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FUTURE WAR PAPER

*Maximizing the Future Force with Minimum Manpower:
The Pairing of Autonomous Aerial Vehicles (AAVs) with Manned Systems*

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OF THE REQUIREMENTS FOR THE DEGREE OF
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Introduction

The United States Air Force (USAF) currently operates both manned aircraft and unmanned aircraft that are designated as unmanned aerial vehicles (UAVs) in support of assigned missions to provide the United States global vigilance, global reach, and global power.¹ The manned systems require at least one pilot, and in some aircraft multiple pilots and multiple sensor operators, in order to achieve their mission objectives. Additionally, these manned systems are generally operated in formations in order to provide redundancy in intelligence, surveillance, reconnaissance, weapon capacity, lethality, and survivability. The current UAVs operated by the USAF, though unmanned, also require pilots and sensor operators in the same manner as the manned systems. Currently, none of the USAF manned systems are trained to or equipped with the capability to operate a UAV that is paired to maneuver with the manned system. This pairing would provide an asymmetric advantage in tactical, operational, or even strategic capabilities, which include providing enhanced situational awareness, reducing pilot workload, the ability to act as a force multiplier, and the ability to operate in extremely hazardous environments. In essence, the USAF operates its UAV fleet as manned aircraft that require robust support and communications capabilities that are vulnerable against the rising threat capabilities of our adversaries.²

The USAF's current approach to conducting UAVs operations, coupled with the pilot shortage facing the USAF that is projected to only increase over the next ten to fifteen years³ and the growing anti-access area denial (A2AD) operating environment⁴, will stress the USAF ability to maintain air superiority enjoyed by the United States and its allies over the past sixty years.⁵ With advancements in artificial intelligence and autonomous systems, pairing autonomous aerial systems (AAVs) with manned systems will provide the USAF an asymmetric

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advantage at the tactical, operational, and strategic level of warfare to include a reduced risk of mid-air collisions, reduced logistical footprint, increase in military deception, and an increase in capacity while addressing the current USAF pilot shortage.

This paper will address the asymmetric advantages that AAVs will provide to the USAF and Department of Defense. Following the advantages, this paper will provide an overview of the emerging technology that the USAF could utilize in AAVs to generate these asymmetric advantages. Finally, the paper will address the current risks to mission success without adopting this emerging technology.

The Asymmetric Advantage

Advances in both artificial intelligence and AAVs that can be paired with manned systems have the ability to provide asymmetric advantages in both permissive and non-permissive theaters of operations. These asymmetric advantages allow the USAF to achieve concentration of mass with a reduction in risk to manned assets, complicates and confuses enemy air defense systems, provides redundancy to achieve mission objectives in extremely contested environments, and act as a force multiplier.

In order to maximize the asymmetric advantages, the number of paired AAVs paired with manned systems would only be limited by the number of available AAVs (unlike the current limit of manned assets due to the number of pilots). This is due to the capability of advanced algorithms that would allow the AAVs to integrate in the most effective operational and tactical manner to achieve desired mission objectives and continue to provide the United States and its allies air dominance for the foreseeable future.⁶

The Future Battlefield

General Joseph Dunford, Chairman of the Joint Chiefs of Staff (CJCS), testified to the Senate Armed Service Committee in September of 2017 that “China poses the greatest threat to

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our nation by 2025” and their increasing investments in A2AD systems will “limit our ability to project power.”⁷ The CJCS has also identified Iran, Russia, North Korea, and violent extremism as threats to our nation and our forces.⁸ All of these nations export their technology, rendering all future battlefields as potentially highly contested areas of operations to all US forces, limiting the ability for US forces to operate with a reduced risk level that has become the norm since the success of Operation DESERT STORM. With the successful employment of paired AAVs with manned assets, the USAF will have the ability to eat through the defense of the A2AD systems either in the threat nations identified by the CJCS, or in areas of operations that have incorporated A2AD systems, allowing follow-on forces to operate with increased situational awareness in a more permissive environment with a reduction in risk to forces.

The future battlefield will not only consist of intelligence gathering and potential offensive operations against threat nations, non-state actors and violent extremist groups. The USAF will need to conduct defensive operations in the protection of United States interests both abroad and at home. In the defensive role, AAVs would provide the defense in depth with the manned asset acting as the selected area of operations commander with the AAVs advancing in front to detect and possibly destroy adversary threats prior to entering any friendly controlled territory.

One major consideration in the future battlefield with AAVs is the importance of the manned asset. The AAVs will operate in such a manner to provide protection to the manned aircraft; however, in the event of catastrophic loss of the manned aircraft, the AAVs would maneuver either to complete their last assigned task and return to base or maneuver to be paired with another manned asset that is operating in relative close proximity. This added flexibility will allow Combined Air Force Component Commanders to determine whether the original assigned mission is continued or the AAVs be reassigned airborne to aid or even accelerate the

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tempo of other missions in their assigned area of operations.

Tactical Advantages

The pairing of AAVs with a manned aircraft will provide the manned aircraft with multiple tactical advantages versus the traditional paradigm in flying with other manned aircraft as part of a formation or package. One major advantage is increased situational awareness. The lead manned aircraft will no longer be required to split time between tactical maneuvering and targeting with monitoring wingmen (and vice versa), maneuvering the formation for optimal tactical success and ensuring deconfliction from potential mid-air collisions. The lead manned aircraft can concentrate completely on the mission with aspects of the mission being automatically accomplished by the AAVs. An additional tactical advantage is the ability for the manned aircraft to operate with mission type orders and receive instant updates from mission configured AAVs operating in extremely contested airspace in order to meet rules of engagement. Legacy systems such as the E-3 Sentry Airborne Warning and Control System, the E-8 Joint Surveillance Target Attack Radar System (JSTARS), and the RC-135 Rivet Joint will be unable to conduct operations in advanced A2AD systems which would limit the ability for manned aircraft to operate with mission type orders and receive the critical information required to meet the ROE.

Another tactical advantage is that the flight lead who is also paired with a refueling AAV will no longer need to navigate towards an air-refueling track. The flight lead can continue operating as required without a pause in operations to determine where the refueling aircraft is, rather the AAV will maneuver towards the flight lead when it is determined that the flight lead requires fuel. Finally, the flight lead will no longer be constrained by the amount of ordnance (either air-to-air or air-to-ground weapons), only by the limitations of time permitted in

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conducting flight operations. As the flight lead aircraft begins approaching the required time to return to base, another manned aircraft can rendezvous with the on-station aircraft and an effective handover of the AAVs can occur without any interruption to the tactical situation.

Operational Advantages

As campaign plans are developed and operations planned, the incorporation of AAVs paired with manned assets will provide multiple advantages at the operational level. One of the major operational advantages is the ability of the AAVs to operate as a force multiplier. The number of AAVs paired to a manned asset would only be limited to the number of AAVs in the area of operations, not on the number of pilots. With an objective of an operation being the neutralization of an advanced A2AD system, one B-2 bomber aircraft with just a crew of two pilots could be paired with customized AAVs versus a traditional strike package of multiple B-2s, F-22s, F-35s, and electronic warfare and required refueling assets. The AAVs could include refueling assets, electronic warfare assets, electro-optical infrared system assets, synthetic aperture radar (SAR) assets, Air-to-Air combat configured assets, and Air-to-Ground combat configured assets. With a detailed mission priority list and rules of engagement (ROE) provided to the AAVs, they would operate independently in order to enhance the survivability of the manned asset while increasing the lethality of the operation. The efficiency of this pairing also applies to operations to locate and engage high payoff targets (HPTs) and high value targets (HVTs). While the number of manned assets could be reduced, there also exists the capability in an operation to completely overwhelm an adversary with an incredible number of both manned assets paired with AAVs. This overwhelming force would be able to not only neutralize an A2AD system, but target in accordance with the joint targeting list while also working in combination with both ground

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and sea assets to provide intelligence.

Another major operational advantage is the reduction in logistical footprint required when utilizing manned assets paired with AAVs. In accordance with the testimony from the CJCS about the threats posed by nations such as China, Iran, North Korea, and Russia, the USAF will need to deploy assets in order to meet stated goals and objectives. AAVs, much like current UAVs the USAF operates, will require less fuel while providing greater range and endurance due to the AAVs ability to carry additional fuel versus allocating room on the aircraft for life support systems and cockpits for the pilots. This reduction in fuel and the capability to have AAVs provide refueling to either manned assets or other mission focused AAVs will reduce the amount of manned refueling aircraft. In addition to this reduction of supporting assets like the KC-10, KC-46, and KC-135 refueling aircraft, the number of B-2s, B-21s, F-35s, and F-22s deployed will also be reduced. An example of the reduction in logistical footprint would be that of a USAF active duty F-35 squadron that consists of twenty-four primary assigned aircraft. If all twenty-four aircraft deployed it would require a minimum of twenty-four pilots and based on historical averages to support operations it would entail thirty-six pilots. With paired AAVs, the number of F-35s required to deploy could be significantly reduced, which would reduce the lodging and sustainment required to support the pilots flying the manned F-35s.

In addition to acting as a force multiplier and reducing the logistical footprint, the incorporation of AAVs will provide planners and combatant commanders an asset that will not lose its data link and be rendered operationally ineffective. The AAVs will be provided with an acceptable level of interference and as the interference begins to near that level, the AAVs will begin to maneuver in closer proximity to their manned flight lead to provide a

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secure communications link. This level of communications security will ensure that these AAVs can be recovered and utilized for follow-on missions versus becoming the property of our adversary due to a lost or compromised data link as in the suspected event by Iran in the capture of the RQ- 170.⁹

AAVs paired with manned assets will also have the ability to achieve military deception to assist in achieving mission success. Whether in offensive or defensive operations, paired AAVs could emit different radar cross sections and fly certain flight paths to deliberately mislead and confuse the adversary as to what force composition are they facing, where the majority of USAF assets are poised for operations, and the overall objective.¹⁰ While manned aircraft could also be used in this role, it would require more pilots and would subject them to extremely dangerous operating environments.

Finally, AAVs have the capability to operate in extremely hazardous environments that either manned aircraft are prohibited from operating in or operate in at extreme risk. One of these hazardous environments is that of extremely high altitudes. One of the risks to operating at high altitudes is that of rapid decompression, which requires extensive life support equipment. The USAF has one manned asset, the U-2S, which operates at extremely high altitudes for intelligence gathering (greater than 70,000 feet).¹¹ The U-2S requires the pilot to be outfitted like an astronaut, and even with increased safety precautions the U-2S is still subject to rapid decompression, endangering the life of the pilot. In addition to the ability for AAVs to operate at extremely high altitudes without risk to pilots, AAVs could also conduct operations at extremely low altitudes (less than one foot above the ground). While manned aircraft train to conduct operations at one-hundred feet above the ground, little focus to other mission tasks can be accomplished at this altitude, and aircraft mishaps

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are statistically greater due to controlled flight into terrain (CFIT). AAVs operating at either extremely high or low altitudes would provide increased capability to complete a mission that requires aircraft to operate at these extreme altitudes due to weather or threat systems.

Strategic Advantages

In addition to providing tactical and operation advantages, AAVs could address one of the major strategic challenges that the USAF is currently faced with. This is the shortage of assets and pilots to meet national objectives. Senior USAF leaders such as Secretary of the Air Force Heather Wilson and Chief of Staff of the Air Force General David Goldfein have stressed in congressional hearings that the “Air Force is too small for the missions demanded of it.”¹² The incorporation of AAVs paired with legacy assets such as the F-16, F-15, B-1, and B-52 and advanced stealth platforms such as the B-2, B-21, F-22, and F-35 would increase both the capacity (more assets airborne with a reduction in pilots) and capability in order to meet national objectives. In addition to addressing a major strategic challenge of a shortage of pilots, nations or groups that rely on A2AD systems will no longer have an impenetrable defense that limits the ability for the United States to project power. Finally, in any theater of operations, the USAF will have an increased ability to find, monitor, and if required engage any target to meet strategic goals, rendering no enemy of the United States immune.

Advancements in Artificial Intelligence and Autonomous Pairing

The asymmetric advantages outlined above require advancements in both artificial intelligence and autonomous pairing with the USAF manned inventory to ensure the legacy platforms and advanced platforms operate at an increased level of capability in the future battlefield. These legacy platforms and even the most advanced platforms with sensor

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fusion provide information that must be processed in order to safely conduct operations and maximize combat effectiveness. However, the amount of information available to a human operator is becoming unmanageable with sacrifices to both safety and mission effectiveness.¹³

Artificial Intelligence (AI) has been utilized in aviation for decades with simple processes such as auto-pilot functions (maintaining a programmed airspeed, altitude, heading, etc) to more advanced functions in modern fighter aircraft. These more advanced functions include electronic warfare capabilities that can automatically identify air-to-air threats and surface-to-air missiles (SAMs), and provide tailored electronic counter measures. The advancements in AI technology are now providing even more robust capabilities with an explosion in capability not over the last decade but in the last year.¹⁴ Of major interest in these recent developments in AI that would provide an asymmetric advantage in the pairing of AAVs with manned aircraft include advances in image recognition and machine learning.

Image Recognition

Modern electronic warfare equipment has the capability to identify emitting air and surface threats (to include threats on naval vessels). However, the USAF and DOD are not only tasked with identifying only air and surface threats electronically but also analyzing visual images from electro-optical sensors and synthetic aperture radar (SAR) maps. In order to facilitate intelligence gathering and targeting, both manned and unmanned aircraft utilize SAR maps and electro-optical infrared systems that currently require human intervention in determining what the image is and whether it should be monitored and possibly targeted. With the advancements in image recognition as currently utilized in applications by Apple, Facebook and Google to identify individuals and objects, electro-optical infrared AAVs

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could search for a prioritized list of military assets or individuals. Falsely identifying targets and prosecuting them is a major concern; however, these systems have reduced error rates from 30% in 2010 to 4% in 2016.¹⁵

SAR map AAVs could also benefit from recent advancements in technology to locate and identify military assets or individuals. Defense Advanced Research Project Agency (DARPA) began work in 2015 on the Target Recognition and Adaptation in Contested Environments (TRACE) program that incorporates machine learning to locate and identify targets in SAR images.¹⁶ With these continued advancements in searching and recognition of images either optically or through SAR maps at a fraction of the time it would require human interpretation and recognition, the USAF will dramatically increase the speed at which they operate to monitor and target.

Machine Learning

Machine learning is another facet of AI that also has made dramatic improvements over the past year. A major difference in machine learning from previous AI systems is that the machine would learn from examples versus being programmed to provide a specific response to a specific situation.¹⁷ As noted earlier, the advanced electronic warfare systems in modern fighter aircraft are programmed to provide a specific response to a specific threat. A dilemma occurs when the current electronic warfare system receives a new or contradictory threat. The current electronic warfare system would not provide any countermeasures, whereas the system with machine learning could predict, based on a large base of examples, what counter measures could work and apply them. Additionally, with machine learning if the selected counter measure did not work, the AAV would adapt and provide another prediction of a suitable counter measure. This process would continue until

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the threat system is either neutralized or destroyed.

Other examples of machine learning in AI, in addition to electronic warfare and image recognition that could benefit manned aircraft with paired AAVs, is that of air-to-air targeting, air-to-ground targeting, and air-to-air refueling. In the air-to-air realm, AAVs armed with air-to-air weapons would be given a set ROE and maneuver freely in relation to the manned aircraft and the other AAVs to act in either an offensive and defensive nature. The AAVs assigned Air-to-Ground weapons would also be given a set ROE and maneuver appropriately to achieve the most beneficial weapons delivery. The air refueling AAVs would monitor each manned aircraft and AAV's fuel state and maneuver towards the asset that requires fuel with the priority given to the manned aircraft in order to have the manned aircraft recover back to base safely.

Autonomous Pairing

The USAF Research Laboratory recently conducted two experimental demonstrations in which a manned aircraft was paired with an unmanned aircraft. While unmanned aircraft have flown in the same operational area with manned aircraft, the unmanned aircraft were flown by a pilot controlled remotely through advanced satellite communication systems. The unmanned aircraft in this demonstration was a 4th generation fighter aircraft, an F-16, that wasn't remotely flown by a pilot through satellite communications as UAVs are currently operated. In the first experimental demonstration, the unmanned F-16 in this demonstration was paired to a manned F-16 and flew formation utilizing automatic collision avoidance software. The unmanned F-16 then broke away from the manned F-16 to conduct a simulated ground attack based on preprogrammed mission priorities and then rejoined once complete.¹⁸ In the second experimental demonstration in 2017, the autonomous paired F-16 initially also

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flew in formation with the manned F-16 and then broke away to conduct a ground attack. However, in this demonstration, simulated enemy air defensive systems were introduced to test the ability of the unmanned autonomous F-16 to react and maneuver appropriately to achieve its mission objective of conducting the ground attack and rejoining with the manned F-16.¹⁹ The second demonstration like the first demonstration was able to successfully conduct its ground attack and meet its mission objectives.

Successful autonomous pairing of manned and unmanned platforms coupled with advancements in AI will continue to mature at an increasing pace that the USAF could begin to incorporate to both legacy and stealth platforms. Legacy platforms would benefit from enhanced survivability and increased lethality (i.e., a F-16 paired with multiple AAVs). While stealth platforms like the F-22, F-35, and B-2 have an advantage over legacy platforms, they are not completely without risk of being degraded or targeted in A2AD areas of operations and would also enjoy the benefits of increased survivability and lethality (i.e., B-2 paired with multiple AAVs).²⁰

Risks to Mission

Without incorporating the advancements in AI and autonomous pairing to benefit from the asymmetric advantages that AAVs can provide, there are a growing number of risks to accomplishing the mission. Air superiority is defined by the Department of Defense as “that degree of control of the air by one force that permits the conduct of its operations at a given time and place without prohibitive interference from air and missile threats.”²¹ This level of dominance has become the norm since 1989 with Operation DESERT STORM. Prior to this operation, the United States suffered losses in the Vietnam War and World War II to air, ground and sea forces that would be inconceivable today, particularly air assets that numbered greater than 4,000 fighters and bombers before Operation OVERLORD began in

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World War II and more than 2,700 fighter aircraft in Vietnam²².

Asset and Manpower Shortages

In addition to the aircraft lost in World War II and the Vietnam War, the USAF also lost thousands of pilots. Even without these losses in the last fifteen years during our operations in the Middle East, the USAF is at a shortage of 1,500 pilots that is causing the USAF to operate under extreme stress to the force.²³ This shortage of available pilots is projected to increase as opportunities exist for pilots outside of military service. In addition to the shortage of available pilots to conduct both manned and unmanned aerial flights, the number of available air assets the USAF has available to conduct operations has dramatically decreased by approximately 3,100 aircraft over the past 20 years.²⁴ This shortage of manpower and assets available to conduct major operations was further clarified by the current USAF Chief of Staff (CSAF), General Goldfein, who testified in 2016 that the USAF could not provide enough air power to execute effectively in a major conflict while meeting current demands.²⁵

Limitations in Operating in A2AD Environment

In addition to an asset and manpower shortage, the difficulty in operating in A2AD environments is growing increasingly prohibitive. Anti-Access (A2) systems are systems that prevent advancing forces from entering an area of operations.²⁶ The range that these advanced systems can now detect and engage air assets is nearly 250 miles²⁷ and these advanced systems are established in potential areas of operations to include the South China Sea, the Baltics, and the Middle East. This advancement in enemy A2 systems now outranges our traditional air assets ability to collect intelligence, provide targeting or even engage adversarial forces. Area Denial (AD) systems are those that limit the ability for

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forces to operate freely in an area.²⁸ This includes the blinding of intelligence assets, the electronic jamming of GPS and communication systems, and the use of ballistic missiles to target air, ground and sea forces. In essence, A2AD systems are layered defenses in depth with advanced technology that limit the United States to meet military objectives that are defined by our overall political goals.

The USAF does have some advanced assets (the B-2 Spirit, the F-22 Raptor, the F-35 Lighting II, the RQ-170 Sentinel, and the future B-21 Raider) that can currently conduct operations in these contested environments, but with continued investment in enemy A2AD technologies, these USAF stealth assets are at risk of being targeted and rendered ineffective unless provided additional assets to complicate, confuse, and saturate the enemy's defensive systems.²⁹ As illustrated by the CSAF, the USAF does not have enough of these assets to execute effectively, and the cost to procure more of these assets is extremely cost prohibitive in the current fiscal environment. With an acknowledged shortage of stealth assets, the USAF would then have to rely on its inventory of existing legacy platforms, which also include the current inventory of unmanned assets (MQ-1, MQ-9, and RQ-4). These legacy manned and unmanned assets would provide limited if any capability while being subject to complete annihilation, unless paired with AAVs to provide asymmetric advantages.

Conclusion

A2AD systems will continue to proliferate in both capability and capacity over the next ten to fifteen years, expanding with the use of not only air, ground, and sea assets but the incorporation of space assets. This proliferation will negatively impact the ability of the USAF to project power in order to accomplish mission objectives in support of national strategy, unless changes in technology are incorporated to provide a more lethal and efficient force. The strategic challenges of the USAF include both a pilot shortage and an aging

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inventory of legacy aircraft and aging advanced platforms such as the B-2, F-22, and F-35. The legacy platforms and even the advanced platforms are no longer impenetrable to the increasing lethality and disruption of A2AD systems. In addition to the risk to these manned assets, unmanned assets such as the MQ-1, MQ-9, RQ-4, and RQ-170 are also not immune to the challenges in penetrating anti-access systems and operating in area denied environments due to being targeted, jammed, or taken over by enemy communication systems.

The advances in artificial intelligence integrated with image recognition and machine learning, along with autonomous pairing integrated into paired AAVs with manned assets, provide multiple benefits at the strategic, operational, and tactical level of war while addressing manpower shortages and aging aircraft. The ability of the USAF to increase lethality and survivability while minimizing risk to forces with paired AAVs that provide asymmetric advantages will ensure that the USAF is equipped and trained to meet the challenges of future war against determined adversaries. The movement towards paired AAVs will require a paradigm shift in how the USAF envisions its future, but a shift that will foster a stronger and more lethal force.

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