Vol. 2, September 2016

MITCHELL INSTITUTE
Policy Papers

Key Points

Mission requirements demand the US Air Force maintain the capability to engage in intelligence surveillance and reconnaissance (ISR), command and control (C2), and air battle management (ABM) tasks through a successor to the E-8C Joint Surveillance and Target Attack Radar System (JSTARS).

This capability must maintain flexibility to evolve as future requirements warrant and technological opportunities allow. While it will remain imperative to track ground targets in battle, the way in which this information is gathered and distributed will change, as technology advances will allow more seamless integration of ISR data from multiple sources.

In the 21st century, the fast evolving world of information technology demands an enterprise-driven approach, in which aircraft will figure prominently, but will not be the sole solution for the capability historically associated with the E-8. The follow-on aircraft to JSTARS will have to grapple with how it will support a transition to future distributed operations, as the Air Force moves towards a future of distributed operations and open systems architecture.

Beyond JSTARS: Rethinking the Combined Airborne Battle Management and Ground Surveillance Mission

By Lt Gen David A. Deptula, USAF (Ret.)
Dean, The Mitchell Institute for Aerospace Studies

with Marc V. Schanz and John M. Doyle

Abstract

The ability to command and control (C2) military forces in combat is a basic requirement for successful operations. Effective C2 allows joint forces freedom of action, and the critical coordination to seize opportunities and address threats as they emerge.

Air battle management (ABM) in the context of the US Air Force's E-8C JSTARS aircraft is a key facet of modern C2. Harnessing a ground moving target indication (GMTI) intelligence, surveillance, and reconnaissance (ISR) sensor and onboard processing capacity, air battle managers direct surface-focused operations at the operational and tactical levels of combat through an array of communication links. GMTI, unlike traditional radar, allows air forces to reveal and track the movement of ground objects in combat in near real time. This capability has provided a key advantage to American military forces since the first combat use of JSTARS in Operation Desert Storm.

To ensure the continued viability of these key GMTI/ABM capabilities, plans to recapitalize the E-8C must be examined in the context of 21st century demands. These capabilities must evolve into a more enterprise-driven effort than when the concept of JSTARS was first imagined. Cold War-era requirements, and technology at the time, dictated a large sensor aboard a large aircraft as the most appropriate solution. Tomorrow's conflicts, though, feature more challenging threats, demanding more capable and flexible solutions. Effective C2 and ABM hinge on the ability to plan, coordinate, direct, and control military forces in conflict, and is the foundation of American power projection. As a result, USAF's C2, ABM, and associated ISR capabilities have proved inseparable from nearly all modern US and coalition operations.

The JSTARS force has generated C2 capability nearly nonstop over the last 25 years through its combination of specialized mission systems and highly trained air battle managers. However, as technology and threats evolve, so do requirements. This consideration necessitates a broader enterprise approach to the future of the JSTARS' mission, not just a program to produce an evolutionary replacement aircraft. More than an aircraft, these capabilities will not only fulfill the mission of the JSTARS, but will have to leverage information sharing among multi-domain weapons systems and sensor platforms that can turn shooters into sensors and sensors into shooters.

Introduction

Since its maturation in the 20th century, aerospace power has been fundamentally linked to the basic military task of command and control (C2). Since World War I, aircraft flying over the battlefield proved well positioned to assess the disposition of enemy forces and advise on how to best coordinate military actions. Since then, timely, accurate, and actionable intelligence, surveillance, and reconnaissance (ISR) information has proved critical in executing C2 for effective military operations.

The US Air Force (USAF) brings immense capacity and capability to bear with its ISR forces to accomplish this task. Put simply, ISR is the act of gathering information on the positions and circumstances of enemy (and friendly) forces in a given contingency or conflict, their disposition relative to friendly forces and non-combatants, and provides this information to commanders to devise actions to generate appropriate military effects with the available resources. This is the essence of command and control.

As technology advanced in the 20th century, so did C2 capability—with human vision being augmented by systems like radar, infrared sensors, advanced data links, and increased processing power. Towards the end of the Cold War, the US military sought an ISR capability that could enable the detection, location, and gathering of precise targeting information on mobile Soviet armor units beyond the forward area of battle. In the 1980s, that task required a large body aircraft that could hold the most modern ground moving target indication (GMTI) radar, associated processing capacity, mission systems, and communications equipment available. This allowed the ability to gather data, and to turn it into actionable information by trained air battle management (ABM) crews, who then coordinate with relevant actors at the tactical, operational, and strategic levels. This advancement helped maximize the most effective and efficient projection of military power, allowing commanders to better understand the relative evolution of a battle in real time. Cutting edge radar research and development led to the fielding of the AN/APY7 side-looking radar array, which is 24 feet long, and needed both the space and power of a converted commercial airliner. In this context, the E-8 Joint Surveillance Target Attack Radar System (JSTARS) program emerged as the solution. This aircraft combined ISR technology in the form of the GMTI sensor, onboard processing capability, communication links, and trained air battle management professionals to facilitate command and control functions. The system was ultimately put to the test during the onset of the 1991 Gulf War.

Whether used for C2 or ABM of combat assets, or acquiring real-time ISR, the JSTARS force has become inseparable from the modern American way of war.

Today, the E-8 force, along with the Block 40 variant of the RQ-4 Global Hawk, comprises the vast majority of the US military's GMTI capability in joint force operations. Given the insatiable demand for ISR and force coordination, these systems are often on the short list of needs for combatant commanders around the world.

Since its Operation Desert Storm deployment, JSTARS has provided tremendous capabilities for joint force operations. Because of these capabilities, the E-8 was rushed to that conflict, and played a vital role in its very first combat application, during the Battle of Khafji—the first major ground engagement of the Gulf War. Whether used for C2 or ABM of combat assets, or acquiring real-time ISR, the JSTARS force has become inseparable from the modern American way of war. Due to its unique mission systems and complement of on-board trained air battle managers, one retired officer with extensive experience in the JSTARS mission said the aircraft is in near continuous demand because it excels at simply "finding things and solving problems"—a capability which has transformed C2 in many scenarios.[1] At the same time, it must be noted the E-8 has operated in environments where it was at little to no risk over the last 25 years, and as threats advance, so does the vulnerability of specialized mission aircraft like the JSTARS.

Success has come at a price for the JSTARS force. The converted Boeing 707 airliners, the airframe that carries JSTARS powerful GMTI radar and mission systems, now face sustainment challenges after 25 years of continuous service. Structural wear and tear of the aircraft is only part of the sustainment challenge, however, as JSTARS

has only periodically been modernized through the years. Though the E-8 aircraft were already used civilian airliners when converted to military specifications, they were also not maintained and sustained using an evolutionary approach that rigidly improved internal systems and other components at regular intervals. In contrast, the RC-135 fleet, another legacy ISR aircraft which first entered USAF service in the early 1960s, has been maintained and upgraded in an evolutionary approach (aided by the Air Force's "Big Safari" rapid acquisition office) which has kept these assets operationally potent with more responsive integration of new technology. At the same time the JSTARS fleet faces escalating sustainment challenges, demand for GMTI capability is growing from all combatant commands (COCOMs). The US Air Force plans to recapitalize the service's current 16 E-8Cs by purchasing a new force of "business jet" aircraft, while continuing to rely on Block 40 Global Hawks to assist in meeting burgeoning mission demand.

To understand the E-8 JSTARS, it is critical to recognize the capability it provides is not just an aircraft, but also a significant information node, connecting to and providing knowledge for a globe-spanning C2 network. Similarly, the E-8's successor will not act alone. It will be used in an era of revolutionary information technology maturation and proliferating threats. This environment demands an aggressive enterprise-driven approach to meet expanding GMTI/ABM mission requirements. This capability must also maintain the flexibility to evolve as future requirements warrant and technological opportunities allow.

To understand the E-8 JSTARS, it is critical to recognize the capability it provides is not just an aircraft, but also a significant information node, connecting to and providing knowledge for a globe-spanning C2 network.

This is why, when assessing the future of the JSTARS program, the GMTI/ABM mission sets, as a whole, must remain under sharp focus. The E-8's successor will be a key node in an emerging distributed "system of systems," linking aircraft, sensors, platforms, and the data they acquire into a virtual cloud of shared information, to meet the needs of the GMTI/ABM mission—and much more. This paper explores these emerging challenges and requirements, explain the potential gains afforded by new technologies, and consider how a modern, self-forming, self-healing, and survivable GMTI/ABM capability could enhance future operations.

GMTI and ABM in a New Era

The successor to the E-8 will enter service in a world far different than when it first deployed in the early 1990s, and in many ways deadlier for US forces. New military challenges presented by the 21st century range from low-intensity insurgencies, to a new and more dangerous threat environment posed by near peer opponents, like Russia and China—as well as the proliferation of these nations' weapons to new regions and actors around the world. Air operations are more challenging than ever for the US and its allies. Modern integrated air defense systems (IADS), advanced combat fighter aircraft, and more lethal and long-reaching surface to air missiles (SAMs) pose varied and complex challenges to potential US military operations in regions around the world.

The threats to aircraft are only part of the portfolio of challenges driving the need for "enterprise level" solutions for missions such as C2, ABM, ISR gathering, and long-range strike. Threats, technological proliferation, information flows, and other factors drive the need to create more rapid and responsive means to project power and gather information. These facts make the push for more information sharing among all US armed services and partner militaries more urgent with every passing year. Better integration will enable air assets to perform across the threat spectrum. Information sharing will affect one of JSTARS's core capabilities, namely GMTI radar—the key sensor of the aircraft which can spot and discriminate a moving target, and distinguish it from stationary ground clutter. This tool is increasingly necessary to empower modern 21st century C2 through the GMTI/ABM construct—the effective and efficient management of combat assets in a given scenario to yield the maximum desired mission effect, while avoiding unnecessary risks. As more tasks and processes in the US military (and in modernized allied militaries) become mechanized and automated,

there will also be a need to task, collect, process, analyze, and distribute intelligence in a secure, and optimized manner to reach back to commanders and forward to aircraft—which any future JSTARS capability will have to anticipate and take into account.

The current JSTARS has provided invaluable service to nearly every US military campaign since Desert Storm, but is now facing the breaking point. At any given time, half of the 16 E-8s in the force—all of them 40-year-old converted Boeing 707 airliners—are undergoing maintenance. The last "new" E-8C upgraded airframe was delivered in 2004, and at that point was already decades old (the oldest E-8 airframe, according to Air Combat Command officials, has a cumulative 78,000 plus flight hours as of 2016).[2] Because of its unceasing operations tempo, replacing the JSTARS force is now the Air Force's fourth-highest modernization priority, after the long-delayed KC-46 aerial refueling tanker, F-35A, and the B-21 Long-Range Strike Bomber (more accurately described as the Air Force's future long range sensor-shooter, or LRSS).[3] To perform key military missions around the globe, the observation of enemy ground forces and the C2 of friendly air and ground units enabled by GMTI technology and ABM airmen is a fundamental task of US military power projection.

As the Air Force begins the process of replacing the E-8 aircraft, it is critical to think beyond the operational and technological constraints defined by the current 25-year-old E-8C fleet.

As the Air Force begins the process of replacing the E-8 aircraft, it is critical to think beyond the operational and technological constraints defined by the current 25-year-old E-8C fleet. Whatever replaces JSTARS sometime in the mid-2020s or beyond, the Air Force and the Department of Defense (DOD) must be careful to not lock in solutions using current technology—a decision that may be more influenced by budgetary restrictions than an honest assessment of threats, available technology, and operational requirements. Though there is need to examine cost efficiency over the life cycle of a program, any efficiency must be weighted against operational effectiveness. This is why the ability to conduct modular sensor upgrades, as well as evolve and integrate enhanced capabilities such as advanced analytics and visualization tools is essential in any new GMTI platform. We must allow for future expansion and eventual improvement or replacement of key sensors and capabilities, as the GMTI/ABM mission evolves. A new GMTI platform must be designed to accommodate future modular technology packages, requiring an open system to be compatible with legacy technologies as well as future ones. Any JSTARS successor program must take into account future "plug and play" capabilities that connect with networks that already exist in "fifth generation" aircraft like the F-22 and F-35, as well as connectivity with assets such as satellites, the B-21, ground, and naval assets. Other considerations include improving standoff communications capabilities to link up with aircraft and other combat assets tasked with penetrating and operating in high threat, heavily defended environments. Augmenting the capability of an E-8 and its follow-on with a distributed enterprise of sensors is simply undeniable. F-35s, F-22s, and B-21s transiting through enemy airspace could use their sensors to gather relevant information and pass it back to the GMTI/ ABM platform for inclusion in the broader informational tapestry.

US military assets, across all domains are increasingly networked, and will only become more so. As yet there is no cohesive, wide-ranging, battle management system of systems linking all assets, from aircraft and satellites to other sensors. However, Air Force leaders are pressing for such a unified intelligence, strike, maneuver, and sustainment complex, in effect a "combat cloud." This concept calls for linking the aerospace systems of the US military and allies with C2 centers of gravity, via cyber capabilities, sea-based assets, and land-based platforms to draw in and exchange information, to move it from the tactical level to the operational and strategic level and back in the midst of battle. Any JSTARS replacement will play a vital role in this future concept of operations. This cloud approach will enhance the effectiveness of joint force operations, while compensating for the vulnerabilities of individual elements, aircraft, and systems by creating a self-healing network providing crucial data in real time, between commanders and their units, regardless of operating domain.

JSTARS, Desert Storm to Inherent Resolve

The E-8C JSTARS is a manned aircraft with a dual mission: harnessing its powerful onboard sensors to gather ISR and disseminate it to commanders up to, and including, the theater of operations level. The largest and most important element of the enterprise is the E-8Cs GMTI targeting system that supplies ground surveillance to guide attack operations and targeting of enemy forces.

JSTARS has an equally important C2 mission, providing ABM capabilities as well as ISR information. This task is often indispensable to effectively commanding and controlling both air and ground forces, as the collection of sensors, analysts, and aircrew help enable the most efficient use of combined military forces in any operation—from large force engagements such as the Gulf War, to humanitarian assistance, to US-led counterinsurgency operations in Iraq and Afghanistan.

The current 16-airplane JSTARS force consists of modified Boeing 707-300 series commercial airframes—obtained from airlines across the globe—extensively remanufactured and modified with radar, communications, operations, and control subsystems in the 1990s. The modified 707 carries a 24-foot side-looking phased array radar antenna housed beneath the forward fuselage in a 27-foot canoe-shaped radome.[4] The antenna can be tilted to either side of the aircraft where it can acquire a 120-degree field of view covering nearly 19,305 square miles (50,000 square kilometers). The radar is capable of detecting targets more than 250 kilometers (more than 820,000 feet) away. To a limited extent, the GMTI radar can also detect helicopters, rotating antennas and low, slow-moving fixed wing aircraft. The radar and computer subsystems on the E-8C can gather and display detailed battlefield information on ground forces, and relay it in near-real time to common ground stations and to other command, control, communications, computers and intelligence (C4I) nodes across the US military.

The genesis of the JSTARS program arose from an urgent demand in the later years of the Cold War to ensure the US could effectively command, control, and track forces in the event of a non-nuclear confrontation with the Soviet Union.

These tasks, however, constitute a heavy workload. To perform its vital C2, ABM, and ISR tasks each aircraft has 18 operator workstations and an extensive communications suite in its main cabin, making the aircraft resemble a cross between a telephone call center, an air traffic control tower, and a packed redeye business flight. The processing capacity onboard an E-8 far surpasses anything found onboard a fighter or bomber aircraft today, which affords the E-8 tremendous mission capability. JSTARS operates with an aircrew of three, plus 18 Air Force and Army specialists and technicians monitoring the radar and other sensors. An augmented crew of up to 34 can be carried for long endurance missions extended by aerial refueling. In every seat, personnel monitor screens and closely communicate with commanders at many levels, sometimes just onboard and other times with decision makers who are thousands of miles away. Typical missions can run from eight to 15 hours, or more with augmented crews.[5]

This concept of operations, a powerful aircraft with a large crew and expansive mission systems, has performed admirably in fulfilling ABM and C2 needs since the E-8 first deployed. However, it was a concept that responded, at first, to a very specific need. The genesis of the JSTARS program arose from an urgent demand in the later years of the Cold War to ensure the US could effectively command, control, and track forces in the event of a non-nuclear confrontation with the Soviet Union. The JSTARS program came together from separate Army and Air Force efforts to locate and attack enemy armor at ranges beyond the forward area of troops, at a time when the Army's "AirLand Battle" doctrine drove investment priorities across the US military. Congress ordered the USAF and Army efforts integrated, and demanded a single system with a joint program office, with the goal of fielding a capability capable of identifying, targeting, and attacking Soviet tanks moving through areas like Germany's Fulda Gap. Like many Cold War systems fielded during the conflict's later years, it would never perform the mission it was envisioned for—but prove itself indispensable to fighting a modern war, in the years following the fall of the Berlin Wall.

JSTARS' trial by fire did not come over the Fulda Gap, but rather in the Middle East during

Operation Desert Storm. By the end of the first Gulf War, that experience helped certify the aircraft as a critical capability needed for most future US operations. The first two developmental aircraft in the JSTARS program, the Boeing 707s bought from American Airlines and Qantas (the Australian carrier), were rushed to deploy to the Persian Gulf in 1991 before their initial operating capability (IOC) certification. Neither of the aircraft had a trained crew, nor were they configured with all the equipment installed and tested to perform the JSTARS mission. Some US officials didn't think it was ready, and feared it would not fare well over Kuwait and Iraq—and would be cancelled afterward. However, Army Gen Norman Schwarzkopf, the coalition forces commander, insisted that if the JSTARS could save lives it was worth putting into action.[6]

It was the Gulf War deployment that proved some of the key capabilities of the JSTARS would become inseparable from the American way of war after the shooting stopped. These included capabilities such as data links, and beyond line of sight communications linking the JSTARS with space-based capabilities.

Schwarzkopf's support of JSTARS was a reflection of the pressing need at the time to fill critical ISR capability gaps before the fighting started. US Central Command (CENTCOM) was desperate for more and better targeting information on Iraqi formations.[7] In the weeks before the start of the Desert Storm air war, Air Force Tactical Air Command (TAC) got a request from CENTCOM leaders in Saudi Arabia to brief on the JSTARS capabilities. Army Gen Freddie Franks, commander of the Army's 7th Corps had seen preliminary test flights in Europe and recommended tapping the E-8 for the upcoming fight. Up to that time, the Army lacked a long range, near-all weather, night and day ISR and targeting capability. The E-8 JSTARS was designed to fill that gap.[8]

It was the Gulf War deployment that proved some of the key capabilities of the JSTARS would become inseparable from the American way of war after the shooting stopped. These included capabilities such as data links, and beyond line of sight communications linking the JSTARS with space-based capabilities. At the Grumman Corporation's Melbourne, Florida facility, where the E-8 developmental aircraft were based, a team of USAF, Army, and civilians were brought together to man the sensors and radar aboard the aircraft, while engineers hurried to get its communications systems and sensors ready. The developmental aircraft, at the time, were equipped with line of sight systems, which then-Col George Muellner (USAF's lead on the project) believed would not be sufficient in the vast open distance of the Arabian Desert. In short order, crew and engineers installed satellite communications terminals on both aircraft, as well as the Tactical Data Link (the precursor to Link 16) so the JSTARS could share information with the two other "big wing" ISR aircraft deploying to the Gulf—the RC-135 Rivet Joint and the E-3 AWACS.[9]

Both E-8s were rushed to Saudi Arabia, as training wrapped up, and the pair touched down on January 12, 1991. Two days later, the first fully manned E-8 flew its first mission, a training flight that turned into an eight hour ISR gathering mission. Two days later, Operation Desert Storm began, and the E-8s went to work identifying the location of Iraqi troop concentrations, and where they were moving as the air campaign progressed. From January 29 to February 1, when the Iraqis attempted a push into Saudi Arabia, the Battle of Khafji proved the JSTARS worth, as it provided critical warnings about the impending Iraqi attack. The two new E-8s conducted sorties that picked up the movement of Iraqi armor near the Saudi border, and proved vital in coalition forces beating back the assault.

After the fighting ended, Army and Air Force officials were quick to praise the program. JSTARS "was the single-most valuable intelligence and targeting collection system in Desert Storm," Brig Gen John Stewart, the G2 (intelligence chief) for US Army Central Command said at the time. "We will not ever again want to fight without a JSTARS kind of system," Air Force Chief of Staff Gen Merrill McPeak stated flatly, in a very prescient prediction.

Since then, JSTARS has flown nearly nonstop in support of various combat, humanitarian, and support missions around the world. Just a few years after Desert Storm, JSTARS went on to support peacekeeping operations in Bosnia, where

its ability to keep tabs on the movement of both vehicles and personnel proved just as valuable as it was in the Gulf War. In the years since, the E-8 has flown in support of all six US regional combatant commands, and participated in nearly every major combat operation involving US forces. Most recently, it has applied its powerful ISR and ABM tools in Operation Inherent Resolve, the coalition air campaign targeting Islamic State forces in Iraq and Syria.[10] The E-8 force, operated by the 116th Air Control Wing at Robins AFB, Ga., has racked up a large flying hour account as a result of these taskings. As of January 2016, the average age of a JSTARS airframe is 46 years.[11] In 2014, E-8Cs supporting CENTCOM out of Al Udeid AB, Qatar surpassed 100,000 flying hours in total for the fleet, 88,000 of those in CENTCOM alone since 2001.[12] In June 2015, the fleet hit 100,000 flight hours in direct support to CENTCOM taskings alone, and the number continues to climb higher.

Demand from all combatant commands for more ISR has driven the Air Force to move money from other areas to meet those needs, as today ISR "has become the coin of the realm," Gen Mark Welsh, the Air Force chief of staff, noted in February 2015.[13] To supplement the need for GMTI information, and to help the stressed JSTARS fleet, the Air Force has pushed to keep and grow its GMTI radar-equipped RQ-4 Global Hawk Block 40 fleet in its Fiscal 2016 budget request—reversing its position from previous years where it proposed divesting the Block 40 fleet to pay for readiness needs. The USAF's Block 40 RQ-4 carries the multi-platform radar technology insertion program, or MP-RTIP—an upgraded synthetic aperture radar (SAR)/GMTI sensor. The MP-RTIP is a similar sensor to the one carried aboard the E-8 JSTARS, but not as large. The Global Hawk Block 40, in contrast to the wide-body and crewed E-8, is a remotely piloted aircraft (RPA) that operates at high altitude and possesses unparalleled persistence and range (RQ-4s routinely fly ISR sorties which can run 30 hours or more). Because of the Block 40's SAR/GMTI capability, and the Global Hawk's connectivity to the distributed common ground system (DCGS) network, it has proved an in-demand asset to meet global ISR needs.

Due to budget pressures however, reductions in the Global Hawk force and other ISR assets are not a foregone conclusion in the coming years. Any further cuts or delays in modernization to USAF ISR forces will have damaging effects on the service's ability to build a global, comprehensive ISR picture for the future force. This applies to manned and RPA assets alike. Systems that can penetrate far enough forward to be of utility, conformal apertures, advanced survivability systems, low signature, high-bandwidth directional communications, and open systems architectures must all be viewed as top priorities for USAF going forward.

Despite advancements in integrating high tech sensors on RPAs to meet ISR demands, combatant commanders around the world continue to specifically request the powerful capabilities of USAF's "big wing" large ISR aircraft. Together, the so-called "Iron Triad" of the RC-135, the E-3 AWACS, and the E-8 JSTARS make up less than 80 airframes in the current USAF inventory, but their specialized sensors and tools are critical to building comprehensive intelligence pictures in a range of scenarios, from pre-conflict to major theater war. The power of their systems, their endurance, and onboard analytic capability is unmatched by any other current assets. The RC-135 fleet, for example, has specialized signals intelligence (SIGINT) and electronic intelligence (ELINT) tools, which combatant commanders could not otherwise obtain from satellites or other ISR aircraft (RC-135U Combat Sent aircraft have specialized sensors to gather information on adversary radars and IADS). In addition to the RC-135, E-3s and E-8s tap their own powerful sensors—their radars—to detect targets in the air (in the case of AWACS) and on the ground (JSTARS' GMTI radar).

Now is the time to take this "triad" into the 21st century, and to enable these assets collective capability and collaboration with the wider ISR enterprise, both for manned aircraft and RPAs. For example, the RC-135 community today is adapting how it performs its missions, embracing more distributed, networked concepts of operation that link up its powerful sensors and systems with ground based analytical capabilities, via wideband satellite communications. Taken together, the

information from all three aircraft can be pieced together via networks and data links to compose a situational awareness picture that would not be achievable without all three working together. A part of the Air Force's ISR modernization plan is to not only improve the resident capabilities in the RC-135, E-3, and E-8, but to link these aircraft and their powerful sensors to the rest of the force (especially modern fifth generation aircraft with powerful ISR capabilities such as the F-22 and F-35). This will be accomplished in part by developing new distributed ISR links and analysis tools, but also improving training and integration.[14]

JSTARS will be the first of the Iron Triad aircraft to undergo recapitalization. The Air Force planned to recapitalize the aging E-8 force since designating JSTARS replacement an acquisition priority in 2013. The urgency was increased after the JSTARS initial planned successor, the E-10, succumbed to requirements growth and cancellation in the Fiscal 2007 budget, as the defense budget prioritized funding counterinsurgency wars in Afghanistan and Iraq.

The Air Force planned to recapitalize the aging E-8 force since designating JSTARS replacement an acquisition priority in 2013. The urgency was increased after the JSTARS initial planned successor, the E-10, succumbed to requirements growth and cancellation in the Fiscal 2007 budget…

However, there are signs the service is not yet taking a holistic view of the future JSTARS replacement, and how it can be leveraged as part of an integrated ISR enterprise capitalizing on every sensor available in a given contingency. As a cost savings measure, the Air Force has repeatedly stated it is seeking a smaller business-class aircraft with fewer aircrew, but it is unclear if the long term perspective on this capability's role in a broader enterprise-driven solution has been taken into account in the defined requirements analysis. Officials announced in February 2016 they would delay the contract award for as many as six months while possibly extending the timeline for declaring the next generation JSTARS force operational to the mid-2020s. Boeing and teams from Northrop Grumman and Lockheed Martin are vying for the replacement JSTARS contract. Raytheon and Northrop Grumman have also received separate contracts in March 2016 to mature their competing radar designs for the new JSTARS.[15] Regardless of the aircraft or sensor developed for the E-8 JSTARS' successor, USAF and the DOD must take care to look beyond the program of record and ensure the GMTI/ABM missions, and their roles in the ISR enterprise, are not overlooked. Whichever aircraft as a host for the GMTI sensor is selected, it must be capable of working in an enterprise fashion, and allow for growth and inclusion of new technology. A repeat of the E-8 platform-driven approach, with a new aircraft, will merely lock in a now 25-year old concept of operations, and may not prove cost-effective in the long term.

External Threats, and Technology Challenges

The threat environment the next generation JSTARS will enter is far different than the one envisioned for its predecessor in the twilight years of the Cold War. In addition to conventional warfare concerns with a near peer military such as Russia or China and persistent irregular warfare and counter terrorism operations, recent conflicts in Ukraine and Syria have highlighted the military challenge of "hybrid warfare." Hybrid warfare involves a mix of non-state actors combined with regular military and high-end military capabilities such as precision weapons, modern C2 and communications networks, and distributed operations.

Because of the diffuse nature of these threats, senior USAF officials have stated repeatedly the demand for theater airpower is pronounced. From confronting a resurgent Russia in Europe, to conducting ISR operations in the South China Sea, airpower, and more importantly the powerful C2 networks it enables, is increasingly the lynchpin for confronting any military challenge.[16] Increasingly, officials from all services envision military operations that will bear little resemblance to the counterinsurgency efforts that the US military has conducted in both Afghanistan and Iraq over the last 15 years. Rather, conflicts will emerge in places such as dense urban areas, and in complex, contested, and connected threat environments—where cyber capabilities can be used by the enemy just as well as the US can bring them to bear.[17]

USAF planners are keenly aware that future conflicts will likely occur in airspace that

is more contested than ever, protected by capable and modernized IADS, modern fourth and fifth generation aircraft, and longer-reaching surface to air missiles (SAMs). Taken together, these technology trends threaten not only the ability of combat air forces to penetrate and strike, but also ISR forces that enable modern aerospace power.

Any future GMTI/ ABM JSTARS-follow-on platform will have to serve as an information node for operations ranging from campaigns in permissible environments to heavily defended airspace.

Though A2/AD threats represent a narrow, yet extremely challenging, slice of the threat spectrum, more challenging environments only reveal an increasing need to diversify and build a flexible enterprise-driven approach to ISR gathering.

Any future GMTI/ ABM JSTARS-follow-on platform will have to serve as an information node for operations ranging from campaigns in permissible environments to heavily defended airspace. A current E-8 JSTARS, for example would have to operate far away from a modern A2/AD threat envelope, reducing its effective ISR reach. Since its fielding however, the E-8, like other legacy aircraft, have always had to operate at safe distance from IADS and potential threats. Modern technology has compounded this trend. Getting GMTI capability pushed forward, and getting that information to and from the front edges of the conflict, must be taken into account.[18]

One way around this problem, according to several experienced USAF ISR officials, is to link the E-8 JSTARS replacement with other aircraft that can penetrate a range of threats, from high end A2/AD to moderately contested and lightly contested airspace, such as the F-22, F-35, B-2, or B-21. While communications architectures and line of sight capabilities presently limit the broad employment of this model, technology developments strongly suggest it is only a matter of time before such collaborative engagement becomes routine. The enterprise-driven approach has great utility in solving some of the more difficult problems facing the US military, and enables a flexible, tailored response to a given scenario because of the ability to push and pull information from a wide variety of nodes, aircraft, and platforms. This approach requires not only tapping into more and more sensors, but also moving the information and data around to where it is needed at a given point in the conflict, facilitated by appropriate degrees of automation. This approach would net together disparate assets to build an ISR information exchange running in real time, a prototype of what could become a "combat cloud."[19]

The use of automation and "man-machine teaming" will also help make future air campaigns more effective in a combat cloud-enabled operation, as valuable C2, BM, and ISR information could be tagged, stored, and retrieved when required. Rather than having a human stare at a screen for hours at a time, a pilot or operator could request specific ISR information on a geographic space for a given time frame, and use it to inform better understanding of the current fight. Any future GMTI capability would be vital in providing some of this valuable data, to enable successful future operations.[20]

Technology, and the Future of US Aerospace Power

Despite moving towards a more network-enabled and connected military, many USAF and US assets—from fighter aircraft to spacecraft to surface naval vessels to land vehicles—cannot communicate directly with each other today due to "stove piped" communications links, lack of open architecture design, and legacy concepts from the industrial age of warfare.

There is evidence that the concept of building a "combat cloud" to enable missions from gathering GMTI to conducting full-scale offensive air campaigns is gaining acceptance and support across the military services. In all future systems, open architecture is essential to maintaining the ability to "adapt, grow, and match" legacy systems to future technology, as well as achieving greater degrees of cost-effectiveness. Navy Rear Adm. Michael Manazir, the service's then-director of air warfare, explained at a Mitchell Institute event in March 2016 that integration and interoperability "is key to the whole kill chain mindset. The kill chain should be a 'kill web,'" he added, and noted the importance of taking a system of systems approach to information sharing through a combat network. Manazir envisions a day when a carrier-

based F-35 is not only communicating with, but also controlling as many as three RPAs. That could expand the F-35s area of air superiority from 25 miles to 100 miles.[21] The MQ-4C Triton maritime surveillance RPA and the Navy's manned P-8 Poseidon patrol aircraft could also be linked into the combat network, he added. Manazir said he was looking to turn a single platform, like an F-35, into an information node in a wider network.

The new GMTI/ABM aircraft will possess more powerful capabilities, greater than the legacy JSTARS, and will be a critical player in any future effort to build networked ISR capability. In the meantime, the demand for ISR, ABM, and C2 capability from the COCOMs is not slowing down. Even with the added capability of Block 40 RQ-4s to aid the JSTARS in its mission, the challenge has been to provide a ready, capable platform to meet the GMTI demands of the combatant commanders. At the same time, ACC is trying to manage the depot challenges associated with a "high demand, low density" fleet, and other issues associated with aging aircraft, such as vanishing vendors, and diminishing manufacturing sources.

The new GMTI/ABM aircraft will possess more powerful capabilities, greater than the legacy JSTARS, and will be a critical player in any future effort to build networked ISR capability.

Because of its importance to the Air Force, the competition for the new aircraft program that will assure critical GMTI/ABM capability with information age modularity and connectivity is ramping up this year. After conducting an analysis of alternatives, the USAF declared the service would pursue a "business-class" airplane for its GMTI/ABM needs, smaller than the Boeing 707 that served as the JSTARS' airframe from its beginnings. As of summer 2016, several major defense firms have outlined offerings for the pending competition, but USAF has recently indicated the contract award for the JSTARS recapitalization effort's engineering, manufacturing and development (EMD) contract has slipped to the first quarter of Fiscal 2018 (placing initial operational capability of a new force around Fiscal 2024). Congress, meanwhile, has urged USAF to accelerate the program citing the need for ABM, C2, and GMTI capability from combatant commanders.[22]

Despite the operational need, prudence is needed with regard to the future of the GMTI/ABM mission. When discussing the future JSTARS program, it doesn't take long to see that the airframe may be the least of the challenges the service faces in attaining new GMTI/ABM mission capability. The more important theme is the collective capability of sensors, how they feed into an information network, and how the enterprise uses multiple nodes to provide robust and rapid ISR/ABM capabilities in combat. When discussing the evolving mission requirements of GMTI/ABM mission sets with industry representatives and former JSTARS operators, there is a tacit understanding that miniaturization has made the mission systems that reside on the JSTARS aircraft smaller and more capable. In the future, the ability to integrate new and more capable sensors and processors will be even more important to take into consideration in any future GMTI/ABM aircraft. There will be engineering considerations to take into account, as any airframe will have to generate enough electrical power to run its GMTI radar and the other mission systems.[23] This is important to consider, since future cutting edge technologies that will be based on the E-8 follow-on have yet to be created.

An honest assessment of the future of ground targeting radar and its role in modern C2 is very challenging if only focused on a single airplane, rather than examining how GMTI will be empowered by an enterprise of distributed systems feeding information among its nodes—including the replacement for the E-8C. The JSTARS successor aircraft will pair with other aircraft, which have their own capable radars, turning disparate streams of data into actionable C2, ABM and ISR knowledge, the essence of a future combat cloud.

Some officials working in the aerospace industry and former USAF officials who worked in the ISR mission speculate the best JSTARS replacement may not be an aircraft at all, due to a radically different threat environment from the one in which the E-8 made its combat debut in back in 1991. This perspective argues the Air Force should scrap its JSTARS recapitalization as currently written altogether, and consider alternative technologies. The supposition is that

the JSTARS' traditional concept of operations is nearly operationally obsolete. Supporters of this approach say today there are enough technology developments—such as distributed sensing and on-board data processing tools—that will allow existing platforms, with some improvements and modification, to perform the JSTARS traditional mission. Regardless, a network of GMTI capability requires some manner of central control—and a missionized modern aircraft, acting in the role of a GMTI/ABM "quarterback" is the rejoinder to the theory that a GMTI enterprise can be assembled with existing aircraft and technologies.

Another alternative solution, forwarded by others who work in the GMTI/ABM mission, is that the existing E-8C fleet could be retained, if its mission systems were upgraded with 21st century technology. New systems, electronics, and other components could afford connectivity throughout the enterprise mission construct. This solution notes while the current JSTARS aircraft is old, it was heavily inspected and repaired over time when they were converted from airlines to their current military configuration. While this approach is potentially possible, it is still important to note this option would require significant investment in new mission equipment, as systems designed from the late 1980s and into the 1990s lack necessary attributes required for modern 21st century warfare. Whether it is worth installing this new equipment in an existing, aging aircraft is up for debate.

When thinking about the future of this unique capability set, it is important not to lose sight of the core JSTARS capability the aircraft brings to bear—its GMTI radar.

When thinking about the future of this unique capability set, it is important not to lose sight of the core JSTARS capability the aircraft brings to bear—its GMTI radar. This sensor fixes moving targets and identifies them against the clutter of stationary objects on the ground in a given radar image. It was this key capability that proved invaluable in Operation Desert Storm, as it was JSTARS radar that identified the first Iraqi armor column crossing into Saudi Arabia at Khafji in January 1991.

The E-8 was able to direct air assets against the moving Iraqi armor, effectively destroying a large force, retired USAF Lt Gen George Muellner noted in recalling the deployment. In the desert, at that time, detection was the easy part, even at night, he noted, as it was flat and isolated with few roads.[24] Even though the E-8 was developed with the plains of Europe in mind, it excelled in the Gulf War because the Industrial Age Cold War construct largely held firm: large combined arms military formations along linear lines of control, with air assets like the E-8 able to discern the movement of the enemy with relative ease.

For 21st century battles, however, military planners are rethinking how they gather ISR and conduct C2 in scenarios beyond tank battles on the plains of Europe or in the Saudi Arabian desert. Today, a range of potential conflict scenarios run from major theater war to distributed low-intensity conflict in major cities and urban areas, where enemy targets often are in close proximity to non-combatants. These scenarios necessitate an information enterprise approach that provides powerful nodes that collect, integrate, and ubiquitously share and disseminate decision-quality GMTI information and other ISR products from a multitude of assets. A powerful phased array radar, like a GMTI sensor on a future aircraft, can be used in a variety of mission sets if modifications or applications are developed to turn the radar into a jammer one moment, a high-powered radio transmitter in another, or become a receiver for information from other nodes or aircraft. Though GMTI is critical to modern warfare in many scenarios, USAF must expand its methodology towards surface domain awareness if it truly wants it to be effective in the conflicts of the future. This highlights the importance of collaboration and enterprise building in the GMTI mission, and how it will make the difference if allowed to mature and grow in capability.[25]

Due in some part to the success of the JSTARS, another challenge facing USAF and the DOD is the tendency for different communities across the US military to see JSTARS as either an ISR or a C2/ABM platform.

"It's both," insists Air Combat Command boss Gen Herbert "Hawk" Carlisle, who notes "C2 and ISR are inextricably linked" in modern war. To maintain C2 leaders need knowledge gleaned from the information ISR platforms obtain," he added. There has been a push by some elements

within the Office of the Secretary of Defense, who see JSTARS as strictly an ISR platform, to replace the manned aircraft with an unmanned one because of this perception bias. But Carlisle and other USAF leaders have largely succeeded thus far in convincing them that JSTARS' C2/ABM mission is essential, and requires on-board personnel to analyze incoming information and rapidly make decisions in combat.

USAF leaders are trying to keep a balance between putting too much capability in "reach back," versus balancing it across platforms and aircraft. "The idea that you're going to design the next platform—the JSTARS recap—based on one little vignette, one scenario, one portion of the capability...that 'you don't need airborne BMC2, you can do that reach back...' well, no, you really can't," Carlisle said. "You need nodes all the way along. And there's certainly reachback capability, but there are forward requirements, too, when you're in the battlespace. That's the discussion we've been having over, over and over. And hopefully we've gotten to the point where we're winning the discussion with some of the folks that see it a little differently."[26]

Though technology has improved and enabled concepts of operation unthinkable three decades ago, the ability to have a trained crew of ISR and C2 professionals aboard the JSTARS successor is another factor which several USAF officials and ISR aircrew have identified as significant.

Though technology has improved and enabled concepts of operation unthinkable three decades ago, the ability to have a trained crew of ISR and C2 professionals aboard the JSTARS successor is another factor which several USAF officials and ISR aircrew have identified as significant. Today, JSTARS, in conjunction with the E-3 AWACS, are two of the more predominant platforms dedicated to C2 and ISR operations in USAF. But only onboard the E-8 does the USAF have a unique collection of personnel who are intelligence and air battle management professionals, in one place, who can quickly and adeptly gather up information regarding actions on the ground and make assessments relative to commander's intent, and then take action in a broad space.[27]

The "human in the loop" in the ISR/C2 mission is often a critical element, Muellner noted. The leverage this dynamic provides was highlighted in Desert Storm, when one of the early JSTARS missions cleared an attack in response to a perceived movement of Iraqi forces in a certain sector. The GMTI radar picked up forces on the move in an area where no friendly forces were operating. Prior to the strike order going through, a New Zealand Army intelligence officer onboard a JSTARS serving as a liaison took a closer look. This officer was familiar with Iraqi equipment, Muellner recalled, and said the target didn't look like an Iraqi formation. The strike was called off, and the column turned out to be a British special operations team that had lost its communications links.

The information potential of an information age GMTI/ABM aircraft is a big reason why the program is the fourth ranked USAF acquisition priority after the need to recapitalize the tanker fleet, modernize the service's fighter aircraft, as well as the long range bomber force structure. A future GMTI/ABM capability, using its sensors networked with other assets, will become indispensable to projecting power around the globe. ISR and C2 are linked in modern military operations, Carlisle stresses, noting that even if a US aircraft detects a target with its sensor suite "if you don't have the ability to do something about it, then you're missing half the equation"—and the so called "find, fix, track, target, engage, and assess" cycle (F2T2EA) cannot be completed.

Next Generation GMTI/ABM Aircraft for Next Generation Solutions

An honest assessment of the lessons learned from recent conflicts involving US forces, from Libya, to Syria, and even in crises where the US is not a belligerent, such as the conflict in Ukraine, acknowledges that success in every war turns on who best controls, understands, and disseminates information in battle. The US and its allies will need to bring together all threads of information—through changing concepts of operation, architectures and adopting distributed systems—to give commanders a real time and actionable ISR and C2 picture.

Gaining and preserving this advantage will depend on maintaining dominance in the

electromagnetic spectrum. Electronic warfare (EW) offers a set of capabilities that can cripple an opponent's ability to sense, communicate, and exercise C2 in a given contingency—which is why some of the US' near peer potential adversaries are pursuing advances in this area. Russia, in particular, possesses increasing EW capabilities that could blind or disrupt digital communications, and help level the playing field when fighting against a superior conventional military.[28] Meanwhile, Chinese military doctrine has concluded that information superiority is the prerequisite to win any future conflict. Drawing lessons from Operation Desert Storm, and their technology gap with U.S. capabilities, they became determined to surpass the United States and win the battle for information in the years after the 1991 war.[29] Recently, acting on the conclusions of a Defense Science Board EW study, Deputy Defense Secretary Bob Work has established an electronic warfare committee inside the DOD to address shortfalls in EW.

Today the DCGS that processes and analyzes video and ISR information from aircraft around the globe is already "drowning in data." The goal now is to find a way to seamlessly transfer the currently unavailable data from sources such as fifth generation aircraft into the DCGS, and have an algorithm analyze it, so it can push the right information out to the right users at the right time.

The next generation JSTARS capability will have to enter an environment where these trends and concerns are of high importance. One long term solution to the EW and information superiority challenge is to better enable individual aircraft and platforms to harvest a wide range of capabilities, from GMTI, to signals intelligence, and other sensor products, and share this critical information in real time.

However, fusing this information is just as much a challenge as collecting it, according to Carlisle, and it forms the essence of what he calls "fusion warfare." Fusion warfare is tapping into all sensor suites from various platforms that can bring together a single common picture for better understanding of a given problem. "The first challenge is that connectivity piece, the combat cloud as it is referred to, where all of the platforms, all of the sensors have the ability to connect, to fuse data and then put all that together for the common picture," he said. A commander can use that picture—not only elements of the force package who are in the forward operating areas—but also the C2 element, be it in the rear at a combined air and space operations center (CAOC), or at other locations or nodes linked to the joint force commander.[30]

Like many senior commanders who see information as the key to future battles, Carlisle would like to tap in to the data from some of the Air Force's most capable assets—the information being collected by the F-22 Raptor, the F-35A Lightning II, the Block 40 RQ-4 Global Hawk, and eventually the B-21 Long-Range Strike Bomber—and use it to feed into this common operating picture. Their stealth capability, making them uniquely able to penetrate sophisticated IADS, paired with their modern sensor and mission systems makes them valuable information assets as well as combat assets. However, today, all the information being collected by the F-22 and F-35's systems, from position, to mission system status, to radar sensor data, remains on the aircraft, Carlisle noted. In the case of the F-22, this information can be passed along to other Raptors, but not to other assets—unless the pilot transmits this information through standard radio communications.

Carlisle and others concede there is another problem to solve once these powerful fifth generation assets can be tapped into a combat cloud, that being managing the data. Today the DCGS that processes and analyzes video and ISR information from aircraft around the globe is already "drowning in data." The goal now is to find a way to seamlessly transfer the currently unavailable data from sources such as fifth generation aircraft into the DCGS, and have an algorithm analyze it, so it can push the right information out to the right users at the right time. This way, ISR airmen do not have to do all this fusion manually, and would be aided by man-machine teaming. "I think we are making progress with this," he added, even though there are challenges with what open mission systems are, what they can do, and what opportunities are available with open architectures.

Outside of the Air Force, others are embarking on this approach already. The Navy,

according to Manazir, is already looking at pushing forward a "system of systems" approach to information sharing through a combat network that will link F-35s up to RPA wingmen that expand a fighter's radar and sensor horizon. Fifth generation war, Manazir declared at a Mitchell Institute talk in March, is "informationalized warfare." The F-35 is a single sensor-shooter platform, but can also be tapped as a node of information feeding into a wider system. Though the F-35 was not designed for operations like this, now the Navy is trying to figure out how to get this information off board "while it's still inside that A2/AD environment." At the same time, the Navy is also working on manned aircraft-RPA teaming between its MQ-4 Triton (the Naval variant of the Global Hawk) and its P-8 Poseidon surveillance aircraft, a concept of operations that could easily be replicated by a JSTARS successor with future RPAs.

A next generation GMTI/ABM aircraft will enter service as the USAF is attempting to move closer towards an updated approach to C2, which emphasizes centralized command, distributed control, and decentralized execution—a philosophy which undergirds a system of systems approach.

Air Force Materiel Command has worked on some advanced technology concepts similar to the Navy's approach. One envisioned an attack force of around 20 or so RPA directed and controlled by the links and sensor capability of an F-35, according to Gen Ellen Pawlikowski, commander of AFMC. AFMC teamed with ACC and other national laboratories to explore ways to move data quickly off aircraft like the F-35 to other assets such as RPAs or ISR/C2 nodes, without a human pushing the data along or having to supervise it.[31] Even the Army is examining how it can pair its AH-64 attack helicopters with RPAs, using these aircraft like forward observers in the air to seek out targets far on the outside of the threat envelope in which the helicopter operates. This approach has gained more traction as the service has retired its fleet of scout helicopters in favor of increased use of RPAs to perform similar tasks.

New GMTI Concepts of Operation

A next generation GMTI/ABM aircraft will enter service as the USAF is attempting to move closer towards an updated approach to C2, which emphasizes centralized command, distributed control, and decentralized execution—a philosophy which undergirds a system of systems approach. But in order to fully embrace this concept of operations, the service must advance its thinking about how to integrate GMTI with the other assets that will feed the future combat cloud.

The operational experiences the Air Force has accumulated since the Gulf War of 1991 can help shape the direction of how the service gathers and provides GMTI information in the future, as well as how it executes C2, and how these core capabilities fit into a combat cloud. This will require close consideration of evolving doctrine, organization, training, materiel, leadership, personnel, facilities, and policy issues (DOTMLPF) as this enterprise grows and gains collective capability.

Future operations, which will face advanced threat environments with A2/AD defenses, will succeed or fail depending on how successfully the USAF adapts its technology advantage inherent in its powerful C2 networks to work with advanced assets such as fifth generation aircraft, and information nodes such as the next generation GMTI/ABM aircraft.

"The way I look at networks, they bring a huge advantage," said one airman currently assigned to the JSTARS mission. The capabilities the US brings to bear in combat are not a secret any more, for the most part, and that these are held together and empowered by rapid communications that can link up with forces around the world. Since its first deployment in the Gulf War, the JSTARS has played a key role in empowering these C2 networks because of the vast geographical area its GMTI radar can cover.[32]

USAF and joint force commanders have used JSTARS extensively because the aircraft's powerful radar and onboard systems have allowed customization depending on the needs of a given conflict or scenario. "I can dedicate as much or as little radar energy to whatever the objective is," the JSTARS operator, an experienced air battle manager, noted.[33] Depending on the C2 capability and need, the JSTARS could service C2 and ISR requests at the same time, which provided a great deal of utility in numerous conflicts, especially during the counterinsurgency campaigns in Iraq and Afghanistan.

However, despite the JSTARS flexible capability, one aspect of its operations is under close consideration as the recapitalization effort advances—not only gathering ISR to aid in C2 and ABM operations, but also being able to positively identify target data at the same time.

A persistent gap in the JSTARS capability over the last 25 years, according to the JSTARS operator, is the JSTARS does not have the ability, like the E-3 AWACS, to positively identify the data it is collecting (the AWACS has what is known as a passive detection system onboard).[34] On an E-3, for example, an air battle manager can not only see a dot on the radar but has a means to determine if the dot was good, bad, or a noncombatant.

Identification of ground moving targets is not just an ISR problem, but also a C2 problem, and one that is on the mind of the Air Staff as they assess what direction the JSTARS recapitalization will go… USAF officials are also looking to leverage assets like the F-22 and F-35 in areas not traditionally associated with fighter aircraft, and act as sensor-shooters—more in the lane of traditional ISR and C2 tasks.

Identification of ground moving targets is not just an ISR problem, but also a C2 problem, and one that is on the mind of the Air Staff as they assess what direction the JSTARS recapitalization will go. Will the ability to positively identify (ID) data be a capability that will be performed organically, aboard the future GMTI/ABM aircraft, or will it be provided by another asset, integrated via networks? Without considering the ID piece of the mission, all a future GMTI/ABM aircraft will provide is a "bunch of great looking moving dots," according to one Air Staff official who works ISR integration issues.[35] On a battlefield, like at Khafji in the desert, that sort of capability is not difficult as nearly all targets are easily distinguished as enemy or suspect enemy vehicles. But in a community, such as an urban setting, where civilians are in close proximity to potential enemy forces, the problem set becomes more acute. "How do we take that information and integrate it with other (intelligence)," the Air Staff official added, noting there are not easy answers as of yet.

To try and solve the problem, ACC is now working closely with the National Geospatial-Intelligence Agency (NGA) on a new initiative known as "structured observation management," which attempts to gather information contained in images, in a more organized manner, for numerous uses.[36] This initiative will examine how ACC performs activity-based intelligence, rather than relying on processes divided up by ISR categories, such as signals intelligence information (SIGINT), electronic intelligence (ELINT), measurement intelligence (MASINT), and other categories. Instead, analysts will be able to examine a geographic area and ask questions about what ISR is available about a given domain. To do this, however, requires having the right "meta data" tagged on ISR information, which is one of the goals of the new collaboration between NGA and ACC. Information must have some kind of geographic context, via tagging or some other process, rather than just existing in a sea of data as a high value piece of information. By improving the tagging of information, ACC will move closer to empowering distributed operations and a "combat cloud" approach in the future.[37]

As these new concepts of operation and ISR sharing are being honed, USAF officials are also looking to leverage assets like the F-22 and F-35 in areas not traditionally associated with fighter aircraft, and act as sensor-shooters—more in the lane of traditional ISR and C2 tasks. This will lead to rethinking how combat air forces perform ABM. As the understanding of the combat cloud advances, more leaders are taking a closer look at the data fifth generation aircraft can gather and deliver to improve C2, ISR, and ABM operations.

One Air Combat Command official, with experience operating fifth generation systems, said the idea to tap into F-22 and F-35 for ABM was a "novel idea" in exercising, but as the Air Force discovered how much capability these aircraft had with their sensors—especially after the F-22's deployment to support Operation Inherent Resolve (OIR)—there is now more urgency to explore their potential in this area.[38]

USAF officials, looking at future threat environments, which feature advanced SAMs and more capable fighter aircraft, don't want to put heavy sensor platforms such as the E-8 JSTARS too close to the reach of these threats. However, based on lessons learned from recent operations,

ACC and USAF officials have come to understand they can manage territory, mitigate risk, and provide assurance for key allies without putting ISR aircraft at undue risk. In recent OIR sorties, there were several instances where F-22 sensors were critical to keeping other aircraft informed about the progress of battle, feeding strike updates, identifying civilian aircraft, and allowing other assets to continue with a mission, the ACC official added.[39] In one instance, a Syrian Su-24 was not picked up as early as it should have, but F-22s identified it and resolved a potential situation that could have derailed the strike mission. The lessons from the OIR campaign drive home the key point to understand the current E-8 recapitalization challenge: the aircraft is only one piece of the mission challenge, the other pieces are about the ability access and exploit a network of distributed information nodes across a joint force operation.

…both the F-22 and F-35 have "magnificent" sensor suites that excel at vacuuming up pertinent information in their vicinity. The challenge in the coming years will be to off board that data, and use it effectively and in a timely fashion.

Carlisle noted both the F-22 and F-35 have "magnificent" sensor suites that excel at vacuuming up pertinent information in their vicinity. The challenge in the coming years will be to off board that data, and use it effectively and in a timely fashion. "I'm trying to figure out a way," he said. These two aircraft have the ability to fuse all their data for the pilot, making him a "decision maker and less the integrator of all the information." While the Air Force has been able to bring that advance to the cockpits of the F-22 and F-35, the next step is to leverage those tools to improve USAF's C2 capability and improve the entire ISR enterprise. Potential areas to affect this change include work with the Defense Advanced Research Projects Agency (DARPA), the Air Force Research Laboratory (AFRL), and others to improve technology which will expand "machine learning"—where a particular mission system can communicate directly with another, reducing the demand for human supervision. Other improvements in this technology area could also lead to great advances in ISR and C2 operations, such as change detection regarding targets or time sensitive ISR tasks.

Conclusion – Beyond the Next Generation GMTI/ABM Capability

When assessing the future environment the JSTARS successor will enter in just a few years, it is clear it will operate in an environment far different than the one the very first E-8 faced as it deployed to the Saudi Peninsula 25 years ago. In addition to bringing its powerful GMTI capability to bear in future conflicts, it will also have to integrate extensively with elements of aerospace power in ways not yet envisioned a quarter century ago.

The new GMTI/ABM aircraft enters the force at an inflection point for both ISR and C2, as future joint force operations will demand more agile, flexible, and multi-domain responses to very difficult military problems. The successor to the E-8 will have to operate in a force that is evolving away from the centralized CAOC-centered C2 construct built up since the end of the first Gulf War, and work in a far more disaggregated and networked operations environment.

This should drive several considerations as the JSTARS recapitalization gains strength, not least of which is to avoid a construct where the airframe becomes the central talking point. In many ways, the airframe is the least challenging aspect of this program, as the new GMTI/ABM aircraft will have to grapple with how it will fit into future distributed operations, how it will allow for open systems architecture, and accommodate the ability to update key technologies and capabilities as time progresses. Aircraft selection must be influenced by a holistic evaluation of efficiency, operational effectiveness, and adaptability to new advanced technologies, as well as execute necessary future GMTI/ABM tasks in a broader enterprise.

Though JSTARS has performed admirably over the past 25 years, it is important to remember the aircraft program ended up using a refurbished airliner to host the powerful GMTI radar because the technologies of the late 1980s demanded this approach to field the capability as soon as possible. There is a range of options to perform the next generation JSTARS mission today, from a single aircraft to a distributed "combat cloud" compatible system. Whichever approach ends up being the choice of the Air Force, it must take care to ensure the new system will be open and upgradeable, to allow for improvements in old technology, or new

technologies in fields such as machine learning, man-machine teaming, and other concepts which capitalize upon the core tenants of aerospace power.

The JSTARS successor must also avoid "stove piping" its capabilities, so we do not have a repeat of the F-22 program that saw a data link stripped out in its development since it was shortsightedly deemed not directly pertinent to the fighter's air-to-air combat mission. The JSTARS successor must be allowed to mature and contribute its valuable ISR, C2 and ABM capabilities across a networked force, and not become a single point of failure in the sky, despite its powerful onboard capabilities.

It is clear the future of GMTI radar capabilities is no longer defined by a single aircraft in an orbit—manned or unmanned. In the 21st century, the fast moving and evolving world of information technology is demanding a more enterprise-driven approach, in which aircraft will figure prominently but will not be the sole solution for the key capabilities historically associated with the E-8 JSTARS.

A "combat cloud" system of systems that gathers and relays information and provides unparalleled situational awareness from all assets, to include modern fifth generation aircraft like the F-35 and F-22, will eventually fulfill the mission tasks associated with the E-8 JSTARS, and a host of other legacy platforms as well. To achieve this, however, will require not just the development of networked capability, but consideration of how these assets will be employed, how to best leverage key "cross-domain" capabilities from the B-21 to cyber warfare tools, and how to enhance their effectiveness as an integrated system.

If we are successful, the US will preserve its critical GMTI capabilities for years to come with this recapitalization program, and lay the groundwork for building a true ISR-strike-maneuver-sustainment complex where every shooter is a sensor, and every sensor is a shooter. ✪

Footnotes

1 Author's Note: interviews with current and former USAF officials, ISR airmen, JSTARS operators, aerospace industry officials, and others were conducted on background to gather perspectives to inform this paper. This anecdote is from an interview with a retired USAF JSTARS officer (Arlington, Virginia), May 15, 2016.

2 Interview, USAF Gen Herbert "Hawk" Carlisle, commander, Air Combat Command (Langley AFB, Va.), author interview, April 29, 2016.

3 David Deptula, "Beyond the Bomber: The New Long Range Sensor Shooter Aircraft and United States National Security," (Arlington, Virginia: Mitchell Institute for Aerospace Studies, 2015), 1.

4 IHS Jane's Fixed Wing Military Aircraft, "E-8 Joint STARS," accessed March, 2016, www.janes.com.

5 Interview, US Air Force JSTARS air battle manager (Robins AFB, Ga.), author interview, March 31, 2016.

6 USAF Lt Gen George Muellner (ret.), author interview, May 27, 2016.

7 Lori Tagg, "JSTARS plays critical role in Operation Desert Storm," Army News Service, Jan. 16, 2015, https://www.army.mil/article/141322/JSTARS_plays_critical_role_in_Operation_Desert_Storm/ (Accessed July 2016).

8 Ibid.

9 Muellner Interview, author, May 27, 2016.

10 Daily Report 4/19/206 "More ISR, Attack Aircraft for ISIS Fight."

11 US Air Force, "Recapitalizing JSTARS: The Airframe," Hanscom AFB, Mass. http://www.hanscom.af.mil/news/story.asp?id=123467200 (accessed July 10, 2016).

12 US Air Force, "Team JSTARS Reaches 100,000 Hour Flying Milestone," Robins AFB, Ga. http://www.robins.af.mil/news/story.asp?id=123409423 (accessed July 10, 2016).

13 Marc Schanz, "ISR's Iron Triad," in *Air Force Magazine*, August 2015.

14 Ibid.

15 Bill Carter, Aviation International News, March 29, 2016, http://www.ainonline.com/aviation-news/defense/2016-03-29/raytheon-northrop-grumman-win-jstars-radar-contracts (accessed April 27, 2016).

16 Air Combat Command commander Gen Carlisle at Air Force Association's Air & Space Conference, Sept. 15, 2015.

17 Panel remarks as reported by author --- Brig Gen Julian Dale Alford, USMC Warfighting Lab, speaking at Modern Day Marine exposition, Quantico, Virginia, Sept. 22, 2015, https://4gwar.wordpress.com/2015/09/28/training-and-equipment-at-modern-day-marine-2015/ (accessed March, 2016).

18 Interview, USAF Air Staff official (Pentagon), author interview, April 20, 2016.

19 Interview, experienced USAF ISR officer working in JSTARS mission, author interview, May 2, 2016.

20 Ibid.

21 Rear Adm. Michael Manazir, U.S. Navy, Air Warfare Office of the Chief of Naval Operations, appearance at Air Force Association's Mitchell Institute for Aerospace Studies, March 22, 2016.

22 Lara Seligman, "Congress Urges Air Force to accelerate JSTARS Recap," Defense News, May 27, 2016, http://www.defensenews.com/story/defense/air-space/2016/05/27/congress-urges-air-force-accelerate-jstars-recap/85031868/ (accessed July 10. 2016).

23 Author's Note: Comments compiled from multiple background interviews of former JSTARS operators, retired USAF officials, and aerospace industry experts speaking about engineering and technical considerations to take into account regarding the GMTI/ABM mission set.

24 Interview, Muellner, May 27, 2016

25 Interview, Carlisle (Langley AFB, Virginia), author interview, April 29, 2016.

26 Ibid.

27 Interview, former JSTARS commander (Arlington, Virginia), May 2016.

28 Lt Gen David A. Deptula, USAF (ret.) address at the Association of Old Crows, Dec. 1, 2015.

29 Panel remarks -- David Fahrenkrug, moderator, "21st Century Warfare: The Combat Cloud," Air Force Association Air & Space Conference and Technology Exposition, Sept. 15, 2014, http://www.af.mil/Portals/1/documents/af%20events/Speeches/15SEP2014-AFA-CombatCloud-Carlisle-Hostage-UrrutiaVarhall-Fahrenkrug.pdf (accessed April, 2016).

30 Interview, Carlisle (Langley AFB, Va.), author interview, April 29, 2016.

31 BreakingDefense.com, Colin Clark, "Pawlikowski On Air Force Offset Strategy: F-35s Flying Drone Fleets," Dec. 15, 2014, http://breakingdefense.com/2014/12/pawlikowski-on-air-force-offset-strategy-f-35s-flying-drone-fleets/ (accessed July 2016).

32 Interview; US Air Force JSTARS operator (Robins AFB, Ga.), Author interview, March 31, 2016.

33 Ibid.

34 Ibid.

35 Interview, US Air Force Air Staff official (Pentagon, Arlington, Virginia), author interview, April 20, 2016.

36 Speech – Sue Gordon, Deputy Director, National Geospatial-Intelligence Agency, Remarks at ESRI FedGIS Conference 2016, Feb. 25, 2016, https://www.nga.mil/MediaRoom/SpeechesRemarks/Pages/Deputy-Director-.aspx (accessed July 2016).

37 USAF Air Staff official (Pentagon), author interview, April 20, 2016.

38 Interview, Air Combat Command staff official (Langley AFB, Virginia), author interview, March 31, 2016.

39 Ibid.

About The Mitchell Institute

The Mitchell Institute educates about aerospace power's contribution to America's global interests, informs policy and budget deliberations, and cultivates the next generation of thought leaders to exploit the advantages of operating in air, space, and cyberspace.

About the Series

Mitchell Institute Policy Papers is a series of occasional papers presenting new thinking and policy proposals to respond to the emerging security and aerospace power challenges of the 21st century. These papers are written for lawmakers and their staffs, policy professionals, business and industry, academics, journalists, and the informed public. The series aims to provide in-depth policy insights and perspectives based on the experiences of the authors, along with studious supporting research.

About the Authors

Lt Gen David Deptula, USAF (Ret.), is dean of the Mitchell Institute for Aerospace Studies, and a decorated military leader with decades of experience in both combat and leadership roles in major joint contingency operations. He has planned, flown, and commanded air operations ranging from humanitarian relief efforts, to small-scale contingencies, to major theater war. Deptula served as the principal air attack planner for Operation Desert Storm in 1991; was a Joint Task Force commander in Iraq in 1998/99; led the initial air campaign of Operation Enduring Freedom in late 2001, and led several other significant joint military operations. Deptula retired after 34 years on active duty, serving in his last assignment as the US Air Force's first deputy chief of staff for intelligence, surveillance, and reconnaissance. He is a prolific author on aerospace power, and a thought leader on defense, strategy, and ISR.

Marc V. Schanz is the Mitchell Institute for Aerospace Studies' director of publications.

John M. Doyle, a Mitchell Institute visiting fellow, is a Bethesda, Maryland-based defense and security writer and journalist with nearly 30 years experience working for the Associated Press, Aviation Week, Seapower magazine, Special Operations Technology, and other publications. He has written extensively on subjects ranging from unconventional warfare to disaster relief operations and cyber security.