

BEYOND THE IRON TRIAD:

The Future of Airborne C2ISR



By Col Matt Hurley, USAF (Ret.)



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The Mitchell Institute for Aerospace Studies

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About the Author

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Hurley has also deployed for duty on assignments in Southwest Asia, the former Yugoslavia, and the Horn of Africa. During his final assignments, he served at the Pentagon as the lead capabilities-based planner for Air Force Intelligence, Surveillance, and Reconnaissance (ISR), and also served as chief of Air Force ISR doctrine and policy.

Hurley is a distinguished graduate of the Air Command and Staff College, Air Force intelligence officer training, and the US Air Force Academy Class of 1990. Hurley was awarded his doctorate in history from The Ohio State University in 2009, having previously earned a master's degree in history at the University of Washington. He has published and presented numerous articles and monographs regarding airpower history, operational design, and ISR, and is currently writing a comprehensive history of Portugal's colonial air campaign over West Africa during the 1960s and 1970s. Hurley resides in Hilliard, Ohio, where he also serves as a guide at the National Museum of the US Air Force at Wright-Patterson AFB, Ohio.

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Foreword

Command and control (C2) and intelligence, surveillance, and reconnaissance (ISR) have always been fundamental to warfare. To address the challenges of the Cold War, the United States built three major aircraft weapon systems to provide C2 and ISR (C2ISR) in a manner to counter the Soviet Union: the Air Force's E-3 Sentry Airborne Warning and Control System (AWACS), E-8C Joint Surveillance Target Attack Radar System (JSTARS), and RC-135V/W Rivet Joint electronic reconnaissance aircraft. Collectively, they have become known as the "Iron Triad." The Soviet military had a doctrinal preference for numerical superiority, massed air and surface assaults, and centralized control. These hallmarks of Soviet operational doctrine were vulnerable to the capabilities built into the AWACS, JSTARS, and Rivet Joint.

But the probable character of future operations has changed since the days when theater commanders worried about linear challenges like repulsing a continent-wide advance by 200 enemy divisions supported by hundreds of enemy aircraft at any given time. Modern conflict will likely involve far more dynamic, rapidly evolving problem sets. Additionally, while the Air Force has modernized subsystems onboard these platforms that make them effective, the aircraft themselves are aging to the point where the service must replace them or they will become increasing economic burdens to its growing geriatric fleet. Furthermore, with recent and future developments, one could see nearly every aircraft in the Air Force inventory able to gather information and fuse it with a host of actors. This portends a revolution for the C2ISR mission set. Accordingly, future C2ISR aircraft—as well as more granular disciplines such as battle management—must account for accelerating changes in the evolution of warfare.

In this study, retired Air Force intelligence officer Matt Hurley addresses the past, present, and future of the Iron Triad, and what the future holds for airborne C2ISR. Any meaningful change in how the US military prosecutes a mission as central as this requires fundamental transformation in thinking, beginning with how planners conceive of future systems and how operators employ them when the results matter most.

Lt Gen David A. Deptula, USAF (Ret.)
Dean, The Mitchell Institute for Aerospace Studies
September 8, 2017

A handwritten signature in blue ink that reads "David A. Deptula". The signature is fluid and cursive, with a long horizontal stroke at the end.

Introduction

The successful employment of military force in any form requires information, or the elements of knowledge necessary to project the right kind of military power at the right time and place.¹ Underlying every aspect of aerospace power is the information acquired, analyzed, and used via command and control (C2) and intelligence, surveillance, and reconnaissance (ISR) activities that, together, match designed ends to desired effects. Stated another way, these activities permit the United States and its allies to employ the right assets at the most advantageous time and place in order to achieve those effects. This capability is what the US Air Force’s “big wing” C2 and ISR (C2ISR) aircraft provide. These three platform types are the E-3 Sentry Airborne Warning and Control System (AWACS), E-8C Joint Surveillance Target Attack Radar System (JSTARS), and RC-135V/W Rivet Joint electronic reconnaissance aircraft.² These airplanes provide critical situational awareness of air and surface activity, as well as adversary intentions. Collectively, they have become known across the US military as the “Iron Triad.”

However, the time has come to progress out of the “iron age.” More precisely, it is time to move beyond the industrial-age warfighting concepts that have decisively shaped American military operations for more than a century. Characterized by large formations, broad logistics lines, and increasingly powerful weapons, the industrial-age warfare paradigm relies predominantly on firepower and mass to achieve policy goals.³ As a result, industrial-age warfare has become closely tied to the concept of “total war” as waged in both of the previous century’s world wars.⁴

In an era increasingly defined by rapid technological innovation, the United States must modernize its military capabilities to reflect the importance of information.

In an era increasingly defined by rapid technological innovation, the United States must modernize its military capabilities to reflect the importance of information. No longer will victory go to the force with the most tanks, ships, or airplanes. Instead, victory will belong to the side that best knows how to employ available assets at the right time and place to maximize desired aims, while minimizing potential vulnerabilities. This is the reality of living in the era of the smart phone, where individuals around the globe now have near-instant access to a huge range of information previously reserved for just a handful of the world’s top powers. Progressively more powerful sensors, processing capabilities, and networks are pervasive in the modern era. While the tenets of industrial-age firepower remain highly relevant, the United States must consider implications brought about by the information tools now at its disposal. Advances in various fields of computer and communications technology have increased the ability to gather unprecedented levels of raw data; harness analytics and processing to transform the data into decision-quality information; and use the information to rapidly enhance how the US military prosecutes operations at the tactical, operational, and strategic levels. As a result, the amount and quality of information available to an individual warfighter today surpass that available to a theater commander in the 20th century.

Building upon these trends, advances in sensor fusion and information dissemination mandate that Air Force officials rethink the way they understand and employ aircraft. No longer is it accurate to think of bombers or fighters in their historically defined roles. For example, a fifth generation fighter, such as the F-22 Raptor, fulfills more than just its intended purpose as an air superiority system, although it serves in that role superlatively. “More accurately, it’s really an F/A/B/E/EA/RC/AWACS-22—a flying sensor-shooter,” said Lt Gen David Deptula, USAF (Ret.), Mitchell Institute dean, during a presentation in April 2017 in Washington, DC.⁵ “It’s a flying ISR sensor that will allow us to conduct network-centric warfare inside adversary battlespace from the first moments of any conflict, in addition to its vast array of attack capabilities.” Such potential is only bound to expand as new systems such as the B-21 Raider stealthy penetrating bomber and anticipated penetrating counter air (PCA) capabilities enter service starting next decade. Given this impressive potential, service officials must now consider questions regarding what type of platform will deliver mission results in the most effective, efficient fashion. There have never been these sorts of options before.



Above: The three Iron Triad aircraft types, (left to right) the E-3 AWACS, E-8C JSTARS, and RC-135 Rivet Joint, parked on the ramp at Robins Air Force Base. (USAF)

Recent and future developments, which could lead to nearly every aircraft in the inventory being able to gather data and fuse this information with a host of actors, foretell a potential revolution for C2ISR. Assets such as AWACS, JSTARS, and Rivet Joint will see their utility radically enhanced as they build situational awareness and optimize force employment. Thanks to increased computing power, networking, and advances in both onboard and distributed sensors, these aircraft are more and more able to reach past their own apertures and gather data from sensors across the battlespace, synthesize the information in an enterprise fashion, and harness this knowledge to ensure available forces can execute their missions in the most effective and efficient way.⁶ For example, a big wing aircraft might receive real-time data from F-35 Lightning IIs operating in contested airspace, add additional inputs from its own onboard sensors and other C2ISR entities, then disseminate a more-complete situational picture throughout the force. This is especially important since frontline combat aircrews will be busy trying to execute their primary tasks, including their own survival. It also reflects the reality that an isolated sensor can gather only so much data. Fusing a number of perspectives will yield a far-more comprehensive picture that can enhance decision-making.

This evolution of modern aerospace power occurs as US forces face a threat that is growing more complex with every passing year. Cyber and offensive kinetic effects (e.g., fifth generation aircraft, long-range missiles) can increasingly threaten the global ground-based C2ISR infrastructure that is built around highly vulnerable air and space operations centers (AOCs) and distributed common ground system (DCGS) nodes. This will make aircraft, such as the Iron Triad, even more valuable in future combat operations as survivable nodes supporting strategic effects as well as operational and tactical effects.

Thus, the successor capability to the Iron Triad must possess more-capable modern C2ISR tools, with advanced sensors and multi-domain fusion and communications systems, and have enough mobility and self-protection to survive in modern combat environments. The Air Force also needs to ensure it can easily upgrade and modernize these future C2ISR aircraft. These platforms

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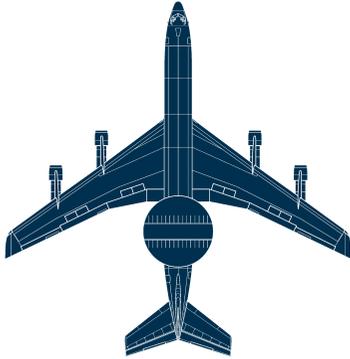
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must be able to participate effectively in a range of future military operations, from operating at standoff distance in high-threat, contested environments to supporting ongoing contingencies in lower threat scenarios, such as counterinsurgency (COIN), peacekeeping, and irregular warfare. As such, they will need the ability to operate in an expeditionary manner from a wide range of airfields and locations where maintenance and security support is lean and agile. At the same time, the Air Force must be able to press them into high-end combat, and they must be able to interact seamlessly with the host of modern capabilities the Air Force is bringing into its force structure in the coming decades.

In the context of 21st century warfighting, the ability to manifest this vision is not a “nice-to-have” luxury, but an essential prerequisite to success. With nearly every mission set of the Air Force increasingly populated with high-demand, low-density aircraft and assets, and the service facing steep modernization needs across multiple mission areas, it is more important than ever for the service to harness the opportunities of the information age to make the most out of every sortie. To use a math analogy, the Air Force is in an era where it must add two plus two together and yield six. Optimizing the use of available mission assets through the mastery of information is the key to delivering success amidst such constraints. It also affords

tremendous mission flexibility, allowing commanders to dynamically create force packages in a “plug-and-play” fashion that best reflects evolving mission requirements. This also speaks to the need for combatant commanders to have options across the spectrum of conflict, ranging from the highest threat scenario to lower end, routine operations. In short, investing in these future C2ISR aircraft now will yield vast improvements in how the United States can use its overall force in the future, and will help preserve valuable assets, such as fifth generation platforms, from overuse in scenarios where other assets could provide the desired effect more efficiently.

Figure 1: The Iron Triad inventory.



Type: E-3 Sentry Airborne Warning and Control System (AWACS)

Mission: Airborne warning and control aircraft with integrated command and control, battle management, and ISR capabilities; provides real-time, all-weather air surveillance picture of a theater of operations.

Key Capabilities:

- Primary sensor: AN/APY-1/2 radar, housed in 30-foot-wide rotodome, 11 feet above fuselage. Pulse Doppler radar ranges more than 250 miles; beyond-the-horizon mode capable of detecting targets up to 400 miles.
- Major subsystems: Navigation and communication, radar and passive detection sensors, and identification tools, which eliminate ground clutter around targets.
- Flight crew of four, plus 13-19 mission specialists who provide integrated ISR, identification, weapons control, battle management and communications functions.



Type: E-8C Joint Surveillance and Target Attack Radar System (JSTARS)

Mission: Airborne battle management, command and control, and air-to-ground intelligence, surveillance, and reconnaissance platform. Supports theater ground and air commanders with key ISR, battle management, and C2 capabilities across full spectrum of military operations.

Key Capabilities:

- Primary sensor: AN/APY-3 high-performance, multi-mode radar system.
- Equipped with moving target indicator (MTI) and synthetic aperture radar (SAR) modes, with range of up to 155 miles and coverage of nearly 19,305 square miles.
- Real-time relay capability to common ground stations, and other ISR and C2 nodes; Standard crew of 22 includes 18 personnel for onboard processing, exploitation, dissemination.



Type: RC-135V/W Rivet Joint, RC-135S Cobra Ball, RC-135 Combat Sent

Mission: Rivet Joint is a signals intelligence (SIGINT) aircraft specializing in communications intelligence (COMINT); Cobra Ball uses telemetry, COMINT, and specialized optical and electro-optical sensors to gather ISR on missile launches; Combat Sent specializes in electronic intelligence (ELINT), particularly on air defense systems and radars.

Key Capabilities:

- Primary sensor suite is varied and upgradable, related to specialty mission needs; allows crew to detect, identify, and geolocate signals throughout the electromagnetic spectrum.
- High degree of systems commonality between variants due to ‘block’ upgrades every 18 months.
- Interior of all variants in USAF fleet fit more than 30 aircrew and other mission personnel.

Sources: US Air Force and Jane's All the World's Aircraft. Graphics: Zaur Eylanbekov

With the E-3, E-8C, and RC-135 advancing in age, today's Air Force faces a rare and potentially pivotal opportunity not only to recapitalize a necessary capability in a more effective and efficient manner, but also to maximize the future returns that airpower yields. These C2ISR aircraft and their associated mission systems are collaborative tools, and service officials should consider their future from an enterprise perspective, not through so-called “stove-piped” linear acquisition efforts that fail to harness potential synergies. The Air Force should not view these acquisition efforts and the new technologies associated with them as yet another layer of “cost,” but instead as crucial investments required to maximize the utility of the future force and meet an increasingly complex set of mission requirements. This paper offers a vision for how the Air Force should proceed in securing the next generation of these critical capabilities: one that seeks to expand mission capabilities, while simultaneously driving down operating cost.

Evolution of Airborne C2, ISR, and the Iron Triad

The ability to gather information, process it, and disseminate it through a robust, sustainable C2ISR enterprise has long set the United States apart from competing military powers. Gaining as complete as possible an understanding of the battlespace, determining when and where to apply combat power most effectively and efficiently, and possessing the assured ability to effectively direct military force have characterized American airpower since the earliest days of military aviation. In every conflict since World War I, American Airmen have performed reconnaissance and surveillance; directed air and surface weapons employment; and pioneered the use of associated technologies.⁷ By the end of the Cold War, the US Air Force had built a C2 and ISR capability that was the envy of allies and adversaries alike.

The Air Force developed the air-breathing components of that capability, particularly the Iron Triad fleet of AWACS, JSTARS, and Rivet Joint airplanes, to fulfill a specific operational requirement, in some cases where no capability previously existed. Airborne warning, for example, was a critical capacity brought online during the early days of the Cold War to guard the United States against attacking Soviet bombers. At the time of their introduction, these systems were notable for their sensor range and aerial endurance, reflecting the United States' expanding global responsibilities, evolving missions, and increased access to advanced technologies.



Above: The E-3 Sentry Airborne Warning and Control System (AWACS). (USAF)

Equipped with a long-range surveillance radar in a rotating dome mounted atop the aircraft fuselage, the E-3 AWACS provides situational awareness of friendly, neutral, and hostile air activity; command and control of air operations within an area of responsibility; battle management of assigned forces; all-altitude and all-weather surveillance of the battlespace; and early warning of enemy aerial activity. It fulfills these tasks through several different functions. First, the airplane acts as aerial surveillance and warning, by, in effect, serving as an airborne air-traffic-control center, maintaining situational awareness of every aircraft in the airspace assigned. Second, AWACS performs air-target detection and tracking to identify and monitor the movements of enemy aircraft. Third, the E-3 executes air battle management, relaying friendly-force information, target specifics, and instructions to air defense assets (airborne or surface-based) to protect friendly forces from enemy aerial attack.⁸ The specially trained crews that execute this mission are expert at making sense of a broad array of rapid-fire, constantly evolving data points. AWACS gives an air commander real-time information on everything flying within 250 miles of the aircraft—more than 200,000 square miles of airspace—while mission crew members employ dedicated sensors and other systems for the surveillance, identification, weapons control, battle management, and communications functions.⁹

The E-3, a modified version of the 707 commercial airframe, grew out of air superiority lessons learned during the Korean and Vietnam Wars. Those conflicts demonstrated that aerial losses to enemy aircraft decreased dramatically when friendly aircraft had advanced warning of impending fighter attacks against them.¹⁰ Since its introduction in 1977, the Sentry, along with its analogous US Navy AWACS aircraft, has participated in every significant American military operation. It provided critical aerial situational awareness and battle management during Operation Desert Storm against Iraq in 1991 and subsequent missions over the former Yugoslavia, leading to a perfect air combat record for Air Force fighters during the 1990s—48 aerial victories versus no air-to-air losses—while preventing adversary air forces from attacking friendly surface forces.¹¹ “What the E-3 brings to the fight is essential to our combat commanders, both in the air and on the ground,” noted Brig Gen David M. Gaedecke as a colonel back in November 2015 when he commanded the 552nd Air Control Wing (ACW) at Tinker AFB, OK.¹² The unit is home to most of the Air Force’s 31 AWACS airplanes.

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When it comes to present AWACS fleet status, the Air Force intends to modify 24 E-3s to the new Block 40/45 standard, while divesting the seven remaining airframes beginning in Fiscal 2019. This upgrade involves replacing 1970s-era mission systems with modern hardware and software. Relevant enhancements include a target/track capability with an improved human-machine interface for time-critical targeting; this is designed to increase combat effectiveness and reduce fratricide. The Block 40/45 work also includes: refinements to electronic-support-measures sensor data processing to improve threat identification; multi-source integration of information from various sensors and producers; a data-link architecture featuring

prioritized bandwidth management for Link 16 and Link 11 tactical data links; new battle management tools; the capability to parse, allow user access to, and integrate air control order/air tasking order data; and an update to secure low-bandwidth internet chat capability. A parallel AWACS network upgrade program will modernize a 20-year-old communication system on the aircraft that has growing sustainment and capability issues, while a new multifunctional information distribution system will provide high-speed, secure, jam-resistant machine-to-machine Link 16 connectivity with a broad variety of military platforms ranging from Air Force fighters to Navy submarines.¹³ The ability to communicate with the distributed force is an essential attribute. Despite an average airframe age approaching 40 years, the Air Force intends for these upgrades to keep AWACS aircraft operationally relevant for nearly two more decades.¹⁴

What AWACS does for the air battle, the E-8C does for surface operations. Indeed, a US Army general in the 1980s reportedly described how the E-8 works as “an upside-down AWACS.”

Since the Air Force began operating the E-3, Britain’s Royal Air Force (RAF) has adopted the platform, as have the French Armée de l’Air and NATO, which operates a multinational flying unit. Drawing on US and allied successes in airborne early warning (AEW) and AWACS employment, adversaries and partners alike have fielded their own similar systems to provide aerial situational awareness. The former Soviet (now Russian) A-50 Mainstay airborne early warning and control (AEW&C) aircraft has been in service since the mid-1980s, and the Russians are now developing the follow-on A-100 Premier. Meanwhile, China fielded its KJ-200 (Y-8 Balance Beam) and KJ-2000 Mainring systems during the 2000s; China’s ZDK-03 AEW&C system currently serves with Pakistan’s air force. Sweden has produced the EerieEye turboprop and GlobalEye business jet AEW&C aircraft. Israel’s current contender on the global market is the Israeli Aerospace Industries conformal airborne early warning aircraft (CAEW), also based on a business jet, which is currently in service with Israeli and Singaporean forces. India likewise is working on an indigenously produced AEW&C aircraft. Boeing has successfully marketed the E-767 AWACS to Japan, while Australia, South Korea, and Turkey have adopted the 737-based E-7 Wedgetail AEW&C aircraft. The accelerating development and deployment of these aircraft in recent years indicate the increasingly important role of AWACS and related capabilities in the air-to-air arena. Other countries, friend and foe alike, increasingly view this capability as critical to warfighting, not a fringe benefit.

What AWACS does for the air battle, the E-8C does for surface operations. Indeed, a US Army general in the 1980s reportedly described how the E-8 works as “an upside-down AWACS.”¹⁵ As an airborne C2ISR platform, JSTARS provides surveillance of enemy surface forces and battle management functions, directing air and ground operations against those elements. The aircraft employs a multi-mode, side-looking radar to detect, track, and classify moving and stationary ground vehicles in all meteorological conditions deep behind enemy lines. It is the only airborne platform in operation that can maintain real-time surveillance over a corps-sized area of the battlefield.¹⁶ Its most distinctive external feature is a 27-foot-long, canoe-shaped radome beneath the fuselage that houses an AN/APY-7 side-looking phased-array radar. The antenna can tilt to either side of the aircraft, resulting in a 120-degree field of view covering more than 19,000 square miles and target detection out to 155 miles distant. In other words, JSTARS can detect and monitor vehicles or other surface targets over an area roughly twice the size of New Jersey.¹⁷



Above: E-8C Joint Surveillance Target Attack Radar System (JSTARS). (Northrop Grumman)

JSTARS grew out of a requirement to use airpower as efficiently as possible against numerically superior Soviet and Warsaw Pact forces in Eastern Europe arrayed against NATO defenders, particularly in the inter-German theater. Defeating an adversary with nearly a three-to-one numerical advantage in tanks, for example, required the most effective use of NATO's predominant countering advantage: airpower.¹⁸ To employ airpower optimally, allied forces needed a detailed understanding of enemy locations and dispositions. This was JSTARS' foundational purpose, at which it excelled.¹⁹ First used during Desert Storm, the E-8 drew praise from Army and Air Force leaders alike, even though only two developmental aircraft were available then for employment. For example, during the Battle of Khafji, the first significant ground combat between Iraqi and coalition forces that took place from Jan. 29-Feb. 1, 1991, JSTARS provided continuous battlefield surveillance in support of the friendly aircraft employed to repel the Iraqi ground offensive into Saudi Arabia. Given the superior situational awareness available to coalition air forces, the outcome was a complete rout of the invading Iraqis.²⁰

As then-Air Force Chief of Staff Gen Merrill A. McPeak presciently observed following the aircraft's combat debut, "We will not ever again want to fight without a JSTARS kind of system."²¹ Since then, the United States never has: JSTARS has starred in every significant US campaign following Desert Storm, including operations in the former Yugoslavia; Operation Enduring Freedom in Afghanistan that began in 2001; and Operation Iraqi Freedom that commenced in 2003. In the process, the E-8 has become the Air Force's hardest worked aircraft, accumulating more flight hours per airframe than any other aircraft in the service's inventory.²² "It has many more uses today in addition to troop overwatch and intelligence collection," said Lt Gen Robert J. "Bob" Elder, USAF (Ret.), the first commander of Air Force network operations and a former head of 8th Air Force at Barksdale AFB, LA, which oversees the Air Force's strategic bombers.²³ Today, JSTARS uses wide-area surveillance to cue full-motion-video collection, and cross-cues with external intelligence information to track potential mobile targets and alert aircraft of potential surface threats, he noted. The E-8 also "conducts traffic analysis to identify likely adversary operating locations," he said.

Like the E-3, the E-8 is based on the Cold War-era 707. Given its expanding mission set and prolific use, the 16-aircraft JSTARS fleet is showing significant wear and tear and has an average age of 47 years per airframe, as of January 2017.²⁴ These factors are increasingly limiting JSTARS employment, despite modifications to mission systems begun in 1997.²⁵ Furthermore, the Air Force cancelled plans to replace the E-8's aging engines in favor of complete recapitalization of the JSTARS force. Current plans call for the Air Force to replace the E-8 fleet with an equal number of new-build aircraft beginning early next decade. The service has not yet determined the replacement aircraft type and onboard sensors.²⁶

Whatever the chosen solution, the Air Force must replace and improve the JSTARS' central technical components: its ground moving target indicator (GMTI), high-resolution imaging synthetic aperture radar (SAR), and suite of airborne battle management capabilities. To ensure the continued viability of these key capabilities, service officials must formulate any JSTARS recapitalization plans in the context of 21st century warfighting demands. The foundational JSTARS capabilities must evolve into a more enterprise-wide effort than when the Air Force first envisioned the JSTARS concept. Technology and threats have evolved since the Cold War, as have warfighter requirements. This necessitates taking a broader enterprise approach for how to incorporate the functions resident on the E-8, rather than simply producing

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a comparable replacement. Future C2ISR aircraft must not only fulfill today's missions, but also leverage information-sharing across domains by turning shooters into sensors, and vice versa, whenever possible and appropriate. One example is leveraging the GMTI and SAR capabilities of the F-35's onboard radar to augment the JSTARS mission in contested airspace.²⁷ Regardless, the imperative to identify, monitor, and track adversary and friendly surface activity while coordinating air-to-ground operations will remain critical to military operations in the future.

RC-135V/W Rivet Joint aircraft, 17 in all today, provide awareness to theater- and national-level command authorities through near-real-time intelligence collection, onboard analysis, and secure information dissemination. The RC-135 is based on the C-135 transport, which is related to the 707 since the progenitor of both was Boeing's 1950s-vintage prototype 367-80 airliner. Rivet Joint's sensor suite

allows the mission crew to detect, identify, and geolocate signals throughout the electromagnetic spectrum, including voice communications and radar emissions. Crew members can then forward the information produced onboard to a wide range of consumers, including other aircraft engaged in ongoing operations, via the RC-135's extensive and expanding communications suite.²⁸ This suite includes data links to platforms such as the F-15E Strike Eagle, A-10 Thunderbolt II, MQ-9 Reaper remotely piloted aircraft (RPA), and Navy's E/A-18 Growler electronic attack aircraft. Such platforms can then suppress or destroy the adversary systems that Rivet Joint detected. Updated Rivet Joint aircraft can also transmit data to and from the combined air and space operations center (CAOC) or through the DCGS to share information with other information-gathering entities.²⁹



Above: The RC-135 Rivet Joint. (USAF)

Rivet Joint's history as a signals intelligence (SIGINT) collector is traceable to earlier Air Force ISR aircraft employed to gather electromagnetic information. This includes the daring "ferret" missions launched throughout the Cold War to intercept Communist Bloc radar emissions and communications in order to inform national decision-makers, commanders, and tactical operators on adversary intent and defensive capabilities.³⁰ Airborne SIGINT demonstrated its value conclusively during the 1960s and 1970s, notably during the 1962 Cuban Missile Crisis and the Vietnam War, when SIGINT aircraft provided information on the dispositions of air defense systems to Air Force planners, gave Soviet ship locations to naval commanders, and passed on potentially threatening enemy fighter activity to US aircrews in flight.³¹

Unsurprisingly, the fleet's longevity reflects this decades-long heritage, with the average RC-135 exceeding half a century of service.³² Nonetheless, the venerable Rivet Joint remains an asset in continual demand by combatant commanders worldwide thanks to its increasing ability not only to collect information of intelligence value, but also to disseminate it throughout the battlespace and beyond.³³ Additionally, as of 2005, the Rivet Joint force completed a series of major upgrades that included newer, more-powerful, and more-efficient turbofan engines; an update of mission systems for electronic warfare officers and intelligence operators; and a replacement of 1960s-vintage analog avionics with state-of-the-art digital systems.³⁴ As a result of these improvements, the Air Force currently plans to keep Rivet Joints flying until at least 2040, despite the fact that some airframes entered service as early as 1964.³⁵

While the AWACS, JSTARS, and Rivet Joint remain capable and relevant, each Iron Triad leg must contend with corrosion, metal fatigue, and parts obsolescence exacerbated by diminishing manufacturing sources. The unrelenting, high operations tempo for these aircraft since the end of the Cold War has amplified this. Missions that planners expected to take a few months or years have merged into a quarter of a century of non-stop deployments.³⁶ Despite recent or ongoing modifications and recapitalization efforts,

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many observers contend this legacy C2ISR fleet will emerge from the next decade worn out and in need of reset. According to Gen Herbert J. “Hawk” Carlisle, USAF (Ret.), former head of Air Combat Command (ACC), the Rivet Joint force is in “dire need” of replacement, while the AWACS fleet, despite its modifications, is “falling off a cliff” in terms of long-term sustainability.³⁷ By some accounts, half of the legacy big wing fleet is operationally unavailable at any given time due to maintenance issues.³⁸

Efforts to re-engine the Iron Triad and modify onboard systems only delay the inevitable: machines get old and old machines break. When it involves such mission-critical systems, breakage puts US forces at increased risk. “We’ve waited too long,” to replace these assets, said Carlisle in an interview.³⁹ Given fiscal constraints and competing procurement priorities, however, the Air Force “really didn’t have any choice” if it wanted to preserve these capabilities in the near term, he said. Additionally, potential adversaries are acquiring and fielding advanced weapon systems, such as long-range surface-to-air missiles (SAMs), advanced fighter aircraft, and long-range air-to-air missiles

(AAMs),⁴⁰ that will make it increasingly difficult for legacy C2ISR aircraft to fly close enough to the battlespace during periods of intense combat to perform their mission.⁴¹ Instead, they will face contested and denied (CDO) airspace. While the current aircraft remain viable in the near term, present acquisition timelines mandate the Air Force begin thinking now about what will follow, including beyond the upcoming system that will one day replace the JSTARS fleet.

Changes in Warfare and Impact on C2ISR

C2 and ISR have always been fundamental to warfare, but it is important to recall that the United States conceived each element of the Iron Triad to counter the Soviet Union, which had a doctrinal preference for numerical superiority, massed air and surface assaults, and centralized control.⁴² The capabilities resident in the E-3, E-8, and RC-135 made these hallmarks of Soviet operational doctrine vulnerable. However, the probable nature of future CDO operations has changed since the Cold War, when the United States and its allies worried about linear challenges like repulsing a continent-wide advance in Europe by hundreds of Soviet and Warsaw Pact divisions supported by multiple enemy aircraft at any given time.⁴³ Modern conflict will likely be far-more dynamic and rapidly evolving in character. Future C2ISR platforms—as well as more-granular disciplines such as battle management—must account for accelerating changes in warfare’s evolution.

The threats the Air Force currently faces include a much wider spectrum of challenges and conflict. These range from terrorism and insurgency to hybrid warfare and through traditional nation-state power projection and associated high-intensity conflict. They also include steady-state peacetime missions like strategic reconnaissance, treaty enforcement, border patrol, humanitarian assistance, disaster relief, and presidential support missions. All of these must play into the calculus of C2ISR recapitalization. Take, for example, the E-3’s support of then-President Barack Obama’s state visits to Myanmar in 2012 and also Vietnam in 2016. Unarmed AWACS platforms flew top cover for Air Force One, helping to protect the President in areas where diplomatic sensitivities prevented the use of fighter aircraft as escorts. This is not a traditional combat mission for the E-3, but it is important in illustrating the range of activities Airmen are required to execute.⁴⁴

Looking to combat operations, information is an increasingly critical asset at all levels of command and execution. The global war against terrorism and counterinsurgency operations have most visibly placed unforeseen and unprecedented demands on the C2ISR force. In such operations, it is exceptionally difficult to distinguish friend from foe, establish network relationships, and identify enemy centers of gravity. Looking back, during the 1970s and 1980s, few would have imagined AWACS guarding against domestic terrorist attack, JSTARS tracking single civilian vehicles and even individuals on foot, or Rivet Joint teaming with jamming aircraft to prevent the detonation of home-built roadside bombs.⁴⁵ Each, however, has come to pass, as the Air Force has had to deal with unanticipated challenges, which continue to represent a national imperative that the next generation of C2ISR aircraft must be able to satisfy. To further complicate the security challenges, even non-state actors can now degrade US space and cyber capabilities, as Carlisle noted.⁴⁶

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There are also other more complex variations of conflict to consider. Take, for example, hybrid warfare, such as what is occurring in eastern Ukraine, where a rival nation-state or major power employs elements of irregular warfare (including guerrilla and terrorist methods that non-state forces wage) in concert with conventional, higher end capabilities. As a result, the challenges of COIN are combined with those of a major conflict, placing additional strain on the Air Force's C2ISR force. Identifying relevant actors, tracking threats, and executing strategy are exceptionally difficult in this muddled type of warfare.

The United States' ability to prevail in major conventional conflict also faces increasing jeopardy, given the global proliferation of advanced technologies that impact operations in every domain. The US military also faces capacity challenges. A conflict against a peer or near-peer opponent is certain to open with an "information battle," which could well prove decisive to the overall outcome. Potential adversaries have been watching the American way of war for the past several decades and they have learned. For example, China's military doctrine emphasizes disruption of "the enemy's system, not just his weapons or forces," wrote Dean Cheng, senior research fellow at the Heritage Foundation in Washington, D.C., in a 2012 essay.⁴⁷ "Central to the conduct of such strikes is the ability to establish superiority, or dominance, over the information realm," he wrote. Consequently, "the ability to interfere with an opponent's [C2 and ISR] functions also became much more important." Russian and North Korean military thinking, too, has long

Future war, even against a peer or near-peer opponent, is likely to feature more-elusive adversary formations armed with an extensive array of information technologies...

reflected the impetus to cripple American information capabilities.⁴⁸ As a result, the Air Force, from the beginning, must design whatever succeeds the present-day Iron Triad to withstand such deliberate challenges, originating from any operational domain.

Future war, even against a peer or near-peer opponent, is likely to feature more-elusive adversary formations armed with an extensive array of information technologies; elements of hybrid warfare incorporating both conventional and irregular components; and kinetic and non-kinetic challenges in space, cyberspace, and the electromagnetic

spectrum. In the information age, it is at least as important, from both a policy perspective and an effects-based point of view, to contend with bytes as well as bombers, and terrorists as well as tanks. The common requirement throughout any future conflict scenario is the need for the United States to seize and maintain information superiority so the US military can prudently employ forces to attain a defined effect. A laptop may now be more potent on a future battlefield than a tank. Just as the US military is seeking to leverage the opportunities inherent in the information age, so, too, are its potential adversaries. Given the comparative agility of their decision-making cycles regarding matters such as materiel acquisition, they are often able to outpace the United States in fielding new technologies and associated concepts of operation (CONOPS). That's why it is imperative to recapitalize the big wing fleet in accordance with evolving information-age warfare principles.

There is no doubt the Air Force's big wing aircraft have served their purpose exceptionally well in the last several decades. In combat, each Iron Triad component has constituted the central node in a "hub-and-spoke" operational model, with AWACS directing the air battle, JSTARS managing the ground fight, and

Rivet Joint supporting both efforts with prompt intelligence and tactical warning. The big wing aircraft served as the hub, while the assets reporting to them and receiving instructions constituted the ends of the spokes emanating from the hub. In other words, the information collectors, analysts, and battle managers aboard Iron Triad aircraft delivered situational awareness to theater commanders and tactical direction to friendly force elements directly engaged in the fight. In this respect, the Iron Triad represents the apex of industrial-age warfare and the perfection of a system that found its first expression during the Battle of Britain in 1940. During that pivotal air campaign, the RAF relied on a centralized network of sensors including radar, visual observer stations, and airborne aircraft, to detect, identify, and report incoming enemy air formations to a central C2 entity. That node, located at RAF Fighter Command Headquarters (the hub) northwest of London, then relayed orders to RAF fighter units (the spokes) best able to respond promptly and effectively.⁴⁹ This proved essential, since the RAF faced a fighter shortfall and had to make the most of what few assets it had available. Knowing where and when to direct its limited forces to intercept attacking bombers was crucial to sustaining an effective defense.

Today, however, advances in telecommunications, sensors, data storage, and processing power are constantly emerging and expanding the capability potential of airborne C2ISR aircraft.⁵⁰ At the same time, the Air Force is currently witnessing a major expansion in the types of missions demanded of its C2ISR force. As it recapitalizes the current Iron Triad, the Air Force needs to ensure it is reorienting the fleet's capabilities to execute the new range of mission demands now placed upon airborne C2ISR crews. The host platform might well look similar to today's big wing fleet, but the mission functions and associated systems must evolve with emerging challenges and opportunities. By way of analogy, an Apple iPod and iPhone may look superficially similar, but the latter performs a far greater range of functions in addition to playing music. Meanwhile, the multirole capabilities that new technologies afford are empowering valuable growth areas for the historical Iron Triad mission sets, in turn, enabling more efficient and effective ways to meet requirements. The Air Force must wholly assess the demands of future conflict across the entire range of military operations and fully capitalize on available and expected technology to fulfill those demands, rather than simply replacing the present big wing fleet with like systems carrying capabilities that merely mimic those flying today. Buying new aircraft and plumbing them with systems from the 1990s and 2000s does not work, given the pace of technological change. Flip-phones are no longer relevant in the smartphone era.

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Equally significant, the Air Force's newest combat aircraft carry an expanding array of sensors, weapons, and communications means that suit them to a variety of tasks, regardless of their originally conceived mission. To illustrate this, today's fifth generation fighters have earned the title of "aerial quarterback" for their ability to gather, process, fuse, and disseminate vast amounts of mission-relevant information to other aircraft.⁵¹ The applications are not limited to air battle management: the F-22 Raptor and F-35 have demonstrated increasing mastery of multi-domain situational awareness and intelligence collection, as have the latest generation of RPA while operating in today's low-threat environments. The distributed capability

of the force to both sense and shoot, combined with the sensor reach and data-processing capabilities of current and future big wing platforms, provides the Air Force with a powerful information advantage. “Frankly, the least important thing you might do is drop a bomb,” said Gen Robin Rand, head of Air Force Global Strike Command, in a March 2017 speech when explaining what he tells his bomber crews that are deploying from home station.⁵² “The most important thing you might do is provide a critical piece of ISR that’s going to save someone’s life,” he said.

Adversaries will seek to challenge US strengths and exploit US vulnerabilities. Thus, the US military needs the flexibility to roll into any fight, anywhere and prevail; this is why the flexibility that airborne C2ISR provides is so important.

In this vein, Air Force officials must also question assumptions regarding survivability and over-reliance on space-based “assured” communications; they risk creating critical vulnerabilities and huge infrastructure costs. Orbital mechanics would also suggest that wideband assets might not be ubiquitous in future non-standard areas of responsibility. This is certain: Adversaries will seek to challenge US strengths and exploit US vulnerabilities. Thus, the US military needs the flexibility to roll into any fight, anywhere and prevail; this is why the flexibility that airborne C2ISR provides is so important.

The information enterprise is also constantly growing and becoming more powerful in terms of both central elements and nodes. Such growth is necessary to meet current and emerging requirements, particularly since potential adversaries are improving their own information capabilities, while diligently working to counter US systems.⁵³ With commercial technology often outpacing gains seen in the military domain, it is exceedingly dangerous to assume the United States retains a monopoly in the ability to harness the information age. It is well worth recalling that smartphones are generally made in China, not the United States.

The Imperative and Opportunity for Change

Today's Iron Triad is showing its age, both physically and conceptually. The last major commercial airlines retired the Boeing 707 in 2011, but the Air Force and a few other air forces continue to fly these airframes.⁵⁴ That they remain airborne is a tribute to the skill of maintenance personnel. However, the aforementioned physical wear, diminishing manufacturing sources, and increasing obsolescence in the face of modern threats are taking an accelerating toll.⁵⁵ Worse, current recapitalization plans fail to address fully the potential of emerging commercial and warfighting capabilities, and instead remain stubbornly rooted in antiquated thinking regarding missions and means. For example, the Air Force's effort to recapitalize its big wing C2ISR force will have to mandate some form of multi-level security or advanced data links onboard these assets, if the service plans to better integrate and employ fifth generation aircraft and C2ISR forces in the future.

Modern and future operational realities demand a more-distributed approach to C2ISR, rather than the stove-piped template embodied by the Iron Triad, since all indications are future combat environments will be more decentralized and populated with multi-domain threats than ever before. Such an approach is envisioned in the concept of the "combat cloud," a cohesive, ubiquitous battle-management system of systems linking all assets, from aircraft to ships to satellites to ground vehicles and other sensors in every domain.⁵⁶ The combat cloud is meant to secure the objective of rapidly moving "data to decision," as Deptula phrased it in congressional testimony in March 2017.⁵⁷ It envisions a secure, multi-level enclave through which any user can access, process, and fuse data from all available sources, enabling operators to use all relevant information in real time.⁵⁸

The combat cloud would function much like the Internet or a cellphone network in that moving from one web server to another, or between cellular zones, is transparent to the user.⁵⁹ Also like the Internet, the combat cloud concept envisions a self-forming and self-healing capability; with ports and nodes resident in every platform, the cloud could withstand the loss of one or many parts, leading to graceful degradation in the face of enemy attempts to shut it down. Much as has been the case in even the most effective cyber attacks against the civilian Internet, the loss or shutdown of even a great many nodes simply would result in the re-routing of prioritized traffic through surviving paths and would not halt the functioning of the network, even if there is some temporary degree of loss in functionality.⁶⁰ Meanwhile, updates are constant to the resident data and the information is scrubbed for errors and ubiquitously available anytime.⁶¹ The desire is to create "an open architecture where the data can reside," Lt Gen VeraLinn "Dash" Jamieson, the Air Force's deputy chief of staff for ISR, told reporters in February 2017. "You have to have a common operating infrastructure where the data can reside so that you can pull out the data that you need."⁶²

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As envisioned by Deptula, the combat cloud would offer “dramatically enhanced situational awareness by transforming disparate data into decision-quality knowledge,” hence the descriptor of the objective as data to decision.⁶³ “Individually networked platforms transform into a broader system-of-systems enterprise integrated through domain- and mission-agnostic information linkages,” he explained in a December 2015 speech outlining the concept.⁶⁴ All elements comprising the combat cloud would share the information they collect. Real-time decision-making, enabled by automated information-sharing, would then enable each platform to remain oriented in a dynamic battlespace and to re-orient actively to frustrate an opponent’s defensive agenda. “The central idea is cross-domain synergy,” said Deptula, describing the vision as “the complementary, vice merely additive, employment of capabilities in different domains such that each enhances the effectiveness—and compensates for the vulnerabilities—of the others.”⁶⁵

The synergy that the combat cloud generates would allow a set number of aircraft to produce greater effects across a wider area, conducting disaggregated, distributed operations over a fluid, unpredictable, and rapidly evolving battlespace.⁶⁶ The technology is currently available, according to Elder. “We can conduct [cloud-enabled operations] today,” he insisted.⁶⁷ “The Air Force Research Laboratory has demonstrated the effectiveness of these technologies for 10 years.” Extant programs, such as Tactical Targeting Networking Technology, vividly demonstrate the viability and potential of the combat cloud.⁶⁸ While dedicated C2ISR aircraft remain integral to the process, incorporating all warfighting platforms in every domain as sensor nodes and sharing the information they acquire would result in transforming the C2ISR paradigm of the last century from a linear set of linkages to an array that is much more robust, redundant, and survivable. Furthermore, such a distributed network would permit better overlapping coverage, extended surveillance volume, and the capability to rapidly fill C2ISR coverage gaps.⁶⁹

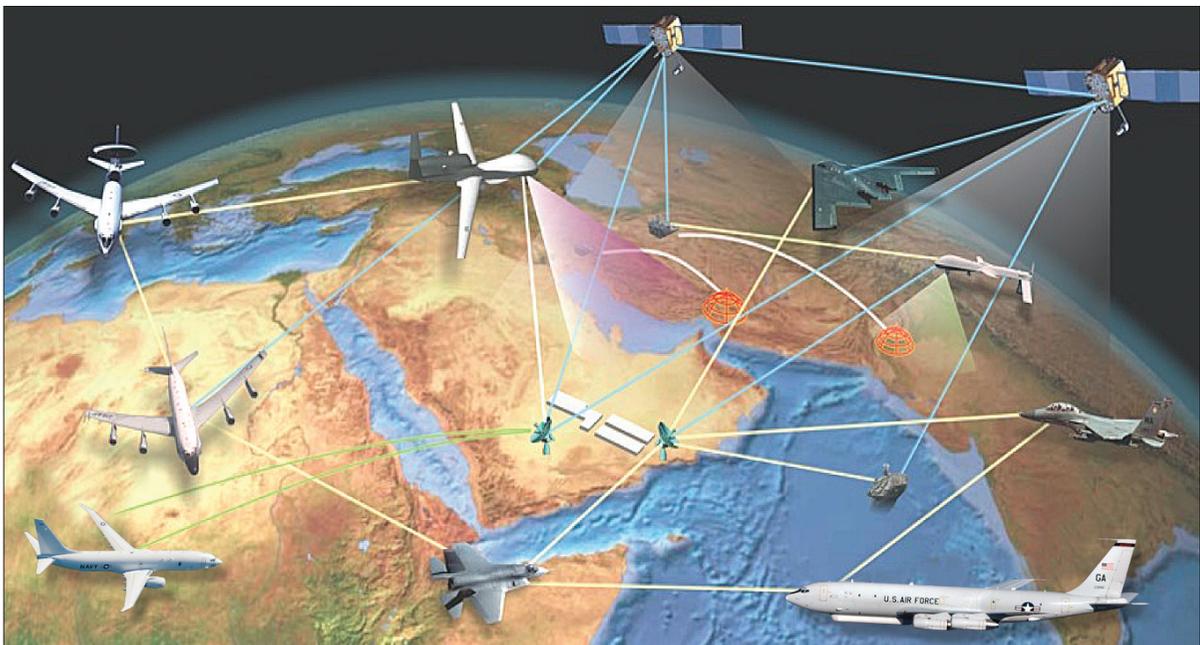


Figure 2: A notional Combat Cloud depiction. (Mitchell Institute)

Moving into the era of the combat cloud, it is crucial to optimize C2ISR recapitalization for information-age requirements. A functioning combat cloud would relieve the Air Force of the burden of merely replacing aging aircraft with new versions of the same assets. This drives a requirement to integrate wideband communications across the C2ISR fleet with multi-level security and with onboard computing and storage capabilities to ensure the combat cloud's ability to self-form and self-heal. When every shooter or effects-generating platform also carries its own suite of increasingly powerful sensors, each contributes more to a holistic operational picture, with the centralized C2ISR system taking this data and turning the information into a picture that can align the entire force and optimize the means to attain desired effects.

The Air Force has already made a tentative entry into this era through the introduction of more-potent, multi-mission aircraft capable of performing many of the tasks formerly reserved for the big wing fleet. For example, GMTI and SAR systems have proliferated beyond the E-8 and today are resident on the Air Force's newest fighters, the F-22 and F-35, as well as RQ-4B Global Hawk Block 40 remotely piloted aircraft. With its concurrent air moving target indicator, the RQ-4B can also augment the E-3 in its air search and tracking roles, while the F-22's radar has demonstrated a limited ability to function as an airborne control system. Serving as aerial quarterbacks as well as impressive sensor platforms in their own right, the F-22 and F-35 have proved capable of providing detailed situational awareness and targeting data to other aircraft operating in the same theater.⁷⁰ "Our fifth generation weapon systems are the eyes, ears, and teeth of war today, and likely for tomorrow's conflicts," observed Jamieson.⁷¹ "They act as a fusion hub by integrating legacy systems, C2, air and space sensors, strike elements, cyber capabilities, and near-real-time ISR feeds across domains."

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Given their stealth characteristics, current and future next generation aircraft will also enjoy the ability to penetrate deep into CDO environments, something the Iron Triad cannot do with any reasonable hope of surviving an adversary engagement. "We need to understand that platforms like the F-22 are information machines ... far above and beyond being killing assets," said Carlisle in March 2017.⁷² A senior Air Force ISR officer also elaborated on this philosophy, noting that, in order to win tomorrow's battles, "all of our airborne combat assets will need to directly contribute in some way to collecting data, to sharing that data to allow analysis and produce intelligence, and ultimately to communicating that intelligence to the appropriate warfighters throughout the entire battlefield to create desired effects and shape outcomes before our enemies do."⁷³

However, while the nodes of the combat cloud will be enormously powerful, it is important to recognize that big wing aircraft will still remain vital in ensuring effective projection of power in a variety of potential combat environments and contingency scenarios. These aircraft will be essential in providing standoff capabilities and enhanced situational awareness in scenarios where fifth generation assets must focus on providing their front-end combat capabilities against modern adversaries. With an unprecedented level

of data flowing throughout the battlespace, it will be more important than ever to have entities in charge of helping weave a tapestry of disparate pieces of information into a regional-based vision for action. The coherence of C2—a centrally directed effort to ensure all operations conform to the attainment of desired ends—remains essential to the efficient operation of the enterprise.⁷⁴ Assets like the B-21, F-22, and F-35 will be engaged in the combat cloud in a highly dynamic tactical fashion. Sometimes, they will be solely dedicated to highly specific missions, such as shooting down enemy aircraft or striking surface targets in a heavily defended region. In those situations, even the most advanced aircraft may find themselves busy just trying to survive.⁷⁵ That will leave little, if any, bandwidth for broader C2ISR functions on the part of the pilots. There will also be times when these aircraft will purposefully go off the cloud network and not

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actively transmit significant quantities of data to avoid detection in hostile airspace. They will, however, likely be able to receive information through passive receivers. This means that the constant in the C2ISR equation will be the successor platforms to today’s big wing mission; they will make the most of their own organic capabilities and those from any and all available distributed assets.

A core of dedicated C2ISR aircraft offers several other advantages across the spectrum of conflict. The first is regional perspective, according to Col Geoffrey F. Weiss, current 552nd ACW commander.⁷⁶ In a football game, said Weiss, the quarterback runs the show for the offense, and today’s big wing ISR assets are arming Air Force quarterbacks in fifth generation cockpits with greater C2ISR capabilities. “But as the quarterback scrambles around dealing with fog, friction, chance, and a thinking opponent, he or

she needs someone who is a bit more-detached and who has the full-time job of keeping an eye on the big picture. This is the role of the coordinator in the booth high above. We will always need that C2 node because perspective is so important,” said Weiss.

Persistence is another attribute Air Force big wing C2ISR aircraft enjoy that other platforms do not. “The operational environment, particularly the air domain, has its own ‘pattern of life,’” noted Weiss. “That pattern cannot be discerned in a matter of just a few hours. A persistent C2 presence affords us the best opportunity to decode the multi-domain battle and make the correct decisions and adjustments as events unfold.”⁷⁷ Finally, the big wing airplanes currently offer extensive onboard data processing and management capabilities that other airborne systems presently lack; this is a central consideration given the increasing amounts of data available and the imperative to fashion the data into usable information.⁷⁸ Consequently, while the Air Force may disaggregate some traditional Iron Triad functions, it will still require “central nodes” of some fashion, according to Carlisle, to orchestrate operations and maintain information dominance in future conflicts.⁷⁹

Projecting power at the lower end of the conflict spectrum is a key scenario where the Air Force could employ future big wing assets efficiently and effectively to fulfill certain operational needs. Fifth generation aircraft are expensive and in short supply; as the “crown jewels” of airpower, the Air Force must prudently

govern their use. It would be a mistake to burn through their flight hours when alternate and less costly solutions are available. Today's big wing platforms, and their eventual successors, fit in this category. In permissive or lightly contested airspace, aircraft such as the E-3, E-8C, and RC-135 can execute the vast majority of C2ISR missions without the need for distributed fifth generation nodes, which are all but essential for success at the higher end of the conflict spectrum. Due to their longer loiter time, reduced need for air refueling, and lower operating costs as measured by mission effect, it is far more affordable to operate big wing assets in these lower threat scenarios than a squadron of modern fifth generation fighters. This is, by far, one of the more compelling arguments in support of modernizing the Iron Triad. Such an investment in airborne battle management and C2 capabilities will give commanders incredible flexibility in how they solve operational problems across a spectrum of operations, without having to over-utilize certain assets, like the F-22, in scenarios where their employment might not be optimal.

These realities drive home the point that acquisition versus force employment is not an either/or choice. There will be times when fifth generation aircraft assets will be the only sensors over a target of interest due to basic survivability concerns. In other circumstances, there will be a mixed presence among different aircraft. In some scenarios, big wing aircraft will fulfill the C2ISR. That is the entire point of force employment in the information age and the combat cloud: the Air Force can develop the package of capabilities in a dynamic fashion that will best meet desired goals in the most prudent and effective fashion. This also complicates enemy planning, for US forces will present a constantly evolving set of capabilities. There will not be a standard model of force employment.

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Not Just the Airframes

Fortunately, the Air Force is taking steps in the right direction with today's Iron Triad, fielding new tools and concepts of operation to take full advantage of modern C2 and ISR systems. Together with its industry partners, the service has advanced cooperation among the AWACS, JSTARS, and Rivet Joint communities, and it is constantly maturing and refining new tactics, techniques, and procedures to ensure the platforms' ability to operate together and share information.⁸⁰ Collectively, Airmen are able to merge the information from these aircraft via networks and data links to compose a situational awareness picture that would not be possible without all three platforms working together.

The next step is to ensure these aircraft have the capability to collaborate with the wider information enterprise. For example, the RC-135V/W community today embraces more distributed, networked CONOPS that link the aircraft's powerful sensors and systems with ground-based analytical capabilities via wideband satellite communications. The Air Force's broader ISR modernization plan seeks not only to improve the capabilities resident in the big wing fleet, but to link these aircraft and their powerful sensors to the rest of the force, especially fifth generation aircraft, with their increasingly powerful sensor suites. Developing new distributed ISR links and analysis tools will accomplish this in part, as will improving training and integration; revising doctrine; educating all personnel appropriately; and making additional refinements throughout the Air Force.⁸¹ Carlisle, while still ACC Commander, asked at a March 2017

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airpower panel discussion how the Air Force would “unleash the potential of the minds of these young men and women [who] are going to use those airplanes.”⁸² The answer lies in an across-the-board, enterprise approach, not an antiquated systems-centric perspective.

To exploit the potential of information-age operations, one must not think of the Iron Triad and other aircraft as mere information collectors or consumers, but rather as nodes serving a broader information enterprise in any context, from operations in permissive environments to missions in or around heavily contested airspace.⁸³ This, in turn, requires rethinking the CONOPS of military systems, including aircraft. However, new thinking is difficult to achieve, much less implement, for systems that have been in use in one particular

fashion for decades, or in the case of some surface systems, for centuries. As Niccolò Machiavelli, the Italian diplomat of the Renaissance period whom many consider to be the father of modern political thought, wrote several hundred years ago, “There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things.”⁸⁴ Airmen and service members must contend with an enduring institutional aversion towards abandoning traditional categories and missions that they “grew up with,” professionally speaking. In the early 20th century, horse cavalry officers of the day bemoaned aviation advocates tampering with the “sacred functions” of cavalry.⁸⁵ Yet, military historians point out how poorly Poland's horse cavalry performed against Germany's *Blitzkrieg*

manner of warfare in 1939. Fortunately, as Carlisle observed, the Air Force's advantage over time has always been the way Airmen think, specifically referring to their ability to adapt and innovate.⁸⁶

With this in mind, it is important to stress that whatever systems or capabilities replace the Iron Triad, the Air Force must design them to accommodate future modular technology packages and open systems so they remain operationally relevant for decades to come. This means the service must also change the way it acquires and fields new aircraft. Service officials can no longer consider open mission systems that are compatible with legacy and future technologies to be nice-to-have options; rather, any successor airborne C2ISR program must include “plug and play” capability that connects to networks already extant in current fifth generation aircraft, as well as space assets, surface forces, legacy aircraft, and future platforms. Incorporating new and more effective sensors or communications capabilities should not require the 10 years it often takes today. Instead, from the onset of any acquisition program, the Air Force should build in the ability to adapt a platform to operate the latest and greatest onboard systems. Upgradability has become as important, or more so, than building the original platform. “Having that open architecture, that open mission system architecture, where you can rapidly reconfigure” is becoming increasingly crucial, noted Air Force Brig Gen Alex Grynkewich, deputy director of global operations on the Joint Staff, in July 2017 at a Mitchell Institute-sponsored forum on air superiority.⁸⁷ He led the Air Force's cross-domain and service-wide study in 2015-16 that examined future air superiority options.

A modular, open architecture approach will also allow the Air Force to decouple buying an airframe from the mission systems hardware onboard.

This kind of open architecture approach will be increasingly essential to maintaining the ability to adapt, grow, and match legacy systems to future technology, as well as achieving greater degrees of cost-effectiveness. This requires the Air Force not only to improve its institutional understanding of how different procurement programs relate to each other in the informational realm, it also mandates placing higher priority on the information capabilities residing on any given aircraft.⁸⁸ A modular, open architecture approach will also allow the Air Force to decouple buying an airframe from the mission systems hardware onboard. If a sensor or analytical tool requires more time to develop, the Air Force could still field an aircraft with current systems, and then add new capabilities as they become available. “Buying ‘things’ is not the overarching goal,” observed Douglas A. Birkey, Mitchell Institute executive director, in a May 2016 opinion piece.⁸⁹ “Instead, we need to focus on desired mission effects and be open to the idea that there may be new, better ways of attaining those objectives,” particularly by capitalizing on increased information capabilities. However, despite the promise, “We’re not there yet,” said Carlisle in August 2017.⁹⁰ “Open systems architecture is a great concept, but it’s hard to do. We’ve got to get there,” he said.

Adherence to obsolete warfighting paradigms is another hindrance to capitalizing fully on the opportunities emerging in the information age. In a universal information environment, using every source and sensor to its fullest capability is essential. The traditional stove-piped model of system design and deployment creates a self-imposed inability to “flex” the C2 and ISR enterprise when necessary to cover contingencies throughout the range of military operations (ROMO). For example, a fully manned CAOC is not required

for every air operation, or even every air campaign, given the demonstrated ability of on-scene assets to acquire, fuse, and exploit the required information, and to do so more quickly and with greater contextual perspective than rear-area command echelons. US warfighting has advanced to the point where the pilot of a single, fifth generation aircraft enjoys as much theater situational awareness, or more, than a theater commander in some previous conflicts.⁹¹ Unfortunately, the experience of more than two decades of theater commanders having greater access to information once solely the purview of warriors at the point of contact of battle has led US and coalition senior commanders to move from a command-and-control paradigm of “centralized control, decentralized execution,” to one of “centralized control, centralized execution.” This was the old Soviet model, which has repeatedly shown itself to be terminally brittle and fatally ineffective under combat stress.

Even a return to the old paradigm of centralized control with decentralized execution would not be enough since today’s rapid access to information and battlespace awareness mandates a shift to the more flexible concept of “centralized command, distributed control, and decentralized execution” (CDD). “The

The notion of centralized control—an airpower C2 model well-suited to fighting in World War II—has become inadequate in the context of a modern contested or denied combat environment, where adversaries will certainly test and quite likely degrade the resilience of networks and command communications.

increasing lethality and reach of adversary weapons will significantly increase the risk to large battle management/C2 platforms like AWACS,” said Grynkewich.⁹² This will limit their ability to see and manage activities in denied and highly contested environments, he added. To overcome these shortfalls, the Air Force should develop concepts that disaggregate this capability by using multiple sensor platforms, including teamed manned and unmanned systems and a robust battlespace information architecture, he said. Such distributed control preserves unity of command, but delegates necessary control authorities to lower levels, which act based on the commander’s previously communicated intent should unforeseen circumstances arise or gaps emerge in a C2 structure. CDD represents not the abandonment of proven models, but a healthy adaptation to the realities of contemporary warfare. The notion of centralized control—an airpower C2 model well-suited to fighting in World War II—has become inadequate in the context of a modern contested or denied combat environment, where adversaries will certainly test and quite

likely degrade the resilience of networks and command communications. Distributed control based on a universal understanding of commander’s intent and rules of engagement permits the continued employment of combat airpower, while adherence to centralized control might paralyze operations in a degraded communications situation. “Unity of command is a principle of war,” observed Elder.⁹³ But, he added, “Have you ever heard of unity of control? Embracing distributed control will make decentralized execution easier.”

Command and control constructs similar to CDD already exist and the Army and US Marine Corps have adopted them.⁹⁴ Fitting them to the unique requirements of aerospace power represents just one of the opportunities the Air Force can exploit to implement a new C2 framework based on advances in

information technology and techniques. Part of that effort will involve breaking current habits. “If you’re a commander who believes in mission-type orders or commander’s intent, you trust your subordinates and inform them of what’s appropriate and what’s not, including the degree of latitude in which they can make autonomous decisions,” explained Carlisle.⁹⁵ “We’ve gotten a little bit lazy in the past 15 years, operating in permissive environments that allow continuous input from higher command echelons. It won’t be that way in a contested environment.” Worse, failing to teach tactical commanders to exercise initiative and exert authority cripples their ability to lead when they become operational leaders themselves.⁹⁶

In addition, with the C2ISR recapitalization effort comes the opportunity to drive greater efficiency into the Iron Triad portfolio of capabilities. The current fleet of big wing assets may look similar to its 707-related lineage, but it reflects a series of disjointed procurement decisions that often focused upon what was easily available versus what actually made the most sense for the mission. Each type uses different airframe versions, flies on different engines and has dissimilar modification packages, such as avionics. In fact, the Air Force’s entire current 707-related force, which also includes tankers and specialized information-collecting assets, is based on at least four different aircraft models employing five different engines.⁹⁷

With this coming round of airborne C2ISR recapitalization, the Air Force should prioritize attributes that will make these systems far more cost-effective to operate across what will undoubtedly prove to be a long service life. Factors such as hourly operating cost, maintenance, parts availability, and broader fleet commonality can sway costs in a dramatic fashion. A smart fleet would provide significant cost savings to the Air Force while easing maintenance and logistics requirements. Harvesting efficiencies would also allow the Air Force to focus on the mission systems. If service officials select a common mission platform, it will be important to maintain this commonality throughout the respective service life of the fleet. The Air Force should apply certain modification programs (e.g., airframe and avionics updates, engine replacement) to all types in the C2ISR fleet in order to capitalize on economies of scale.

With this coming round of airborne C2ISR recapitalization, the Air Force should prioritize attributes that will make these systems far more cost-effective to operate across what will undoubtedly prove to be a long service life.

How the Air Force acquires these aircraft in the first place also requires change in order keep the big wing force current. Carlisle has highlighted the importance of “speed to ramp” acquisition in this regard, particularly regarding JSTARS recapitalization.⁹⁸ He pointed out that, in the past, the Air Force “bought and procured and fielded systems kind of in a stove-piped way.”⁹⁹ Yet, the service’s acquisition system still relies on highly bureaucratic, industrial-age procurement methods that take many years to field major new systems. Such an approach is no longer tenable as potential adversaries diligently exploit the ongoing explosion of commercially available technology to rapidly field new capabilities. “We can’t ... close our eyes and wait 15 or 20 years ... and allow all these technology development cycles to occur inside that 15- or 20-year cycle,” said Col Tom Coglitore, chief of ACC’s Air Superiority Core Function Team, at the July 2017 Mitchell Institute-sponsored air superiority forum.¹⁰⁰

To illustrate this point, it takes seven to eight years to produce and deploy a military space payload, compared to the three-year commercial standard—and that is after clearing lengthy design and budgetary hurdles, a process that can take an additional 14 years. According to the oft-cited Moore’s law, which forecasts a doubling in computer processing power every 18 to 24 months, a military payload launching in 2020 will potentially lag 16 generations behind the state-of-the-art. In other words, a launch operator’s smartphone in 2020 would conceivably pack 32,000 times the computing capacity as the satellite on the launch pad.¹⁰¹ This distressing truth extends throughout the Department of Defense’s information enterprise. Antiquated acquisition practices have resulted in an average of six and a half years between the time a new military computer receives its first funding to the date it becomes operational. Many C2 and ISR systems suffer similar technological obsolescence when fielded. “We cannot accept industrial-age acquisition timelines in an information-age world,” wrote Grynkewich in a July 2017 Mitchell Institute policy paper on future air superiority.¹⁰² According to the air superiority study he led, “capability development requires adaptable, affordable and agile processes with increasing collaboration between science and technology (S&T), acquisition, requirements, and industry professionals. Failure to adopt agile acquisition approaches is not an option. The traditional approach guarantees adversary cycles will outpace US development, resulting in ‘late-to-need’ delivery of critical warfighting capabilities and technologically superior adversary forces.”¹⁰³

Conclusion

Today, the Air Force faces yet-another technological pivot point, one as significant as the development of nuclear weapons, introduction of jet aircraft, and revolution in precision. The advent of the information age has changed the way US forces communicate, interact, and deliver effects. At the same time, the Iron Triad, an industrial-age construct that originated during the Cold War, is fast approaching the end of its operational utility, as newer technological and operational trends reshape warfare. “We will still need airborne C2ISR, including man in the loop,” according to Carlisle, but “it needs to be networked, and it needs to be integrated. It can be a combination of manned and unmanned or even semi-autonomous systems, especially in contested environments. ... It’s got to be netted back to a command node, but also capable of distributed control and graceful degradation.”¹⁰⁴

The need to protect airborne C2ISR nodes in any future US contingency or combat scenario is indicative of the increased threats facing the United States’ global land-based C2ISR network. Cyber attacks are growing more capable, adversary missile systems are becoming more potent, and the world has spent the last quarter century studying the American way of war and how C2ISR systems are the lifeblood of its success. The most appropriate way to discuss the future of C2 and ISR is in terms of a collaborative, modular, and distributed information enterprise. In some cases, particularly during high-end engagements, attack advantage will rely on sensors mounted aboard low-observable penetrating aircraft. These platforms, operating forward in heavily contested airspace, will be part of the combat cloud, linking with other “sensor-effectors” in every domain and to dedicated C2 and ISR aircraft operating in more secure airspace. They will build the degree of situational awareness necessary to succeed in their relevant area of operation.

The advent of the information age has changed the way US forces communicate, interact, and deliver effects. At the same time, the Iron Triad, an industrial-age construct that originated during the Cold War, is fast approaching the end of its operational utility, as newer technological and operational trends reshape warfare.

To consider that AOCs and DCGS will have geographic sanctuary would be naïve, and to rely on space-based or “assured” communications will create critical vulnerabilities that a peer or near-peer adversary will target for exploitation. These next-generation C2ISR aircraft will leverage the respective strengths of all the various aircraft involved in an operation. However, there will be scenarios and future missions where dedicated C2 and ISR aircraft freely overfly areas of operation in permissive airspace and act in a more-autonomous fashion, as demonstrated by ongoing operations in Afghanistan or over Iraq and Syria against Islamic State forces. Such sorties may often prove more cost-effective than relying on fifth generation nodes, while offering commanders enhanced mission flexibility. In the future, the Air Force may indeed conduct other more disparate GMTI missions in a peacekeeping context, as it did in Bosnia during the 1990s, as well as build comprehensive situational awareness in a heavily contested battlespace. The Air Force needs to be able to operate in all of these environments and have options available to cover any mission requirement, and do so as cost- and mission-effectively as possible.

This further emphasizes the need for an open-architecture approach regarding the design and modification of C2 and ISR mission systems, which, in turn, argues for significant acquisition reform. The Air Force must develop and maintain the ability to integrate existing aircraft with new capabilities as they appear, especially since no one can confidently predict the full range and potential of future technologies. In this regard, at least one element of the current Iron Triad represents something of a success story: “The proven successful cyclic modernization process allows the RC-135V/W to remain the leader within the Iron Triad in terms of mission and capability,” said one senior Air Force ISR leader. “Sustained priority and stable funding within the global integrated ISR portfolio will continue this [Department of Defense] benchmark success.”¹⁰⁵ Yet, as technology matures and the Air Force moves

...any meaningful change in how the US military prosecutes a mission as central as airborne C2ISR requires a fundamental evolution in thinking, beginning with how defense officials conceive of future systems and how operators employ them when the results matter most.

towards a more distributed C2 and ISR approach, the service cannot sacrifice capability and growth potential. It must seek solutions that will satisfy the demands of national security strategy and honestly articulate those requirements and what they will cost, rather than gravitate to sub-optimal systems simply because they appear to be the least expensive option at the time.

Finally, any meaningful change in how the US military prosecutes a mission as central as airborne C2ISR requires a fundamental evolution in thinking, beginning with how defense officials conceive of future systems and how operators employ them when the results matter most. For most of the history of war, military theorists like Sun Tzu and Carl von Clausewitz had no realistic conception of what people now call air-, space, and cyber power. Yet their fundamental lesson remains as applicable today as it did in their times: the human

element is ultimately paramount when communities of any sort come to physical blows. Humans have keen senses, however, and a brain to interpret the input it receives. Warfare remains a matter of perception, deliberation, and decision.

The men and women in the back of the big wing aircraft perform those functions every day, their senses extended by mechanical wonders inconceivable to their predecessors. That imperative will endure and become even more important in the future. As today’s Iron Triad passes into history, the country should leave it a worthy legacy by building on its accomplishments and moving three-dimensional warfare into a new era. 

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(From the foreground to background) An E-8 JSTARS, E-3 AWACS, and RC-135 Rivet Joint are displayed on the parking ramp of Shaw AFB, S.C., and joined by other aircraft during a 10th anniversary air tattoo and victory celebration for Operation Desert Storm, held in February 2001. (Photo by SrA Greg L. Davis, USAF)



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