CONSOLIDATING THE REVOLUTION:

Optimizing the Potential of Remotely Piloted Aircraft

MITCHELL INSTITUTE for Aerospace Studies

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The Mitchell Institute for Aerospace Studies

Air Force Association

Arlington, VA

June 2017

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About the Author

Lt Gen David Deptula, USAF (Ret.), is the dean of the Mitchell Institute for Aerospace Studies. A decorated military leader with decades of experience in combat and leadership roles in major joint military operations, he has planned, flown, and commanded campaigns ranging from disaster relief efforts to major theater war. Deptula served as the principal air attack planner for Operation Desert Storm in 1991, was the Joint Task Force commander in Iraq from 1998-1999 where he commanded no-fly zone operations, led the initial air campaign that kicked off Operation Enduring Freedom in 2001, and commanded several other significant joint operations. Deptula retired in 2010 after 34 years on active duty, serving in his last assignment as the US Air Force's first deputy chief of staff for intelligence, surveillance, and reconnaissance (ISR). He is a prolific author and analyst on aerospace power, and a thought leader on defense, strategy, and ISR.

Deptula would also like to acknowledge the contributions of Richard Whittle, Col. Eric Mathewson, USAF (Ret.), Douglas Birkey, and Marc Schanz to the research, preparation, and writing of this study.

Cover design by Kristina Parrill; photos: USAF/DARPA

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Preface

Fifteen years of dramatic growth in demand for the sensor and strike capabilities that remotely piloted aircraft (RPA) afford have left the Department of Defense (DOD) struggling to meet burgeoning mission demand. Despite efforts by the Office of the Secretary of Defense and military services to surge RPA capacity, their collective actions have been largely uncoordinated. This has yielded a disjointed enterprise where effectiveness and efficiency are not what they could have been, or can be.

With large wartime budgets dramatically shrinking, the military must make a host of important decisions regarding how best to meet valid requirements in a sustainable fashion. These actions will affect all aspects of the RPA enterprise, from personnel policy and training to organization and acquisition to force allocation and employment. While the path to this goal is far from certain, this is sure: the intelligence, surveillance, and reconnaissance (ISR) capabilities and strike options that RPA enable will remain in high demand across the range of military operations for decades to come. It is time to optimize DOD efforts to meet that demand best.

This study examines the challenge from several vantages: first, by exploring the history that yielded the present system; second, reviewing the current state of play; and third, prescribing a set of actions that will result in a sustainable path to deliver necessary capacity and capability to achieve RPA mission effects.

In addressing the RPA issue, success will only be possible by prioritizing national security objectives and keeping an open mind regarding how best to meet those overarching goals. Key to meeting this objective is taking an enterprise-wide perspective across DOD, capitalizing on the strengths of each of the service approaches, exploring new modes of operation, and exploiting new technological capabilities.

Focusing on Terminology

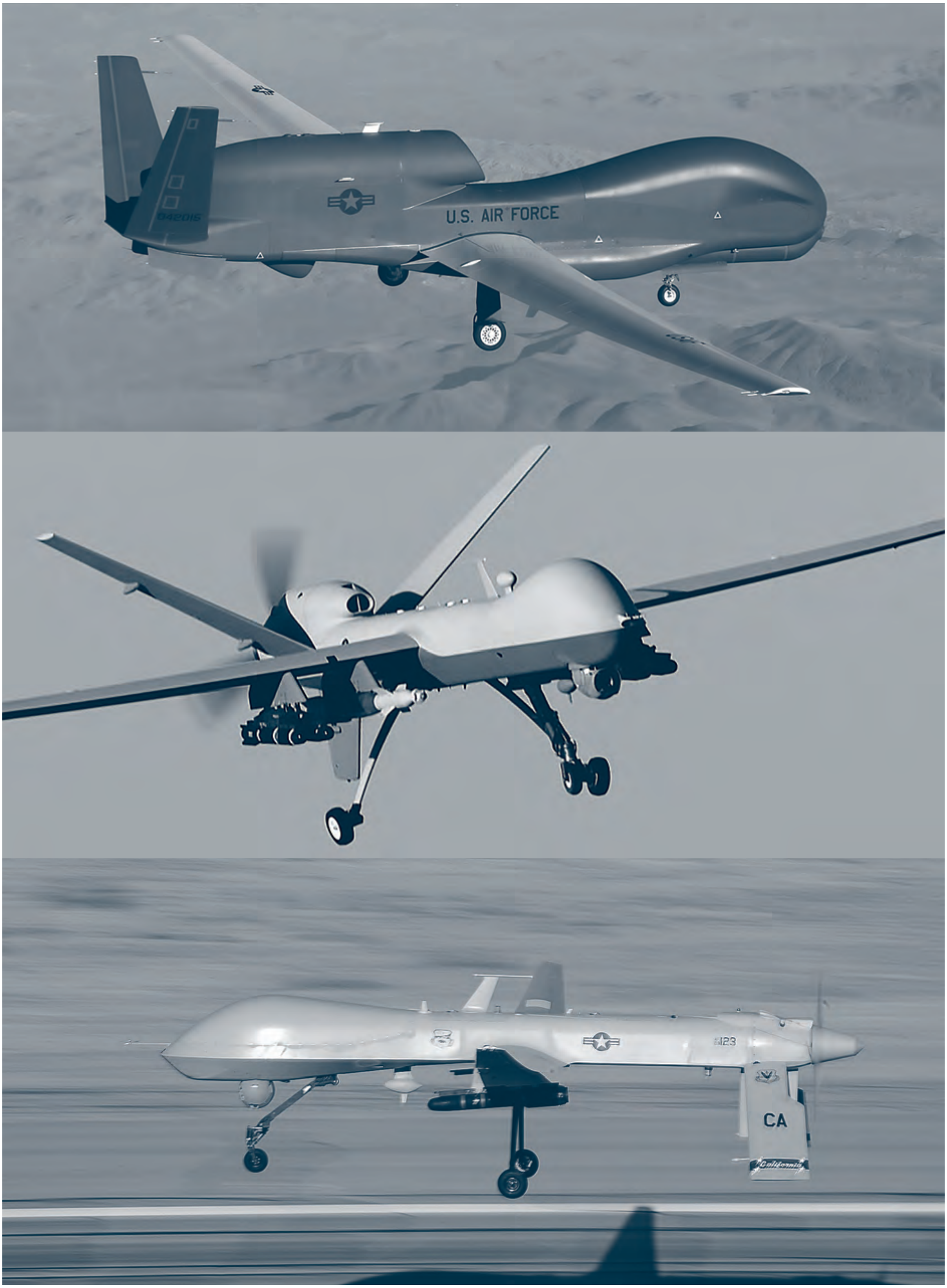
Words matter. That's why the US Air Force changed how it refers to this technology as *remotely piloted aircraft* (RPA) as opposed to *unmanned aerial systems* (UAS). The latter phrase was designed to reference the enterprise nature of unmanned aerial vehicles (UAV). However, people misinterpreted the terminology and concluded that the systems operated with total autonomy. Nothing could be further from the truth: Current RPA demand a tremendous amount of human interaction to achieve mission results.

Similar challenges arise from the media's common use of the term *drone*. Their preference for this is simple: a single word, versus three, helps reduce word count. However, this choice conflates two radically different technologies. In military parlance, a drone is a flying target—not a multirole aircraft with a variety of sensors and weapons controlled under the watchful eyes of highly trained crews. The word "drone" connotes a degree of autonomy that today's remotely piloted aircraft simply do not possess.

Inaccurate terminology choices perpetuate misperceptions regarding these aircraft and their use. A sensor ball or a missile is agnostic as to the platform to which it is attached. Whether discussing the act of intelligence, surveillance, and reconnaissance (ISR) operations or the employment of munitions, the end effect has little to do with whether a manned asset or a remotely piloted one is used. The effect is the same.

— D. Deptula

Lt Gen David A. Deptula, USAF (Ret.)
Dean, The Mitchell Institute for Aerospace Studies
May 26, 2017



From top: RQ-4 Global Hawk, MQ-9 Reaper, MQ-1 Predator

Photos: Northrop Grumman, USAF (two)

Executive Summary

Remotely piloted aircraft (RPA) presently engage in three distinct roles. First, they undertake intelligence, surveillance, and reconnaissance (ISR) missions to gather data through a broad arrange of sensors. Second, some RPA can also employ munitions, yielding a powerful, single-point integrated sensor-shooter capability. Third, certain unmanned aircraft engage in specialized missions, like flying as communication gateways or pioneering vertical-lift cargo applications.

While manned aircraft can execute all of these activities, RPA present unique values in distinct areas:

- RPA afford mission duration well beyond that of manned aircraft, allowing the ability to observe, evaluate, and respond to pre-planned and emerging subjects of interest. This persistence can either translate to covering a large geographic area, or focusing on a smaller number of operating areas for an extended period of time.
- These aircraft are uniquely suited to achieving mission objectives in an incredibly precise fashion through kinetic strike, limiting collateral damage and unintended casualties.
- The military services can forward deploy RPA indefinitely, reducing overall force structure requirements. Mission crews are based in the United States, with very small numbers of forward-stationed support personnel rotating, as required.
- Planners can integrate these aircraft into the broader battle enterprise in a highly collaborative, fused fashion regardless of domain: ground, sea, air, space, or cyberspace.
- Engineers can design existing technologies, such as sensors, weapons, and low-observability innovations into these RPA, capitalizing upon decades' worth of investment.
- Missions are flown without putting pilots in harm's way.
- RPA have proven to be more affordable to operate, maintain, and sustain for low-threat operating environments. This is an important consideration for the US Air Force as it seeks to extend the life of its legacy fighters and bombers, while prudently employing new fifth generation aircraft.

The scale and complexity of RPA vary widely depending on their application. Some are as large as a Boeing 737 airliner, while others can fit in a backpack. The common denominator with all of these aircraft is their positive impact on the way in which the services can execute missions to achieve strategic, operational, or tactical effects.

This study focuses on the missions of ISR and kinetic strike for two specific classes of remotely piloted aircraft: medium-altitude, long-endurance (MALE) systems that nominally fly up to 30,000 feet in altitude for hundreds of miles; and high-altitude, long-endurance (HALE) systems that nominally operate at much greater altitudes than 30,000 feet on missions in excess of 1,000 miles. While the entire portfolio of RPA activities demonstrates tremendous value, demand for these two mission classes has experienced extremely rapid growth over the past 15 years. Given their potential, it is critical to ensure the services use them as prudently as possible to ensure maximum desired effect. Meeting this need requires some changes in approach relative to how the US military has managed RPA over the last decade and a half.

Since the Pentagon introduced RPA during a time of war, military officials never developed the doctrine, organizational constructs, personnel issues, and technology standards surrounding them in a coordinated fashion to comprehensively maximize output for joint force operations. Instead, each of the services largely went their own way in developing solutions to meet near-term tactical objectives. While much of this ad hoc approach reflected a desire to surge assets to the fight, it is important to note that certain decisions reflected political opportunism to bolster individual service budget and policy prerogatives. Such action often undercut what was best for the broader national security system.

With the services facing significant concurrent funding demands, and mission need for RPA still on the rise, it is time to develop a better approach for the acquisition, management, and employment of the remotely piloted aircraft force. Looking past individual RPA, it is also important to recognize that these aircraft are part of a joint enterprise network. There must be a new construct that optimizes the flow of information in decision-making processes among the full range of involved mission systems, specifically: aircraft, satellites, ground forces, ships, and the US intelligence architecture. Rarely are combat effects secured in isolation; it takes a collaborative approach from a multitude of actors. In the future, this "combat cloud" will become the principal concept of operations for US joint force operations.

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This study explains how the remotely piloted aircraft revolution, fueled by wartime needs and budgets, resulted in disorganized development in the years after September 11, 2001; examines key problems facing RPA mission categories; and prescribes a set of actions that will result in a more coherent path forward for optimizing RPA for joint force operations. Accordingly, it recommends that Congress and the Department of Defense (DOD) consider the following actions to place the remotely piloted aircraft enterprise on a path toward coordinated, expanded, and enhanced effects.

1. Prioritize technologies that are able to reduce manpower requirements, boost mission efficiency, and rapidly seize new opportunities:
    a. Ensure new technologies are built to open mission system standards to facilitate modular plug-and-play integration between aircraft, sensors, and other payloads.
    b. Design RPA to integrate in a combat cloud enterprise: the ability to interface in a seamless fashion with systems throughout a particular area of operations in a collaborative, disaggregated, additive fashion.
    c. Improve control interfaces to allow better situational awareness and improved decision-making capability for RPA crews.
    d. Automate key functions including landing; multiple aircraft control; sense-and-avoid systems; and automated ISR data analysis.
    e. Integrate new waveforms, bandwidth-efficient data links, and software-defined radios to ensure resilient, robust protected communications.

2. Streamline the acquisition process to facilitate buying modern RPA technology in an agile, responsive fashion:
    a. When transitioning the RPA enterprise from an ad hoc wartime activity to a core enterprise mission, seek to develop common standards.
    b. Acquire sensors and aircraft in a decoupled, modular fashion through an open mission systems approach.
    c. Become an early adopter of better buying power initiatives, such as using technology maturation risk-reduction demonstrations, and cooperative research and development demonstrations and experimentations.
    d. Ensure RPA improvements are implemented in a joint fashion, while also seeking to implement positive developments from the civilian sector.
    e. Incentivize non-traditional defense firms to offer solutions to present challenges, especially when it comes to technology services like automated video analysis and data management.
    f. Streamline foreign military sales so that US allies, partners and friends can access American technologies and the US government can benefit from amortizing development costs.
3. Optimize the Pentagon's RPA organizational construct to net greater capability by aligning the use of systems in a more efficient and effective fashion:
    a. Establish an executive agent coordinating authority for DOD's remotely piloted aircraft enterprise.
    b. Ensure all RPA of the medium-altitude, long-endurance (MALE) class and above are under the direction of the appropriate unified command's joint force air component commander (JFACC), not individual units.
    c. Integrate RPA into the US airspace for training and domestic support missions.
    d. Ensure technological investment and procurement is focused on attaining optimal desired effects.
    e. Rethink traditional mission identification nomenclature for the RPA fleet, but avoid the temptation to treat these assets the same as traditional fighter aircraft. RPA should not be counted as part of the Air Force's fighter inventory, as this would risk serious capacity perceptions of the combat air force.

Introduction

In April 2001, five months before the terrorist attacks of Sept. 11, 2001, and six months before the first lethal missile strike ever launched from a remotely piloted aircraft (RPA), the Office of the Secretary of Defense published "Unmanned Aerial Vehicles Roadmap 2000-2025." This comprehensive, 131-page study was the product of a calendar year's work by the offices of the Undersecretary of Defense for Acquisition, Technology, and Logistics; the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence; and the military services. It offered this projection:

> *Today, the DOD [Department of Defense] has 90 UAVs [unmanned aerial vehicles] in the field. By 2010, this inventory is programmed to grow to 290, with UAVs performing a wider variety of missions than just reconnaissance.*[1]

As the old saying goes, it's tough to make predictions, especially about the future. By the end of 2010, the US military fielded not a mere 290 remotely piloted aircraft, but more than 7,000 RPA of 15 different types.[2] The vast majority were small, including even hand-launched flying machines equipped with cameras for use by troops to see over hills and around corners during battery-powered flights lasting as briefly as minutes. However, more than 250 of the 7,000 RPA were full-sized aircraft: medium-altitude, long-endurance (MALE) armed Air Force MQ-1 Predators, MQ-9 Reapers, and US Army MQ-1C Gray Eagles (a diesel-powered Predator derivative). Another 25 were high-altitude, long-endurance (HALE) unarmed RQ-4 Global Hawks, aircraft roughly the size of a Boeing 737 airliner.

Combined, this new breed of aircraft has fundamentally changed military operations thanks to seven distinct advantages they afford over their manned airborne counterparts:

- RPA afford mission duration well beyond that of manned aircraft, allowing the ability to observe, evaluate, and respond to pre-planned and emerging subjects of interest. This persistence can either translate to covering a large geographic area, or focusing on a smaller number of operating areas for an extended period of time.
- These aircraft are uniquely suited to achieving mission objectives in an incredibly precise fashion through kinetic strike, limiting collateral damage and unintended casualties.
- The military services can forward deploy RPA indefinitely, reducing overall force structure requirements. Mission crews are based in the United States, with very small numbers of forward-stationed support personnel rotating, as required.
- Planners can integrate these aircraft into the broader battle enterprise in a highly collaborative, fused fashion regardless of domain: ground, sea, air, space, or cyberspace.
- Engineers can design existing technologies, such as sensors, weapons, and low-observability innovations into these RPA, capitalizing upon decades' worth of investment.
- Missions are flown without putting pilots in harm's way.
- RPA have proven to be more affordable to operate, maintain, and sustain for low-threat operating environments. This is an important consideration for the US Air Force as it seeks to extend the life of its legacy fighters and bombers, while prudently employing new fifth generation aircraft.[3]

The relative value these attributes offer to an operation depends upon the respective circumstances. For example, the record-setting range of the Global Hawk is a powerful tool when seeking to gather ISR data over a large area like the Pacific Ocean. One RQ-4 can cover a distance in excess of 10,000 miles on a mission lasting more than 30 hours, something far past the endurance of a manned aircraft without refueling. This global reach provides the United States the ability to respond from any of the Global Hawk's operating bases within hours to a crisis anywhere on the globe, as opposed to days for manned aircraft requiring airlift support. With a different set of attributes, the combined sensor-shooter capability of Predator, Reaper, and Gray Eagle RPA offers unique engagement options in present operations against the Islamic State (IS) in Syria and Iraq. Operators are able to gather unmatched situational awareness, and teams of experts can review the situation in question and select a time to strike that maximizes mission goals, while significantly reducing the potential for collateral damage.

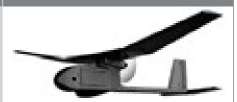
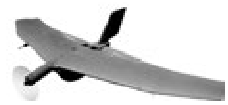
RPA Groups	Maximum Weight (lbs)	Normal Operating Altitude (ft)	Speed (kts)	Representative Aircraft
Group 1	0-20	< 1,200 AGL	< 100	 RQ-11 Raven  Wasp
Group 2	21-55	< 3,500 AGL	< 250	 Scan Eagle
Group 3	< 1,320	< FL 180	< 250	 RQ-7 Shadow
Group 4	> 1,320	< FL 180	< 167 < 117	 MQ-1C Gray Eagle (Armed)  MQ-1 Predator (Armed)
Group 5	> 1,320	> FL 180	< 200 < 310	 MQ-9 Reaper (Armed)  RQ-4 Global Hawk

Figure 1: Remotely Piloted Aircraft (RPA) in active US military service.

Source: DOD
Graphics: Zaur Eylanbekov

Combining ISR-strike capacity on a single aircraft has fundamentally changed what it means to conduct an airstrike. To effectively attack an item of interest from the air, one must discover (find) the target, precisely locate (fix) it, and then engage it with an appropriate weapon to achieve the desired outcome (finish). These elements make up what is called the “kill chain.” Prior to the advent of modern RPA, separate aircraft had to accomplish the find, fix, and finish functions over a relatively long period of time. In World War II, the kill chain process could take many weeks. Reconnaissance aircraft would take aerial pictures; Airmen would fly the film back to a base where others developed it; intelligence professionals would analyze the images; planners would develop future missions to address areas of interest, strikes would occur, and then a follow-up mission would take place to assess target destruction. As technology evolved, the time decreased, but the process remained many hours even in the absolute best of circumstances.

This changed with the advent of armed remotely piloted aircraft in the form of the Predator. This aircraft consolidated the functions required to find, fix, and finish a target from multiple aircraft over a long period of time to one platform able to accomplish all these functions in a matter of single-digit minutes. Fielding an aircraft with the persistence to be able to find and fix a target, combined with the weapons to “finish” it, was truly revolutionary. Commanders fundamentally understand the tremendous power inherent within this model. As Air Force Maj Gen Thomas H. Deale, director of operations for Air Combat Command (ACC), said in fall 2016, “What I don’t want to do is drive our force to the point where we’ll be able to see the adversary in real time and in color [high definition], but not have strike capacity in order to affect it.”[4]

It is also important to note that an RPA’s persistence allows for a broad range of engagement options: act quickly or observe, orient, and wait for a specific set of circumstances to net a specific goal.

The reason for Deale’s commitment on this issue is clear: armed RPA are tremendously accurate given their powerful ISR capabilities, precision munitions, and crews trained to minimize both collateral damage and unintended casualties. At times, lawyers and other relevant experts may even be brought into the force employment decision-making process to ensure maximum possible ethical oversight. Such circumstances simply do not exist with traditional forms of military engagement. Nor is this advancement at a standstill. Modern technology is now expanding the notion of a kill chain to an “effects chain,” where non-kinetic actions delivered through electronic attack and cyber actions will yield desired results.

It is also important to note that an RPA’s persistence allows for a broad range of engagement options: act quickly or observe, orient, and wait for a specific set of circumstances to net a specific goal. This is far different than the vantage a pilot has in a manned aircraft: busy multitasking, flying at several hundred miles an hour, with a limited time to remain over the target, and viewing the situation from a distance or through a small display of limited fidelity.

To this point, a key driver behind the Predator’s success was incorporating sensors capable of relaying real-time full-motion video (FMV) to a broad number of users at the tactical, operational, and strategic levels. The ability to gain situational awareness by watching a live scenario proved invaluable. As recently as 2003, aerial and even satellite reconnaissance largely relied on still photos that might take hours or days to develop and analyze. Today, intelligence analysts, commanders, and forces deployed nearly anywhere in the world can receive live ISR feeds that flow into dedicated distribution systems from Predators, Reapers, Global Hawks, and other RPA types.

Another advancement that powered the rapid ascent of RPA was the 2001 invention of remote split operations (RSO), a system that enables Predator, Reaper, and Global Hawk pilots to fly their aircraft, and sensor operators to steer the ISR sensors, on the other side of the planet from bases in the United States through a network of fiber-optic cables and satellite links.[5]

Aside from the obvious cost savings and quality-of-life benefits associated with not forward deploying the majority of personnel involved with operating RPA, the real advantage comes down to efficiency. RSO allow the Air Force to squeeze three times the combat power from the same number of aircraft versus forward deploying the entire RPA operation. The reason is simple: if crews and RPA rotate in and out of theater on a standard deployment schedule, the vast majority of their time is spent at home in dwell status. Through the Air Force's RSO model, the aircraft never leave the combat theater. Crews and their aircraft are able to focus nearly all their effort on actual missions. Army RPA do not currently follow this model and instead deploy in a legacy format.

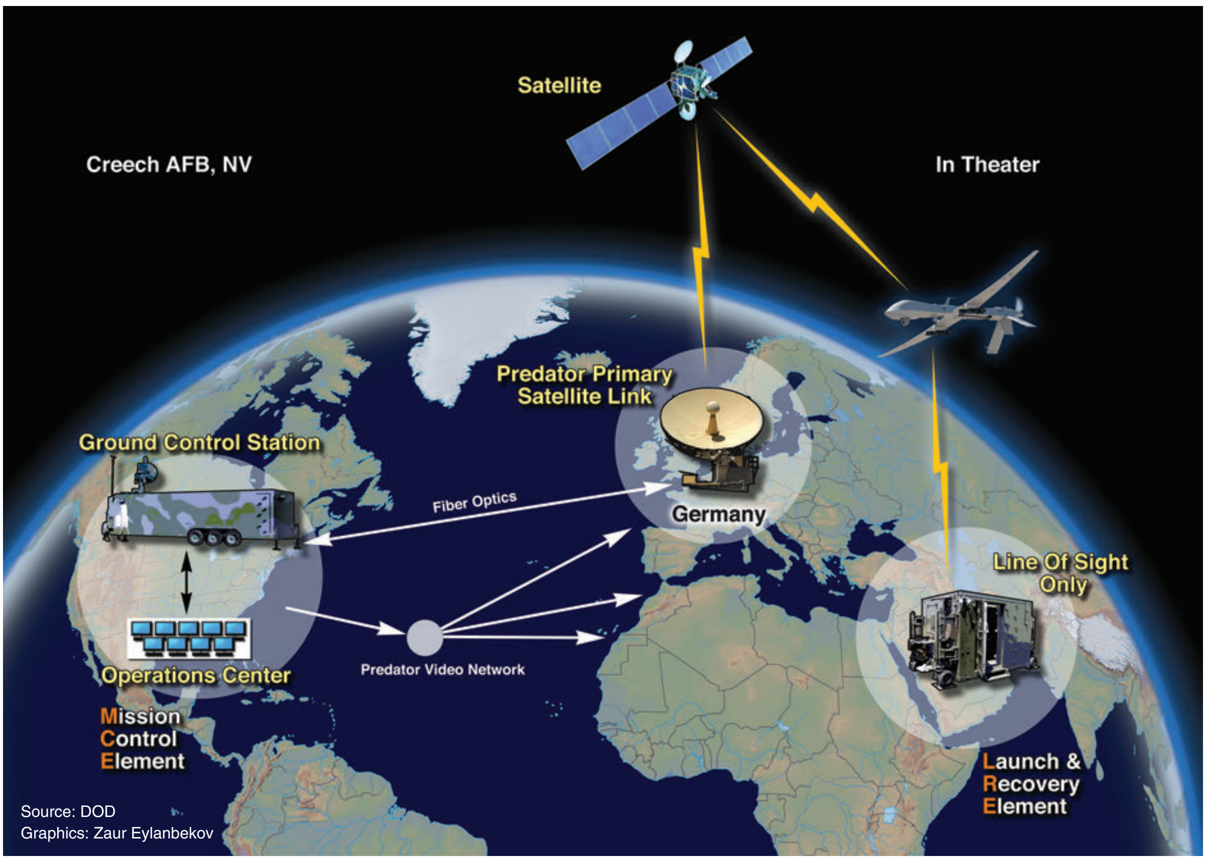


Figure 2: This diagram illustrates the remote split operations (RSO) concept.

Observing these virtues in action in Iraq, Afghanistan, and elsewhere, top US leaders and fielded military forces rapidly embraced the options that RPA afford, especially the Air Force's armed Predators and Reapers, in addition to the extremely long-endurance Global Hawks. Today, the US military has more than 9,000 remotely piloted aircraft. That number includes over 400 Predators, Reapers, and Gray Eagles, along with 33 Global Hawks.[6] Despite those numbers, combatant commanders cannot get enough of the persistent ISR and precision strike these aircraft provide and continue to have requests for these forces that exceed supply.

From the start of operations in Afghanistan and Iraq, in 2001 and 2003, respectively, the services, especially the Air Force, strove to meet the skyrocketing demand for RPA. However, revolutions tend to break much glass, and the remotely piloted aircraft revolution was no exception. The modern RPA is a disruptive technology, wreaking havoc on the services' best-laid plans, impacting their budgets, organization, and doctrine. Those changes also came during a time of war, when the need for speed in supplying forces to the field often led to ad hoc decisions. Service parochialism, impulse, and emotion often shaped these actions, rather than thoughtful, analytical planning to address enterprise-wide factors best.

A prime example of this sub-optimization occurred in 2008 when then-Secretary of Defense Robert M. Gates directed the Air Force to provide 15 additional combat air patrols (CAPs), the quantitative unit of measure that defines RPA productivity.[7] To meet this goal of growing from 50 CAPs to 65, Gates instructed the Air Force to surge the number of aircraft deployed versus exploring ways in which new technologies could make existing aircraft more productive from an output perspective. ISR data gathered, analyzed, and disseminated are what matters. The number of aircraft, or "tails" sitting on a ramp does not necessarily correlate to that goal. It is possible to equip RPA with enhanced ISR systems to view multiple aim points in a wide-area surveillance application. This sort of solution can exponentially enhance the efficiency and effectiveness of the RPA force. This is an especially important point given manpower limitations handicapping this mission set. Fielding the Gorgon Stare system in limited numbers on the Reaper in 2011 initially proved this capability.[8]

The modern RPA is a disruptive technology, wreaking havoc on the services' best-laid plans, impacting their budgets, organization, and doctrine.

Pressed to respond to Gates' edict, the Air Force began using the term "CAP" in a diluted fashion. To meet the stated requirements, service officials described what are, in fact, single-aircraft sorties lasting less than 24 hours over target as a CAP versus using the term for a relay of three or four RPA timed to keep one in the air over a particular area 24 hours a day. They did not do this to trick the system; instead, this was a reality dictated by a manpower shortfall. Pressed to meet immediate operational wartime mission needs, the Air Force shifted instructor personnel to maximize the number of individuals flying combat missions. While useful in the very short term, this proved counterproductive in the long run by stunting the pipeline of incoming pilots.[9] This clearly put the Air Force on an unsustainable path, for seeking to rapidly increase combat assets deployed at a given moment without considering the broader considerations risked breaking the force.

Organization is another major challenge facing RPA. Given that the services can base these assets forward through remote split operations, there is no reason to tie airframes to units rotating out of a theater where mission requirements still exist. Yet, this is precisely what DOD chose to do by allowing the Army to continue "organically" assigning MALE remotely piloted aircraft to specific units. This resulted in the majority of the Army's total RPA inventory not engaged in missions, but instead rotated back home when a unit's tour was completed. Of particular note, this situation developed at the same time in 2008 when the Pentagon leadership mandated that the Air Force grow its number of CAPs. The leadership imposed these additional resource demands on the Air Force, while, at the same time, the Army had more than 80 CAP equivalents of RPA capable of providing full-motion video—the desired output from the commanders in theater—sitting at home.[10] However, due to the way the Army organized and assigned its assets, it did not deploy those orbits to the fight.[11] The fact that commanders in theater wanted more full-motion video capabilities provided by RPA was understandable, but the solution should have incorporated all the service components—not just the Air Force—in a true joint, enterprise-wide approach to the problem.

Given that demand for RPA continues to grow and resources remain constrained, it is crucial to reassess how to execute this mission. Congress took note of many of these challenges in the Fiscal 2016 National Defense Authorization Act, which President Obama signed into law on Nov. 25, 2015. Lawmakers added $43 million to the Air Force budget for RPA pilot training; they also mandated a report on "actions the Air Force will take to rectify personnel shortfalls."[12] The Air Force is also taking action, with Air Combat Command announcing the results of a study on Dec. 11, 2015, regarding RPA pilot shortfalls and a long list of actions it plans to take "in an attempt to normalize operations and ensure long-term mission success."[13] The Department of Defense, meanwhile, has approved an Air Force "RPA Get-Well Plan" allowing the service to temporarily reduce its own CAPs from 65 to 60 per day, requiring the Army to contribute 16 CAPs, and authorizing contractor pilots to fly 10 CAPs.[14] The challenges of the RPA revolution, however, and the ISR needs of the future, go far beyond the number of CAPs flying or how many RPA pilots the Air Force can recruit and train.

It is time to institute a common and truly joint approach for the acquisition, management, and employment of the unmanned aircraft force.

Over the past two decades, the services have largely gone their own ways in developing RPA and the methods of using them. It is time to institute a common and truly joint approach for the acquisition, management, and employment of the unmanned aircraft force. This approach would facilitate integrating the ISR that force produces into a fused combat cloud fed by platforms of all types: RPA, manned aircraft, satellites, ground forces, and ships. The aim of this study is to provide a set of recommendations to make that a reality sooner rather than later. It is time to consolidate the revolution. Charting a successful path for RPA employment comes down to the basic task of aligning aircraft attributes with mission requirements.

To that aim, this study recommends the following actions:

1. Prioritize technologies that are able to reduce manpower requirements, boost mission efficiency, and rapidly seize new opportunities:

    a. Ensure new technologies are built to open mission system standards to facilitate modular plug-and-play integration between aircraft, sensors, and other payloads.
    b. Design RPA to integrate in a combat cloud enterprise: the ability to interface in a seamless fashion with systems throughout a particular area of operations in a collaborative, disaggregated, additive fashion.
    c. Improve control interfaces to allow better situational awareness and improved decision-making capability for RPA crews.
    d. Automate key functions including landing; multiple aircraft control; sense-and-avoid systems; and automated ISR data analysis.
    e. Integrate new waveforms, bandwidth-efficient data links, and software-defined radios to ensure resilient, robust protected communications.
2. Streamline the acquisition process to facilitate buying modern RPA technology in an agile, responsive fashion:
    a. When transitioning the RPA enterprise from an ad hoc wartime activity to a core enterprise mission, seek to develop common standards.
    b. Acquire sensors and aircraft in a decoupled, modular fashion through an open mission systems approach.
    c. Become an early adopter of better buying power initiatives, such as using technology maturation risk-reduction demonstrations, and cooperative research and development demonstrations and experimentations.
    d. Ensure RPA improvements are implemented in a joint fashion, while also seeking to implement positive developments from the civilian sector.
    e. Incentivize non-traditional defense firms to offer solutions to present challenges, especially when it comes to technology services like automated video analysis and data management.
    f. Streamline foreign military sales so that US allies, partners and friends can access American technologies and the US government can benefit from amortizing development costs.
3. Optimize the Pentagon's RPA organizational construct to net greater capability by aligning the use of systems in a more efficient and effective fashion:
    a. Establish an executive agent coordinating authority for DOD's remotely piloted aircraft enterprise.
    b. Ensure all RPA of the medium-altitude, long-endurance (MALE) class and above are under the direction of the appropriate unified command's joint force air component commander (JFACC), not individual units.
    c. Integrate RPA into the US airspace for training and domestic support missions.
    d. Ensure technological investment and procurement is focused on attaining optimal desired effects.

Historical Background

Unmanned aircraft have been around in one form or another since the advent of powered flight and designers built them in numerous configurations for a variety of missions. The US military first tried to develop pilotless aircraft during World War I, testing "aerial torpedoes," which were small biplanes designed to carry explosives to the target under guidance by rudimentary autopilots. The United States never used them in operations during the conflict.[15] Of distinct note, future World War II Army Air Forces head, and father of the modern US Air Force, Gen Henry H. "Hap" Arnold was a major proponent of one of these systems, nicknamed "the Bug."

In the late 1930s, the British movie actor Reginald Denny—a pilot and former Royal Flying Corps tail gunner who also owned a hobby shop in Los Angeles—formed a company to produce radio-controlled monoplane target drones for the US Army, which bought thousands of them to train antiaircraft gunners during World War II.[16] The Navy also used Radioplane Company 12-foot wingspan drones for anti-aircraft training, but developed fighter-airplane-sized drones as well.[17] These TDR-1 aircraft, controlled by a trailing "mother plane," could carry bombs or fly under direction into enemy targets kamikaze-style. They successfully flew a couple of minor combat missions in the Pacific theater, but the Navy quickly abandoned the experiment.[18] More famously, the Navy and the Army Air Forces both crammed explosives into rundown B-17 Flying Fortresses and PB4Y-1 Liberators and rigged them for radio control from a nearby mother ship. After a takeoff crew got one of these unmanned aircraft airborne, the crew bailed out, and the mother ship crew would then remotely fly the platform into heavily defended German military targets.[19]

During the Vietnam War, in a small and initially secret operation, the Air Force used modified Ryan Aeronautical Company jet target drones to fly reconnaissance missions on preprogrammed flight paths over North Vietnam and its ally China.[20] Ryan drones also flew as decoys to fool North Vietnamese air defenses, drop propaganda leaflets, and conduct electronic warfare. But unlike the Predator and other modern RPA, these Firebees, Fireflies, and Lightning Bugs were unable to return to base and land. After taking their photos, they would fly over the ocean, where their engines would shut down, a parachute would deploy, and a specially rigged helicopter would snatch them out of the air and bring them and their film back to base. Military personnel would bring the still-photo film back to the United States to develop, print, analyze, and annotate it and then fly the finished product back to commanders in theater a day or more later.

> During the Vietnam War, in a small and initially secret operation, the Air Force used modified Ryan Aeronautical Company jet target drones to fly reconnaissance missions on preprogrammed flight paths over North Vietnam and its ally China.

With the end of US combat involvement in Vietnam in 1973, military focus on unmanned aviation quickly waned. That interest revived after the conflict in Lebanon a decade later, when Israel used small, camera-equipped RPA to find and target Syrian surface-to-air missile batteries concealed in Lebanon's

Bekaa Valley.[21] A joint US-Israeli project of the late 1980s produced the catapult-launched RQ-2 Pioneer, which the US Navy used to good effect in the 1991 Gulf War to spot targets for the 16-inch guns of the battleships USS *Wisconsin* and USS *Missouri*. In the final days of the Gulf War, Iraqi soldiers were so defeated that a group of them famously surrendered to a Pioneer, waving white flags at the RPA as it circled overhead.[22] Also during Operation Desert Storm, the opening days of the air campaign saw the use of the BQM-74 target drone in an innovative fashion to replicate manned aircraft. The intent was to cause the Iraqi air defenses to radiate them with radar. That unveiled the enemy positions and allowed coalition forces to destroy many Iraqi surface-to-air missile systems.[23]

An Army RPA program begun the same year the United States withdrew from Vietnam fared far more poorly. The service's Aquila was a small unmanned aircraft designed to carry a laser designator to guide artillery shells to targets. By 1987, the Army had spent $1.2 billion on the project, yet in tests at Fort Hood, Texas, the Aquila performed correctly on only seven of 105 flights.[24] Aquila's dismal record led Congress to halve the budget for RPA development and consolidate it under an unmanned air vehicle joint program office led by the Navy.[25]

Despite the Pioneer's success, military interest in RPA remained tepid prior to the Balkan wars of the 1990s. The inadequacies, inconveniences, and complexity of unmanned aircraft ensured that they were a niche technology.

Despite the Pioneer's success, military interest in RPA remained tepid prior to the Balkan wars of the 1990s. The inadequacies, inconveniences, and complexity of unmanned aircraft ensured that they were a niche technology. But in 1994, in response to a White House demand for better ISR, the Central Intelligence Agency began flying camera-equipped medium-altitude Gnat 750 RPA over Bosnia by line-of-sight radio control.[26] In parallel, after a competition among four industry entrants, the Pentagon awarded the maker of the Gnat 750, General Atomics Aeronautical Systems, Inc. (GA-ASI) of San Diego, a contract to develop a more capable derivative.[27]

The Department of Defense set only a few requirements for this new RPA. It had to be capable of flying 500 nautical miles or more from its launch point and of remaining on station at that distance for 24 hours or more. It had to be able to spend those 24 hours at altitudes between 15,000 feet and 25,000 feet. It had to be able to carry 400 pounds to 500 pounds of sensors, which had to include daylight and infrared video cameras and synthetic aperture radar (SAR). It also had to be capable of transmitting its video and receiving its control signals via satellite. The result was the Predator, which made its first flight in July 1994 and which, despite its name, was unarmed for the first seven years of its existence.[28]

Technically, the Predator was just an experiment: an advanced concept technology demonstration (ACTD), an acquisition category the Pentagon created to test "mature and maturing technologies" in actual operations.[29] After the Army's successful use of the Predator as an ISR aircraft in Bosnia, DOD transitioned the program to the Air Force. In 1998, the Air Force took full control of its first long-endurance RPA.[30] Spurred by the wars of the late 20th century and early 21st century, rapid development of the Predator ensued, aided by the fact that this activity took place almost entirely outside of the regular acquisition system.

In 1999, during the US-led NATO air war against Serbian forces in Kosovo, a special Air Force acquisition organization nicknamed Big Safari modified the Predator's video feed to add metadata, a feature that enabled viewers to map the geographic coordinates of scenes they were viewing via the RPA's cameras. In a rush project, Big Safari also equipped one Predator with a laser designator to guide weapons released by manned aircraft to targets. The next year, the Air Force decided to arm the Predator, and, by the summer of 2001, had modified three of the aircraft to fire AGM-114 Hellfire air-to-ground missiles. The service used this new Predator hunter-killer version for the first time during the first night of the war in Afghanistan on Oct. 7, 2001.[31]

Three days after the Predator fired that first missile in combat, President George W. Bush asked at a National Security Council meeting, "Why can't we fly more than one Predator at a time?" He added, "We ought to have 50 of these things."[32] A few weeks later, in December 2001, Bush gave a speech to the corps of cadets at the Citadel in Charleston, South Carolina, where he said, "Before the war, the Predator had skeptics because it did not fit the old ways. Now it is clear: The military does not have enough unmanned vehicles."[33] The next day, the Air Force Chief of Staff ordered the arming of all the service's Predators, which now took on the designation MQ-1.

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Even before Bush spoke, the Air Force had deployed another type of RPA to combat in Afghanistan to join the Predator: Northrop Grumman Corporation's RQ-4 Global Hawk. This unarmed high-altitude, long-endurance RPA had its launch as an ACTD in 1995. Six years later, fewer than half a dozen of these large and highly automated RPA existed. Despite the fact that the Pentagon's schedule did not call for Global Hawk achieving an initial operational capability (IOC) until 2005, the Air Force began employing two Global Hawk ACTD aircraft over Afghanistan as part of Operation Enduring Freedom in the fall of 2001. Flown by 12th Expeditionary Reconnaissance Squadron pilots and sensor operators from a mobile ground control station at Ramstein Air Base, Germany, the RQ-4s operated out of Al Dhafra AB in the United Arab Emirates.[34] Despite Global Hawk's nascent development stage, over the next two years, these aircraft provided more than 1,000 hours and 15,000 images to US Central Command.[35] In 2003, Global Hawks took part in Operation Iraqi Freedom. Only now, Airmen in ground control stations at Beale AFB, CA, flew them using the same remote split operations method created two years earlier for the Predator.

In 2004, seeking to build upon the incredible success of the MQ-1 Predator, the Air Force fielded a "larger cousin" in the form of General Atomics' MQ-9 Reaper. Nearly 10 feet longer and wider than its predecessor, the Reaper has a greater range, payload carrying capacity, and endurance. It is equipped with several sensors, including infrared technology, a television camera, synthetic aperture radar, and laser designating capability to direct precision munitions. In addition to the Hellfire missiles carried by the Predator, the MQ-9 can employ GBU-12 and GBU-38 guided munitions; both are 500-pound ordnance normally carried by fighters and bombers. The Reaper's combat record stands strong, and the type is expected to remain in service for decades, affording significant opportunities for modernization and development to hone this proven platform. Gathering intelligence and striking targets in one integrated platform has yielded an incredibly potent option for actors at the tactical, operational, and strategic levels.

Another round of RPA mission expansion occurred in 2012, when the Air Force awarded Northrop Grumman a contract to integrate two Battlefield Airborne Communications Node (BACN) payloads on two Global Hawk aircraft to augment the fleet of four E-11A manned aircraft. The latter platforms provide an airborne communications gateway that translates and distributes imagery, video, voice, and data, often from disparate elements, thereby enhancing situational awareness, communications, and coordination for military personnel in the air and on the ground.[36] The genesis for this mission was simple, yet critical. In the mountainous terrain of Afghanistan, forces on the ground, in the air, and beyond were having an extremely difficult time communicating due to blocked signals and a variety of disparate communications technologies. With the Global Hawk carrying BACN—the Air Force designated these airframes EQ-4s—the joint task force commanders in US Central Command's area of responsibility could now maintain operational communications support 24 hours a day, seven days a week. Putting BACN on an unmanned, long-dwell RPA ensured efficient, enduring coverage versus manned alternatives. Highlighting the importance and value of BACN, a task force leader reported that "[BACN] was absolutely indispensable in the execution of [our] mission, … as fundamental as ammunition and chow."[37]

While RPA technology would likely have advanced under general circumstances, this is clear: The 9/11 terrorist attacks, the war in Afghanistan, the wider conflict with Al Qaeda, and hostilities in Iraq ignited the RPA revolution in a way few could have imagined.

From Niche Technology to Revolution

Given advances in the subsidiary technologies that make modern RPA what they are (e.g., GPS, lightweight composite materials, digital communications, microchips, smaller and more sophisticated cameras and other sensors), unmanned aircraft very likely would have become more than just a niche technology in the absence of war. When the armed Predator debuted in 2001, the Pentagon already was developing several unmanned aircraft whose names are familiar today: the Air Force RQ-4 Global Hawk, Army RQ-7 Shadow, and Navy MQ-8 Fire Scout helicopter. But in 2001, the fielded RQ-2 Pioneer and RQ-5 Hunter were in "sunset" status, meaning scheduled for phaseout. The Air Force planned to buy 87 more Predators than the 15 in its inventory, plus a total of 77 Global Hawks; the Army planned to procure 176 Shadows; and the Navy planned to acquire 75 Fire Scouts.[38] The conflicts of the early 21st century radically altered those plans.

Combat operations in Afghanistan and Iraq, along with counterterrorism operations elsewhere around the world, quickly created an insatiable demand for RPA and the capability they brought with them: combined precision strike and ISR capabilities; full-motion video in color or infrared; powerful radars for detecting movement on the ground; sensors able to intercept communications; and a communications relay. The unprecedented ability of the Predator and Reaper to loiter over a target area for hours at a time made the modern RPA a revolutionary tool. This loitering time allowed aircrew to observe or stalk known or suspected enemies, then assist forces on the ground or direct manned aircraft to the target or attack themselves, condensing the find-fix-finish targeting cycle on one aircraft. Global Hawks also radically expanded the art of the possible by providing vast amounts of intelligence data in real time to commanders at the strategic and operational levels and acting as a node that extended communication ranges, bridged radio frequencies, and translated among incompatible communications systems. Never before could a single operational asset stay airborne for more than a day on a single mission. This fundamentally evolved the entire understanding of ISR's role in modern military operations.

When the armed Predator debuted in 2001, the Pentagon already was developing several unmanned aircraft whose names are familiar today: the Air Force RQ-4 Global Hawk, Army RQ-7 Shadow, and Navy MQ-8 Fire Scout helicopter.

These early missions rapidly yielded lessons learned and new requirements. For example, engineers established a means to directly transfer the Predator's video output to aircraft with large weapons loads. In a similar vein, in early 2002, at the request of an Army Special Forces unit, the Air Force's Big Safari office, with L-3 Communications, created a portable device called the Remotely Operated Video Enhanced Receiver, or ROVER for short, that allowed forces on the ground to watch live RPA video feeds while on the move in combat.[39] About the same time, an armed Predator helped Army Rangers and Navy SEALs survive a battle with entrenched Al Qaeda fighters on a mountaintop in Afghanistan later becoming known as "Roberts Ridge."[40]

The Army quickly began acquiring more ROVERs and embarked on a rapid RPA buildup of its own. This included reversing its plan to phase out the RQ-5 Hunter, ordering the first of hundreds of 12-foot-wingspan RQ-7 Shadow tactical RPA, and initiating the program that developed its version of the Predator, which it dubbed the Gray Eagle. In fall 2016, Army Vice Chief of Staff Gen Daniel B. Allyn said the land service in 2018 will start using the Improved Gray Eagle (IGE).[41] This advanced variant of the Air Force's MQ-1 Predator, he said, will triple the range of existing systems and increase payload capability to support soldiers at extended distances. The Army began procuring IGEs in 2016.[42] The Marine Corps and Navy also began acquiring RPA of various types, including the MQ-4C Triton, the Navy adaptation of the Global Hawk.

The Global Hawk introduced new capability to the world of unmanned aircraft and would continue to do so in succeeding years. Envisioned as both a complement to, and a potential replacement for, the Air Force's high-flying, manned U-2 Dragon Lady, the Global Hawk differs markedly from the Predator, Reaper, Gray Eagle, and Improved Gray Eagle, not only in size and configuration, but also in how the service flies and uses it. The Global Hawk's wingspan, just shy of 131 feet in its latest variants, is twice that of the Reaper (66 feet) and more than double that of the Predator (55 feet). The RQ-4 has a far larger fuselage as well and with a turbofan engine cruises at about 360 mph, far faster that the propeller-driven Predator, Reaper, and Gray Eagle.

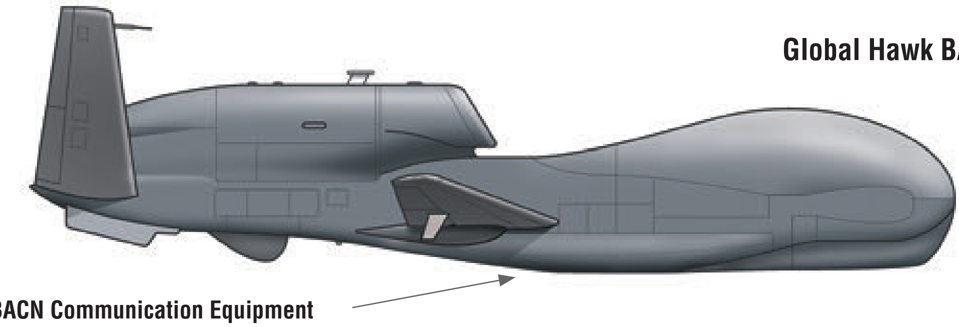
The JROC, like those in the Pentagon responsible for RPA matters, confuses input measures such as CAPs, and specific types of aircraft, with the output of those systems, which is really what is in demand.

The Global Hawk also flies operationally at more than 50,000 feet in altitude, but is not armed. It employs an array of powerful sensors to provide critical information and execute key mission tasks. Inspired by the difficulty of finding Iraq's Scud ballistic missiles during the 1991 Gulf War, the Global Hawk, unlike the Air Force's other RPA, is primarily an intelligence asset, used to collect large amounts of data over wide areas of surveillance for long periods of time. Upon delivery of the final three aircraft this year, the force will include 35 RQ-4 air vehicles in three mission configurations: the Block 20 serves as a communications gateway relay aircraft; the Block 30 carries sophisticated imaging and electronic signals sensors; and the Block 40 provides ground moving target indicator data through a large radar array.

While Global Hawks are flying every day, their CAPs do not count against DOD's mandated minimum of 60 daily CAPs by Air Force RPA. That is an issue that requires further consideration given the scale and scope of data provided. Instead, the Pentagon's Joint Requirements Oversight Council (JROC) determined in 2011 that only three high-altitude, information-gathering CAPs were required. The JROC, like those in the Pentagon responsible for RPA matters, confuses input measures such as CAPs, and specific types of aircraft, with the output of those systems, which is really what is in demand. A Soldier, Sailor, Airman, or Marine, does not care how many CAPs are airborne, nor what type of aircraft provides the information that increases his/her situational awareness. These personnel simply want situational awareness, where, when, and in a quantity and quality that enhances their mission effectiveness.

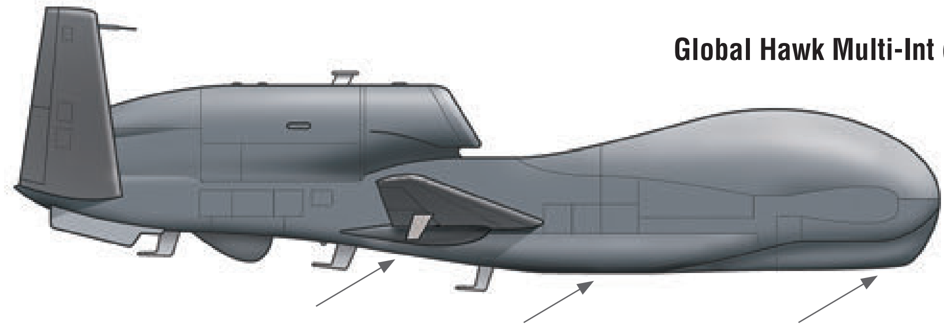
Figure 3: Operational Global Hawk configurations.

Global Hawk BACN



BACN Communication Equipment
- Persistent communications at the tactical edge; a "gateway" that connects radios for ground troops and aircraft
- Relays and translates for both voice and data networks
- Deployed and operating in CENTCOM
- Demonstrated value for command and control, and strike missions linking commanders to warfighters

Global Hawk Multi-Int (MI)



SIGINT Radar Camera
- Simultaneous optical, radar, and signals intelligence (SIGINT) gathering
- Flies missions where no other high-altitude asset can reach
- Supports operations around the world every day
- Modernization plan underway to improve sensor capabilities in all areas

Global Hawk Wide Area Surveillance (WAS)

MP-RTIP Radar
- Provides all-weather capability
- Can track thousands of targets at the same time
- High resolution radar imaging
- Initial formal testing completed in fall of 2015

Source: Northrop Grumman
Graphics: Zaur Eylanbekov

Today, a typical RQ-4 aircrew consists of a rated officer pilot and an enlisted sensor operator, the same makeup as a Predator or Reaper crew. However, the Air Force in October 2016 began the first combined enlisted and officer training course, which will train enlisted Airmen to fly the Global Hawk.[43] The first crop of enlisted Airmen graduated in May 2017. "Looking at new ways to operate within our RPA enterprise is critical given that ISR missions continue to be the number one most requested capability by our combatant commanders," said Air Force Chief of Staff Gen David L. Goldfein in July 2016, summing up the importance of this initiative. "We expect that will only continue to expand. We know our enlisted Airmen are ready to take on this important mission as we determine the right operational balance of officer and enlisted in this ISR enterprise for the future."[44]

Unlike the Predator and Reaper, the Global Hawk is virtually autonomous. With the control console lacking the stick and rudder pedals, the RQ-4 pilot is more "on-the-loop" than "in-the-loop," since control signals transmit to the aircraft and the aerodynamic and navigational results return to the crew. The pilot's job is to direct the Global Hawk's autopilot where to fly and let computers do the rest, which includes calculating flight paths and inputting commands that maneuver the Global Hawk's control surfaces and keep the aircraft in trim. The Global Hawk design is so automated that one pilot can fly three of them at a time. The Air Force has yet to take advantage of that capacity. However, as with so many outgrowths of the RPA revolution, the Global Hawk's development over the past 15 years has occurred in fits and starts, and often in ad hoc fashion. The BACN-equipped EQ-4, for example, came about in response to a joint urgent operational needs statement from US Central Command in 2011. Although the three such EQ-4 aircraft the Air Force flies are in high demand, the BACN has yet to become a formal program of record, despite the demand for the system from other combatant commands.

As the RPA revolution spread through the military, the Air Force, DOD, and Congress made several attempts to organize the development, acquisition, and use of unmanned aircraft technology better.

As the RPA revolution spread through the military, the Air Force, DOD, and Congress made several attempts to organize the development, acquisition, and use of unmanned aircraft technology better.[45] In the Fiscal 2004 National Defense Authorization Act, Congress required the Pentagon to develop a "fully integrated ISR roadmap and coordinate activities across the military services, defense agencies, and combatant commands."[46] In a step toward this greater coordination, the then-Air Force Vice Chief of Staff, Gen. T. Michael Moseley, on March 11, 2005, wrote then-vice chairman of the Joint Chiefs of Staff, Marine Corps Gen Peter Pace, telling him the Air Force "stands ready to serve" as the Pentagon's executive agency for certain classes of RPA.[47] "I am concerned the JROC process is drifting into a world of programmatic 'county options,'" Moseley told Pace, lamenting the lack of standards that "creates *redundancy* and … *duplicative expenditures*" for unmanned aircraft across the services.

At the time, the then-Deputy Secretary of Defense Paul Wolfowitz was an advocate for the Air Force becoming the executive agent for medium-altitude and high-altitude RPA. However he departed that position in May 2005, and upon his departure, the JROC recommended against the proposal. Instead, the council established the Joint Unmanned Aircraft Systems Center of Excellence (JUAS COE) to improve interoperability among the services. It also created the Joint UAS Overarching Integrated Process Team (JOIPT), later renamed the Joint UAS Material Review Board (JUAS MRB), to provide a forum to resolve requirements/materiel issues regarding interoperability and commonality of unmanned aircraft.[48] Both these alternatives did not have the authority that an executive agency would possess, and, as a result, failed to accomplish coordination of effort among the Pentagon's different efforts. The individual services proceeded to acquire organic RPA regardless of the capabilities that the other services' unmanned platforms already possessed.

In July 2006, the Air Force established the position of deputy chief of staff for intelligence (AF/A2) for a three-star general. The first incumbent of that position, Lt Gen David A. Deptula, requested that the Air Force chief of staff integrate surveillance and reconnaissance to the position's portfolio. The justification was that the move would institute an enterprise approach to achieve unity of effort for the totality of ISR. On Jan 1, 2007, the Air Force leadership re-designated the position as the deputy chief of staff for intelligence, surveillance, and reconnaissance, making it the ISR focal point for the Air Force, including RPA duties at the Air Force headquarters level.[49]

In 2007, Moseley, now the Air Force chief of staff, having witnessed two years of the JUAS COE, and JUAS MRB achieve no progress in coordinating the Pentagon's RPA efforts, renewed the call for the Air Force to serve as the executive agency for all medium- and high-altitude remotely piloted aircraft.[50] Alluding to the Army's policy of assigning its Gray Eagles to individual divisions and keeping those aircraft with those units whether they were deployed or not, Moseley argued instead for using Gray Eagles to help meet "growing theater demands" for ISR. "With some services' exclusive assignment of medium-altitude ISR assets to individual units, the joint (air commander) responsible for airborne ISR … is constrained in conducting a truly joint, strategy-driven ISR campaign," he wrote. Strategic mission objectives, not parochial service-centric priorities, should stand as the driving force, he stated.

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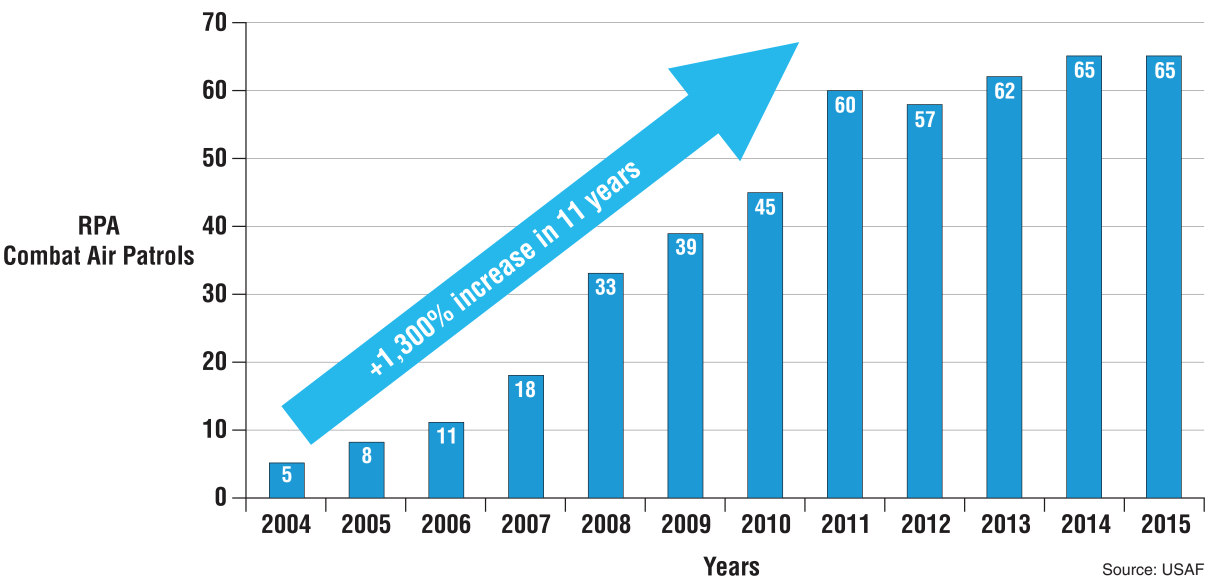
On July 16, 2007, the then-JROC director and Vice Chairman of the Joint Chiefs of Staff, Adm Edmund P. Giambastiani, endorsed the establishment of an executive agency for medium- and high-altitude RPA under the Secretary of the Air Force. The agency would address equipment standardization and acquisition streamlining across DOD, but would not have authority to direct operations.[51] The other services lobbied the Pentagon leadership hard against this decision. On Aug. 31, 2007, Marine Corps Gen James E. Cartwright became the Joint Chiefs' vice chairman—meaning, too, the new JROC director—succeeding Giambastiani. Several weeks later, on Sept. 13, 2007, Gordon R. England, the relatively new deputy secretary of defense, who had previously served as Navy Secretary, issued a memo directing actions "in lieu of establishing an executive agent" to provide for common, joint, and operationally effective" RPA programs. He directed the under secretary of defense for acquisition, technology, and logistics to create an Unmanned Aerial Systems Task Force.[52] The task force was meant to coordinate RPA requirements among the services, push the services to field "interoperable systems and networks," and foster "joint solutions" in unmanned aircraft acquisition programs. This outcome merely repeated the experience from 2005, with the JUAS COE and JUAS MRB failing to coordinate the Pentagon's remotely piloted aircraft efforts.

The task force faced major challenges from the start since it had no authority to cancel redundant programs or compel the services to combine programs. Unsurprisingly, little coordination or synchronization resulted.[53] By 2011, the Government Accountability Office reported that a special DOD task force was trying to help the under secretary of defense for intelligence, the nominal overseer of all military ISR, to decide "how to integrate into the long-term base budget more than 500 ISR capabilities that were developed to meet urgent operational requirements in Iraq and Afghanistan."[54]

Meanwhile, the demand for RPA continued to grow. Figure 4 shows the results of the Air Force's official CAP objectives for medium- and high-altitude RPA.

Figure 4: Growth in remotely piloted aircraft combat air patrols, 2004-2015



The Air Force has been in a "surge" mode with its remotely piloted aircraft for more than 10 years. The 2006 Quadrennial Defense Review (QDR) set the Pentagon's official program of record for the MQ-1 Predator at 21 combat air patrols by 2010.[55] Just one year later, in 2007, the "demand signal" from US Central Command increased far in excess of that benchmark. The Air Force responded by rapidly adding capability well beyond that 21 CAP goal, sometimes with multiple demand changes during one year. Requirements finally stabilized in 2010 when then-Secretary Gates issued his call for achieving 65 CAPs.

The demand for RPA capacity has thus far almost exclusively focused on aircraft tails. While this is important and the inventory must continue to grow to meet mission demands, it is also important to consider how to maximize the efficiency of each aircraft. For example, on missions where ISR is the primary objective, wide-area surveillance systems (WAAS) can view multiple sectors concurrently from one RPA. This stands in contrast to the directed view of an MQ-1 or MQ-9 of one area at a time. Allowing multiple sensory aim points at a given time enhances ISR mission effectiveness and affords benefits from both a fiscal and manpower perspective. When looking to put bombs on target though, it is important to emphasize that present technology requires a sufficient number of airframes to carry the munitions in question.

The Office of the Secretary of Defense granted an 18-month "reconstitution period"—essentially a reduction in remotely piloted aircraft CAPs—in 2012 to "right size" and improve the health of the RPA community, including the goal of fixing the manning in training units. The intent was to get back on the plan for 65 CAPs with better manning, morale, and quality of life for the RPA community in the long term. That came after US ground troops withdrew from Iraq, but before budget sequestration hit the Pentagon in 2013—severely curtailing defense spending—and the rise of the Islamic State and corresponding operations against it in 2014.

In June 2014, Airmen at Creech Air Force Base began flying the 65th of the 65 daily CAPs then-Secretary Gates established as a requirement for the Air Force years before.[56] However, the planned recovery efforts of the reconstitution period had fallen short and the Air Force RPA force was at the breaking point once again. Recognizing this, in 2015, then-Secretary of Defense Ashton B. Carter approved a "get-well plan."

Throughout this period and the ongoing quest to field the "right requirement" for numbers of RPA, it is abundantly clear there is no end in sight for growth in demand. However, resource constraints will not allow for unconstrained growth. The Pentagon must optimize the manner in which it acquires, organizes, manages, and executes the RPA force to achieve the greatest possible cost-effectiveness balanced with all the other capabilities necessary for DOD to support the national security strategy. The remainder of this study will address this.

Optimizing the Potential of Remotely Piloted Aircraft

Developing a sustainable RPA enterprise requires focus in two major categories. The first is broadly characterized as institutional changes; the second deals with technological initiatives. These recommendations have the objective of initiating change that will result in optimizing the RPA enterprise's potential as well as shaping the RPA force of the future to meet better the needs of the nation's security, with recognition of ongoing resource constraints.

Of the two categories, the institutional changes will be the most difficult to implement due to the challenges in redirecting long-established organizations, processes, and doctrine. Officials must overcome the ingrained mindset of "that's the way we've always done it." Furthermore, following and abiding by the established practices is how the current institutional leaders achieved their positions of control, so there is built-in resistance to change. Here is where Congress may be able to help by legislating initiatives for change that the institution of the Pentagon is unable to accomplish on its own. The analogy of how Congress was instrumental in establishing current DOD joint doctrine comes to mind.

When it comes to technology, automation is the master key that can unlock solutions to many of the challenges facing the Office of the Secretary of Defense and the services in manning, managing, and manipulating RPA and the efforts they yield. We trust automatic elevators. We trust personal computers. We trust smart phones to navigate for us via GPS as we drive. We trust the avionics on manned aircraft to operate flawlessly. We need to place greater trust in automation of RPA and sensor technologies as well.

Automated hardware and software are never foolproof, but we now face circumstances where failing to harness the attributes of automation will yield more vulnerability than the technology itself. Fears of automated warfare might be rational if robotic warfare were the goal. However, no one is advocating turning decisions to take lethal action over to machines or software. Defense Department Directive 3000.09 explicitly requires that, "Autonomous and semi-autonomous weapon systems shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force."[57] The automation we advocate here applies only to the non-lethal aspects of RPA. In that realm, automation mitigates risk; is statistically more dependable than human operators; and can pay rich dividends.

Against that backdrop, we recommend that the Air Force, DOD, and the Congress take steps to optimize the RPA enterprise in four overarching areas: 1) near-term actions to alleviate stress on the present force; 2) prioritize technologies that are able to reduce manpower requirements, boost mission efficiency, and rapidly seize new opportunities; 3) streamline the acquisition process to facilitate buying modern RPA technology in an agile, responsive fashion; and 4) optimize organizational constructs to net greater capability by aligning the use of systems in a more efficient and effective fashion.

Recommended Institutional Changes:

Near-term actions to alleviate stress on the present force

1. Accelerate funding to install an automated takeoff and landing system on all MQ-9 Reaper aircraft. Since the fielding of the MQ-1 Predator and MQ-9 Reaper, the majority of mishaps have occurred during the takeoff and landing phases of flight, with most of those accidents attributed to pilot error. During this same period, the Army began fielding its MQ-1C Gray Eagle with an integrated automated takeoff and landing system. As of early 2016, this technology has resulted in more than 75,000 Gray Eagle takeoffs and landings without a single mishap.[58] The Air Force's RQ-4 Global Hawk also uses a built-in, automated takeoff and landing system and has suffered no associated mishaps. The service has sought to install this capability on the Reaper, but budget constraints have slowed this effort.[59] By industry estimates, preventing the loss of three Reapers—at $15 million per aircraft—in landing accidents would more than fully fund the cost of fielding automated takeoff and landing on every MQ-9 in the fleet.[60]

The Air Force would also harvest additional savings since automated takeoff and landing technology obviates the need for launch and recovery element (LRE) aircrews at the forward bases from which Reapers fly. These LRE crews operate the RPA during takeoff with line-of-sight radio control. Then, LRE personnel hand the aircraft off to a mission crew in the continental United States (CONUS). When the sortie is complete, the CONUS crew returns control to the LRE operator. (The burden is large enough today that the Air Force is currently creating dedicated LRE squadrons.) By using automated takeoff and landing technology, the same CONUS crews who fly Reaper missions would be able to take off and land the aircraft. The Air Force would no longer need LRE aircrews, saving significant funds for training, maintenance, and deployment. This would also make Air Force RPA units easier to deploy. Crews previously assigned to the LRE training and deployment pipeline would now be available for flying operational missions. As one industry chief executive officer explained: "Reduce the level of training required and reduce the number of people required."[61]

2. Implement automated video-processing technology. The Air Force would benefit from harnessing commercially available technology to automate video-analysis processes. Software presently exists that is able to filter mass quantities of video data in an effort to reveal specific points of interest and trends. This technology would prove most useful in helping the Air Force process through tremendously voluminous quantities of data. For example, if mission planners were looking for a white pickup truck, the software could flag sightings, tag them with metadata to afford effective indexing, and empower human analysts to focus their energies in a more precise fashion, versus watching hours of irrelevant feed in hopes of finding the desired piece of information. The ability to harness open standards and open-source methodology promises to drive down costs, while also utilizing expertise previously developed in the private sector.

3. Accelerate the funding and fielding of sense-and-avoid systems. These technologies allow RPA to safely avoid other aircraft and meet the "see-and-avoid" standard that apply to manned aircraft as mandated by Federal Aviation Regulation 91.113.[62] To date, the Federal Aviation Administration (FAA) has severely limited the flying of RPA in US civilian airspace because unmanned aircraft lack the sense-and-avoid systems necessary for a ground-based RPA pilot or an automated flight control computer to “see” other aircraft and change course to avoid them. This capability would enable Air National Guard remotely piloted aircraft to rapidly support domestic missions and facilitate training. The Department of Homeland Security’s Customs and Border Protection service could better patrol US borders and maritime approaches if it could equip its RPA with this technology. Sense-and-avoid systems also would assist transiting RPA to areas of interest throughout international airspace.

Industry has developed a sense-and-avoid system for medium-altitude, long-endurance RPA that is able to detect all aircraft within a 20-nautical-mile range and direct flight inputs to avoid a collision. This capability is now at Technology Readiness Level 7, a level of maturity indicating that engineers have tested a prototype and the system is ready for integration in existing RPA. In fact, Customs and Border Protection has already bought and fielded a sense-and-avoid system. As of April 2017, this system was a finalist to be a Pentagon joint capability technology demonstration (JCTD). The fall 2016 presidential election and transition to the Trump Administration have delayed the DOD acquisition shop’s selection of the JCTDs, however. The Air Force Research Laboratory (AFRL) is also working on similar solutions. Clearly, sense and avoid is an important priority to pursue.

4. Ensure the appropriate use of officers and enlisted personnel as RPA operators. This is an issue that has direct relevance when seeking to increase the capacity of the Pentagon’s RPA enterprise. Enlisted personnel are more available and less costly than an equivalent number of officers. While they are also clearly capable of operating RPA, the respective level of responsibility, the capabilities of the particular system, and the implications of that particular system’s employment should dictate the divide between officer and enlisted functions. There is a significant difference between the situational-awareness requirements, authorities, and responsibilities of operating a hand-launched, four-pound, camera-only RQ-11 Raven that has no weapons capability, and controlling a 10,000-pound MQ-9 Reaper that can deliver 3,000 pounds of high-explosive ordnance. The Reaper provides close air support to friendly troops in contact with adversaries, in an urban environment, in close proximity to civilians, all while in congested airspace where multiple other aircraft are operating. Just as disparate operational realities dictate different rating requirements for a pilot of a Cessna 150 versus that of a Boeing 747 airliner, the RPA community also faces the same circumstances. DOD, FAA, and International Civil Aviation Organization regulatory and safety requirements are currently the same for RPA as they are for manned aircraft.

The Air Force did—and still does today—have enlisted personnel operating the same class of remotely piloted aircraft RPA that comprises more than 99 percent of the Army’s RPA force: small platforms like the Raven.[63] However, the majority of the Air Force’s RPA inventory are long-range, weapons-capable aircraft like the Predator and Reaper.

The Air Force needs to continue exploring manpower alternatives to meet increased RPA demand, rated management challenges, and appropriate levels of responsibility; however, this must occur with a view to the future, not the past. To this effect, the service recently made the decision to open RQ-4 Global Hawk operations to enlisted personnel.

There is also an institutional vantage to this issue. As RPA expert Thomas P. Ehrhard commented, "UAVs [unmanned aerial vehicles] lack institutional buy-in, and this cannot be accomplished if the UAV representatives in the headquarters, planning cell, or operations center are enlisted."[64] RPA require champions in the service's higher rank echelons. This requires robust officer involvement. To put it simply, an RPA pilot should be a candidate to be a future Air Force Chief of Staff. This will only happen if the career field is manned at rank parity with other areas of similar responsibility and authority.

5. Encourage operational innovation and experimentation to yield more effective and efficient processes. Ever since demand for RPA surged in the wake of the attacks on Sept. 11, 2001, wartime requirements have stretched aircrews thin. To a degree, this has inhibited the ability to explore new concepts of operation at exercises like Red Flag that may yield enhanced methods of attaining desired effects. Also, since operations in Afghanistan, Iraq, Syria, and elsewhere have largely been quite similar over the past 15 years, there may be new applications and methods of employment that non-combat experimentation could reveal to benefit the force. As one Global Hawk pilot explained:

> *Combat air forces [CAF] integration is our number one priority to increase combat capability for the aircraft. [That means] figuring out how to collaboratively engage with other aircraft. You need resources to integrate with the CAF though, and historically 95 percent of our sorties have supported overseas operations. It is very hard to give a talented captain the keys to the jet to go figure out what it can do when you have an operational utilization rate near 100 percent.*[65]

Appearing before Congress in March 2016, then-Air Combat Command head Gen Herbert J. "Hawk" Carlisle concurred with this assessment, explaining: "RPA units must now borrow time during combat sorties to conduct training, such as upgrades, and improving skills, tactics, and weapon-delivery procedures. This places severe limitations on their effectiveness."[66] It is time to change these dynamics by empowering Airmen to explore, experiment, and discover enhanced operational concepts with their RPA. While such actions come with a cost—outright cash expenditure and occasional lack of success—failing to learn and progress will ultimately prove unaffordable.

...since operations in Afghanistan, Iraq, Syria, and elsewhere have largely been quite similar over the past 15 years, there may be new applications and methods of employment that non-combat experimentation could reveal to benefit the force.

One way to advance experimentation and concept development is by partnering with industry. For example, a cooperative research and development agreement (CRADA) provides a vehicle for experimentation and innovation that allows for the rapid insertion of new capabilities and evolution of new concepts of operation, tactics, techniques, and procedures. One example is the 2015 agreement between the Air Force and Northrop Grumman, which through the application of a universal payload adapter, allowed the company to integrate and demonstrate the ability to fly U-2 ISR sensors on the Global Hawk in early 2017.[67]

6. **Invest in advancing the concepts of operation and tactics, techniques, and procedures associated with RPA employment. Educate RPA consumers about the full spectrum of capabilities available via the enterprise of available systems.** Over the past 15 years of operations in Afghanistan and Iraq, combat units often sought to secure direct overhead presence from a dedicated RPA. Such organic assignment is not just inefficient; it is unsustainable and may often lead to strategic priorities undermined by tactical objectives. Combatant commanders ultimately need to be able to control when and where they employ finite assets to meet their objectives. This is not to say that tactical requirements are not valid, but instead to suggest that means other than total organic control of a given asset can meet these demands. Modern RPA sensor technology, combined with other theater assets, is often able to provide desired effects, without tying a particular aircraft to a specific tactical unit for a prolonged period of time. As one Airman explained, it comes down to "building trust and understanding that we could accomplish a set of their mission tasks rather than be told to be [at a particular location] to shoot the camera."[68] It is critical to educate individuals at all levels—tactical, operational, and strategic—about the most effective and efficient ways to harness RPA to ensure their prudent use. It is also important to use the full spectrum of RPA capabilities beyond just full-motion video, such as imagery intelligence (IMINT), signals intelligence (SIGINT), hyperspectral sensing, and net-centric collaborative targeting. This requires robust investment in ensuring that officials continually develop effective, efficient concepts of operation (CONOPs) and tactics, techniques, and procedures (TTPs) and that RPA operators, commanders, and fielded forces embrace best practices.

Combatant commanders ultimately need to be able to control when and where they employ finite assets to meet their objectives.

7. **Seek to develop common standards and configurations when transitioning the RPA enterprise from an ad hoc wartime activity to a core enterprise mission.** Due to the rapid wartime pace involved with fielding RPA systems, the evolving nature of the technology, and ad hoc procurement methods, the present RPA inventory is comprised of numerous disparate variants. As one Air Combat Command representative explained, "We have a Vietnam fighter problem where we had lots of different fighters, none of them easy to sustain, and we have too many sub-varieties. I can't coordinate all of them."[69] Illustrative of this challenge, the Air Force was modifying RPA systems so rapidly, it struggled to develop and publish corresponding technical orders to guide maintenance efforts. Going forward, it is critical for the acquisition and development process to adopt a rapid acquisition mindset in order to field new capabilities to the war fight quickly. Organizations like Big Safari and Air Force Special Operations Command have successfully embraced these rapid acquisition processes to great success. This is important to ensure the RPA systems in the inventory are sustainable for the long term.

Prioritize technologies that are able to reduce manpower requirements, boost mission efficiency, and rapidly seize new opportunities

1. **Ensure new technologies are built to open-systems standards to facilitate modular plug-and-play integration between aircraft and sensors.** Recognizing that different missions require specific sensor packages, along with the need to integrate the latest technological developments rapidly, it is important to harness open mission systems and modular technology to decouple RPA aircraft from the sensors they carry.

This will facilitate incorporating rapidly customizable payloads. This will also allow better development of RPA and senor technology on independent tracks, meaning challenges in one area will not undermine the total mission system.

By divorcing the RPA “truck” from the sensors, the Air Force could incentivize actors in both arenas to manage risk better, try new ideas, and pursue upgrades. It would also be easier to integrate legacy systems, which have costs already invested. An RPA with a Litening ISR pod, for example, would be a prudent, quick-turn opportunity to enhance mission options. Failure with a specific sensor or a platform variant would not undermine the entire system. Instead, maintainers would sideline the challenged item for further work, while they configure the remaining components for employment. (This is comparable to a smartphone and associated applications. The device still functions with remaining applications, with the new app uploaded when it is technically mature.) If officials cannot solve the problem, the Air Force could cancel the item in question without too much disruption to the RPA enterprise capability. This sort of flexibility does not exist with present operational RPA, where the sensors and aircraft system are highly integrated in an interdependent fashion. The Air Force needs to prioritize concept development to afford this capacity.

Regardless of the platform, fielding multi-aircraft control will yield increased combat capability, either steady state with increased CAPs or by providing capacity for the Air Force to surge RPA operations.

Open mission systems are also relevant in modernizing the communications architecture of RPA. This facilitates the rapid insertion and upgrades of new capabilities. For example, software-defined radios and waveforms permit enhanced capabilities to meet urgent warfighting needs in a plug-and-play fashion. They provide resilient, robust assured communications against a dynamic and evolving threat environment.

2. Embrace RPA multi-aircraft control technology to maximize mission effect through the efficiencies of automation. In the early 2000s, the Air Force developed, built, and fielded a prototype system that allowed one pilot to fly four Predators simultaneously. This technology was neither elegant nor without problems, but it did prove the concept of multi-aircraft control, and the system operated successfully for a number of years with Predators flying over Iraq and Afghanistan. This significantly increased the existing aircrew’s combat capability and helped the Air Force rapidly grow RPA combat air patrols. The Air Force dropped the concept because only one of the four aircraft could conduct a weapons attack at any given time with a sole operator in the loop.

This capability is already resident in RQ-4 Global Hawks, allowing one pilot to control three aircraft at once. Given that Global Hawk is an ISR asset, there are not the challenges regarding weapons employment. As one Global Hawk pilot explained, “The jet has it and we’ve paid for it.”[70]

Regardless of the platform, fielding multi-aircraft control will yield increased combat capability, either steady state with increased CAPs or by providing capacity for the Air Force to surge RPA operations. If a "man in the loop" is required due to the complexity of a mission or a dynamic operational environment, the Air Force can always add additional personnel to a mission as requirements dictate. At the very least, the service could harness multiple-aircraft control when flying RPA to and from their mission areas.

3. Pursue integrated, collaborative partnering between RPA and other weapons systems. Modern technology is affording weapons systems the opportunity to engage in a collaborative fashion to achieve desired effects. For example, an RPA gathering ISR data could relay imagery to another aircraft to assist in directing a strike. Likewise, a manned aircraft could direct an RPA to fire a weapon on a designated target. RPA can also function as "loyal wingmen," carrying extra munitions and sensors to supplement manned aircraft.

The Army is presently expanding the application of such technology through a program known as Manned-Unmanned Teaming (MUM-T), which involves transferring command and control of Gray Eagle, Shadow, and ScanEagle RPA with manned AH-64D/E Apache helicopters. To date, Apache crews have been able to achieve so-called Level 3 control of RPA, meaning they can receive data from unmanned aircraft sensors, while also aiming and manipulating those sensors. The goal, however, is to give Apache crews Level 4 and Level 5 control, allowing them to fly an RPA from takeoff to landing, control its sensors, and even launch its weapons from their cockpit.

If the Air Force were to embrace current MUM-T technology, this could increase the number of RPA airborne at any given time without escalating the demand for ground-based aircrews.

The Air Force should seek to benefit from this effort by studying what lessons the Army has learned and what technology the sister service has developed to achieve it. The "loyal wingman" concept envisions Air Force pilots of the future exercising Level 5 control of far more automated and faster RPA than currently exist. If the Air Force were to embrace current MUM-T technology, this could increase the number of RPA airborne at any given time without escalating the demand for ground-based aircrews. With automated takeoff-and-landing capability paired with RPA controls in manned aircraft cockpits, CONUS-based crews could launch a Reaper, for example, fly it to a given area, and hand it off to a manned airplane's crew for mission execution, whether that might mean finding and lasing a target, or striking one. When the manned aircraft needs to return to base, the crew could hand the long-endurance RPA off to a second manned aircraft, which after finishing its use of the RPA could hand it off to yet a third, relaying use of the unmanned aircraft until it needed to return to base itself. At that point, the final manned aircraft in the chain would hand control of the RPA back to its CONUS base.

MUM-T will enable the Air Force to use RPA as weapons "mules," loitering over a given area with a load of ordnance, adding firepower to manned aircraft by literally increasing the weapons payload and variety available to its crew. The inverse is also true, as RPA have demonstrated the ability to develop a large number of targets for manned aircraft. As manned aircraft check in on station with limited time, an RPA can "buddy lase" a target for these aircraft to quickly and efficiently strike. MUM-T will also enable enhanced ISR and electronic-attack capabilities, opening new avenues for conducting air-to-air combat, releasing air-launched swarms of small RPA to flood defenses, attack targets, or serve as decoys. The possibilities are as numerous as they would be revolutionary. The Air Force should be devoting thought and resources to further developing MUM-T.

4. Use available technologies to improve the survivability of present RPA for increasingly denied environments. Air operations over the past 15 years have occurred in highly permissive environments. To assume such access will occur in future operations invites undue risk and projects much liability. While it will take time and resources to develop a new generation of RPA that will be able to incorporate the virtues of stealth, speed, and sophisticated electronic defenses to survive robust anti-access technologies, there are basic steps the Air Force can take to improve the survivability of present systems significantly. Such options include reducing electronic emissions; facilitating navigation in the absence of GPS and radio-frequency systems; utilizing satellite spot-beam technology to afford greater control resiliency; incorporating anti-jam GPS technology to address denial attempts; taking advantage of increased automation to reduce dependence on frequent control inputs; using secure command and control reachback; increasing the robustness and resiliency of data links; employing a terrestrial data link relay system to ensure connectivity in the advent of satellite signal jamming; having more onboard processing to afford selective information download; and implementing enhanced rules of engagement.

5. Harness a new generation of ground control stations to allow better situational awareness and improved decision-making for RPA crews. Airmen operating unmanned aircraft are currently doing so through first generation equipment. While representing leading-edge technology when fielded and still functional, such systems are often not user-friendly and lack the ability to integrate disparate flows of data into actionable knowledge. New systems offer solutions that will reduce user workload, improve functionality, and fuse information to optimize RPA tasks better. The Air Force's recent focus on securing open-architecture systems presents a valuable opportunity for RPA operators. The ability to "plug and play" new technology from various commercial firms, customize systems for specific missions, and enhance collaborative engagement between other mission assets would radically enhance the effectiveness of the ground control station (GCS) function. The present effort to update the Global Hawk's control station and the current pursuit of the Block 50 GCS for the Reaper fleet represents a positive step in this direction.

While representing leading-edge technology when fielded ... such systems are often not user-friendly and lack the ability to integrate disparate flows of data into actionable knowledge.

6. Seek to automate labor-intensive portions of the RPA mission, especially processing, exploiting, and disseminating the intelligence material. While RPA are massively capable, their ability to gather vast quantities of information is yielding extreme challenges for the services as they seek to translate this raw data into actionable intelligence. Currently collected are thousands of hours of streaming video, millions of images, immense amounts of electronic signals intelligence, mountains of synthetic aperture radar feed, and more. The processing, exploitation, and dissemination (PED) of this information is incredibly labor intensive and requires highly skilled personnel. As then-Air Force Chief of Staff Gen Mark A. Welsh III explained on the PED infrastructure in May 2016: "[I]t is a new tool with a whole lot of people, … from the people actually operating the controls, the people who are watching the feeds that it sends, to the people who make the decisions on what to do with that information. It is a heavily manned enterprise."[71] New technologies exist that are able to facilitate significant portions of the PED process in an automated fashion. While there is risk that an automated process could fail to recognize important pieces of information, officials must put such concerns in context with the reality that present data volumes are so great that there is a perpetual backlog of unprocessed intelligence information. Captured, but unprocessed data are useless. Harnessing automation would reduce this risk considerably. In seeking to address this issue, it is also critical to point out the role non-traditional technology firms may play in delivering potential solutions. Numerous commercial firms utilize data-management technology. The Department of Defense needs to encourage participation by such actors to derive the best available solutions.

7. Explore options for onboard processing capabilities to prioritize data packages that are relayed from the RPA when bandwidth flow-through-volume, or accessibility challenges arise. Considering that the vast majority of ISR information collected is not relevant to a given mission, transmission corridors carry superfluous material. Given that networks often face volume-throughput challenges or may face difficulty maintaining assured, high bandwidth capacity in a denied environment, the Air Force would be well served by ensuring the data streams that future RPA transmit are of value. High-capability onboard processing will yield a lower volume requirement for data transmitted in real-time. Such systems could store information deemed less important onboard for Airmen to download for future analysis when mass reaming is available or the aircraft returns to base.

Streamline the acquisition process to facilitate buying modern RPA technology in an agile, responsive fashion

1. Establish a fast-track technology-acquisition pilot program for RPA. Technology is evolving faster than the Pentagon's acquisition system can move. Commercial high-tech companies field new systems every few months while the US military takes years just to write requirements and decades to field major equipment. No one uses a 1990s-era cellphone these days, but even the newest RPA in the Department of Defense's inventory are based largely on 1990s technology. This must change, especially if the US military is to realize the benefits of an "offset strategy" and maintain or increase its qualitative edge compared to potential adversaries. The military services need to be able to field technological advances far more rapidly. Nowhere is this truer than in the realm of remotely piloted aircraft.

Even as the Air Force and the Department of Defense have sought to accelerate acquisition of RPA, acquisition bureaucracy has dogged these efforts. As one industry leader explained: "The [unmanned aerial vehicle] technology area is still rapidly changing. The Air Force never should have adopted something [i.e., an acquisition approach] that is going to work so slow with this technology."[72] An example of this is that until recently it took the Air Force more than three years to field the latest software block upgrades for its Reaper fleet (program changes have brought the fielding timeline down to every 12 to 18 months). It is also worth expanding this point past RPA and looking at the broader portfolio of aircraft, since the ability to work rapid upgrades in the information age will be paramount.

Further summarizing this situation, Frank W. Pace, former president of General Atomics Aeronautical Systems, Inc., concluded: "There is rapidly changing technology and the country needs to overcome [its] fear of taking on risk to be able to move down this rapidly changing technology path."[73] Given the pace of technological advancement, requirements evolution, and real-world pressures, such lengthy acquisition cycles undermine attaining necessary systems in a rapid, responsive fashion. RPA are the perfect vehicle for implementing and testing new approaches to development and acquisition, for the risk is lower without Airmen onboard, and circumstances are demanding faster results. Incorporating lessons learned from the Air Force's Rapid Capabilities Office, Big Safari technology development organization, and the acquisition element of Air Force Special Operations Command, the service is well positioned to develop a fast-track technology-acquisition program, or FASTTA.

A key part of this effort will involve allowing the Air Force to take risks, learn from demonstrated results, and continue pressing forward. This means accepting an "80-percent solution" rather than seeking perfection, a goal the current acquisition system too often sets.

> RPA are the perfect vehicle for implementing and testing new approaches to development and acquisition

2. Streamline RPA acquisition for allies and partner nations. High demand presently exists for US-made RPA capabilities and associated operating systems. However, few nations are able to acquire these systems in a timely, responsive fashion given the present bureaucratic process and limitations tied to the Missile Technology Control Regime (MTCR). It is a voluntary effort among numerous nations, including the United States, to curb the spread of ballistic missiles and other unmanned airborne systems that could deliver weapons of mass destruction. As one industry executive explained: "It's a system that was constructed for the Cold War when the US had one major adversary and we were the undisputed tech leaders and the idea that you could lock up the crown jewels was viable. There were two million drones sold in the US [in 2015], most built in China. That's a very different world."[74]

Countries with pressing requirements are unable to wait years to acquire technologies that are available elsewhere in the international market. Just look at what partner nations engaging against the Islamic State seek versus what the United States is willing to export in a timely fashion to empower commonly held strategic goals. This leads to allies funding RPA development efforts outside the United States, including with potential adversaries such as China. Failing to secure these sales drives up acquisition costs for the US military, for industry is not able to amortize costs across a broad production base. It also limits potential resources industry could harness to design improved systems. As one industry expert explained: "It is certainly easier for us to bring new technology to bear if we know there is a broader audience."[75] Finally, such dynamics also hinder allied cooperative interoperability: the benefits that accrue when nations fly the same equipment. It is time to stop obsessing on the risks associated with exporting RPA-related technology and instead appreciate the cost of failing to do so.

3. Continue pressing forward with new designs and concepts of operation. The Air Force must rapidly translate lessons learned and new operational demands into requirements for future RPA to replace the Reaper and Global Hawk beginning no later than 2020. If the Predator is the RPA-equivalent of the

Wright Flyer, the Reaper and Global Hawk, though highly capable, are merely the World War I-era Spad and Sopwith Camel biplanes, respectively.

In looking at the next generation of systems, it is important to consider the following questions: What missions will the Air Force expect the Reaper and Global Hawk replacements to accomplish? What capabilities or features would enhance the efficiency and effectiveness of executing these missions? Should some or all RPA be able to defend themselves? What role will these systems play as “loyal wingmen” to manned aircraft, escort to ground or sea convoys, or armed overwatch over vast distances in places such as North Africa and South Asia? These are all valid questions, but it is important to highlight that every new RPA need not be able to do every mission. Future threat environment will range from the relatively permissive to challenging, full spectrum combat with near-peer adversaries. Capabilities come at a cost, which makes advance planning imperative—and also suggests “the 80-percent solution.”

Recognizing that the present budget environment will also see legacy RPA retained for a significant period of time, it is also important to explore what upgrades will help ensure the relevance of these aircraft. With modest investment, RPA like the Reaper may engage in contested environments, especially after the most lethal threats are degraded. The addition of capabilities such as Link-16 tactical data link, radar warning receivers (RWR), and self-protection jamming pods could contribute tremendously to the operational utility of the aircraft. Enhancements to allow the aircraft to operate from more-remote and austere airfields would enable CONOPs that allow distributed operations across a theater with little impact to already congested airfields.

...it is also important to explore what upgrades will help ensure the relevance of these aircraft. With modest investment, RPA like the Reaper may engage in contested environments, especially after the most lethal threats are degraded.

To realize these potential attributes—enhancing today’s RPA and designing tomorrow’s systems—it is time for the Air Force to give future RPA planning the priority and funding it deserves before the next major war, not in the middle of it.

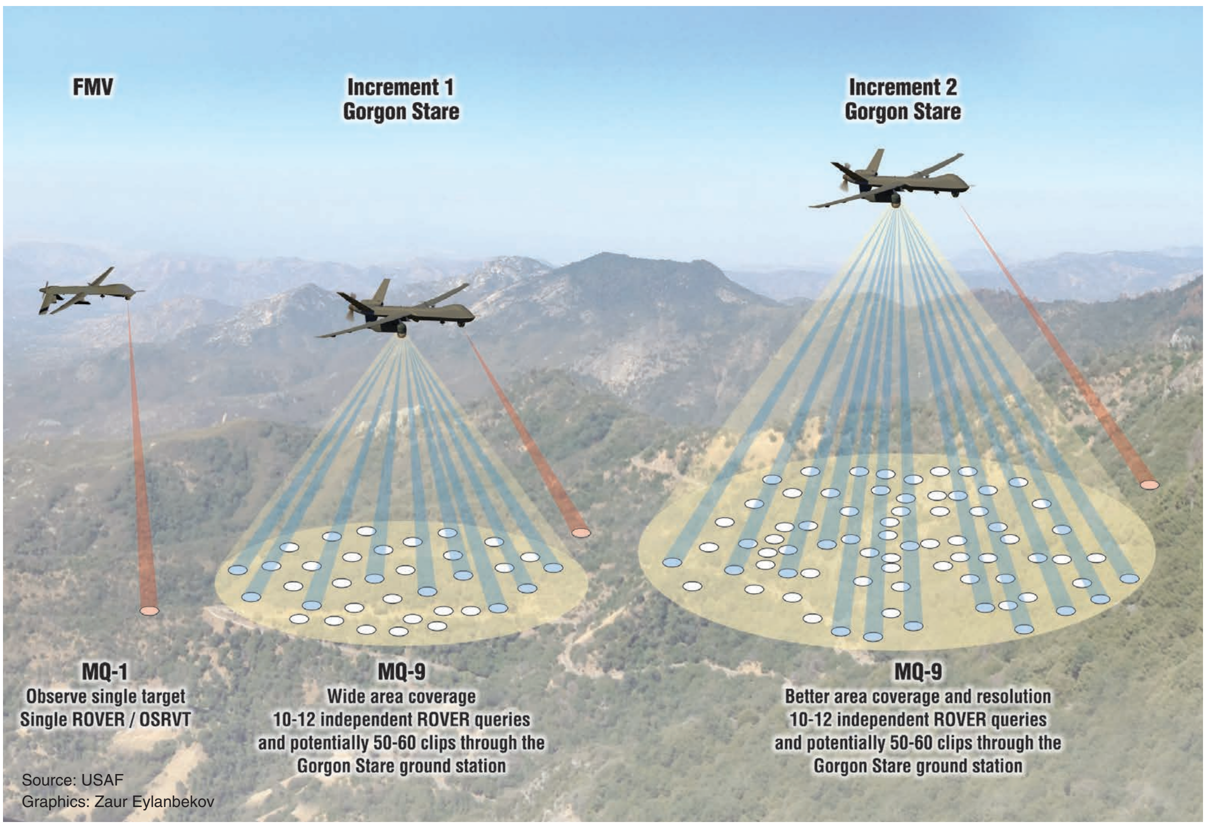
Optimize organizational constructs to net greater capability by aligning the use of systems in a more efficient and effective fashion

1. Improve the measure of merit currently in use to determine the desired output of the RPA enterprise. The most important first step that the Department of Defense has within its power to implement now is to correct the measure of merit it currently uses regarding RPA to determine their demand. The simplest way to understand this point is to compare a standard-equipped MQ-9 Reaper today with a Reaper carrying a wide-area surveillance system like a Gorgon Stare pod. The former can provide one full-motion video image over an area a couple hundred meters in diameter, while the latter can surveil an area several kilometers in diameter via more than one dozen FMV images. Yet, Pentagon officials have historically characterized these different scenarios in the same manner: as “one CAP” (see Figure 5). Clearly the optimal way to make more ISR available to US forces is to increase the capability of each RPA (i.e., the output it produces) versus adding more RPA, which is an input measure.

2. Update mission vernacular to describe mission capabilities better. Elaborating on this challenge, not all combat air patrols (either manned or unmanned) are created equal. Each brings different capabilities to the warfighter and requires different levels of support for operations. A Shadow RPA provides only full-motion video and flies at lower altitudes. Conversely, a Global Hawk operates at much-higher altitudes and carries multiple ISR sensors of various capability that require significant amounts of manpower for PED. Yet, DOD officials call each of these RPA launched on a mission today a CAP. The Pentagon currently measures and identifies RPA force structure by the number of CAPs or "orbits" it can launch at any one time. This is a misleading measure at best, and has the potential to lead to sub-optimal resource allocation and reduced value to the combatant commands at worst. Responding to this challenge, the Air Force is adopting a new description of how it allocates and employs RPA: combat lines per day. There is still much work to do across DOD to accurately define RPA mission capabilities.

A new definition for RPA capability is required. One alternative is to consider adopting the term "remote air mission" (RAM) to denote RPA-only activity. This approach offers a way to identify mission flexibility; is in-line with joint doctrine and the other services' terminology; and has application to a full range of joint mission areas.

Figure 5: Output differences per CAP, dependent on payloads.



Source: USAF
Graphics: Zaur Eylanbekov

Officials could adjust the term with a suffix and prefix to provide fidelity to capability of interest. For example, one could describe sortie duration with an "H" suffix; this enhances planning and capability expectation. Thus, a Reaper flying a 16-hour mission would receive the designation "RAM-H16." A "V" suffix could identify video sources, indicating the numbers of streaming images provided. A Reaper with a Gorgon Stare Increment One pod provides 11 video spots; this would show as "RAM-V11." Combining descriptors would display multiple capabilities: for example, "RAM-H16/V11" is a Reaper mission with 16-hour coverage with 11 video streams.

Adding a prefix to describe altitude and mission type provides a means to describe RAMs with even greater fidelity. If an official knows that an aircraft is an RPA and has some altitude and mission info, then that official broadly knows RPA type and, thus, its effect. An RPA would receive a prefix for the mission types it conducts (e.g., "I" for ISR). Since the typical operating altitude provides greater detail into effects, such as mission duration and general types of capabilities, adding another prefix enhances description. If an ISR remotely piloted aircraft flies at high altitudes, it would receive the prefix "H." If the ISR RPA operates in the medium-altitude range, it would receive the prefix "M," and so on.

RAM with a prefix and suffix allows for scalable levels of specificity and complexity:

- RAM (remote air mission): More specific, now only applies to RPA.
- RAM-H16 (RAM, 16-hour mission): Adds high altitude and mission endurance to the descriptor.
- I-RAM-H16 (ISR-RAM, 16-hour mission): Adds joint mission tasking and aircraft role to the descriptor (other possible types: close air support and offensive counter air).
- 5I-RAM-H16 (Group 5, ISR-RAM, 16-hour mission): Adds RPA classification based on size, weight, operating altitude, and speed to the descriptor.
- 5I-RAM-H16/V11 (Group 5, ISR-RAM, 16-hour mission/11x video feeds): Adds imagery sources to the descriptor.
- 5I-RAM-H16/V11/S1 (Group 5, ISR-RAM, 16-hour mission/11x video feeds/1x signals intelligence): Adds SIGINT sources to the descriptor.
- 5I-RAM-H16/V11/S1/G2 (Group 5, ISR-RAM, 16-hour mission/11x video feeds/1x SIGINT/2x weapons): Adds weapons capability to the descriptor.
- 5I-RAM-H16/V11/S1/G2/X (Group 5, ISR-RAM, 16-hour mission/11x video feeds/1x SIGINT/2x weapons/X PED): Adds processing, exploitation, and dissemination to the descriptor.

Using "remote air mission" provides a path to allow for precision in daily use; accounts for future systems for which applying "combat air patrol" would be less appropriate; and provides a clean break from "CAP." Here is a suggested definition of remote air mission: Remotely piloted or autonomous aircraft over an objective area; the force protected; or the critical part of an area of interest, for the purpose of providing long-endurance, multi-sensor persistent ISR, overwatch, kinetic or non-kinetic effects, communications, or a combination thereof.

3. Move to a joint approach as the solution to a joint demand problem. There are two often-confused and comingled aspects to this particular topic. The first is joint operational use of RPA and service ownership of the RPA in use. The second is coordination (or lack thereof) in managing the Pentagon's entire RPA enterprise. To understand these two related issues better, it is important to understand the different roles of the services and the combatant commands since the implementation of the Goldwater-Nichols Act. Since passage of the law in 1986, no longer do the individual services fight the nation's wars; instead, the combatant commands do the fighting under a designated joint task force (JTF) commander. The services organize, train, and equip what are called service component forces that are assigned to the combatant commands; the JTF commander conducts operations with them. The way America fights essentially boils down to this: individual services do not fight; they organize, train, and equip. It is the combatant commands that fight under the unifying vision of the joint force commander (JFC).

Service mission sets require realignment to minimize duplication of effort and allow resource concentration to secure maximum value. As the nation moves into a more fiscally constrained future, the Pentagon needs to seek ways to optimize the effectiveness of all its medium- and high-altitude RPA for the benefit of all joint warfighters.

Demand for remotely piloted aircraft exceeds supply and will continue to exceed it even after the services build all their programmed RPA.

DOD's "Joint Publication 2.0: Joint Intelligence" reads, "Because operational needs for intelligence often exceed intelligence capabilities, prioritization of collection and production efforts, and intelligence resource allocation are important aspects of the (intelligence production) process."[76] This statement also holds true for the force-application capacity of RPA. Demand for remotely piloted aircraft exceeds supply and will continue to exceed it even after the services build all their programmed RPA. This reinforces the notion that the best possible way to get ISR (and force application) from medium- and high-altitude RPA to US forces is by allocating the capability to where the forces need it most across an entire theater. It also argues against permanently assigning medium- and high-altitude RPA to individual tactical units, since that precludes their use and benefit to the entire theater joint fight.

Consider the analogy of a city made up of 50 blocks, where the mayor owns five fire trucks. If the mayor designated each truck to one block, those five trucks would cover only five blocks. A joint approach would leave it up to the mayor—or joint force commander—where best to allocate the five fire trucks based on which blocks needed them most.

Critics of this joint approach suggest that theater-capable RPA assigned to a joint force commander do not provide "assured support," and are not responsive to the needs of ground maneuver units. This thinking confuses a sufficiency problem for a lack of responsiveness and blurs the differences in capability between theater-capable and local-effects RPA. It also discounts the lessons learned early in World War II: lessons paid for with American blood, from which joint doctrine evolved.[77]

It is important to highlight that the points made here refer to theater-capable remotely piloted aircraft. Those RPA that can only achieve "local" effects are appropriate for assignment "organically" to units below the JFC level to provide assured support. However, lack of coherent control over taskings for theater-capable remotely piloted aircraft has too often resulted in the inefficient use of scarce RPA resources.[78] The US military cannot afford this, either from economic or operational perspectives.

Alleviating this situation demands clearly assigning roles and responsibilities for optimizing employment of theater-capable RPA to the component commander who is tasked by the JFC responsible for theater air operations. To get the most out of theater-capable RPA requires exploiting their capability to the fullest. The key to achieving that potential is maximizing RPA use throughout a theater wherever they are needed. Centralized planning in accordance with JFC priorities accomplishes this best, along with decentralized execution to meet the immediate needs of the joint forces requiring the RPA. Furthermore, in the context of the current fiscal environment, the low-density/high-demand nature of theater-capable RPA, and future threat environments, building service interdependency is what is needed most to enhance joint warfighting capabilities. Officials can do this by leveraging unique service core competencies that are optimally employed with sound joint doctrine.

Today, every Air Force operationally designated medium- and high-altitude RPA dedicated to US Central Command is at the disposal of the joint task force commanders. There are no such things as Air Force targets; there are only targets that are part of the joint campaign. That is not the manner of employment for medium- and high-altitude RPA that the Army and Navy possess. At some point, the Pentagon will allocate medium- and high-altitude RPA to theaters other than CENTCOM's area of responsibility, perhaps in locations without a significant US surface presence. Today, the Army assigns its medium-altitude RPA to individual units. This means if that unit is not in the war zone, then neither are those RPA. It would greatly increase the effectiveness of the Department of Defense's RPA enterprise and increase supply to meet current high demand, if DOD would operationally allocate remotely piloted aircraft to units in need versus allowing their permanent assignment to units not deployed.

The objective of a joint approach is to get the ISR distribution of medium- and high-altitude remotely piloted aircraft to be as transparent as the GPS signal is to all the services.

The objective of a joint approach is to get the ISR distribution of medium- and high-altitude remotely piloted aircraft to be as transparent as the GPS signal is to all the services. The Air Force owns the GPS mission 100 percent and Airmen operate GPS satellites 100 percent of the time, yet all the service components use GPS without any concern. DOD leadership has it within its discretion to do that with medium- and high-altitude RPA.

It is instructive to note how the US military can use medium- and high-altitude RPA in a joint context. Air Force component-provided RPA are routinely tasked to conduct tactical operations for forces on the ground. When an enemy sniper was pinning down Marine ground forces in Iraq during Operation Iraqi Freedom, a Predator RPA that Air Force personnel operated out of Nevada spotted and identified the insurgent. The Predator delivered video of the sniper's location directly to a Marine controller in the fight, and the Marine used that video to direct a Navy F/A-18 fighter jet into the vicinity. The Predator's laser designator guided the Navy airplane's bombs to the enemy position, eliminating the sniper. This engagement took less than two minutes.[79]

This is what joint warfare is all about. A joint approach for the use of RPA is all about getting the most out of ISR resources to increase this kind of capability for America's sons and daughters on the ground, at sea, and in the air, all while promoting service interdependency, and the wisest use of American's tax dollars. The Pentagon cannot buy enough RPA to meet the combatant commanders' growing demand, so it is imperative DOD move to a joint approach to employ RPA more wisely to meet joint task force commanders' needs.

As RPA become normalized in their application and continue to increase in numbers and capability, it is becoming increasingly important to bring theater-capable RPA more fully into an employment construct that is driven by joint doctrine.

4. Organize RPA as an enterprise across DOD. For more than a decade now, the Department of Defense has been in search of a solution to manage the individual service RPA forces as an enterprise. This is not to usurp the services from organizing, training, and equipping their component forces, but rather to optimize those elements of RPA where coordination of effort would enhance the entire Pentagon RPA enterprise. Unfortunately, as outlined earlier in this study, service parochialism has prevented much advancement toward this goal.

Today, DOD continues to segregate service approaches to RPA concepts of operation, airspace control, defense against enemy attack, and acquisition. To address these standing issues, the Pentagon is still taking essentially the same actions as it has for more than a decade, yet hoping for different outcomes. There is currently no single office responsible for, or empowered to, integrate RPA efforts across the DOD as an enterprise. The "answer" to the proposal of a decade ago to stand up such an organization with appropriate authority (i.e., an executive agency) to compel unified action was the creation of the UAS Task Force under the under secretary of defense for acquisition, technology, and logistics. However, the task force's charter did not give it the authority to direct the military services to adopt any of its suggestions. Rather, task force members act in an advisory capacity and make recommendations to the services and Joint Requirements Oversight Council. It is time to change that approach. Coordination of separate service-specific medium- and high-altitude RPA will:

- Reduce or eliminate acquisition duplication of effort,
- Reduce RDT&E funds and timelines by leveraging existing investments,
- Reduce logistics and sustainment funding requirements by eliminating redundancies,
- Increase interdependency and interoperability,
- Build joint solutions, not service-specific solutions, and
- Provide more capability sooner.

There are myriad reasons to address these challenges now, as there were 10 years ago. They include improving distribution of RPA intelligence across all theaters and service components; avoiding duplication of separate service acquisition efforts by centralizing procurement of all medium- and high-altitude RPA and their associated ground equipment; decreasing time and cost to field new capabilities; standardizing RPA operations, training, and combat tactics, techniques, and procedures; standardizing RPA downlinks;

expanding and integrating international partners' use of RPA; and controlling expanding RPA bandwidth to ensure prioritized intelligence distribution.

The UAS Task Force approach has failed to solve the challenges identified more than a decade ago. Parochial service concerns in 2007 killed the initiative to designate a Pentagon executive agency for medium- and high-altitude RPA to oversee coordination of all remotely piloted aircraft that operate above a coordinating altitude. Perhaps service and DOD leadership has matured in the interim, and can objectively consider the benefits of coordinating research, development, test, and evaluation (RDT&E) and procurement of these systems. Such a path would be more efficient and cost-effective than the individual services duplicating their efforts; is an acquisition area in which DOD could realize tremendous dollar savings and better buying power; and deserves reappraisal in the current era of constrained resources.

Parochial service concerns in 2007 killed the initiative to designate a Pentagon executive agency for medium- and high-altitude RPA to oversee coordination... Perhaps service and DOD leadership has matured in the interim...

5. Think differently about RPA mission classification — but remember today's RPAs are not replacements for high-end fighter forces. The Air Force presently faces a challenge with regard to how it classifies RPA, such as the MQ-9 Reaper, as these aircraft have evolved beyond traditional naming conventions and historical mission identification.[80] While they possess mission characteristics that allow them to perform both ISR and kinetic strike, they do not presently possess air-to-air capabilities, or high-g maneuverability that is necessary to survive in modern air defense threat environments. RPA now fielded in the force structure today will surely be incorporated in conflict scenarios as threats are appropriately mitigated. However, current RPA are not yet viable substitutes to perform missions such as those taken on by high performance fighter aircraft.

Accordingly, the current RPA force should not be counted as part of the US Air Force's fighter force structure. To do so would risk serious misunderstanding of capacity consideration when it comes to accounting for aircraft capable of effectively operating and surviving in high threat environments. While the MQ-9 can strike ground targets with various types of ordnance in permissive airspace, they are unable to engage in counter-air operations against enemy aircraft, and can only engage at a significantly elevated risk of loss in high-threat environments. While "fighter" designated aircraft have predominantly been used for air-to-ground strikes in the campaigns following September 11, 2001, this does not mean that their counter-air capabilities will not be necessary in future combat operations. This is not meant to take away from the dramatic contribution of the MQ-9 and other MALE RPA aircraft to contemporary warfare. However, specific capability distinctions will be even more important in the contested combat environments of the future.

Conclusion

The remotely piloted aircraft "revolution" of recent years is still unfolding at a rapid pace and likely will continue to do so for years to come. Few would have predicted the speed and impact with which RPA would burst onto the national defense scene and become invaluable contributors in both combat and non-combat operations. The speed with which the Department of Defense has incorporated these systems into its inventory has been unprecedented. In the sprint to employ these systems, the evolution of RPA capabilities has outpaced the development and implementation of an enterprise approach to govern their use. The Pentagon must remedy this situation now, and set itself to the task of forging an appropriate RPA coordination, acquisition, and employment strategy. This will ensure the integration of these resources within DOD to optimize their use in joint force operations.

The magnitude of the contribution unmanned aircraft already are making today is significant. Yet, even as quickly as these systems are advancing and maturing, demands for what they bring to operational environments are growing at an even faster pace. As RPA become normalized in their application, and as they continue to increase in numbers and capability, it is increasingly important to bring them more fully into this type of construct. Historically, lack of coherent control over what military planners have tasked theater-capable RPA to do too often has resulted in the inefficient use of scarce RPA resources, The Pentagon cannot afford this, from both economic and operational perspectives. Leadership can alleviate this situation by clearly assigning roles and responsibilities for optimizing employment of theater-capable RPA to the component commander responsible for theater air operations, as assigned by the joint force commander.

To get the most out of theater-capable RPA requires ensuring that military personnel exploit their capability to the fullest. The key to achieving that potential is maximizing RPA use throughout a theater wherever US forces need them. That is best accomplished by centralized planning in accordance with the joint force commander's priorities and decentralized execution to meet the immediate needs of the joint forces requiring them. Furthermore, in the context of the current fiscal environment, the low-density/high-demand nature of theater-capable RPA, and future threat environments, building service interdependency is what is needed most to enhance joint warfighting capabilities. Officials can do this by leveraging unique service core competencies that are optimally employed with sound joint doctrine.

It is time to develop a better approach for the acquisition, management, and employment of the remotely piloted aircraft force. Looking past individual RPA, it is also important to recognize that these aircraft are part of a joint enterprise network. The recommendations made in this study are offered as actions that Pentagon officials can take now to build and codify a joint RPA paradigm that gets the most out of these resources. This will increase capability for joint forces, while promoting service interdependency and the wisest use of America's tax dollars. ✪

Endnotes

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10 Authors' note: At the time (October 2009) the Army possessed 1200 RQ-11B (RAVEN) systems with 3 aircraft per system. Some 281 of those systems were deployed (23 percent). Assuming a one hour a day capacity for each of the systems not deployed, the result is 38 full motion video (FMV) equivalents. At the same time the Army possessed 71 RQ-7 (Shadow) systems with four aircraft per system and 20 of those systems were deployed. Assuming a 20-hour per day capacity for each of the Shadow systems not deployed results in 42 FMV equivalents. Combined, there were 80 FMV orbits of capability available but not deployed. This data is cited from the US Army's UAS status reports, from October 2009.

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75 RPA technology engineer and company official at unnamed aerospace firm, author interview, February 10, 2016.

76 Joint Staff, *Joint Publication 2.0: Joint Intelligence,* October 22, 2013, http://www.dtic.mil/doctrine/new_pubs/jp2_0.pdf (accessed April 2017).

77 Authors' note: At the time, the US military used aircraft for the direct support of ground forces and held the attitude that the mission of the air arm was the mission of the ground forces and that ordinary air units would fall under ground commanders. Under such a philosophy of air operations, the air campaign during late 1942 and early 1943 in North Africa proved to be a model of inefficiency. Consequently, in the aftermath of the battle at Kasserine Pass, the War Department shifted American airpower under the centralized control of Airmen. Ensuing doctrine stated: "Land power and airpower are co-equal and interdependent forces; neither is an auxiliary of the other. … Control of available airpower must be centralized and command must be exercised through the air force commander if this inherent flexibility and ability to deliver a decisive blow are to be fully exploited." See: *War Department Field Manual 100–20: Command and Employment of Air Power* (Washington, DC: US Government Printing Office, 1944), http://www.au.af.mil/au/awc/awcgate/documents/fm100-20_jul_1943.pdf (accessed April 2017).

78 GAO, "Intelligence, Surveillance, and Reconnaissance: Preliminary Observations on DOD's Approach to Managing Requirements for New Systems, Existing Assets, and Systems Development," GAO-07-596T (Washington, DC, 2007), https://www.gpo.gov/fdsys/pkg/GAOREPORTS-GAO-07-596T/content-detail.html (accessed April 2017). Authors' note: The report specified the need for the JFACC to have visibility into platform taskings against targets. As justification, the report cited an example of a single ISR requirement that resulted in two different services' RPA going to the same target at the same time.

79 Remarks of Lt Col Greg Harbin, USAF, "US Department of Defense – How We Fight," YouTube video, 0:00-2:00, posted by "EarBot.com," May 26, 2007, https://www.youtube.com/watch?v=3lxJSZQ93gI (accessed May 3, 2017).

80 John Tirpak, "Counting RPAs," *Air Force Magazine's Daily Report,* April 19, 2017, http://www.airforcemag.com/DRArchive/Pages/2017/April%202017/April%2019%202017/Counting-RPAs.aspx (accessed April 28, 2017).

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