



## The Mitchell Forum

# The Tactical C2 Imperative: Building a Resilient, Mobile Command and Control Grid

by Lt Col Daniel Longstreet, USAF

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### Abstract

China's military strategy frames modern conflict as a competition for information, indicating that U.S. command and control (C2) systems will likely be a high-value target, especially in the early phases of conflict.<sup>1</sup> Yet, the Air Force continues to rely on a static, ground-based command and control architecture that cannot survive inside a peer adversary's weapons engagement zone. Advancements in China and other adversaries' long-range strikes, electronic warfare, and proliferated unmanned capabilities can now hold U.S. fixed C2 nodes, which are predictable, targetable, and sustainment-intensive, at risk. These threats could collapse U.S. situational awareness and decision speed at the moment they matter most. Current modernization efforts, including the E-7 and future space-based capabilities, promise a robust theater-level sensing, communication, and command framework, but the Air Force must complement them with a mobile, federated C2 grid that distributes sensing and communications across maneuverable airborne and ground nodes to fully realize the value of these assets at the tactical edge. This comprehensive approach integrates three mutually reinforcing layers: tanker-hosted Battlefield Airborne Communications Nodes to provide resilient standoff bridging; low-cost aerial vehicles with modular sensor and communication payloads to create a meshed "inside fight" network; and mobile ground sensors to close gaps and reduce reliance on fixed infrastructure. Together, these elements create a resilient transport backbone that degrades gracefully under attack and preserves decision advantage. This, in turn, bolsters the "sense" and "act" functions essential to Joint All-Domain Command and Control and enables the early offensive counter-air and counter-missile operations required to reduce threat density and regain the initiative in contested environments. A mobile C2 grid is not an optional enhancement; it is the prerequisite for fighting and winning in contested environments.

## Introduction

The character of contemporary war is increasingly defined by competition for information, where the ability to sense, make sense, and act faster than an adversary determines operational success. The United States Air Force (USAF) performs this function today through a network of fixed, ground-based assets anchored by the Control and Reporting Center (CRC)—the foundational tactical C2 unit that deploys with an organic suite of sensors, radios, and datalinks.<sup>2</sup> The CRC's radar provides the primary air picture; UHF and VHF radio networks enable voice command and control between controllers and aircrew; and tactical datalinks such as Link 16 distribute the recognized air picture across the force. These feeds flow into the Tactical Operations Center (TOC), where battle management teams monitor and direct air operations from their C2 systems—detecting threats, tasking aircraft, and coordinating the movement of assets across the battlespace in real time. This architecture served U.S. forces well in the permissive environments of the post-Cold War era. Against near-peer adversaries with modern integrated air and missile defenses, it is now brittle—rapidly degraded or denied through long-range strikes, electronic attack, and persistent intelligence, surveillance, and reconnaissance (ISR) operations.

The USAF must transition away from static nodes and focus on a mobile, distributed C2 grid that integrates tanker-hosted Battlefield Airborne Communications Nodes (BACN), low-cost aerial vehicles (LCAVs), and mobile ground sensors to ensure tactical C2 remains survivable, adaptive, and effective in contested environments. Crucially, the mobility of this approach provides the survivability and resilience needed to conduct offensive counter-air and counter-missile operations that reduce the density of the adversary's strike capability. These physical and transport layers are the backbone of effective

combat operations and must survive contact—especially in the highest-threat-density environments. While the “sense-making” portion of the sensing-to-acting cycle is also an important part of the equation, even the most advanced fusion engines or decision tools are rendered ineffective if the underlying transport layer fails. By strengthening the “Sense” and “Act” functions through a mobile, federated grid, the Air Force secures the connective tissue that allows U.S. and coalition forces to survive the opening blows and immediately transition to the offensive operations necessary to regain the initiative.

## The Lethality of the “Inside Fight”

China's People's Liberation Army's (PLA) anti-access/area-denial (A2/AD) force posture in the Indo-Pacific theater illustrates the severity of the threat facing U.S. tactical C2. The PLA's A2/AD capabilities integrate long-range precision strikes, layered air defenses, robust electronic warfare (EW), and distributed ISR networks designed to deny freedom of action, erode initiative, and limit the ability of U.S. forces to sense and act within a high-intensity “inside fight” arena, as they must operate under persistent threat from ballistic missiles, cruise missiles, and integrated air defenses. Systems such as the DF-21 ballistic missile family extend this threat depth across the first island chain. They turn fixed radars and semi-permanent ground stations into liabilities, as the predictable emissions and sustainment requirements of these sites provide adversaries with lucrative targets.<sup>3</sup>

Electronic warfare compounds this vulnerability. Modern adversaries can jam, spoof, or deny satellite communications (SATCOM), GPS, and tactical datalinks, degrading sensor fusion and reducing track quality during the time frames commanders most need clarity.<sup>4</sup> These effects have been

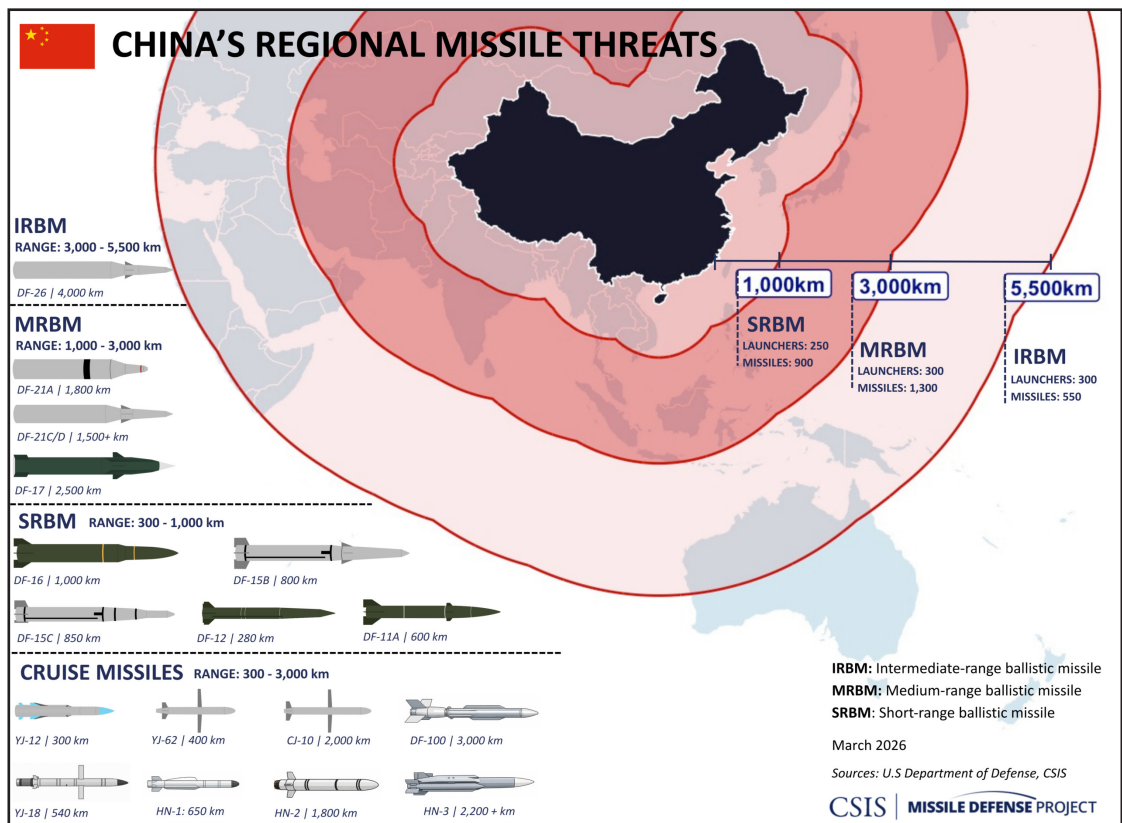


Figure 1: China's Regional Missile Threat. The first red shaded area represents the inside fight zone, where many of China's short-range missiles pose a threat to U.S. operations out to 1,000 km from China's coastline. While based on the maximum range of some of China's highest-density threats, it is important to caveat that China's missile assets are not entirely concentrated along its coast but are likely dispersed across its geographic depth. The larger two red shaded areas and beyond represent ranges from which U.S. operations would necessitate outside fight capabilities.

Credit: [Map courtesy of CSIS, updated March 18, 2026.](#)

well documented. In Ukraine, Russian EW systems—including the Krasukha-4 and Borisoglebsk-2—have repeatedly degraded GPS, disrupted tactical datalinks, and suppressed Ukrainian drone operations, forcing units to revert to voice and courier communications during critical windows.<sup>5</sup> In Syria, Russian forces operating from Khmeimim Air Base conducted GPS spoofing that disrupted navigation for U.S. military drones and coalition air operations, with Gen Raymond Thomas, then-head of U.S. Special Operations Command, describing Syria as “the most aggressive electronic warfare environment on the planet.”<sup>6</sup> In each case, even temporary loss of sensor feeds produced hesitation and delayed effects. In the inside fight, where seconds matter, this degradation directly undermines decision speed and initiative.

Cheap, proliferated unmanned systems further stress static architectures. Swarms of small unmanned aerial systems (UAS) and loitering munitions can saturate defenses, probe coverage gaps, and impose unfavorable cost-exchange ratios.<sup>7</sup> Their low cost and mass allow adversaries to accept the attrition of these assets while forcing U.S. forces to expend expensive interceptors or risk losing critical nodes, especially inside the threat envelope. The ratio is punishing: CSIS estimates the Shahed-136-class loitering munition costs roughly \$20,000–\$50,000 per unit, while a single Patriot PAC-3 interceptor runs approximately \$3.7 million—a cost-exchange ratio of up to 185:1 in the attacker's favor.<sup>8</sup> Adversaries willing to mass cheap UAS can rapidly exhaust finite missile magazines while achieving only selective effects.

Immobility produces predictability, emissions provide targeting cues, and sustainment creates additional vulnerabilities. The cumulative effect of this truth and the myriad PLA threats is a battlespace in which a static C2 architecture cannot survive. Once fixed nodes are degraded or destroyed, situational awareness collapses, decision speed erodes, and commanders lose the ability to shape the fight. This threat environment demands a transition from a fragile, static C2 network to a resilient, federated, and cost-efficient mobile C2 grid designed to degrade gracefully under attack. Most importantly, it must enable a Joint All Domain Command and Control (JADC2)—the DoD’s operational concept for linking sensors, decision-makers, and shooters across all domains into a common kill web that allows U.S. and coalition forces to sense, make sense, and act faster than the adversary.<sup>9</sup> The mobile C2 grid proposed here serves as JADC2’s physical and transport layer foundation. Without survivable connectivity at the tactical edge, JADC2 remains a concept without a nervous system: fusion engines and decision tools are rendered irrelevant if the underlying links that feed them are severed in the opening hours of conflict.

### **The Failure of Fixed Architecture** \_\_\_\_\_

Static C2 architectures long provided a critical advantage to U.S. operations in permissive environments. However, future operating environments are growing increasingly contested, leaving these same C2 systems susceptible to extreme communications degradation. They are now recognized as a major vulnerability in the inside fight with a peer aggressor. Their immobility, predictability, and sustainment were originally attributes that optimized and economized them for a different combat sphere that no longer exists against the United States’ biggest adversaries. They are

now limitations that create exploitable seams that peer and near-peer adversaries can target with long-range strikes, electronic warfare, and proliferated unmanned systems.

Immobility, once an attribute that enabled greater reliability, sustainability, and security in C2 networks, is now, perhaps, the most fundamental weakness. Fixed radars and semi-permanent ground stations provided high-bandwidth data feeds that supplied warfighters with a comprehensive picture of the battlespace and enabled targeting and tracking for precision strikes. But they cannot maneuver once emplaced, and their locations are now easily discoverable through advances in emissions detection, satellite imagery, and human intelligence. In a high-intensity conflict, adversaries can pretarget these nodes with long-range strikes, ensuring that they are destroyed or degraded early in a campaign.<sup>10</sup> Moreover, as the battlespace shifts, static nodes cannot reposition to cover new corridors of approach or emerging threat vectors; they remain locked to their initial placement even if that placement becomes irrelevant or threatened. This immobility is particularly problematic in the Indo-Pacific, where geography imposes a tyranny of distance and dispersed basing. A single radar or communication node emplaced on one island cannot support operations across thousands of miles of ocean, leaving coverage gaps that adversaries can and will exploit.

Predictability compounds this vulnerability. Static nodes emit continuously, producing reliable signatures that can be detected by passive sensors and mapped over time. Their logistics and sustainment patterns—fuel convoys, maintenance activity, and security presence—also reveal which nodes are most critical, giving adversaries clear indicators of priority targets. With this information, adversaries can pretarget fixed C2 nodes with ballistic missiles, cruise missiles, and drones, confident they will be present and

emitting when a campaign begins.<sup>11</sup> The knowledge of these behaviors enables efficient strike planning for U.S. adversaries, allowing them to exploit a cost-exchange ratio that disadvantages U.S. forces by using relatively inexpensive munitions to destroy high-value, irreplaceable C2 nodes early in a conflict.

Sustainment is a third major limitation. Static nodes impose heavier manpower and logistics burdens the further forward they are in the battlespace: they require convoys to deliver fuel, spare parts, food, and other essentials; protection details to defend against ground attack; and maintenance teams to restore functionality after degradation. Each of these activities creates additional signatures that a capable adversary can exploit.<sup>12</sup> Attempts to reduce this burden through autonomous or minimally staffed ground C2 sites have consistently underdelivered. Hardware degrades, software requires updates, and knowledge atrophies as personnel rotate—creating a persistent gap between the capability aircrew expect and what is available when it matters.<sup>13</sup>

Contested environments only compound these failure modes, introducing conditions that demand human judgment that no automated system can yet reliably replace. Protecting fixed sites also diverts offensive capacity: fighters and air defense assets re-rolled for site defense are aircraft no longer available for strike or suppression missions. In a contested environment, a large sustainment footprint becomes a liability rather than an asset. In a future conflict, a capable adversary need not strike a node directly—disrupting the logistics tail or degrading the maintenance cycle is sufficient to collapse C2 capability at a critical moment.

These attributes—once strengths, now liabilities—combined with overall reductions in C2 force structure, are why once-robust U.S. architectures are now brittle. If a fixed ground surveillance radar is destroyed early

in a campaign, coverage across a wide area will collapse. Commanders will lose critical SA, which will force them to deploy vital, finite assets into contested space without reliable information. If a ground station is jammed, communications will degrade, preventing commanders from directing forces coherently. If sustainment convoys are denied access to ground nodes, C2 will gradually deteriorate. Each of these outcomes imposes disproportionate costs on joint operations, eroding initiative and shaping campaign results before commanders can respond.

The vulnerability of static C2 architectures has grown as threats themselves have evolved and become more sophisticated. During the Gulf War, fixed radars and command posts provided reliable coverage because adversaries lacked the ISR and precision strike capabilities to target them. In Iraq and Afghanistan, static architectures continued to function effectively because insurgent groups could not meaningfully contest them. Against a modern peer competitor, that dynamic has shifted. In recent conflicts in Iraq and Syria, the proliferation of small UAS has enabled persistent attacks on coalition bases, culminating in the January 2024 drone strike on Tower 22 in northeastern Jordan—killing three U.S. soldiers and marking the first U.S. fatalities from an enemy aircraft since North Korean biplanes killed two Army soldiers on Cho-do Island on April 15, 1953.<sup>14</sup> These losses are a strategic harbinger: hardened, fixed sites no longer enjoy the protection they once did. Syria does not represent the only warning; static command posts, radars, and communications nodes in Ukraine have been repeatedly targeted by precision strikes, electronic warfare, and first-person-view (FPV) drones, forcing commanders to improvise and rely on mobility and dispersal tactics.<sup>15</sup> These lessons underscore that static architectures are no longer survivable in contested environments.

Doctrine already recognizes these limitations. Joint Publication 3-0 emphasizes the operational importance of maneuver, adaptability, and resilience, while Joint Publication 6-0 highlights the need for communications architectures that can survive degradation and denial.<sup>16</sup> Together, these publications caution against reliance on single nodes or predictable architectures. Current practice, however, diverges from this guidance. Fixed radars and ground nodes remain central to tactical C2 systems, even in contested theaters. High-demand airborne platforms vulnerable to long-range strikes, such as the E-3 AWACS and E-2 Hawkeye, remain irreplaceable for wide-area battle management and sensor fusion—but they exist in too few numbers and face serious survivability constraints inside contested airspace. This mismatch between doctrine and practice creates seams that adversaries can and will exploit.

Importantly, static C2 architectures fail not because of a single flaw, but because their numbers and design assumptions no longer match the threat environment. Their immobility, predictability, and sustainment demands make them rigid in the inside fight, where survivability requires dispersion, mobility, and graceful degradation. Their small inventories do not mitigate this challenge—they exacerbate it. These vulnerabilities create a requirement for mobile, distributed, and resilient C2—requirements that current modernization efforts only partially address.

### **Why Current Modernization Efforts Are Insufficient**

The Air Force is pursuing several initiatives to address the challenges of operating in a robust A2/AD environment, but each provides only a partial solution. One major effort is the potential procurement of the E-7 Wedgetail to replace the aging E-3 AWACS fleet.<sup>17</sup> The E-7 offers exceptional wide-area sensing and fusion capabilities, yet its survivability inside contested airspace

### **PACE (Primary, Alternate, Contingency, Emergency)**

#### **Per the Cybersecurity and Infrastructure Security Agency:**

*PACE planning helps organizations establish an order to deploy communications assets when capabilities are disrupted or degraded. The Primary level is a typical day-to-day method of communication. Alternate is the backup to the Primary. Contingency is used if both Primary & Alternate have failed. Emergency is the fourth level if all other levels are not working. A PACE plan moves from level to level based on failures of the current communication mode. Additionally, a plan for communications failures is good practice for critical missions.<sup>59</sup>*

remains limited. Integrated air defenses, electronic warfare, and long-range strikes make forward employment prohibitively risky, especially if the procurement scale of these airframes is small relative to the vast Indo-Pacific theater. As a result, the E-7 is best positioned at standoff ranges, where it can contribute fused tracks and localized battle management without becoming a single point of failure. This improves critical theater-level awareness but does not provide persistent tactical C2 inside the threat envelope.

Space-based architectures represent another major line of effort and will eventually form the primary global sensing and communications layer. These systems promise multimodal sensing, more resilient connectivity than today's SATCOM, and the ability to distribute information across domains at scale. However, that future remains years away, and space alone cannot shoulder the burden of a high-end fight. Reliance on a single domain creates a single point of failure, particularly early in conflict when space assets may be degraded, denied, or temporarily isolated. While this highlights the importance of Space Force's mission to establish superiority

in the domain, U.S. C2 should not be entirely dependent on access to one domain. A resilient architecture should integrate space capabilities within a broader PACE (Primary, Alternate, Contingency, and Emergency) construct, ensuring that sensing and communications persist across all domains rather than depending on space as the singular solution.<sup>18</sup>

Together, these initiatives reflect meaningful progress, but they do not fully address the demands of operating inside the threat envelope. Standoff platforms and future space layers provide critical contributions, yet neither can independently deliver the survivable, distributed, and persistent sensing and connectivity required in the inside fight. Closing this gap requires additional approaches that extend the architecture forward, increase resilience, and distribute risk across more maneuverable and survivable assets.

### **A Recommended Path to Assured C2**

To address the limitations of space-based and airborne C2, as well as the vulnerability of static ground nodes, the Air Force must strengthen the overall C2 architecture by adding a proliferated airborne layer, ensuring sensing and communications avoid reliance on any one domain. A mobile, federated airborne layer denies adversaries predictable targets and ensures that the loss of individual nodes does not collapse the architecture. Equally important, mobility provides the operational freedom required to support the early offensive counter-air and counter-missile actions that blunt the adversary's long-range strike complex. Together, these features create a resilient system that can withstand attrition, adapt to electronic attack, and maintain operational depth even when degraded. Combatant commanders need these mobile C2 architectures to preserve initiative in contested environments. Adopting this mobile, federated grid entails three complementary measures: leveraging tanker-hosted BACN-like

capability, modularizing LCAVs to support both sensor and communication payloads, and proliferating mobile ground sensors.

### **Tanker-Hosted BACN**

The first measure, and the most pragmatic near-term solution for resilient tactical C2, is the adaptation of aerial refueling tankers as hosts for BACN-like payloads. Tankers already operate in every theater, loitering at higher altitudes to support fighters, bombers, ISR aircraft, and other combat support aircraft. Their long endurance and loiter capability, as well as large payload capacity, make them ideal platforms for additional communications nodes. Integrating BACN-like capabilities onto tankers creates survivable, high-altitude communications bridges that federate disparate networks, extend voice communications, and sustain operational depth even when primary nodes are degraded.<sup>19</sup>

Operationally, tankers are indispensable assets in any campaign, as they must be present to sustain sorties. Their orbits place them at standoff ranges that provide a greater temporal buffer against incoming threats, allowing the tanker to serve as a persistent relay while remaining outside the densest concentrations of enemy integrated air defense systems (IADS). This positioning enables them to function as the last assured communications link between tactical C2 and aircraft entering the inside fight. Tankers also possess the physical space, power, and cooling to host communications payloads without fundamentally altering their primary mission. By dual-tasking tankers as refueling and communication bridging platforms, the Air Force leverages existing assets to fill a critical gap in tactical C2 without waiting for new acquisitions. This approach is cost-efficient, timely, and operationally compelling.

BACN has demonstrated its value as a communication bridge since its inception. One of its most critical functions is enabling tactical C2 battle management nodes to establish



Figure 2: HVAA Pod on KC-135.  
Credit: [U.S. Air Force Photo, November 19, 2025.](#)

a back-haul connection and communicate through BACN's suite of secure line-of-sight UHF radios with assets requiring voice control—including fast movers executing time-sensitive targeting and rotary-wing assets operating below radar line-of-sight. BACN also translates disparate communications links from various platforms across the datalink environment, ensuring that fighters, bombers, ISR aircraft, and ground command centers can share a common tactical picture. In permissive theaters like USCENTCOM, BACN has delivered an invaluable operational impact. Flying continuous orbits over Afghanistan and later Iraq and Syria, E-11 aircraft enabled voice and datalink connectivity between assets that could not otherwise communicate—linking low-flying Army aviation, ground special operations forces, and higher-echelon air operations centers across terrain that degraded line-of-sight radio.<sup>20</sup> At its peak in Afghanistan, a single E-11 sortie could bridge communications for dozens of simultaneous users across the battlespace, effectively multiplying the reach of tactical C2 with minimal additional forward infrastructure. Despite operating with a fleet of just two to four aircraft, BACN sustained around-the-clock availability through persistent orbit scheduling, demonstrating what even

a small proliferation of nodes can achieve.<sup>21</sup> The challenge is adapting this capability for contested environments and providing a much greater number of nodes to ensure tactical C2 remains effective. A tanker-hosted BACN-like capability provides a pathway to address this challenge, specific to the “outside fight.”

Back-haul communications are the cornerstone of assured connectivity and must be governed by a strict PACE planning construct. Currently, BACN is undergoing upgrades to support Ka-band back-haul SATCOM, which provides connectivity from virtually anywhere on the globe. This upgrade removes dependence on the Payload Control Element-Mission (PCE-M)—a dedicated ground station previously required to uplink tasking and route data to the BACN payload, which constrained where BACN aircraft could operate and required forward-basing of sensitive ground equipment. The Ka-band upgrade frees BACN-equipped aircraft to operate from any location with satellite access, dramatically expanding basing flexibility and reducing the logistics footprint required to sustain the capability—a critical enabler for the dispersed, austere basing that Indo-Pacific operations demand.<sup>22</sup> However, because Ka-band remains vulnerable to jamming and

environmental effects, the architecture must integrate Starshield—SpaceX’s government-exclusive, secure, low-Earth orbit (LEO) satellite network—as an alternate transport layer.<sup>23</sup> Starshield’s proliferated constellation allows the C2 back-haul to degrade gracefully; if an adversary denies one orbital segment, the tanker-hosted node can dynamically reroute data through surviving nodes. This multi-measure approach ensures that connectivity is never dependent on a single communication path or a small number of vulnerable satellites, complicating adversary targeting while preserving line-of-sight (LOS) bridging as “Contingency” and “Emergency” options, should all space-based assets be denied.<sup>24</sup>

Enabling this tanker-hosted capability will require addressing engineering challenges and standardizing configurations. During Exercise REFORPAC (Resolute Force Pacific) 2025, a modified KC-135 mounted a High Value Airborne Asset (HVAA) Pod to extend datalink capability (see figure 2).<sup>25</sup> Creating and standardizing wing-mounted BACN pods removes the need to drill additional holes into the airframe for extra antennas, thereby avoiding potential drag penalties and structural load challenges. Regardless of pods or internal configuration, BACN will require internal server racks with adequate power, cooling, and compatibility with refueling systems and avionics. Instrumented flight trials must assess aerodynamic effects, electromagnetic interference, and maintenance burdens to determine optimal configurations.

Operational employment of tanker-hosted BACN requires rehearsals in campaign-scale exercises to correct deficiencies and capture lessons learned, ensuring those lessons reach key stakeholders.<sup>26</sup> Planners must integrate refueling sorties with tactical C2 requirements and assess the impact of tankers as multi-role aircraft. While dual-tasking introduces complexities in electromagnetic signature management, these can be mitigated through

intermittent emission profiles and coordinated mission timing. Exercises must validate that tankers can transition between silent refueling and active C2 bridging without compromising the survival of the platform or the strike package. Employment must also incorporate lessons from industry and the recently activated 472nd Electronic Combat Squadron, whose experience operating BACN in real-world theaters is essential for refining standards and procedures.<sup>27</sup> Because these standards must function across combined operations, they require pre-authorized integration to support tanker bridges with allied waveforms. Sustainment modeling is also necessary to ensure payload maintenance does not degrade sortie generation or add undue burden to tanker maintainers. Finally, exercises must stress EW and SATCOM degradation and include attrition scenarios to validate PACE plans and meshed networking.<sup>28</sup> This not only aligns with joint operational and Air Force doctrine, but it will also be critical in a future fight with a PLA that prioritizes information dominance in its strategy.

### **LCAV-Hosted Modular Payloads**

The second measure focuses on heavily contested airspace, where the acceptable level of risk (ALR) significantly increases for manned assets. A capability solution designed to operate under these conditions must first complement and extend tanker-hosted communications. LCAVs could provide the agile nodes necessary for persistent meshed sensing and communications, serving as the connective tissue that extends the reach of tactical C2 into the most contested zones. Their utility to the inside fight lies in providing on-station presence at scale, where high-value airborne C2 platforms cannot safely operate. Their modularity, affordable mass, and attritability make them uniquely suited to highly contested airspaces characterized by electronic warfare and swarming unmanned threats.<sup>29</sup>



Figure 3: Concept rendition of Saab's AEW&C pods on an MQ-9B.  
Credit: Image courtesy of GA-ASI.

First, LCAVs must be modular. Standardized payload bays, common power and data harnesses, and plug-and-play sensor and communication suites enable rapid reconfiguration. Payloads can include compact Active Electronically Scanned Array (AESA) radars, which provide high-resolution air and surface search; Ground Moving Target Indicator (GMTI) sensors optimized for detecting low-slow-small threats such as UAS and ground vehicles; passive RF receivers that geolocate emitters without revealing the LCAV's position; Electro-Optical/Infrared (EO/IR) packages for visual identification and targeting; and BACN-like communication modules that extend the mesh communication network into contested airspace (see figure 3).<sup>30</sup> Modularity reduces spare types and enables a “swap-not-fix” sustainment model, which is essential for austere Agile Combat Employment (ACE) basing models. By utilizing self-calibrating sensors and ruggedized line replaceable units (LRUs), the technical burden is shifted from dispersed forward operational locations to their centralized repair main operating bases or organic depots.<sup>31</sup> Maintainers at remote operating locations would perform only organizational-level maintenance—high-level

diagnostic checks and physical pod swaps—restoring full sensor capability in minutes rather than hours. This reduction in forward maintenance allows for a lean logistical tail, ensuring that LCAVs remain responsive operational assets rather than maintenance-intensive liabilities.<sup>32</sup> Treating these modular payloads with the same logistics philosophy as munitions allows for a high personnel tempo and rapid reconstitution of the sensing mesh in the inside fight.<sup>33</sup> This sustainment model requires prepositioned modular spares and cryptographic material at coalition hubs to ensure rapid replenishment if attrition outpaces resupply. Finally, to ensure these nodes can be generated from degraded locations, LCAV platforms should utilize runway-independent launch systems, such as pneumatic catapults or rocket-assisted take-off (RATO).<sup>34</sup>

But perhaps the most decisive operational feature of LCAVs is scale. Affordable, attritable nodes increase the number of distributed emitters and radios, complicating an adversary's ability to economically or operationally remove C2 from the chessboard. Enabled by collaborative autonomy, these platforms can operate as a collective mesh, reducing the C2 burden on human controllers while increasing

the system's resilience. If a dozen LCAVs are destroyed by kinetic strikes or degraded by electronic warfare, more remain to sustain the grid and can maneuver autonomously to ensure priority locations are covered. Attrition must be accepted as part of the calculus; sensing and acting are not achieved through invulnerability but through redundancy. This inversion of the cost-exchange ratio forces adversaries to expend disproportionate resources to achieve minimal advantage.<sup>35</sup> The strategy, therefore, is to make disruption costly on the adversary for temporary tactical wins while preserving the ability of U.S. commanders to generate effects despite losses.

LCAV employment must also consider roles and sustainment. Forward LCAV pickets should emphasize detection and cueing with long-dwell sensor modes, passive reception of emissions, and stealthy profiles. Midline LCAVs perform relay, translation, and mesh functions to bridge terrain and maritime gaps, while trailing LCAVs provide redundancy. Swarm control and mesh logic should allow dynamic controller handoff between ground C2 nodes, tanker hosts, or airborne C2 fusion nodes, so authority flows to the node best positioned for survivability and decision speed.<sup>36</sup> This layered employment ensures that loss of forward nodes does not collapse the architecture, but rather triggers a dynamic rerouting of data through the surviving midline mesh.

Even with robust sustainment and layered LCAV roles, human-in-the-loop considerations remain critical as operators must interpret expanding sensor reports and make decisions when conditions are contested or unclear. Sensor-equipped LCAVs and ground sensor networks will generate vast amounts of data. These nodes can transmit digitized sensor reports without saturating available datalinks by utilizing standardized, low-bandwidth message formats such as ASTERIX. The C2 architecture must ingest

these disparate, structured feeds to provide a common, fused picture for human judgment to govern lethal or escalatory responses. Automation at the C2 node should manage simple failover, routing tasks, and the initial correlation of these text-based sensor reports, while elucidating contested decisions for human controllers. Training pipelines must incorporate federated feed management and degraded operations under electronic attack and node loss.<sup>37</sup> Without rigorous training, human operators risk being overwhelmed by data volume, misled by degraded feeds, and confused by how to appropriately respond. The architecture's resilience depends on the C2 system's ability to synthesize these standardized sensor reports into actionable intelligence.

Testing and experimentation are vital to successfully employing LCAVs as a meshed swarm. Golden Horde experiments demonstrate collaborative autonomy and dynamic target changes, while mixtures of exquisite and low-cost sensing systems illustrate how swarms can generate actionable ISR.<sup>38</sup> These experiments show that LCAVs can operate as a federated swarm, dynamically allocating tasks and rerouting coverage, even with attrition. The ability to mass low-cost platforms with advanced autonomy creates resilience that static architectures cannot replicate.

The Air Force must heavily invest in LCAVs as a part of the Collaborative Combat Aircraft (CCA) program to enable platform-agnostic C2 and inside fight communications. LCAV sensors provide the maneuverable nodes necessary to sustain tactical C2 in contested environments where fixed infrastructure is compromised. Their modularity, redundancy, and federation compel adversaries to expend disproportionate resources to achieve minimal advantage. Ultimately, LCAVs could ensure that tactical C2 remains effective in the inside fight—transforming the sensing grid from a vulnerable chain into a resilient, self-healing mobile mesh.

## **Proliferated Mobile Ground Sensors**

Another measure needed to enable more effective C2 is the proliferation of a suite of mobile ground sensors. Ground sensors complement airborne nodes with low-signature, persistent coverage purpose-built for three functions: cueing airborne assets onto inbound threats, providing base defense early warning, and sustaining a common tactical picture at forward locations where airborne C2 cannot continuously orbit. While LCAVs provide maneuverable sensing, ground-based passive arrays offer a terrestrial anchor that remains on-station regardless of weather or flight-time constraints. Passive arrays provide cueing without generating the continuous emissions that light up their targetable location, effectively neutralizing an adversary's ability to employ passive-homing munitions. These nodes can detect targets without ever revealing their own position by leveraging bistatic and multi-static geometries to exploit ambient electromagnetic energy—such as adversary radar or commercial broadcasts. Smaller active radars should be sparingly used, operating in low-probability-of-intercept/low-probability-of-detection (LPI/LPD) modes, and relocated frequently to deny geolocation. The architecture's utility depends on federation and self-healing: Base Defense Operations Centers (BDOC), tactical controllers, LCAV relays, tanker hosts, and airborne C2 fusion nodes must be able to access surviving sensor inputs concurrently so no single loss significantly degrades the tactical picture.<sup>39</sup> Ground sensors thus provide resilience through dispersion and federation, complementing airborne attritability with terrestrial persistence.

Current tactical C2 ground sensors in the Air Force inventory are easily detectable, provide limited detection capability, and have challenging sustainment considerations. The current solution is to replace an outdated radar with a new, far more capable sensor able to detect modern stealth systems and small

UAS. This active radar provides a needed capability but can easily be targeted by a near-peer adversary and should not be the only ground-based sensor fielded in the broader C2 architecture.<sup>40</sup> C2 program management offices must not stovepipe solutions to organic, single-sensor solutions. Rather, sensors should be treated as platform-agnostic contributors to a greater sensing grid that battle management units can leverage for control. To achieve true “meshed sensing,” the architecture must incorporate modal diversity—integrating acoustic, seismic, and infrared sensors alongside RF arrays to create a spoof-resistant sensing layer.<sup>41</sup> Single-type sensor solutions are dangerous at best and catastrophic at worst, as adversaries can overwhelm wide-area surveillance sensors with a variety of munitions. The solution must include a mixture of sensors and active and passive radars, called “meshed sensing,” across different bands, with maneuver and mobility integrated into the architecture from the outset.<sup>42</sup> By digitizing these multi-modal detections into standardized sensor reports at the point of origin, the sensing layer ensures immediate, actionable data is available to the broader C2 grid.

## **Optimizing Integration**

Operational concepts must integrate all components of the architecture: tanker-hosted BACN, LCAV swarms, ground sensors, tactical C2, and space. Sensor-to-shooter flows must be rehearsed under contested conditions to ensure that data from ground nodes and LCAVs can be routed through space assets or tanker-hosted BACN, then fused by E-7s or ground C2 before reaching shooters. This rehearsal is critical to validating the “self-healing” nature of the mesh, ensuring that if a space-based link is jammed, the logic automatically re-routes sensing data through a tanker-hosted bridge or an LCAV bridge without manual intervention.

To sustain these flows, BACN should be conceptualized as a Family of Systems (FoS),

with podded variants mounted on tankers and other aircraft providing survivable standoff bridging, and LCAV-integrated variants proliferating inside contested airspace. This approach ensures resilience through diversity, simplifies sustainment through shared baselines, and elevates BACN from a low-density enabler to a portfolio capability that keeps sensor-to-shooter integration adaptive across the spectrum of operations. This tiered BACN approach allows the outside fight tankers to remain tethered to the inside fight LCAVs through a common waveform architecture.

Translating the FoS concept into practice requires automated mission-management tools to assist in modeling BACN tasking and tanker allocation to balance refueling and communication-extension missions. Integration with ACE and distributed operations must be rehearsed, ensuring that LCAVs and ground sensors can be sustained across dispersed hubs. Exercise design must stress attrition, electronic warfare, and coalition complexity, forcing the architecture to adapt under pressure. The goal of these exercises must be to find the failure points of the mesh, identifying the minimum number of surviving nodes required to maintain a functional common tactical picture.

Doctrine provides clear opportunities to test and experiment with new characteristics of warfare. The USAF must emphasize rapid technological adaptation and resilient communications and experiment in joint operational environments.<sup>43</sup> Additionally, the JADC2 operational concept frames the imperative to connect sensors to shooters across domains, advocating layered redundancy and federation rather than dependence on single nodes.<sup>44</sup> These doctrine-based guidelines will help facilitate rapid development of tactics, techniques, and procedures (TTPs), particularly around PACE construction and acceptance criteria for attritable systems. Experiments must be campaign-scale, designed for measuring the sensor-to-shooter

timeline, latency, and sustainment costs.

Legal, policy, and governance issues must be addressed. The use of commercial SATCOM and Global Navigation Satellite System (GNSS) augmentation and automated control handoffs require preexisting legal frameworks and policy waivers to operate under crisis. JADC2 governance must delineate authorities for data translation and define rules and classification handling for bridged data through streamlined Cross-Domain Solution (CDS) authorities.<sup>45</sup> Expediting this must include preapproved exceptions and emergency authorities; without them, robust technical federation risks being constrained by legal or political stagnation and delays. Finally, acquisition authorities must prioritize modular payloads with common harnesses and simplified calibration so that maintenance levels at ACE hubs remain manageable. Without a comprehensive framework, JADC2 and its subsequent lines of effort risk stovepiped development and slow progress.<sup>46</sup>

### **Counter-Arguments: Fidelity, Vulnerability, & Scaling**

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A common criticism of a distributed C2 grid is the perceived trade-off between cost and capability. Skeptics argue that attritable sensors lack the fidelity of high-end, exquisite platforms. However, multi-node sensor netting mitigates this limitation; by fusing overlapping, complementary modalities from different geometries, the architecture could produce composite tracks that rival—and in some cases exceed—the accuracy of a single exquisite sensor. This approach aligns with JADC2's emphasis on distributed sensing and cross-domain fusion rather than dependence on any single platform.

Cost concerns also arise regarding the procurement of large numbers of LCAVs. Yet this critique overlooks the advantages of portfolio optimization. By treating payloads

like munitions—modular, swappable, and platform-agnostic—the Air Force avoids the traditional acquisition model in which sensors are permanently tied to specific airframes. Shifting to this philosophy mirrors the strategic imperative to decouple mission capability from legacy airframes, ensuring every platform—from tankers to LCAVs—can act as a sensor and collaborator in the mesh.<sup>47</sup> This reduces lifecycle costs, increases flexibility, and accelerates fielding.

Critics of the outside fight often focus on tanker vulnerability, arguing that hosting BACN on refueling aircraft creates “magnet” targets out of already high-value platforms. This view mischaracterizes the operational reality: tankers are already priority targets in contested environments. Integrating BACN does not increase their risk profile; it transforms them from passive logistical assets into active contributors to the kill web.<sup>48</sup> Moreover, the Family of Systems approach ensures that no single tanker becomes a critical node. If a tanker-hosted relay is forced to egress or is attrited, LCAV relays and surviving airborne nodes automatically reroute data, preventing the catastrophic C2 collapse associated with the loss of a traditional airborne C2 platform.<sup>49</sup> The architecture is designed to degrade gracefully rather than fail abruptly.

### **Cost Considerations: Fielding Velocity & Fiscal Efficiency**

The financial and operational case for a distributed C2 grid rests on two pillars: accelerated fielding and significant cost savings relative to legacy “exquisite” airframes. First, tanker-hosted BACN can be fielded rapidly through Minimum Viable Product (MVP) approaches. Exercises such as NORTHERN EDGE 2023 and REFORPAC 2025 demonstrated that the KC-135 Datalink Enhancement (DE-MVP) can already assume primary forwarding and Net Time Reference (NTR) responsibilities

traditionally performed by E-3 and E-11 platforms.<sup>50</sup> Because the program leverages proven technologies and software in use across the Department of Defense—specifically the Real-Time Information in the Cockpit (RTIC) program scheduled for installation on 266 KC-135s—the Air Force can achieve widespread bridging within years rather than decades.<sup>51</sup> Furthermore, using the KC-135 Federated Mission Systems ensures that upgrades “rarely impact aircraft airworthiness,” allowing the service to improve the speed of integration and test via Open Mission Systems (OMS) and Universal Command and Control Interface (UCI) standards rather than lengthy structural modifications.<sup>52</sup> This modularity allows the fleet to integrate future waveforms as a pathway to enable long-range kill webs.

Second, the fiscal costs are a fraction of traditional C2 acquisition. The Air National Guard KC-135 Strategic Roadmap notes that external pods can be procured for approximately \$500,000 per set of two for the KC-135, with an additional \$800,000 to equip the tanker with internal power and data transmission lines if needed.<sup>53</sup> Transitioning the pods to the KC-46 would incur approximately \$120,000 per set of two pylons. Additionally, the DE-MVP has evolved from two full pallets of equipment to a single 19-inch server rack, enabling a lean, roll-on/roll-off (RORO) capability that can be deployed as missions dictate.<sup>54</sup> By leveraging the existing KC-135 fleet—which will continue to provide the preponderance of refueling capacity to 2060—the Air Force buys down risk for the Next-Generation Air-Refueling System (NGAS) and KC-46 programs while simultaneously fielding a resilient, cost-effective C2 mesh.<sup>55</sup> This approach forces adversaries to expend disproportionate resources to disrupt a distributed architecture that is inexpensive to proliferate, quick to regenerate, and delivers meaningful capacity in the short term.

## Summary of Executable Recommendations Across the Force

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Programmatically, near-term prioritized recommendations must be pursued with speed and across multiple lines of effort. First, the U.S. Air Force should initiate tanker BACN-pod trials in theater with allocated sortie packages that mirror expected operational refueling tempos. Trials should measure aerodynamic, maintenance, and sortie-generation effects as well as EW resilience and routing performance. Second, the service can accelerate LCAV procurement with C2 portfolio-determined modular payload kits, standard harness interfaces, and calibration tools for austere swaps.<sup>56</sup> Additionally, the Air Force should look toward pairing procurement with forward attritable replenishment and coalition-supported and interoperable logistics plans to increase resiliency. Third, field mobile, passive-heavy ground sensor mixes with strict emplacement and Standard Operating Procedures (SOPs) tied to base defense centers and integration into the federated grid.<sup>57</sup> Finally, continue procurement of space-based capabilities, the E-7 Wedgetail, and the E-2D as standoff C2 and fusion nodes to exploit their sensor reach while accepting survivability limits.

### Conclusion

The character of modern warfare has shifted decisively against static command and control architectures. Precision strike, advanced electronic warfare, proliferated sensing, and attritable unmanned systems now allow capable adversaries to locate, target, and degrade fixed C2 nodes with speed and confidence. In this environment, immobility, predictability, and sustainment requirements are no longer manageable risks; they are decisive liabilities. Tactical C2 that cannot maneuver, adapt under attack, and degrade gracefully will fail early in a high-end conflict and cede initiative at a critical moment. Survivable command and

control preserves decision advantage during the opening phase of conflict, creating the conditions necessary for immediate offensive counter-air and counter-missile operations that disrupt the systems generating that threat.

Preserving initiative in contested environments requires a fundamental transition from a static, node-centric architecture to a layered, mobile, federated grid designed with attrition, disruption, and uncertainty in mind. Such a grid must integrate tanker-hosted BACN-like capabilities to sustain assured communications outside the inside fight, proliferate low-cost aerial vehicles to provide a stand-in, attritable sensing and communication bridge, and disperse mobile ground sensors to provide persistent, low-signature sensing and resilience. Together, these elements form a mutually reinforcing architecture that denies U.S. adversaries the ability to catastrophically degrade tactical C2 through the loss of a few high-value assets. The objective is not to operate indefinitely beneath missile saturation, but to enable rapid suppression of the launch, sensing, and air defense systems that make such saturation possible.

Critically, this approach does not seek invulnerability. Instead, it embraces controlled attrition, redundancy, and federation as the means of sustaining decision advantage under attack. By inverting the cost-exchange ratio and compelling adversaries to expend disproportionate resources to achieve only temporary or localized disruption, a mobile C2 grid restores operational depth and compresses the sensor-to-shooter timeline, even as individual nodes are degraded. Initiative is preserved not because the architecture is unbreakable, but because it is adaptive, distributed, and difficult to dismantle at scale. Preserving decision advantage enables operations to transition immediately from absorbing initial strikes to degrading the adversary's long-range strike complex at its source.

The Indo-Pacific theater presents the most demanding test of this concept. Vast distances, dispersed basing, coalition complexity, and dense A2/AD systems mean that the traditional solutions of large, exquisite platforms and fixed infrastructure cannot be relied upon as primary enablers of tactical C2. A mobile, federated grid instead enables U.S. and allied forces the ability to target and disrupt long-range strike complexes and integrated air defenses, reducing the density of the threat envelope over time. While future platforms like the E-7 Wedgetail and space-based sensors will be indispensable for wide-area sensing and fusion, their survivability constraints require that they operate as stand-off-to-stand-in contributors to a broader federated grid rather than as central, forward-employed hubs. Platform-agnostic tactical C2 must be designed from the outset to function when these platforms are constrained, degraded, or temporarily unavailable.

The technology required to build this architecture largely exists today. The primary obstacles are not technical feasibility, but institutional inertia, programmatic stovepipes, and delayed acceptance of attrition as an operational reality. Failure to act now risks preserving a precarious, antiquated C2 infrastructure that adversaries are already rehearsing to dismantle. Conversely, deliberate experimentation, rapid prototyping, and campaign-scale coalition exercises that stress degradation and attrition can accelerate the transition to a survivable C2 grid aligned with joint doctrine and JADC2 objectives.

It is imperative that tactical command and control evolve before conflict exposes its vulnerabilities at scale. A layered, mobile, federated grid is not an optional enhancement but the prerequisite for fighting and winning inside the contested battlespace of the Indo-Pacific and beyond.<sup>58</sup> This architecture provides the backbone necessary to sustain the “Sense” and “Act” functions under fire. More importantly, it provides the critical linkage required to execute a rapid offensive counter-air and counter-missile campaign that denies adversaries sanctuary to sustain saturation attacks. By federating airborne, space, and ground layers into a survivable system, the Air Force ensures the connective tissue of the force remains intact. Survivability preserves decision advantage, but offensive action restores freedom of maneuver. A federated, mobile C2 grid enables both and ensures U.S. forces can absorb the initial blow, dismantle the systems that produce it, and regain the initiative in contested conflict. ✪

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## About the Author

**Lt Col Daniel Longstreet, USAF**, is a Master Air Battle Manager and student at the Air War College, where he focuses on joint warfighting, strategic leadership, and principles of strategy. He has over 2,200 flying hours in the E-3 AWACS, including more than 500 combat hours, and led as the Director of Operations and Commander of two different Control and Reporting Centers (CRC), including a CENTCOM-based CRC that operated through the intense fighting of 2023–2025. His operational experience spans the AWACS, the CRC, and Air Operations Center (AOC), serving as the Korea Joint Interface Control Officer and Senior Air Defense Duty Officer. He has held C2 leadership roles at Pacific Air Forces Headquarters and has deployed multiple times in support of CENTCOM and SOUTHCOM operations.

