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Key Points

Decades of budget-driven force-structure divestments have eroded the comparative U.S. military advantage over China, and current command and control must evolve to meet new warfighting demands.

Built upon the advantages of space-based capabilities, JADC2 will enable information and decision superiority and become the operational commander's pathway for creating effects in all warfighting domains.

Space is the ultimate high ground, affording an extremely broad view for sensor data collection. This is critical to establishing a JADC2 architecture in the Indo-Pacific region.

Given that capabilities in the space domain are the cornerstone of a viable JADC2 construct, the U.S. Space Force should lead and oversee the integration and interoperability of the entire JADC2 system.

DOD must define the overarching operational concepts and strategies directing the use of JADC2. Integration of service-designed components into the space elements of JADC2 requires open architectures and data standardization.

Orbital JADC2 assets must be resilient and defended, given adversaries have declared their intent to attack U.S. capabilities on orbit.

The Indispensable Domain: The Critical Role of Space in JADC2

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Abstract

Coming out of the Cold War, the U.S. military possessed the capabilities and capacity to dominate global military operations when and where it chose. Due to three decades of budget-driven force structure divestments, this is no longer the case, and U.S. military capabilities and capacity simply have not tracked with growing peer adversary threats. Furthermore, adversary strategies that prioritize information and decision-making superiority indicate that success in future wars will go to the side that possesses better battlespace knowledge, makes better decisions, more efficiently directs its forces, and closes kill chains faster.

Space will empower all these critical actions. This is the vision of Joint All Domain Command and Control (JADC2). JADC2 will collect information from any sensor and any domain, rapidly transmit large volumes of data across vast physical distances, process the information to support dynamic battle management and commander decisions, and then ensure that the right information gets to the right warfighters at the right time to achieve the desired effect, all at a global scale.

This can only be achieved with foundational space-based capabilities. Only the space domain can move information at the speed, size, and range required of an effective JADC2 architecture. If the United States hopes to prevail in a peer conflict, the Department of Defense and the Space Force must prioritize a robust space transport layer, sensors, and the space superiority to protect these capabilities.

JADC2 will fundamentally rely on its space-based elements, so its space architecture must be resilient and defendable. This requires pursuing both passive and active defense features, to include the rapid acceleration of offensive and defensive space warfighting concepts and capabilities. If not understood and resourced with urgency, DOD's force design will lay vulnerable in the face of China and other countries seeking military dominance in space ahead of the United States and its allies.

Introduction

Warfighting in the space domain will determine the outcome of future conflicts. The reason for this is simple: success in war will go to the side that possesses superior battlespace knowledge, makes better decisions, directs forces more effectively, and closes kill chains faster. Technologies on orbit are pivotal in securing this advantage, especially when it comes to sensors and connectivity.

Realizing the importance of information and decision advantage, defense leaders have formulated a concept termed Joint All Domain Command and Control (JADC2). It envisions an enterprise in which data is collected from a broad array of multi-domain sensors, rapidly transmitted across vast distances, processed into actionable information, and provided to consumers on a demand-relevant basis to empower smart decision-making across the tactical, operational, and strategic command realms.[1] Importantly, this concept is not a singular program or capability. It comes down to using the right mix of capabilities to get relevant information to each warfighter at the right time to achieve the desired effects, all at a global scale. As the Department of Defense's (DOD) official JADC2 strategy explains, the goal is to "produce the warfighting capability to sense, make sense, and act at all levels and phases of war, across all domains and with partners, to deliver information advantage at the speed of relevance."[2]

The schema does not imply all actors will know everything all the time. Instead, the aim is to supply the right pieces of information to the appropriate actors in a timely manner to best inform a given set of decisions. Given the significant capability and capacity limitations facing U.S. military forces, as well as the scale, breadth, and sophistication of adversary threats facing them, this sort of advantage will prove crucial. It is a force multiplier and reduces risk on multiple levels.

Space-based technologies will prove absolutely essential for manifesting this vision—especially when it comes to global communication links able to move data from all sensors. As the U.S. Space Force's doctrine emphasizes, "One key distinction of warfare in the Information Age is that many weapon systems rely on external sources of information to function."[3] Space is the ultimate high ground, affording an extremely broad view for sensor data collection. This vantage also enables forces separated by tremendous distances to connect, which is particularly important in the critical Indo-Pacific region, where distance is one of the primary challenges to fielding effective defenses against China. Space Force leaders understand this imperative and the centrality of these capabilities, and it is why Chief of Space Operations General Jay Raymond explained that "our ability to sense from the space domain, transport and make sense of data, and then get that data into the hands of our joint warfighting partners on land, in the air and at sea, is what the Space Force delivers to JADC2. . . . Space capabilities underpin modern warfare."[4]

However, manifesting this vision requires the national security space community, and particularly the Space Force, to develop a new suite of sensor capabilities and a robust space transport data transmission layer scaled for global operations.[5] While JADC2 will be the operational commander's pathway for creating effects in the air and on the ground, its orbital assets must then be resilient and defended, given that multiple adversary nations have declared their intent to attack U.S. capabilities on orbit. This latter point reflects a major paradigm shift in the way the U.S. national security establishment views the space domain. Former Commander of the Space and Missile Systems Center General Ellen Pawlikowski pointed out in the year leading up to the creation of the Space Force that, in previous eras, "survivability [in space] wasn't even on the sheet."[6] U.S. defense leaders recognize that circumstances are now far different.

Anyone questioning the necessity of JADC2 should reflect on the Battle of Britain in the summer of 1940. It is a classic example of how information and decision superiority can be the deciding factor in conflict. Having just occupied France, Germany was set on invading the United Kingdom, and an air offensive was the first component of their campaign. Royal Air Force (RAF) combat aircraft were badly outnumbered by more than seven-to-one. When the Luftwaffe raids commenced, over 3,500 German combat aircraft were massed across the English Channel. The RAF possessed only 446 operational fighters. In the ten days between August 8 and August 18, 1940, the RAF lost 154 pilots, with only 63 green airmen available from training squadrons to backfill casualties.[7] Yet British forces prevailed against these overwhelming odds because their information and decision superiority enabled them to direct their Hurricane and Spitfire fighter aircraft more effectively and efficiently against the more numerous Luftwaffe. The system allowed the posturing of fighter aircraft at the right time and place to best defend the homeland while avoiding zones of undue risk.

Chain Home radars along the English coast and ground observers inland gathered enemy aircraft position data and transmitted it for processing via telephone and radio networks to Fighter Command Headquarters. There, highly trained personnel processed this data into actionable information and then alerted fighter squadrons to scramble their aircraft. They also helped vector the fighter pilots to their targets once they were airborne. Without this system to maximize their limited assets, the RAF would have had to keep a large percentage of their fighters roaming around the sky searching for Luftwaffe aircraft. This approach would have diluted the effectiveness of limited aircraft numbers, and it would have failed to detect many incoming attacks. Instead, Fighter Command Headquarters knew exactly where incoming raids were located, at what altitude, and how many aircraft, and this enabled them to use their fighters precisely and efficiently in the defense of England.[8]

While the technology, systems, and processes have changed over the ensuing decades since the Battle of Britain, information and decision superiority remain vital military attributes, especially when a force is stretched thin—exactly the circumstances facing the U.S. military in a fight against China. As Deputy Secretary of Defense Kathleen Hicks explained, "Command and Control in an increasingly information-focused warfighting environment has never been more critical."[9]

There is no question that space capabilities will be critical to realizing the JADC2 concept. However, what specific systems and capabilities are needed, how many, and at what cost remain undefined. While many technologies may already be available, many are still on the drawing board. Moreover, there is no clear path for procuring and fielding these capabilities. Confusion regarding the ultimate scale and scope of the JADC2 construct has not helped these efforts. Overarching operational concepts and strategies directing their use must be defined, especially those related to JADC2 functions on orbit.

This analysis aims to explore the JADC2

construct, define space's role in helping manifest this vision, and highlight key areas that must be prioritized to realize this vision. Key recommendations include:

1. Congress should reinforce the authority of the Chief of Space Operations as the Space Force design architect by ensuring the service has the primary responsibility of overseeing the integration of the entire JADC2 system. This authority should include bounding requirements and establishing standards for incorporating machine learning, optical communications, cyber and crypto security, software-defined networks, and distributed computing capabilities for JADC2 across all of DOD.
2. Congress should provide definitive guidance and funding in the Fiscal Year (FY) 2024 National Defense Authorization Act that creates an unrestricted path for the Space Force's development of space control doctrine, missions, and capabilities needed to assure the functionality of JADC2.
3. Congress should require DOD to report on its plan to ensure that the fielding of the JADC2 architecture is concurrent with DOD's fielding of adequate defenses of its components.
4. Congress must approve robust resourcing to enable the Space Force to deliver enhanced space domain awareness and to develop space-based weapons systems that are specifically designed to defend the JADC2 space transport layer against kinetic and non-kinetic acts of aggression.
5. DOD should modify its defense strategy to identify the critical need to defend the JADC2 architecture and ensure this priority is reflected in programming and resourcing choices across the services.
6. DOD should also frequently review the Space Force's JADC2 integration efforts to ensure interoperability remains a top priority for all service-specific JADC2 programs. Keys to achieving this interoperability include open architectures that enable communications between satellites and terrestrial platforms; data standardization; the deployment of wide-band arrays that receive and transport JADC2 levels of data; and capabilities that incorporate all waveforms used by U.S. and allied military and commercial assets.
7. The U.S. Space Force must rapidly transform its ethos from being an enabler and provider of services to a service that provides capabilities that create war-winning effects to, in, and from the space domain. This will be necessary to conceive and field an effective defense of the JADC2 architecture.
8. The U.S. Space Force must develop a realistic training, test, and range capability to exercise and mature JADC2 functionality while developing Guardian warfighting skills. This will require advances in both current simulators and doctrine to align with the reality of fighting in a contested domain against a peer adversary. Simulators must mirror the environment Guardians will engage in and incorporate how other domains will support operations. This preparation of warfighters is essential for successful campaigns and is consistent with warfighters in any other domain.

Addressing these priorities will not be easy, but progress is essential. As Gen Raymond explained earlier this year, "Space underwrites the joint force—our joint missions don't close without space. We can't fight, communicate, target, precision-strike, or maneuver . . . without space."[10] Given the threats facing the United States and our allies, this is an undertaking that must succeed.

The DOD Must Evolve its C2 Systems and Processes to Survive and Prevail in Peer Conflicts

The comparative military advantage of the United States against China has deteriorated significantly both quantitatively and qualitatively. This stark reality demands that operational modes in all warfighting domains must transform. This includes strategy, technological innovation, and warfighting concepts. Current command and control (C2) systems and processes must evolve to meet new warfighting demands and survive in a peer conflict.

America's military primacy has eroded over the past three decades. This fact is not well understood by the American public used to hearing that the United States has the biggest and best military in the world. Contrary to this popular dogma, aggressive post-Cold War force structure reductions, two decades of overriding focus on counterterrorism operations in the aftermath of 9/11, and too many curtailed or canceled modernization programs have left the services in a less certain position of having both the capacity and capability to credibly deter, and if necessary, defeat a peer adversary.

Circumstances in the U.S. Air Force are perhaps the best illustration of these circumstances. As U.S. Air Force Air Combat Command Commander General Mark Kelly recently explained, "Many people envision today's Air Force as the one that went to Desert Storm—a force that featured 134 Fighter Squadrons. The reality is that we only have 56 now and I can point to comparative force reductions in nearly every other mission area."[11] While not cut to the same degree, similar statements could be made about other services. It is why both the U.S. Air Force and U.S. Navy have declared force structure objectives far larger than the aircraft and ship inventories they presently operate. The air and naval forces required to realistically meet the objectives of the National Defense Strategy fall far short of what the services operate today.[12]

This challenge is further compounded by the reality that China has carefully studied core strategies, operational concepts, and technologies favored by the United States for over three decades. America's successes in the Operation Desert Storm, Kosovo, and Iraqi Freedom campaigns taught them about the war-ending effectiveness of the U.S. ability to rapidly deploy and sustain forces and conduct precision strikes on the one hand and about the U.S. military's total reliance on its C2 infrastructure on the other. China's military modernization pathway reflects the implementation of these lessons learned, and the People's Liberation Army (PLA) has specifically molded its strategies and forces to counteract the U.S. ability to achieve the same effects of the Desert Storm campaign in the same way. If the United States is to secure a credible military advantage with respect to China, it must rethink how it commands and controls its forces. More must be delivered by less. Much like the Battle of Britain challenge that faced the Royal Air Force in 1940, the U.S. military risks being overwhelmed by a highly capable adversary. Warfighting success will depend upon ensuring combat assets are employed at the best time and place to secure desired effects while mitigating points of vulnerability.

Two militaries on divergent paths

The challenges faced by commanders today are wholly different than those they were asked to address over the past three decades. The capabilities and capacity of the respective services simply have not kept pace with evolving demands. Coming out of the Cold War, the U.S. military possessed the capabilities and capacity to dominate global military operations when and where it chose. The world saw a clear demonstration of this during the 1991 Operation Desert Storm campaign against Iraq, where U.S. and coalition forces were able to project decisive power against what, at that point, was the world's fourth-largest military force. In fact, Iraq's army was bigger than the U.S. Army and Marine Corps combined.[13]

With the U.S. enjoying its post-Cold War victory and a world relatively free of major threats, political leaders ordered the aggressive downsizing of U.S. military forces. Modernization efforts were also aggressively reduced. With few predicting a credible peer threat on the horizon, defense officials prematurely reduced B-2 stealth bomber procurement to 21 airframes from an originally planned buy of 132 aircraft. Other services saw similar cuts. Key elements of the military toolkit grew small and increasingly old as most believed America faced few serious security threats.

Operations throughout the 1990s in places like Bosnia and Kosovo, and the establishment of no-fly zones over northern and southern Iraq, largely seemed to justify this thinking. Desert Storm-like results could seemingly be secured with a reduced set of capabilities. U.S. and coalition forces appeared to be dominant, with limiting factors self-imposed for political and diplomatic reasons, not for want of actual military power. Threats could prove worrisome, but rarely were they viewed as existential.

Even when the United States was attacked on September 11, 2001, the nature of the strikes was asymmetric. The resulting combat operations in Afghanistan, Iraq, and elsewhere saw tremendous emphasis on counterterrorism operations. Demand for large-scale land occupation forces rocketed dramatically. Improvised explosive devices appeared to be the most pressing concern at the time, not high technology threats fielded by another nation-state like China. That is why Secretary of Defense Robert Gates ended the F-22 program at 187 aircraft instead of the validated military requirement for 381 advanced stealth fighters.

Certain areas of military capability grew, especially reconnaissance-strike capabilities via remotely piloted sensor-shooter aircraft like the MQ-1 Predator and MQ-9 Reaper. However, these new systems and their corresponding operating paradigms operated in regions free from serious enemy counteractions and were dependent on non-secure commercial satellite communication links. Networks, sensors, command and control practices, and overarching concepts of operation were optimized for conditions in which U.S. and coalition forces had domain superiority in the air, space, sea, and electromagnetic spectrum. While danger was significant for individuals in direct contact with enemy forces on the ground, the rest of the U.S. military operated in permissive environments. This permissiveness was apparent in U.S. power projection—which was largely achieved at a time and place of a commander's choosing—and the U.S. ability to assure command and control, gather necessary data, and ensure connectivity.

However, while the United States was engaged in Afghanistan and Iraq amidst the challenges of a counter-insurgency fight, China had not forgotten the lessons of Desert Storm. In fact, the U.S. example laid out a blueprint for their military modernization plans. The power of technology, force structure mass, information dominance, and decision advantage all stood as top military goals for a nation rapidly evolving into an ascendant superpower.

U.S. leaders finally began to track the scale and scope of this threat in the 2010s, with the 2018 National Defense Strategy announcing:

> *Today, we are emerging from a period of strategic atrophy, aware that our competitive military advantage has been eroding. We are facing increased global disorder, characterized by decline in the long-standing rules-based international order—creating a security environment more complex and volatile than any we have experienced in recent memory. Inter-state strategic competition, not terrorism, is now the primary concern in U.S. national security.*[14]

The 2018 National Defense Strategy Commission echoed these concerns when it declared, "U.S. military superiority is no longer assured and the implications for American interests and American security are severe."[15] This drumbeat of concern continued, with a 2020 report from the U.S.-China Economic and Security Review Commission concluding that DOD "must be prepared for the possibility of a costly and protracted conflict" if it "comes to the defense of an ally or partner in the wake of a PLA attack."[16] Most recently, the 2022 National Defense Strategy unclassified summary document again established "the People's Republic of China (PRC) as our most consequential strategic competitor and the pacing challenge for the Department."[17] Bottom line, the U.S. military is on the brink of failure given the challenges on the horizon—failure to deter adversary aggression in the first place, as well as failure to defeat an adversary in full open conflict.

Defense leaders across a span of administrations are clearly tracking on an aligned threat assessment, but the reality is that nearly every major defense decision made since the end of the Cold War has sub-optimized U.S. forces and undercut the necessary competencies to succeed against a peer threat like China. Core capabilities needed to prevail against this sort of threat—things like air superiority; deep strike systems; base defense; resilient logistics; and a survivable intelligence, surveillance, and reconnaissance (ISR) enterprise—are in extremely short supply. To this point, 186 F-22s and 20 B-2s, the current and very limited inventories of long-range 5th-generation strike aircraft, will only convert to so much combat power.

Updated assumptions regarding domain permissiveness in the air, on orbit, at sea, and at rear bases are 180 degrees different than those that shaped today's forces. Commanders now face a situation where nearly every element of the force in every domain could be at risk concurrently. The conception of JADC2 is the realization that extremely timely and comprehensive cross-domain command and control is both a requirement and key to maximizing the potential of every single combat asset.

Challenges of the Indo-Pacific operating area

As if the challenges facing America's defense establishment were not daunting enough, there is another crucial factor to consider: a conflict with China will require tremendous situational awareness and the integration of forces distributed across the vast expanse of the Indo-Pacific and beyond. As the nation projecting power into this area of responsibility (AOR), The United States faces disproportionately greater hurdles playing an "away" game than China playing a "home" game in regard to conflict.

Compared to Europe or the Persian Gulf regions, the Indo-Pacific AOR is enormous, spanning a hundred million square miles, or roughly 52 percent of the Earth's surface.[18] Furthermore, because the

An Undersized Force

To fully understand the scale of the challenge facing U.S. leaders, consider Commander of Air Combat Command Gen Kelly's description of a force undersized relative to basic demand:

Consider how a scenario would play out today in the case of an escalating European peer threat. The Air Force would hear from General VanHerck at NORTHCOM, requesting that we take airspace control level to a higher readiness state. That would obligate fighters, AWACS, and tankers to the homeland defense mission. Added to that, a peer threat would see Admiral Richard of STRATCOM seek to put the bomber force at a higher state of alert, which also obligates tankers. Next, we would see General Dickinson advising that he is reorienting the space architecture to support EUCOM. General Cavoli would then call to expedite the "halt force" needed for a peer fight in Europe. We would also hear from General Fenton from SOCOM asking for conventional support to Special Forces in support of EUCOM. General LaCamera would call to ensure there is enough combat power to check North Korea's cycle of provocation so we could deter against opportunistic adventurism at a time when the U.S. is focused on Europe. A similar set of calls would come from General Kurilla regarding the threat posed by Iran. After the fourth conversation—the request from General Cavoli—we are out of capacity. This is even with the Air National Guard and Air Force Reserve fully mobilized. Not only does this see us without the resources to execute this one scenario, but I would have done little to check potential action by the Chinese. Nor have we factored in what it would take to sustain combat operations in the first scenario if I needed to start backfilling for attrition and combat losses. The numbers simply are not there.

Source: Email correspondence between Lt Gen David Deptula, USAF (Ret.) and Gen Mark Kelly, USAF, September 4, 2022.

theater is mostly covered by water, U.S. and coalition forces lack the advantages of strategic depth that operating from a large landmass offers. Instead, they must operate from a limited number of bases and facilities located on U.S. and allied territories that are all within range of adversary weapon systems. U.S. forces must leverage movement and maneuver across vast distances and operate from dispersed locations to be even minimally survivable considering that, due to the theater's geography, forces will likely be separated by hundreds or thousands of miles of water.[19]

Existing force structure, already too small given post-Cold War cuts and anemic modernization efforts, will also be diluted by the expanse of the Indo-Pacific. Fighter and bomber aircraft will have low sortie generation rates due to long transits from distant U.S. bases. Consider the example of B-52s flying during the Vietnam War from Anderson AFB in Guam. That roundtrip B-52 flight between Guam and Vietnam spanned nearly 6,000 miles and lasted 12 to 14 hours.[20] Potential targets in a China fight might expand those distances even further. Without exquisite and timely off-board intelligence feeds, these transits render strikes from these platforms irrelevant against modern mobile targets. This contrasts with recent operations in Iraq and Syria, where a single jet could turn multiple sorties in that same period and remain in constant contact with its principal command and control element. China is a very large country involving numerous aim points. Consider that allied air forces attacked about 40,000 aim points in Iraq during Operation Desert Storm.[21] The list of aim points in a conflict with China is going to be far larger and more complex. This challenge is not restricted to airpower, with ships and ground forces similarly spread thin by the realities imposed by the theater's physics. Combat assets need highly efficient direction to meet campaign objectives while avoiding areas that present undue risk. Consequently, U.S. forces require information and decision advantage.

Collectively this will place greater emphasis on sensor systems and beyond-line-of-sight (BLOS) communications to connect and integrate existing tactical battle networks to enable coordination and positive collaboration. In other words, data will need to be collected, processed, and moved at speed, scale, and range to enable warfighters. All the while, the enemy will be doing everything in its power to disrupt these functions.

China is developing its own information and decision advantage

A key lesson Chinese leaders internalized from the U.S. and coalition Desert Storm victory was the importance of an information advantage. They have spent the subsequent decades working to understand how the U.S. military seeks to harness information and decision superiority, looking particularly at U.S. efforts to understand the battlespace, move data for processing into actionable information, execute C2 functions, and complete kill chains. China's investigation into these areas resulted in a major campaign to modernize its physical military capabilities—everything from building aircraft carriers and forward operating islands in the South China Sea to stealth fighter aircraft and standoff munitions. Their information enterprise modernization efforts included precision navigation and timing, datalinks, precision strike, enhanced ISR, advanced processing, and more.[22]

The net effect is the United States now faces a peer state with a robust inventory of modern systems paired with an information-centric approach to warfighting that seeks to maximize decision advantages for their own forces while denying the same to their adversary. This is often referenced in Chinese strategic writings as "informationized warfare," with follow-on, more refined efforts seeking to "intelligentize" Chinese forces. Informationized warfare seeks to maximize the information advantage for tactical and technical objectives—for example, to provide precise coordinates for a weapon. To intelligentize forces means to expand capabilities in a far more dynamic, comprehensive fashion through technologies like artificial intelligence, decision aides, massive data processing, and enhanced C2 to orchestrate highly complex, integrated multi-domain operations.[23]

Either concept is a complex undertaking that will take time for the Chinese military to fully implement, but as a U.S. Air Force assessment explained, China is well on its way to "speed[ing] up the construction of a military power system that adapts to the form of informationized warfare, and effectively enhance[ing] the ability to win informationized warfare." Full implementation also demands updating the bureaucratic structures that will harness this new technology. That is why the PLA established the Strategic Support Force (PLASSF) to bring the synergies of cyber, space, and electromagnetic spectrum power projection under one umbrella.[24] While the scale and scope of the PLA's modernization efforts are hard to decipher, it is important to understand that they set a goal to win "local informatized wars" by 2035.[25]

U.S. centers of gravity in the Pacific region, including bases and logistics, and individual combat assets, like planes, ships, space assets, and ground forces, will face a new level of vulnerability given these trends. Consider the impact of the United States no longer holding a monopoly on precision strike operations. This is a major factor that is driving U.S. military leaders to rethink how they expect to project power in the Pacific and beyond. This introspection is crucial. Left unchecked, an intelligentized force will enable China to gain a decisive military advantage in the Pacific.

China will deliberately target U.S. C2 systems and processes

While Chinese military leaders keenly appreciate the advantages they hope to accrue through an informationized and intelligentized approach to military operations, they believe their power improves by denying these attributes to their opponents. Accordingly, China has developed a theory of victory and strategies that prioritize targeting critical nodes of the U.S. command and control system. The Chinese theory of "Systems Confrontation" understands warfare as a contest between two capabilities, and its strategy of "System Destruction" seeks to collapse adversary capabilities by targeting keystone connections in the kill chain.[26]

The Chinese approach to System Destruction seeks to blind, isolate, and silence U.S. forces at the tactical, operational, and strategic command levels, paralyzing U.S. operations and destroying or nullifying fielded forces. ISR systems, networks, datalinks, and C2 platforms are prime targets in this regard. The effect of this approach is well-known to U.S. military strategists. Wargames and other analytical exercises that account for this Red Team approach routinely demonstrate highly negative results for American forces. As former Deputy Assistant Secretary of Defense for Force Development David Ochmanek, director of many of these exercises in his time at the RAND Corporation, makes clear, "Blue gets its ass handed to it."[27]

Transforming C2 to Prevail Against the Pacing Threat—China

The U.S. defense enterprise must adjust to the new battlespace realities if it is to secure and maintain information and decision superiority—it is vital to prevailing against our adversaries. America's military is too small and too old, and it will be stretched thin as it operates across a massive region. It is facing an adversary that has optimized its capabilities to undermine core U.S. military strengths—especially command and control. U.S. defense leaders are aware of these compounding challenges, and that is why they are pursuing next-generation C2 concepts and technologies via JADC2. The services, in coordination with the Joint Staff and the Office of the Secretary of Defense, are seeking to create an information and decision superiority advantage. While the various pathways may differ, all agree on the fundamental objective.

The Department of Defense describes these functions in its March 2022 Summary of the Joint All-Domain Command & Control (JADC2) Strategy:

> *JADC2 provides a coherent approach for shaping future Joint Force C2 capabilities and is intended to produce the warfighting capability to sense, make sense, and act at all levels and phases of war, across all domains, and with partners, to deliver information advantage at the speed of relevance.*[28]

In many regards, this is taking Col John Boyd's classic Observe, Orient, Decide and Act (OODA) Loop and applying it to modern warfare, across the joint force, and with the attributes of the information age.

The capability to "sense" is the ability to gather data from all domains, across all domains, and throughout the electromagnetic spectrum. To support this capability, the DOD intends to develop and implement advanced data collection technologies, methods, and information management systems to enhance situational awareness.

"Making sense" of the data collected transforms the information into actionable knowledge. To achieve this knowledge, JADC2 will require the "ability to fuse, analyze, and render validated data and information" from any domain.[29] If this data can't be fused at the speed to make it operationally relevant, forces lose the advantage. Connectivity is key to facilitating these data flows between various processing centers.

The final JADC2 capability is the ability to "act"—to decide upon a course of action and disseminate orders to the force for execution. This will include a mix of machine and human actors combining to yield rapid, well-informed, and agile decision-making to best task mission assets during high-pressure, constantly evolving, often-confusing real-time military operations. The scale of this sort of enterprise is far larger than anything seen over the past two decades: where counter-insurgency operations saw a few dozen missions executed a day, a peer conflict will likely see thousands of mission activities executed each day.

Given this objective, there are several key principles that will be crucial for JADC2 architects to follow. JADC2 is only as effective as the data empowering it. Data inputs are the backbone of information and decision superiority. Sensors must be positioned at the right time and place to secure necessary insights regarding adversary activities, force composition, and points of vulnerability. Data is also important when seeking to command and control U.S. and allied forces, secure key infrastructure, and track incoming adversary threats. The scale and scope of the Pacific region, paired with the nature of the Chinese threat, will demand a new generation of sensors to gather the data necessary to empower smart decision-making. This includes systems that can penetrate, see, or sense deep behind enemy lines and provide persistent observations.

JADC2 must move information at the speed of need. Mobility and speed have always been imperatives in warfare. Historically, however, the focus has been on how operators or platforms could leverage these advantages physically. In the information age, successful military operations increasingly depend on the abilities of sensors, processing power, and human actors in the decision sphere to understand the battlespace. This includes finding and fixing military targets to best secure desired effects while reducing vulnerability.[30] That's the crux of the modern era of warfare—the tools of the industrial age still matter—the planes, ships, tanks, satellites, and fielded forces—but now, information superiority is of equal if not greater importance. Current U.S. capability

JADC2 at the Service Level

JADC2 is the overarching organizational and visionary construct used by DOD leaders. It's actual functionality largely rests on individual service programs being developed concurrently and ultimately integrated into an overarching construct to meet these broad objectives.

- Project Convergence is a U.S. Army learning campaign leveraging a series of joint, multi-domain efforts to integrate systems to improve battlefield situational awareness. These are designed around five core elements—soldiers, weapons systems, command and control, information, and terrain.
- The U.S. Navy's Project Overmatch, as described by ADM Michael Gilday, the Chief of Naval Operations, is "a collection of networks, infrastructure, data, and analytic tools that connects our distributed forces and provides decision advantage."
- The Advanced Battle Management System (ABMS) is the U.S. Air Force's effort to create a next-generation command and control system utilizing "an internet of things" allowing for sensors and C2 systems to be disaggregated from one another.

and capacity shortfalls further exacerbate the importance of the information advantage. Existing assets need to be directed to execute operations at the best time and place while avoiding undue risk to maximize force efficiency. That requires situational awareness and connectivity.

JADC2 must be global in scale. Most current DOD networks are limited in geographic range primarily because of the scope of past requirements and limitations inherent in legacy technologies. Consider that when DOD was developing its past concepts for precision-strike complexes near the end of the Cold War, the primary planning consideration was Warsaw Pact forces attacking through the Fulda Gap or across the North German Plain. The breadth of this theater was relatively small in scale compared to the more global scale of the Pacific theater. While the ability to conduct deep strikes against second-echelon forces required collaboration between sensors and weapons, they only really needed to be able to extend the battlespace around 150 kilometers beyond the Forward Edge of the Battle Area (FEBA). Consequently, the communications networks developed to support these operations were designed with geographically limited requirements in mind. For example, the range limitation of the venerated Link-16 network that connects different sensors and shooters together is only about 300 nautical miles.[31] It is over 5,000 nautical miles from Hawaii to mainland China, or 16 daisy-chained Link-16 networks. While current tactical datalinks will remain useful, U.S. information age combat forces require enterprise solutions built at scale. Current systems band-aided together reduce speed, are fragile, and are susceptible to enemy interference. Space-based capabilities are critical to achieving this necessary global scale of operations—it cannot be achieved through terrestrial means.

JADC2 must integrate capabilities across all domains. U.S. joint operations are fought by combatant commands, and as such, they must have interoperable C2 capabilities that can integrate various systems regardless of originating service or domain. Most C2 networks fall short of this objective. They are optimized for internal service communications and, in many cases, employ disparate, incompatible datalink standards, making lateral, inter-service, and multi-domain communications difficult.

As former Vice Chairman of the Joint Chiefs of Staff General John Hyten pointed out, the current C2 structure reflects the limitations of these technologies and is organized around divided areas of operations between domains and services: "Wherever we go, if we have to fight, we established the forward edge of the battle area, we've established the fire support coordination line, the forward line of troops, and we say: 'OK, Army can operate here, Air Force can operate here'."[32] However, in order to achieve the decision speeds and requisite force integration necessary to prevail in peer conflicts, future operations must embrace and master "dynamic integration" where service-specific "coordination" lines are eliminated and truly joint C2 systems are fully compatible. Furthermore, as explained the "forward edge of battle" in the Indo-Pacific theater is on a wholly different scale to those of Cold War battlespaces. It all comes down to effectively competing against a Chinese military that is optimizing itself to exacerbate the weaknesses projected by these seams and across hundreds, if not thousands, of miles.

Fusing various JADC2 subsystems is a difficult undertaking, but it is imperative considering that the overarching system will need to rely on multiple capabilities to act in concert. A modular open-system approach to systems design is pivotal to success because it allows the DOD and partners to design systems with highly cohesive, loosely coupled, and severable hardware and software modules that can be changed independently. This approach allows multiple commercial vendors to participate in the enterprise, which fosters the much-discussed need for rapid technology insertions as new innovations are developed. It also better allows JADC2 to be both "forward" and "backward" compatible with old and new sensors that are continually being removed from, added to, or altered for the collaborative sensing grid.

Spacepower's Contributions to JADC2

Effects delivered through the space domain are crucial in delivering JADC2. Sensors, processing power, and C2 expertise all linked by robust connectivity are the keystone elements that comprise this vision. The space domain affords distinct advantages in all these areas, but space is particularly important when it comes to sensors and connectivity.

Sensing

Data collection is a critical component of the JADC2 effort. It all comes down to placing sensors in the right place and time to gather desired inputs across the battlespace—from friendly lines to deep over enemy territory. In the past, these collection functions were largely executed from the air domain, which afforded the ability to rapidly span large swaths of territory and observe areas of interest with the advantage of altitude. While the NRO provided overhead ISR as well, its tasking was based on priorities for the overall intelligence community and not adequate to support the needs of operational commanders. Today's air domain is not only increasingly contested and denied over enemy peripheries, but air-based data collection capabilities must also transit extremely long distances from U.S. and allied bases of operation to effectively reach the front line, much less behind enemy lines. While the air domain will still be important in this regard, data collection missions will increasingly transition to space. The ability to cover vast portions of the earth with rapid refresh rates and constant coverage, avoid traditional air defenses, and do so without having to sustain large rotations of mission aircraft to net the desired result is a tremendous advantage afforded by systems on orbit.

While there are numerous examples of data collection efforts migrating from the air to space, moving target indicator (MTI) applications, both for air (AMTI) and ground (GMTI) purposes, stand forth as key examples of this trend and provide a useful model to better consider the factors involved with sensors increasingly moving to space. Popularly associated with their large array 707-based mission aircraft like the E-3 AWACS (AMTI) and E-8 JSTARS (GMTI), the Air Force has long been identified with these missions. Aircraft fly to assigned operating tracks and use their onboard radars to identify and track points of interest, such as aircraft, vehicles on the ground, and ships at sea. Onboard computing power then transforms this data into actionable information for C2 professionals, who further process the information to guide friendly actors in the battlespace. The end goal is to help tactical actors achieve better outcomes through an enhanced, real-time understanding of the battlespace. This includes knowing the location of adversary forces, how to engage to best attain desired mission results, and how to stay away from undue threats.

This is a mission focused on the front edge of the battlespace, with the C2 professionals addressing specific geographic regions so they can provide rapid guidance.

Too much data, too broad of an area of responsibility, or too much bureaucracy would rapidly undermine the effectiveness of the mission. C2 and longer-view intelligence functions further up the chain of command can also pull from this data as they would like, but effective MTI C2 demands tremendous discipline to ensure the realms of tactical, operational, and strategic mission execution are not conflated.

The original vision for this capability first gained momentum in the 1970s in the wake of the Vietnam War, with the E-3 AWACS executing the aerial portion of the AMTI mission. Then-Commander of Air Force Tactical Air Command General Robert Dixon explained the value afforded by AWACS: "The perfect vision of potentially hostile air activity will enable a commander to position his forces with economy and mass at the proper time to deter, or to fight. We will have time to think, reason, and act, rather than just react."[33] Data, transformed into information and harnessed as actionable knowledge, was the key to making the best use of available forces to meet mission intent. The development of the E-8 JSTARS in the 1980s, with an initial fielding during Operation Desert Storm, saw this combined high-fidelity sensor, processing, and C2 capability extend to the ground domain.

AWACS and JSTARS are both considered high-demand, low-density assets, with mission demand outstripping available mission capacity from both an airframe and aircrew vantage. The airframes and their onboard equipment are now decades old and need to be replaced. As Gen Kelly explained, "There's a reason why exactly zero airlines around the globe fly the 707. Because it takes a miracle . . . every day just to get it up in the air."[34] Additionally, Air Force leaders seek alternative mission options to address survivability concerns in a contested environment, where an airliner derivative aircraft could easily be shot down. Major General James D. Peccia III, Deputy Assistant Secretary for Budget in the Office of the Assistant Secretary of the Air Force for Financial Management and Comptroller, explained this as part of the rollout for the FY 2023 budget request when he stated the E-3 and E-8 "are not survivable—they'd be gone in a minute."[35]

It is clear, however, that space-based GMTI and AMTI sensors can better meet tomorrow's mission demands. Advances in these technologies mean that the co-location of sensors, processing power, and C2 experts is no longer required. The system can now be disaggregated, presuming datalinks can be assured. Service leaders have long been thinking in this vein, with Gen Raymond revealing in a 2021 speech a previously classified program to move a portion of the E-8's mission to orbit: "We're building a 'GMTI from space' program."[36] A service spokesperson further explained, "The space-based GMTI system will surpass the range limitations of current air platforms and will provide capabilities in contested and non-contested environments."[37] This correlates with FY 2019 and 2021 National Defense Authorization Act language in which the Secretary of Defense certified that classified space-based capabilities existed to meet various Combatant Commander GMTI requirements around the world.

The net effect is that the Air Force is seeking to divest the E-8 JSTARS weapons system, a process that began in FY 2022 and is expected to continue until the aircraft is retired from service in FY 2024.[38] Additional GMTI sensor aircraft, like the Global Hawk Block 40, are also slated for divestiture in FY 2027 according to service documents.[39] GMTI sensors on orbit connected to terrestrial processing and C2 expertise appear to be the way of the future.[40]

Potential for these solutions also exists for the AMTI mission, with Air Force Chief of Staff General Charles C.Q. Brown explaining, "As we look to the future, ideally we'd like to be able to look at capability that can be defensible, to be able to do AMTI from space at some point."[41] While airborne systems will continue to perform in this mission area, considering the Air Force's decision to pursue an E-7 Wedgetail aircraft as a means to execute the AMTI mission, the trend toward space-based sensors makes sense as technology continues to mature. Their broader vantage, ability to circumvent air defenses, and a more persistent level of coverage offer tremendous advantages. DOD, and the U.S. Air Force in particular, must look past how traditional MTI missions have been defined and executed based on decades-old constructs imposed by legacy airframes and associated mission systems and conceive of novel and space-centric models.

However, for a space-based MTI mission to succeed, there are several important factors to consider. First, disaggregating the sensor from the data processing power and C2 experts demands assured communications links that are highly resistant to enemy attack, to include the detonation of a nuclear weapon in low earth orbit. Sensor coverage must adequately cover broad areas of interest, many of which will be hard to anticipate given the unpredictable nature of the future security environment. One advantage inherent in the E-3 AMTI and E-8 GMTI aircraft is their global mobility. Combatant Commanders, no matter the theater in question, could always request an aircraft and expect coverage if their requirement was deemed a priority. A space solution will need to provide a broad global view or be extremely flexible to afford the necessary presence in regions of interest where assets might not exist. Importantly, where systems in space may exist and extend extremely broad coverage, to receive and use the data they provide requires adequate uplinks and downlinks to the operational and tactical warfighter. Further, increased reliance on this data by multiple platforms in all domains will drive interoperability between communication waveforms and standards. Coverage also needs to be persistent, given that a key portion of the MTI mission involves tracking highly dynamic mission activities. C2 professionals need to have real-time insights.

Space-based MTI sensors must also plug into an organizational paradigm that respects tactical, operational, and strategic centers of C2. To this point, tactical C2 requires decisions in seconds and minutes in a focused geographic region. That demands a very disciplined focus on a particular part

The Power of Processing

While sensors on orbit offer tremendous power, it is important to recognize that they are merely one portion of a broader mission system. Data processing and information displayed through tools like a tactical ground system are also important to help transform data into actionable information for warfighter use. The Army's Tactical Intelligence Targeting Access Node (TITAN) stands as an example in this regard. TITAN is designed to take space-based tactical ISR data, like GMTI, and process it using machine learning to lessen the sensor to shooter timeline. These ground systems will eventually be a modular, scalable, and open-system architecture that leverages space, aerial, and terrestrial layer sensors to provide targetable data to warfighters. Programs must be managed to account for this entire enterprise. Success demands a balanced approach of sensors, connectivity, and processing power.

Source: "TITAN Update," Army.mil, June 28, 2022.

of the battlespace. Strategic C2 involves broader vantage in both time and area covered. As tactical C2 systems, E-3s and E-8s generally align with this model by virtue of their technological architecture. Their sensor range, mission duration, and processing power factors were sized to their tactical zone of focus—they can only cover so much area and be on station for so long. Space sensor constellations are far different because they have a real-time theater-wide view. Effective use of this capability demands an appropriately tiered C2 construct that ensures the respective needs of tactical battle management, operational and strategic levels of command, and intelligence functions are met. These are all very different functions, and roles matter. Just because data could theoretically be available to all does not mean mission objectives would be enhanced by confusing lines of responsibility. As a 1999 RAND Corporation C2 study highlighted, "In the age of abundant, almost limitless, information and communications capabilities, decision-makers are increasingly faced with the problem of too much information, rather than too little." RAND's report points out the obvious solution: "Understanding what information is most essential for decision-making—so that the information being communicated, processed, or displayed can be bounded—is now a major issue in the design of computer-aided decision support systems."[42] The challenge of processing, filtering, and directing information flows appropriately aligned to a broader C2 vision across the battlespace will escalate to levels previously unimaginable thanks to the power of space-based nodes paired with global connectivity. An effective JADC2 construct must anticipate these challenges and develop a model that will ensure new technologies enhance mission effectiveness, not overwhelm it. That means understanding what platform, unit, or individual in the battlespace needs what information, when, and for how long.

Space sensors, whether MTI or other types, must also be designed as nodes in a broader multi-domain sensor net. It all comes down to gathering disparate flows of information, fusing them into a whole that reveals more actionable knowledge of the battlespace than can be provided by any individual source. While space-based sensors will obviously yield crucial inputs, sensors located in the air, on land, or at sea could also prove equally valuable. The real power is achieved through fusing inputs from all these sources in a highly dynamic, effects-oriented fashion to best achieve mission results.

Space Transport Layer

Operating and managing the global JADC2 space transport layer and associated infrastructure is a critical mission the Space Force will accomplish in the next few years. Sensors in space and other JADC2 nodes offer significant potential, but the entire enterprise must be connected to deliver desired results. While a range of terrestrial networks in the form of various datalinks will remain important, an overarching global communication backbone is required to fully connect all the various elements of the JADC2 enterprise in a dependable, high-speed, seamless, resilient fashion. That is a requirement that can be met best through space-based capabilities due to their global perspective, global persistence, and global information connectivity.

This is not a new mission for the space community but instead builds upon decades of experience in this realm. Assets on orbit first entered the communications realm in the Cold War as they helped empower operations related to strategic deterrence and the nuclear triad. The enterprise took a significant step forward into the operational realm during Operation Desert Storm when space-based systems integrated information across multiple weapon systems. Over 90 percent of all U.S. communications in operations were delivered by communication satellites. Command authorities were dependent on satellite communications to maintain contact with their forces.[43] Additionally, these links were critical in relaying missile warning data to deployed forces. This was the culmination of efforts stemming from a DOD realization that U.S. forces must develop more technologically advanced capabilities to offset numerically superior military adversaries operating in eastern Europe and central Asia.

Since then, the roles for DOD's communications satellites and other space assets within its battle networks have grown dramatically as the demand for real-time connectivity has scaled aggressively. Just consider their role in supporting real-time remotely piloted aircraft operations in Iraq and Afghanistan, as well as around the globe: this concept that seemed plucked from science fiction was operationalized in rapid order at scale in the aftermath of the 9/11 attacks. This could only happen thanks to the connectivity backbone provided by space. That sort of integration and collaboration has been repeated multiple times across a broad range of mission areas in recent years. It is a key reason why activities in the space domain are fundamental to what happens to military operations on earth. The bottom line is that America's global military posture demands rapid, responsive, decision-quality information to empower operations at range, over widely distributed areas, and in remote locations. Space provides that global, rapid connectivity.

It is important to highlight that this rapid increase in demand for operational satellite communications (SATCOM) capabilities occurred during an era in which space was assumed to be a benign environment. U.S. adversaries were not challenging these assets, and their assuredness was not questioned. This contributed to a sense of complacency where too many assumed today's SATCOM architecture and technology would be equally assured and meet tomorrow's JADC2 demands. That is a faulty assumption. Most current SATCOM systems were driven by legacy requirements and designs that date back to the Cold War. Efficiency and increased capability were prioritized ahead of resilience. Systems were designed to fulfill specific requirements with little consideration for the enterprise-wide architecture required for a concept as broad-reaching as JADC2. It is one thing to connect a few dozen users in real-time and quite another to connect thousands. As a result, core military satellite communications today span just 36 satellites. Reliance on such a small number of nodes presents a network vulnerability where the loss of just a few platforms could result in critical failure of the system. Adversaries with deep magazines of counterspace weapons could readily exploit this weakness in a conflict. Gen Hyten explained this vulnerability best during his time as head of U.S. Strategic Command when he said, "I won't support the development any further of large, big, fat, juicy targets."[44]

Despite its past success and the continued vital role it will play, the DOD SATCOM enterprise today finds itself at a crossroads. The current architecture is the product of choices and analyses predicated on now-outdated assumptions and operational concepts. Simply put, it has not remained apace of the growing threat posed by China and others to contest and degrade the assured U.S. access to the space domain, nor is it designed for the speed, scale, and range that information-age, all-domain operations demand. The Space Force cannot continue to simply procure incrementally better versions of the same kinds of exquisite space systems the U.S. military has relied on in the past. They are too centralized, unresponsive to new missions, and lag behind both the evolving threat environment and cutting-edge technologies. They also lack the ability to readily pass the volume of data exchange JADC2 will likely require—a demand that has been on the rise for years. As former Director of Defense Information Systems Agency Lieutenant General Alan Lynn explained, "The requirement just keeps growing. Every day we have more throughput requirements."[45] This would be akin to expecting a 1990s dial-up modem to deliver 5G wireless functionality. The technology does not align to the requirements, and the enterprise must be modernized.

A better set of capabilities begins with a distributed, resilient architecture involving far more SATCOM satellites than are currently on orbit. This will increase resilience, responsiveness, and functionality. To make up the sheer quantity required, the JADC2 space transport layer will likely be a combination of government and commercial space systems distributed over many orbital regimes and evolve over time to emphasize different link technologies, satellites, and orbits.

That is why the Space Development Agency (SDA) is developing its Space Data Transport layer in support of its National Defense Space Architecture. Said more simply, this is a far more numerous, distributed set of satellites that will empower the JADC2 transport layer in a way that helps avoid single points of failure and that will also bring more modern capabilities to orbit. DARPA's Blackjack program is a related effort designed to assess the potential

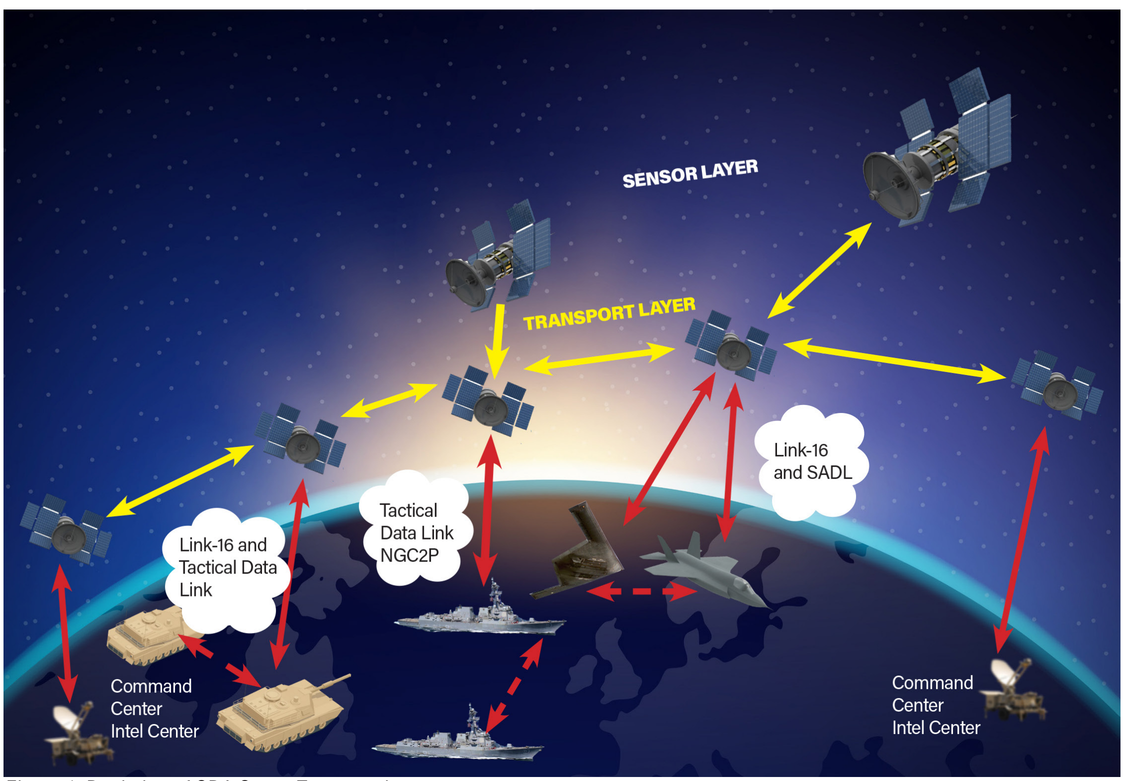

Figure 1: Depiction of SDA Space Transport Layer

Credit: The Mitchell Institute, Dash Parham, Mike Tsukamoto/Air and Space Force Magazine, and Adobe Stock of a low earth orbit constellation of capabilities. The former Blackjack Program Manager explained, "If one satellite has fallen, its replacement is coming over the horizon 10 to 15 minutes later. You have a different approach to resiliency."[46] The SDA will launch a constellation of Low-Earth Orbit (LEO) satellites integrating the services' tactical networks to create the transport layer of a meshed network. The SDA views the transport later as primarily an integration problem—integrating multiple service efforts into a cohesive whole. As such, the SDA is working with the individual services on specific integration requirements.

Space Force is also currently working with commercial and coalition partners to develop interoperable architectures to "enable space mission assurance and unity of effort."[47] In other words, the Combined Space Operations Center (CSpOC) is working with commercial partners in the Commercial Integration Center (CIC) and with coalition space forces assigned to the CSPoC to share data and provide a single operational picture of the domain. The goal is to enable mission assurance across all space assets.[48]

As these sorts of increasingly sophisticated, distributed SATCOM networks proliferate, it will be important to focus on the ability to transfer sensor data to, from, and through space at rapid speeds. The goal of the JADC2 approach is to develop a modular and scalable system. To achieve this, the SDA plans the initial capability for the transport layer to be a traditional Link-16-like node from space.[49] Eventually, new additions to the transport layer will provide both radio frequency and optical solutions for downlinks. This latter technology—optical data transmission with lasers—is especially important because it enables the transfer of far larger quantities of data that exceed standard radio frequency (RF) transmission capabilities used by many current SATCOM systems. It is all about facilitating an information advantage at the speed of relevance. In addition, optical communications provide more security against adversary interception and jamming. When coupled with optical downlinks, the net effect is high-speed, flexible, secure communications. A JADC2 space transport layer with optical capabilities to communicate can integrate the terrestrial services' systems that it requires.[50]

Given the number of JADC2 nodes in play, especially given the service-specific approaches to manifesting this vision, interoperability will demand a modernized SATCOM enterprise. Furthermore, it will require the U.S. Space Force to manage the integration and operation of this SATCOM enterprise for joint operations. Present systems lack the agility necessary to allow plug-and-play interaction across several disparate JADC2 nodes. They process data with single-use apertures that are slow to move. Systems will instead require electronically steered apertures to respond faster. In other words, as we proliferate low earth orbit systems and rely on commercial capabilities that use frequencies different from those of traditional military satellite communications, it becomes clear the old architecture is not fit for purpose.

These interoperability goals must be incorporated into JADC2 programs because the approach demands a network that allows for a wider range of frequencies and incorporates dozens or more space systems and constellations from allied, coalition, and commercial partners. As the Space Force designs the JADC2 space transport layer, it must employ wide-band array capabilities, enabling them to send and receive from multiple satellites on multiple frequencies in multiple orbits. This is like a modern cellphone, which is able to rely upon multiple proprietary networks in a way that appears seamless to the user and provides an encompassing range of service.

Space Force leaders fully understand the importance of on-orbit communication capabilities in realizing the JADC2 vision. As Vice Chief of Space Operations General David "DT" Thompson explained, "JADC2 is an absolute priority for the United States Space Force. Enabling JADC2 by connecting the Joint Force through space may well be our greatest contribution to joint operations in the next decade."[51] It all comes down to a simple reality: the power of JADC2 is wholly reliant on integration and collaboration. No matter how much the DOD invests in sensors, processing power, C2 centers, or front-line assets, none will really matter without the ability for robust, rapid, and resilient space-centric communications.

Space Force's Combat Role for JADC2

The effectiveness of JADC2 depends upon whether the U.S. Space Force is prepared to fight to, in, and from space to defend those assets. The advantages U.S. and coalition forces will derive from a robust JADC2 enterprise will be obvious to an adversary. China has anticipated the need to undermine this sort of capability by denying an information and decision advantage, which is already a key component of their intelligence warfare strategy. That is why Chinese military writings explicitly discuss "destructive strikes to the enemy [in space] . . . in order to fight rapidly, conclude the operation rapidly, and to withdraw from the confrontation."[52] Space-based sensors and communications links will be prime targets because impeding the ability to gather data and collaborate will yield a debilitating effect on the rest of the combat force. The entire JADC2 construct depends on data inputs, and if a combat asset like a plane or a ship is cut off from the broader C2 enterprise, it will lose situational awareness, the ability to team with proximate forces, and the advantages afforded by informed C2. Cut off from this information advantage, the danger the individual combat asset poses to Chinese forces is substantially reduced. The possibility of essentially negating U.S. combat assets without destroying them is extremely attractive to adversaries like China.

Given this known vulnerability, it is fully reasonable to expect both kinetic and non-kinetic combat actions to extend into space to degrade and destroy sensors and the transport layer. Countering these attacks demands defensive and offensive strategies, operational concepts, tactics, and technologies to protect assets on orbit, as well as their terrestrial components. Such thinking is not revolutionary—it is how every other warfighting domain operates.

Deploying a JADC2 architecture without the corresponding space combat systems charged specifically with defending sensors and the space transport layer would induce extreme risk. Without space combat forces capable of defending and, if necessary, defeating non-kinetic and kinetic attacks, JADC2 will not be able to achieve an advantage by any means. In fact, left vulnerable, the systems that make up the JADC2 vision would serve only to make the joint force of the future infinitely more brittle.

Space Force JADC2 requirements

The first requirement for the JADC2 space transport layer architecture is resilience and survivability. As such, the sensor nodes on orbit and space transport layer must be hardened, be deployed as proliferated networked systems, and undertake system resilience measures. Mission assurance will be the main objective. The joint force must trust that it is able to receive mission-critical information from the JADC2 enterprise even if the system is damaged.

Defending JADC2 in Space

The U.S. Space Force must be prepared to defend sensors on orbit and in the space data transport layer. Key elements required to achieve this include:

1. A survivable JADC2 enterprise composed of hardened, proliferated networked systems (made of military, commercial, and alliance assets) across multiple orbits (LEO, MEO, GEO, and cislunar) to enhance system resilience, complicate adversary simultaneity of targeting and attack, and provide defense in depth (to include rapid reconstitution).

2. Robust Space Domain Awareness, including space-based ISR platforms (such as the Geosynchronous Space Situational Awareness [GSSAP] spacecraft) for LEO, MEO, GEO, and cislunar orbits to detect and identify adversary threats and prevent attack.

3. Space weapons to defend and defeat active attacks on the JADC2 architecture and the space transport layer's lines of communication. These will need to be both offensive and defensive as well as all-domain.

One promising technique to achieve resiliency is disaggregated space architectures. This involves the "dispersion of space-based missions, functions, or sensors across multiple systems spanning one or more orbital plane, platform, host, or domain."[53] Given the nature of JADC2 to be collaborative and distributed among many different allies, partners, and systems, disaggregation is baked into JADC2's DNA. This will provide natural defenses against threats, preserve information mobility even after taking moderate damage, remain survivable under enemy attack, and be able to reconstitute quickly.[54] Coupling this concept with new advanced cryptological technologies will increase the necessary defenses against cyber-attacks.

Designing with deterrence in mind is another essential element that will contribute to resilience. Much like the Cold War triad-based nuclear deterrence concept, JADC2 must be distributed and disaggregated to complicate enemy targeting. The Soviet Union would have had to destroy all three legs of the U.S. nuclear triad simultaneously to avoid a retaliatory strike. The odds of accomplishing that feat are clearly small. JADC2 must present a similar problem to adversary war planners. Disaggregation of the JADC2 critical information mobility nodes will cause an enemy to face a virtually impossible simultaneous attack problem to bring down the entire system. An adversary should also understand that an attack on the U.S. JADC2 enterprise will garner an overwhelming counterattack.

Another key component a robust JADC2 construct on orbit requires is space domain awareness. Given the lack of human presence to provide feedback regarding attacks, technology will need to provide that situational awareness. The Space Force defines space domain awareness as the "effective identification, characterization, and understanding of any factor associated with the space domain that could affect space operations."[55] Army General James Dickinson, U.S. Space Command (USSPACECOM) commander, has defined space domain awareness as "the command's top priority." Not only does this require mapping the physical location of objects on orbit, but the intent of the assets, both friendly and malign, must also be understood.

Resources necessary for this mission include ground-based radars and optical sensors, as well as space-based radars and sensors across all orbital regimes. Maneuverable spacecraft capable of identifying the adversary's intent by conducting close-in inspection will prove useful in achieving this goal. Space domain awareness reconnaissance capabilities in cislunar space will also be necessary. As China continues to develop capabilities and presence on and in orbits and Lagrange points around the moon, the United States will need to prevent any maneuvering to attack JADC2 assets from a non-Earth-centric orbital trajectory.[56]

The Space Force must, perhaps most importantly, be able to act decisively if deterrence fails and the JADC2 space transport layer is attacked, whether by non-kinetic or kinetic means. These threats include non-kinetic electromagnetic "jamming" means, as well as kinetic space attacks like direct ascent anti-satellite weapons and co-orbital anti-satellite platforms. Even if the Space Force is defending a well-designed JADC2 space transport layer with robust defenses and superior space domain awareness, the Space Force will need armed weapons platforms to defeat incoming attacks. Absent clear and immediate consequences from active defenses such as these, adversaries may be willing to gamble relatively minimal blowback to attack and permanently take out essential U.S. space-based capabilities.

For the last few decades, discussion about "weaponizing" space has ebbed and flowed around American defense circles. It is a controversial issue but given adversary lines of development that clearly demonstrate their ability to project combat power on orbit, the United States must respond with like capabilities. This requires weapons capable of defending key assets on orbit as well as those capable of disrupting, denying function, or destroying adversary space assets.

Conclusions and Recommendations

A stark reality faces the nation: the United States is at risk of failing to deter China's hegemonistic ambitions in the Indo-Pacific because its Air Force and Space Force currently lack the lethality and capacity to prevail in a peer conflict. This does not have to be the case. One approach to achieving a war-winning level of combat power with today's forces is to transform how DOD commands and controls its future operations in all warfighting domains. Creating a C2 structure that exploits superior decision cycles and levels of information will enable America's combatant commanders to seize the initiative. Possessing an information and decision advantage is an instrumental precondition to a credible ability to blunt and then defeat Chinese aggression. The Battle of Britain in 1940 is one example where a C2 system was designed out of necessity to posture limited RAF forces to be at the right place at the right time to achieve decisive results. Operation Desert Storm was likewise a success story of a force that was developed on the principle of fielding technologically advanced forces that exploited superior C2 systems to offset numerically superior forces in the Cold War. In the current era, JADC2 is a conceptually parallel path to regaining a dominant warfighting posture for the U.S. military.

Space capabilities developed and fielded by the U.S. Space Force will be the essential element of JADC2's effectiveness. Freedom to operate in the space domain is the fundamental enabler of the JADC2 concept—this fact must be internalized and championed by the DOD and Congress. Capabilities in the space domain that provide substantial advantages in perspective, reach, and effect are requisite for beating China's war machine.

An adversary will always attempt to interdict key nodes of command and control. Consequently, a JADC2 architecture must be defended to maintain information and decision superiority in highly contested operational environments that will exist in peer conflict. This includes the defense of the sensors on orbit and transport layer, two of JADC2's centers of gravity. Maintaining U.S. freedom of action in space and defending these elements will be more than a matter of increasing its design resiliency and pursuing other passive defense measures. Instead, the Space Force must be organized, trained, and equipped to both defend and attack across the spectrum of effects to, from, or in space to maintain a secure JADC2 capability. Every other warfighting domain follows these principles. Warfighting in space is no exception. This will require increased investment and policy reforms that will help institute tangible consequences, both kinetic and non-kinetic, for attacking U.S. assets in space and their broader supporting enterprise. Establishing standards of behavior is a positive effort in the U.S. approach to space, but establishing consequences also matters to drive adversary decision-making.

The U.S. Space Force is the responsible service that must create the elements of a JADC2 space transport layer that other services will use as a baseline to integrate their specific C2 systems, including the Army's Project Convergence, the Navy's Project Overmatch, and the Air Force's Advanced Battle Management System. The Space Force must also be assigned the responsibility for developing the capabilities and capacity to defend the JADC2 space transport layer architecture. This means the other services would prepare and posture to support Space Force missions, whether protecting surface, air, sea, or cyber components of the JADC2 architecture or by contributing to the offensive counterspace mission. In short, success in peer conflict means the Space Force must transform from being merely the enabler of all other service command and control capabilities to lead integrator of the operational design, planning, and execution of JADC2.

The following recommendations are key to achieving these JADC2 objectives as quickly as possible:

1. Congress should reinforce the authority of the Chief of Space Operations as the Space Force design architect by ensuring the service has the primary responsibility of overseeing the integration of the entire JADC2 system. This authority should include bounding requirements and establishing standards for incorporating machine learning, optical communications, cyber and crypto security, software-defined networks, and distributed computing capabilities for JADC2 across all of DOD.
2. Congress should provide definitive guidance and funding in the FY 2024 National Defense Authorization Act that creates an unrestricted path for Space Force's development of space control doctrine, missions, and capabilities needed to assure the functionality of JADC2.
3. Congress should require DOD to report on its plan to ensure that the fielding of the JADC2 architecture is concurrent with DOD's fielding of adequate defenses of its components.
4. Congress must approve robust resourcing to enable the Space Force to deliver enhanced space domain awareness and to develop space-based weapons systems that are specifically designed to defend the JADC2 space transport layer against kinetic and non-kinetic acts of aggression.
5. DOD should modify its defense strategy to identify the critical need to defend the JADC2 architecture and ensure this priority is reflected in programming and resourcing choices across the services.
6. DOD should also frequently review the Space Force's JADC2 integration efforts to ensure interoperability remains a top priority for all service-specific JADC2 programs. Keys

to achieving this interoperability include open architectures that enable communications between satellites and terrestrial platforms; data standardization; the deployment of wide-band arrays that receive and transport JADC2 levels of data; and capabilities that incorporate all waveforms utilized by U.S. and allied military and commercial assets.

7. The U.S. Space Force must rapidly transform its ethos from being an enabler and provider of services to a service that provides warfighters and capabilities that create war-winning effects to, in, and from the space domain. This will be necessary to conceive and field an effective defense of the JADC2 architecture.
8. Finally, the U.S. Space Force must develop a realistic training, test, and range capability to exercise and mature JADC2 functionality while developing Guardian warfighting skills. This will require advances in both current simulators and doctrine to align with the reality of fighting in a contested domain against a peer adversary. Simulators must mirror the environment Guardians will engage in and incorporate how other domains will support operations. This preparation of warfighters is essential for successful campaigns and is consistent with warfighters in any other domain.

The comparative military advantage the United States held against China has deteriorated significantly both quantitatively and qualitatively over the last 30 years. During that same time, the space domain went from a benign environment to a congested and contested domain, with China's space program on track to outpace the U.S. program by 2045. Gen Thompson warns, "They intend to use space the way they have watched us use it for decades, in addition to building a whole suite of counterspace weapons to deny us. They have come a long way very quickly. They are close to being an equal if they continue at their pace."[57] There is no doubt this will be an expensive and complex program, but the opportunity costs of ignoring the threat and overall impact on U.S. forces and warfighting capabilities are far greater.

Current DAF leadership understands the import of these efforts, as Gen C.Q. Brown said this year, "We cannot afford to lose a day in this effort. Speed, agility, and resilience are essential to decision-making and battle management in future highly contested environments. The progress we make in JADC2 will be determinate in our success as a joint force."[58] We cannot afford to wait on this imperative; the time is now to fully imagine what JADC2 can be and how critical space will be to this effort. ✪

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