



Fifth Generation Air Combat: Maintaining the Joint Force Advantage

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Abstract

Fifth generation aircraft have come of age, and are now a critical element in US power projection and combat operations. This paper aims to provide joint and combined commanders, functional component commanders, allies and coalition partners, as well as interagency and congressional leaders a foundation-level explanation of a “concept of employment” (or CONEMP) for fifth generation aerial warfare capabilities.

The authors lay out the characteristics and requirements of fifth generation aircraft systems, and describe how these assets are leveraged in present and future joint and combined warfare. Five basic concepts are highlighted, as focus areas for commanders and others, to ensure an adequate understanding of the support structure these aircraft require. These concepts include preparations, mission data elements, deployment, employment, as well as logistics and sustainment.

This paper focuses on explaining what a commander needs to be aware of in each of these areas to facilitate air campaign success. With these concepts detailed, the paper concludes with a theoretical vignette, set 10 years in the future, describing an unfolding conflict with a narrative on how fifth generation air forces are utilized in successful joint operations. This scenario shows how these capabilities can ensure success in the most challenging of future environments, and simultaneously highlights priorities to focus on today, and going forward, in order to ensure this success.

Introduction

“Fifth generation” aircraft are coming of age, becoming a key element in US power projection in the 21st century. The F-22 Raptor, first conceived in the later years of the Cold War as a response to advances in Soviet air combat capabilities, has now operated in the combat air force for over a decade, and played a key role in the kickoff of Operation Inherent Resolve over Syria in September 2014, and subsequent operations.

In addition to its speed, maneuverability, and stealth capabilities, commanders have discovered the Raptor brings immense situational awareness capabilities by utilizing its sensors in ways few could have imagined in the program’s infancy over three decades ago. The F-22’s ability to perform strikes, conduct escort operations, collect and manage information, pass taskings in real time, and provide dynamic targeting information “has even exceeded our expectations,” said Air Combat Command chief Gen. Herbert “Hawk” Carlisle in February 2015.¹

The F-22 has the ability to make every asset it works with better, as it connects and leverages the entirety of a strike package in ways older combat aircraft could not do. This holds great implications

for the future of air combat, and for joint operations as a whole. Fifth generation aircraft “are key to military success in future conflict,” Carlisle said. The technologies in the F-22, and the F-35, provide situational

awareness of a conflict that is unparalleled in modern war, and lethal tools that enable both aircraft and capabilities in other domains to perform at a higher level. Fifth generation assets employed by joint forces give the US “the asymmetric advantage we need to win our nation’s wars,” Carlisle added.

This paper aims to explain not just what makes fifth generation aircraft such vital assets for the American way of war, but how these systems could be employed in future conflicts, by joint and com-

bined force commanders, functional component commanders, allies, and coalition partners. It also aims to demystify some of the assumptions about just what fifth generation aircraft do, and are capable of doing in modern warfare, for officials in US interagency organizations, Congress, and members of the general public.

This paper illustrates and defines a “concept of employment” (or CONEMP, as it is known within the US Air Force) for fifth generation aircraft. It focuses primarily on airborne systems. But this focus is not an oversight. There are inherent linkages between fifth generation aircraft and the larger “fifth generation enterprise” which includes space and cyber capabilities. This enterprise also deserves an equal level of attention and awareness. But the rapid growth of fifth generation aircraft in the force structure over the next decade demands a focused examination of the collective enterprise these tools enable for joint force operations, in order to maximize their strategic, operational, and tactical advantage.

Fifth Generation Aircraft, Defined

For the purposes of this paper, we must define what a “fifth generation” aircraft means in the context of modern military operations. A fifth generation aircraft is capable of operating effectively in highly contested combat environments, defined by the presence of the most capable current air and ground threats, and those reasonably expected to be operational in the foreseeable future. Currently fielded fifth generation aircraft include the Air Force’s F-22A Raptor and the US Marine Corps F-35B Lightning II, with the USAF F-35A targeted to achieve initial operational capability later this year.

There are many characteristics of fifth generation aircraft that separate them from older aircraft. These include, primarily, multi-spectral low observable (LO) design features (such as radar, infrared sensors, and visual situational awareness tools), along with self-protection and radar jamming capabilities that delay or deny enemy systems the ability to detect, track, and engage the aircraft. These aircraft also feature integrated avionics, which autonomously fuse and prioritize the

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aircraft's multi-spectral sensors and off board data, providing an accurate real-time operations picture for the pilot, and the ability to download data for post-mission analysis. This is a present-day example of "man-machine teaming." Advanced on-board diagnostics help vital monitoring of the aircraft's health, accurately reporting faults as they occur, increasing overall system performance and reliability.

Resilient communications, navigation, and identification tools and techniques are also crucial aspects of fifth generation aircraft, designed to counter enemy attempts to jam, deny, or confuse these vital capabilities. Fifth generation aircraft are also empowered by robust networks, linking individual aircraft to create a common, accurate, and highly integrated picture of the battlespace for friendly forces. The aircraft and its subsystem designs are also closely integrated, far more intricately than older aircraft. This helps to maximize lethality and

survivability while enabling decision-making superiority by reducing the number of actions required by the pilot. The effect of these tools in total turns operators of these advanced aircraft into mission commanders, rather than having them focus on managing and operating subsystems (like in older third and fourth generation "legacy" aircraft).

Despite their capability, at present fifth generation aircraft comprise a fraction of the current combat air forces. The average age of a current USAF airframe is 27 years, and rising.² Modernizing fighter and bomber forces with sufficient numbers of fifth generation aircraft is critical for continued combat relevance, especially in light of three important trends:

- Modern Integrated Air Defense Systems (IADS) have created regions where fourth generation aircraft cannot effectively penetrate and hope to survive.³

- Threat aircraft, air-to-air missiles (AAMs), electronic attack (EA), and electronic protection systems have advanced beyond the capabilities of US fourth generation fighters.⁴
- Fifth generation aircraft provide a wider variety of wartime options in many scenarios, preserve US technological advantage over near-peer threats, and serve as force multipliers by increasing the situational awareness and combat effectiveness of legacy aircraft.

Understanding Fifth Generation Operations

"The F-35 Lightning II will be the keystone to future US airpower. It is critically important that this fifth generation system is integrated into the Pacific theater in a well-informed and collaborative manner to leverage the benefits of not only our sister services, but also those of our trusted partners in the largest theater on the planet."

*Gen Lori R. Robinson, USAF
commander, US Northern Command
former commander, Pacific Air Forces*

An effective capability, such as fifth generation aircraft, is only a tool—and must be properly utilized with effective preparation to perform at its best and empower joint operations fully. To achieve success with any fifth generation aircraft requires all personnel associated with the generation and employment of these capabilities, to include aircrew, maintenance, and support personnel, to optimize their roles in ensuring effective combat operations.

Airmen must have an intuitive understanding of their aircraft and how it performs in relationship to the threats it might encounter.⁵ They must train for the most demanding scenarios against the latest IADS and enemy aircraft, and US military services, allies, and partner nations must also develop a strategy with fiscally realistic and executable plans to adequately train against advanced adversary advanced capabilities (including air-to-air, surface to air, space, and cyber threats). These plans and preparations

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must include an appropriate mix of live, virtual, and constructive (LVC) training scenarios and exercises.⁶ This is of added importance in the context of fifth generation aircraft, as flight simulator training is even more important than with older aircraft. Given the current Department of Defense (DOD) fiscal forecast, the US military

will need to increasingly rely on the LVC environment to rehearse for realistic combat scenarios with improved fidelity. To a greater extent than training with legacy aircraft, fifth generation simulators must provide realistic training through timely concurrency with the aircraft, sufficient fidelity for realism, and appropriate connectivity to other assets for realistic exercising.

In addition to operators, maintenance personnel require more training to adequately keep up fifth generation aircraft and their vital low radar signatures.

To improve survivability against adversary IADS, the signatures of fifth generation aircraft must be actively managed, much like airframe inspection and engine maintenance schedules.⁷ Commanders must ensure that training resources are adequately provided for these assets to capitalize on the unique capabilities they bring to the operational environment. All personnel must be trained to understand the importance of specialized security requirements for fifth generation aircraft. From ensuring physical security and cyber standards to balancing protection of classified capabilities with realistic training, personnel must appreciate and carry out security guidelines for daily operations effectively, as well as those for allied, coalition, and partner training exercises and combat operations. Lastly, commanders and support personnel must understand the fifth generation aircraft global sustainment system, for both home station and during deployed operations. Commanders should consider and actively track changing threat conditions, and how these can impact the ability to sustain their fifth generation operations.

Fifth generation aircraft bring incredible capability into combat, but are also some of the most data-dependent machines in the US inventory, and require significant amounts of information in order to operate at their best.

Fifth generation aircrew and aircraft rely on mission data files to enable onboard systems to accurately identify friendly, neutral, and adversary systems. This data allows fifth generation pilots to enhance their stealth, or low observable (LO) signature management, enabling the aircraft to survive and maintain situational awareness of events in combat even when operating in close proximity to advanced threats. The US Air Force, sister services, allies, and the intelligence community have an essential role in populating and updating these files. Not only is this mission data necessary for internal operation of these aircraft, this data also contains the capability for fifth generation systems to communicate their fused sensor products off board to other aircraft, providing an integrated common operating picture of a conflict or contingency. In the future, near-real time exploitation of fifth generation aircraft's unique information collection capabilities will become increasingly mandatory to operate in more sophisticated threat environments.

To achieve true combat systems integration, this fused sensor information must be linked up with USAF's much larger legacy aircraft forces, and select command and control nodes via data links and cloud-based communication architectures. By linking this information to the entire force, an actionable common operating and targeting picture can be created for commanders and decision makers. As sensors, communication protocols, and data links improve, all friendly forces should be able to share the multi-domain situational awareness fifth generation aircraft can generate, in cooperation with other assets. To perform this effectively, though, requires a detailed systems understanding of data link architectures, and protocols to ensure communication compatibility across the enterprise.⁸

Squadrons of fifth generation aircraft deploy today extensively, much like fourth generation units that preceded them (aircraft such as F-16s, F-15s, and others). But to realize the potential of fifth generation aircraft in modern joint operations, fifth generation communities in the USAF must make several improvements.

First, units must improve deployment reaction time and speed, as windows of opportunity to penetrate IADS or to destroy high value targets may be fleeting. Second, fifth generation aircraft units must work diligently to minimize the required amount of forward-deployed equipment and personnel, and fully understand the logistics, sustainment, and communications limitations at a deployed location. Third, the Air Force must work to increase flexible basing options available for fifth generation aircraft

(such as increasing the number of airfields the Air Force can deploy to), and build a fuller understanding of the impact these options will have on operations, maintenance, and command and control in dispersed locations. This includes not only conducting combat operations from bases owned by our international partners, but also operating at relatively austere locations.

Deploying and operating from limited support locations does come with some challenges. The US and its allies must ensure support (logistics and connectivity) can be delivered to forward airfields where commercial carriers may not operate. Finally, fifth generation aircraft sustainment and support systems must be hardened with sufficient redundancy to ensure resilience under attack. This hardening must be multi-domain, and the sustainment and support systems must be able to survive and operate in the face of both kinetic and cyber attack.

Combat employment of air assets may occur across a wide spectrum of potential conflicts, from permissive environments, where legacy and fifth generation aircraft can operate together with ease, to highly contested environments, where only fifth generation aircraft can operate effectively. In permissive or moderately contested environments, the force packaging of airpower can combine both legacy and fifth generation aircraft to maximize survivability, and the lethality of the force. Since legacy aircraft sensors alone may be insufficient to detect threats, or may be overwhelmed by the quantity of threats, fifth generation aircraft may provide the most utility by sharing their fused operations picture via a well-constructed data link—feeding this information into the communications architecture, which disperses this picture to as many legacy aircraft as possible.

Likewise, legacy aircraft increase a force's ordnance capacity due to the internal carriage configurations of fifth generation aircraft. Modern fifth generation aircraft can offer targeting solutions for fourth generation assets via established data links, while themselves targeting threats only by exception. This gives commanders an incredible amount of operational flexibility. In highly contested environments, an air component commander might use only fifth generation aircraft to bypass an IADS and neutralize the objective. Alternatively, fifth generation aircraft can destroy or degrade enemy defenses to create a temporary or localized permissive (or semi-permissive) environment where legacy aircraft can operate with relative freedom of action. This often requires fifth generation aircraft to operate on the leading edge of the force package, allowing legacy aircraft to ingress and destroy priority targets. Once combat begins, however, adversaries may adjust tactics, as well as the operating parameters of their systems. Thus, leaders will need to ensure that appropriate intelligence, surveillance, and reconnaissance (ISR) assets report this information quickly to the mission data enterprise supporting fifth generation aircraft and other elements of joint force operations.⁹

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This kind of seamless information sharing must be achieved to enable rapid reprogramming and re-release of mission data files for optimum employment of all allied assets.

In order to make this employment concept a reality, collaboration is critical. USAF units must be able to share lessons with other US military services and, as required, select allied and coalition partners. Sharing with international partners

USAF units must be able to share lessons with other US military services and, as required, select allied and coalition partners. Sharing with international partners while balancing security concerns will be paramount to successful future fifth generation aircraft employment.

while balancing security concerns will be paramount to successful future fifth generation aircraft employment. Joint and combined training, exercises, and even “cross talks” at forums like tactics conferences and training review boards will also be critical learning and development opportunities. In addition, it is

necessary to ensure fifth generation pilots, as well as maintenance and logistics personnel, fill key billets on major command, headquarters, and joint staff positions to inform senior leaders, and enable appropriate enterprise-wide resource planning and decision making.

Maintenance of fifth generation aircraft also requires careful planning to keep the force ready for combat operations.¹⁰ While fifth generation aircraft require the same maintenance considerations as legacy aircraft, such as maintaining flight systems and engines, there are additional requirements to maintain their low observable (LO) characteristics.

This adds another level of complexity USAF leadership must proactively manage. The Air Force must understand how the logistics enterprise can support the unique capabilities of fifth generation aircraft both in garrison and during deployed operations. While deployed, leaders and commanders must understand how to leverage in-theater fifth generation assets, along with sister US military service or partner nation logistics networks. When the answers to these sustainment challenges are discovered, they should be analyzed

rapidly with respect to the changing phases of a given campaign, training exercise, or other engagement involving fifth generation aircraft.

Fifth generation aircraft are capable of providing a wide variety of options for any given contingency. While it may be difficult to visualize how these aircraft can provide an asymmetric advantage to US and partner nation forces, it is not difficult to forecast scenarios where fifth generation aircraft could be leveraged in response to an adversary nation’s invasion of a neighboring US-aligned country.

Scenario 2026: Seizing The Advantage

In one of these potential crises, the year is now 2026. The USAF now fields a mixed force of legacy and fifth generation aircraft. In response to rising tensions in a key region abroad, continental US (CONUS) based aircraft are mobilized along with other assets. Adversary-sponsored cyber attacks immediately attempt to target unclassified computer systems supporting fifth generation aircraft deployment, including the F-35’s Autonomic Logistic Information System (or ALIS), but are successfully thwarted by a combination of cyber defense and backup capabilities.

While CONUS-based fifth generation aircraft gear up for future combat missions, several squadrons of fifth generation aircraft rapidly deploy and disperse to numerous military and civilian airfields, effectively avoiding concentrating no more than a single squadron at any one location. Consequently, adversary planners and targeteers are unable to effectively use ballistic or cruise missile attacks to score a pre-emptive “knock-out” blow against forward deployed aircraft, and fifth generation missions continue with little impact. Though some expeditionary airfields have navigation or air traffic control facilities, by 2026 F-35 and F-22 pilots are now adept at conducting autonomous all-weather operations (such as landing in inclement weather using the aircraft’s own sensors to find the runway). This also reduces the number of personnel and equipment required for deployment, while greatly increasing the number of airfields available as the conflict breaks out.

As combat operations begin, US military fifth generation aircraft (both CONUS and forward-based assets), along with F-35s from coalition countries effectively integrate and collaborate in the opening phase of operations, thanks to prior consideration and exercising of security, maintenance, logistics, and C2 plans.¹¹ There are no surprises concerning the multi-level security construct of the operation, as the US military has built transparent relationships with key allies and partners in the preceding years for just this sort of contingency.

During the opening days, fighting focuses on the battle for air superiority as aircraft from both sides clash over contested territory. Heavy radar and communications jamming confront US and coalition forces, but fifth generation aircraft leverage their networked multispectral sensors to detect and target enemy aircraft, while supporting a common operating picture through data links and communication architectures. Though legacy aircraft operate at a distance from the most dangerous threats, they provide critically important layered defense in depth for ongoing operations.

During the initial days of the conflict, F-35s occasionally return to their bases—only to discover several are heavily damaged from enemy missile attacks. Executing contingency plans, they divert to a nearby civilian airfield and use pilot swap-out procedures to reposition aircraft to another F-35 operating location, allowing these assets to continue fighting despite heavy airfield attacks. In one instance, a USAF F-35 is forced to recover at an Australian F-35 airbase after an inflight malfunction makes it impossible to return to its original deployment location. Royal Australian Air Force (RAAF) maintenance technicians are able to quickly repair, rearm, and refuel the USAF F-35 in a manner similar to US maintenance and regeneration practices. The F-35 in question rejoins combat operations the next day.¹²

Also during the initial stage of the conflict, several civilian aircraft are damaged during airfield attacks, halting commercial logistics operations. In response, contingency plans link up commercial and military distribution channels to enable adequate supplies of spare parts, weapons,

and fuel destined for dispersed airfields. This effort sustains these locations for several weeks until enemy cruise and ballistic missile inventories are depleted or destroyed.

As operations continue, it becomes apparent stealth aircraft like the F-22, F-35, B-2 and B-21 are the only aircraft capable of operating over the contested territory in the conflict due to the large number of adversary mobile advanced Surface to Air Missile systems (SAMs) deployed. Fifth generation fighters achieve most of the adversary air-to-air kills, since older fighters find themselves vulnerable to the long reach and lethality of advanced SAMs, keeping these fighters at a distance from the main fight. Fortunately, F-35s use advanced geo-location capabilities, combining with their stealth signature and electronic warfare (EW) tools, to neutralize many of these SAMs, allowing joint force operations to steadily increase their freedom of action.

Despite heavy kinetic and non-kinetic attacks on the Combined Air Operations Center (CAOC), the air commander is still able to provide command and control (C2) to legacy and fifth generation units by using preplanned distributed C2 procedures specifically designed to allow the entire force to operate, even when the CAOC is offline. These procedures rely on redundant communication systems requiring little bandwidth and commanders guidance distributed in the runup to conflict, specifically tailored to ensure decentralized operations that contribute to campaign objectives. F-35s and F-22s put their advanced sensors and long-range communications to use, as key elements of these decentralized operations. Aircraft take off with minimal information—little more than a general target area that may be more than 1,000 miles away. On the way to target, the fifth generation aircraft receive minimal tanker, threat, and target information, but sufficient updates to enable them to ingress, identify, and prosecute targets successfully before returning to operating airfields.

During one adversary attack on an operating location, several operations and maintenance personnel are killed in a ballistic missile strike. Allies provide personnel to fill in for these casualties, and maintain the current operations tempo until US reinforcements arrive.

As the conflict continues, fifth generation aircraft seek out, degrade, and destroy advanced SAMs in contested territory, creating a more moderate threat environment. This enables legacy aircraft to operate alongside their fifth generation counterparts. The mature integration and full operational capabilities of fourth and fifth generation aircraft working together proves the turning point in the conflict, as the mix provides US and coalition forces needed flexibility, mass, and depth of munitions to gain the advantage.

Conclusion: Employing Our Advantage for Joint and Combined Force Operations _____

The above concept of employing fifth generation airpower lays out and defines the operational need for these vital aerial warfare systems. But employing these aircraft in future combat requires careful attention across several phases and aspects of employment beyond the aircraft themselves. These aspects include advanced planning, preparation, ensuring effective use and dissemination of mission data, how deployment of fifth generation aircraft is conducted, actual combat employment design, and supporting operations with appropriate logistics and sustainment practices. The above potential future combat scenario illustrates how each of these elements could come together and enable success in a modern air campaign or joint combat operation.

While fifth generation aircraft do not provide decision makers with a single-point solution, their demonstrated ability as valued contributors to strategic deterrence, capacity as advanced airborne echelons, and operational utility as enduring force multipliers make them indispensable to future joint force operations.

In addition to the elements of fifth generation airpower described in this paper, future concepts of employment should aim to focus on several integration priorities. These areas include refining connectivity between legacy and fifth generation aircraft, improving connections between fifth generation airborne platforms, improving integration with space and cyber capabilities, and integrating fifth generation platforms with other components of joint and combined force operations. Integration advances in these areas will aid progress towards the goal of creating a cloud-based architecture—where every element of air, space, and cyber power contribute to conducting disaggregated, distributed operations over a wide area. The complementary employment of capabilities from all domains will enhance the effectiveness of future combat operations, and help compensate for vulnerabilities.

The need to explore these concepts will only increase. In the coming decade, fifth generation aircraft will grow and mature in sufficient numbers to give the US and our allies a definitive strategic advantage to counter the advancement of modern weapon systems used by potential adversaries. These potential adversary weapon systems, from aircraft to cruise missiles to advanced SAMs and cyber capabilities, are currently contributing factors to the destabilization of contested regions around the world. Fifth generation aircraft are critical to returning the military balance to our favor. Along with thoughtful integration and investment in select legacy aircraft, the maturation of fifth generation aircraft capabilities in sufficient numbers will better enable joint force operations that will provide the US and its allies a wider range of options to secure our interests in a scenario like the one described, or many others which could emerge in the coming years. ★

Footnotes

1 Arie Church, "Debutant to Combat Workhorse," *Air Force Magazine Daily Report*, Feb. 13, 2015, <http://www.airforcemag.com/DRArchive/Pages/2015/February%202015/February%2013%202015/Debutant,-to-Combat-Workhorse.aspx> (accessed May, 2016).

2 James and Welsh, "Fiscal Year 2015 Air Force Posture Statement," p. 6

3 Surface to Air Missile (SAM) capability available for export from countries like Russia and China has steadily increased in recent years. Relatively inexpensive SAMs increasingly provide an improved barrier for nations seeking defenses against air attack, especially against older aircraft. Maximum ranges and targeting capability for these SAMs have immensely improved, and many are often mobile, presenting a challenging targeting set for fourth generation systems. While these SAMs remain a formidable threat, fifth generation systems have a greater capacity to overcome and operate in environments defended by these weapons.

4 The DOD has not heavily invested, compared to our adversaries, in electronic attack (EA) capabilities for our fighters. Over the years, we have continued to rely upon the X band in the Radio Frequency (RF) spectrum for our targeting and engagement capability and therefore, continue to play "catch up" in countering their advancements in EA capabilities. This history, combined with advancements in air-to-air missiles and adversary employment ranges, increases the risk to our legacy assets. The characteristics of fifth generation aircraft mitigate that risk.

5 Fifth generation aircrew must understand their aircraft's signature and its expected detectability against threats. While pilots can expect their aircraft will be within the expected signature specification at the start of a mission, degradation can occur. All aircrew must know when they should and should not expect to be detected, to enable necessary adjustments for a given mission.

6 It is imperative to develop a strategy for fifth generation aircraft training. Fifth generation aircraft cost per flight hour is currently too high to be used in replicating adversary threats, given the preponderance of adversary air do not possess LO attributes.

7 Maintaining fifth generation aircraft signatures is similar to managing the hours until the next inspection or engine maintenance schedules of legacy aircraft. The signature of an entire squadron of fifth generation aircraft must be tracked and managed very closely. If not managed, the man-hour bill required to bring a squadron back to specification can quickly become unmanageable, impacting aircraft availability and training.

8 Well-designed data link and communication architectures are vital for success. All aspects of legacy and fifth generation aircraft contributions to this system must be understood. When designing the architecture, partner capabilities must be considered and an understanding of any partner contribution to the network is required. Ensuring a common operating picture requires awareness of how targets, tracks, IDs and other information are propagated and integrated into data link displays of all coalition aircraft.

9 There must be a robust processing exploitation dissemination (PED)-like process for analyzing the data fifth generation aircraft collect. Commanders need to proactively ensure operations data is linked properly with the intelligence enterprise. This linkage will allow for the proper analysis of information, and more importantly, the proper application of learned information.

10 The signature health of fifth generation aircraft must be closely managed. If the health of these signatures are not maintained, it is possible the ability to deploy to a contingency situation will be impacted by the amount of time needed to return aircraft to specifications.

11 Leaders should look for opportunities to leverage exchange tours to increase collaboration with partners. Further, broadening exchanges to both officer and enlisted personnel across the spectrum of operations, maintenance, intelligence, space, and cyber specialties will significantly improve interoperability.

12 In this vignette, Australia is chosen as a representative ally; the goal would be to enable all partners to participate and respond similarly.