Beyond the Air Domain: Battle Management in Space Operations

BY

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The undersigned certify that this thesis meets masters-level standards of research, argumentation, and expression.

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The conclusion and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

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ABSTRACT

This study aims to show that a new control system is necessary for space battle management in light of the recent development of counter-space capabilities by competitors of the US. By studying the history of both air and space domain control, the paper seeks to show how contextual development impacted “control” in each domain. Next, by studying current air and space doctrine, the text highlights missing guidance for future contested space operations when compared to the more extensive set of air operations documentation. It next examines the air domain control architecture, known as the Theater Air Control System (TACS) through a series of case studies. The first case study outlines the decentralized nature of TACS and its ability to sectorize airspace to handle large volumes of tactical engagements. The second case study distills the value of having TACS sensors and procedures in place before the start of a conflict. Otherwise, fog and friction inevitably occur trying to integrate new systems during war. The third case study empirically displays the value of a tactical battle management system by showing gains in combat effectiveness with TACS missing and then in-place. The paper concludes with recommendations for a future space battle management construct modeled on the doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) framework as defined by the Joint Capabilities Integration and Development System (JCIDS) process. The result aims for a space control system organized, trained, and equipped to provide core battle management competencies and core functions analogous to the Theater Air Control System.

CONTENTS

Illustrations

Chapter 1

Introduction

Conflict will likely move into space. If it does move into space, our job will be the same as it is in any other domain: to deter that conflict…but if it does happen, to figure out how to fight it, and win.

-General John E. Hyten,
Commander US Strategic Command

The US is heavily reliant on an array of satellite constellations and the capabilities they provide. There are other countries, however, such as China and Russia, which have been reported to be actively pursuing counter-space capabilities. The vulnerability of strategic US assets and the US' current inability to dynamically manage these assets presents a challenge for the US.[1] US senior leaders have publicly warned of the dangers posed by the current asymmetry between US space dependencies and growing threats.[2] Given the potential vulnerability of today's space systems, would-be adversaries consider US satellite constellations to be soft targets.[3] Fielding a space battle management capability focused on tactical-level control would reduce US vulnerability and increase deterrence of space aggression.

Current space battle management architecture is oriented to support operational-level centers such as the 614 Air Operations Center, known as the Joint Space Operations Center (JSpOC) and the National Space Defense Center (NSDC).[4] At units underneath these operations centers, mission crews comprised of captains, sergeants, and airmen attempt to act tactically against the growing threat, without a supportive network to inform their efforts, such as a common operating picture or a tactical command and control (TAC C2) system. These mission crews must fight without a means to develop battlespace awareness of friendly and enemy actions. They must also contend with a cold-war legacy command and control system that often cannot provide timely direction, provides limited redundancy, and centralizes execution at the JSpOC.

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[1] Sinclair, Harriett. "Russia And China Are Building Space Weapons To Target America, U.S. General Says." Newsweek, December 3, 2017. http://www.newsweek.com/russia-and-china-are-building-space-weapons-target-america-us-general-says-729779.

[2] Shelton, William. Threats to Space Assets and Implications for Homeland Security, § House Armed Services Committee (2017).

[3] Liang, Qiao, and Wang Xiangsui. Unrestricted Warfare. Beijing: PLA Literature and Arts Publishing House, 1999.

[4] The JSpOC also has a role in tactical C2 of electronic warfare for the 4th Space Control Squadron. See areas for future study for more regarding EW integration

Principally the current architecture has a limited ability to surveil adversaries, share information, communicate amongst crews, and control forces in a decentralized, tactically relevant time-frame.[5] These deficiencies become stark when one compares the support aircrews receive via the theater air control system to what little space crews obtain.

As the menace of war extending into space becomes increasingly plausible; the US must be prepared to defensively defeat threats and possibly gain space domain control in critical orbits or regions above the earth. Fundamentally, the US must have a space tactical battle management system that can reduce the complexity inherent in today's conflicts, and it must do so for the operations crews manning satellites and radars, not just to leadership within the AOC and above.

Battle Management

Battle Management is defined as "the management of activities within the operational environment based on the commands, direction, and guidance given by appropriate authority."[6] Applying the definition above into practice, battle management results in a continuum of control between the commander down through operational and tactical echelons of command, ending in the cockpit or at the console of individual crews. *Tactical* battle management, the missing piece in space operations, is the controlling concept for assigned forces within a battle management area (BMA). Typically, in the air domain, this role is fulfilled by tactical command and control, or TAC C2. The TAC C2 role falls to aircraft and ground units specially configured to surveil the BMA, build awareness, and communicate up and down echelon.[7] TAC C2 often has the authority required to direct forces to meet a commander's intent and efficiently direct friendly systems to a location at a time to most effectively attack a target, defeat a threat, or to protect friendly assets.[8]

Effective battle management requires an accurate assessment of enemy actions and intentions, the ability to monitor the domain and direct friendly forces. This ability to connect commander's intent to tactical action is essential.

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[5] Maj Card, "Decentralizing Command and Control of Space Operations."
[6] Joint Staff, "JP 1-02 DoD Dictonary of Military and Associated Terms," 23.
[7] Docauer, "Peeling the Onion: Why Centralized Control/Decentralized Execution Works," 5.
[8] Lt Col Conine, "Future Considerations of BMC2. BMC2 Must Be Both Horizontally and Vertically Integrated to Maximize Information Exchange and Fusion."

For space operations, a tactical battle management system is necessary to ensure units operating satellites on-orbit or manning ground-based sensors are collectively working as a team and aware of what is around them. From this situational awareness, crews and the TAC C2 system will work together to determine the best course of action to achieve a commander's intent or defeat threats. To create such a system within the space domain will demand new organizations, training, equipment, and personnel as well as breaking down the old space control doctrine that holds authorities at the operational level or higher.

The USAF, the service with the preponderance of military space assets, has the lead in developing the future space battle management (SBM) construct.[9] Since its inception in 1947, the USAF has a long history of battle management within the air domain. The tactical battle management system has evolved over decades of aerial combat. The Theater Air Control System (TACS) was the result of this iteration. As Eliot Cohen and his team discerned in the Gulf War Air Power Survey, "the [Theater] Air Control System was the constructed organization that was comprised of trained personnel, equipment, and coordinated activities that resulted in an ability to communicate, analyze, and decide to provide command and control to theater-level airpower." [10] TACS was built to respond to large-scale and fluid battles in which decision-making must occur at the lowest level of command to ensure adequate agility and response in time and function.[11] TACS supports operational commanders and, *most importantly,* front-line units and crews.

The USAF must build upon this institutional bedrock and transition Air Force Space Command (AFSPC) to an operations concept necessary to provide tactical battle management for mission crews in the newly aggressive space domain. The complexities of modern combat require support from tactical command and control, namely by building battlespace awareness and timely direction to space mission crews to defeat aggression or attack adversary

[9] Gruss, Mike. "House Panel Wants More Details on New Space Battle Management System." SpaceNews.com, April 25, 2016. http://spacenews.com/house-panel-wants-more-details-on-new-space-battle-management-system/.
[10] Cohen, Dr. Eliot. "Gulf War Air Power Survey:" 1, no. 1 (February 1993).
[11] Docauer, "Peeling the Onion: Why Centralized Control/Decentralized Execution Works," 9.

systems. How then should the USAF construct a space battle management structure to support tactical level forces?

Space Capabilities and Threats

To understand the current state of the space domain, it is necessary to discuss the physics in play. Satellites orbit the earth within the bounds set by Keplerian and Newtonian motion. Orbits are generally categorized as low earth (LEO), medium earth (MEO), geosynchronous (GEO), or highly elliptical orbit (HEO). Once separated from the launch vehicle, satellites are mostly locked into a kind of perpetual free-fall, known as an orbit. The amount of fuel stored onboard constrains the satellites' ability to alter its altitude even slightly. Even more, fuel is needed to modify a satellite's latitude or orbital inclination. Thus, with a few exceptions, satellites are limited in their maneuverability.[12] Each of the orbits provides essential attributes for the specific mission-types of payloads on orbit. Figure 1 below visualizes the most oft-used orbits, with an example of mission-type and orbital characteristics.

[12] Joint Staff. "JP3-14, Space Operations." US Department of Defense, May 29, 2013.

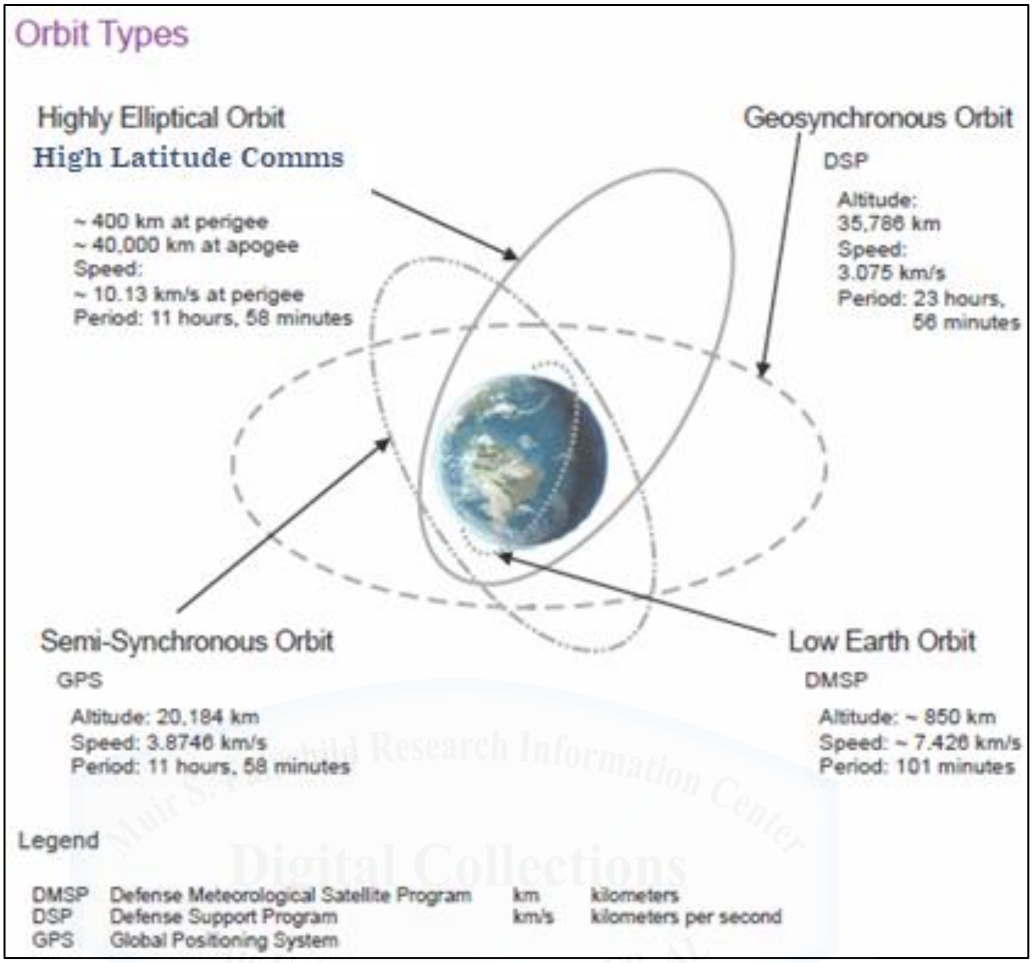

Figure 1, Typical Orbits
Source: JP 3-14, Joint Space Operations

From these orbital vantage points, the US has deployed numerous assets to provide a wealth of capabilities to today's expeditionary forces. Examples of US systems on-orbit include global communications; positioning, navigation, and timing (PNT); services; environmental monitoring; space-based intelligence, surveillance, and reconnaissance (ISR); and early warning. These services reside within the DoD, the intelligence community, and, increasingly, the commercial sector. Business entrants into the market include remote sensing systems like XpressSAR's radar-imaging Synthetic Aperture Radar (SAR) and DigitalGlobe's GeoEye Electro-Optical system.[13] New ground-based systems include space

[13] Germroth, David S., 2016 in Features, and Spring 2016. "Commercial SAR Comes to the U.S. (Finally!) | Apogeo Spatial." Accessed January 27, 2018. http://apogeospatial.com/commercial-sar-comes-to-the-u-s-finally/.

situational awareness abilities such as LeoLab's phased array radar in Alaska.[14] US military assets deployed worldwide can see over the next hill and communicate with virtually anyone else on the globe while also knowing their precise location, local time, and weather forecast because of space-based capabilities. Because of the exquisite enabling effects of these spacecraft, adversaries are forgiven for looking for ways to defeat or degrade them. Geopolitical rivals have taken that charge, and conflict in space, once a cold-war fear inexorably linked to nuclear Armageddon, is no longer a fantasy.

High-level US government officials are sounding the alarm that the space domain is increasingly contested.[15] Multiple adversaries are fielding a series of capabilities to hold almost any US space systems at risk. The threats include reversible (meaning non-permanent) means such as electromagnetic interference, jamming, and cyber-attacks.[16] Threats encompass destructive means as well, such as direct ascent anti-satellite missiles, co-orbital anti-satellite systems and soon, ground-based lasers or high-powered microwave systems.[17] Underlying all of these active space control systems is an increasingly sophisticated space surveillance and tracking system to provide orbital data and targeting to the weapon systems.[18] The summary of the 2018 US National Defense Strategy (NDS) outlines the fact that space is again no longer a sanctuary and the era of peer competition is back.[19] Adversaries are increasingly likely to extend the next conflict into space to deter or degrade US conventional capability.[20]

As the military use of space pivoted from supporting the nuclear enterprise to supporting conventional military forces, competitors began to procure counter-space capabilities to threaten US reliance on these satellites.

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[14] Russell, "LeoLabs, Planet Collaborate on Stewardship Model for LEO."
[15] Sinclair, Harrett. "Russia And China Are Building Space Weapons To Target America, U.S. General Says." Newsweek, December 3, 2017. http://www.newsweek.com/russia-and-china-are-building-space-weapons-target-america-us-general-says-729779.
[16] For a cyber example, all Telemetry, Tracking, and Command systems rely on software and computers to communicate with the satellite. A nefarious actor may attempt to hijack the TT&C link and upload rogue software onto satellites. See http://www.australianscience.com.au/technology/satellite-hacking-a-closer-look-to-the-sky/ for a synopsis.
[17] Shelton, William. Threats to Space Assets and Implications for Homeland Security, § House Armed Services Committee (2017). & Lt Gen Raymond, Jay. Statement Of Lieutenant General John W. Raymond Commander JFCC-Space On Fiscal Year 2016 Budget Request For Space Programs, § House Armed Svcs Subcommittee on Strategic Forces (2015).
[18] Weeden, Brian. Global Space Situational Awareness Sensors, 2010.
[19] Mattis, Jim. "Summary of the 2018 National Defense Strategy," n.d., 14.
[20] Harrison, Johnson, and Roberts, "Space Threat Assessment 2018," 25.

The wake-up call to that effort arrived in January 2007, as the People's Republic of China (PRC) operationally tested a new direct-ascent anti-satellite (DA-ASAT) system against an orbiting defunct weather satellite.[21] Once fielded in sufficient numbers, a LEO DA-ASAT unit can hold significant US and allied capability at risk. Although, such a system is generally limited to engaging targets overflying a country's territory.[22] If an aggressor nation sought to obliterate a constellation, it would thus require hours or days to execute due to overflight time of the LEO spacecraft as they passed through the threat envelope.[17] For example, a notional engagement between a sun-synchronous space situational awareness (SSA) satellite, Sapphire, and a notional launch point has limited opportunities. Only two passes during a 24-hour period take the spacecraft within the horizon limits of the site.[23] Furthermore, these two particular intercepts would occur in the daylight, requiring radar tracking by both ground-based sites and by the kill-vehicle itself. The sun would likely blind any optical or infrared (IR) seekers attempting to discriminate the satellite.[24] Additionally, a LEO-capable missile would only be able to hold objects orbiting near earth at risk, not constellations such as GPS or missile warning systems that orbit much higher. While a low earth orbit direct ascent ASAT capability is worrisome, due to its limitations, competitors have determined that an integrated approach across multiple orbital regimes is necessary.

More worrisome are threats at GEO due to the stability of the orbit and persistence in the field of view (FOV) of ground sites within an opponent's territory. The physics limitations are somewhat more straightforward from the perspective of finding and fixing the target satellite. Historically, GEO had been seen as less at-risk from direct ascent type weapons due to the distances involved. A suspected 2013 Chinese direct ascent test from Xichang, however, showed a previously unseen capability to loft a suborbital payload near a GEO altitude.[25] The expected flight time for this type of system to intercept an object

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[21] Weeden, Brian. "2007 Chinese Anti-Satellite Test Fact Sheet." Secure World Foundation, November 23, 2010.
[22]Sankaran, Jaganath. "Limits of the Chinese Antisatellite Threat to the United States." Strategic Studies Quarterly 8, no. 4 (2014). P6.
[23] Author determined line of sight and orbital passes with JSatTrack software. See Appendix A Figure A and B for visualization
[24] Baird, "Maintaining Space Situational Awareness and Taking It to the Next Level," 62.
[25] Wright, David. "How High Did China's May 2013 Launch Go?" All Things Nuclear, March 13, 2014. https://allthingsnuclear.org/dwright/how-high-did-chinas-may-2013-launch-go.

at GEO is approximately 5-7 hours.[26] Mapping the trajectory of the test launch and the closure area of the falling rocket body, it seems likely this potential system puts systems within the Indo-China equatorial plane at risk.[27] Within this plane sits a large number of US, allied, and commercial payloads supporting the western Pacific and Indian Oceans. The longer reach GEO ASAT does operate under constraints, similar to the LEO version as well. Since direct ascent ASAT is a suborbital capability, a kill-vehicle would only have one potential engagement window before it reached apogee and began returning to earth, making these direct ascent systems somewhat one-shot dangers.

Risks to space systems are not limited to direct ascent attack, however. Other threats, including co-orbital kinetic or electronic attack ASATs, are also feasible within the GEO belt.[28] As noted previously, because of the orbital characteristics of satellites at this altitude, co-orbital engagements, or Rendezvous and Proximity Operations (RPOs) can occur under persistent control of one ground station and engage a target operating under predictable maneuver characteristics. The consistent fixed point in the sky mitigates logistical and communications requirements necessary to attack a GEO target compared to LEO ones. Threats may have been emplaced much earlier or may detach from mother satellites nearby, complicating indications and warnings compared to the urgency of a fiery plume of an ASAT launch from the surface of the earth.[29] Additionally, co-orbital ASATs have the benefit of persistence. They will remain in orbit in the case of a “miss” or engagement abort, unlike the fleeting encroachment of the ASAT’s kill vehicle. This potential slow differential velocity could also allow for lower-than-catastrophic or less-than-kinetic engagements. For example, co-orbital threats may snap off necessary equipment with grappler arms, nudge a satellite out of its desired orbit, or spray paint on vital solar cells. These types of threats also plausibly lower the threshold for use since they would not create large-scale debris clouds that

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[26] Weeden, Brian. “The Space Review: Through a Glass, Darkly: Chinese, American, and Russian Anti-Satellite Testing in Space (Page 1).” The Space Review, March 17, 2014.
[27] Weeden, “The Space Review: Through a Glass, Darkly: Chinese, American, and Russian Anti-Satellite Testing in Space (Page 1),” 20.
[28] Kattan, Ari, Tasia Paraskevopoulos, Brian Rose, and Maya Sharma. “Russian and Chinese ASAT Capabilities in Geosynchronous Earth Orbit: Threats and Responses,” n.d. p15
[29] Attan, Ari, Tasia Paraskevopoulos, Brian Rose, and Maya Sharma. “Russian and Chinese ASAT Capabilities in Geosynchronous Earth Orbit: Threats and Responses,” n.d. p15

would undermine the GEO belt above the adversary and invite international condemnation.

Other non-kinetic means of disabling or degrading satellites are also possible. Laser dazzling of optical sensors or degradation of the focal plane array are worrisome threats. Electronic attack (EA) via jamming or spoofing of either the uplink or downlink have also been theorized or developed.[22] A co-orbital ASAT may transmit high-powered microwaves into a satellite bus from a nearby station-keeping location, degrading or destroying delicate electronics within the target satellite.[30] All told, there are multiple mechanisms to disrupt, degrade, deceive or destroy spacecraft.

The threat is not theoretical. The US has seen concerted efforts by countries that seek to degrade US conventional advantages by having the capability to attack space systems. The Honorable Dan Coats, Director of National Intelligence, during his testimony to the Senate Select Committee on Intelligence, gave this testimony outlining the US Intelligence Committee's unclassified assessment:

> Both Russia and China continue to pursue antisatellite (ASAT) weapons as a means to reduce US and allied military effectiveness. Russia and China aim to have nondestructive and destructive counterspace weapons available for use during a potential future conflict. We assess that, if a future conflict were to occur involving Russia or China, either country would justify attacks against US and allied satellites as necessary to offset any perceived US military advantage derived from military, civil, or commercial space systems. Military reforms in both countries in the past few years indicate an increased focus on establishing operational forces designed to integrate attacks against space systems and services with military operations in other domains.
>
> Russian and Chinese destructive ASAT weapons probably will reach initial operational capability in the next few years. China's PLA has formed military units and begun initial operational training with counterspace capabilities that it has been developing, such as ground-launched ASAT missiles. Russia probably has a similar class of system in development. Both countries are also advancing directed-energy weapons technologies for the purpose of fielding ASAT weapons that could blind or damage sensitive space-based optical sensors, such as those used for remote sensing or missile defense.

[30] Wright, David, Laura Grego, and Lisbeth Gronlund. "The Physics of Space Security." A Reference Manual. Cambridge: American Academy of Arts and Sciences, 2005. p143

> Of particular concern, Russia and China continue to launch "experimental" satellites that conduct sophisticated on-orbit activities, at least some of which are intended to advance counterspace capabilities. Some technologies with peaceful applications—such as satellite inspection, refueling, and repair—can also be used against adversary spacecraft.
>
> Russia and China continue to publicly and diplomatically promote international agreements on the non-weaponization of space and "no first placement" of weapons in space. However, many classes of weapons would not be addressed by such proposals, allowing them to continue their pursuit of space warfare capabilities while publicly maintaining that space must be a peaceful domain.[31]

Given that the risk to US space capabilities is real and evolving, coupled with the difficulty of operating within the space domain, there exists a definite necessity to re-configure US space battle management systems. The goal is to be able to address the threats by shortening the time between observing an action, orienting US forces, deciding on a defensive or offensive course of action, and then acting within a tactically relevant time-frame.[32]

Purpose

The purpose of this research paper is to help identify what structure implements a Space Battle Management Command and Control (SBMC2) system that may help defeat recently developed competitor threats. The system must focus between the current operational-level of war C2 system and tactical units and enable a capability to inform and direct mission crews operating satellites and ground-stations in light of recent threat developments. This paper outlines three case studies, encompassing two air-domain and one space-domain study. The objective of each case study is to identify the most relevant aspects of the battle management control system in use within the example to inform a future SBMC2 system. The case studies will show how the battle management systems are utilized to control the forces in play. They will explain how having or missing a BM system in place either enhances warfighter effectiveness or is a source of fog and friction. When appropriately utilized,

[31] Coats, Worldwide Threat Assessment of the Intelligence Community.
[32] This framework is captured elegantly in Col John Boyd's Observe-Orient-Decide Act (OODA) loop and helps explain the intent of a battle management system placing forces in a place of advantage in a timely manner.

BMC2 systems integrate strategic, operational, and tactical levels of war and efficiently place friendly weapons systems in a place and time of competitive advantage. Comparison and contrasting of the case studies will illuminate capabilities necessary for a space tactical battle management system as well as pitfalls to avoid.

Methodology

The paper seeks to answer what aspects of a tactical space battle management system need to be developed to support mission crews as they prepare for a newly contested operating environment in space. It comprises six sections and a conclusion. Up front, a primer on the space domain and the increase in threats provides a basic understanding of how space has now become a contested environment after decades of sanctuary. Next, a review of history and doctrine are outlined for both the air and space domains to understand the divergent roots of the control systems. Following the academic foundation, a series of cases are presented for contextual and thematic illustrations. The cases will focus on three large-scale air-control or battle-management scenarios: a theoretical engagement fought over the Cold War's Fulda Gap, Operation Desert Storm's Battle of Khafji, and the opening days of Operation Odyssey Dawn (OOD). The air-based case studies of Fulda Gap, Khafji, and OOD, provide insight into complex conflicts where decentralized execution and battlespace awareness rely on the TAC C2 system to act within a timeframe advantageous to tactical success.

After the case studies identify the essential element TACS provided for commanders and aircrew; the paper will recommend steps to create a future space control system analogous to the TACS that may provide increased responsiveness and decentralized control for space operations. A forthcoming space battle management construct must include a force organized, trained, and equipped to execute the identified core functions. Namely, it must surveil adversary maneuvers, intuit likely courses of action for both US and enemy assets, share information up and down echelon, operate with redundant communications paths, and have the authority to direct crews to ensure their placement in time and space to gain continuing advantage.

Assumptions

The author acknowledges certain limitations, especially with the examination of how the Air Force planned to manage battle in the Fulda Gap during the Cold War. This case required assumptions on the expected number and type of forces for employment. Engagements and the flow of C2 data, decisions, and authorities are also assumed based on doctrine, systems, and wargames of that era.

The term space control is defined as an action to employ offensive and defensive space control operations to ensure freedom of action in space and, when directed, defeat efforts to interfere with or attack US or allied space systems.[33] A space control system, analogous to TACS, is a system to implement tactical control (TACON) of assets under their authority. While the terms space control and space control system are inter-related, one (space control) deals with the level of domain control the US enjoys while the other (the space control system) is the ways and means the US implements TACON of space forces.

Due to the classified nature of a majority of space operational planning documents and space capabilities on the horizon, this paper assumes potential technological developments for its near-term hypothetical case study in space. These assumptions are grounded in the reality of the physics in play and on unclassified statements, reports, and journals. The examination of both the Fulda gap and space cases are meant to paint a picture for the reader, to enable a mental framework on which to see differences between the two domains of control. Gaps in capabilities, duty titles, timelines, engagement outcomes, and adversary actions are subjective and assumed as non-factors when viewed through a qualitative lens seeking the why and how over the who, what, where, and when.

The Air Force, as the service provider with the majority of forces as well as command and control ability, is the focus of this paper. While war-fighter functions are resident within USSTRATCOM and its associated JFSCC, the requirements to organize, train, and equip a battle management architecture will fall mostly to the Air Force. Other services will provide capabilities that

[33] Joint Staff, "JP 3-14 Space Operations," II–2.

augment or add complementary capability. These systems will need to be considered and integrated correctly but are outside the scope of this paper.

The National Space Defense Center (NSDC) mission area is evolving, and information regarding its span of control and mission is often classified or For Official Use Only (FOUO). This paper assumes NSDC will have a future role in Space BMC2, but it will not speculate on what that role may be. Some functions and limitations prescribed by the paper to the JSpOC may no longer be entirely accurate as the NSDC becomes further integrated into the collaborative SSA framework. The fact that the JSpOC and NSDC relationship is in a state of flux is built into the paper's broad-brush narrative and does not detract from the overall points regarding the necessity of establishing a space battle management architecture that can provide the core functions and competencies outlined within it.

Current efforts to improve the alignment of title 10 functions within US Strategic Command (USSTRATCOM) and title 50 functions with the National Reconnaissance Office (NRO) in the space domain do not feature prominently here. These actions typically focus on integrating space situational awareness.[34] Inter-agency coordination that results from collaboration is above the scope of this paper. An adequately architected space control system, analogous to TACS, will only enhance the integration efforts underway between the two organizations. Due to the upper-command tier nature of the USSTRATCOM and NRO coordination, it is assumed to be out of scope for an in-depth review of this paper. See areas for future study for more details.

Additionally, while the NRO and USAF are working a joint defensive concept of operations, this paper does not address battle management constructs at the NRO's National Reconnaissance Operations Center (NROC). It may be feasible to implement a unified space control system that includes NRO systems, but to scope the material to USAF history, doctrine, and case studies, a unified system is left to another writer.

Decisions on whether to operationalize the space domain with warfighting capabilities are the purview of the US government. Policy positions and concerns regarding the weaponization of space are outside the scope of this

[34] Clark, "Air Force Teams With NRO For Secret SSA Bird."

paper. Battle management functions have value regardless of the type of conflict. The key attributes, core competencies, and functions provided by the recommendations in this text work in a purely defensive mindset as well as any potential offensive posture. Current on-orbit systems and the personnel who operate them will still require a support structure to preserve in the face of aggression.

Space under Threat

A review of open source reporting and discussion on the topic of national security within the space domain paints a picture of multiple technologies and systems under development with the intent to hold US spacecraft at explicit risk. The Chinese have tested a robotic-arm equipped satellite that could be assigned a counter-space mission.[35] Both Russia and China have deployed technology demonstrators that exhibit the ability to perform RPO-type maneuvers, which could allow for easy development of a co-orbital anti-satellite system.[36] Both are pursuing ground-based lasers, with China lasing US intelligence satellites as early as 2006.[37] Both have a growing stable of counter-space electronic warfare equipment that seeks to remove significant portions of the electromagnetic spectrum from use.[38] Given the prevalence of counter-space system proliferation, publicized writings on the subject, and new-established units, adversaries have begun to organize, train, and equip for future wars that extend into space, and are likely making inroads into employment doctrine and battle management concepts that include these capabilities.[39] What then of the US effort? To understand why there is the gap in ability, it is necessary to explain how the US policy on space operations came to be.

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[35]Axe, David. "Is China's Mysterious New Satellite Really a Junk Collector—or a Weapon?" https://www.thedailybeast.com/is-chinas-mysterious-new-satellite-really-a-junk-collectoror-a-weapon.

[36] Kattan, Ari, Tasia Paraskevopoulos, Brian Rose, and Maya Sharma. "Russian and Chinese ASAT Capabilities in Geosynchronous Earth Orbit: Threats and Responses," n.d. p15

[37] Kattan, Ari, Tasia Paraskevopoulos, Brian Rose, and Maya Sharma. "Russian and Chinese ASAT Capabilities in Geosynchronous Earth Orbit: Threats and Responses," n.d. p15

[38]Harrison, Todd, Kaitlyn Johnson, and Thomas Roberts. "Space Threat Assessment 2018." CSIS, April 11, 2018. https://aerospace.csis.org/space-threat-assessment-2018/.

[39] Clark, "China Reaches Out To US For Space Data."

Chapter 2

From Strategic Imperative to Sanctuary to Tactical Target

Whoever has the capacity to control space will likewise possess the capacity to exert control over the surface of the Earth.

-General Thomas D. White,
USAF Chief of Staff, 1957-1961

Space Control History

The lofting of Sputnik in October 1957 put the concept of space control at the forefront of the US national security apparatus.[1] Knowing what was physically overhead was the pressing problem of the day for US politicians and military leaders. The US required warning of inbound Soviet ICBMs given their short time of flight. Additionally, there was concern that other nefarious things may be orbiting perpetually above. In 1959, development began on the US Space Detection and Tracking System (SPADATS), which was an integrated system of radars, optical sites, and computers able to determine trajectories using orbital perturbation calculations.[2] The SPADATS system helped establish the space catalog, which was an updating list of all near-earth orbiting objects under a program called SpaceTrack.[3] To an extent, this system began the Space Situational Awareness (SSA) program enabling the US to know at least where objects in orbit were and predict where they ought to be in the future, barring any maneuvers by the satellite. The Ballistic Missile Early Warning System (BMEWS) enabled a complementary capability to detect and monitor missile reentry vehicles while also contributing to the SpaceTrack mission.

In 1961, the physical object tracking mission coupled with a National Security Agency (NSA) program intent on collecting communications and electronic intelligence from non-cooperative foreign satellites in an attempt to paint a composite picture of location, purpose, and intent of the operators of non-US satellites.[4] By coupling the known orbital characteristics with the specific types of electronic transmissions coming from the satellite, it was

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[1] Spires, David N, and United States. Beyond Horizons: A Half Century of Air Force Space Leadership. Air University Press, 2011. 52

[2] Spires, David N, and United States. Beyond Horizons: A Half Century of Air Force Space Leadership. Air University Press, 2011. 72

[3] Spires, David N, and United States. Beyond Horizons: A Half Century of Air Force Space Leadership. Air University Press, 2011. 94

[4] VADM Frost, L. DIRNSA. "Space Surveillance Development. Planning." National Security Agency, March 15, 1961.

plausible to determine the likely purpose of the orbiting object. An important first step of controlling space was understanding what was there.

In addition to monitoring objects, the US sought to have an offensive means to negate threats on orbit. In early 1963, the USAF cobbled together Project 437, a nuclear-tipped Thor missile in an ASAT role while the Army added a secondary ASAT role to its nuclear-armed Nike-Zeus SAM system.[5] With these systems, the US had a nascent space warfighting capability able to destroy Soviet satellite threats such as the nuclear-capable Fractional Orbit Bombardment System (FOBS) under development. This early ASAT capability was tightly linked to nuclear conflict and seen as a strategic weapon.[6] Regardless of its strategic nuclear ties, it was the first operationalized counter-space capability, and it drove a requisite command and control system to employ it.

In 1965, the USAF Air Defense Command and the joint US and Candian North American Air Defense (NORAD) Command established the Space Defense Center (SDC), consolidating SPADATS functions in one location.[7] The SDC acted as the targeting center for two US counter-space systems. The 1st Aerospace Control Squadron operated the SDC and its associated computers. It also created the tasking plan for its subordinate radar sites such as BMEWS.[8] With the establishment of the SDC, the USAF took the first meaningful steps of operationalizing space as a war-fighting domain with a proto-battle management system.[9]

In 1979 the SDC rebranded as the Space Defense Operations Center (SPADOC) as both the US and Soviet Union fielded ASAT systems. It became necessary for the US to plan for space system defense since the US became increasingly dependent on space-based communications, imagery and signals intelligence, navigation, and missile early warning as part of its MAD Nuclear Deterrence policy.[10]

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[5] Chun. "Shooting Down A 'Star' Prgm 437, the US Nuclear ASAT System," April 2000. http://www.dtic.mil/get-tr-doc/pdf?AD=ADA377346. 5-8
[6] Chun. "Shooting Down A 'Star' Prgm 437, the US Nuclear ASAT System," 2000. http://www.dtic.mil/get-tr-doc/pdf?AD=ADA377346. P20
[7] NORAD Office of History, "Wayback Machine."
[8] "The Air Defense Command."
[9] Spires, David N, and United States. Beyond Horizons: A Half Century of Air Force Space Leadership. Air University Press, 2011. 198
[10] Spires and United States, *Beyond Horizons*, 175.

The SPADOC maintained the old SDC tasks of timely characterization of launches. It also reported advisory warnings of hostile threats or impending collisions with the US or other allied satellites.[11] Most importantly for its eponymous defensive mission, it implemented ASAT countermeasures.[12] It likely could provide direction to satellites at risk, given Soviet ASAT system's need for two orbital revolutions before attempting an intercept.[13] An offensive counterspace capability associated with the SPADOC system never left the development phase.[14] The subsequent two decades saw improvement to the defensive operations system. The improvements included adding of phased array radars and updated celestial cameras, automating functions, and an ever-increasing catalog of tracked objects in space.

The SPADOC was a strategic system. It was embedded deep within Cheyenne Mountain, within the North American Air Defense (NORAD) complex. It was tied to strategically vital communications and early warning systems. Any envisioned space war tightly coupled with nuclear war.[15] The strategic use of space kept offensive and defensive actions by the rival nuclear powers limited or muted in that domain.[16] An attack against space systems had a high likelihood of being interpreted as the opening salvo of a nuclear exchange.[17] Therefore, a mutual "hands-off" policy existed for anything short of thermonuclear war.[18] The "hands-off" policy did not mean that each side forsook counterspace systems. On the contrary, the Soviets pursued new co-orbital systems such as the GEO-capable Naryad.[19] But development is not the same as use, and during the Cold War, the red-line against the use of counter-space capabilities held true.[20]

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[11] Sturdevant, Rick. Air Power History, Winter 2008, n.d., 23. 14

[12] Spires, David N, and United States. Beyond Horizons: A Half Century of Air Force Space Leadership. Air University Press, 2011. p198

[13] Weeden, *Through a Glass, Darkly: Chinese, American, and Russian Anti-Satellite Testing in Space*, 37.

[14] Akin, Edward N. Anti-Satellite Weapons, Countermeasures, and Arms Control. US Government Printing Office, 1985. P59.

[15] Akin, Edward N. Anti-Satellite Weapons, Countermeasures, and Arms Control. US Government Printing Office, 1985. P56

[16] Brzezinski, Matthew. Red Moon Rising: Sputnik and the Hidden Rivalries That Ignited the Space Age. Reprint edition. Holt Paperbacks, 2008. P103

[17] Futrell, Robert F. "Ideas, Concepts, Doctrine: Basic Thinking in The United States Air Force, 1961-1984. Volume 2." AIR UNIV MAXWELL AFB AL, 1989. P 687

[18] Russell, "Defending US Space Assets from Foreign Attacks - Via Satellite -."

[19] Spires, David N, and United States. Beyond Horizons: A Half Century of Air Force Space Leadership. Air University Press, 2011. 188

[20] Kattan, Ari, Tasia Paraskevopoulos, Brian Rose, And Maya Sharma. "Russian And Chinese ASAT Capabilities In Geosynchronous Earth Orbit: Threats And Responses," N.D. P39

After the fall of the Berlin Wall, the Soviet Union, as well as its MAD and ASAT threat receded. Space systems progressed beyond singularly supporting nuclear conflict to becoming the vital enabling architecture for the unique expeditionary power latent in the post-Cold War US military. GPS, satellite communications, space-based intelligence, weather, and warning systems became deeply embedded in how the US fought wars and a refocusing and reorganization of space forces was necessary to posture space systems to integrate into the joint fight. The most prominent change was the disestablishment of US Space Command.

Following the shuttering of US Space Command in 2002, reorganization within the command structure put the SPADOC within the combatant command authority of US Strategic Command and continued under service control of US Air Force Space Command. Over the next half-decade, a series of organizational changes put the space mission areas within a newly created command. In 2005, the Joint Functional Component Command for Space (JFCC-Space) became operational at its headquarters at Vandenberg AFB, California. Following the reorganization, the Joint Space Operations Center (JSpOC) co-located with JFCC-Space, subsumed the SPADOC mission area, equipment, and personnel and moved into an old rocket processing facility at Vandenberg AFB. The US military had an organization purpose-built to centralize command and control for the integration of space force enhancement effects (e.g., PNT, SATCOM, ISR) for geographic combatant commands on behalf of USSTRATCOM.

In the absence of any counter-space threat, the JSpOC focused primarily on the *force enhancement* mission for the Geographic Combatant Commands such as Pacific Command (PACOM), European Command (EUCOM), and Central Command (CENTCOM). It also maintained its SSA mission, which took on a Space Traffic Management (STM) focus, especially after two significant events mid-decade: the Chinese 2007 Low-Earth Orbit (LEO) ASAT test and the 2009 collision between an Iridium Satellite and a defunct Russian Satellite, COSMOS-2251. After these formative events, US Strategic Command (STRATCOM) directed that JFCC-Space and the JSpOC would provide conjunction assessment on all operational satellites within the catalog in an attempt to mitigate the likelihood of future collisions.[21] Just as the same technical skills support air traffic control and air battle management, space traffic management relied on the old SPADOC systems. The use of SPADOC for space traffic management came with deemphasizing military functions related to fighting a war in that domain. Over time the skills for space battle management atrophied even further from the pinnacle of ability during the old USSPACECOM SPADOC days. Along with these skills, the supporting procedures, processes, and tactics also faded from memory.

Given the US numerical advantage in space, and the associated force enabling capabilities space provides US conventional military power, it is logical that competitors would look for means to degrade that benefit. Numerous times in history, when one nation possesses an asymmetric advantage due to technology or capability, other nations seek offsets against that advantage. The requirement for US military conventional forces to access space systems provides a rationale for a counter-space capability. Due to the critical requirement for space force enhancement, it is telling that these spacecraft sit undefended due to previous US design, operations decisions and assumptions.[22]

To say US space systems are inviting targets for the nation's competitors is to understate the matter. Deterrence strategies that had been developed during the Cold War to deal with nuclear weapons and the associated command and control systems are not likely to be effective protecting current space assets from attack in a future conflict. [47] Adversary strategies may choose quite the opposite position if it feels it *must* act in some way to compel the US. Given a choice between spilling American blood or destroying a satellite, adversaries could see the spacecraft as the more-inviting target, especially since "satellites have no mothers."[23]

With the current systems already on-orbit and at-risk, the US finds itself scrambling to redefine how to fight a future war extending into space. The USAF and USSTRATCOM are revamping deterrence strategies, requesting funding for

[21] Weeden, Brian, And P Cefola. "Computer Systems and Algorithms for Space Situational Awareness: History and Future Development." Quebec, Canada, 2010.
[22] Browne, Ryan, and Barbara Starr. "US General: Russia and China Building Space Weapons to Target US Satellites." Cable News Network, n.d. http://www.cnn.com/2017/12/02/politics/russia-china-space-
[23] Colby, "Commentary."

newer, more resilient systems, and reorganizing yet again. USSTRATCOM took steps to appoint a new Joint Forces Space Component Commander (JFSCC) position to provide additional focus on space as a warfighting domain with a dual-hatted four-star functional component commander at its head. At the ceremony dedicating the occasion, General Jay Raymond, the newly minted JFSCC, said, "This is a significant milestone. We are now focused on further integrating space…on taking tried and proven methods of joint warfighting and applying them to the space domain to ensure normalization across all mission sets." [24] Recently, the US government has decided to transfer the STM mission from the Department of Defense to the Department of Commerce, ostensibly to refocus DoD personnel on warfighting within the domain.[25]

In addition to the reorganization, Air Force Space Command is attempting to change the culture within the command to create a warfighting mindset.[50] At the strategic level, examples of change include the Space Enterprise Vision (SEV) and Space Warfighting Construct (SWC). These efforts outline a concerted attempt to re-look at how the US organizes, trains, and equips US DoD space forces. Operational-level initiatives include the establishment of the NDSC and the JSpOC transformation and the development of software such as the JSpOC Mission System (JMS).[26] At the tactical level, the Space Mission Force (SMF) has upended how AFSPC presents forces to USSTRATCOM, embodying a deployed-in-place mental attitude.[27] SMF's associated advanced training plan focuses heavily on potential adversary capabilities as well as the development of new TTPs for mission crews to thwart emergent threats.[28] These initiatives set out both the strategic vision as well as the tactical mindset of front-line squadrons.

However, there is a missing linkage between the operational commander's intent and the mission crews executing tasks. There must be an entity empowered with authority to act as the intermediary between the

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[24] AFSPC Public Affairs. "AFSPC Commander Becomes JFSCC, Joint Space Forces Restructure." Air Force Space Command. Accessed March 23, 2018. http://www.afspc.af.mil/News/Article-

[25] Foust, Jeff. "Commerce to Take Responsibility for Space Traffic Management under New Policy." SpaceNews.com, April 16, 2018. http://spacenews.com/commerce-to-take-responsibility-for-space-traffic-

[26] JMS was recently defunded after a series of schedule slips and cost overruns in favor of a new Enterprise Battle Management System

[27] Gen Hyten, John. "Space Mission Force: Developing Space Warfighters for Tomorrow." Air Force Space Command, n.d. http://www.afspc.af.mil/Portals/3/documents/White

[28] Gen Hyten, John. "Space Mission Force: Developing Space Warfighters for Tomorrow." Air Force Space Command, n.d. http://www.afspc.af.mil/Portals/3/documents

operational-level JSpOC or NSDC and the front-line mission crews. The need is especially acute given that increasing threats are likely to result in an increasing task workload on both the operations centers and the mission crews. The current system, shown in Figure 2, is an architecture that resulted from a peace-time view of space operations. It centralizes control at the JSpOC.

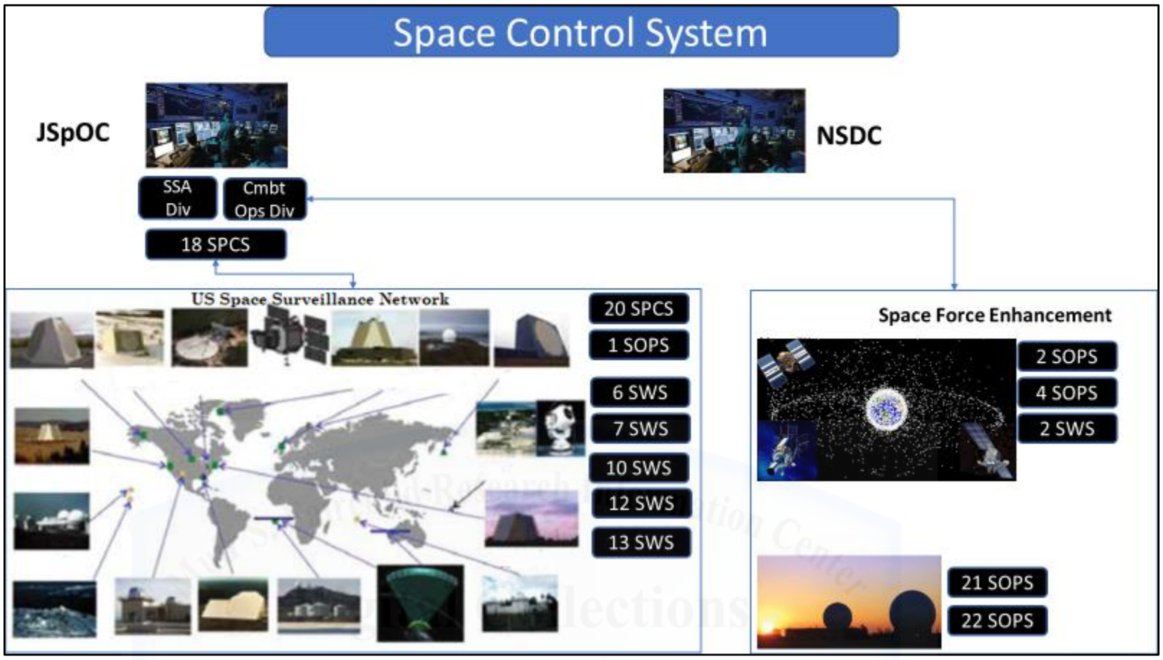

Figure 2, Space Control System
Source: Modified from Baird "Maintaining Space Situational Awareness."

Additionally, a TAC C2 system allows for sectorization of the operating area providing a beneficial ability to handle large volumes of tactical engagements by independently acting in each sector. The lack of a TAC C2 system becomes even more acute when tactical units become more proficient due to the SMF advanced training pipeline. As young space operators hone their tactical focus and build TTPs to react to today's emergent threats, they will begin to demand enormous volumes of information and guidance from the operational nodes such as the JSpOC, the 18th Space Control Squadron, and the NSDC. Without a robust architecture built to provide the information and direction requirements, the newly capable space mission task force will quickly become frustrated and disillusioned. Or even worse, the US could fail when confronted with the first conflict extending into space.

The history of space control has come full circle. Space control ran the gamut from initial shock of Sputnik to the extension of nuclear MAD, the establishment of a Space Defense Operations Center, to a post-Cold War sanctuary, and now back to a contested domain. As the risks re-emerge and the US reorients to prepare for conflict in space, doctrine has not kept pace.

Doctrine

While the significance of space control and warfighting in, from, and through space was not lost on the US, the USAF has been slow to operationalize the space domain further. Even with the renewed focus on space control in post-cold war USAF writings, including AF Manual 1-1, Basic Doctrine, and the subsequent AF Doctrine Document (AFDD) -1, it amounted to little more than words on paper.[29] And while the USAF produced a specific document in 2004, AFDD2-2.1 Counterspace Operations, it followed up with a rewrite in 2011 that reduced the counterspace portion to a minor subset of the overall text. The 2011 doctrine removed wording defining and outlining the uses of offensive and defensive space control as well, showing a reluctance to advocate for counterspace capability and operational use openly. The new language heavily tied space lines of effort to terrestrial joint force commanders and combined forces air component commanders (CFACC).[30] The fact the doctrine links to another component's campaign shows the weight of emphasis was on countering terrestrial uses of space within a joint operating area versus acting within a USSTRATCOM-assigned space operating area.

Current doctrine, enshrined in JP 3-14 Space Operations and USAF Annex 3-14 Space Operations, have limited guidance on campaign planning concerning space domain operations. The documents outline space force enhancement functions, including global integrated ISR operations, launch warning and tracking, weather, communications, position, navigation, and timing (PNT) as well as enabling functions such as satellite support operations, assured access to space, and space situational awareness (SSA).[31] The joint publication and

[29] Brzezinski, Matthew. Red Moon Rising: Sputnik and the Hidden Rivalries That Ignited the Space Age. Reprint edition. Holt Paperbacks, 2008. p115
[30] US Air Force, "AFDD 3-14 Space Operations."
[31] US Air Force, "AFDD ANNEX 3-14 Space Operations."

USAF annex both identify SSA as the bedrock component of all other space tasks.[32] Follow-on sections of JP3-14 outline other space mission areas such as space force enhancement (SFE), space support (SS), space control (SC) and space force application (SFA). The primary focus of the documents centers on SFE and SS, with nuanced details on how to implement plans for those two functions. The remainder of the texts gives very little guidance on space control or force application.[33] In the case of force application, the material directs readers up to DODI S-3100.13, Space Force Application, which is a controlled document dating back to September 2000. Operational planners have little physical text on which to develop concepts of operations for conflict in space. The ones that do exist are dated and difficult to access.

The consequence of the "strategic/nuclear entanglement" approach taken during the Cold War and "space sanctuary" approach taken post-Cold War resulted in a shortage of processes and doctrine outlining *how* to fight a war in space. Space doctrine does not provide nearly as much guidance on how one would establish space superiority, nor establish a space control system nested within a joint operational area. By comparison, the air domain has significant doctrinal hooks on the integration of air effects into an overarching campaign and operational doctrine on the establishment of an air control system.

Air Control History

Historically, the air domain had the opposite starting point from space, tracing its roots back to tactical warfare. Air control and superiority became sought-after conditions as early as World War I.[34] Systems, procedures, and specialization grew to meet the challenge of control of the air. Aircrew and those tasked with defending against adversary aircraft realized that to command the air they needed awareness of what was in the domain and the ability to provide direction on where to intercept the enemy. Historical examples of a lack of situational awareness abound. Examples include the Zeppelin raids on London during World War I and the Japanese aerial bombing of Pearl Harbor during World War II.

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[32] Joint Staff, "JP 3-14 Space Operations," II–1.
[33] Joint Staff, II–9.
[34] Kennett, *The First Air War: 1914-1918*.

Aerial battle management came into existence because of an acknowledgment that control of the air was too complicated to perform merely by scanning the skies and focusing on the immediate battlespace. World War I intercept rates showed the exertion required to find and intercept inbound enemy aircraft.[35] This led to an initial belief prevalent among early airpower theorists that "the bomber would always get through."[36] Radar and radios were early developments, however, which hinted at the promise of what a defensive network could do to track and intercept enemy aircraft.[63] With the development of radar and radios, it became feasible to construct a system to detect inbound planes and then pass the information forward to interceptors configured and prepared for engagement with the enemy.

Tactical battle management can trace its roots to the United Kingdom's Fighter Command and its associated Early Warning Network and Ground Control Intercept system, known as the Dowding system. The Chain Home radar centered prominently within this system.[64] Using radio waves bounced off of incoming aircraft to determine range and bearing, radar was a new sensor that did not rely on sight or sound. The radar provided a means to create a wide-area picture of the airspace across from Britain. This picture meant multiple nodes within a C2 system could share the same knowledge of what was happening at the same time. This ability established the first common operating picture (COP), which enabled British forces to react to inbound Nazi bombers. From this COP, Fighter Command was able to make decisions on when to scramble or where to fly to intercept targets within a tactically-relevant time.[65] Without the Dowding System and its COP, fighters would likely have not made intercept times, as was experienced in World War I.

A technical capability like radar was only one aspect of the Dowding system. It was an interconnected system of sectors, fighter bases, anti-aircraft artillery, and headquarters. It was the first battle management architecture

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[35] Kennett.

[36] Biddle, *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas about Strategic Bombing, 1914-1945 (Princeton Studies in International History and Politics).*

[63] Lt Col Liepman, Jr., James. "Cnth, Inth Xyz, TACS, and Air Battle Management: The Search for Operational Doctrine." Airpower Journal, no. Spring 1999 (1999). P8.

[64] Bungay, Stephen. The Most Dangerous Enemy: A History of the Battle of Britain. Aurum Press (2015), Edition: Reprint, 512 pages, 2015.

[65] Kometer, Michael W. Command in Air War: Centralized versus Decentralized Control of Combat Airpower. Maxwell Air Force Base, Ala: Air University Press, 2007. P.43

built by any nation. One important innovation was the division of the contested area into sectors under the control of a centralized hub that then reported up echelon to the group and finally fighter headquarters. This structure, shown below, enabled a sort of decentralized execution to handle complex and large numbers of engagements.

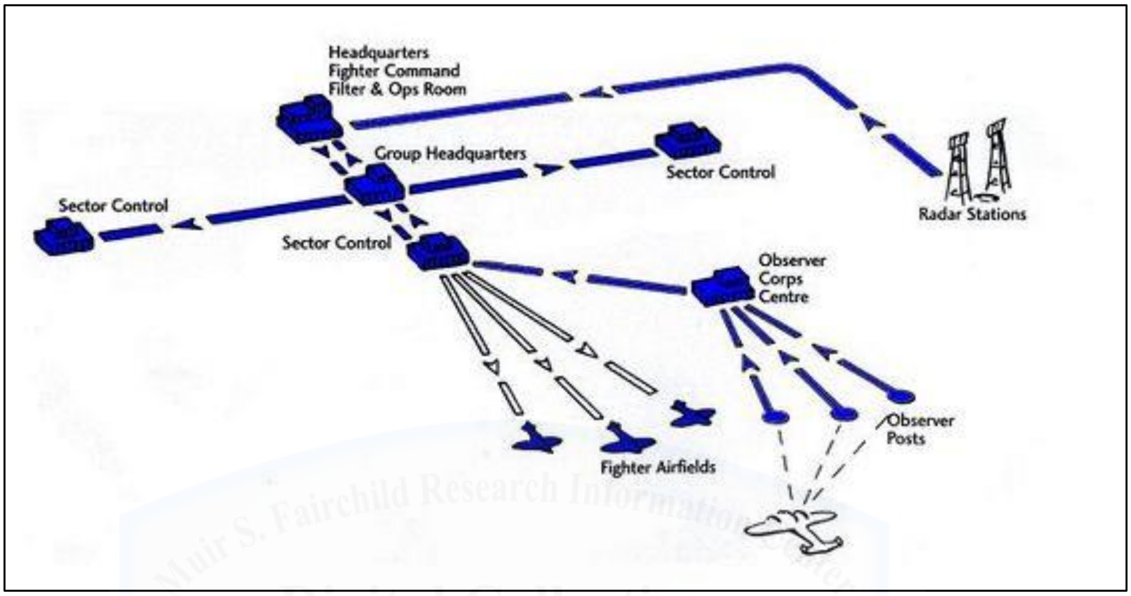

Figure 3, Dowding System circa 1940, which depicts decentralized execution
Source: "The British Air Defence system" http://www.militaryhistories.co.uk

The importance of trained personnel operating the system was another key lesson learned. Ground-Control Intercept (GCI) personnel had to intuit where the likely Nazi target was and determine the most appropriate response given resources available at the time.[37] At the tumultuous time, many of the tactics and procedures were created through trial and error. Ground controllers had on-the-job training from technical manuals or via periodic conversations with fighter pilots. Other times, pilots were re-assigned to act as the controllers themselves. Often aircrew were chosen because of their ability to use language other pilots understood; a common vernacular enabled quicker transfer of information.[38] For the British and Americans, this ad-hoc arrangement continued throughout World War II.

For the USAF, formalized tactical battle management school started in 1947 with the establishment of the first air controller's course, entitled the

[37] BeYourFinest.com, "An Overview of the Dowding System"
[38] Bungay, *The Most Dangerous Enemy: A History of the Battle of Britain*, 66.

Basic Weapons Controller School (BWCS).[39] No longer would battle management be reliant on an ad hoc training program without structure. The focus of the instruction was to instill core battle management competencies into a cadre of trained personnel specifically authorized to direct and employ air forces on behalf of the air commander. These weapons controllers, later to be known as air battle managers (ABM), learned to create accurate, integrated common operating pictures and to interpret that picture to direct friendly forces into a position of advantage against an adversary. They also were trained to build situational awareness for assets within their span of control. To pass this situational awareness, they trained in techniques to map plots and pass information via telephone and radio. To integrate between levels of command, the ABM trained on communicating both up to commanders and down to aircrew. This ensured operational-level commanders had an understanding of the battle and tactical-level units entered fights knowing pertinent information for their slice of the war. Air Battle Managers honed the art of translating real-time awareness, commander's intent, and friendly capability into the decisive direction to win tactical victory.[40]

As the Air Force continued to refine how it integrated and managed air assets, it iterated using ever more elaborate equipment. Systems such as the Airborne Command and Control Center (ABCCC) were utilized successfully for air-to-ground integration, with great success during the battle for Khe Sahn.[41] Also in Vietnam, the beginnings of Airborne Early Warning and Control (AEWC) aircraft began to be used operationally. The Lockheed EC-121 Warning Star, call-sign COLLEGE EYE, served as the primary C2 asset forward for the Air Force's infamous Route Pack 6A over Hanoi.[42] The Vietnam war saw the advent of the RC-135 Rivet Joint, which allowed for integration of signals intelligence (SIGINT) with the air picture, an evolutionary step beyond just physical battlefield awareness.[43] Even with newer advanced sensors, ABMs were still reliant on grease pencils, paper plots, and telephone lines just as their RAF

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[39] Maj. Roach, "The Case for Increasing Production in the Air Battle Management Career Field," 8.
[40] Lt Col Conine, "Future Considerations of BMC2. BMC2 Must Be Both Horizontally and Vertically Integrated to Maximize Information Exchange and Fusion," 36.
[41] Momyer, Lavalle, and Gaston, *Airpower in Three Wars*, 100.
[42] Momyer, Lavalle, and Gaston, 170.
[43] SIGINT is both Communications Intel (COMINT) and Electronic Intel (ELINT). Kometer, *Command in Air War*, 43.

cousins in World War II. The system was unable to create an automated, integrated battlespace picture.[44]

Following Vietnam, the US refocused on major combat operations with the Soviet Union, which led to the development of advanced battle management systems, including the E-3 Sentry, Airborne Early Warning and Control System (AWACS) and the E-8C Joint Surveillance Target and Attack Radar System (JSTARS or Joint STARS), both heavily modified Boeing 707 aircraft. Additionally, ground-based radars such as the AN/FPS-117 and later the TPS-59 came online. These phased-array radars provided ABMs with exceptional abilities to track multiple targets out to extended ranges.[74] In a system of systems approach, these new battle management platforms were networked to other nodes via a common architecture, such as Link-11 and Link-16.[45] These datalinks allowed the broadcasting of a common operating picture to all like equipped units, which included air, land, and sea weapons systems. Furthermore, satellite communication capabilities were integrated into the platforms to allow for beyond-line-of-sight communication, significantly extending the networking capabilities of the TACS. The result was an air control system with the requisite pieces to build a truly shared understanding of the battlespace and to shorten the amount of time necessary to go from sensor observation to force direction and target engagement.[46]

The history of airspace control shows a stark difference between air and space domains. Space control capability remained theoretical and at a high-level of command, inexorably linked to thermonuclear war. The air domain had learned through decades of trial and error as well as iterative OT&E cycles to create a system of systems such as TACS to establish control. The USAF and joint forces then worked to document how TACS and ABMS fit within an overall joint campaign via doctrine. The doctrine helped to identify best practices, which the Air Force used to set operational frameworks and definitional

[44] Kometer, 51.
[45] Northrop Grumman, "Understanding Voice and Data Link Networking," 2–3.
[46] Tying back to the earlier point about Boyd's OODA loop, battle management's key objective is completing the OODA loop in a tactically-relevant timeframe (i.e., before the adversary destroys our systems or defeats our attack through defensive means)

context, so the system was replicable regardless of geographic location or situation.[47]

Air Control Doctrine

The air control operating concepts have made their way into USAF and joint doctrine with a much higher specificity than exists within current space doctrine. USAF Volume 1 Basic Doctrine explains Centralized Control and Decentralized Execution, a core tenet of aerospace power. First, it establishes unity of command by designating one functional component commander, usually an airman, for command of all assets within the air domain.[48] This unity of effort provides centralized control to all assigned forces and helps to provide integration of effort and efficient force management. The second postulate of the tenet, decentralized execution, is defined as "the delegation of authority to designated lower-level decision-makers to achieve…tactical flexibility."[49] Joint doctrine defines command and control (C2) as "the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission."[50] Previous USAF doctrine had further defined tactical-level command and control as "the level of war w*here individual battles and engagements are fought*." [emphasis by author] The tactical level of war deals with how to employ forces, via what tactics and against what targets. The goal of tactical level C2 is to achieve commander's intent and desired effects by gaining and keeping the offensive initiative."[51] These core principles tied with other tenets of airpower such as flexibility and versatility as well as principles of joint operations such as objective, mass, maneuver, and unity of effort provide the guidance for airpower to integrate with the joint fight.

The unity of command centers on an individual called the Combined Forces Air Component Commander (CFACC).[52] He or she is vested with

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[47] Lt Col Liepman, Jr., "Cnth, Inth Xyz, TACS, and Air Battle Management: The Search for Operational Doctrine," 3.
[48] US Air Force, "USAF Basic Doctrine Vol 1."
[49] US Air Force.
[50] Joint Staff, "JP 1-02 DoD Dictonary of Military and Associated Terms."
[51] US Air Force, "AFDD Vol. 1, Air Force Basic Doctrine, Organization, and Command."
[52] Doctrinally, this title can also be called the Joint Forces Air Component Commander (JFACC), however recent history and US National Security Policy highlights the fact that the US seeks to fight wars as

authorities that enable efficient planning, tasking, and control of joint air operations. Specified responsibilities, authorities, and roles include planning, directing, defending, targeting and tasking from and through the air as the airspace control authority (ACA), and area air defense commander (AADC). Together, the abilities mentioned above allow the CFACC to centralize control of the air domain within his air operations center and decentrally execute taskings across the entire theater with the tactical air control system.[53]

Below the CAOC at the tactical level of war, battle management area controllers' on-board AWACS or at a Control and Reporting Center (CRC) have authorities to direct forces in support of CFACC intent. These authorities are mission-planned and trained within the TACS before execution both for offensive and defensive engagements in and from the air. The system allows for centralized control through the CAOC and decentralized execution across as many deliberate strikes and air sectors. A failure of the CAOC at the top doesn't necessarily collapse the entire air campaign. The lower echelons can execute as fragged, implementing the now-incommunicado commander's intent. Per doctrine, this system is the USAF version of *mission command* or decentralized execution.[54]

The AF doctrine and Joint doctrine are linked, printed in a series of publications that outline how to operationally apply airpower into an integrated joint force accomplishing the Joint Force Commander's intent. The higher level documents, such as JP 5-0 Joint Planning and JP 3-0 Joint Operations provide the strategic and operational levels of the framework. Functional-level texts, like JP 3-30 Command and Control of Joint Air Operations, JP 3-60 Joint Targeting, JP 3-01 Countering Air and Missile Threats, JP 3-09 Joint Fire Support, JP 3-09.3 Close Air Support, and JP 3-52 Joint Airspace Control, among others, set how the functional components integrate together. The series of air-focused joint publications outlines how to implement CFACC's authorities with organizational processes, procedures, and structures. For example, JP 3-52,

members of a team of nations, within a coalition. In this scenario, the title changes to CFACC.

[53] US Air Force, "AFDD Vol 3, Command."

[54] Joint Staff, "JP 3-30 Joint Air Operations," I–3.

Joint Airspace Control explains how the Airspace Control Authority should establish a theater system of air control measures and procedures.[55]

The joint air doctrine documents inform and synergize both service and functional components to fight our nation's wars in an integrated fashion. Most importantly, the operational doctrine provides detail on how to properly plan and execute an integrated campaign plan from strategic level oversight down through unit-level mission planning and execution under a decentralized tactical command and control system.

Putting doctrine into practice, the USAF has constructed a C2 system entitled the Theater Air Control System (TACS) headed by an air operations center (AOC). This operational-level center has an air functional component staff and associated personnel with a CFACC as its head, usually dual-hatted as the Command of Air Forces (COMAFFOR). Here, the *command* functions remain with the COMAFFOR.[56] The *control* functions, executed by TACS, allow the down-echelon direction of forces within the span of control of the CFACC.[57] The AOC provides a base framework of products, processes, tactics, techniques, and procedures. The main elements of this framework include: the Joint Air Operations Plan (JAOP), the Air Operations Directive (AOD), the Master Air Attack Plan (MAAP), the Air Tasking Order (ATO), the Area Air Defense Plan (AADP), the Air Control Plan (ACP), the Standing Rules of Engagement (ROE), the Special Instructions (SPINS) and often a Threat ID matrix among other products. These documents outline the campaign plan, the commanders intent, operational and tactical objectives, defensive operations plan, and daily plan of attack as well as explicit guidance and mission-type orders. The TACS and its personnel must then adhere to the directives provided. It centralizes the overall concept of operations of the air campaign.

Just as with the Dowding system, battle management areas or sectors establish decentralized execution authority within the TACS, as shown in Figure 3. This authority is vested in a senior controller or a Sector or Regional Air Defense Commander (SADC or RADC). Often a SADC or RADC at a CRC is

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[56] Air Land Sea Application Center, "AFTP 3-2.31," 57.
[57] Kometer, *Command in Air War*, 60.

the lowest echelon that possesses engagement authority to commit on enemy air threats.[58] This sectorization ensures each portion of the TACS balances workloads and keeps the CAOC from becoming task saturated or inundated with information. Clear lines of authority empower these controllers to act within their BMA and direct forces to achieve success.[59] The sectors also enable aircrew to quickly understand who the controlling authority is for their assigned airspace. Aircrew can trust that the SADC for their sector has oversight of both their flight as well as threats within the battlespace, without worrying about adjacent airspace concerns like a CAOC may have.

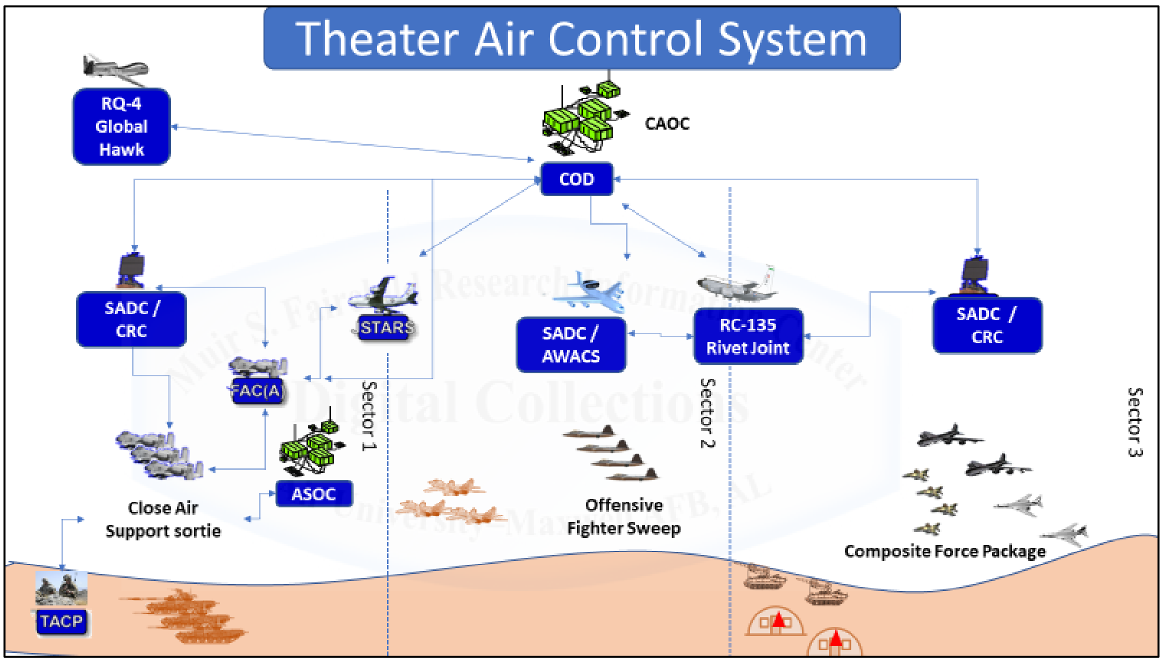

Figure 4, A notional Theater Air Control System
Source: Author

The heart of the TACS lies at the *tactical-level of command and control*, where it's expected that forces deal with a high level of fluidity. The USAF established a robust training program to create TACS operators who understand the complexity of air control and who demonstrate initiative, situational responsiveness, and tactical flexibility—the hallmark of effective decentralized control. A mission-certified ABM must understand and act on CAOC guidance and ROE, assess the threat picture, monitor, ID, and track

[58] Air Land Sea Application Center, "AFTP 3-2.31," VI–2.
[59] Joint Staff, "JP 3-30 Joint Air Operations," 18.

traffic within their assigned area, and ensure proper tactics are employed.[60] Due to training, each TACS node and its associated personnel are aware of their area of responsibility as well as locations, fuel states, and weapons remaining of blue forces at their disposal as well as the general makeup and vector of the inbound threats. This ability to build battlespace situational awareness is taught through academics, repetition in training events, and in combat. The system does not solely focus training on air-domain battles. It also prepares for tactical control of air-to-ground sorties in support of a ground component commander as well.

Within the ABM career field, this ability to build situational awareness and direct engagements has coalesced into a defined set of core functions: *force management, integrated surveillance and identification, tactical data management, and a continuum of control.*[61] These core functions are the expected outputs and are tasks accomplished on behalf of the CFACC in support of assigned forces. ABM personnel train to a specific set of core competencies that provide the foundational knowledge and training necessary to accomplish the core functions. These include *battlespace awareness, surveillance and identification, dynamic battle management, tactical fluid control, dynamic information management, C2 integration, and operational integration.*[62] Tables 1 and 2 provide doctrinal definitions for the outputs of the TACS and its underlying required knowledge, or competencies to enable those outputs. A future tactically-focused space battle management system ought to pull from the definitions of the functions and competencies.

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[60] US Air Force, "Air Force Instruction 13-1CRC Volume 2," 21.
[61] Maj Watson and Maj Carroll, "Air Battle Management Core Functions Proposal."
[62] Lt Col Conine, "Future Considerations of BMC2. BMC2 Must Be Both Horizontally and Vertically Integrated to Maximize Information Exchange and Fusion."

Table 1, Battle Management Core Functions

Force management	The iterative process of planning for and executing force accountability, packaging, positioning, and resource management (e.g., sorties, fuel, stores)
Integrated surveillance & Identification	The fusion of organic and remote sensors, coupled with the application of ROE, to build a common operational picture
Tactical Data Management	Collecting, processing, and disseminating mission relevant data to make and influence tactical and operational decisions
Continuum of Control	The act of maneuvering Forces within the battlespace by maximizing the use of Controller and Aircrew situational awareness to achieve operational and tactical effects

Source: Watson and Carroll, *ABM: Establishing a common thread for integrating cross-domain operations in the 1st Century*. Air Command & Staff College, Air University. 2014

Table 2, Battle Management Core Competencies

Tactical Fluid Control	• Detailed knowledge of friendly and enemy capabilities and tactics • Efficiently placing friendly systems in a place and time to effectively defeat threat and/or protect assets
Dynamic Battle Management	• Minimizing the complexity of war by synchronizing the integration of joint assets • Making timely kill-chain decisions through execution of guidance (SPINS, tasking orders, control orders) • Ensure proper execution of rules of engagement
Surveillance & Identification	• Knowledge of sensor capabilities within their control • Detect and identify targets with active/passive sensors • Provide timely and accurate threat warning
Battlespace Situational Awareness	• Creating accurate, integrated and common operational picture • Interpret the battlespace, prioritize tasks, information and communication flow • Anticipate, react, and mitigate problems, at all levels and communicate these effects
Dynamic Information Management	• Controlling data systems to provide friendly/enemy order of battle and propagate information from sensors up and down echelon
C2 Integration	• Knowledge and understanding of in- and cross-domain systems to fuse into a cohesive C2 architecture
Operational integration	• The integration of Air, Space and Cyber domains at the operational level • Direct planning, coordination, allocation, tasking, execution, monitoring and assessment of kinetic and non-kinetic effects in designated area of responsibility

Source: Lt Col Conine, Joshua. “Future Considerations of BMC2.” *Journal of the JAPCC* 19, Autumn/Winter 2014

Implications

National space policy has inhibited US military doctrine from the onset of the space age with documents written at the strategic level in the context of nuclear war. These guidance documents were light on operational details and integration. Because of this strategic focus, space doctrine has lagged when compared to the operationally hefty and historically-iterated air domain doctrine. While war-fighting concepts exist in the space doctrine documents, namely definitions of space superiority as well as offensive and defensive space control, very little is explicitly written on their operational employment. Correspondingly, limited tactical-level C2 has been developed to direct offensive and defensive actions in, though, and from space. The result is a system that has the same etymology as air domain doctrine and similar processes with a CAOC-like joint space tasking cycle but is almost wholly lacking in combat mission capability.

If we considered the implications of how limited combat mission capability would severely inhibit the application of US air power in a contested environment, similar limitations in space present severe restraints on our ability to "fight" the domain. The application of airpower, limited by the same corresponding constraints as space operations, would be too slow to react to battlefield dynamics. Luckily, the necessity of adaptation drove airpower battle management into what became the TACS. Space operations has yet to have an external force large enough to shake it from its inertial status quo.

The current inability to execute what space control doctrine that does exist makes sense when viewed historically. After the shackles of nuclear deterrence fell away, the US was in a unipolar world without peer. The clear victory in the 1991 Gulf War highlighted how on-orbit systems greatly enhanced conventional warfighting capabilities.[63] This feat led to a persistent focus on integration and force enhancement supporting activities by AFSPC, USSPACECOM, and USSTRATCOM. Without a meaningful peer competitor in space, doctrinal language advocating for counter-space capabilities often had no viable targets on which to be employed. Thus, the concepts received little-to-no funding nor attention. Even as recently as 2014, during an interview with 60 minutes, then-commander of Air Force Space Command, General John Hyten pointed to a single

[63] Brzezinski, *Red Moon Rising*, 98.

example of fielded equipment for this mission area, the Counter Communications System (CCS), which relies on electronic attack to deny or disrupt an adversary's use of SATCOM.[64] Within recent history, US space control efforts have not progressed beyond situational awareness via tracking of objects. Nor have battle management tools and systems been deployed for use by tactical-level mission crews. The competitors of the US have not been so lethargic.

With space no longer a sanctuary, the USAF has launched multiple efforts to prepare for conflict, spanning a wide-ranging swath of impetus from strategic visions through coaching a tactical warfighting culture within front-line space operations crews. These efforts still fall short. They are missing a critical enabling linkage between the operational and tactical control of combat forces. AFSPC should explore how the Air Force has honed its ability to establish air superiority and wrest control of the domain in a contested area, starting with doctrinal frameworks.

The current doctrine has not established a clear space control authority nor battle management architecture below the operational level. The lack of a space-equivalent JP3-52, Joint Airspace Control, leaves gaps and seams on how to manage a contested space domain with procedures, authorities, rules of engagement, and battle management areas. Until recently, this oversight in operational doctrine had little impact on the US military. There were little to no offensive or defensive space control systems to employ the doctrine and little in the way of adversarial threats.

Comparing the air and space doctrine linkages in Figures 4 and 5, it becomes apparent that a significant amount of work exists for AFSPC to meet the capability that exists within the air domain's TACS. The air system links strategic intent through tactical control with personnel trained in core competencies and equipped to execute core battle management functions to assigned tactical forces. The system is supported with operationally-detailed doctrine and fulfills core USAF tenets of airpower such as centralized control and decentralized execution. The space system lacks linkages, doctrine, trained personnel, defined core competencies, tactical control equipment, standardized products, and in some cases equipment for the assigned mission area itself.

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[64] Martin, "60 Minutes: The Battle Above."

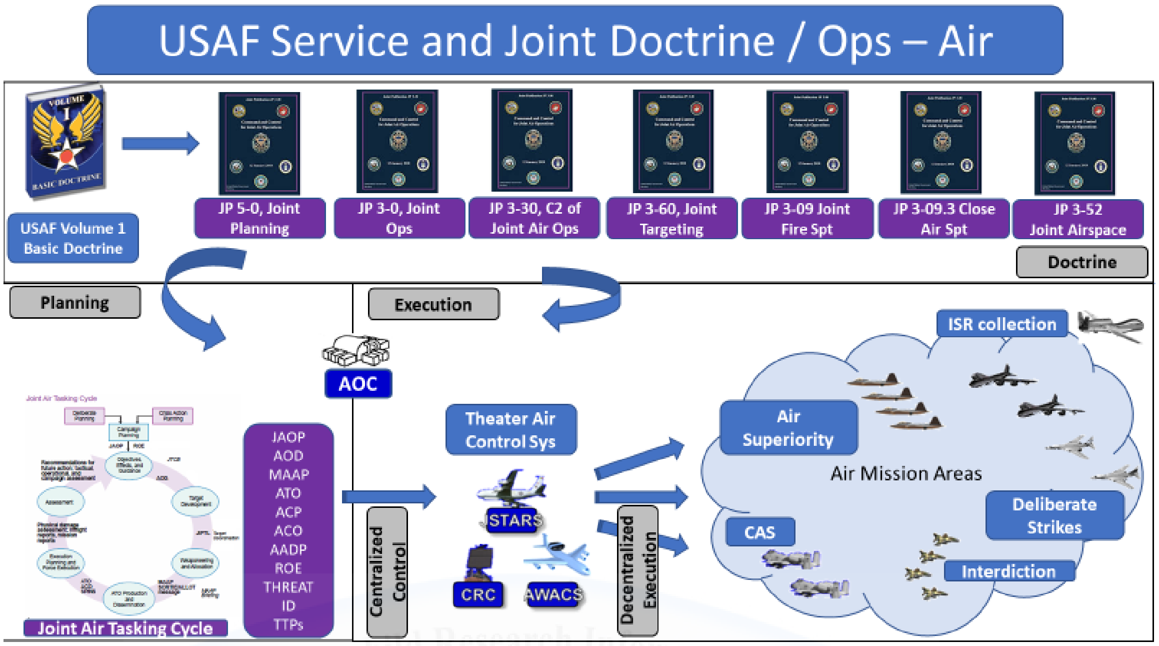

Figure 5, Air Doctrine to Execution linkages
Source: Author

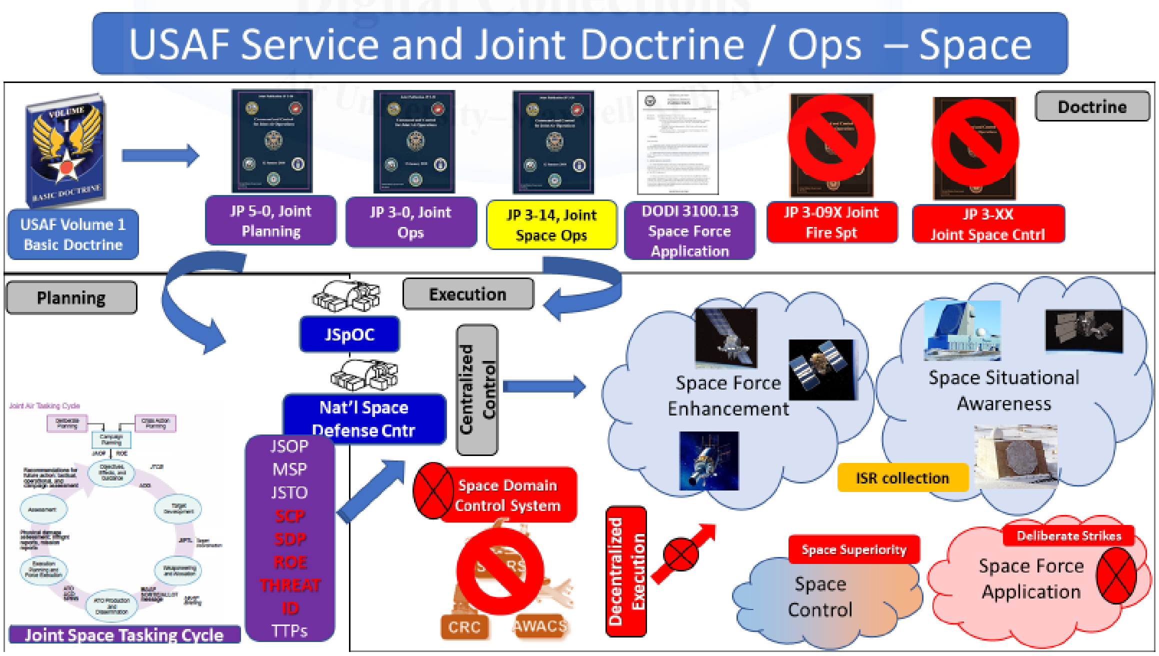

Figure 6, Space Doctrine to Execution Linkages
Source: Author

Chapter 3

The Fulda Gap: Battle Management of large-scale conflict

What exactly does tactical battle management deliver to air combat forces that AFSPC would want to emulate? The term battle management is somewhat nebulous and it is easy to obscure its meaning with jargon. Those within the Air Battle Management career field, entrusted with manning TACS and executing battle management, themselves struggle with meaning and definitions.[90] Through the following series of case studies, this paper seeks to illuminate the key competencies and capabilities the TACS brings for airpower that likely will be necessary for a space conflict, as well as gaps and limitations within the current space control system.

During the 1980s the USAF faced a potential conflict in Western Europe where it ran the risk of being overrun by the vastly superior numbers of the Warsaw Pact. To deal with what was likely to be an overwhelming number of aerial engagements, US Air Forces Europe (USAFE) and the North Atlantic Treaty Organization (NATO) constructed a redundant, resilient, decentralized tactical air control system made up of sectors. It is essential to understand how the USAFE's TACS dealt with task saturation and multiple engagements. TACS had to work as a system of systems, disaggregating decision-making, and direction to forces to allow for the management of large numbers of engagements expected in a war in Western Europe. The system was intended to be fault tolerant and able to absorb the destruction of individual nodes.

The Cold War Turns Hot

For illustrative purposes, the following is a hypothetical engagement, which the study will use to show how the US would have employed the USAFE TACS against a Soviet invasion of Western Europe. In the mid-1980s, rising tension between the Soviet Union and the United States culminated in miscalculation during the 1983 Able Archer exercise. This miscalculation led the Soviet Union to execute a surprise attack aimed at disrupting what the Soviet's believed was NATO's impending pre-emptive attack.[1] Across the frontier of Western and Eastern Germany, mechanized machines would have

[1] Hoffman, "In 1983 'War Scare,' Soviet Leadership Feared Nuclear Surprise Attack by U.S."

torn into dirt, roads, and hillsides in multiple prongs into the interior of Western Germany. as depicted in the true-life declassified Soviet scheme of maneuver below entitled "Seven Days to the River Rhine."[2]

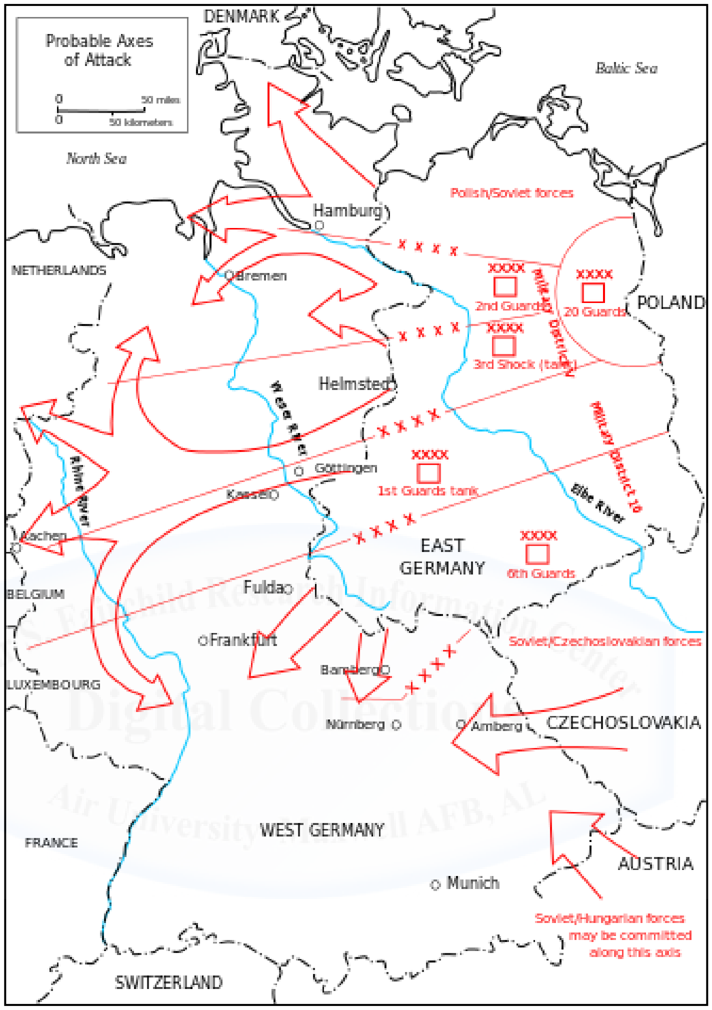

Figure 7, Seven Days to the Rhine
Source: Catcher, Redd. DECODED: The Cold War in Europe 1945-1995: Nuclear War in the West: Seven Days to the River Rhine.

At the beginning of the notional Soviet offensive, Warsaw Pact fighters would have risen into the sky to marshal beyond the line of sight of NATO ground-based radar systems and followed the standard Russian *maskirovka* practice of military deception and camouflage. While not entirely sure if conflict was imminent, AWACS aircraft would have been airborne and able to peer deeper into the iron curtain than the ground-based portions of TACS. As the

[2] Catcher, "DECODED."

number of tactical aircraft airborne grew, it would become increasingly clear the war was starting. In the sky above, hundreds of tactical fighters from both sides would have vied for air superiority, executed close air support (CAS) and interdiction missions. The NATO side, specifically the USAF, would attempt the “deep battle” design concept from the joint AirLand Battle Doctrine, focusing on interdiction and utilizing the Follow-on Forces Attack (FOFA) plan.[3] To execute this concept of operations, an integrated air defense system coupled with a layered C2 system would seek air superiority over the battlespace. For defensive operations, the front was divided into sectors with associated Control and Reporting Posts (CRP) underneath Control and Reporting Centers (CRCs). These CRCs would have reported to the Sector Operations Center (SOC) which would, in turn, notify the Tactical Air Control Center (TACC), or Air Defense Operations Center (ADOC) which would have sought to maintain situational awareness of the entire battlefront. For offensive control, AWACS would have orbited behind the front lines, and able to vector fighter-bombers as they streaked over into Eastern Germany.

Hypothetically, the TACS would have been put to the test, as masses of Soviet tactical fighters wing overhead in a race to battle for air supremacy over the engaged land forces.[94] US air superiority fighters, namely the F-15C and F-16, would have attempted to clear the sky of Soviet MiGs and Sukhoi's to allow F-111Bs and A-10s to execute deep interdiction and close air support per FOFA doctrine.[4] Within each sector, the CRC, AWACS, and CRPs would have polled, tracked, and directed airborne fighters within their control and coordinated force management decisions that would have occurred at the ADOC. Integrated ISR and identification would have happened at the lower tier echelons with the CRC, AWACS, and CRPs pooling sensor data into a fused air picture and applying threat matrix criteria to ensure the proper tagging of radar tracks as hostile, bandit, bogey, or friendly. Without this sensor fusion, the tactical fighters would have had difficulty positively identifying threats beyond visual range. As forces would have flown into battle, the continuum of control would have ensured all missions were aware of the critical pertinent information.

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[3] Lambeth, *The Transformation of American Air Power*, 57.
[4] Mizokami, “NATO vs. Warsaw Pact: How the Ultimate Cold War Showdown Could Have Killed Millions.”

A theoretical fight over the Fulda gap would have executed within Sector 8 (S8) of the USAFE TACS.[5] As the C2 system would have reacted, the ADOC at Kindsbach would have flushed alert fighters from airfields at Sembach and Ramstein. Additionally, within S8, the SOC at Darmstadt, the CRC at Lauda and airborne AWACS would have established authorities between the controllers and verified the ROE as well as air defense status with HHQ and airborne fighters. The CRPs at Doebraberg and Wasserkuppe would have monitored the air picture and taken engagements off the plate of the CRC as it became saturated. As the waves of inbound Warsaw Pact fighters streamed into S8, responding fighters would have fallen under the tactical control of these TAC C2 units within S8's system, shown in the figure below.

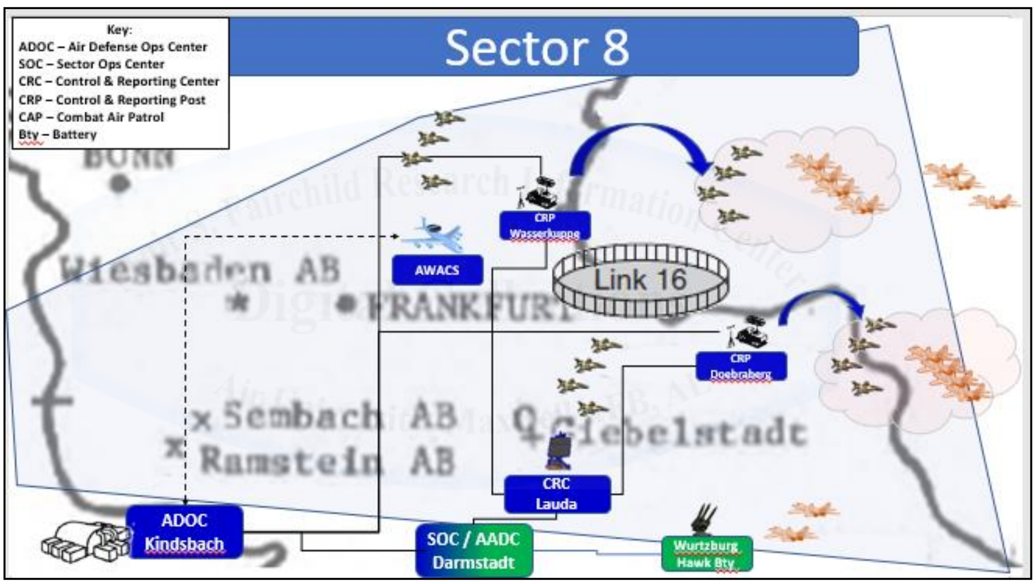

Figure 8, USAFE's Sector 8
Source: Modified from www.usarmygermany.com

One of the most critical aspects of TACS was its ability to pass status and situational awareness rapidly within minutes for radio communication or seconds utilizing machine-to-machine datalink. As a flight of fighters scrambled and checked-in with the orbiting AWACS, they would have been directed into an engagement area, then checked-in with the CRC or CRP that had control of that particular engagement or zone within the sector. Simultaneously fighters would have been trying to decipher the datalink picture provided by the TACS as well

[5] "Tactical Air Control System, US Air Force Europe."

as the intra-flight situational awareness provided by the fighters' organic radars. Using their datalink and UHF/VHF radios, the flight would have communicated weapons status, engagements, as well as fuel state both to TACS as well as the internal members of the four-ship. During the hour or two they'd likely be airborne before expending their air-to-air munitions or fuel, the fighters would have been enmeshed in this TACS of systems, ingesting as well as producing information for overall situational awareness. As fighters returned from the battle area to aerially refuel, they could have been confident that their loss of tactical focus and situational awareness could have been quickly replaced upon their return by the AWACS or CRP responsible for them.

Having a sectorized battle management area (BMA) also meant the lower echelon tactical C2 node, such as the CRP, would have had ownership of a smaller battlespace. As the conflict exploded in complexity, the sectorized system would have allowed for tactical control to keep BMAs synchronized to the overall fight. The CRP or weapons controller team on-board an AWACS could have communicated with inbound or engaged fighters as they transited the airspace. These fighters would not have to worry about a bandit sneaking around their flight or wonder if the tanker would have been on-station back behind the line. The TAC C2 node would have tracked details such as those, acting as another thinking entity one step above the fray. In return, the tactical fighters would have protected the high-value C2 nodes as long as possible in the face of losing odds.

The symbiotic system was built to be fault tolerant as well. If the CRP at Wasserkuppe on the border of West and East Germany had fallen victim to the onward rush of Warsaw forces, other elements of TACS would have picked up for the lost node. The CRC at Lauda or an airborne AWACS could have covered the gap in tactical control. This is not to say that degradation would not have had impacts to the efficiency in the system. Regardless, it is a vital capability of TACS to gracefully degrade instead of failing catastrophically. The system would have ensured someone had ownership of a battle management area at all times.

Implications

The USAF TACS earns its value as the go-between for the operational and tactical level. It offloads tasks from encumbered warfighters and passes critical status information up to higher level C2 nodes. From this fused battlespace awareness, one can make force management decisions faster, and have a more complete understanding of the environment. The BSA enables decisions such as who will get priority for air refueling, when to flush ground alert reinforcements, and when high-value assets need to turn tail from an inbound threat. The system enabled localized battlespace awareness, even when the aircraft under control did not have onboard means to build SA. TACS also allowed for graceful degradation if there was destruction of TAC C2 nodes. Its structure was set up for sectorization, to reduce the complexity into a manageable area. Without the system comprised of trained personnel, specialized equipment, operational doctrine, products, and processes in place, it is feasible that airpower would have been relegated to fight as it started out in World War I. Or worse, the operational-level command nodes would freeze under an inundation of communications requesting information, tasking, and status of threats.

The air-to-air study showcased the importance of managing complex, large-scale conflicts with a sectorized system focused on battle-management areas. The air-to-ground studies will highlight the importance of having previously agreed upon concepts of operations, while also showing the value of dedicated specialized sensors that can be tasked to collect on battlefield dynamics. The battle of Khafji, where the E-8 JSTARS made its operational debut, provides rich detail on the impacts of a previously unknown technical capability rushed into combat. The E-8 did so as a pre-operational weapons system when few planners, commanders, or operators understood its value.

Chapter 4

The Battle of Khafji: Ad Hoc Battle Management

Khafji would be remembered as a day that the Air Force would like to forget because the JSTARS clearly showed advancement of armor moving South

-Lieutenant General Buster Glosson
CENTAF director of campaign plans, 1991

While the USAF had structured the TACS much earlier than the start of the 1991 Gulf War, it was still caught somewhat unprepared for the introduction of a completely new sensor suite that was unheard of prior.[1] The JSTARS baptism by fire, before even reaching initial operational capability (IOC), revolutionized how TACS could support tactical air forces conducting CAS, interdiction, or kill box operations. The Battle of Khafji provides a cautionary tale for space operators who seek to bring special access programs or other restricted systems into play *after* a conflict has begun.

Context of Khafji

After a sustained air campaign had begun to impact morale within the Iraqi military, Saddam Hussein ordered the Iraqi army south into Saudi Arabia to exact retribution and throw the coalition off balance.[2] The newly developed E-8 JSTARS detected the Iraqi maneuver and reported up to the Tactical Air Control Center, the air component operational C2 node for Desert Storm. The US military was slow to react, however, once the Iraqis crossed the border. Initially, the thrust was deemed a feint and did not warrant a significant response force.[3]

Opposing the Iraqi armored column was a coalition of forces, including US 3rd Marines as well as Saudi National Guard (SANG) and Qatari armored forces. The US and Coalition forces in the vicinity of Al Khafji had established observation posts to monitor the border. On the evening of 29 January, 60 Iraqi T-72s and many BMPs supported by close to 2,000 entered the town.[4] The first

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[1] Palmer, Scott, and Toolan, "The Battle of Khafji: An Assessment of Airpower," 23.
[2] Head, "The Battle for Ra's Al-Khafji and the Effects of Air Power January 29-February 1, 1991 Part I," 13.
[3] Newell III, "Airpower and the Battle of Khafji: Setting the Record Straight," 15.
[4] Head, "The Battle for Ra's Al-Khafji and the Effects of Air Power January 29-February 1, 1991 Part I," 10.

contact point, OP-4 manned by Marines from Task Force Shepard, began to see streams of troops and armor envelope them via their night vision goggles. After up-channeling the enemy maneuvers and beginning taking fire, OP4 was directed to withdraw. Probing during darkness, Iraqi forces began to push the coalition forces back, as the coalition had not expected any offensive action on the part of the Iraqis.

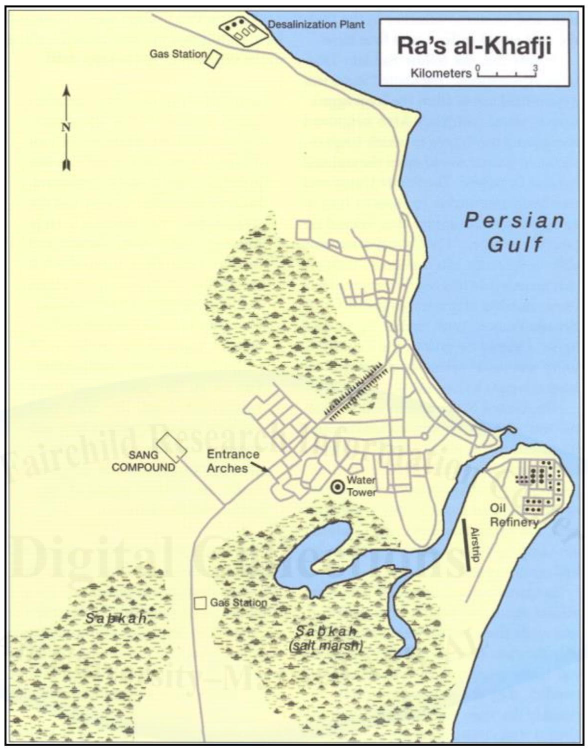

Figure 9, Al-Khafji overheard view
Source: Head, William P. "The Battle for Ra's Al-Khafji and the Effects of Air Power"

Once control of Khafji was ceded, Saudi King Fahd directed the restoration of Saudi sovereignty, even if it meant leveling the town.[5] A day later, a combined Saudi and Qatari ground force began to make its way into Khafji to retake it. Overhead, US airpower circled menacingly to provide close air support. The battle was baptism by fire for Qatari forces, who had yet to fire a shot in anger since the establishment of their country.[6] The rushed planning resulted in deficiencies. US advisory forces recommended a delay to allow for

[5] Newell III, "Airpower and the Battle of Khafji: Setting the Record Straight," 43.
[6] Head, "The Battle for Ra's Al-Khafji and the Effects of Air Power January 29-February 1, 1991 Part I," 27.

better-integrated planning and for airpower to attrit the Iraqi forces within the city. King Fahd wanted no further delay and ordered the attack.[7] The initial frontal assault failed, with both sides breaking contact to resupply and regroup. The problem for the Iraqis was resupply and relief had to travel over open desert under the watchful eye of the E-8.[8]

After shaking off the initial malaise, the TACC pushed significant CAS sorties into an established killbox overhead. Over the four-day period, almost every F-15E sortie and one-third of the F-16 missions helped the fight for Khafji.[9] Instrumental in this fight, the E-8 JSTARS was pressed into service to locate Iraqi armor and mechanized forces. After it quickly became apparent that the E-8 was able to find and fix targets, the JSTARS became an ad-hoc battle management center. It was to the ground campaign what AWACS and CRCs were to air campaigns.[10] Its electronically scanned array radar was able to provide wide-volume surveillance that provided moving target indications. The JSTARs ability to watch for ground vehicle maneuver gave both the air and land components insight and a level of awareness unavailable to their adversary.[11] The JSTARS provided battlespace situational awareness unavailable in a tactically relevant manner by any other means. The integrated platform had an organic ability to surveil inherent in the sensor suite, backed up with a robust communications suite, and manned by personnel wishing to make a difference in the tactical fight. Because of the JSTARS capability, the air control arrangement changed on 28 January, and as a result, the E-8 became the defacto controlling agency for the battle of Khafji.[12]

[7] Titus, "The Battle of Khafji: An Overview and Preliminary Analysis," 19.
[8] Head, "The Battle for Ra's Al-Khafji and the Effects of Air Power January 29-February 1, 1991 Part I," 11.
[9] AFSAA, "Joint Stars Data Analysis The Battle of Khafji," 19.
[10] Newell III, "Airpower and the Battle of Khafji: Setting the Record Straight," 51.
[11] Titus, "The Battle of Khafji: An Overview and Preliminary Analysis," 13.
[12] AFSAA, "Joint Stars Data Analysis The Battle of Khafji," 19.

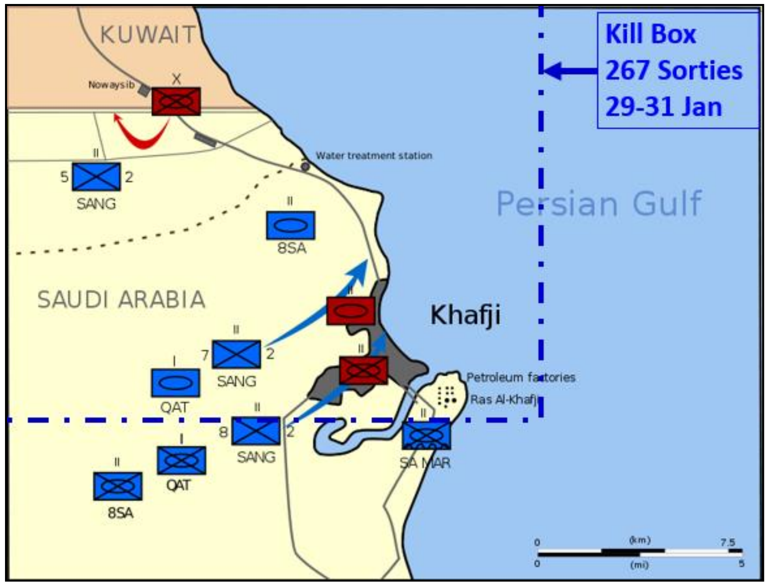

Figure 10, Al-Khafji land scheme of maneuver
Source: Modified from www.wikipedia.com

After more than 1,000 attack sorties in and around Khafji, the Iraqi III Corps commander repeatedly asked to break the engagement, even after repulsing the initial coalition ground offensive.[13] The results of the combined close air support and interdiction campaign against the Iraqi assault resulted in over 540 tanks, 310 armored personnel carriers, and 425 artillery pieces destroyed. Analysis showed almost two-thirds of all equipment and personnel losses were due to air interdiction and close air support.[14] The E-8 was *the* single most significant asset in the battle for Khafji. As tactical sorties checked into the killbox, the E-8 was able to vector them onto targets, providing situational awareness to crews. This support increased their confidence in positive identification and reduced risks to fratricide.[15]

Implications

The story of the Battle of Khafji is part success, part cautionary tale when it comes to the use of battle management platforms, processes, and personnel. The JSTARS platform was a revolutionary upgrade for the air-to-ground portion of TACS, providing unique capabilities enabling battlespace situational awareness of moving ground targets, and the ability to control

[13] Titus, "The Battle of Khafji: An Overview and Preliminary Analysis," 18.
[14] Titus, 23.
[15] Titus, 24.

engagements for air-to-ground strikes much like AWACS did for air. JSTARS was rushed into service before the start of the conflict, however, and had yet to iron out where it fit within the TACS architecture. The effect resulted in on-the-fly creation of JSTARS tactics, techniques, and procedures. Once rushed to the theater at the start of the air campaign on 17 January, the E-8 was an ISR entity providing support to other battle management nodes within the TACS.[16] Fortuitously, this constraint was changed on January 28th to give the E-8 controlling authority to direct strikes. The change occurred just in time for the battle of Khafji. Additionally, there was a limited number of the airframes, so it was tasked to fly an orbit near the Iraqi border but with only one aircraft operating at a time. JSTARs attention was quickly consumed by one sector of the theater at a time, as visualized in figure 12 below. Lastly, contractors worked the JSTARS sensors and they had either limited experience operating in a theater of war or were no longer combat certified, having long ago retired from active duty service.[17] The contractors performed admirably but were not as polished as their active duty counterparts implementing special instructions or following communications procedures.

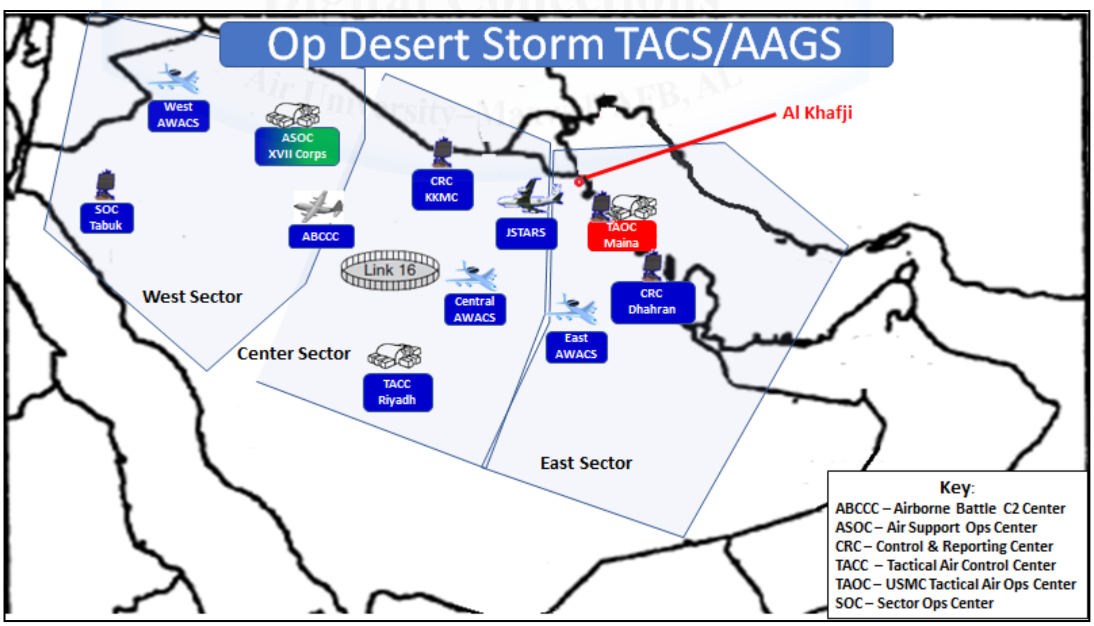

Figure 11, Gulf War TACS
Source: Modified from Eliot Cohen, "Gulf War Air Power Survey"

[16] Cohen, "Gulf War Air Power Survey," vol. II Pg 341.
[17] Major Luka, Air Battle Management discussion.

Issues with implementation aside, the E-8 was instrumental in detection and reporting of the Iraqi maneuver. No other fielded capability would have allowed for such a feat. Although, truthfully there had been some bit of luck in JSTARS' initial detection of Iraqi forces maneuvering towards Khafji. The crew had expected to focus their attention on western Iraq during the sorties just before the assault on Khafji to suppress Iraqi SCUD fire into Israel and Saudi Arabia. Only by happenstance did the crew have the sensor system sweeping the southern part of Kuwait to notice the impending attack. Critically, the E-8 was able to provide an unambiguous picture of Iraqi intent based just on the numbers of ground moving target indicator (GMTI) tracks it saw streaming towards Al Khafji, approximately one hour before OP-4s engagement.[18]

Since the JSTARS rushed to the theater before its operations acceptance, many of the data flows and procedures to integrate with other systems were built during an active conflict.[19] The fact the processes were immature is somewhat understandable, given the fact that the E-8 was still in the engineering and manufacturing phase of acquisitions [20] Delays in information propagating up and down the chain reduced the effectiveness of the JSTARS weapons system. Even when given TAC C2 authorities, crews on JSTARS were hobbled by poor information flow by incompatible systems between other nodes like the TACC, ABCCC, and AWACS.[21] Common planning tools like the use of brevity words and standardized radio terminology were immature or non-existent with the new system. Had establishment of communications paths and brevity terms been accomplished before the start, it could have forestalled some of these issues, or at the very least increased the overall efficiency. The impact of this fog and friction was a reduced use-rate of CAS and interdiction sorties within the Khafji killbox and ultimately reduced effectiveness from airpower.

The JSTARS success story in the battle of Al Khafji has a cautionary note for Space Operations. Often space systems remain highly classified, even internal to sister-units within the same command. If the battle management

[18] Head, "The Battle for Ra's Al-Khafji and the Effects of Air Power January 29-February 1, 1991 Part I," 4.
[19] Titus, "The Battle of Khafji: An Overview and Preliminary Analysis," 20.
[20] AFSAA. "Joint Stars Data Analysis The Battle of Khafji." Air Force Studies and Analyses Agency, May 8, 1997. http://www.dtic.mil/dtic/tr/fulltext/u2/a336272.pdf.

[21] Palmer, Scott, and Toolan, "The Battle of Khafji: An Assessment of Airpower," 15.

system has yet to account for the impact of an unknown capability or spacecraft, it will likely mirror issues JSTARS had with authorities, communications, and procedures at the onset of the battle of Khafji. Incorporating new systems, techniques or procedures during an active conflict carries risk and is often a focus area when historians begin to study the event.

Eliot Cohen and the Gulf War Air Power Survey (GWAPS) outlined the risk of new systems employed in the heat of battle:

> If facing the uncertainty and stresses of war, the personnel in military command and control organizations abandon their practiced and codified procedures and create informal and ad hoc organizations and procedures, they run two risks. The first is that they will get bogged down in efforts to put together a new structure to support the theater commander. The second risk is that their new procedures will actually not work as efficiently as they anticipate, leaving them with ineffective command and control at the theater level.[22]

The risk of implementing a new structure under wartime conditions came to pass in the instance of the JSTARS and the battle of Khafji. Communications often broke down between the AWACS, JSTARS, ABCCC, and the Direct Air Support Center (DASC).[23] The result was aircraft flying into the killbox over Khafji without taskings as the JSTARS worked to handle a large number of aircraft overhead. The task saturation resulted in unused sorties ending up low on fuel and returning to base.[24] Without TTPs in place, communications were misunderstood or strained. It would be another eight years before the E-8 JSTARS was fully operational and another thirteen years before JSTARS again proved the value of having a tactical battle management platform.

[22] Cohen, "Gulf War Air Power Survey," vol. 1 Pg 4.
[23] Palmer, Scott, and Toolan, "The Battle of Khafji: An Assessment of Airpower," 21.
[24] Palmer, Scott, and Toolan, "The Battle of Khafji: An Assessment of Airpower," 21.

Chapter 5

Operation Odyssey Dawn: Going it Alone or with TACS

[TACS] job was to orient shooters, pair shooters with targets, solve battlespace problems, speed accurate decision-making

Lieutenant General Margret Woodward
Operation Odyssey Dawn CFACC

Operation Odyssey Dawn (OOD) highlighted the impacts of forsaking a tactical battle management system by showing what delays and friction occurred without it and what efficiency gains existed with it. The takeaway lesson is that technically complex targeteering and force management tasks are most efficiently accomplished by parties one step removed from the tactical engagement. Even with advances in sensor and communications capabilities on front-line US fighters and bombers, it becomes apparent that saddling aircrew with tasks normally accomplished by TAC C2 has a significant degradation on airpower effectiveness. The lack of a battle management team dedicated to orienting and pairing shooters, fixing battlespace and communications problems, and acting as a bridge between operational and tactical echelons drove frustrations both at the CAOC and for the aircrew flying over Libya, some 1200 miles away.

Fighting a Pickup Game -- Operation Odyssey Dawn

Mohamed Bouazizi, a hopeless vegetable vendor set himself a-fire on 17 December 2010 in Tunisia in a fatal protest against his government and his lot in life.[1] Few expected those desperate flames to spark an uprising throughout the Maghreb and into the Middle East itself. As the wildfire of revolution swept across the desert, the fall of Egypt on 11 February 2011 stoked the fires still hotter. Most national governments were caught unprepared for the unrest. Colonel Muammar Qaddafi was not an exception. He was not reluctant to stamp out the fire of rebellion with overwhelming force, however, as a few days into the revolt he employed troops and aircraft against civilians. He further declared that if the unrest did not stop, he would "cleanse Libya house-to-

[1] Fahim, "Slap to a Man's Pride Set Off Tumult in Tunisia."

house."[2] Initially, the US condemned Qaddafi's actions, but polling indicated the American public had ambivalence towards intervention in the conflict.

As European allies and the US Congress pressured President Obama to act, a course of action developed around the idea of establishing a No-Fly-Zone over the cities of Libya. The idea began to seem more likely as a new organization, the National Transitional Council (NTC) coalesced from the Libyan Opposition movements. Now with a singular voice asking for outside assistance to stop the violence against civilians, international security organizations such as NATO and the United Nations (UN) began to debate intervention.[3]

There was still resistance to embroiling the US, the UN, and NATO in another conflict in the region. As regional powers debated and hamstrung alliances from acting as a unified whole, a coalition of some NATO and Middle Eastern powers began to solidify around the idea that something had to be done to stop the bloodletting.[4] Finally, the UN Security Council passed resolution 1973 which provided diplomatic authorization for any nation, regional organization or arrangement to take action necessary to protect civilian life.[5] Qaddafi failed to make any overtures about ceasing operations, instead vowing to turn rebel-held Benghazi into a bloodbath.[6] It was apparent only intervention would halt Qaddafi's guns and keep his aircraft from flying. An amalgamation of nations, including France, the US, Denmark, the UK, Qatar, UAE, and others slowly inched towards committing combat forces. Without the unanimous approval of all NATO members, and without a united US government position, the initial effort at quelling Qaddafi's rampage is best described as slapdash. [7]

Hastily put together, the planning and execution team for OOD was a disparate group of cobbled together units and assets. At the onset of the conflict, it was apparent that US Africa Command (AFRICOM) was ill-equipped for commanding an active fight. Generally, AFRICOM operations are predominately humanitarian related.[8] European Command's 603rd AOC at Ramstein AB, Germany, over one thousand miles away from Libya, was the only

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[2] Mueller, *Precision and Purpose*, 12.
[3] Mueller, 16.
[4] Anrig, "Allied Air Power over Libya: A Preliminary Assessment," 2.
[5] Anrig, "Allied Air Power over Libya: A Preliminary Assessment."
[6] Tirpak, "Lessons from Libya," 34.
[7] Mueller, *Precision and Purpose*, 21.
[8] Mueller, 21.

logical choice for operational C2.[9] The ad-hoc planning and execution of OOD at its start hobbled the employment of US and NATO airpower. US officials noted limited ISR and tactical control were the principal constraints in supporting OOD's offensive air campaign.[10] AWACS aircraft were not available for the first five days while JSTARS did not flow into the theater until the seventh day.[11] The coalition had little choice but to act. Qaddafi had explicitly stated his goal of a bloodbath of any and all Libyans in the rebel-held city of Benghazi. His forces were observed maneuvering towards the city outskirts, in defiance of UNSCR 1973. Given the time imperative to halt Qaddafi's forces from entering Benghazi, the fog and friction expected in such a hasty operation had to be an acceptable risk.[12] Either airpower was going to be thrown into the fray haphazardly, or Libyan rebel forces ran the danger of being massacred by advancing Qaddafi forces.[13] Flying without the aid of TAC C2 was a novel concept for American airmen, having become accustomed to the core battle management functions the TACS provides. There was no time to wait for the creation of a TACS, however, as the fight was on.

On 19 March 2011, as the operation commenced, multiple fixed air defense sites were struck, as well as the first air-to-ground strikes. As the counter-land campaign got underway, the impact of the missing TAC C2 was felt immediately. Without local tactical control guiding them, aircrew flew into the assigned area without situational awareness. They spent a significant amount of their allotted time searching for valid targets. Sorties had about one hour on station after spending four hours flying to the theater and four hours returning to base.[121] The time spent sorting information and searching for targets placed an undue burden on the crews. An ad-hoc tactical battle management system sprung up, as returning aircraft radioed as they passed inbound sorties, providing the details on where to look, almost like two passing ships discussing where the fish were biting.[14]

[9] Mueller, 84.
[10] Mueller, 29.
[11] Mueller, 126.
[12] Mueller, 21.
[13] Mueller, 192.
[121] Tirpak, John A. "Lessons from Libya." Air Force Magazine 94, no. 12 (2011): 34–38.
[14] Tirpak, "Lessons from Libya," 37.

The vast majority of strikes during the opening days of OOD were dynamic targets, with only ten percent of sorties executing against pre-planned ones.[15] This lopsided targeting framework resulted from a chaotic battlefield primarily focused on defeating fielded forces before they could overrun rebel strongholds. The ever-shifting shell-game of finding, fixing, and finishing Qaddafi's troops before they massacred rebels placed a big demand signal on aircrew to be their own ISR support. The burden becomes clear when looking at the landscape through a targeting pod while flying 500 knots above an unfamiliar country while simultaneously maintaining airspace deconfliction and scanning for threats.[16] As aircrew entered the battle area, reliance on Strike Coordination and Reconnaissance (SCAR) and dynamic targeting tactics placed more responsibility on aircrew to establish positive identification. The necessity to ID Qaddafi's forces from rebels led to some reluctance on the part of aircrew to employ munitions, as they could not be sure enough to shoot.[17] The CFACC of OOD, General Woodward noted decisions like these to employ weapons are often done through heavy collaboration with local air battle managers who have direct visibility in the unfolding engagement.[18]

Burden did not solely rest with the aircrew. The 603 AOC is typically connected to the battlefield with the TACS networks, via voice and data as well as by radio and satellite communications. Without a TACS, the CAOC was disconnected from the aerial battle ensuing in Libya. Servicemembers at the CAOC were reliant on a limited amount of SATCOM bandwidth to direct individual aircraft flying close air support and interdiction missions in Libya a continent away.[19] The normally quick tasking process bogged down from seconds and minutes to upwards of ten to twenty minutes. The result was missed targets as battlefield conditions changed while the CAOC tried to update forces.[20]

After the establishment of battle management areas and incorporation of TAC C2 assets like JSTARS, more normal decentralized execution processes

[15] Anrig, "Allied Air Power over Libya: A Preliminary Assessment," 88.
[16] Tirpak, "Lessons from Libya," 37.
[17] Tirpak, 37.
[18] Tirpak, 37.
[19] Major Luka, Air Battle Management discussion.
[20] Major Luka.

took over. JSTARS set up killboxes and other control measures in a bid to deconflict platforms and provide targeting assignments to crews flowing into the theater.[21] Coupled with AWACS, the TAC C2 elements established a tactical battle management system over the northern portion of Libya, as shown below. Within the C2 chart embedded in figure 13 below, it is clear to see the reduction in C2 fragmentation as a result of the addition of these systems, as well as the approximate locations of the killboxes utilized during OOD.

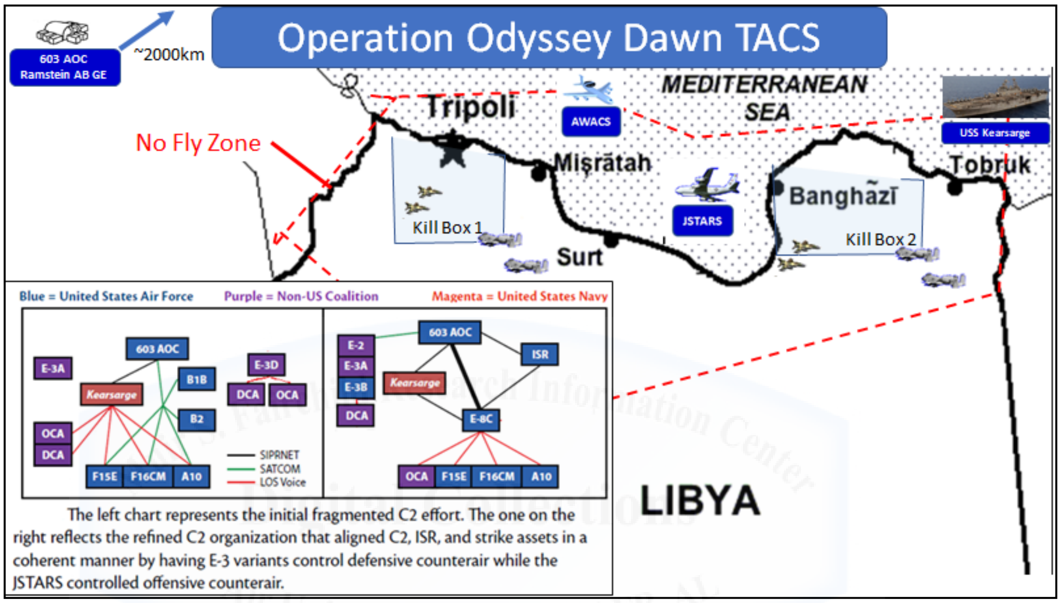

Figure 12, OOD TACS and C2 system
Source: Modified from Majors Matlock, Gaustad, and Scott, and Captain Bales. "Command and Control in Africa: Three Case Studies before & after Tactical C2"

As crews checked in with TAC C2, they received a lowdown of various threats that may be operating in their area as well as the initial targeting vector. Multiple modes of communications allowed for the assured flow of information. The JSTARS could receive information via Internet Relay Chat or SIPRNET connectivity and then retransmit relevant taskings to airborne crews using line of sight or satellite radios. The new battlespace awareness sped up decision-making in theater and also added a layer of safety. After identifying targets, the JSTARS crews ran ROE determinations using their ability to observe the target area as well as reach back to integrate other forms of ISR that a tactical fighter

[21] Maj Matlock et al., "Command and Control in Africa: Three Case Studies before and after Tactical C2," 119.

does not have the time or communications ability to match.[22] If there was a risk to civilians or undesirable collateral damage, the JSTARS crew could call off the strike.[23] The introduction of tactical battle management assets like JSTARS turned night into day for low SA fighters flying in Libya. Tasking timeliness dropped from tens of minutes to under a minute.[24]

As OOD drew to a close on March 31st, giving way to NATO's Operation Unified Protector, US assets took a sharply reduced role in the air campaign against Qaddafi's forces. During the few days of the conflict, over 150 US aircraft deployed to theater, flying 2100 sorties and employing over 760 weapons. Overcoming the friction present during the first few days, the US established a tactical battle management system over Libya comprised of JSTARS and AWACS aircraft. The crews were able to sync organic radar data and off-board ISR data and then communicate across the TACS enterprise up and down echelon, establishing battlespace awareness across the enterprise. This interlinked command, control, and communications system was a critical requirement. JSTARS and AWACS oriented forces, paired them with targets, and solved tactical problems with communications. The result was a much speedier and more accurate decision-making process for all forces involved.[25]

Implications

The opening salvo of Operation Odyssey Dawn showed the consequences of operating without a tactical C2 layer. Strike units flew without the situational awareness and force management direction they were accustomed. The CAOC operated without its expected communications paths to assigned forces. The missing TAC C2 resulted in task saturation on strikers and reduced situational awareness up and down echelon. A lack of TAC C2 violated the USAF core tenet of decentralized execution. The battle management team associated with the TACS explicitly acted on three out of the four tasks of Boyd's OODA loop. Without TAC C2, aircrew were forced to make on-the-fly force management,

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[22] Maj Matlock et al., 125.
[23] Tirpak, "Lessons from Libya," 34–38.
[24] Major Luka, Air Battle Management discussion.
[25] Tirpak, "Lessons from Libya," 34–38.

ISR, and tactical data management decisions that reduced overall throughput and efficiency of the air campaign.

The requirements for battle management core competencies and functions are immutable. In situations where warfighters must operate without the benefit of a continuum of control stretching from operational to tactical layers, the front-line unit must take on additional task complexity to accomplish the mission. In OOD, without AWACS and JSTARS, aircrew had limited battlespace awareness. Sortie success rates suffered as a result.

Chapter 6

Conclusions

Space is a warfighting domain just like air, land, and sea. We have to be prepared to fight a full range of operations.

General John "Jay" Raymond,
AFSPC and JFSCC Commander

From Air to Space

From the review of doctrine, history, and case studies a consistent theme has emerged highlighting the importance of a battle management system that provides battlespace awareness to tactical operators, executes decentralized control of forces to place tactical systems in a position of relative advantage over the adversary, and acts as an intermediary between entities like the CAOC and JSpOC and mission crews. The air domain has learned and adapted to this foundational truth over the 100 years of warfighting aviation from the Dowding System of the RAF through to today's TACS. The airplane transitioned from an observation and communication platform towards specialized pursuit and attack systems and onward to 5th generation sensor-shooter complexes enmeshed in a supportive tactical control system known as TACS that works together to meet commander's intent and react to battlefield dynamics.

The TACS and the current air domain C2 system evolved over many years to what exists today. As threats and tasks progressed beyond what aircrew could single-handedly handle, the USAF developed the air battle manager careerfield and equipped them with systems such as AWACS, JSTARS and the CRCs as well as products, processes, and TTPs to link strategy to tactical execution. As data management became a critical requirement, the US created the Joint Tactical Information Distribution System (JTIDS), known colloquially as Link-16, and other automated information systems to ensure smooth flow of information. Taken together, it is a layered C4ISR system that can act upon the commander's intent through multiple levels of war and at low and high-intensity conflict. The TACS operates in-domain as well as cross-domain, supporting another functional component with fires. Within it, certain key capabilities bear extrapolation into a space control system.

Recommendations

Space operators need a new purpose-built space control system (SCS) to manage a future conflict that extends into space. Vitally important, the new SCS *must* shorten the OODA loop in response to emergent threats that span multiple attack vectors. Response times need to drop from days and hours to minutes and seconds to have tactically-relevant chances to defeat aggression or achieve tactical success.

A fundamental requirement to shorten response times hinges on the ability for JFSCC to push authorities down. Currently many are held at the General Officer-level or, in some cases the JSpOC Director or Squadron Commander. The objective is to turn control over to young space operators battle managing via the SCS. Historically, space operations was inexorably linked to strategic frameworks and decision-making. While today's spacecraft are still exquisite systems, they are not uniquely expensive or irreplaceable. USAF B-2 bombers are unique strategic systems, but they train and operate within TACS. RC-135s are irreplaceable national assets, yet again they are entrusted to TACS. US Navy AEGIS Destroyers cost over $1B, yet are commanded by O-5s, and often under the control of O-3s as the Officer of the Deck.[1] These systems often have strategic implications just as space assets do. Other domains have enabled the pushing down of authorities to lower-echelons by constraints and restraints that higher headquarters withholds as a means to manage risk and probability of escalation. Space operations can take a similar tack by establishing right and left bounds of the delegated authorities. Regardless, space operations must honor the newly-developed threats and adapt its authorities. It must have a new control system.[2]

The new system must take into account the lessons learned from the development of TACS. It must be able to handle complex and diverse threats as contemplated in the Fulda Gap, it must be built before conflict with established procedures, authorities, and TTPs as proven during the battle of Khafji, and it must provide decision-quality information for task-saturated crews as shown by

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[1] Fabey, "Surface Warfare Officers School Reviews OOD Competency | Jane's 360."

[2] A word of qualification on this statement is in order: control system here implies the ability to direct and control forces under the command of a space functional commander, not control of the domain, such as establishing space superiority.

US experiences in OOD. It must have a doctrine that provides operational guidance, akin to JP 3-52 and JP 3-30 for the air domain. It must have new organizations to equip and man new space control squadrons. It must identify a sectorization framework in order to ensure decentralized control and to reduce risks due to task saturation. It must have trained personnel steeped in core competencies and functions for battle management. It must have new automated information systems (AIS) to process and manage data, as well as an open-architecture COP to display it. The SCS must have specialized personnel in which to develop experience in the mission area. It must transition from the current architecture to a new warfighter-focused one, as shown below, as soon as practical.

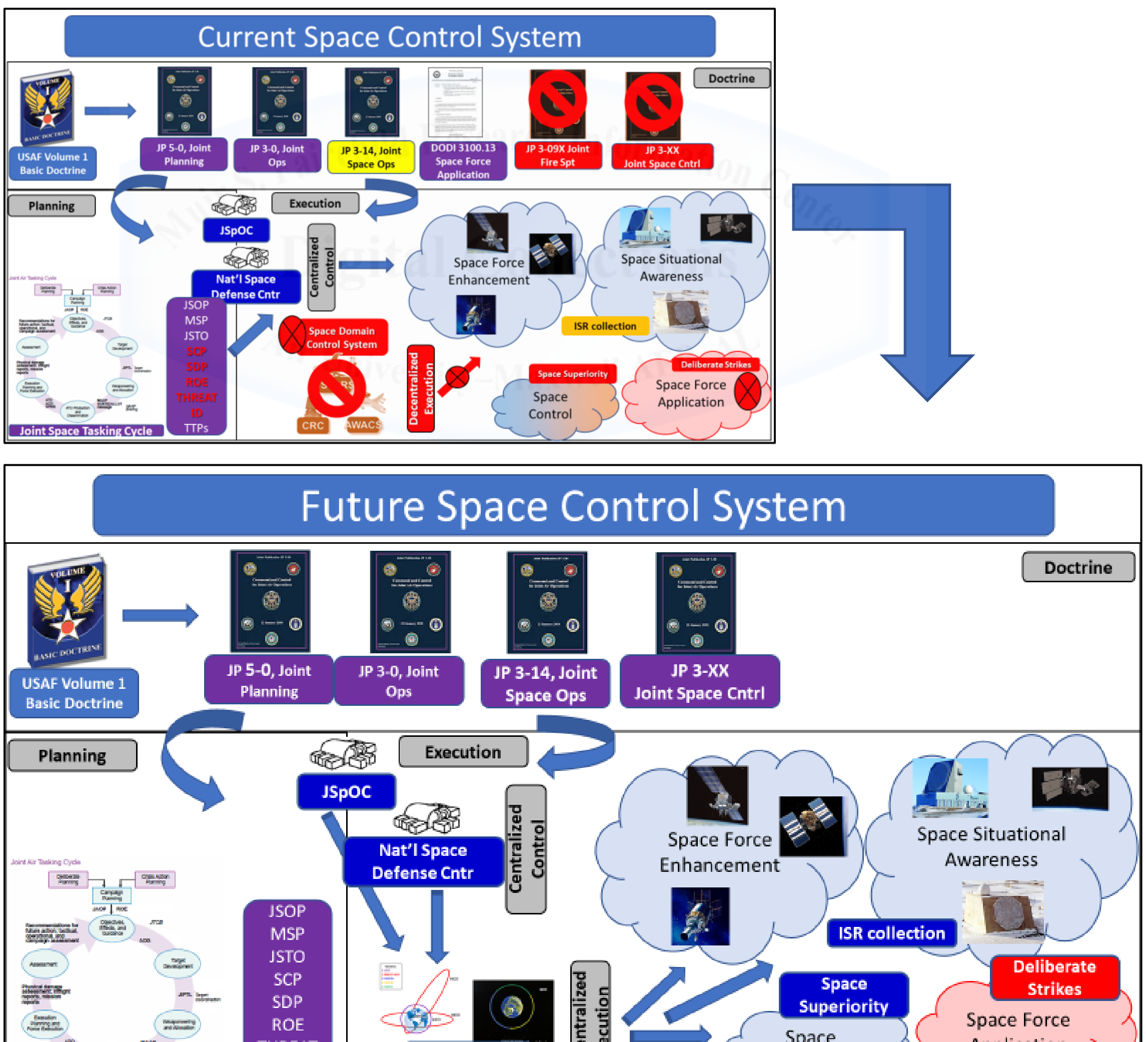

Figure 13, Current to Future SCS
Source: Author

Doctrine

Of the items required for a future space control system, doctrine is the easiest to implement. The USAF and JFSCC through USSTRATCOM should begin drafting operational doctrine for defensive and offensive space control systems if they are scheduled to be fielded soon. Even without any additional capability on-orbit or terrestrially, the USAF should focus on ensuring a continuum of control between operational and tactical C2 to make the most efficient use of advances such as the Space Warfighter Construct, Space Enterprise Vision, and Space Mission Force. The Air domain documents provide a good starting place for development.

Examples of missing space doctrine products currently in use within geographic air components include Area Air Defense Plans (AADP) and its associated Area Air Defense Commander (AADC), Rules of Engagement, threat identification matrices, Air Control Plan, Air Control Order, and brevity terms. These procedural and doctrinal support items allow air campaigners to have initial starting guidance, which when paired with an air operation plan and subsequent air operations directive, and ultimately, an air tasking order, provide the tasking and left right limits for the employment of airpower via the TACS.

One critical shortfall for a future SCS centers around authority to direct forces. Currently, within space operations, authorities are held at the operational-level or higher. Space operations need a similar capability to allow for efficient task delegation and decentralization. Some within AFSPC have already reached this conclusion, writing white papers on future battle management and personnel constructs.[3] Recommended changes include the establishment of a Space Control Authority, who analogous to the Air Control Authority, would have the power to establish orbital control measures that dictate how US military, allied, and associated spacecraft maneuver within the domain. The JFSCC Commander would seem to be the appropriate level of command for this authority. Empowering this new authority, a Space Control Plan (SCP) would need to be developed to provide detailed planning data to those who operate under the construct. Associated with SCA and SCP a new

[3] Major Grosselin, Interview on Future Space Battle Management.

Rules of Engagement (ROE) and Special Instructions (SPINS) would require drafting to cement what authorities are undertaken at each level of control. For example, SPINS may allow for spacecraft operations crews to defensively maneuver if under threat, without needing direction from a squadron commander or the SCS.

Additionally, a revamped JP 3-14 could include many of the tenets of counter-air threat doctrine laid out by JP 3-01. By re-orienting doctrinal terms and frameworks around the need to counter orbital and terrestrial threats to spacecraft, missing pieces of US defensive counterspace planning should become more self-evident. One current gap centers around an authority called the Area Air Defense Commander (AADC). This authority is usually vested with the JFACC and has the responsibility to plan, coordinate, and integrate the joint force defensive counter-air operations. A new authority, the Space Defense Commander (SDC), would empower the JFSCC with the ability to synergize US military efforts for defensive counter space operations.[4] The new JP 3-14 and its new authorities should highlight the fact that US policy towards the militarization of space trends towards defensive actions. It takes into account the fact that the majority of US investment in space is already on-orbit and at risk.

Organization

Organizationally, a future SCS should sectorize the space domain into subsets to heighten the ability to decentrally execute in space. As shown in the Fulda Gap scenario's sector system, and Khafji' s and OOD's killbox structure, dividing a region into battle management areas allows TACS to implement decentralized control. Sectorization also acts as a hedge against task saturation. Without sectorization, the SCS runs the risk of task saturation at either the JSpOC or NSDC as subordinate units. While the space domain is an infinite expanse, some relevant orbital planes and regimes are most often used by military, commercial, and civil spacecraft. Therefore, a regime-based sectorization may be feasible. One option is to divide the BMAs by major orbital

[4] Maj Card, "Decentralizing Command and Control of Space Operations," 2.

regimes: LEO, MEO together with HEO, and GEO.[5] With GEO, it would likely be best to sectorize that orbit still further, perhaps with one sector over North America, one over Europe and one over Asia, dividing the orbit into thirds. Except a few orbital states, the vast majority of spacecraft remain in their initial operational orbit once emplaced.[6]

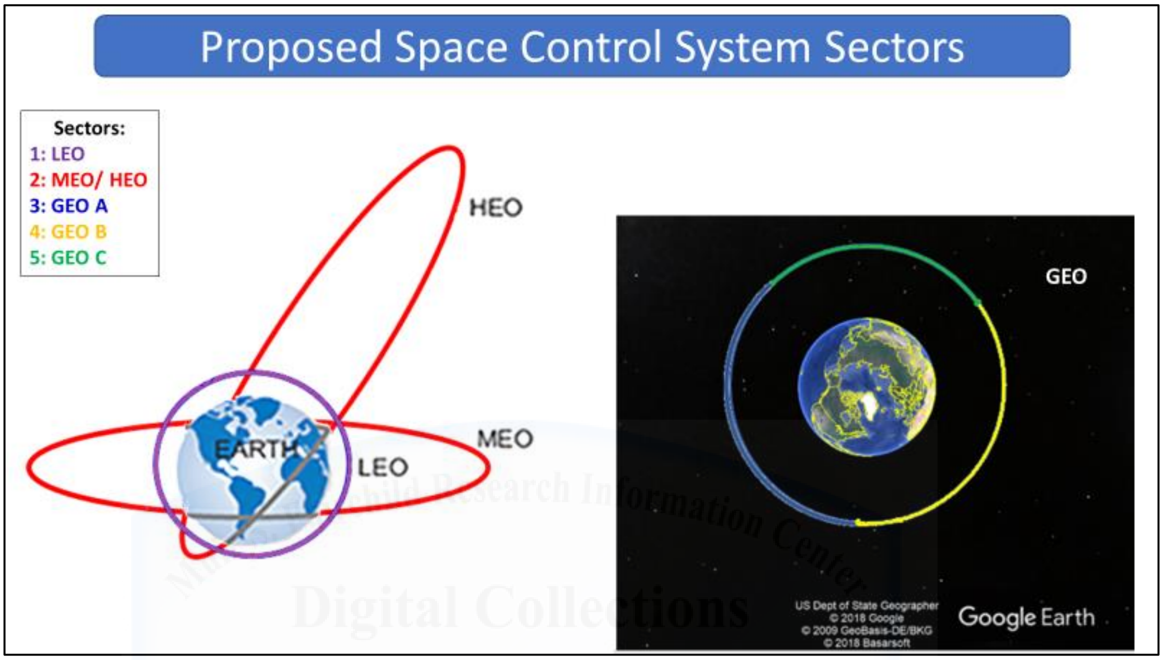

Figure 14, Proposed SCS Sectors
Source: Modified from Ross, "Satellite Communications" and Google Earth

Within each sector, the SCS should establish a SADC, as the singular authority within the sector. Just by this act alone, the SCS would have five individuals tasked with the responsibility to manage conflicts or events within their BMA. The SADC, reporting to the NSDC, would have the responsibility to build battlespace awareness of their sector and work with mission crews operating spacecraft within the assigned sector. Each sector should have tasking authority of Space Surveillance Network sensors that are collecting within their sector. By virtue of their designs, the majority of SSN sensors are either constrained to or optimized for certain orbits. This fact makes delegation of authority fairly straightforward. Friction points would likely exist, however, as some sensors provide SSA as a collateral sensor (i.e., as a secondary

[5] Maj Card, 10.
[6] Geo-Transfer Orbit (GTO) is an exception, but a future SCS could account for this by tagging these few situations within a COP, so the LEO and GEO SADCs could both be aware of the threat-potential

mission).[7] With tasking authority SADCs would be able to respond to dynamic situations where threat actors are either maneuvering co-orbitally, under boosted flight from earth, or moving from one orbit to another. Similar to how TACS modifies the ATO as needed to achieve commander's intent, a SCS would act to update the JSTO or collection plan for the SSN sensor to ensure the hostile spacecraft is tracked. The objective would be to provide mission crews with a single entity for all tactical battle management tasks while also keeping the NSDC or JSpOC from managing the entirety of the domain.

Administratively, the SCS should organize itself with Space Control Squadrons, equivalent to Air Control Squadrons (ACS) that operate the USAF portions of the TACS.[8] These squadrons have precedent within the command, with 4 SPCS, 16 SPCS, 18 SPCS and 20 SPCS all carrying the moniker. By the standards outlined in this paper, only 18 SPCS and 20 SPCS have an applicable claim to their name. The 18th and 20th could be the initial set of squadrons, with 20 SPCS taking over LEO SADC roles, while 18 SPCS takes MEO and HEO. 1 SOPS, the operators of the Space-Based Surveillance Satellite (SBSS) and the Geosynchronous Space Situational Awareness Program (GSSAP), could reorganize to become the 1 SPCS, and take responsibility for the GEO SADC role.

Training

AFSPC's Space Mission Force Advanced Training Program provides a great starting point towards implementing a new SCS concept. After creation and manning of the SCS, it will be necessary to develop standards as well as begin TTP development. As shown in the Battle of Khafji, it is very inefficient to plan and implement new control systems and sensors mid-battle. Systems introduced into the fray of battle often disrupt established TTPs and communications paths. While JSTARS ended up helping CAS sorties and the Marines with its ability to track ground targets, research showed it did so without maximizing its capability or efficiency within the system. By using

[7] There are ways around this concern, by establishing right of first use, or by ensuring radar allocation for missile warning never drops below an agreed upon threshold.
[8] Ground-based Air Control Squadrons operate the CRCs. Aerial Air Control Squadrons (ACCS) operate the AWACS and JSTARS platforms.

advanced training scenarios, the JSpOC, NSDC, the SCS, and space operations mission crews can begin to work out issues with authorities, procedures, and communications without the need for trial-by-fire.

Personnel associated with the SCS will need to become proficient in battle management. The USAF learned over time that its TACS personnel must be trained to a standard series of core competencies to enable the tasks expected of them. These core competencies: battlespace situational awareness, dynamic battle management, tactical fluid control, surveillance and identification, dynamic information management, C2 systems integration, and operational-level integration, are the benchmark standards to which TACS personnel are trained and evaluated. In this respect, the SCS personnel may not be starting from scratch, as the historic SSA mission does provide some subcomponents that align with the core competencies of surveillance and identification and battlespace situational awareness. Importantly, the SSA skillset *enables* dynamic battle management and tactical fluid control, so there will be the larger superstructure of competency above the foundational SSA knowledge.

To adequately train for SBM core competencies, a structured training program will need to be created. Current Undergraduate ABM Training (UABMT) spans nine months, with 170 training days covering nine blocks.[9] A USBMT course would likely require similar timelines. Once development of a training program is complete, there will likely be requirements for simulators, and other specialized equipment in order to provide high-fidelity training and evaluation capability. The structure and repeatability of the training are paramount; as shown by the historical examples of the Dowding System and USAF's development of BWCS soon after its founding as a separate service, on-the-job training was inadequate to ensure proficiency on such a complicated function as battle management.

Security is one additional hurdle that will hamstring implementation of a new SCS. Space operations have worked in the cloak of secrecy since its inception.[10] Often, the stove-piped nature of security classification keeps

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[9] Maj. Roach, "The Case for Increasing Production in the Air Battle Management Career Field," 11.
[10] McLeod et al., *Enhancing Space Resilience Through Non-Materiel Means*, 29.

knowledge of capabilities low within the space operations career field. Information sharing during peacetime could lead to more integrated tactics among crews.[11] The air domain has recognized that unveiling new capabilities at the start of conflict leads to needless friction. The salient example from the study being JSTARS implementation at the beginning of Operation Desert Storm. The USAF learned the lesson well enough to implement an access program for aircrew to practice with and plan for new systems. The Coal Warfighter program provides key warfighters access to special capabilities in an effort to support training and TTP development.[12] AFSPC should build from this example by implementing an umbrella program of capabilities that its operators are briefed into at the start of exercises like Space Flag, or USAF Weapons School's Distributed Operations Mission.[13]

Materiel

Doctrine, organizational change and training, while not easy to create, are correctable by non-material solutions. More arduously, a future SCS requires new communications, integrated data management systems, as well as potentially new weapons systems to adequately execute a space control concept of operations. There is likely a requirement for a phased-approach to design, field, and check-out new systems, software, and communications equipment considering historical USAF space acquisitions timelines.

Today's space operators command their satellites with little ability to discern anything other than satellite state-of-health. Future spacecraft should have the ability to integrate into a SCS as a key performance parameter set into their design. In the air domain, this meant the ability to sense around one's aircraft, whether visually or electronically. Most USAF aircraft fly with a mix of radar, radar warning receivers (RWR), targeting pods, and other sensors. A subset of these aircraft can offboard that data into the JTIDS picture for TACS and other aircrew to digest. Spacecraft should field at least a baseline set of sensors to detect whether it is a target of an active sensor suite (like RWR) or be

[11] McLeod et al., 29.
[12] McLeod et al., *Enhancing Space Resilience Through Non-Materiel Means*.
[13] WSDOM, run by the 328 WPS, is a mid-course large-scale training event for the students within the Space Superiority Weapons Instructor Course. It farms out students to various host units within AFSPC, where they mission plan to a theoretical space and geographic conflict set in the near future.

outfitted with optical sensors to observe the region of space around it. Additionally, the data collected by these sensors should feed into a common operating picture shared by all military entities within the domain.

The SCS would require a common operating picture, supported by redundant communications and information management systems in-which to pass data to assigned forces. With few exceptions, AFSPC spacecraft and operations crews have very limited means to visualize domain awareness today. Even when provided systems and tools to support awareness, they operate as cylinders of excellence without an internetworked capability to share. The JSpOC collects observations into the space catalog but is unable to disseminate the resultant information effectively. The 20th Space Control Squadron, who operates the only dedicated SSA phased-array radar to track space objectives, augments its capabilities with AGI's Satellite Tool Kit (STK), to help provide visualization for ops crews.[14] Similar to the Dowding System's plotter boards in World War II, each use of STK for visualization must be configured at individually and manually by each site, versus a machine-to-machine interface like JTIDS used by TACS.

Datalink and associated software supply the air-domain's common operating picture at the AOC and the ground TAC C2 nodes. The datalink speeds actions across the entire enterprise. As shown in OOD, by establishing a TACS with an associated JTIDS network, the E-8 was able to digitally task interdiction sorties to halt Qaddafi's troops. Without the system in place, significant delays occurred as the CAOC used radio means to talk pilots onto the target. To avoid the same fate for the SCS, a JTIDS-like COP would share satellite observations and ELINT indications immediately to all players via a graphical or another easy-to-use interface. Most importantly, it would allow for TAC C2 to pass taskings via machine-to-machine interfaces to space forces.

While physical awareness is, for the most part, sufficiently covered by the SSN, a significant segment of the domain is under-surveilled. The electromagnetic spectrum (EMS) is the common ethereal connection to any spacecraft operating remotely on orbit. Commands to and information from satellites must transverse via the EMS to ground stations on Earth. Also, non-

[14] McCullion, "20th SPCS Visit."

kinetic attacks on space systems require EMS as their modus operandi. A SCS must have a complementary detection capability for signals and RF energy emanating to, though, and from the space domain. The air domain recognized the value of these types of sensors within the TACS, fielding both the RC-135 and a passive detection system on the E-3 AWACS to feed battlespace awareness with SIGINT. While it may not be feasible to construct a system that covers the entirety of the space operating area, there must be a taskable sensor apportioned to the JFSCC for this mission area. Relying on Title 50 Intelligence Community systems is not ideal. The TACS and CFACC have apportioned organic ISR platforms, as do other warfighting domains. The space domain should be no exception.

Personnel

Just as air operations career fields branched out after World War I and again after World War II, resulting in the ABM career, so too should space operations consider introducing a Space Battle Manager (SBM) officer and enlisted specialty codes.[15] The battle management core competencies are *taught* and *grown* over the course of a career for assigned personnel, so the USAF must also grow institutionally as well. A SBM should begin a career assigned within a space control squadron, learning the core competencies and growing in experience. As the SBM grows in experience and knowledge, they can take on additional responsibilities such as SADC or branch out into specialty skills such as weapons officer, chief of training, instructor or evaluator.

Closing thoughts

With the space domain now under threat, and senior leaders as well as elected representatives sounding the alarm, the USAF must work to implement a new architecture in space that allows for core functional tasks to be supported by doctrinal tenets such as decentralized control and decentralized execution. When compiling the requisite assemblage of personnel, training, equipment, and authorities, it becomes apparent a space control system

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[15] For historical completeness, the Cold-War SPADOC did have a SBM position, which executed functions similar to those advocated within this paper, though still for limited ends during expected nuclear conflict.

postured to support mission crews will require significant investment in resources and manning. It will also likely require a phased-approach to acquire, field, and check-out new systems, software, and communications suites. A fully fielded space control system should increase the resilience of on-orbit systems, as well as better posture USAF and joint forces to react, defeat, and impose costs on adversaries within the space domain.

To implement a future space battle management architecture that includes support for mission crews, the USAF should execute an Enterprise Capability Collaboration Team (ECCT) to determine the current state of Space Battle Management, and review the recommendations within this paper.

Areas for Future Study

Joint Warfighting Functions

Space is a warfighting domain. As a warfighting domain, all seven joint functions apply C2, movement, and maneuver, fires, protection, intelligence, information, and sustainment.[16] This paper utilized a framework centered on the TACS. By studying other frameworks such as the joint functions, it may be possible to find gaps that exist from limiting to one framework over others.

Title 10 and Title 50 synergies

Within the new SCP and SCA documents, it will be possible to address current unity of effort concerns held by the USAF and NRO. As alluded to in the assumptions section of this paper, there are significant historical logjams between these two organizations. Tasking authority for space-based title 50 assets will likely reside with the title 50 organization that operates it. The TACS operates with non-title 10 entities transiting the airspace often. While the CFACC's ACA provides authority to direct associated forces, it also carries a responsibility to inform non-associated or unapportioned forces of threats and other relevant information within their airspace. Similarly, the JFSCC and their SCA would have a responsibility to alert title 50 organizations of threats, what the organization does with that information is outside of JFSCC control.

[16] Joint Staff, "JP 3-0 Joint Operations," III–1.

Space Force Application and Offensive Counter-Space

If US policy and geopolitical realities allow for the creation of a space-to-ground weapons system or offensive counter-space systems, further study will be necessary to include these types of systems into a SCS. Space-to-ground weapons do not appear to be likely within the next decade. Offensive counterspace capability is technically feasible and would integrate within a SCS similarly to offensive counterair or interdiction sorties integrate within TACS. Namely, operations occurring within orbital regimes controlled by the SCS will need to coordinate and adhere to space control procedures, just as in aircraft adhere to air control procedures.

Composite Force Packaging

One technique the air domain uses in conjunction with TACS is the composite force package (CFP) concept. The Space Enterprise Vision outlines the intent for space operations to follow-suit.[17] By mission planning and executing dissimilar spacecraft together, the additive effects may be more capable than the sum of the parts. This concept also brings additional C2 structure usually, in the form of a Mission Commander (MC) who has responsibility for the force package. A SCS concept would dovetail nicely as its supportive architecture would provide a means for the MC to build situational awareness independent of their sensors or without expending time and resources to do so. This battlespace awareness should drive better decision-making for the MC. A future study should look to USAF best practices for CFPs and TACS TTPs to implement in a future SCS.

Multi-Domain C2 (MDC2)

The USAF is focusing on a future construct that may synergize or modify the recommendations in this paper. An ECCT recently completed a study and issued an MDC2 ECCT Campaign Plan.[18] Readers are advised to read both this text and the campaign plan for overlaps, gaps, and conflicts. One aspect of MDC2 that will need addressment in the future is connectivity between TACS

[17] Major Harrigan, Interview on Future Space Battle Management.
[18] Davenport and Atkins, "***OTH Anniversary*** Multi-Domain Command and Control."

and the SCS for rapid execution of air taskings in support of space objectives and vice-versa. Another key finding of the ECCT outlines the desire for the USAF to develop a new career, 13O, that will execute MDC2.[19] Since MDC2 is an amalgamation of air, space, and cyber operations, the new 13O career field will likely have some authorities and functions associated with the proposed SCS.[20]

Organization continued

A future study should be conducted to weigh ways, means, and risks associated with the assignment of limited SSN sensor tasking authorities for the systems in Figure 13 to the orbital SADCs advocated for in this paper.[21]

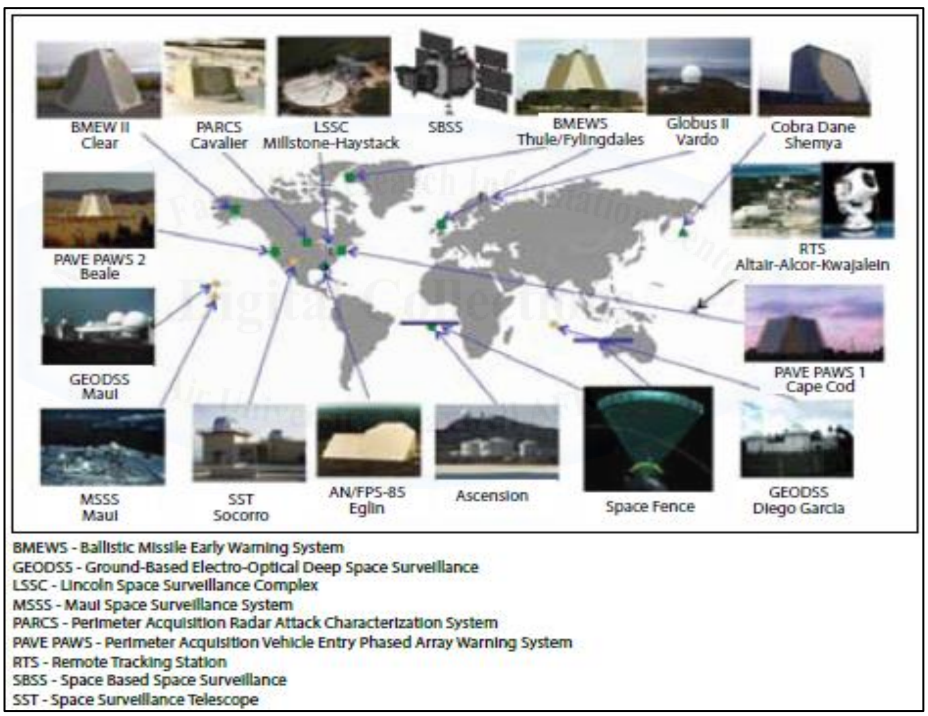

Figure 15, Space Surveillance Network 2018
Source: Baird. "Maintaining Space Situational Awareness."

Additionally, squadrons or units that operate constellations across the entirety of the GEO belt would have to coordinate with three different SADCs depending on which spacecraft as at risk. Reducing the GEO SADCs back to one results in

[19] McCullough, "Facing the Unknown in a Multi-Domain Command and Control Environment."
[20] Davenport and Atkins, "***OTH Anniversary*** Multi-Domain Command and Control."
[21] "Limited" sensor tasking authority means that collateral sensors will still require right-of-first-use by their primary mission set. For example: the SADC could not direct a missile warning radar to cease looking for inbound warheads to ensure track of a space object.

the problem becomes too large to manage. One option is to look at a regional satellite commanding construct (RADC), especially for special cases like at GEO. A single RADC would then control a single mission crew.[22]

Leadership and Personnel continued

A study should be accomplished to validate unit manning document requirements to ensure new SBM officer and enlisted tracks are viable within personnel caps set by Congress. The career fields should also verify adequate career progression mile-stones would exist for upward mobility within the career pyramid. Leadership positions for space control squadrons, groups, and possibly a wing should be considered.[23]

With the advancement of space operations towards a warfighting domain under the direction of the JFSCC, there could be a need for the incorporation of a new advocate emplaced in other component or GCC staffs. Currently, the Director of Space Forces sits within most COMAFFOR staffs worldwide, but this position often has no space forces to direct. Also, as a member of the A-Staff, the DIRSPACEFOR is ill-positioned to champion causes on behalf of the JFSCC, as they are expected to support the COMAFFOR's needs for space-integration coordination. Perhaps a flip of the arrangement is in order. By adding a Joint Air Component Coordination Element for each GCC at JFSCC, integration concerns have a centralized point within JFSCC to adjudicate problems. Additionally, the creation of a Joint Space Component Coordination Element (JSCCE) at each GCC could begin the effort necessary to plan for supportive fires from a GCC on behalf of USSTRATCOM or JFSCC to defeat counter-space threats or meet counter-space objectives.

Facilities

Whether the SCS has multiple SADCs in one location or disaggregated across a number of locations warrants further study. By disaggregating, the

[22] Major Grosselin, Interview on Future Space Battle Management.
[23] It is recommended to read Major Eric Snyder's SAASS Thesis " Jacks of all Trades or Masters of Some? Alternatives for Occupational Specialization in USAF Space Operations" for a more in-depth review of a specialized Space Battle Manager career field.

SCS can remove a current risk to the system in that the JSpOC is a single point of failure. Multiple nodes execute taskings independent of direction from operational-level centers and in concert with other nodes. As the system degrades, alternate nodes pick up for destroyed or partially-capable units.

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