure truths provide a succinct summary of the value of infrastructure to the mission and a framework of important considerations for decision-making. ✪

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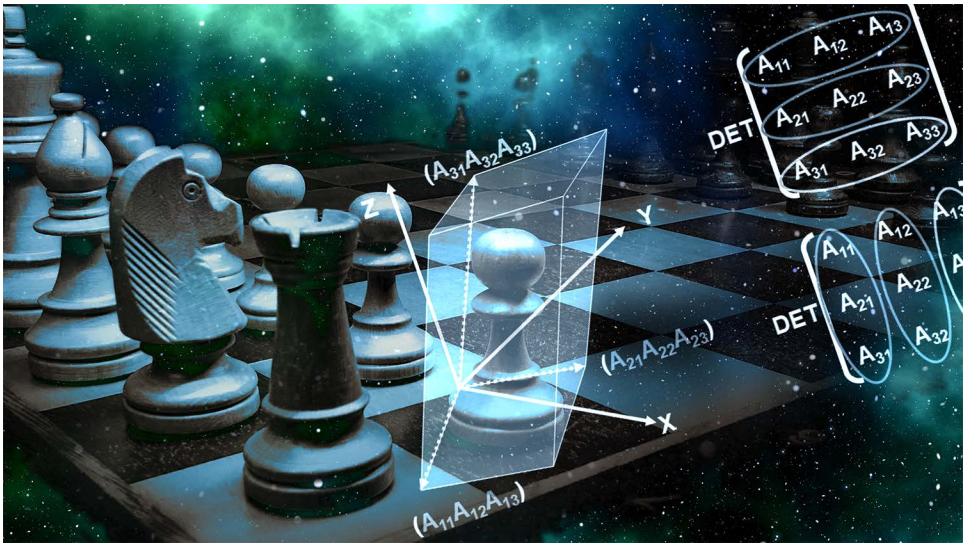
FEATURE

Media Interaction Warfare Theory

A Novel Analytic Process Supporting Space Warfare Planning Operations

Michael P. Scardera*
Dr. B. T. Cesul



Introduction

With the debate settled over whether space is a war-fighting domain and whether an independent space force should be established, the discussion now shifts toward providing analytic frameworks to answer more strategic questions about space warfare in general. Why do space forces matter? How do they integrate with war fighting in other domains? What is the "intellectual basis" for space superiority? What utility do space warfare capabilities bring to the joint military campaign, and at what levels are they necessary to achieve effects on the battlefield? These and many other questions have dogged the space community since the first militarily useful satellites were launched in the 1960s into the present. We describe a novel approach called the "media interaction theory of warfare," which

*The research, analysis, results, views, and opinions expressed in this article are those of the authors alone. The authors conducted this work independently of any affiliation. The work does not represent the official position of Millennium Space Systems, The Boeing Company, The Centauri Corporation, National Air and Space Intelligence Center, or any other entity.

provides a unique and simple way to evaluate different integrated force structures, offering a true joint forces perspective to begin addressing these questions while providing a basis for more analytic treatment.

Past military theorists were surveyed, providing a foundation for the premise behind media interaction warfare theory. From these past works, we construct a simple model containing interactions between different domain media. This construct leads to a media interaction matrix mathematical model based on linear algebra. This unique model development separates the analysis from previous work in the area. Based on an order of battle, an integrated force structure matrix can be built, and a determinant taken to provide a single value for the force structure's relative strength. This relative strength may, in turn, be compared to other very diverse force structures to find the dominating integrated armed force. The theory's implications and general ability to "unify" past military theories are briefly discussed. This media interaction warfare theory can validate or refute past ideas, and we focus on applying treatment to famous past airpower theory examples. We move on to illustrate an application to the joint air-sea-land battlespace with the World War II Guadalcanal campaign. Finally, we predict future applications with and without space warfare capabilities building a representative North Atlantic Treaty Organization (NATO)-Warsaw Pact conflict hypothetical scenario circa 1985.[1]

Past Military Theories of War: Background and Relevance

Reviewing famous military theorists' major works (fig. 1), they applied historical or rhetorical analysis in developing their ideas. Sun Tzu, Carl Von Clausewitz, Antoine-Henri Jomini, and B. H. Liddell Hart are among the best-known warfare theorists. Though these theorist's experiences and writings dealt with land warfare, many ideas, principles, and applications are generally applicable to all warfare media, whether on land, sea, air, or space. Sun Tzu pointed out the inherent differences between offense and defense. Meanwhile, Clausewitz discussed the asymmetry between offense and defense, elaborating with his "polarity" concept when applicable. Both Clausewitz and Jomini emphasized "geometric" principles. Liddell Hart emphasized indirect warfare, disrupting equilibrium, and combined arms operations warfare needs. However, these famous theorists generally did not consider how warfare might be affected by operations in media other than land. Understandably so, as their experiences were based on continental warfare, and the sea was not a significant player from their perspective.[2]

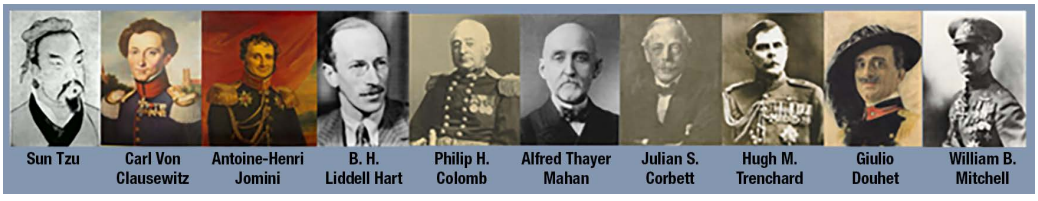


Figure 1. Famous military theorists based their ideas on experience, historical, and rhetorical analysis.

Sea power theory came into its own during the nineteenth century primarily through the works of Philip Colomb, Alfred Thayer Mahan, and Julian Corbett. "Command of the sea" is a common theme among these three theorists, though there are significant similarities and differences on what the theme meant and how command should be achieved. The sea power concept came to a powerfully heightened understanding during this era, maturing distinctly from military power with a significant effect on armed conflict. The first obvious principle states the sea is not a territory to be held like land, but a separate and distinct medium. Naval "lines of communications" was introduced by Colomb to address how sea control could be achieved. Mahan made an overwhelming argument sea control is essential for victory in warfare. Finally, Corbett made the sea power case encompass more than command of the sea but interactions with the land as well. Colomb was the first person to relate how interfaces between the land and the sea matter. He discussed how combined operations are superior to one force alone. Corbett echoed and expanded these ideas by pointing out the Army or Navy cannot win wars by themselves. Corbett also expanded Clausewitz's polarity concept to its necessary conclusion, defining offensive capability as a positive force and defense as an opposing negative force. Mahan expanded a strong case naval force's first objective is to defeat the enemy's naval force. Corbett takes a strategic naval view as one aspect of the entire war, where ultimately defeating the enemy's naval force may or may not be required to achieve sea control.[3]

Unlike land and naval power, airpower burst onto the scene in the early twentieth century, trying to justify itself as a real military capability relevant to the art of war. Airpower practitioners developed strategy, tactics, and operational art, while making the case air forces should rely on their professional corps. With airpower's global nature, overarching both land and sea, early airpower theorists presumed air control was a prerequisite to obtaining command of the sea or domination over the land. World War I provided an early incubator for airpower theories. Based on advocate observations, many theorists thought once air forces matured, they could win wars by airpower alone. Given the novel operations in the air medium, this idea was at least conceivable despite contradicting naval theorists' conclusions.

Hugh Trenchard, Giulio Douhet, and Billy Mitchell are the standout airpower theorists during this time. Trenchard was a tireless advocate who successfully created a separate air force in Great Britain during World War I. Like Mahan, he saw the Air Force's mission as the need to destroy the enemy's air forces. Similar to Corbett's sea power views, Trenchard saw air forces also applying to other missions.

Douhet is best known for his theories regarding offensive strategic bombing to be the sole air force purpose. His theories became very influential to all air forces before World War II. Generally, the offensive is paramount among all airpower advocates, whereas defense can be inherently found in the offensive. Both Trenchard and Mitchell had more multidimensional views about how airpower should support war fighting in total; they looked to bombing, interdiction, ground attack, observation, and supply as important roles to fulfill. Billy Mitchell gained fame in the US, conducting experiments to prove naval vessel vulnerability to airpower and notoriety when he was court-martialed for overzealous airpower advocacy. Clearly, airpower advocates saw air as its own war-fighting medium with dominating influences over the sea and the land media.[4]

Throughout the military theorists' history, there are many similarities and contradictions in their writings based upon the time, place, and experience upon which they have written and worked. General warfare principles have been developed and generally accepted. However, some common themes are represented briefly in table 1 that directly apply to formulating the media interaction hypothesis.

Major war theorists common themes	**Comments/examples**
Interactions within the media dominate	Army-Army contests dominate land warfare, Navy-Navy confrontation dominates naval warfare, and air-air combat dominates aerial warfare.
Each new medium has a dominating influence over the other media.	For the land warfare theorists, sea power was largely irrelevant and airpower largely unknown. Sea power theorists saw naval forces dominating the land once sea control has been gained and did not initially recognize airpower significance; airpower theorists believe air forces dominate both land and naval forces.
Interactions between media are important	Despite dominating influence applied to individual media, land in defending from seaborne attacks, sea into providing seaborne attacks at vulnerable locations, and air in attacking either the land or the sea. Combined operations are acknowledged as desirable.
New media greater mobility gives an initiative advantage.	Air forces are more mobile than sea forces, which are, in turn, more mobile than land forces. This mobility also provides an initiative advantage to the superior medium over the inferior medium.
Offense has a proactive aspect, while defense is retroactive.	General recognition offense and defense are different but can be described as opposing magnitudes as in a physical vector.
A geometric or mathematical construct is possible.	Many writers suggest a mathematical or geometric relationship could describe their ideas, but none are proposed.

Table 1. The commonality between land, naval, and airpower advocates and theorists presents applicable themes for a unified theory.

Media Interaction Warfare Theory Genesis

Figure 2 illustrates warfare evolution regarding land, sea, air, and space media, which portrays an obvious geometric growth in interactions. If a friendly and enemy side are considered for land warfare alone, there is only one interface or interaction. When sea power is included, possible interactions grow to four. Add airpower, and there are nine possible interactions. Finally, adding space forces creates 16 interactions.

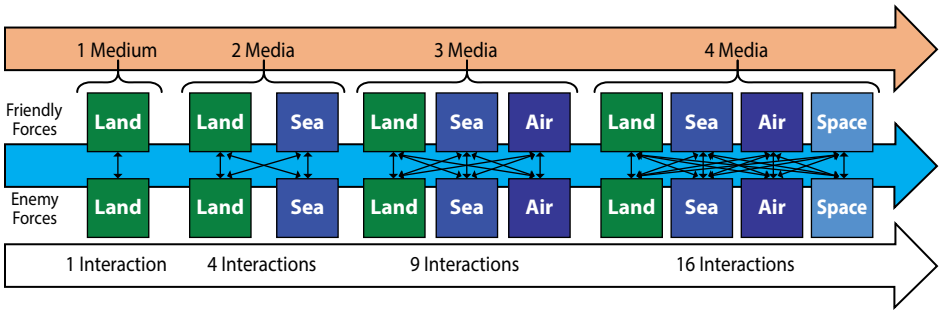


Figure 2. The number of interactions between opposing forces grows geometrically with additional media inclusion.

The progression shown in figure 2 clearly implies warfare complexity grows geometrically whenever a new medium is added to the mix. Looking at the interactions, the side dominating the greater number of interactions has a better chance winning a conflict. But looking at this construct with more scrutiny, one could surmise some interactions may be more dominant than other interactions. To make this construct useful, we need to convert this logical relationship into a useable mathematical construct. One simple idea models each individual interaction as a distinct entity. Applying this idea results in the matrix approach demonstrated in figure 3.

The first interaction modeled is land-to-land as a single block, the most important and fundamental baseline interaction. Controlling land and what occurs on land is the foundation for all warfare where everything ultimately begins and ends. Whatever other media is involved in warfare, the result always affects the people, economies, and other activities occurring on land. As civilizations evolved and the sea became important for commerce, naval power was born, and the interactions between the two media grew to four. When adding the sea medium, the sea-to-sea interaction is analogous to the land-to-land interaction. Additionally, we also include a sea-to-land offensive interaction and a land-to-sea defensive interaction.

Later, powered flight's invention introduced the third media, air, leading up to nine interactions in war. When adding the air medium, the air-to-air interaction is analogous to the land-to-land and sea-to-sea interactions. Expanding the ma-

trix previously constructed, air-to-sea and air-to-land offensive interactions, and a land-to-air and sea-to-air defensive interactions, fill in the interaction blocks to form a logical three by three matrix.

Long-range missile development and Sputnik's launch heralded a new medium for military operations. Further continuing the logic, the next step adds space interactions to the land, sea, and air interactions. When adding the space medium, the space-to-space interaction is analogous to the land-to-land, sea-to-sea, and air-to-air interactions. Adding to the matrix, space-to-air, space-to-sea, space-to-land offensive interactions and land-to-space, and sea-to-space and air-to-space defensive interactions fill in the interaction blocks to form a logical four by four matrix. Interactions between all other media continue to be conveniently addressed within this matrix. As media are added to the land-land base, the higher degree medium at each stage adds greater mobility to the forces involved. Also, the greater mobility creates more complexity resulting from the higher degree interactions at each stage.

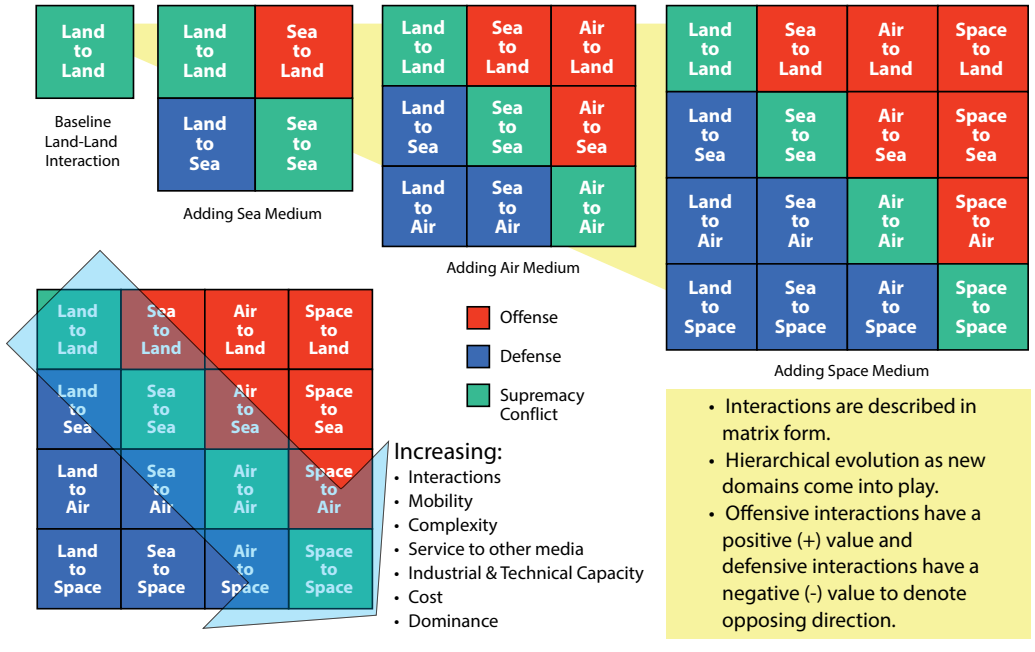


Figure 3. Media domain interaction warfare theory matrix evolution and general attributes

Corbett defines offensive forces as having a positive attribute and defensive forces as a countervailing opposite attribute, resulting in a direct counter for each other in tactical and operational scenarios. Similarly, this theory defines offensive interfaces as having a positive aspect and defensive interfaces with a negative aspect.

Assuming a mathematical/geometric construct, each box in the matrix can be represented by a number of relative merit, strength, or other relevant value for force structure denoted by the matrix location. These numeric values can be viewed as an n-degree vector on either the associated matrix's columns or rows. It should also be clear the medium matrix of degree (n) can be constructed, and this medium construct can be thought of as an "n-space" volume in a geometric sense.

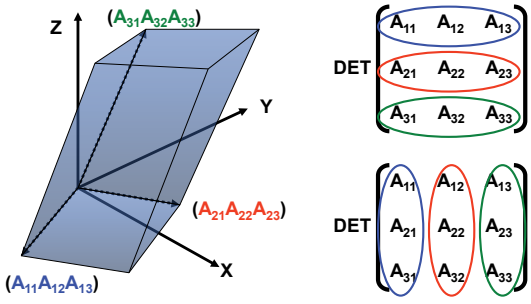


Figure 4. Determinants provide n-space volumes—matrix determinant equals parallelepiped volume in n-dimensional space.

One generally recognized method to calculate an n-space volume is to calculate a determinant. A determinant is used in matrix algebra, a higher order math, to determine a single matrix value. A determinant is calculated by a closed-form equation dependent on the matrix degree. Before modern times, matrix determinants have been considered "magical" by the mathematics community as they manifest many special properties, but they bear little more than a mention in modern matrix algebra books. The fact the determinant is a single-value matrix representation is most interesting. Vectors represent the n-dimensional volume "sides" as shown in figure 4. The main special property is the determinant is a linear function of the first row. Given "everything begins and ends on land," we can choose to make all other matrix values dependent upon defensive land operations or make all other matrix values dependent upon offensive land operations. Given offensive operations are inherently more mobile, and as a result, more dominant as matrix degree increases, we chose to make the matrix dependent on the offensive land vector.

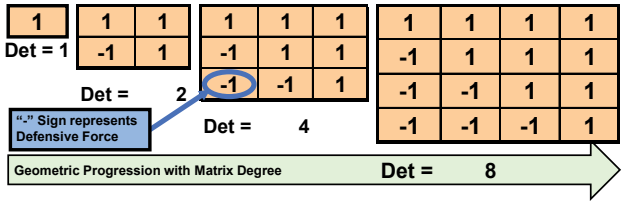


Figure 5. Using identity matrices for simplification, maximum relative interaction strength can be observed through each identity matrix's determinant for the degree medium involved.

For a simple illustration, unity matrices are used. A "1" or a "0" represents all or nothing. When using these identity matrices, we assume all other factors are, in fact, equal. A negative one, "-1," represents a defensive force, while a positive one, "1," represents an equal strength offensive force. Under this construct, the land-land force determinant is "1." The fully populated land-sea matrix determinant is "2." The fully populated land-sea-air matrix determinant is "4," and the fully populated land-sea-air-space matrix determinant is "8." This treatment validates and quantifies the intuitive idea the higher degree force structure is stronger than the lower degree force structure. Everything else being equal, a land-sea force is twice as strong as a land force. A land-sea-air force is twice as strong as a land-sea force, and a land-sea-air-space force is twice as strong as a land-sea-air force (See fig. 5).

Several implications become evident from this mathematical construct and may become axioms with respect to applying this approach to military theories. First: the best way to defeat a force within a certain medium is by a force in that same medium—that is, land forces are best to defeat land forces, naval forces are best to defeat naval forces, air forces are best to defeat air forces, and space forces are best able to defeat space forces. This matrix theory attribute justifies the ideas over the ages of military domination, command of the sea, air superiority, and space superiority discussed by many military theorists. Second: a land force alone cannot defeat a naval force. Third: a land and sea force alone together cannot defeat an air force. Finally, a land, sea, and air force alone cannot defeat a space force. These rules apply whether dealing solely with the direct medium interactions or with all interactions within the same degree. This rule set applies since the superior degree media is always more mobile in space and time, allowing access to potential weak spots. Some observers will point out apparent violations where a an inferior media force defeated a sea or air attack. Certainly, local attacks can be defeated. This series of axioms apply in the general sense when all else is equal. As a corollary, where lower degree media cannot defeat higher-degree media, the inverse is true where higher-degree media can defeat lower-degree media forces. Naval forces can defeat land forces, air forces can defeat naval and land forces, and space forces can defeat land, sea, and air forces. Just because they can doesn't necessarily mean they do for many reasons. Again, that is situational, whereas if all other factors are equal, the higher-degree media forces have an inherent advantage over the lower-degree media. These media interaction theory axioms may be summarized:

- The best way to defeat a force is with a force in the same medium.
- An inferior medium force cannot defeat a superior medium force.
- A superior medium force can defeat an inferior medium force.

Another axiom following from media interaction theory is general superiority in any given medium cannot be achieved unless superiority in all higher media has been achieved. Figure 6 shows a cascading relationship between media: space superiority must be achieved before air superiority is achieved, air superiority must be achieved before command of the sea is achieved, and command of the sea is necessary before land domination is possible. This relationship is predicated on all media (domains) being involved, (one can argue a military scenario involving a landlocked area, sea power is significantly diminished in importance). With that said, it doesn't mean there's a temporal relationship where one superiority level has to precede the next superiority level before the following occurs, although there's some history to that flow. As superiority contests will be occurring in all warfare media simultaneously, all this axiom says is superiority in an inferior medium cannot occur until superiority in all higher-degree media has been achieved. It is conceivable superiority in all media could occur simultaneously in an all-out struggle.

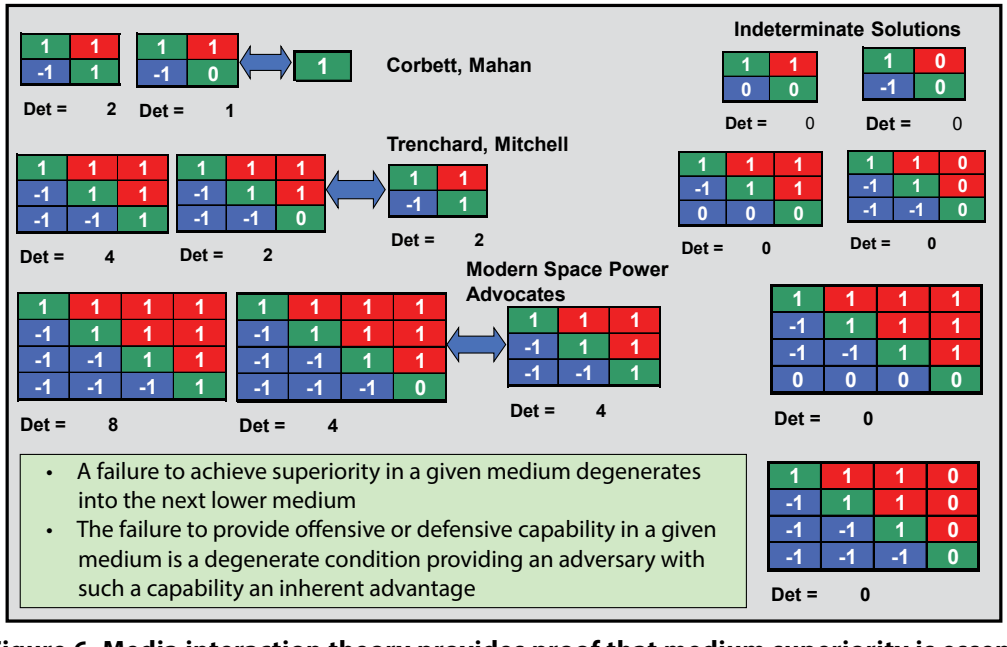


Figure 6. Media interaction theory provides proof that medium superiority is essential in multidomain conflict.

The matrix can be filled out with an infinite range of values, grounded in reality to provide rationally intuitive and nonintuitive results. An infinite variety of possible force structures can be evaluated. However, unless the matrix produces an indeterminate (zero) solution or is fully populated at the maximum values, it is very much possible to have two or more widely different force structures with

essentially the same overall capabilities or alternatively having force structures convention says should be equivalent but are widely disparate in their capability.

Two additional general rules can be stated with the regards to meet superiority in a given medium:

- A failure to achieve superiority in a given medium degenerates into the next lower medium.
- The failure to provide offensive or defensive capability in a given medium is a degenerate condition providing an adversary with superior capability an inherent advantage.

This point is applied to the condition when one combatant has the capability and the other doesn't, whether by intent, design or through loss. These rules apply when a new medium is added to the mix.

Applying Media Interaction Warfare to Military Theories (Classical Air and Contemporary Space Power)

The media interaction theory supports or refutes past military theorists and how general characteristics and rules may be divined from the theory. Applying the theory to airpower, Hugh Trenchard and Billy Mitchell advocated the need to win and maintain air superiority early into World War I. Both officers also supported a broad airpower capability mix. In a land-sea-air media matrix, as shown in figure 7, if the capability to achieve and maintain air superiority is missing, all else being equal even with rudimentary offensive and defensive capabilities, the force structure is not any more powerful than a simple land-sea matrix. Therefore, at the simplest level, Trenchard and Mitchell were right in their theories, and in the purest form, their theories expanded upon the sea power theorists.

One airpower theorist, Giulio Douhet, was mistaken in one of his main ideas. Using the media interaction theory to evaluate and examine his premise, only offensive airpower matters, and bombers alone were the superior force. As stated previously, without air-air superiority, the land-sea-air matrix degenerates in capability to half its full potential.

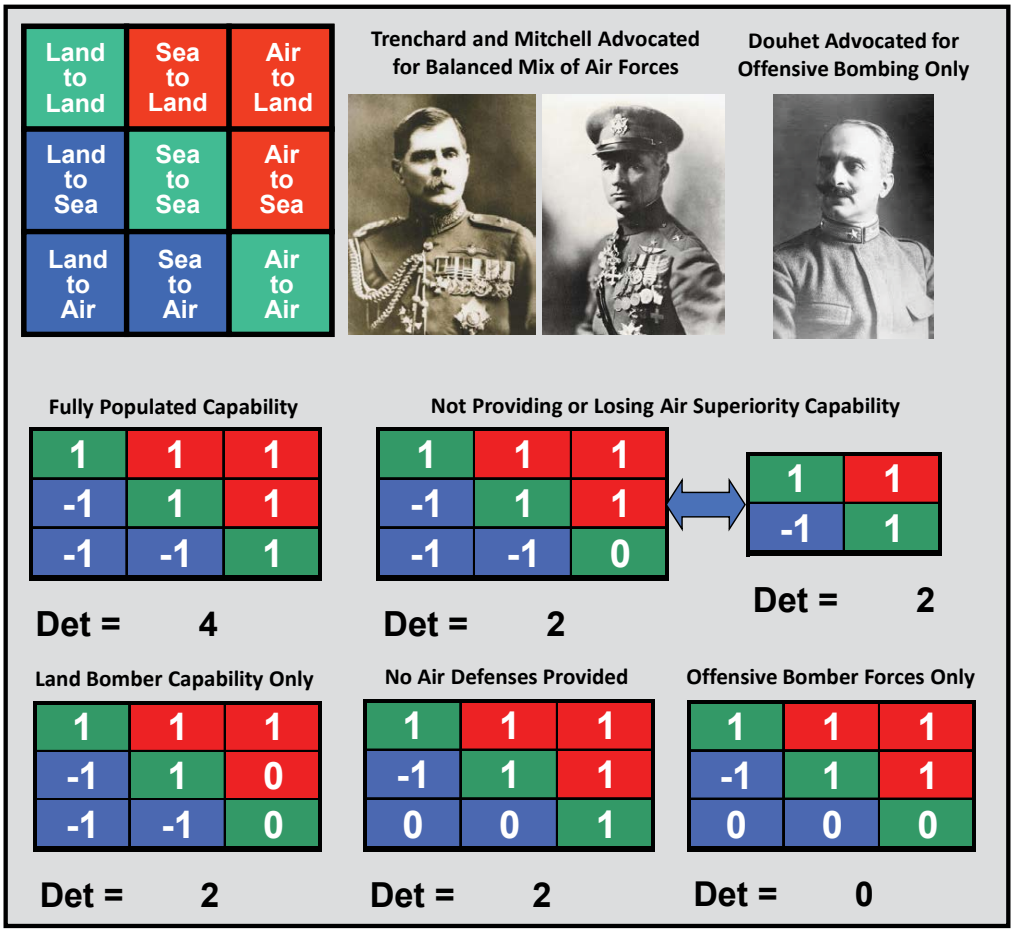


Figure 7. Trenchard and Mitchell were right, Douhet was wrong: air-air superiority is essential, air offense alone is disadvantageous, and neglecting air defense completely is an indeterminate condition. You must have air superiority to win.

This point alone should refute Douhet, but eliminating defensive air forces also degenerates to half the capability. Removing offensive airpower except for land-ground forces likewise degenerates to half power. Eliminating all defensive airpower, including air-air, is a degenerate case. Airpower, to be effective, must have the ability to achieve and maintain air superiority and must have integrated offensive and defensive capabilities; otherwise, there is probably no utility to having air forces at all.

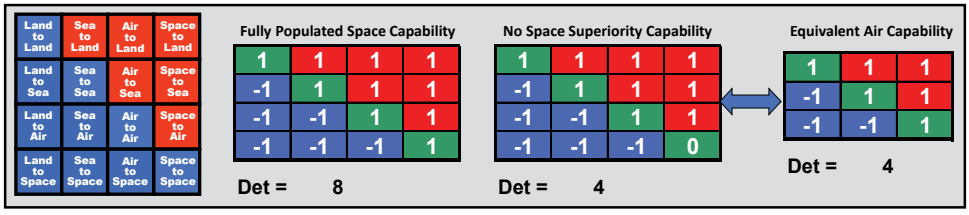


Figure 8. Media interaction theory applied to space power. Space as "the ultimate high ground" is a valid concept, and space superiority is essential to achieve superiority in other media.

Analogous to the land-sea and the land-sea-air matrices, the land-sea-air-space matrix likewise shows space superiority as essential. Without space superiority, the land-sea-air-space matrix has the same value as a fully populated land-sea-air matrix. The land-sea-air-space matrix is indeterminate without offensive or defensive space capabilities. There's common wisdom existing today only defensive counterspace is either necessary or less expensive. This common wisdom is wrong. Just as with air forces, an integrated force structure is necessary in the space medium for military effectiveness. In this modern age, space superiority is absolutely essential if superiority in any other media is to be achieved. The space power advocates who have claimed space as the ultimate high ground are essentially correct. Now, how to achieve offensive space capability and what capabilities cobble together to form an offensive strength in the space medium is a matter of debate. Space offensive strength can be achieved via other media (i.e., ground-based satellite jammers [offensive land-space] stationed on the land media, but the effect is on the space media)—one factor making space superiority analysis more complex than other media.

Since space power does not truly exist today, it's a good idea to make some predictions based upon the matrix theory to provide fodder for future verification. The first prediction has already been stated and is evident: the best way to achieve space superiority is with space-space capability (see fig. 8). Several obvious corollaries, such as how negating an enemy's space activities, are best done from space. Other predictions are illustrated in figure 9. From a defensive point of view, perfect space-space and air-space capabilities would mitigate the need for land-space and sea-space defenses, with all else being equal. In the real world, this prediction really states space-space and air-to-space defenses are far more important than land-space and sea-to-space defenses. This prediction does not consider actual strategic, tactical, and defense in-depth needs.

Similarly, from an offensive point of view, with all else being equal, perfect space-space and space-to-land capabilities produce no need for either space-sea or space-air capabilities. Given the "everything begins and ends on land" axiom, this observation makes intuitive sense. These predictions are the tip of the iceberg.

We could make many more explicit and implicit predictions based on applying different values to the media interaction theory matrices shown.

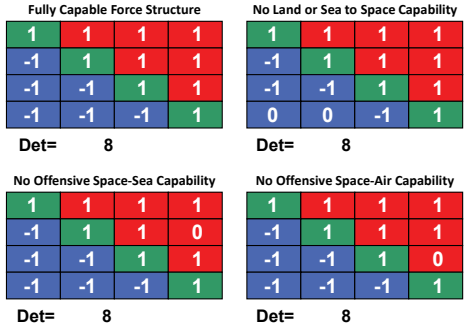


Figure 9. A sampling of media interaction warfare theory idealistic predictions for space power applications

Applying Media Interaction Theory to a Historical Campaign (Guadalcanal in World War II)

We applied this method to several historical battles and found consistency with the history in the cases studied. For this article, we chose to illustrate the Guadalcanal campaign in early World War II as a combined force example of land, sea, and air forces—*a priori*, it is not evident which side had the superior overall force structure. In World War II, the 1942–43 Guadalcanal campaign was the first American offensive in the Pacific Theater. Possessing Guadalcanal was an important contest as the island was strategically located for both sides in the Pacific Theater. The Japanese were endeavoring to cut off sea lanes between America and Australia while the Allies needed to protect those sea lanes to build-up their forces in Australia.[5]

Dates	Battle/Situation	Victor
7 August 1942	American Marines land on Guadalcanal, Tulagi, and Gavutu-Tanambogo. Unopposed on Guadalcanal	American
8 August 1942	Marines secure airfield and name Henderson Field	American
9 August 1942	Japanese naval force defeats allied naval force at battle of Savo island—Allied fleet withdraws	Japanese
18 August 1942	Japanese land reinforcements on Guadalcanal	Japanese
20 August 1942	19 fighters and 12 dive bombers arrive at Henderson Field	American
21 August 1942	Battle of the Tenaru	American
24 August 1942	Naval Battle of the Eastern Solomons	American
12 September 1942	Battle of Edsons's Ridge, near Henderson Field	American
24–27 September and 6–9 October 1942	Battles of the Matanikau	American
11 October 1942	Naval Battle of Cape Esperence	American

Table 2 (*continued*).

Dates	Battle/Situation	Victor
14 October 1942	Japanese battleships bombard Guadalcanal	Japanese
24 October 1942	Battle for Henderson Field, American Victory	American
26 October 1942	Naval Battle of the Santa Cruz Islands	Japanese
13 November 1942	Naval Battle of Guadalcanal	Japanese (Tactical) American (Strategic)
30 November 1942	Naval Battle of Tassafaronga	Japanese
18 December 1942– 4 January 1943 and 10–23 January 1943	Allied land offensives	American
14 January– 7 February 1943	Japanese evacuation operations	American

Table 2. Guadalcanal campaign summary. Land, sea, and air were all closely contested.

The American landings came as a complete surprise to the Japanese. There were numerous ensuing land, sea, and air battles. Several significant land battles occurred temporally close to large sea battles, and air superiority was contested throughout the campaign. In the end, the island and its environs were contested over approximately seven months with America and its allies victorious when the Japanese evacuated the islands. Table 2 summarizes the actual Guadalcanal campaign history. Studied and evaluated in many ways over the years, the Guadalcanal campaign was unique for including land, sea, and air forces in a sufficiently small microcosm whereby evaluation using this media theory is relatively simple and straightforward.

The Guadalcanal campaign had relatively well defined geographic "lines" which acts as a control boundary—forces inside the boundary are considered relevant to the campaign, and forces outside the boundary effectively did not contribute. The campaign had force structure elements engaged which fully populates the media theory force matrix structure. In World War II, the air, sea, and land battles around Guadalcanal were not effectively or intentionally coordinated. However, they were still integrated land, sea, and air forces by default, all contributing to the outcome. The fight over Guadalcanal can be summed up as an attrition battle between two opposing forces over several months. As such, the total force structure certainly matters, and the ability to assess and compare different force structures effectively would be very useful and insightful.

Media theory application can be summarized with a general process. There are three primary steps in applying media theory to determine relative force structure comparisons. The first step is the necessary research to develop an order of battle. The second step is to score the order of battle. The final step is to apply the media theory by filling out the matrix with the total scored forces in each element and then taking a matrix determinant (see fig. 10).

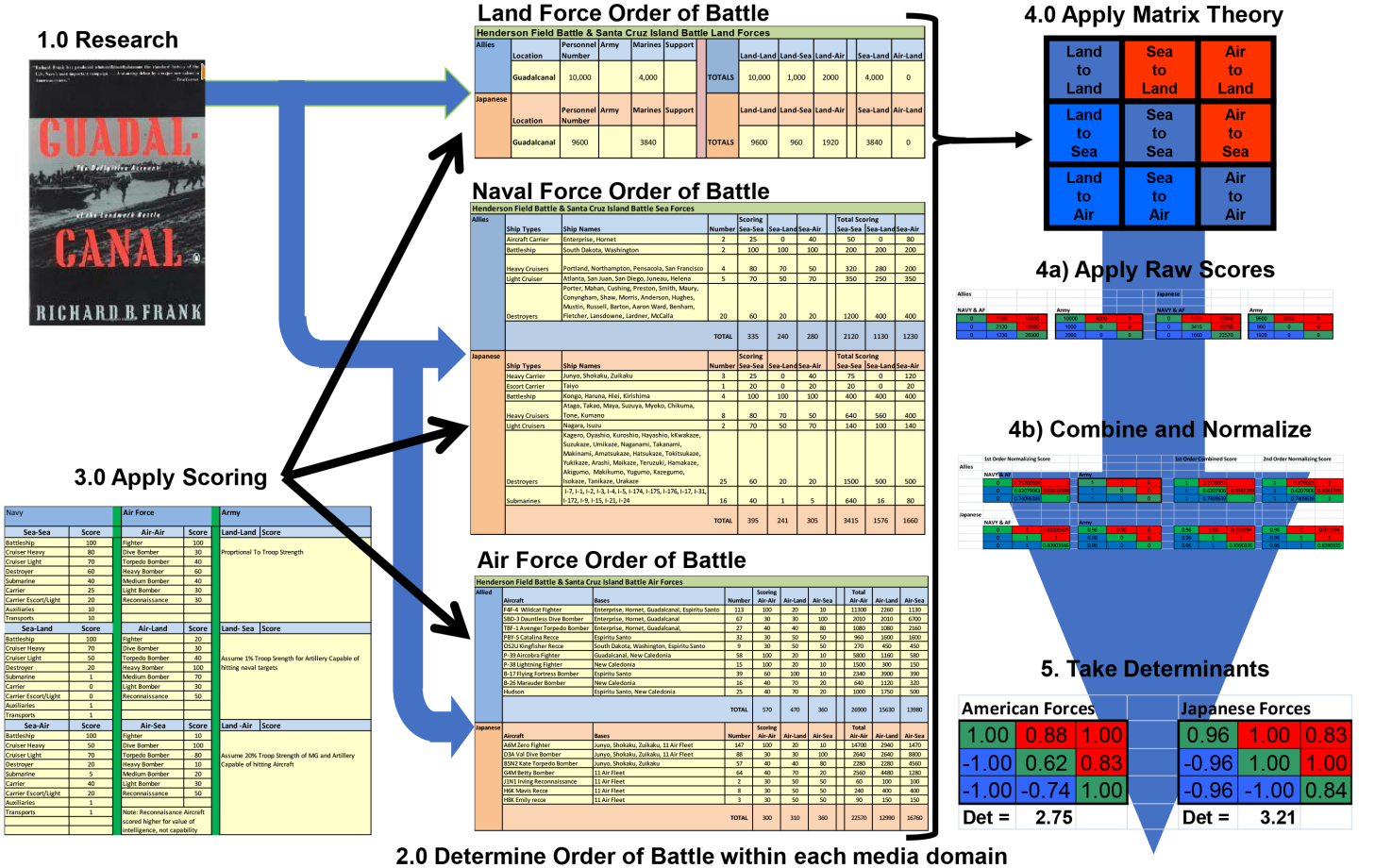


Figure 10. Media Matrix Theory Process applied to the Guadalcanal campaign (one of five events shown as an example)

The Guadalcanal campaign was evaluated at five distinct checkpoints. The first point was the American landings; the last point was when the Japanese withdrew their forces. The middle three points cover land and sea battles occurring within a few days of each other. These points were selected both for their significance and for the fact full land, sea, and air orders of battle were available and distributed evenly over time. From research, the order of battle was generated for each picked checkpoint.

Values were placed on the land forces for land-land, land-sea, and land-air capabilities. Likewise, values were placed on sea forces for sea-sea, sea-land (including Marines), and sea-air capabilities. Finally, values were placed on air forces for air-air, air-sea, and air-ground (including paratroops) capabilities. Scoring was subjective but not arbitrary. For example, battleships scored higher than cruisers which scored higher than destroyers for both sea-sea, and sea-land capabilities. Fighter aircraft scored higher than bombers for air-air but lower for air to ground. Dive bombers and torpedo bombers scored higher than fighters and bombers for air-sea, and so forth. To score the Guadalcanal campaign force structure elements without getting too deep into details, we modeled equivalent forces as quantitatively the same while ignoring any qualitative differences. For example, due to its armor and armament, the Imperial Japanese Navy *Yamato* battleship could be considered superior to the USS *North Carolina* battleship. Both ships participated in the Guadalcanal campaign, but they are assumed to be equivalent weapons classes for the purposes of the analysis, so any battleship is the same as any other battleship. Likewise, cruisers equaled cruisers, destroyers equaled destroyers, and so forth.

Similarly, the Mitsubishi Zero is generally acknowledged as the better air superiority fighter as compared to the Grumman Wildcat, but for this analysis, they are scored the same. Likewise, a Japanese soldier is equivalent to an American Soldier regardless of the actual reality either way. This scoring methodology also allows "home team biases" (i.e., internal evaluations like "I know my fighter is superior to the enemy, so it should be double the strength value of the enemy's asset" tend to overestimate the domestic capability and underestimate the foreign capability; this tendency is especially true in situations where intelligence information confirming those beliefs are lacking) to be relatively mitigated throughout the analysis.

The scoring is then applied to each campaign checkpoint's order of battle by simply multiplying the force numbers times the scoring for each capability within the framework. The scores are tallied and placed in the appropriate matrix theory cell for each campaign's major force. Raw scores are normalized to the highest value between like cells when comparing two force structures. The matrices are normalized with respect to each other. The determinant for each matrix is calculated, and the resulting scores are compared.

1.0 Initial Landings

American Forces		
1.00	1.00	1.00
-1.00	1.00	1.00
-1.00	-1.00	1.00
Det =	4.00	

Japanese Forces		
0.37	0.22	0.23
-0.37	0.35	0.19
-0.37	-0.35	0.19
Det =	0.11	

2.0 Tanaru & East Solomons

American Forces		
1.00	0.65	1.00
-1.00	0.45	1.00
-1.00	-0.50	1.00
Det =	1.89	

Japanese Forces		
0.96	1.00	0.70
-0.96	1.00	0.75
-0.96	-1.00	0.99
Det =	3.24	

3.0 Henderson Field & Santa Cruz

American Forces		
1.00	0.88	1.00
-1.00	0.62	0.83
-1.00	-0.74	1.00
Det =	2.75	

Japanese Forces		
0.96	1.00	0.83
-0.96	1.00	1.00
-0.96	-1.00	0.84
Det =	3.21	

4.0 Naval Battle & Japanese Landings

American Forces		
0.73	0.60	1.00
-0.73	0.52	1.00
-0.73	-0.69	1.00
Det =	1.76	

Japanese Forces		
1.00	1.00	0.61
-1.00	1.00	0.82
-1.00	-1.00	0.58
Det =	2.38	

5.0 Japanese Withdrawals

American Forces		
1.00	1.00	1.00
-1.00	0.86	1.00
-1.00	-1.00	1.00
Det =	1.76	

Japanese Forces		
0.26	0.68	0.54
-0.26	1.00	0.54
-0.26	-0.54	0.47
Det =	2.38	

Conclusion: The Guadalcanal Campaign was a near run endeavor. Allied leadership and perseverance tipped the balance.

Figure 11. Guadalcanal Matrix Theory application results

By following this process, we create a single number representing force structure value, which can be compared against other force structures evaluated in the same way. The final normalized combined force evaluation matrices and the determinant results for each evaluated point are displayed in figure 11. There is one matrix and determinant for the Allied forces and one for the Japanese forces at each named checkpoint.

Since the Americans only dominated in total force structure at the campaign's beginning and end while the Japanese dominated at all other times, the Allies could have easily lost the Guadalcanal campaign. The battle was a close-fought near-run campaign. This analysis indirectly points to the overall superior Allied leadership, tactics, techniques, procedures, and perseverance. If the Japanese had better leadership and employed their available forces more effectively, they might have won.

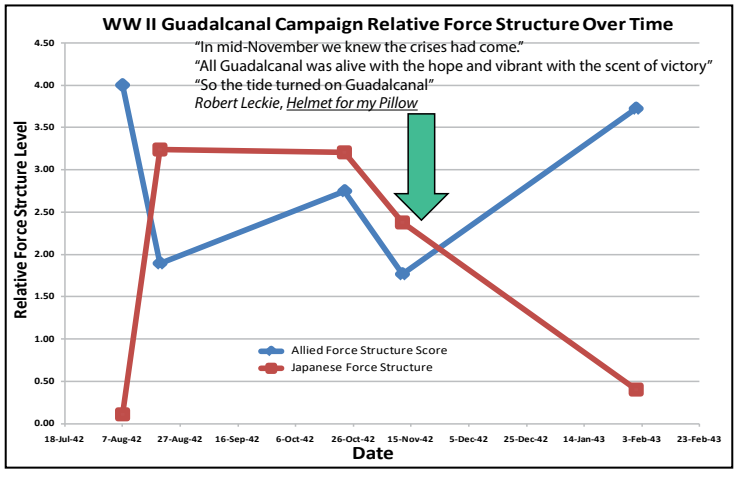


Figure 12. Force structure relative comparison over time shows the dominating integrated order of battle at each point during the World War II Guadalcanal campaign.

By plotting the analyzed campaign checkpoints from figure 11 over time and "connecting the dots," an interesting picture appears.

The analysis performed was based on the prebattle force structure order of battle for each checkpoint. Otherwise, the analysis was completely agnostic to the actual history and situation at any point in time. However, by connecting the dots shown in figure 12, a clear crossover point between Japanese force dominance and Allied force dominance occurs approximately in November 1942. As noted in the figure, according to Robert Leckie in his book, as well as other authors, analysts, and commentators, the Guadalcanal campaign appeared to move in the Allies' favor in November 1942. This coincidence is a tremendous qualitative affirmation the theory has some potency in force structure evaluation. Though not covered here, this media matrix analysis may be applied to "what if" situations by changing the order of battle as desired to see the outcome.

Applying Media Interaction Theory to Space (Hypothetical NATO-Warsaw Pact Engagement)

Now, how can we apply this theory to space forces? Based on the work described so far, we assume the media theory represents a valid means to describe and compare combined force structures. Also, all else being equal, the media theory results predict the likely outcome of a conflict between two opposing integrated force structures. Given these axioms, we can apply the media theory to a hypothetical NATO-Warsaw pact conflict circa 1985 with and without some conjectural space forces that could have existed at that time (see fig. 13).[6]

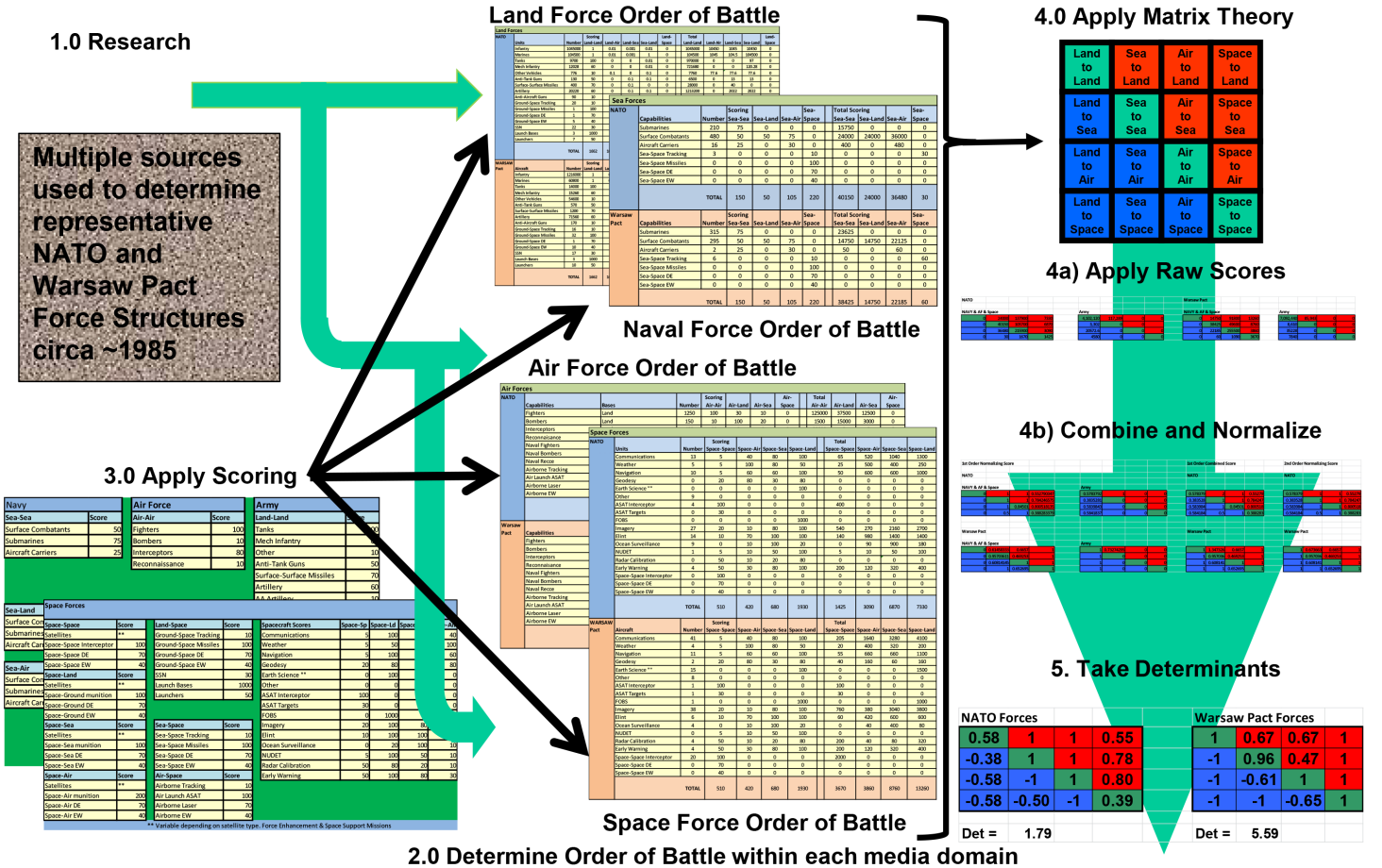


Figure 13. Media Matrix Theory applied to NATO versus Warsaw pact Cold War campaign, including hypothetical 1985 space forces

Using the available open sources, we established 1985 as the approximate year the force structures were valid for a hypothetical conflict between NATO and Warsaw Pact forces. Though the data is not valid for any specific point in time, the resulting order of battle for both sides is generally representative in this era. For space forces, open literature research and development capabilities at the time were used to estimate space force hypothetical capabilities—that is, ISR satellite capabilities for both combatants, US F-15 ASAT, USSR SL-11 Coorbital ASAT, USSR Sary Sagan Laser, US MIRACL Laser, and others. Nuclear forces were not included in this analysis. Scoring is adjusted to reflect these more modern "circa-1985" systems and their associated capabilities as opposed to the World War II-era capability scoring done previously. Otherwise, the scoring application to the order of battle, media theory application, and determinant results are the same as was performed for the previous Guadalcanal analysis.

The '60s-'80s held contentious debates in the West over whether NATO's conventional forces in Europe could withstand the Warsaw Pact onslaught without resorting to nuclear weapons. Many different quality versus quantity arguments were made regarding whether NATO or the Warsaw Pact forces were superior, particularly when comparing land, naval, or air forces directly.

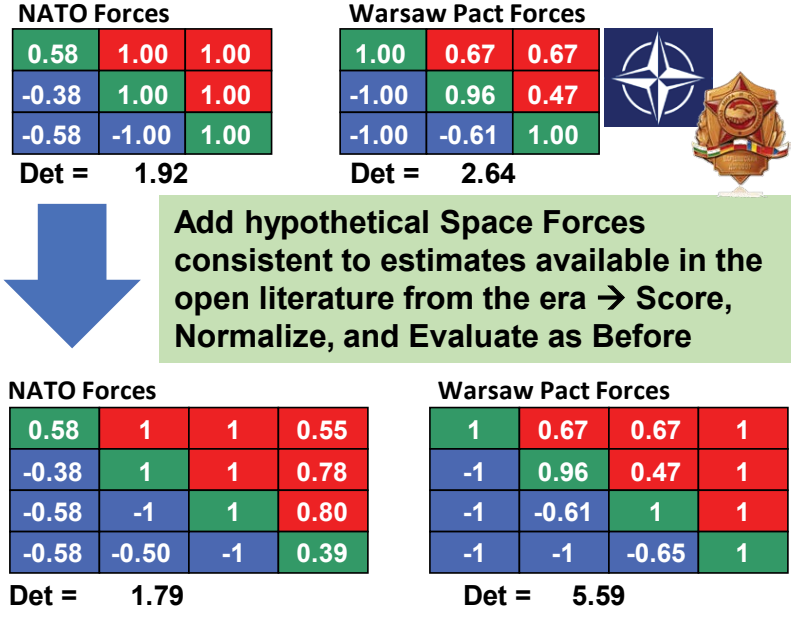


Figure 14. Vintage 1980s NATO versus Warsaw Pact force structures show superiority, both with and without space forces included.

When comparing force results directly (fig. 14), the Warsaw Pact had clear dominance over all land forces, but NATO and the Warsaw Pact were at or near parity for naval and air forces (look at the diagonals). Over land-sea-air diagonals, NATO has clear domain over offensive capability, while the Warsaw Pact does better defensively (except in sea-air). Intuitively, one could guess the NATO forces are superior. However, media theory application says the Warsaw Pact force structure in total was 27 percent superior to the NATO force structure.

Adding in the hypothetical space forces to the same analysis, the Soviet Union appeared to have superior capability in conducting space warfare for the time period. However, the superiority was not completely uncontested. Intuition would assume the superior space forces added to the dominant force structure would lead to an even greater superiority. However, by applying the media theory and comparing results, the analysis indicates the Warsaw Pact would have had 300 percent greater superiority over NATO forces. This result appears to be an overwhelming supremacy. If this analysis has any factual basis, it was a very good thing NATO and the Warsaw Pact never actually crossed conventional swords over Europe. This analysis also reinforces the nuclear deterrent's strategic importance. In evaluating operational or tactical engagements, media theory suggests the Warsaw Pact should have pressed the advantage; that they did not emphasize the overwhelming impact strategic weapons had on the decision to engage.

Summary/Conclusion

The media interaction warfare theory extends past work by military theorists to unify a large degree of their work through modern mathematical techniques. The theory proposes a construct using matrix algebra to represent land, sea, air, and space force structures. This construct is applied to validate or refute past military theories, help explain past historic events, and predict future possible situations—most notably in analyzing potential multidomain operations or campaigns. The theory strongly endorses space force utility and importance when integrated into an overall force structure. The media interaction theory may also be used to illustrate and analyze military service roles and missions and any force structure mix variety. The media interaction theory provides one of the first analytic tools to emerging US Space Force planners and strategy developers. If this theory is valid, it opens-up a distinct, logical approach to joint forces analysis, modeling, and simulation; also, the approach has broad applicability to the world of military affairs, and space force warfighting capability importance and applicability to those affairs. ✪

Michael P. Scardera

Mr. Scardera (SB, Massachusetts Institute of Technology; MS, University of Maryland) has more than 36 years' experience in aerospace engineering and leadership roles. He is currently vice president of Advanced Concepts at Millennium Space Systems, A Boeing Company, where he is responsible for early stage space system concept and program development for future flight programs. He leads teams responsible for developing space systems from concept through detailed design and supporting subsequent development activities through launch and operations. Previously Mr. Scardera was director for aerospace systems at Innovative Technology Systems and chief systems engineer at Pioneer Rocketplane. He served 12 years as a USAF officer, innovating in space superiority, space control, space surveillance, and global positioning system mission areas.

B. T. Cesul, PhD

Dr. Cesul (BS, University of Michigan; ME, University of Michigan; PhD, Air Force Institute of Technology) is a technical fellow and principal systems engineer (space) with Centauri, now a KBR company. He is responsible for supporting customers in national security space and the commercial utilization of space capabilities. Dr. Cesul previously worked as a space systems engineer and principal intelligence analyst for multiple entities within the national security space community.

Notes

1. Michael P. Scardera, "Media Interaction Theory of Warfare (Military Domain Matrix Theory), A Hypothesis Unifying Past Military Theories and The Theoretical Basis for an Independent U.S. Space Force," 76th Military Operations Research Society Conference (MORS), US Coast Guard Academy, 10–12 June 2008; and Michael P. Scardera, "Media Interaction Theory of Warfare (Military Domain Matrix Theory)—An Update; Applying the Media Interaction Warfare Theory," 80th MORS Conference, US Air Force Academy, 12–14 June 2012.

2. Land power source material surveyed included: Sun Tzu, *The Art of War*, trans. Samuel B. Griffith (New York: Oxford University Press, 1971); Carl Von Clausewitz, *On War*, trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1984); Antoine-Henri Jomini, *The Art of War*, trans. G. H Mendel and W. P. Craighill (Long Beach, CA: Apostrophe Books, 1862); B. H. Liddell Hart, *The Remaking of Modern Armies* (Boston: Little, Brown and Company, 1928); B. H. Liddell Hart, *The Revolution in Warfare* (New Haven, Yale University Press, 1947); and Brian Bond, *Liddell Hart, A Study of his Military Thought* (New Brunswick, NJ: Rutgers University Press, 1977).

3. Naval power source material surveyed included: Alfred Thayer Mahan, *The Influence of Sea Power Upon History 1660–1783* (New York: Dover Publications, 1987); Philip Howard Colomb, *Naval Warfare, Its Ruling Principles and Practice Historically Treated, Volumes 1, 2, & 3* (Annapolis, MD: Naval Institute Press, 1990); and Julian Corbett, *Some Principles of Maritime Strategy* (Annapolis, MD: Naval Institute Press, 1988).

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5. The source material used to describe the Guadalcanal Campaign and construct the Order of Battle include Richard B. Frank, *Guadalcanal: The Definitive Account of the Landmark Battle* (London: Penguin Books, 1992); "A Guadalcanal Chronology & Order of Battle 7 August 1942–6

March 1943," http://www.friesian.com; "Solomons Campaign: Guadalcanal," Naval History and Heritage Command, https://www.history.navy.mil; John Miller, Jr., "United States Army in World War II—The War in the Pacific, Guadalcanal: The First Offensive," https://www.ibiblio.org; Joseph N. Mueller, *Guadalcanal 1942—The Marines Strike Back* (Oxford, Osprey Publishing, 1992); and Robert Leckie, *Helmet for my Pillow, From Parris Island to the Pacific* (New York: Bantam, 2010).

6. The source material used to describe the North Atlantic Treaty Organization (NATO) versus Warsaw Pact European War Scenario and construct the Order of Battle include: "An Assessment of Soviet Forces Facing NATO—The Central Region—and Suggested NATO Initiatives," DNA 4343 F, 30 September 1977, https://apps.dtic.mil; "Assessing the NATO/Warsaw Pact Military Balance," Congressional Budget Office, December 1977, https://www.globalsecurity.org; and Christopher Redman, "East-West Battle of the Bean Counters. If Euromissiles are outlawed, will NATO be outgunned?" *Time Magazine* 129, no. 24, 15 June 1987.

COMMENTARY

An Information Warfare Framework for the Department of Defense

Maj Andrew Caulk, USAF

Introduction

As we begin to grapple with the role the Air Force should play in the information domain, we must also lift our gaze beyond the tasks of our service to also consider the framework, or lack thereof, in which we participate.

The information environment (IE) is a noisy, risky, and asymmetric place. It is noisy in the sense that it takes a significant signal to break through the noise to create an impact. It is risky, as unlike conventional munitions, the munitions we fire here (ideas, messages, and engagements) can always be turned back against us. It is also inherently asymmetric as large actors, such as the US, present more target area to potential adversaries and often respond more slowly than smaller opponents.

P. W. Singer, author of *LikeWar*, recently said that the US has no information strategy.[1] The last time the US had something approaching a strategy was 2007.[2] This lapse is a significant shortfall. While the Department of Defense (DOD) has begun to outline information engagement concepts such as the Joint Concept for Operating in the IE (JCOIE),[3] we have yet to establish clear national or military information objectives, determine required resources to achieve those objectives, understand how to assess those objectives, or build a framework that can operationalize said objectives.

This article attempts to outline a conceptual framework that provides one potential vision to operationalize DOD information engagement. This concept is not the only way to organize. It does, however, provide a reasoned and comprehensive approach to unifying information related capabilities (IRC) across services, combatant commands (CCMD), and the DOD.

First, though, it is necessary to define the problem. Setting aside the larger, political issue of the lack of US information strategy, the overarching question for the DOD is, "What issues must the DOD address to present an effective information war-fighting capability?"

Through past observation, research, and conversations with multiple experts across IRCs, five major shortfalls emerge:

- Operational and campaigning framework

- Continuing education for IRC personnel
- Culture change through commander education
- Interagency integration
- Influence assessment and visualization

This article addresses the first shortfall while providing brief recommendations for the other four.

DOD Information Warfare Framework

There exist myriad organizations, capabilities, and authorities related to information warfare, and it seems each of those is attempting to find ways to create effects in the IE. Yet, these dispersed capabilities have no comprehensive framework that allow them to unify their efforts in a way that provides sufficient signal to noise ratio and effective engagement. Figure 1 illustrates how global reach-back capabilities could integrate through the Joint Staff and geographic CCMD commander (GCC) operational authorities to create synchronized effects.

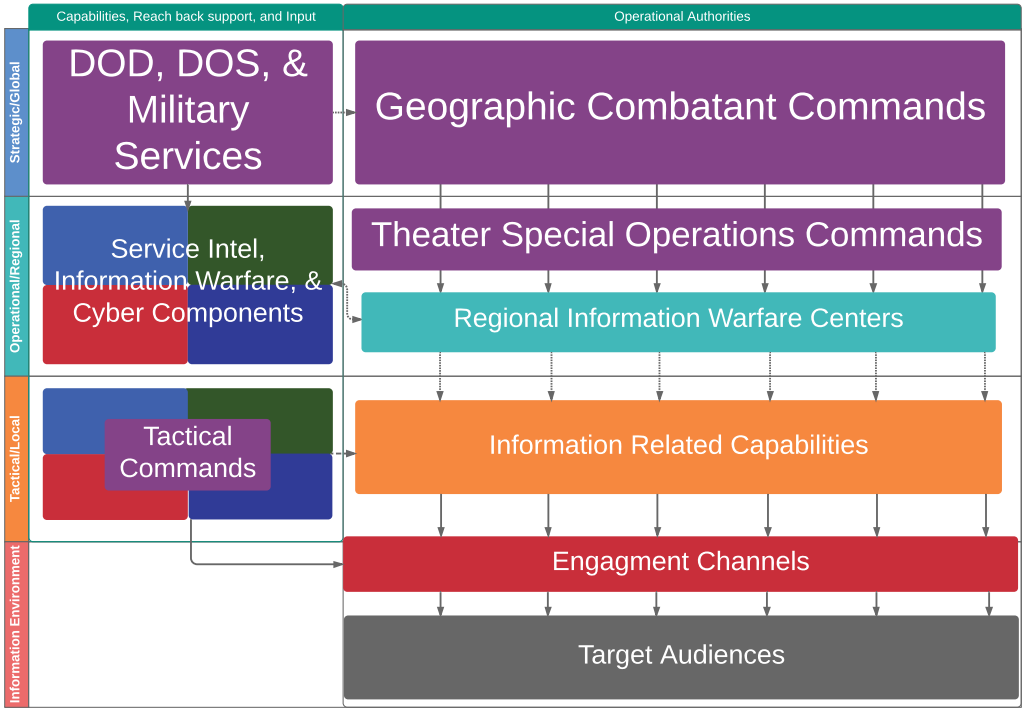

Figure 1. A concept diagram of the relationships between supported and supporting commands across the DOD

Strategic/Global Level and Authority Delegation

At the top of the figure in the blue "Strategic/Global" row sit the DOD, Department of State (DOS), combatant commands, and services. In the left column, and in the context of DOD information engagement, sit service capabilities, functional CCMDs, and the DOS are reach-back capabilities available to the GCCs. In the right column, the GCCs wield most of the operational authorities to execute information engagement, while the Joint Staff retains only the most sensitive.

Currently, IRCs' personnel, resources, and engagement authorities are fragmented across multiple GCC components and reach-back capabilities. Instead, I propose identifying one component under GCC to be the supported command for information (though other components retain their IRCs). Clearly delegating supported command status for information would be a significant shift in DOD policy as information engagement authorities are typically withheld at the GCC level or higher—presumably to mitigate perceived risk. However, such delegation would be in line with command doctrine and the idea of centralized command but decentralized execution.

Delegation is critical, and withholding engagement authorities at too high a level is ineffective for multiple reasons.

1. By design, GCC staffs will never have enough capacity to create sustained effects in the IE against all target audiences considering the required signal-to-noise ratio. A GCC's primary organizational mission is to translate national guidance into theater strategy and acquire the resources to implement that strategy. A GCC's staff, but especially the commander, simply do not have the capacity to make all decisions required by current authorities related to the IE let alone all traditional military activity. Instead, we should take direction from Joint Publication 3.0, *Joint Operations*, "Drive synergy to the lowest echelon at which it can be managed effectively."[4]

   An example that illustrates GCC staff capacity shortfalls is the comparison of lethal versus non-lethal delegation of engagement authorities. Lethal authorities are delegated to individual combat troops or units under established rules of engagement. Centralized lethal engagement authority at the GCCs level would render combat capabilities nearly ineffective—even in conflicts as small as Iraq and Afghanistan. The same holds true for nonlethal authorities in the IE as worldwide information competition is orders of magnitude larger and more complex and therefore requires further delegation.

2. Reserving authorities at such a high level distances responsible commanders from tactical input, over-aggregates information without enough

detail to adequately target, and eliminates layers of bureaucratic protection or plausible deniability from the responsible GCC. Said another way, the GCC could provide cover for an operational commander and walk back information engagement that inevitably goes astray regardless the authority level.

3. By doctrine, operational commands are designed to translate strategic guidance from GCCs into operational campaigns and orders for subordinate units.[5] Operational commands, then, are the appropriate level to "fight" in the IE as they are for conventional conflict.

4. Maintaining authorities at the GCC level creates stovepipes where any request for reach-back support must travel through a GCC's staff, then often to OSD or CJCS, then back through to service or interagency capabilities. Information engagement processes must be agile to be effective. Stove-piped coordination processes directly impede agile engagement.

This concept of delegation would require risk assumption by the GCC and for that person to trust (but verify) their subordinate commanders and campaigns. While leaders may say they trust their commanders, current bureaucratic processes communicate otherwise. If left unchecked, the over-centralization of authorities will stifle effective information engagement. Therefore, we must have critical conversations about trust and delegation moving forward.

There are many other pros and cons to delegating authority and supported command status, and opinions on the matter will differ. More debate regarding delegation is both necessary and inevitable but would be better suited for future discussion. Regardless, delegating authorities to an operational component commander, with appropriate safeguards, would seem to dramatically increase unity of command and operationalization of information for a GCC.

Operational/Regional Coordination

As depicted in figure 1, establishing connectivity at the operational level across geographic CCMDs, reach-back capabilities, and interagency organizations cuts through bureaucratic stovepipes to create an operational coordinating level that can synchronize with other GCCs and reach back to diverse US-based capabilities. Operational commands would, of course, routinely brief, synchronize, and receive input from GCCs, as each command echelon also serves in an operator role in engaging the IE.

As previously stated, Theater Special Operation Commands (TSOC) appear to be the ideal component to designate as the supported command for information for the following reasons.

1. As commands that report to both the GCC and Special Operations Command (SOCOM), TSOC can access more resources and authorities than service components. Specifically, SOCOM owns the civil affairs, counterterrorism, counterinsurgency, military information support to operations (MISO), Joint MISO WebOPS Center, and unconventional warfare capabilities.[6] TSOCs wield many of those SOCOM-specific capabilities, using both GCC and SOCOM authorities.

2. The preponderance of personnel related to direct tactical and operational information engagement (e.g., civil affairs, psychological operations, military information support teams, etc.) are assigned to TSOCs in each theater. Other components usually have only a handful of personnel in these direct engagement roles. TSOCs also tend to have much more robust J39 divisions (information operations) and supporting regional information support teams to augment information engagement planning.

3. While other components' capabilities focus on conventional warfare, TSOC forces, operating structure, and culture are tailor-made for irregular and unconventional warfare. In that vein, TSOCs often maintain a network of special operations forces liaison elements, civil military support elements, and military information support teams at specific US embassies that facilitate better region-wide coordination.

Under each TSOC in figure 1 falls an information warfare center (IWC). Only some TSOCs and GCCs have these constructs currently, and none of the TSOCs have the supported information command designation to the authors knowledge. The IWC basic concept bears a striking resemblance to an air operations center (AOC). Each would have a research, future operations, and current operations section supported by planners from each IRC as shown in figure 2. These functions mirror the strategic research, plans, and current operations divisions of an AOC. The IWC would be responsible for planning, coordinating, prioritizing, and deconflicting all component and reach-back engagement in their respective geographic theater.

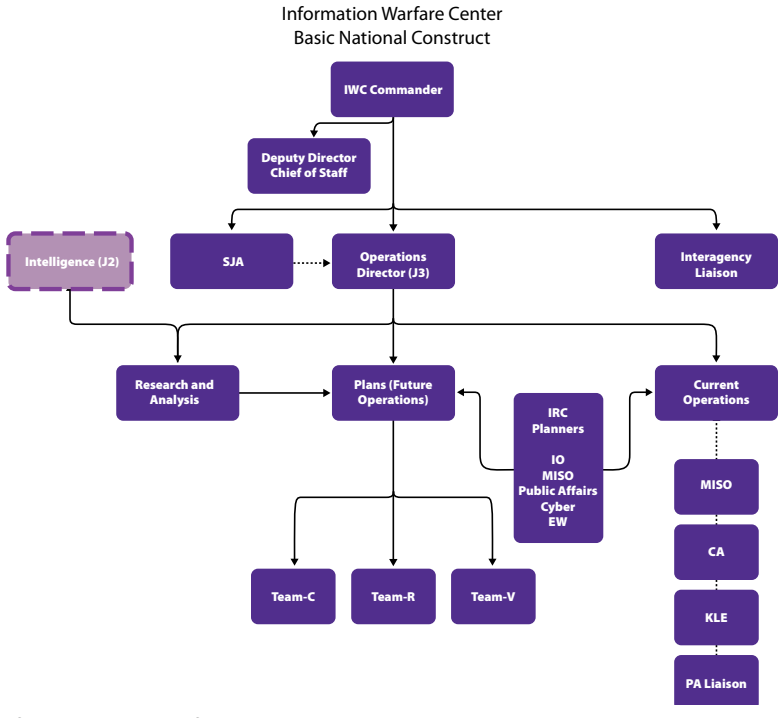

Figure 2. Information Warfare Center notional construct

By designating each TSOC with the supported information command and allocating dedicated resources to an IWC, the DOD would focus the number of supported entities down to six operational-level organizations, establish clear authorities for reach-back, eliminate significant coordination redundancy, increase cross-component synchronization, and reduce information fratricide.

In the reach-back column and operational row of figure 1, the services and functional CCMD provide their subordinate reach-back capabilities to the supported operational components for each CCMD. These reach-back organizations, such as Sixteenth Air Force, bring unique capabilities to the information fight. As geography agnostic organizations, they maintain a global view that balances the regional focus of GCC information supported commands. Supporting only six designated organization, instead of the myriad uncoordinated teams today, would streamline requests for support and clarify engagement authorities.

Interagency Consideration

The DOD can and should present a robust information engagement capability to our nation's leaders. However, we should not be our nation's primary communicator. That responsibility, both by law and sensibility, goes to the DOS. That

said, the DOD currently enjoys a budget 10 times that of the DOS.[7] Much like GCC staffs do not have the capacity to create enough signal-to-noise ratio to impact the IE, the DOS does not have enough resources to engage with prioritized audiences adequately to create sufficient impact. Many embassies have only one US staff member for public affairs and public diplomacy (PAPD), and most of their time is spent on administrative work.[8] Therefore, the DOD could serve as the information engagement framework into which the DOS can plug and play under defense support to public diplomacy. The military's ability to conduct planning and synchronize operations across multiple theaters would dramatically help the overwhelmed DOS PAPD function around the world.

Other Issues

Adopting this framework would be a significant first step in the direction of preparing the DOD to effectively engage in the information domain. However, the other four problem components remain.

Continuing Education for IRC Personnel

Skill levels vary widely between information practitioners and are generally far too low. The future of information warfare will require IE operators to include expertise in data science, sociology, linguistics, machine learning and artificial intelligence, military operational planning, advertising campaigns, communication strategy, and more. Yet, there is no requirement for continuing education in many of the military IRCs. For example, public affairs officers require no additional training beyond their initial technical school to be a CCMD public affairs director.[9] No operational structure can be effective if not staffed by well-trained personnel regardless of how well organized.

Culture Change through Commander Education

Military culture is biased toward physical action by centuries of conditioning—and it shows. We must educate commanders and leaders on IE impacts, planning, and strategy. Strategy is an area with historic developmental shortfalls.[10] Many commanders, but not all, are exposed to strategy but never deliberately learn it and end up as graduated tacticians at higher levels of command. If we fail to train commanders and bring about culture change, information will remain a lesser function despite the Joint Staff designation as one of the seven war-fighting functions.[11]

Interagency Integration

The DOS has the lead for the US in each country, which often frustrates DOD engagement and slows the speed with which the US can engage due to DOS shortfalls. However, it is a reality we must face and overcome through cooperation. Establishing the recommended operational framework will help, but the DOS must also look for ways to refine their own processes and adequately resource information efforts.

Influence Assessment and Visualization

The most technically challenging component of effective information engagement is how to assess and visualize influence. We know how to map physical gains and assess battlefield damage in the military, but we have little idea on how to keep score in the information domain. While the Command and Control of the Information Environment tool is likely a potential long-term solution to this problem (and is getting better), it still needs significant development to fulfill information warfare needs (e.g., have a good, global IE common operating picture, be able to coordinate IE activity, and be able to assess influence of friendly, neutral, and adversary activity).

Conclusion

None of these issues are simple or quick fixes. The DOD and DOS are large bureaucracies with many processes still anchored in post-World War II thinking. The IE is evolving far faster than our traditional culture, organizations, and processes can adapt, so we must make more drastic changes. While the DOD may not adopt the ideas described in this article, I hope it begins a conversation that moves us rapidly forward. Despite the difficulty of the task ahead, I am optimistic we change in time. I choose to be optimistic because the alternative is for the US to effectively cede the entire information domain to adversaries who, unchecked, assail our interests abroad and our citizens at home. So, I choose to believe we can change because my children's future depends on it. ✪

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COMMENTARY

Is It Time to Forget about Cyber Deterrence?

Maj Cameron Ross, USAF

On 7 August 1945, one of the nation's foremost naval strategists drove to the local drugstore with his wife to pick up a copy of the *New York Times*. When he opened the paper, he was taken aback by the headline "First Atomic Bomb Dropped on Japan." After quickly scanning a few paragraphs, he turned to his wife and bluntly said, "Everything I have written is obsolete."[1]

Bernard Brodie immediately grasped that the atomic bomb necessitated a fundamental change to military strategy. For most of human history before 1945, military conflict and security planning focused on the back and forth of offensive and defensive capabilities. While war was to be avoided if practicable, it was universally recognized that it was *possible,* and thus, nations needed to prepare to fight. Accordingly, the military forces' primary organizing principle was war fighting—offensive operations to inflict cost and defensive actions to blunt damage.[2] In the offense-defense framework, the state's security rested on its ability to understand the balance of its war-fighting capabilities in relation to its rivals and choose the approach that would achieve the best outcomes.

The arrival of nuclear weapons dramatically altered the balance between offense and defense and created the ultimate offense-dominant environment.[3] In a nuclear war, the defense would always lose, and the cost of the war would be catastrophic for mankind. The horrifically destructive and undisputable nature of the weapon demanded an entirely new strategic framework to manage the atomic age. Brodie's 1946 classic, *The Absolute Weapon: Atomic Power and World Order,* advanced the concept of nuclear deterrence, which would serve as the foundation of US security throughout the Cold War and into the twenty-first century. Deterrence itself was not a new idea—traditional statehood included elements of conventional deterrence to achieve national objectives or avoid war. For example, forces could be deployed to borders to signal resolve and dissuade an adversary from attacking. However, Brodie recognized that nuclear weapons represented incontestable threats of unacceptable cost, so strategists had to completely change how they approached deterrence and military affairs. As he famously stated, "Thus far, the chief purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them."[4]

As a result, the dominant organizing agenda for military forces became deterrence and the avoidance of war. Theorists introduced a radical concept that a nation's security would no longer rest in its offensive and defensive abilities but rather in its opponent's mind. Further, the purpose of possessing military weapons (in this case, nuclear weapons) was to never use them.[5] The massive cost of these incontestable weapons became the source of deterrence stability and maintenance of peace between nuclear powers. Ever since, deterrence has served as the primary strategic framework for America's national security.

Consequently, ideas about cyber deterrence have naturally accompanied the growth of cyberspace and cyber operations. The disruptive and revolutionary nature of cyber and its potential for massive effect resembled the arrival of nuclear weapons in many ways. However, many theorists and strategists quickly noted the challenges to reconciling cyber with ideas of classical deterrence. During the Cold War, deterrence was straightforward. For example, it was easy to know who launched an attack; there was a significant scientific barrier to creating nuclear weapons; every bomb could be as powerful as the first; any use of a nuclear weapon crossed an acknowledged threshold; redlines were usually grounded in geography and easy to conceptualize; and motives were generally discernable and tied to strategic interests.[6] Almost none of these apply to the world of cyber. Attribution can be incredibly difficult and usually takes an inordinate amount of time—if one can discern the origins of the attack at all. The low barrier to entry enables many actors, and what would deter each actor is almost as varied as the actors themselves. The use of a cyber weapon makes it less likely that it will be effective in the future as defenders patch the vulnerability. Defining substantive thresholds and redlines is almost impossible. Yet, despite all the barriers to effective deterrence, most authors believe it is possible and should be pursued. But is deterrence the right framework for approaching cyberspace? Perhaps the friction strategists face is indicative of the need for a paradigm shift.[7]

A handful of thinkers have begun to argue just that. They maintain that anchoring America's cybersecurity capabilities around a primary strategic objective of war avoidance is not achievable in any sustained manner.[8] In addition to the challenges already noted, their analysis of the nature of cyber operations points to a framework more akin to offense-defense than deterrence. Just as conventional deterrence is less stable than nuclear deterrence because of the contestability of conventional weapons, the highly contestable nature of cyberspace makes cyber deterrence even less stable.[9] Further, by definition, cyberspace is interconnected, which means that action is never absent and that national security actors are in constant contact with adversaries as well as numerous nongovernmental entities.[10] Finally, every new version of software, hardware, and integration configuration

presents new opportunities for offense and new challenges for defense. The lack of any steady-state in cyber "terrain" means there is no steady state of defense. Instead, "defense is a dynamic construct relative to the offensive opportunities that emerge with each 2.0 or 3.0 of the terrain."[11] The combination of contestability, interconnectedness, constant action, and ever-changing terrain creates an entirely new strategic environment: one of offensive-persistence.[12]

As opposed to the environment of nuclear weapons, where the presumption is that the defense will lose, an offensive-persistent environment presumes that the defense can lose, but it is not structurally inevitable. Defense is possible in any specific moment within the dynamic terrain of cyberspace and can be sustained over periods of time through active adjustments to the environment. However, defense can never be decisive. "The defense can achieve tactical and operational success, but the offense will persist, the contact with the enemy will remain constant, and the defense will need to adjust as the terrain to defend and the vectors to attack evolve."[13] Just as the unique strategic environment of nuclear conflict necessitated a change in strategy to address it, cyberspace policy and operations must address the distinctive nature of cyberspace. As Richard Harknett explains, "Strategic frameworks must map to the realities of strategic environments; the reverse is not possible."[14]

The framework Harknett and Michael Firsherkeller propose for the offense-persistent environment of cyberspace is cyber persistence. They maintain that the current approach of cyber deterrence, and its associated operational restraint until norms can be established, has created a strategic deficit as others operate without similar concerns and gain advantage. By adopting an approach of cyber persistence, the US would seek to "use cyber operations, activities, and actions (as opposed to the threat of force) to generate through persistent operational contact (as opposed to avoiding contact) continuous tactical, operational, and strategic advantage in cyberspace so that the United States could ultimately deliver direct effects in, through, and from cyberspace at a time and place of its choosing."[15] Cyber persistence focuses on gaining and retaining initiative and includes active engagement with an active operational domain.[16] Instead of a threat-based strategy, which focuses on who might threaten the US, they suggest a capabilities-based strategy that anticipates our vulnerabilities while simultaneously leveraging the vulnerabilities of others. This framework echoes the ebb and flow of offense-defense as opposed to the lack of offensive activity in deterrence. Of course, the activities involved with cyber persistence may cause an opponent to pause in their consideration of the next steps—in essence, creating a deterrence residual. But it would not "change the attacker's decision calculus from one seeking to achieve objectives through aggression to one that seeks the same objectives while avoiding

war (the difference between an offense-defense strategic environment and a deterrence dominated strategic environment)."[17]

There is much more work to be done in exploring these ideas. Characterizing the strategic environment as offense-persistent deserves further assessment. The same is true for the applicability of previous research on offense-defense theory to cyberspace operations. Moreover, if cyberspace requires a nondeterrence framework, there must be additional thought applied to how the US would integrate multiple strategic frameworks, as deterrence is still necessary for nuclear warfare and its associated conventional warfare. This requirement is particularly important since the traditional domains of air, land, and sea rely on and regularly interact with cyberspace. However, this framework suggests the time has come for cyber strategy and thought to receive fresh consideration outside the confines of a deterrence approach. The success of deterrence theory with one new technology has led many to try and apply it to another, but we seem to have reached the point where it is inhibiting progress in cyberspace rather than advancing it. Rather than attempting to make deterrence work within cyberspace, perhaps now is the time to devote more effort to understanding the nature of the environment and then work to develop a framework that matches it. As Harknett said, let us use these friction points not to "resuscitate and stretch deterrence thinking, but to logically and creatively move beyond it."[18] ✪

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Reframing Air Force Suicide Prevention

A Human Capital Strategy to Normalize Help-Seeking Behaviors

Maj Nicholas J. Mercurio, USAF

Introduction

In 2019, 137 Total Force Airmen died by suicide, representing a 33 percent increase from the previous year.[1] The five preceding years showed a statistically consistent rate of approximately 100 Total Force suicides per year, and senior leaders, alarmed by the sharp increase in suicide deaths, called for culture change.[2] Unfortunately, when this article was written, a coherent strategy to achieve that change had not emerged. Air Force suicide prevention programs have historically focused on leadership involvement and increasing literacy (i.e., Airmen's knowledge of suicide and suicidality).[3] More recently, Department of Defense suicide prevention efforts have leveraged a 2017 Centers for Disease Control and Prevention framework of seven broad public health strategies to inform initiatives across the service branches: (1) Strengthening economic supports; (2) strengthening access and delivery of suicide care; (3) creating protective environments; (4) promoting connectedness; (5) teaching coping and problem-solving skills; (6) identifying and supporting people at risk; and (7) lessening harms and preventing future risk.[4] Absent from these programs and strategies is a comprehensive, evidence-based approach to transforming Air Force culture that simultaneously reduces the stigma associated with mental health issues and promotes help-seeking behaviors.

The current trajectory of Air Force suicide prevention efforts is akin to building a bigger, faster, and more efficient bilge pump for the *Titanic,* when the goal should be to avoid hitting the iceberg in the first place. That said, this article does not take issue with the quality of the clinical interventions, education resources, or toolkits currently utilized by the Air Force; on the contrary, they have proven effective when employed.[5] Instead, this article outlines a way to increase the likelihood interventions occur and that Airmen utilize the tools and resources in a crisis. Accordingly, this article does not identify the problem with Air Force suicide prevention efforts as one of clinical efficacy, and thus the solution proposed does not reside in the mental health practitioner's arena. Instead, the solution requires a strategy to move upstream of the problem and consequently lies in the discipline of behavior change communication. To accomplish this aim, this article proposes a social norms approach leveraging the human capital of the force to normalize help-seeking behaviors. The three-phase campaign described in the

following sections employs peer-delivered messages detailing real help-seeking successes within the Airmen population, in concert with physical alterations to shape the environment, to promote help-seeking and reduce mental health stigma, ultimately normalize help-seeking behaviors as part of Air Force culture.

Author Positionality Statement and Anecdotal Case Study

The following section relates the author's perspective and personal experience regarding the subject matter of this article. It is meant to disclose potential biases upfront and present an anecdotal case study from the author's life that serves as an example of behavior change communication. Everything that follows regarding suicide prevention communication best practices and recommendations for a behavior change communication campaign the author has either spoken about, detailed in writing, or presented in various forms in meetings throughout the previous 12–18 months. At varying times, the author was energized, encouraged, frustrated, and furious as the ideas did not survive first contact with the Air Staff. Upon reflection, the author concluded that part of this failure could be attributed to the curse of knowledge—the prevailing thought that if people just knew what the author knew, they would arrive at the same conclusions and subsequently adopt the author's recommendations. This mode of thinking framed how the author presented ideas and more than likely undermined any chances of success in effectively communicating with key publics.

Even more detrimental, though, was what leading change consultant C. Otto Scharmer referred to as the voice of judgment.[6] The inner voice of judgment prevents an aspiring change agent from what Scharmer called presencing or existing within the moment and letting go to let come.[7] The author eventually realized the voice of judgment was coming from a place of insecurity, both personally and professionally. Professionally, it had been the author's experience that the Air Force Public Affairs enterprise suffers from collective insecurity as an often misunderstood, overlooked, and under-utilized staff function amidst an operationally-focused Air Force institution. The resulting collective insecurity had permeated the author's personality and manifested itself in an aggressive, directive tone during interpersonal interactions that made collaboration difficult at times.

The author's personal insecurity, however, stems from something deeper. Upon reflection, how that insecurity has influenced the author's approach to life—fueling a constant need to prove a level of education and accomplishment—should be attributed to the impostor syndrome phenomenon.[8] A backfire effect often characterizes the result of this fundamentally flawed approach, wherein the desired appearance of intelligence and confidence is actually perceived as arrogance and conceit. It became clear that any reticence toward the proposed suicide prevention

ideas was not indicative that the ideas did not hold merit; it was reflective of a personal failure to present the ideas in a way that would overcome the author's personal shortcomings and resonate with the audience. The author determined it would be necessary to model one form of the proposed product as part of the innovation: the peer-delivered testimonial. Doing so afforded the opportunity to engage the affective side of the audience by cultivating an emotional connection that would allow them to become more receptive to the tenets of the idea. What follows is a modified version of that story, edited for clarity and brevity.

> Things I've learned: My wedding day was the happiest day of my life. You should never bet against Tom Brady. Black labs are the best dogs, period. Those surprise military homecoming videos make me cry *every single time.*
>
> What else have I learned? The second time being shot at is by far the worst. You open body bags from the middle so you don't see the faces because they stay with you forever. Combat brings you close with your brothers, a kind of closeness you cannot replicate when you make it home. But not everyone makes it home. You watch friends die and cry at their memorials, when photographs of their children receiving a folded flag surface on the internet, or when you close your eyes and can still hear their gasping and gurgling.
>
> Other things follow you as well: loss, sadness, guilt, and anger. Little things set you off now. Inconveniences become mountains of imposition, galling in their impertinence. You see the pained expression on the faces of friends and loved ones. They see that you are different; your laughter comes more slowly and less often, and your smiles are more measured than before. Your silences begin to take up more real estate in your life. You feel isolated. You're relieved to no longer be over there, and yet you feel like you missed a few steps on the way back, because you carry the same stress, same watchfulness, same aggression. These are all things you wish you could have turned in alongside your M4 and IOTV. You don't feel like you have permission to be home.
>
> Professionally, things aren't going so well, either. You finally realize that in the space between going from the number one ranking on your performance report, to the following year with no stratification at all, lives unresolved trauma. You learn that either you deal with trauma, or trauma deals with you, and it's never at a time or place of your choosing.
>
> So, what do you do? Well, I got help. I talked to mental health. I developed coping strategies and leaned on the social pillar. I talked about my experiences with my brothers, shared the messy feelings, and in the process located, contextualized, and processed that trauma. It will never leave; I know it still resides somewhere in there, inside the temple of Mars, but now I choose when I visit. And

> because of that, I turned things around. I made it to the Pentagon, the altar, to Air Command and Staff College. I made it because I learned a fundamental truth: that being resilient and asking for help are not mutually exclusive. In fact, the latter is proof of the former.

Stories like this one—raw, authentic, vulnerable, and deeply personal—about turning post-traumatic stress into post-traumatic growth, and that originate from a source Airmen are able to identify with (as opposed to celebrities or senior leaders), form the foundation of the social norms approach described in the campaign overview that follows.

Air Force Suicide Prevention Campaign Overview

Background, Purpose, and Focus

Background. To meet the demands of the *National Defense Strategy*, the Air Force requires a disciplined and ready force. As such, efforts must be undertaken to enhance the capacity of Total Force Airmen and their families to thrive in their daily personal and professional lives and persevere through adversity. To do so, this plan will leverage a social norms approach and focus on the following lines of effort (LOEs): reducing the stigma of help-seeking behaviors; normalizing the behaviors by creating and promoting the perception that they are both a sign of strength and institutionally valued; and enhancing Airmen's confidence and competence in performing resilience-related and help-seeking behaviors.

Purpose. Leverage empirically validated social science research in the fields of both suicide prevention communication and behavior change communication to produce a theoretical framework underpinning the actions recommended in the following communication campaign. The primary objective of the campaign is to increase the likelihood Total Force Airmen will perform desired help-seeking behaviors when in crisis.

Focus. The recommended behavior change campaign focuses on normalizing help-seeking behaviors by reducing perceived social pressures preventing help-seeking as well as stigma associated with mental health issues. To do so, the campaign creates and perpetuates the perception that the desired behaviors are valued by the institution and modeled by peers and aspirational figures.

Situation Analysis

The author performed a review of the organization's strengths and weaknesses while also assessing opportunities and threats in the external environment (table).

Strengths (internal)	Weaknesses (internal)
• Air Force senior leaders are invested in Airman resilience and willing to commit funding as needed • Improving resiliency aligns with the 2018 National Defense Strategy call to increase readiness • Aligning various aspects of resilience under one directorate allows for synchronization of effort	• Limited communication channels exist to reach Air Force squadron leaders whose position best empowers them to influence change • Negative opinions about mandatory training can undermine effectiveness • Perception as cliché—overuse/reliance on resilience buzzword may dilute understanding of its critical components (i.e. mental, physical, spiritual, social well-being)
Opportunities (external)	**Threats (external)**
• National interest in aspects of resilience such as violence prevention and suicide prevention provide the opportunity for engaged conversation	• Congress may oppose Air Force initiatives or diminish Air Force authority to implement initiatives • American culture still struggles to understand the importance and various aspects of resilience • National interest in various aspects of resilience such as sexual assault and suicide prevention may politicize internal conversations

Table. Strengths, weaknesses, opportunities, and threats analysis

Literature Review. Suicide prevention messaging campaigns designed to achieve a knowledge-based objective—that is, increasing literacy of prevention programs and resources—while not addressing latent stigma regarding mental health issues and help-seeking are *not* effective in increasing the likelihood target

audiences will perform the desired help-seeking behaviors.[9] Given this reality, suicide prevention communication must be reframed to deliver a more nuanced and ultimately efficacious approach. To start, the issue must be considered within the context of social learning theory, which stipulates a reciprocal, deterministic relationship between an individual's attitudes, behavior, and the environment—altering one has corresponding effects to the others.[10] Based on this theoretical framework, there are two guiding heuristics for effective behavior change communication:

1. Present simple, clear messages repeated often by a variety of trusted sources.
2. Make the desired behavior appear easy, fun, and popular.[11]

When this framework is applied within a suicide prevention messaging context, studies show that effective messages alter individual perceptions related to intervention and help-seeking behaviors through targeting attitudes toward desired behaviors, perceived social pressures regarding desired behaviors, and individual perceptions of ability to perform the desired behaviors.[12] Building upon this premise, by applying the elaboration likelihood model and utilizing positively-themed messaging, effective suicide prevention communication campaigns make help-seeking behaviors appear easy to perform, highly valued by the institution and the social norm, and modeled by peers and aspirational figures.[13] On this last point, peer-to-peer messaging campaigns have been empirically shown to produce the highest rate of interventions, as identification with the message source is a key mediator of the effects.[14]

After producing a theoretical understanding of an effective suicide prevention messaging campaign design, the research shifted to methods for leading organizational change and transformation. The most applicable model within the emotionally-fraught landscape of suicide prevention is the rider-elephant-path model proposed by Chip and Dan Heath.[15] In this model, the rider is the rational, analytical mind sitting astride the elephant, which represents the emotional, instinctual mind. They are walking down a path symbolizing the environment. A key tenant of the metaphor is that while the rider may direct the elephant in a desired direction, the elephant can change its mind at any time and overpower the rider, moving in whichever direction it chooses. The underlying lesson is that emotional reactions will override logical choices and, pertinent to the organizational change context, emotional appeal is a more powerful driver of change than logical argument. Subsequently, a change agent should employ a see-feel-change chain as opposed to the default analyze-think-change chain often utilized.[16] This "find the feeling" approach, combined with the Heath brothers' recommendation to shrink

the change and tweak the path—optimizing the environment by removing barriers to performing the desired behavior—inform this behavior change campaign.

Target Audiences

- Primary audiences: Total Force Airmen segmented corresponding to risk factors or stigma prevalence; ideally each category of Airmen will be represented in a "Save Story." Based on suicide data, the majority of Save Stories should feature young, enlisted Airmen.[17]
- Secondary audiences: squadron, group, and wing command teams
- Tertiary audiences: major command (MAJCOM) command teams and Surgeons General

Behavior Objectives and Target Goals

The following goals are to be measured against existing baseline numbers, such as those reported in the figure or maintained by the Air Force Integrated Resilience Directorate (AF/A1Z) and Air Force Office of the Surgeon General (AF/SG). If corresponding baseline numbers are currently measured and reported, the previous calendar year figures should be used as the baseline for comparison. In instances where a valid measurement does not currently exist, an appropriate survey instrument should be utilized to acquire the necessary data as soon as possible. Data suitability determinations and new survey requirements should be made by A1Z in coordination with SG and the Air Force Survey Office.

- Total Force Airmen perceive help-seeking behaviors as the norm and highly valued by the Air Force, measured one year after implementation at greater than 50 percent.
- Airmen's reported perceived self-efficacy in performing help-seeking behaviors increased by 20 percent, measured one year after implementation.
- The perception of mental health stigma reduced by 20 percent, measured one year after implementation.
- Mental health patient contacts increase 15 percent in the first quarter after implementation, then 5 percent each subsequent quarter until one year after implementation.
- Suicide rate reduced 35 percent one year after implementation. (Note: Baseline numbers should be based on a rolling five-year average to provide an accurate assessment of program efficacy).

Target Audience Barriers

A recent study of military members reported barriers to seeking help for mental health issues and revealed that perceived social pressure (i.e., the stigma of mental illness and a fear of becoming associated with them) was the leading barrier to help-seeking, as depicted in the figure. Notably, concerns related to stigma and loss of privacy were reported 38 percent more often than issues with resources such as a lack of familiarity with the tools available or limited confidence in their efficacy. The data is clearly indicative that further attempts to improve literacy through additional knowledge objective-based initiatives would not mitigate the most prevalent impediment to help-seeking. Instead, the data suggest reframing the prevention approach to one targeting mental health stigma would be the most beneficial.

Perceived Barriers to Help-Seeking, Department of Defense					
Stigma	Loss of Privacy	Negative Career Impact	Lack of Confidence in Chain of Command	Not Knowing Which Resource to Use	Lack of Confidence in Available Resources
65%	65%	59%	59%	47%	47%

Figure. DOD barriers to help-seeking

Source: "Resilience Tactical Pause," lecture, Air Command and Staff College, 2019

Campaign Positioning Statement

The following statement describes the organizing principles upon which the campaign is built: Resilient Airmen thrive personally and professionally by maintaining their well-being, persevering through adversity and, when challenges become too great, displaying strength and awareness by asking for help.

Marketing Mix Strategies

Phase 1 of the campaign features a five-to-seven part "Save Stories" video series of Total Force Airmen testimonials describing instances where they sought help for mental health or resilience-related issues and are now thriving. Each individual video would be between two-three minutes in length and packaged into a combined video featuring senior leader testimonials and endorsement for promotional purposes (four-five minutes). Secretary of the Air Force Public Affairs would be responsible for producing the video series and disseminating it through an Air Force-wide promotional campaign. Campaign launch should occur at a signature event such as the fall or spring Air Force Association symposium, as devoting stage time during a marquee event affords implicit communication that the institution is committed to responding to the suicide issue and the success of the initiative.

Phase 2 of the campaign immediately follows the rollout of the Save Stories series and involves a new Wingman Day construct designed to aid command teams in organically sourcing similar powerful content from Airmen within their formations. The construct consists of a framework that guides command teams, in coordination with installation behavioral health clinicians, enabling them to identify Airmen from within their units willing and able to share their own resilience success stories in a manner that is both safe and will resonate with their peers. The proposed Wingman Day construct represents a departure from traditional Wingman Days wherein the theme, associated content, and activities were supplied by higher headquarters. Accompanying the guidelines for sourcing organically derived testimonials will be toolkits designed to support normalizing help-seeking behaviors across tactical units.

The focus of the campaign's third phase resides in shaping the environment on installations to set conditions that increase the likelihood of positive behavior change. The first recommended LOE is to co-locate the mental health clinic with the physical therapy clinic and rebrand them as the Airman resilience clinic. Doing so would communicate that mental health issues are the same as physical injuries—they require treatment, are recoverable, and should not be a cause for shame. A target of opportunity may be to leverage ongoing Air Force Medical Service (AFMS) transformation efforts that involve clinic moves to reorganize into the two-squadron construct of the Air Force Medical Reform model.[18] Additionally, a recommended second LOE is an extensive, and publicized, policy and resource review by MAJCOM commanders and the Surgeon General. The goal of this review is two-fold: to secure alignment between command team messaging and the ground-truth Airmen experience, and ensure that no Airmen who performs the desired behavior (help-seeking) is turned away from available resources. Pitch-perfect messaging cannot survive the cognitive dissonance such a situation would create.

Plan for Monitoring and Evaluation

The following outputs will be measured to assess implementation progress and when phase transition should be executed.

- Save Story videos produced and views
- Wingman Day construct and toolkit reported uses
- Number of co-located resilience clinics
- Additional clinicians and contractors hired

To assess the effectiveness of the campaign, the following outcomes will be measured through existing data aggregation processes and by a survey instrument:

- Decreased perception of mental health stigma
- Increased perceived self-efficacy in performing desired behaviors
- Increased Airmen contacts with resilience-related resources—for example, mental health clinic; primary care/flight medicine providers (where mental health referrals are made); military and family life consultant engagements (raw numbers only to maintain confidentiality); chaplain and religious affairs contacts (raw numbers only to maintain confidentiality); wingman engagements (conversations mentoring, and counseling related to mental health and resilience issues)
- Decreased suicide rate

Budget

Approximately $12,000 will be required for a save series video production by an Air Force Public Affairs Tier 1 production unit (i.e., the 2nd or 3rd Audiovisual Squadrons). Creating the Wingman Day organic construct and accompanying toolkit should not incur additional expenses. Developing Airman resilience clinics by co-locating the physical therapy and mental health clinics at each Air Force installation may incur additional costs in military construction depending on several factors. These factors include, but are not limited to, the timeline and plans for implementing the medical reform model (i.e., reorganization to the two- or three-squadron model), which may be leveraged as a preexisting effort, and the plans for the transition of services to the Defense Health Agency. Additional funding for assessing campaign outcomes may be required but is not expected to exceed $20,000.

Conclusion

At the time this article was written, the preponderance of suicide prevention messaging efforts has focused on increasing literacy—i.e., educating Airmen about suicidality; raising awareness of suicide prevention programs, helping agencies, and other resources; or providing command teams toolkits for prevention, intervention, and postvention.[19] However, research has shown messaging purposed toward knowledge-based objectives is not effective in increasing the likelihood a population will perform desired help-seeking behaviors to decrease suicides.[20] The most effective suicide prevention messaging drives attitude and behavior changes by

demonstrating help-seeking behaviors are highly valued by the community and the norm, easy to perform, and modeled by peers and aspirational figures.

Utilizing a phased social norms approach, the behavior change communication plan described in this article leverages the affective power of collected and disseminated "Save Story" testimonials from a diverse demographic of Total Force Airmen at the Air Force level in Phase 1. Following successful implementation of this initial phase, Phase 2 features a standardized Wingman Day construct designed to amplify the behavior change effort that, unlike previous downward-directed programs, enables command teams to organically source the content from within their formations, dramatically increasing its resonance with Airmen. The third and final phase may be initiated in parallel with Phase 2 and focuses on shaping the environment to remove barriers hindering the performance of help-seeking behaviors.

During the last 10–15 years, the Air Force has significantly invested in a robust array of suicide prevention programs, tools, and resources that, when utilized, are highly effective. However, issues persist in enhancing the likelihood of intervention—getting Airmen in crisis to those helping agencies and resources. While there are no panaceas, studies have shown that some methodologies are more effective in increasing the likelihood of intervention. A social norms approach to suicide prevention that employs a positive-themed, peer-to-peer messaging campaign to normalize help-seeking behaviors presents the best opportunity for success. As a human capital-centric strategy, the collective efficacy generated by successful implementation will drive increased engagement with AFMS resources and services. The resulting higher performance rates of sustainable, resilience-amplifying behaviors across the Total Force will enhance the capacity of the AFMS to deliver combat-ready Airmen in support of national military objectives. Suicide is the leading cause of death among Total Force Airmen.[21] Reframing the Air Force's suicide prevention strategy to engender long-term culture change will save lives and better preserve the force the nation needs. ✪

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Nuclear Authority: The IAEA and the Absolute Weapon by Robert L. Brown. Georgetown University Press, 247 pp.

Nuclear holocaust devastated the Japanese Empire at the conclusion of World War II, and the specter of even more cataclysmic super-bombs haunted the imagination of generations of Cold Warriors. Even today, the western world lives with anxiety over an unexpected nuclear attack in Eastern Europe from revanchist Russia, genocidal intentions on Israel by Iran, or an incomprehensible act by North Korea. Similarly, revisionist powers suspiciously view the US's overwhelming nuclear triad. In parallel, in the past 70 years, advanced economies under fewer international regulations enjoyed disproportionate benefits from nuclear technologies in a number of sectors such as medicine, agriculture, and electrical generation while states without mature nuclear programs lacked sufficient access to these technologies.

While masterworks like Henry Kissinger's *World Order* provide an overarching view of the post-World War II order, every security analyst should place a copy of Robert L. Brown's *Nuclear Authority* next to Kissinger's seminal work. In his debut book, Brown traces the history of international efforts to implement nuclear nonproliferation regimes while maintaining developing nations' access to peaceful technologies and details the motivations and obstacles of the international community to establish the International Atomic Energy Agency (IAEA). Throughout his work, Brown focuses on how the IAEA acquired the independent power to issue rules and make commands in some areas of nuclear policy and why states feel compelled to comply. Unique among many attempts at international oversight and governance, Brown details how the IAEA acquired power as a political authority, a power that arises out of the persistent demand for agency autonomy and the international community's continued willingness to cede authority.

To his credit, Brown provides a systematic analysis of the bases of power and authority within the international community while noting the nuances of each example within its historical context. His intellectually honest approach reinforces his thesis even as he candidly notes vulnerabilities within the IAEA and international governance. Brown succinctly organizes nuclear policy into four issue areas: nonproliferation, disarmament, safety and security, and the promotion of peaceful uses. Then, he overlays the different nuclear policy areas onto four distinct epochs within the IAEA's history: the birth of the IAEA (1945–61), the adolescence of the agency (1962–85), IAEA-challenged (1986–98), and nuclear authority (1998–2013). With this framework, the reader emerges with a developed understanding of how nuclear policy shaped the post-World War II order. Much more than a historical account, *Nuclear Authority* explores the development of how an international entity amassed controls authority over the nuclear policy arena.

Brown acknowledges the work's main limitation in the introduction. He clearly advertises his role as a political scientist—not a nuclear engineer. While the author provides references to leading technical authorities, the author approaches certain technical aspects from too shallow an angle. Specifically, a marginally more detailed description of enrichment technologies and process would provide readers greater context for current challenges such as Iran and the Joint Comprehensive Plan of Action.

Nuclear Authority's provision of context for the evolving nuclear tensions in the present day showcases the book's most immediate and profound aspect. With an understanding of the international framework, the security analyst better understands the impacts of Russia's doctrine of "escalate to de-escalate" and the US's withdrawal from the Intermediate-Range Nuclear Forces Treaty. These contemporary case studies provide salient examples of why the IAEA remains a critical agent within the international system. As nuclear deterrence theory evolves in the post-Cold War era, it is essential to examine which methods of bilateral, multilateral, private, and governmental agreements produce the greatest returns on investment.

Also, *Nuclear Authority* explores several unintended consequences from international cooperation. As a part of the grand bargain between the Nuclear Weapons States (NWS) and all other

states, the NWSs agreed to share peaceful-use technologies with aspiring countries via the IAEA. However, the author honestly juxtaposes the good intentions of enabling developing countries to benefit from nuclear power plants with the reality that technology sharing with North Korea and Iran laid the foundation for modern-day proliferation concerns.

In his conclusion, the author notes the utility of using the study of the IAEA as a general analysis of international frameworks, which may prove useful for future efforts in organizing international technology policy. While Russia and China continue to build new stockpiles of tactical nuclear weapons, an ever more frightening number of countries, commercial entities, and transnational criminal organizations continue to build new and more powerful cyber weapons capable of effects equivalent to large-scale nuclear attacks. Present-day technologists and policy researchers draw many parallels between the nuclear arms race and the pursuit of artificial intelligence (AI) development. Frequently, these researchers call for the establishment of an international organization with similar authorities to the IAEA to provide international governance for cyber and AI development. However, while many similarities exist between the AI arms race and the Cold War nuclear arms race, unresolvable differences exist. Those AI enthusiasts seeking to regulate the peaceful use of AI without unleashing the negative aspects of weaponization should examine many of the successful methods pursued by the IAEA as well as distill the lessons learned.

This well-organized and readable book equips the reader with a clear understanding of the IAEA's history and potential future as well as a crash course in international governmental policy development. *Nuclear Authority* constitutes mandatory reading for defense policy professionals, civilian energy analysts, and artificial intelligence researchers. In an era of increasing nationalism when many politicians challenge the value of international institutions such as the IAEA and the United Nations, senior leaders must articulate compelling narratives about the successes of the international community in establishing and maintaining the post-World War II order. Additionally, analysts at all levels of the establishment should remain cognizant of the deficiencies and limitations of existing institutions to address the obstacles faced by the IAEA and ensure that the demonstrated vulnerabilities and failures of the IAEA are not recreated in institutions currently under design to manage twenty-first-century challenges such as artificial intelligence governance.

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Women and Gender Perspectives in the Military: An International Comparison, edited by Robert Egnell and Mayesha Alam. Georgetown University Press, 270 pp.

The role of gender perspectives and women in the military is a critical but often glossed-over topic in security and defense. Robert Egnell and Mayesha Alam use a multipronged approach with chapters discussing the experience, status, and progress of women and gender perspectives in the military around the world: Sweden, the Netherlands, Canada, the US, the United Kingdom (UK), Israel, Australia, and South Africa. Additionally, the North Atlantic Treaty Organization (NATO) is featured in a chapter that champions the alliance's progress in integrating gender perspectives into the core institutional framework. These chapters range in scope, research methods, evidence, and target subjects but all focus on the central questions of how and why to advance the role of women and gender perspectives overall in the military. Together, they successfully uncover many of the common obstacles that women face in the military and the consequent challenges that states face in shifting the balance. This latter challenge, in particular, is often self-inflicted as many states demonstrate their lack of interest via absent funding or complacent leadership. They conclude by summing up lessons learned, considering different approaches, and cautioning against overgeneralizing any challenges or successes as the standard.

The title of Charlotte Isaksson's chapter "Two Steps Forward, One Step Back," may well be the rallying cry of the book—women and gender perspectives in the military are generally moving

forward, but progress is stubborn, stilted, and slow. The agenda is often reliant on the agency of motivated individuals or specific organizations such as NATO and seemingly falls dormant when these enlightened leaders move on or when political institutions change tack.

Discrimination, abuse, and access to combat roles rear their heads as the usual suspects plaguing female service members and directly degrading both retention and recruiting efforts. There is a discussion about whether the offenders are simply bad apples like any other organization might have or whether a rotten barrel is infecting previously equality-minded members. Women perceived themselves as held to different social and cultural standards. For example, obstacles that stand out include a British officer whose command officer rebuked her because "[his] wife would not behave like that" after her professional relationship with her senior noncommissioned officer was incorrectly interpreted to be sexual by her colleagues (p. 144). Even when women are included, they must still function according to hypermasculine military culture and norms, as *honorary blokes* or one of the guys, not as the professional female warriors they are. The respective action, or lack thereof, by direct supervisors, leadership or the military and political institutional responses is another common theme. In support of research on these experiential factors, several authors comment on the critical nature of leadership, to instill, model, and uphold cultural values of equality as Clare Burton argues that "discrimination issues are leadership issues first and foremost" (p. 191). In the all-too-common situation where "institutional commitment is more rhetorical than real," (p. 195) the desired progress is slow and inconsistently applied.

Despite the continuing frustration with the slow pace, lack of initiative, and entrenched cultural obstacles that stymie efforts toward gender perspective integration and equality, success has come in many forms. In the UK, women are not recognized indiscriminately by their male marine counterparts, but rather are "accepted as 'equivalents' [and] 'sisters'" (p. 145). These marines are appreciated for building capacities the unit previously could not provide. Elizabeth Kier and Robert J. MacCoun's research recognizes that the current military relies on members' professional skills to execute effective teamwork, meaning women do not have to share a social or gender background with male colleagues to be considered full team members. The Australian Defence Department (ADD) advocates that "diversity leads to better team decision making and therefore more effective operational capability" and therefore cannot rest on its laurels as an otherwise superior organization while lacking in gender equality and integration (p. 190). The drive to include women is not merely toward equality but more effective operations. In fact, the ADD's 2016 white paper specifically recognizes the need to continue forward motion on reforms because "gender equality and increasing female participation in the Defence workforce and in senior leadership roles is fundamental to achieving Defence capability now and into the future" (p. 192). NATO stands out as an organizational model, not completely transformed but institutionally committed to gender equality. The alliance went so far as to require potential NATO Headquarters to demonstrate necessary gender perspective integration capability and capacity before being certified operational. The South Africa chapter shows progress, bringing female participation to 14 percent of deployed peacekeepers and a quarter of the standing South African Defense Force (SADF). Additionally, targets such as 30 percent female participation in decision making at all levels of operations and peace keeping maintain a focus on gender perspectives. Other recommended improvements include Egnell's work, which is cited in the SADF chapter, advocating for gender advisor efforts to focus internally to enhance mission effectiveness. He advocates specifically focusing on female participation in operations execution, enhancing authority within the local community, and promulgating deeper cultural perspectives, will show that the internal gains significantly outweigh and outlast any efforts to employ gender equality values to increase local women's rights or community approval.

In focusing on women as a key factor for operational effectiveness, this diverse volume succeeds in championing a niche topic and brings it out of the realm of feminist theory where

anything gender-related is often relegated and into the more military-approachable area of security studies. The variety of sources, research, and individual authors meld well to show a unified position toward the critical nature of improving equality and employing gender perspectives with the goal of longer-lasting, more stable peace through better military and peace-building operations and more effective institutions.

Maj Caitlin Diffley, USAF

The Phantom Vietnam War: An F-4 Pilot's Combat over Laos by David R. "Buff" Honodel. University of North Texas Press, 2018, 307.

Lt Col David R. Honodel does more than just tell the war as it happened in *The Phantom Vietnam War*; he also adds a personal and engaging perspective with multiple unique points of his experiences fighting in Laos throughout his autobiography.

Honodel's goal with this work is to tell the story of his experiences in Laos, highlighting the fact that, even though the war was in Vietnam, pilots and equipment were lost in Laos. Although there are parts of the author's story that precede the assignment in Laos, and there is a chapter at the end that looks at some parts of his life following his first tour overseas, Honodel sticks to his originally stated intentions. His approach to writing a concise and focused personal Vietnam memoir is refreshing as other authors might focus only a small portion of their entire work on actual war experiences with the majority of the book about the rest of their lives. Honodel's perspective gives the book a good, in-depth look at a specific part of the war through the eyes of a single fighter pilot. This perspective also allows Honodel to focus on the interpersonal relationships, worldviews, and larger Air Force interactions that are sometimes found in other memoirs but often condensed or not fully explained.

One of the major strengths of this work is Honodel's focus on the loneliness of combat experience in Southeast Asia. His experience in the war was of a replacement pilot to his unit, knowing only a single pilot who was quickly placed in a different squadron. Although he was part of a team, he was an individual. The author reinforces the comradery of the unit and willingness to sacrifice oneself for brothers in combat that are part of most Southeast Asia fighter pilot perspectives. Yet Honodel keeps coming back to what was lacking in his assignment as a replacement pilot as compared to what he experienced in units before fighting overseas. This perspective on how he felt about fighting in the war bridges the gap for modern Airmen and Soldiers who can find themselves on random operations as individuals plugged into a unit overseas. The ability to bridge this generational divide is a phenomenon that can bring modern Airman and Vietnam veterans together on a very personal level.

Another refreshing perspective that continues throughout the book is an appreciation of tanker pilots and their willingness to support. In many stories captured in literature, tanker support to fighters is portrayed as rigid regarding rules and regulations on what, where, and how the tanker could support the fighters and bombers that went in and out of the hostile areas. However, Honodel often speaks fondly and offers gratitude to the tanker pilots who supported him and his fellow aviators during the year he was in the war. Through a few specific examples of where the tankers came in to help and saved him and his comrades, the reader gets a unique perspective on how the tanker support was more than just aircraft flying a racetrack pattern behind the line of battle.

Ultimately, everyone with interest in the war in Southeast Asia should read Honodel's account of his wartime experiences. Not only does *The Phantom Vietnam War* cover those subjects, the author also discusses leadership, comradery, and many other topics. The memoir is an easy read as the style, word choice, and narrative of the writer engage the reader throughout the work. Since Ho-

nodel does such a good job retelling his wartime experiences, this book should be a must-read for most people in and out of uniform.

Maj Richard P. Loesch III, USAF

Chief: My Journey Thru Iraq at the Peak of War by Scott H. Dearduff. Dearduff Consulting Agency, 2013, 376 pp.

CMSgt Scott H. Dearduff uses his memoir, *Chief: My Journey Thru Iraq at the Peak of War*, to present a detailed account of his time serving as the senior enlisted advisor to the 332nd Air Expeditionary Wing commander at Balad AB, Iraq. His tour, which began in July 2006 and ended in July 2007, was a time of increased combat operations and casualties that caused numerous leadership challenges that he describes throughout his book. From receiving notice of the deployment until his return home more than a year later, Dearduff holds little back while examining the professional and personal challenges he confronted. In doing so, he leaves his readers with a sense of fulfillment for the accomplishment of the Air Force mission and tragedy for the Airmen who fell in the line of duty.

Dearduff succeeds in his deliberate effort to relate to the reader several of the more personal stories of Airman and military members serving in Iraq that he feels are often overlooked by the media. He has the advantage of a unique perspective of Air Force operations given his extensive daily interactions with Airmen of all ranks—from Airman first class through general officer—and professions, from the support personnel who remained on base for the entirety of their tours to security personnel who frequently went beyond the wire. He offers descriptions of the various missions accomplished by pilots, aircrew, explosive ordinance disposal (EOD) Airmen, pararescuemen, special agents, medical staff, and various support functions, using his position to help his reader understand how these various elements worked together in a challenging combat environment. Indeed, the author's deep appreciation for the work of special agents, pararescuemen, security forces personnel, and EOD personnel is ever apparent throughout the book as he details his frequent interactions with them and efforts to ensure these Airmen have sufficient resources to accomplish their objectives.

Throughout the book, Dearduff describes his passionate efforts to honor fallen Airmen, 13 of whom were killed during his tour. Several of the stories Dearduff tells, including those of EOD Capt Kermit Evans and F-16 pilot Maj Troy "Trojan" Gilbert, will be familiar to readers having been extensively covered in media and other accounts of the Iraq War. He offers moving accounts of both officers and other fallen Airmen based on his personal interactions with the fallen Airmen themselves and their units. In doing so, the author gives his readers a brutally honest understanding of the sacrifices that many Airmen are called upon to make in combat zones, the emotions their comrades experience over their losses, and the need to quickly return to work despite significant emotional challenges. He follows these themes through to the final entry of this book, dated 19 December 2016, when he writes a rather detailed and moving account of the internment of Major Gilbert's remains at Arlington National Cemetery. Without a doubt, this account will leave the reader with a sense of tragedy and closure.

Several times, Dearduff focuses on matters of discipline that may strike some readers, both with and without military experience, as rather petty. One example is when he describes his interactions at the dining facility with two female Airmen from the medical group who are not wearing their physical training uniforms properly, drawing a conclusion that they may not be following the standards of their immunization clinic if they are not following the standards of uniform wear. This encounter so troubles him that he chooses to eat his meal in his own quarters instead of with his Airmen in the dining facility (pp. 111–12). The reader may be left wondering why Dearduff

dwells on several of these minor details given the more immediate threats to the lives of Airmen that he worked to mitigate on a daily basis.

Another shortcoming of the book is that Dearduff often refers to important discussions and events in passing without describing their significance and consequences in greater analytical detail, depriving the reader of more extensive insights that he certainly has to offer. For example, he describes morale and leadership challenges he encounters while visiting Airmen at a forward operating base on 14 May 2007 but does not engage in an assessment of what these challenges could be attributed to (pp. 238–41). His insights into such challenges would be interesting to readers who face similar scenarios in their own careers.

Despite minor shortcomings, Dearduff's memoir is an engaging read for those interested in the operations of an air base during war from a senior enlisted member's point of view. Given his experience with Airmen of all ranks and backgrounds, Dearduff offers a more nuanced approach of the Air Force mission than many accounts in the media or memoirs by junior enlisted and officers of all ranks who focus on specific missions without placing them in a broader context. Many accounts of the modern USAF focus on specific communities and operations without necessarily focusing on a larger picture of how these various functions cooperate in a deployed environment to accomplish their collective missions. Dearduff successfully reminds his readers of the necessary cooperation across career fields, both operational and support, that ensures the success of the US Air Force.

Capt Herman B. Reinhold, USAF

Come Fly with Us: NASA's Payload Specialist Program by Melvin Croft and John Youskauskas. University of Nebraska Press, 2019, 457 pp.

The Air Force ROTC Detachment 365 at the Massachusetts Institute of Technology (MIT) that I joined in the fall of 1981 as a freshman cadet was filled with aspiring astronauts. Having been inspired by the Apollo missions during elementary school and with the first flight of the space shuttle completed a few months before, it seemed like we were in the perfect time and place to achieve our dreams. Not only was the National Aeronautics and Space Administration (NASA) growing its ranks of pilot and mission specialist astronauts, but a new kind of crewmember—the payload specialist—appeared. Typically, these payload specialists would be researchers who personally would conduct their experiments in orbit. One of MIT's own—Byron Lichtenberg—would be one of the first two payload specialists to fly on the inaugural Spacelab mission. And in the ranks of the cadets, a new acronym caught our imagination: MSE, which stood for manned spaceflight engineer. MSEs were USAF officers who would fly in space as payload specialists on military missions.

Come Fly with Us fills an important gap in the growing literature on the space shuttle program, by telling the story of the payload specialists. Before the space shuttle, the American astronaut corps was staffed by a small number of pilots, all either active duty military or with a military background. Two classes of scientist-astronauts were chosen in 1965 and 1967, but only one scientist-astronaut flew on Apollo and three on Skylab. The space shuttle promised routine access to space with the need and ability to fly a broader of range of crewmembers. As well as pilots, NASA would employ mission specialists who would focus on tasks such as payload deployment, manipulator arm operation, and extravehicular activity (space walks). The space shuttle would be large enough to bring along payload specialists, who would come from organizations conducting research on missions but not be career NASA astronauts. Based on NASA archives, the authors trace the genesis and development of the payload specialist concept. Payload specialists were closely connected to the Spacelab research modules that flew in the payload bay of the space shuttle orbiter. Given that the NASA Johnson Space Center owned the astronauts, but Spacelab was a primarily European program with the NASA Marshall Space Flight Center with American responsibility for the Spacelab program,

the concept of payload specialists became a major source of contention between the NASA centers. Many at the NASA Johnson Space Center questioned the need for payload specialists, arguing that mission specialists tended to have similar academic backgrounds and could do anything that a payload specialist could do. This was more than just a theoretical argument; payload specialists would occupy precious seats on flights that NASA's new mission specialists coveted.

Ultimately the payload specialist program moved forward, and payload specialists would fly on missions between 1983 and 2003. Three would die on the two space shuttle tragedies. As well as researchers and two MSEs, the roster of flown payload specialists would include a teacher, politicians, and various foreign guests. The most famous payload specialist was John Glenn, the first American astronaut to orbit Earth. Later a senator, Glenn used the considerable influence of his position to obtain a seat on the space shuttle, and at 77, became the oldest person to fly in outer space. While NASA mission specialists may have generally resented payload specialists as a class, the individual crews welcomed their assigned payload specialists who contributed to the success of their missions.

Come Fly with Us is a deeply researched and well-written account of the payload specialist program and its origins, the individuals who served in that role, and the missions on which they flew. As well as making excellent use of NASA archives, the authors conducted extensive interviews, including many with payload specialists. NASA has no plans to fly payload specialists on its upcoming Orion spacecraft. The MSE program appears to have been the end of the military man-in-space aspirations previously seen on the aborted X-20 DynaSoar and Manned Orbital Laboratory programs. But with commercial space flight on the horizon, the payload specialists who flew on the space shuttle may come to be seen as the first of the nonprofessional space flyers.

Kenneth P. Katz

Global Defense Procurement and the F-35 Joint Strike Fighter by Bert Chapman. Palgrave Macmillan, 2019, 396 pp.

The F-35 Joint Strike Fighter plays an important and still developing role in the intersecting fields of aviation, defense investment, coalition dynamics, and military history. The complexity of the program—twice the economic size of the US manned lunar program of the 1960s—contributes to the importance of understanding the F-35 while it simultaneously adds to the challenge of doing so. Bert Chapman should be commended for providing an effective and informative look at the program and its US and overseas procurement.

The book's structure brings coherence to a complicated topic. The first chapters provide context about where the F-35 fits in a larger trajectory of aviation development and describe potential aerospace threats with which the F-35's designers recognized their platform might need to contend. Subsequent chapters examine US experiences, dealing with Australia, Canada, and the United Kingdom (UK) in turn. The author reserves two chapters for a study of various North Atlantic Treaty Organization and other friendly states and their purchase or consideration of the F-35.

Frequently touted as a "fifth-generation fighter," the position of the F-35 is clarified by the synopsis Chapman presents regarding the first four generations of jet fighter technology, spanning from World War II to the 1990s. Concise information about peers includes views of the army and naval air components of the People's Republic of China (PRC) that are expected to possess more than 2,500 aircraft. Chapman also includes a preponderance of highly maneuverable fourth-generation platforms, the status and posture of Russia's air forces, and the inventories of Iran and North Korea with considerable numbers of legacy platforms in their air forces that are bolstered by ballistic missile forces.

A key point in understanding F-35 procurement is that, on the international stage, it is, from a practical standpoint, the only fifth-generation game in town. As a joint strike platform, the F-35

originated in the belief that commonalities among Air Force, Naval, and Marine platforms would deliver important economic and logistical efficiencies. The same concept had propelled defense department advocacy of the F-111, a third-generation jet burdened by cost overruns and development complications, during the 1960s. The F-22 Raptor, also a fifth-generation fighter, is expressly excluded from export beyond the US. Aircraft like the PRC's J-31 and possibly Russia's Su-35 are suspected of having drawn on exfiltrated information about the F-35; thus, the countries that produce potential fifth-generation peers are the same countries whose air activities spark overseas interest in a fifth-generation platform in the first place.

Consolidation of the aerospace industry in the 1990s narrowed the field of potential developers and contenders for contracts. The decade following the end of the Cold War witnessed the elimination, by purchase or merger, of half a dozen of the leading companies in the US market to leave Lockheed Martin and Boeing as the sole "credible combat air fighter contractors" (p. 17). Chapman makes clear that expanding the domestic industrial base would be a prerequisite for the emergence of competitor platforms and the potential cost advantages that might emanate as a result.

That absence of competition, coupled with the degree of superiority envisioned for the F-35 relative to other platforms, explain the rising cost curve in the F-35 development. Those factors combine with ongoing security issues and with the advancing age of the fleets of aircraft such as the F-15, F-16, and F-18 used by the US and partner nations, to explain the pattern of reluctance to abandon the program in favor of an alternative. Platforms like the Eurofighter Typhoon or the improved Saab Gripen reportedly cannot match the performance of the F-35 and are only debatably eligible for consideration as alternatives. While the F-35 is not the first program to encounter cost overruns or delays, both have been substantial. The geographic and political dispersal of contracts connected to the F-35 also reportedly insulates the program from potentially dire effects of criticism and controversy in the US, Canada, the UK, and elsewhere involved in sourcing or fabrication.

Although Australia, Canada, and the UK are notable important participants in the program and the FACO plant at Cameri, Italy helped assemble the plane, Israel and Italy became the first non-US countries to receive F-35 deliveries, in December 2016. The first Japanese assembly at FACO followed suit seven months later, and the first combat use of the plane occurred in May 2018 when an Israeli Air Force F-35 struck Hezbollah targets in Lebanon. For Japan, as for Canada and other partners and customers, mounting numbers of foreign sorties threatening national airspace points to the requirement for up-to-date fighter aircraft. Across all the countries Chapman examines, a common theme emerges, in which rising cost, developmental challenges, and delivery delays spark controversy and criticism, but the F-35 generally remains the only viable fifth-generation option.

The double-edged sword regarding any work examining current events is that while, on the one hand, its currency underlines its relevance, the inevitable processes involved in undertaking and disseminating such a study require time in which dynamics may be altered, and landmark events may be overtaken by other events. In several places, Chapman works to gird his book against such problems, such as by commenting on how the likely alternatives of upcoming parliamentary contests in partner or client nations might shape future interest and engagement with the program.

For readers interested in current defense procurement and students of airpower history broadly, *Global Defense Procurement* is a valuable and accessible resource. It is not the first study of post-Cold War military aircraft procurement to point to the value of an expanded industrial base, and

it will probably not be the last. But it is a worthwhile and effective study pointing to the parallel conversations about the F-35 that take place in the US and among its allies.

Nicholas Michael Sambaluk, PhD

"Radar Contact!" The Beginnings of Army Air Forces Radar and Fighter Control by Randall DeGering. Air University Press, 2018, 96 pp.

"Radar Contact!" is the lost history of air control and a seminal piece for students and leaders of airpower. It is the authoritative untold history of how air superiority came of age. At the dawn of World War II, dire circumstances drove brilliant men and women to accelerate the technological development of radar and radio and conceive innovative organizations and procedures to revolutionize air superiority. In this Air University Press book, Randall DeGering competently and thoroughly summarizes the people, organizations, technology, and milestones that connect early experiments to the decisive asymmetric advantage that saved Britain from invasion and set the stage for the Allied reversal of Axis momentum. This telling is a welcome addition to airpower heritage and is rich with a perspective that is as useful in considering contemporary airpower challenges as it is informative to historic analysis.

DeGering is both a competent and informed writer. The work is the public culmination of years of research into the history of command and control of the air and rests on the credibility of the Air Force Historical Agency and Air University. As a retired air battle manager, the author was a career practitioner of systems directly descended from those described in the book. That perspective enables a precise and prioritized survey that succinctly fits years of rapid advancements into less than a hundred pages.

The book is short and light enough to be an accessible casual read while being dense enough to serve as a go-to reference. The writing is professional but not dry. He quantifies staggering stakes and describes dramatic battles, allowing readers to engage their imaginations despite an emphasis on facts and an academic tone. It is well-organized, making it easy for researchers to navigate and enabling casual readers to skip technical descriptions without losing track of the narrative. Uniquely, the author methodically emphasizes the evolution of the language of air tactics, still in use today. This feature adds flavor to the book and context to words Airmen take for granted every day, including *scramble*, *bandit*, *tally*, and the titular *radar contact*.

DeGering is diligently objective and states no explicit thesis, but the implications of the narrative are obvious. The Battle of Britain would have been lost without the Chain Home air defense system. The potential of airpower was maximized not by an improved airplane but through technological and tactical innovations in surveillance, control, and communications.

It's a logical conclusion. The Luftwaffe had greater numbers, superior aircraft, more experienced pilots, and the advantage of the offense. Yet the Royal Air Force (RAF) was victorious. The RAF's asymmetric advantage was the combination of radar, controllers, and radios that formed the Chain Home air defense system. The efficacy of Chain Home so frustrated the Axis that they indefinitely postponed their invasion of Britain. When Winston Churchill famously acknowledged the debt of "so many," the "so few" weren't just the heroic Commonwealth pilots but also included the pioneers who developed, fielded, and employed the world's first integrated air defense system.

This is not just a history lesson. Despite all its new tools, the modern theater air control system would be fundamentally recognizable to a World War II ground-controlled interception controller. Surveillance, communications, and control networks are still essential enablers and potent force multipliers for air operations. Those who can accurately perceive, rapidly decide, and reliably communicate through the air domain have an overwhelming advantage over those who cannot and a competitive advantage over those who do so, but poorly. This concept is foundational to air superiority, yet typically assumed instead of deliberately planned.

Surveillance, control, and communication systems enable an air component to mass and maneuver as a unified whole. Capability improvements in control systems generally have a greater impact on operational performance and strategic outcomes of the force than investments in the lethality or survivability of individual weapons systems.

These lessons from the Second World War are still relevant today. Technology has not yet reliably overcome the physical and physiological challenges of distance and span of control that require intermediate decision-making support between the commander and cockpit. Yet vital integrating capabilities such as the netting of existing sensors, machine assistants for battle management, and local airborne Internet Protocol networking, and defensive systems for the platforms required to host them continue to be misunderstood, irregularly advocated, and underfunded.

"Radar Contact!" fills a gap in the origin story of the US Air Force and illustrates the foundations underpinning airpower as we know it. DeGering explains that it was the combination of airplanes, radars, radios, and innovative Airmen that made airpower potent enough to be independent. It reveals truths and heroes oft-forgotten and is thus both pertinent and potent as the Air Force struggles with issues of identity and innovation, culture, and modernization. Every Airman, especially every rated officer, should read and reference this seminal work.

Lt Col Gerrit H. Dalman, USAF