ARMY AND AIR FORCE UNMANNED AIR RECONNAISSANCE:
WARRIOR AND HYDRA NAVIGATING A MAZE OF STRATEGIC HEDGES

BY

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14. ABSTRACT

During the post-9/11 Iraq and Afghanistan counterinsurgencies, the Air Force and Army acquired similar unmanned air systems (UAS) to provide intelligence, surveillance and reconnaissance (ISR), though with different degrees of success. The Air Force selected the MQ-1B/-9 Predator/Reaper family of vehicles, while the Army chose the MQ-1C, unofficially named Sky Warrior. Although the air vehicles had comparable performance, the services selected different command and control (C2) and sustainment mechanisms that defined the relative effectiveness of the systems. As the counterinsurgencies intensified, the ISR platforms from both services were inadequate to meet increasing requirements. As the services surged, they quarreled over ISR request and airspace-control processes as well as the efficiency of their respective systems. Although the services moved to harmonize their processes, the Air Force drew criticism from Secretary of Defense Robert Gates for not providing enough UASs, which contributed to the relief of the Secretary of the Air Force and Chief of Staff of the Air Force in 2008. In conjunction, observers charged that the Army UAS was an unnecessary duplication that infringed upon Air Force roles and missions. In a resource-constrained environment, the public debate continues on the wisdom of buying two UASs with roughly equivalent capabilities and similar missions. This study analyzes the relative effectiveness of the services UASs in meeting national security objectives in the context of the Global War on Terror and future wars. Given the similarity in the air vehicles, the UAS C2 and sustainment mechanisms served as the basis of comparing the service solutions. The hedging constructs in the National Security and Defense Strategies provided the criteria for this comparison. This analysis revealed that both services UASs could serve as effective hedges to meet requirements for most of the scenarios examined. Further, relative to each other, the services UASs are equally effective in the aggregate, but the Air Forces remote-split operations (RSO) concept has greater potential capability due to its inherent flexibility and adaptivity. However, shortfalls in the Air Forces C2 and sustainment mechanisms have prevented RSO from reaching its full potential. In contrast, effective management of the Armys corresponding mechanisms facilitates its UAS service as a hedge. Why did the services develop their UASs in this manner? Civilian intervention in the affairs of the services played the most significant role in the services UAS innovations, though interservice and intraservice factors contributed. The studys results reflect a historic role reversal in which the Army successfully innovated to create a viable, effective UAS, and the Air Force declined in its relative ability to innovate. After historically poor performance in UAS fielding, the Armys success can be traced to Secretary of Defense Donald Rumsfelds defense transformation. His direction to create smaller ground units led the Army to transfer UASs to the powerful aviation branch to improve their ISR performance. In doing so, Army UASs gained advocacy and aviation-system-management experience. In contrast, the Air Force developed the RSO system internally, and it proved very effective despite limitations. Historically drawn to new technologies, the service unsurprisingly adopted this innovation. Under pressure from the Army to produce more UAS ISR for Iraq and Afghanistan, however, Air Force vi leadership resisted innovating RSOs C2 and sustainment mechanisms as well as dedicate additional resources to UASs at the perceive expense of other missions, past a certain point. Gates installation of new Air Force leadership in 2008 removed the Services resistance opening the way to system improvements already evident in the course of this analysis. Finally, this civilian intervention ensured the continued fielding of the services complementary UASs and sowed the seeds for future interservice rivalry over the battlefield ISR missionas well as healthy innovation.

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The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

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ABSTRACT

During the post-9/11 Iraq and Afghanistan counterinsurgencies, the Air Force and Army acquired similar unmanned air systems (UAS) to provide intelligence, surveillance and reconnaissance (ISR), though with different degrees of success. The Air Force selected the MQ-1B/-9 Predator/Reaper family of vehicles, while the Army chose the MQ-1C, unofficially named "Sky Warrior."   Although the air *vehicles* had comparable performance, the services selected different command and control (C2) and sustainment mechanisms that defined the relative effectiveness of the *systems*. As the counterinsurgencies intensified, the ISR platforms from both services were inadequate to meet increasing requirements. As the services surged, they quarreled over ISR request and airspace-control processes as well as the efficiency of their respective systems. Although the services moved to harmonize their processes, the Air Force drew criticism from Secretary of Defense Robert Gates for not providing enough UASs, which contributed to the relief of the Secretary of the Air Force and Chief of Staff of the Air Force in 2008. In conjunction, observers charged that the Army UAS was an unnecessary duplication that infringed upon Air Force roles and missions. In a resource-constrained environment, the public debate continues on the wisdom of buying two UASs with roughly equivalent capabilities and similar missions.

This study analyzes the relative effectiveness of the services' UASs in meeting national security objectives in the context of the Global War on Terror and future wars. Given the similarity in the air vehicles, the UAS' C2 and sustainment mechanisms served as the basis of comparing the service solutions. The hedging constructs in the National Security and Defense Strategies provided the criteria for this comparison. This analysis revealed that both services' UASs could serve as effective hedges to meet requirements for most of the scenarios examined. Further, relative to each other, the service's UASs are equally effective in the aggregate, but the Air Force's remote-split operations (RSO) concept has greater potential capability due to its inherent flexibility and adaptivity. However, shortfalls in the Air Force's C2 and sustainment mechanisms have prevented RSO from reaching its full potential. In contrast, effective management of the Army's corresponding mechanisms facilitates its UAS' service as a hedge.

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Illustrations

INTRODUCTION

In time of crisis or war, military doctrine will be tested against the qualitative and quantitative adequacy of the forces provided in times of peace. [1]

Colin Gray*, Explorations in Strategy*

The Secretary and Chief of Staff of the Air Force get Fired

In June 2008, in an unprecedented move, Secretary of Defense (SECDEF) Gates relieved both the Secretary and Chief of Staff of the United States Air Force (SECAF and CSAF.) The press cited the failure to manage the Air Force's nuclear force as the primary reason for the firing in addition to perceived failure by the Air Force to support the Global War on Terror (GWOT) with adequate unmanned aircraft system (UAS)-based intelligence, surveillance, and reconnaissance (ISR) capability. [2] Indeed, in late 2007, the US Combatant Commanders (COCOMs) had collectively prioritized UAS reconnaissance and surveillance (RS) capability as their number one unmanned system priority. [3] Later in the spring of 2008, Secretary Gates had very publically expressed his dissatisfaction with the Air Force's progress in providing UAS ISR capability, and Army leadership in theater seemed to echo the SECDEF's assessment. [4] Overlaying this controversy were competing demands for (and control of) limited assets in Iraq and Afghanistan to meet the almost unlimited ISR requirement at both the operational and tactical levels in support of the counterinsurgencies (COINs). [5] Subsequent efforts by the

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[1] Colin Gray, *Explorations in Strategy* (Westport, CT: Praeger, 1998), 113-4.

[2] Richard B. Gasparre, "Less Ego, More UAVs," *Air Force Technology,* 17 July 2008, http://www.airforce-technology.com/features/feature2104/*,* James Joyner, "Air Force Secretary, Chief of Staff Fired," *Outside the Beltway*, June 5 2008, http://www.outsidethebeltway.com/archives/air_force_secretary_chief_of_staff_fired/, and Michael Hoffman, "Gates: No More Cuts to US Air Force Personnel," *Defense News,* 9 June 2008, http://www.defensenews.com/story.php?i-=3570646, Karen Walker, "Air Force Firings: The Right Decision," *Defense News,* 9 June 2008. http://www.defensenews.com/story.php?i=3570572.

[3] US Department of Defense, *Unmanned Systems Roadmap 2007-2032,* (Washington DC: Office of the Secretary of Defense, 10 December 2007), i, 21.

[4] Michael Hoffman, "Gates Issues Call for More UAVs, Fresh Thinking," *Defense News,* 19 October 2008, http://www.defensenews.com/story.php?i=3490138.

[5] Richard B. Gasparre, "Less Ego, More UAVs."

Services to develop and evolve their command and control (C2) and sustainment mechanisms to solve the UAS ISR problem are the subject of this analysis. Or put another way, which of the services' UAS solutions more effectively supports national security objectives in the context of the GWOT as well as future wars…and why?

The COINs in Iraq and Afghanistan served to light the fire of disagreement over UAS employment within the context of historic battlefield ISR shortfalls. Both the Air Force and the Army had been operating unmanned aerial vehicles (UAVs) of various types for reasons ranging from limited theater ISR for the Air Force to artillery spotting and some tactical reconnaissance for the Army, on and off for many decades.[6] The expansion of the insurgencies in Iraq and Afghanistan rapidly expanded the demand for ISR by both the COCOM and Army ground units, down to the platoon and squad-level.[7] The UAS and manned units available to the Air Force and Army were inadequate to meet the demands of all customers.[8] Further, C2 of the air vehicles remained a source of tension as the Army wanted improved responsiveness that organically owned assets would inevitably allow. In contrast, the AF felt its doctrinally-prescribed, resource-efficient centralized control with effective processes could provide the desired responsiveness.[9] Far from being unusual, this lack of battlefield ISR capability was a historic continuation of failure by both services since World War II to obtain adequate

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[6] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation" (PhD diss., Johns Hopkins University, June 2000), 221-306, 407-501.

[7] US Department of Defense, *Unmanned Systems Roadmap 2007-2032,* (Washington DC: Office of the Secretary of Defense, 10 December 2007), 21.

[8] Richard B. Gasparre, "Less Ego, More UAVs."

[9] Austin Bay, "Behind Gates Decision to Fire up the Air Force," *Strategy Page*, 10 June 10 2008, http://www.strategypage.com/on_point/2008061023332.aspx and US Department of Defense, *UAS Roadmap 2005-2030,* (Washington DC: Office of the Secretary of Defense 4 Aug 2005), 68-9. New CSAF acknowledged the argument of roles with the Army after taking the helm. Ben Iannotta, "Schwartz pledges to remake UAV culture," *Air Force Times,* 19 September 2008, http://www.airforcetimes.com/news/2008/09/af_isr_schwartz_091808w/. Air Force Irregular Warfare Doctrine released in 2008, also calls for centralized control of air assets even in COIN warfare as noted in Air Force Doctrine Document (AFDD) 2-3, *Irregular Warfare,* 7 November 2007. Michael L. Downs, Lt Col, USAF, further explored this issue in "Rethinking the Combined Force Air Component Commander's Intelligence, Survey, Reconnaissance Approach to Counterinsurgency," *Air & Space Power Journal,* Fall 2008, http://www.airpower.maxwell.af.mil/airchronicals/apj/apj08/fal08/downs.html.

tactical ISR resources prior to the next war after a scarcity of resources in the previous one.[10]

Through the course of the Global War on Terror (GWOT), the Army and Air Force arrived at similar UAS solutions but created fundamentally different C2 and sustainment concepts for their employment, despite superficially similar missions. Using innovative remote-split operations (RSO) satellite-based technology overlaid onto existing Predator MQ-1 UAVs, the Air Force created a continental US (CONUS)-based air crew force that could fly the MQ-1 from ground-control stations (GCS) in the US via a global network. RSO, as will be detailed later, has inherent inter- and intra-theater flexibility that theoretically allows the national command authority or a specific Combined/Joint Forces Air Component Commander (C/JFACC) to shift a focus of effort rapidly from one location to another.[11] Nevertheless, the system is complex; somewhat vulnerable at key nodes; doctrinally immature in terms of C2 and sustainment, and creates a perceived gap between the Air Force and the front-line customer due to the removal of the pilots from in-theater interaction. Finally, despite relatively low cost, the Air Force still treated the systems as low density/high demand assets. The service attempted to leverage the flexibility of the system to provide ISR support theater-wide as opposed to purchasing vast quantities of UASs and providing crews for sustained support to smaller units.[12]

In contrast with the Air Force's novel RSO solution, the Army fielded several traditionally configured UASs with C2 and accompanying focus tailored to the character of the war in which they were embroiled. The COIN character that evolved in Operations Iraqi Freedom and Enduring Freedom heightened the normal Army focus on relatively "local" operations in front of the division or even platoon involved in the fight. As such, the Army developed a range of UAS options to provide ISR (and other functions) from hand-launched vehicles to an MQ-1 variant--"C" model--that overlapped the capability

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[10] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 601-2.

[11] US Department of Defense, *Unmanned Aircraft Systems Roadmap 2005-2030,* (Washington DC: Office of the Secretary of Defense, 4 Aug 2005), C-3.

[12] AFNEWS, "General provides clarification on UAV use," *Air Force Link,* 25 April 2007, www.af.mil/news/story.asp?id=123050533 and Jim Hodges, "Relief for Strained Predators," TSJOnline.com, 28 March 2009, www.tsjonline.com/story.php?F=3607762.

and mission of the MQ-1B (Predator) and evolutionary MQ-9 (Reaper) Air Force variants.[13] With this asset growth, the Army outpaced the Air Force in UAS hours at the height of the insurgency from 2005 through 2007.[14] For the MQ-1C variant, instead of RSO, the Army chose a more traditional organizational and technological construct of forward-deployed operators and assets due to, among other reasons, desire to ensure in-theater, organic control of the assets and to improve localized teaming with ground units.

Having arrived at alternate solutions to a similar wartime problem, the question remains which one (or a combination of both) represents the optimal solution in terms of C2 and sustainment to support national security objectives.   The effectiveness of the service approaches to development, follow-on adoption, and integration of their systems will be reflected in their C2 and sustainment constructs.[15] The focus on C2 and sustainment also balances the problem along operational and support axes with a natural tension between the two. C2 is defined as the service's concept for commanding and controlling resources globally, operationally (i.e. theater-level) and tactically in both Joint and allied Combined command structures. Sustainment, denotes the various elements required to field, support, and maintain the UAS forces in combat to include pilot training. In this respect, if a preferred C2 solution for a UAS is not viable due to training or logistics constraints, the support will have to be altered, or degradation in operational effectiveness will have to be accepted, all other things being equal. The National Security Strategy (NSS) and National Defense Strategy (NDS), which define the goals and, as a result, the implicit characteristics of systems that are required to support those objectives, provide the benchmark against which the merit of the ultimate balance accepted by each service is judged. Developing the criteria to evaluate the C2 and sustainment of the services' respective systems against the NSS and NDS occupies the first part of this effort. The analysis then utilizes the criteria to evaluate each service's solution as well as compare them to determine which one is optimal or at least represents a "better" solution relative to national strategic objectives.

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[13] US Department of Defense, *Unmanned Aircraft Systems Roadmap 2005-2030,* 7, 8, 13, 15, 41-4 and US Department of Defense, *Unmanned Systems Roadmap 2007-2032,* 66. See appendix A for discussion of the capabilities of the MQ-1B Predator, MQ-1C Sky Warrior, and MQ-9 Reaper.
[14] Briefing, UAS Task Force, HQ AF/A2, "Air Force and Army UAS," 9 March 2009.
[15] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 12-3.

Determining which services' solution is superior is only half the battle, however. Answering "why" the services took their chosen path provides context on the quality of their solution and serves as a guidepost for defense planning. Fielding new weapon systems in response to a wartime requirement is nothing new for either service. However, inputs from civilian leadership and bureaucracy as well as the service's leadership, culture, organization, and global responsibilities shape the perceived importance of the requirement and quality of the resulting solution. Interservice rivalry may also influence the outcomes and will be examined, though it has not historically been a dominant factor in UAS development and fielding...***except with regard to Predator***.[16] The evaluation of "why" will follow the deductive analysis that determines the quality of the service's systems as hedges for an uncertain strategic future.

The Army's "Right to Fly" Versus Centralization

There is no disputing the fact that the Army needs some organically-controlled, non-theater-level UASs to accomplish its Combined/Joint Forces Land Component Commander (C/JFLCC)-dictated ground mission in support of the Joint Force Commander's (JFC) objectives. As stated in US Joint Publication 3-30, *Command and Control of Joint Air Operations,* "Joint air operations do not include those that a component [service] conducts as an integral part of its own operations."[17] In this respect, there is ample historical evidence that suggests, when resources are available, the Army's direct ownership and control of air assets improves mission effectiveness. *Indeed, in the 1990s, the Air Force even agreed that the Army could field its own Predator unit.*[18] While tainted by non-utilitarian, political considerations, historic decisions by the Department of Defense (DOD) and respective services at least tacitly acknowledge the logic of this concept and will not be debated further in this analysis.[19] For the Army, specifically, smaller UASs such as the Shadow and Hunter provide invaluable reconnaissance, surveillance, and target acquisition (RSTA) as part of small-unit ground

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[16] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 606-7.

[17] Joint Publication 3-30, *Command and Control of Joint Air Operations,* 5 June 2003, vii.

[18] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 550.

[19] Ian Harwood, *Interservice Rivalry and Airpower in the Vietnam War* (Fort Leavenworth, Kansas: Combat Studies Institute Press, 2006), 179-80 and US Department of Defense, *Unmanned Aircraft Systems Roadmap 2005-2030,* 41-4.

operations where consistent Air Force support is possible but an Army-centric solution is more effective.[20] Recent moves to improve the Army's control of its organic fixed-wing, tactical lift capability also suggest that, when enough resources are available, allowing the Army to control some aviation assets improves force effectiveness.[21] While possibly *inefficient* from a global resource availability standpoint, this distribution of assets is more *effective* in supporting forces under control of the C/JFLCC, which can be as important as C/JFACC support of joint force commanders.[22]

The criteria, therefore, that govern when or how much to centralize assets under Air Force control to provide theater-wide and global support inform the presumptive quest of this treatise. Resource constraints provide one criterion. Providing a miniature Air Force to each Army division would never pass fiscal muster even with the US' world-leading defense budget. As such, areas where there are overlapping capability, like the MQ-1 (and -9) series of UAVs, appear to offer economies if techniques such as centralizing C2 and eliminating duplicative sustainment efforts were initiated.   The Air Force's notionally fiscally-efficient, centralized processes and resources have been, however, historically unable to meet the *requested* effectiveness for *all* Army missions-- especially ISR, CAS, tactical airlift.[23] Though the Army's required level of effectiveness for each mission type is usually a matter of debate between the services, during both times of peace when force structures are built and in wars when they are used. Thus, while fiscal constraints provide boundary conditions for how many resources can be bought; the mix of resources, how they are employed, and by what service should be

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[20] US Department of Defense, *Unmanned Aircraft Systems Roadmap 2005-2030,* 7-8, 41-4. RQ-7A Shadows are smaller UASs with performance and capabilities below that of the MQ-1C and are intended to support divisions and subordinate units.

[21] US Government Accountability Office (GAO), *Defense Acquisitions: Assessment of Select Programs,* GAO-08-467SP, (Washington DC: United States GAO, March 2008), 99-100.

[22] Historically, for certain types of contingencies, this solution makes sense to a certain degree. For example, the French Air Force decentralized C2 of their CAS and ISR platforms as part of their Algerian counterinsurgency to better support ground forces down to the company-level. In the same conflict, however, Air Defense remained centrally controlled since it was more efficient and effective. E.E. Conger, A.H. Peterson, and G., C. Reinhardt, eds., *Symposium on the Role of Airpower in Counterinsurgency and Unconventional Warfare in the Algerian War,* RAND Memorandum RM-3653-PR (Santa Monica, CA: RAND Corporation, July 1963), 20-1, 22.

[23] Conrad C. Crane, *American Airpower Strategy in Korea 1950-3,* (Lawrence, KS: University Press of Kansas, 2000), 60-2, Richard G. Davis, *The 31 Initiatives: A Study in Air Force-Army Cooperation,* Air Staff Historical Study(Washington DC: Office of Air Force History, 1987), 2-3, 5, 77-9, and Ian Harwood, *Interservice Rivalry and Airpower in the Vietnam War*, 102-15.

guided by the nation's projected strategic requirements.[24] Recent experiences with the insurgencies in Iraq and Afghanistan have suggested theater assets, as much as possible, should have decentralized C2 to support the current COINs.[25] The NSS and NDS, however, intend the military to be prepared, or hedge, for a range of conflicts, not just COIN, resulting in a need to be flexible and not wedded to a single solution.

Measures of Merit in Twenty-first Century Defense Planning

For the US, the NSS and NDS are the foundation documents for determining which weapon system services purchase and how they should be employed. In the face of uncertainty in the global political environment, the US has adopted a "hedging strategy" with regard to purchase and employment of its weapon systems.[26] As noted by the 2006 NDS, *"The Department will invest in hedging against the loss or disruption of our traditional advantages, not only through developing mitigation strategies, but also by developing alternative or parallel means to the same end. This diversification parallelism is distinct from acquiring overmatch capabilities (whereby we have much more than an adversary of a similar capability). It will involve pursuing multiple routes to similar effects while ensuring that such capabilities are applicable across multiple mission areas."[27]* Thus, in the context of acquiring weapon systems that are structured to support a variety of possible US global commitments, the government's fiscal and mission-employment balancing act is exceedingly complex. Since there is no guarantee that a regional or global conflict will confine itself to one theater, US forces typically need strategic reserves or adaptive capability to hedge against multiple worldwide threats of varying character and scale of intensity. Even a single theater for US forces typically encompasses multiple countries, sometimes separated by thousands of miles, requiring a combination of extremely flexible, adaptive forces and/or sufficient reserves to meet

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[24] Colin Gray, *Explorations in Strategy* (Westport, CT: Praeger, 1996), 117-25.

[25] Austin Bay, "Behind Gates Decision to Fire up the Air Force," *Strategy Page*, 10 June 10 2008.

[26] George W. Bush, *National Security Strategy of the Unites States of America,* US Government Publication (Washington, DC: White House, March 2006), 36, 42.

[27] US Department of Defense, *National Defense Strategy,* (Washington, DC: Office of the Secretary of Defense, June 2008), 22.

emergent threats.[28] Finally, in each theater, balance between fiscal constraints and required effectiveness to support both ground and air objectives is required when determining UAS force structures and accompanying C2 and sustainment concepts.

The hedging strategy stated in the NSS and NDS will provide the criteria for evaluating the effectiveness of the services' UAS solutions, while history and organizational theory will guide the search for "why" the services implemented their particular solution.   Using and expanding upon existing literature, the author will develop baseline criteria in chapter 1 for evaluating the Army and Air Force UAV C2 and sustainment concepts' effectiveness in meeting the tenets of a hedging strategy. Comparison of the service's concepts relative to these criteria will then take place, separately, in chapters 2 and 3 followed by an examination of the results relative to each other in chapter 4. An "optimal" solution will be sought based on the relative quality of the C2 and sustainment of the two systems in supporting the NSS and NDS with proper regard to potential vulnerabilities of the systems that could impact their performance.   As Edward Luttwak noted in the acquisition of new systems, however, "The sphere of strategy is defined precisely by the presence of a reacting enemy and that is what prohibits the pursuit of optimality."[29] Thus, while an optimal solution serves as this analysts' unicorn, ultimately the crucible of war and deterrence will pass judgment on the efficacy of the acquisition and utilization decision. Chapter 5 will attempt to answer "why" the Services were/were not able to produce the best solution.

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[28] Sam J. Tangradi, Captain USN, "All Possible Wars? Towards a Consensus View of the Future Security Environment, 2001-2025." (McNair Paper 63 [online .mht file] prepared for 2001 Quadrennial Defense Review, National Defense University, Washington DC, November 2000), Chapter 8.
[29] Edward N. Luttwak, *Strategy: The Logic of War and Peace* (Cambridge, MA: Belknap Press of Harvard University Press, 2001), 31.

CHAPTER 1

Hedging to Meet National Security Objectives

*The most fundamental such question for this topic is the issue of how to determine
the character and quality of the air power which should be acquired…a prudent
defense posture is calculated with reference to circumstances likely to seem
remote from, and hence implausible in terms of, those today.*[1]

Colin Gray

Origin and Definition of Hedging

The relative value of the Army and Air Force UAS ISR platforms ultimately rests
on how well each service's system supports national security objectives.[2] The 2006
National Security Strategy (NSS) and 2008 National Defense Strategy (NDS) state that
"hedging" strategies with supporting weapon systems and processes are required to meet
the strategic uncertainty of the twenty-first century.[3] The ability of a specific weapon
system to generate the tactical results leading to the effects required by a hedging strategy
is therefore the measure or merit (or effectiveness) in judging the system's ability to
support the NSS and NDS. Quantifying the measure of merit is not straightforward,
however, since the existing US military doctrine does not define "hedging"; and tying
tactical results to strategic effects, as noted by General J.N. Mattis, is a difficult
calculation at best.[4] Nevertheless, the US has used hedging since at least the end of the
Cold War to account for changing, reacting enemies.[5] With the onset of perceived

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[1] Colin Gray, *Explorations in Strategy* (Westport, CT: Praeger, 1998), 113-4.

[2] Mark Clodfelter, *The Limits of Air Power: The American Bombing of North Vietnam* (Lincoln, NE: University of Nebraska Press, 2006), 211-215.

[3] George W. Bush, *National Security Strategy of the Unites States of America,* US Government Publication (Washington, DC: White House, March 2006), 36, 42 and US Department of Defense, *National Defense Strategy,* (Washington, DC: Office of the Secretary of Defense, June 2008), 22.

[4] General J.N. Mattis, commander, US Joint Forces Command, to US Joint Forces Command, memorandum, 14 October 2008. Also note discussion in Colin Gray, *Modern Strategy* (Oxford, G.B.: Oxford University Press, 1999), 25. Edward Luttwak also noted that historically technical innovations at the tactical can be negated at each succeeding level of strategy due to inappropriate deployment/employment of the innovation Edward N. Luttwak, *Strategy, The Logic of War and Peace* (Cambridge, MA: Belknap Press of Harvard University Press, 2001), 235.

[5] Stephen P. Rosen, *Winning the Next War, Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 218-9.

increases in international uncertainty in the 1990s following the Cold War, multiple authors have explored hedging as a strategic concept as well as how a specific weapon system's characteristics and employment would support the technique. The following discussion settles on a definition of hedging and a framework for measuring the value of a UAS' potential tactical contribution to meeting a national hedging strategy.

The US has used hedging, successfully and unsuccessfully, for defense research and procurement through the post-Cold War era. Hedging guided missile development in the 1950s allowed the US to deal with uncertainties associated with the Soviet Union and the pace of technology innovations.[6] By pursuing development of multiple systems in parallel, the US ensured that regardless of what happened it had bet on the right weapon system. Nevertheless, such a course of action can be resource-intensive and expensive, which might be acceptable depending on the threat that is being hedged against. For example, Defense Secretary Robert McNamara increased missile warhead and delivery system procurement in the 1960s to hedge against a perceived Soviet threat that later turned out to be fictional. As noted by the Secretary, hedging was necessary based on what was known, but the expense of expanding the US nuclear arsenal unnecessarily made reducing uncertainty by obtaining better information a continuing objective.[7]

At its core, the NSS' hedging is a strategy for dealing with uncertainty that drives military planning decisions. In the twenty-first century, this uncertainty stems from the National Security Council's (NSC) inability to define all potential threats to US interests due to the ever-present "unknown unknowns" in the global environment. Threats range from the possible emergence of a conventional and nuclear peer competitor in the form of a resurgent China to shadowy terrorist groups capable of spectacular terror attacks a la 9/11. Evelyn Goh, in a larger grand-strategic definition, explained US hedging as a mixture of realistic power-balancing and liberal Kantian-engagement strategies designed both to mitigate uncertain future intentions of multiple global actors and to fuel integration with targeted nation-states.[8] In embracing this concept, the NSC has guided

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[6] Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 245.
[7] Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military*, 218-9.
[8] Evelyn Goh, "Understanding 'hedging' in Asia-Pacific Security," *PacNet 43,* 31 August 2003.

the US military in developing force structures and employment concepts capable of deterring a range of opportunities and threats across the spectrum of violence and capabilities, around the globe. Rather than relying on an omnipotent Cold War-like enemy to drive acquisitions, training, and processes, US military forces must operate *effectively* across the spectrum of missions rather than maintain a singular focus and hope for effectiveness in 'ancillary missions.' To this end, in light of the hedging strategy, the National Defense Strategy stated the need for adaptive, multi-mission weapon systems to stay ahead of the traditionally slow information feedback loop in military planning and meet unknown threats. In addition, alternative, parallel means--across DOD--to accomplish the same end would sometimes be pursued.[9] Alternatively, a military may hedge by maintaining sufficient quantities of reserve forces with the predicted capability requirements, in addition to the required sustainment infrastructure.[10]

Even with a focus on multi-mission systems, as noted by strategist Colin Gray, defense planners face a "…bewildering array of interdependent variables…" and, as a result, must make fault-tolerant decisions to deal with the uncertainty in the process and maintain an effective air power deterrent.[11] Ideally, the systems acquired and organizational construct in which they are employed should be designed from the outset to support deterrence or compellence, as required, of all realistic threats in the projected timeframe in which the instruments are employed. In reality, due to the time horizon and expense of acquiring major weapon systems, the US will likely employ military systems not originally designed for their current mission. As such, most acquisitions, which occur under this cloud of uncertainty, are either readily replaceable (i.e. existing commercial systems) or sufficiently robust to allow upgrades to the systems and their support infrastructure. As defined by Benjamin Lambeth, "…airpower is a complex amalgam of hardware and less tangible but equally important ingredients bearing on its *effectiveness*, such as employment doctrine, concept of operations, training, tactics, proficiency,

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[9] Thomas C. Schelling, *Arms and Influence* (New Haven, CT: Yale University Press, 1966), 274 and Department of Defense, *National Defense Strategy*, 21-22.

[10] Sam J. Tangradi, Captain USN, "All Possible Wars? Towards a Consensus View of the Future Security Environment, 2001-2025." (McNair Paper 63 [online .mht file] prepared for 2001 Quadrennial Defense Review, National Defense University, Washington DC, November 2000), Chapter 8.

[11] Colin Gray, *Explorations in Strategy*, 112.

leadership, adaptability, and practical experience."[12] Ensuring both the tangible hardware capabilities and the intangibles are sufficiently fault-tolerant and flexible become the keys to the defense planner sustaining the effectiveness of airpower and hedging against uncertainty.

With global responsibility and uncertainty surrounding the location and timing of contingencies, multi-mission systems must be simultaneously locally effective and globally flexible. A system's relative value in a hedging strategy is measured against its effectiveness in support of the nation's global strategic requirements as well as the theater combatant commander's operational and tactical needs. For example, the ability of a system to rapidly redeploy or even simultaneously adjust to meet both an existing and a new global threat is a distinct advantage in hedging strategic uncertainty. However, if the same system cannot effectively support the combatant commander directly or a subordinate unit executing a mission in support of that commander, then the system's global flexibility is of little value. Tradeoffs between the UAS' ability to support global and local operations must be evaluated for sufficiency in supporting both. Optimizing the ability of the UAS to support US global requirements with minimum resources while meeting theater and local requirements should be the ultimate objective.

In preparing for the 2001 Quadrennial Defense Review, Captain Sam Tangradi of the US Navy investigated a series of threats ranging from most likely in which the US should have an existing counter capability to ones which were less likely but sufficiently important to *hedge* against. For threats needing a hedge, Captain Tangradi recommended developing either a "strategic reserve" or an "adaptive system" capability, as shown in table 1. Though prepared for the 2001 QDR, the events in the table are still applicable even today.[13] In fact, the "world of warriors" event presciently corresponds to the rise of violent Islamic extremism, and the measures taken, though not in accordance with a hedge developed prior to 9/11, correspond to what the US military did do or attempt to do during the GWOT. As noted by Secretary of Defense Gates, however, the Air Force has

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[12] Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca, NY: Cornell University, 2000), 9. "Effectiveness" italicized for emphasis in this paper.
[13] Tangradi, Captain US Navy, "All Possible Wars?" Chapter 8.

been slow in developing "detection and surveillance" systems to hedge for the other events listed in table 1.[14]

Table 1. Recommended Hedging Solutions for Anticipated Scenarios

Scenario	Reserve Capability	Adaptive System
Eventual emergence of a military near peer	Strategic reserve capable of being rapidly expanded	Systems capable of being rapidly upgraded in terms of lethality and sortie rate
Potential alliance of regional competitors	Strategic reserve capable of being rapidly expanded	Systems capable of being rapidly moved between theaters
Attempts to leapfrog into space warfare	Hedging force of anti-satellite systems maintain in storage for force on demand	Hardening of current space systems against future increase in threats
Collapse of key ally or regional support	Multiple regional allies that could provide similar level of operational support	Long-range systems that operable from bases outside the region
Trend towards a world of warriors	Expanded reserves of special operating forces and other highly-trained low-intensity warfare units	Detection and surveillance systems capable of identifying combatants from non-combatants

Source: Adapted from Tangradi, Unlabeled Table, Chapter 8.[15]

For this analysis, the categories in table 1, somewhat modified, will serve as criteria for gauging whether or not a UAS' characteristics and utilization support an overarching hedging strategy. UASs would arguably be useable in all of the scenarios

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[14] Michael Hoffman, "Gates Issues Call for More UAVs, Fresh Thinking," *Defense News,* 19 October 2008, http://www.defensenews.com/story.php?i=3490138.
[15] Tangradi, Captain US Navy, "All Possible Wars?" Chapter 8.

listed in table 1 with the exception of the rise of a space competitor.[16] For each scenario, however, Captain Tangradi's response is not necessarily the most effective. Rather, his recommended response is merely one option from a pantheon of potential hedging solutions. In this light, the value of the Army versus the Air Force UASs will be compared by assessing their absolute and relative performance in six of the distinct hedging solutions for four of the scenarios as shown in table 2. Note, for the collapse of a key regional ally, Tangradi's suggested strategic-reserve solution of having "multiple regional allies providing similar levels of support" is subsumed in an umbrella characteristic called *system interoperability* that will address intra-service, inter-service and inter-allied dimensions of the characteristic. With sufficient interoperability, each service's or allied country's UASs can serve in a larger global network on virtual standby in support of a larger hedging strategy. Thus, depending on the context and requirement, interoperability can provide an improved strategic reserve or a more adaptive system with which to hedge.[17]

Argument Construct

In subsequent chapters, the Air Force's and Army's C2 and sustainment systems' ability to meet each specific characteristic in table 2 will be analyzed in isolation and ultimately compared to determine their relative capability to meet the demands of global and theater requirements. In chapters 2 and 3, the paper will evaluate the independent and overlapping C2 and sustainment variables shown in figure 1 in detail for their impact on the flexibility and adaptivity of each service's weapon system. Subsequently, this information will be evaluated against each hedging capability shown in table 2 to determine how well each system will likely perform in support of national security objectives. In chapter 4, a comparative analysis of the results from the previous two chapters will attempt to determine which concept is optimal for meeting the hedging concepts laid out in the National Defense and Security Strategies. The course of action (COA) comparative analysis employed by the C/JFACC staff in the Joint Air Operations

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[16] Peter Layton, Group Captain, Royal Air Force, "Hedging Strategies, UCAVs, budgets, and improbable threats," *Armed Forces Journal,* April 2008, http:/www.armedforcesjournal.com/2008/04/3273026/.
[17] 2006 Quadrennial Defense Review (QDR) advocates the use of greater allied interoperability as a strategic hedge. US Department of Defense, *Quadrennial Defense Review* (Washington DC: Office of the Secretary of Defense, 6 February 2006), 30.

Planning process outlined in Joint Publication 3-30, is a similar methodology to the one employed here.[18] In conjunction, the paper will evaluate why the services achieved their level of system quality by examining civilian and military leadership decisions, organizational factors and other variables, to the extent that information is available. Finally, based on this analysis, the author will provide recommended improvements for the Army and Air Force.

Table 2. Hedging Solutions and Classification Categories

Hedging Solution	Category
Strategic reserve capable of being rapidly expanded	Strategic reserve
Expanded reserves of special operating forces and other highly-trained low-intensity warfare units	Strategic reserve
Systems capable of being rapidly upgraded in terms of lethality and sortie rate	Adaptive system
Systems capable of being rapidly moved between theaters	Adaptive system
Long-range systems operable from bases outside the region	Adaptive system
Detection and surveillance systems capable of identifying combatants from non-combatants	Adaptive system
System interoperability (Intra-/inter-service and inter-allied)	Strategic reserve & adaptive system

Source: Author's Original Work with Information Taken from Table 1

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[18] Joint Publication 3-30, *Command and Control of Joint Air Operations,* 5 June 2003, III-1-III-15.
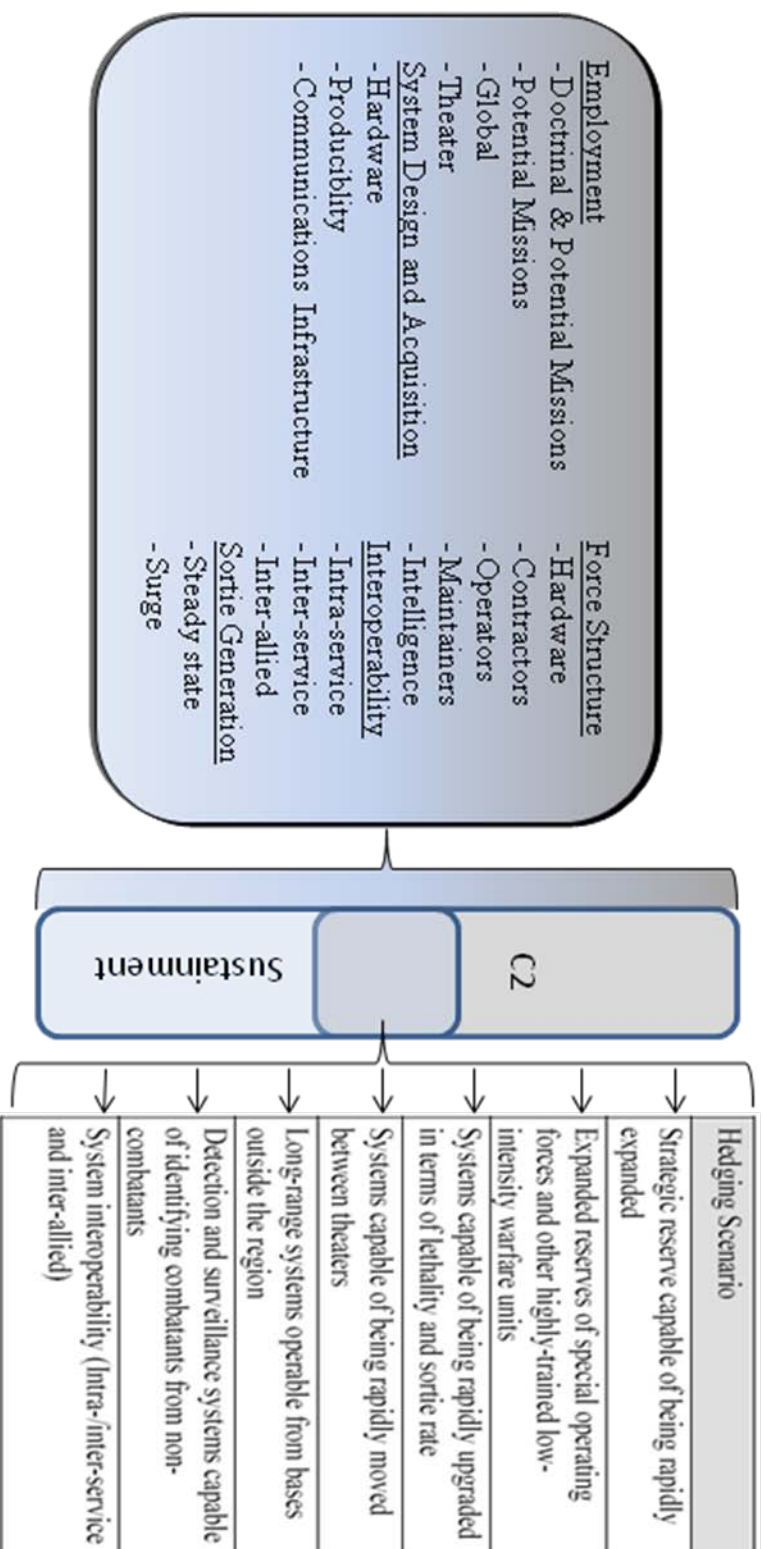
Figure 1. UAS System Characteristics Deductive Tie to Hedging Strategies

Employment
- Doctrinal & Potential Missions
- Potential Missions
- Global
- Theater

System Design and Acquisition
- Hardware
- Producblity
- Communications Infrastructure

Force Structure
- Hardware
- Contractors
- Operators
- Maintainers
- Intelligence

Interoperability
- Intra-service
- Inter-service
- Inter-allied

Sortie Generation
- Steady state
- Surge

Sustainment

C2

Hedging Scenario
- Strategic reserve capable of being rapidly expanded
- Expanded reserves of special operating forces and other highly-trained low-intensity warfare units
- Systems capable of being rapidly upgraded in terms of lethality and sortie rate
- Systems capable of being rapidly moved between theaters
- Long-range systems operable from bases outside the region
- Detection and surveillance systems capable of identifying combatants from non-combatants
- System interoperability (Intra-/inter-service and inter-allied)

Source: Author's Original Work

CHAPTER 2

US Army: Planning a Path through the Strategic Maze

The major difference between the Air Force and the Army, in my opinion, is the Army decided early what its UAS could do to support the ground force and implemented a deliberate strategy for acquisition, development, and employment.[1]

Colonel Robert Sova, Director US Army UAS Center of Excellence

For as long as there has been an Army, there has been a need for reconnaissance, and, to an extent, surveillance supporting an intelligence development process for the ground scheme of maneuver. Over time with technological improvements, that requirement has morphed from predominately ground-based mechanisms such as cavalry to airborne systems of one type or another. In the counterinsurgency (COIN) fights in Iraq and Afghanistan, various UAS types, owned by either the Army or the Air Force, have fulfilled the requirement. As the conflicts have matured, the Army has substantially increased its requirement for ISR, which is not unexpected given the character and dynamics of the conflict. The equipment solution the Army has settled on reflects a desire to not only divorce itself substantially from depending on the Air Force's ISR platforms but also a modern vision of how UASs can be substantially woven into the Army's scheme of maneuver via expanded internal interoperability.

The MQ-1C Sky Warrior, as planned, represents a fundamental improvement in the Army's UAS platforms in terms of payload capabilities and vehicle performance.[2] When fielded, Sky Warrior will be the Army's "high end" UAS and will significantly

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[1] Colonel Robert J. Sova, (Director, US Army UAV Center of Excellence, Fort Rucker, AL), in discussion with the author, 11 Dec 2008.
[2] "Sky Warrior" is not yet the official name of the UAS. Rather, the Program of Record is for the extended range/multipurpose MQ-1. However, due to its expected adoption by the Army and its common usage within the defense establishment, this paper utilizes "Sky Warrior," "ER/MP," and "MQ-1C" interchangeably.

surpass the performance of existing platforms such as the Raven, Hunter, and Shadow as well as the earlier Block A and 0 Sky Warriors. Although the weapon system has not completed final development, early use of pre-production models combined with hundreds of thousands of hours of Air Force combat employment on similar platforms has significantly reduced the risk of meeting requirements. Too, the subsystems and payloads chosen by the Army do not represent a quantum leap in existing technologies flying on other UAS, and, in some cases represent only incremental improvements or modifications for Army-specific purposes.[3] All other things being equal, the Warrior should meet expected performance criteria within normal statistical deviations. The analyses here will proceed under this assumption.

The predicted performance of the Warrior has raised the question of the need to have a capability that overlaps existing Air Force capabilities. The Sky Warrior is the only one of the Army's UAVs that significantly overlaps (and even exceeds for some models) existing theater-level Air Force UAV capabilities. The Sky Warrior's aerodynamic capabilities and payload lie roughly between that of the Air Force's MQ-1B Predator and MQ-9 Reaper UAVs.[4] See appendix A for a comparison of capabilities and projected missions and roles of each. The performance overlaps among the three UAVs are not necessarily a bad thing, however. As noted by Chairman of the Joint Chiefs of Staff, Admiral Michael Mullen, in line with the 2008 National Defense Strategy, consolidating similar service capabilities in a joint effort sometimes reduces operational effectiveness. Or, in other words, multiple services with similar capabilities is a valid construct if dictated by the services peculiar missions and the end result is better support for national security objectives. With this sanctioned similarity in the services' vehicles,

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[3] Kimberly Kasitz, "First Sky Warrior Aircraft for Army ER/MP Program Takes to the Air," General Atomics Aeronautical website, 15 April 2008, http://www.ga-asi.com/news_events/index.php?read=1&id=31&page=2, Kimberly Kasitz, "First Sky Warrior To Support Ground Forces in Iraq," General Atomics Aeronautical website, 12 June 2008, http//www.ga-asi.com/news_events/index.php?read=1&id=145&page=1 and "MQ-1C Warrior," GlobalSecurity.org, http://www.globalsecurity.org/military/systems/aircraft/warriori-program.htm (site accessed 26 January 2009). Army is accelerating deployment of the Sky Warrior to support immediate GWOT needs; as a result, the fielding timeline was unclear and dependent on which variant of the MQ-1C is under discussion. The original fielding timeframe was supposed to be 2011 for the minimum capable system to be given to the CABs.

[4] Army Field Manual (FM) 3-04.15, *Multi-service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems*, August 2006, I-7, II-1-II-2.

the Sky Warrior's ability to support the National Security Strategy and Defense Strategy (NSS and NDS) relative to Air Force's UASs depends on how the Army intends to use its system as well as control and sustain it. Of specific importance will be the flexibility and adaptivity of Sky Warrior's C2 and sustainment systems in supporting both Army battlefield missions and unforeseen ones for broader NSS and NDS hedges.

Employment

Missions. As conceived, a Sky Warrior company will deploy with a combat aviation brigade (CAB) forming ad hoc aviation task forces supporting division and brigade combat team (BCT) commanders as well as lower-echelon units. Operating in 12-aircraft companies, the Sky Warrior will deploy in support of a division commander to provide "…responsive, agile, and *flexible*…" capacity to perform the roles and accompanying tasks as shown in table 3.[5] Although fundamentally different from a helicopter unit in form, the MQ-1C's deployment concept will be similar in that the unit's total manpower and equipment package deploys with it. The same CAB and division provide basing, sustainment, and C2 of the company as well. The organizational structure allows flexible tasking of the MQ-1C, and the Army's C2 nodes can re-task the UAV to meet on-the-fly Combined/Joint Force Land Component Commander (C/JFLCC) or lower mission objectives, depending on mission requirements and platform configurations.

Outside of Army ground-centric operations, the question remains: will the Army take a share of the growing number of combatant commander requests for airborne ISR? The prescribed mission of the Sky Warrior companies is to provide localized support to the ground formations of divisions and subordinate brigades. Although theoretically capable of relatively modular operations absent a supporting division or brigade, the Army does not appear to be planning to train and equip the MQ-1C companies for these types of operations. Nevertheless, the Army's task force system would allow it to develop ad hoc C2 and sustainment arrangements if called upon to support non-Army

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[5] Colonel Robert Sova, Director Army UAS Center of Excellence "UAS Component Analysis – Human Element, U.S. Air Force Research Institute" (briefing, Air Force Research Institute Training, Fort Rucker, AL, 11 December 2008)

units in a deployed location.[6] However, announcements by the Army in late 2008 indicated that UAV operations would systematically expand beyond normal battlefield roles into areas where the principal mission will be ISR in direct support of joint task forces in a modular, independent role.[7] Indeed, to meet unfulfilled Predator and Reaper ISR requests, the potential utilization of Army assets with fundamentally similar capabilities as Air Force UAVs seems likely. In fact, as part of the two services' combined efforts to develop a Joint UAS Concept of Operations (CONOPS), the Air Force has pressured the Army to take on expanded Joint missions in addition to their battlefield role.[8] Under such circumstances, it is reasonable to expect that a Sky Warrior company would report through the senior army officer present into a joint command structure. Tactical employment would take place under the auspices and guidance of the Joint UAS CONOPs and other doctrine.[9]

A Sky Warrior's in-theater and global flexibility reflect normal limitations of lift (air or otherwise), readiness of a specific unit to deploy, and training to do so. In a best-case scenario, the system should be capable of 72-hour global flexibility, assuming availability of lift (air or otherwise) and readiness of personnel, equipment, and supply assets to deploy.   After arrival in theater, sufficient Sky Warriors could be built up as fast as 24 hours to begin operations. This time estimate assumes the Sky Warrior's deployment performance will be on par with the Predator Launch and Recovery Element (LRE) on-call deployment posture and tear-down/build-up capabilities. If the Sky Warrior requires specialized support equipment because of its size--larger than Predator,

[6] Sergeant Major (SM) Donald R. Sanders (Command SM, US Army Aviation Center of Excellence, Fort Rucker), interview by the author, 18 December 2008.

[7] Kris Osborne, "New Missions Seen for US Army UAVs in 2009," *Defense News,* 12 December 2008, http://www.defensenews.com/story.php?i=3861135&c=AME&s=AIR.

[8] Elaine Belcher, "Air Force, Army leaders lay out joint UAS future," *Air Force Link,* 25 February 2009, www.af.mil/news/story.asp?id=123137021 and Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem," *National Defense Magazine,* December 2008. http://www.nationaldefensemagazine.org/archive/2008/December/Pages/ArmyAirForcetoOperateArmed DronesinTandem.

[9] Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem." Other joint direction and doctrine includes FM 3-04.15, *Multi-service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems*, August 2006, FM 3-60-1, *Multiservice Tactics, Techniques, and Procedures for Targeting Time Sensitive Targets, April 2004,* as well as other specific documents on air operations and airspace control. The latest Joint CONOPs entitled *Joint Concept of Operations for Unmanned Aircraft Systems* that is available is the March 2007 edition but is under revision now. In the Joint CONOPs, pp. II-13-II-20 specifically discusses C2 of UAS assets across the service components.

smaller than Reaper--both the tear-down and build-up phases of the deployment will take at least another 24 to 48 hours. Finally, whether or not the personnel are on stand-by, are proficient at build-up and teardowns, and have completed deployment training will determine the speed of the capability.

Table 3. Sky Warrior Roles and Tasks

Role	Tasks
Reconnaissance, Surveillance, and Target Acquisition (RSTA)	Battle damage assessment; imagery, signals, and electronic intelligence; synthetic aperture and moving target indication; chemical warfare detection
Manned-Unmanned Teaming (MUMT)	Distributed targeting; fire support; laser range finding/designation; persistent presence; air-to-air, air-to-ground, ground-to-air support to other air and ground vehicles
Communications Relay	Aerial relay; extended voice; network extension; air data relay; satellite communications (SATCOM) and Tactical Common Data Link (TCDL)
Force Protection or Target Attack	Support of ground forces with onboard non-kinetic and kinetic means

Source: Colonel Robert Sova, Director, US Army UAV Center of Excellence, "UAS Component Analysis—Human Element, U.S. Air Force Institute," (briefing, Fort Rucker, AL, 11 December 2008).

Global C2. Currently, the Army does not have a global C2 system for ground-independent UAS ISR operations, but the baseline Sky Warrior design may be flexible enough to develop one readily. Beyond the typical construct for deploying forces to and from a specific theater, the Army's assumed mission set is purposefully set up with control by aviation brigades in support of division, brigade combat team, and lower-echelon activities. As a result, in contrast with the Air Force's remote-split operations system described in chapter 4, the Army's planned mission set does not have the doctrine or infrastructure needed for a real-time C2 system on a global scale. The Army, however, has tested the remote-split operations concept with the Hunter UAV; and the Sky Warrior, given its heritage, could be modified to do so. [10] In addition, designed-in interoperability may provide the technological leverage for the Army to use the Air

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[10] Colonel Eric Mathewson, US Air Force HAF/A2 DCS ISR, "Air Force ISR in a Changed World: ISR Transformation, the Importance of Jointness and AF Unmanned Aircraft Systems," (PowerPoint presentation given at C4ISR Conference, 17 October 2008).

Force's RSO backbone if required. (See interoperability discussion below). Under these circumstances, if the Army takes on more missions outside of the immediate battlefield due to the new Joint CONOPs, the service may need a more robust global C2 process similar to the Air Force's on-the-fly, CONUS-based C2 construct.

      Theater C2.   Based on stated intent and analysis of current Joint and Army doctrine, Army division, brigade combat team, and combat aviation brigade organizations will organize, train, and equip to provide C2 of Sky Warrior operations over the immediate battlefield area. In this respect, the division commander will have direct C2 over the Sky Warrior with the intent of having a platform that can provide, primarily, highly responsive RSTA and manned-unmanned teaming, followed by its other assigned missions, for the commander's priorities. The combat aviation brigade's tactical operations center (TOC) and brigade combat team's brigade aviation element provide support of planned and real-time objectives as well at the direction of a division commander and overarching C/JFLCC.   In this respect, the TOC will coordinate with C2 nodes in the C/JFLCC for efforts like time-sensitive targeting for tactical forces as well as coordinating Air Force support for additional needs through the assigned air liaison officer and Air Support Operations Cell (ASOC).[11] The TOC and brigade aviation element coordinate and control organic MQ-1C operations on the battlefield as well as provide air control over the battlefield up to the agreed-upon coordination altitude. As conceived, a Sky Warrior company could provide support to a neighboring division via an ad hoc arrangement quite easily, though not as a matter of preference. Finally, use of unemployed Army assets to support additional theater-level requirements will require coordination between the air and ground functional commanders C2 nodes via direct communication between their respective liaison elements--ASOC and Battlefield Coordination Detachment.

      Although the precise details of the above C2 arrangement will vary in time and with location, the process allows the Army to mitigate the perceived lack of support for its ISR requirements. Currently, forward Army units nominate ISR requirements and pass them through their chain of command to be adjudicated competitively with the

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[11] FM 3-60.1, MCRP 3-16D, NTTP 3-60.1, AFTTP(I) 3-2.3 *Multi-Service Tactics, Techniques, and Procedures for Targeting Time Sensitive Targets*, April 2004.

combined/joint force commander's other priorities. The C/JFACC oversees airborne ISR utilizing a 72-hour process based on the air tasking order (ATO), which features substantial mission planning prior to execution. The Army has complained that the process is too long and does not provide sufficient priority to its requirements. The Air Force has countered this argument with the fact that the 72-hour process can be interrupted; that the joint-mandated ISR request process takes too long; and that the combined or joint force commander determines ISR priorities anyway.[12] Regardless of recriminations from either side, the Army's control of its own assets below the Corps level will ensure that it has some mastery of its own destiny. However, in mitigating the problem in this manner, the question of what support is required from the Air Force becomes muddled. Further, the basic misunderstandings and faulty processes remain unfixed, though the services are trying to resolve these problems jointly.[13]

System Characteristics

Hardware. See appendix A. for a complete set of proposed specifications for the MQ-1C Sky Warrior.

The Sky Warrior MQ-1C, as a descendant of the Predator MQ-1B, features multiple technological improvements that standout from its immediate predecessor. From a maintenance and logistics standpoint, its heavy-fuel (diesel or jet fuel) engine has less relative scheduled maintenance than the sortie-limiting Predator engine. Sky Warrior's engine requires 2400-hour overhauls as opposed to 60-hour and 360-hour minor and major overhauls for the Predator. In addition, the adoption of a common standard battlefield fuel, as opposed to Predator's commercial aviation gasoline, makes the system more logistically supportable. Automatic takeoffs and landings will also reduce the dangers associated with human error in crashes during the critical phases of flight as compared to the Predator and Reaper's historically problematic manual system. Similarly, the use of the Reaper's triple-redundant flight control system and dual-redundant flight controls should eliminate some of the single points of failure on the

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[12] Grace V. Jean, "Army, Air Force to Operate Drones in Tandem," December 2008 and Kris Osborn and Michael Hoffman, "Finally Ground Rules for Air Ops," *Defense News,* 19 October 2008, http://www.defensenews.com/story.php?i=3723662.
[13] Elaine Belcher, "Air Force, Army leaders lay out joint UAS future," 25 February 2009.

Predator. The capability to carry two mission payloads in addition to a complement of four under-wing weapons hard points provides improved mission flexibility and expanded capability.[14]   In addition, the Army's One System Ground Control Station (GCS), in conjunction with complementary air vehicle systems, will automate much of the operator's flying tasks and utilize the NATO Standardization Agreement (STANAG) 4586 interface protocol to facilitate inter- service and allied UAS interoperability.[15] Finally, the system's Ethernet and Tactical Control Data Link (TCDL) will increase interoperability between Army, Air Force, and allied platforms and facilitate data transfer to external intelligence sources.[16]

Choosing the General Atomics' Sky Warrior system provides numerous opportunities for future hedges against uncertainty. First, the air frame's antecedents, the General Atomics Predator, Reaper, and I-gnat, have flown hundreds of thousands of combat hours that, while not flawless, provide a substantial base of knowledge for the next evolutionary step, the MQ-1C Sky Warrior.[17] The Sky Warrior's airframe and system of components signifies evolutionary steps based on relatively proven designs and not a problematic revolutionary leap. Second, some degree of hardware commonality

[14] US Government Accountability Office, *Defense Acquisitions, Assessments of Selected Weapons Programs*, GAO-08-467SP, (Washington, D.C.: Government Printing Office, March 2008),157-8 and "MQ-1C Warrior," *Global Security.org,* http://www.globalsecurity.org/military/systems/aircraft/warrior-program.htm (accessed 26 January 2009), and Colonel Robert Sova, Director Army UAS Center of Excellence, "Unmanned Aircraft Systems" (briefing, Armed UAS Conference, Washington, DC, 28 October 2008).

[15] Colonel Robert Sova, Director Army UAS Center of Excellence, "Unmanned Aircraft Systems" (briefing, Armed UAS Conference, Washington, DC, 28 October 2008) and "Army orders ground control station for Warrior UAV," *Military & Aerospace Electronics,* 4 October 2005, http://mae.pennnet.com/Articles/Article_Display.cfm? ARTICLE_ID=238154&p=32. "NATO STANAG 4586 expanded explanation: "Currently, NATO Standardization Agreement (STANAG) 458621 provides a standard for design of Data Link, Command and Control Interfaces, and Human Control Interfaces. The objective of STANAG 4586 is to provide a standard for these three important interfaces while allowing countries to develop their own national core software. Efforts like STANAG 4586 are good models for industry and government agencies to follow in future development of JUAS." Located in *Joint Concept of Operations for Unmanned Aircraft Systems,* March 2007, II-13.

[16] Kris Osborn, "DOD to Set UAV Standards by Summer," *Defense/News* 24, no. 3, 19 January 2009, US Government Accountability Office, *Defense Acquisitions, Assessments of Selected Weapons Programs*, GAO-08-467SP, 157-8 and, "Sky Warrior UAS Completes First Successful Automatic Takeoffs and Landings From ER/MP One System Ground Control Station", General Atomics Press Release, 6 October 2008, http://www.ga.com/news.php?read=1&id=165&page=1.

[17]"GA-ASI War Fighter Support Reaches Historic Proportions," General Atomics Corporation press release, 15 September 2008, http://www.gaasi.com/news_events/index.php?read=1&id=161&page=1 and "MQ-1C Warrior," *Global Security.org.*, http://www.globalsecurity.org/military/systems/aircraft/warrior.htm (accessed 26 January 2009).

between the Sky Warrior and Air Force UASs facilitates operational interoperability and shared sustainment systems. This is true especially with regard to sharing intelligence feeds and possibly, in the future, mutually supporting reserves of pilots, maintainers, sustainment pipelines, training, testing, and even production. All players involved in either or both of the programs, to include the Office of the Secretary of Defense, SECAF/CSAF, Joint Unmanned Aircraft Systems (JUAS) Center of Excellence (COE), and multiple Army organizations, have recognized this and have given guidance to pursue these courses of action.[18] However, the lack of a common acquisition policy with regard to the MQ-1C as well as MQ-1B and MQ-9 has hindered this effort thus far. In addition, the Army and Air Forces chosen operating philosophies and accompanying software make high degrees of interoperability in terms of operations, maintenance, and sustainment problematic. Finally, a common industrial base means that the Army can leverage General Atomics and other contractor expertise in supporting MQ-1C-like systems in the field. At the very least, this provides a strategic reserve of technicians (and even pilots) in case demand does outstrip the Army's supply.[19]

Sky Warrior's planned communications architecture is optimized for battlefield control of the air vehicles and simultaneous delivery of information via the same pathways to tactical and land-force headquarters units. Tactical Control Data Link (TCDL) and satellite communications provide line of sight line-of-sight and beyond-line of-sight capability respectively, between the Sky Warrior and the ground-control station. The satellite control system as well as the TCDL automatic launch and landing system were successfully field tested in October 2008. Other communications subsystems including the Warrior's ethernet are still being matured, but slower backup systems are available if they do not mature rapidly enough for fielding.[20] Alternatively, other

[18] Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem," December 2008, Secretary of the Air Force and Chief of Staff, United States Air Force, to MAJCOM Commanders and HAF 2-letters, 22 Jan 2009, and Honorable John J. Young Jr., Undersecretary of Defense for Acquisition, Technology, and Logistics, to Secretary of the Air Force and Secretary of the Army, Predator/Sky Warrior Acquisition Decision Memorandum, 19 May 2008.

[19] Colonel Robert Sova, Director Army UAS Center of Excellence, "Unmanned Aircraft Systems" (briefing, Armed UAS Conference, Washington, DC, 28 October 2008).

[20] US Government Accountability Office, *Defense Acquisitions, Assessments of Selected Weapons Programs*, GAO-08-467SP, March 2008, 157-8 and "Sky Warrior UAS Completes First Successful Automatic Takeoffs and Landings from ER/MP One System Ground Control Station, First Successful

aircraft or ground units with appropriate permissions or capability can control and/or receive information via the TCDL and a common NATO interface standard.[21] In addition to battlefield interoperability between Army forces, adoption of this standard could, in the future, provide the basis for increased Air Force and allied interoperability.

The Army intends to expand compatibility of MQ-1C data feeds as much as possible to support external customers, though the system is not yet compatible with all potential customers' communications nodes. The ultimate dissemination of the information off the battlefield to in-theater headquarters and operational units as well as CONUS-based intelligence organizations will depend on the in-theater communications architecture and its interface with transoceanic, allied, and Defense Information Systems Agency networks. One System Remote Video Terminal, as currently planned, will provide a full-motion video and/or metadata to other airborne and ground users over the battlefield, to include joint users via such systems as Falcon-view.[22] Though affected by the Sky Warrior's capabilities and requirements, this global communications architecture is part of much larger DoD communications infrastructure development. With a mission focused primarily on support of battlefield units, purpose-built gateways to ensure gathered intelligence can be transmitted back to rear-based intelligence operations may or may not be in the offing. As noted by the Army, however, the capability to send the information to external agencies is a valid requirement. One would expect advances in technology that will ensure Sky Warrior's compatibility with the existing Joint and allied systems that provide similar pathways for Predator and Reaper ISR feeds. STANAG

Flight via SATCOM Also Achieved," General Atomics Press Release, 6 October 2008., http://www.ga-asi.com/news_events/index.php?read=1&id=165&page=1.

[21] "MQ-1C Sky Warrior Project Overview," http://www.cdlsystems.com/index.php/projects/sky-warrior, (accessed 26 January 2009).

[22] Colonel Robert Sova, Director Army UAS Center of Excellence, "Unmanned Aircraft Systems" (briefing, Armed UAS Conference, Washington, DC, 28 October 2008). Per a Senior Research Engineer at Georgia Tech Research Institute where FalconView was developed, "FalconView™ is a non-proprietary GOTS (Government Off-The-Shelf) application for analyzing and displaying geographical data crucial to the warfighter. Its ease of use and wide variety of applications has made it the system of choice for the warfighter and the standard for data interchange in Iraq and Afghanistan." Chris Bailey, "Department of Defense Usage of FalconView™," FalconView white paper, Georgia Tech Research Institute, http://www.blm.gov/pgdata/etc/medialib/blm/nifc/aviation/airspace.Par.77886.File.dat/FalconView.pdf, (accessed 10 March 2009).

4586 compatibility, as described above, should facilitate information transfer off the battlefield via allied or joint networks in the future.[23]

Many of the Sky Warriors system's advantages are double-edged swords. First, the selection of General Atomics as a prime contractor could be problematic due to the company's historic production difficulties in the face of high product demand.[24] While DOD has mandated streamlined acquisition efforts in which the Air Force must procure only MQ-1C in future buys, this guidance is not necessarily helpful and will be discussed further in Chapter 3. Even with a common platform, competition for General Atomics' largely in-house repair and depot lines, unless sized appropriately, could produce bottlenecks with no agreed-upon mechanism for determining priorities. Similarly, common-use testing facilities, engineering resources, and other limited resources, have the potential for creating similar chokepoints. For example, producing manufacturing drawings took longer than expected as requirements shifted and the company continued to mature the design.[25] For both the line of sight and beyond line of sight missions, the frequencies needed by the Army and Air Force to control their aircraft and obtain video feeds likely will be similar. Deconfliction in theater will be done at the combatant commander level, but the requirement for such a process in and of itself means that neither service is likely to be able to operate its systems to full potential. Given the scarcity of satellite communications bandwidth, any Army beyond-line-of-sight missions will compete with the Air Force and other services for the same available spectrum band of the electromagnetic spectrum.

Force Structure

Aircraft and Ground Control Stations. There will be sufficient Sky Warrior companies for 11 CABs intended to support as many divisions.[26] Army officials plan to

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[23] "STANAG 4586," *CDL Systems,* http://www.cdlsystems.com/index.php/projects/stanag4586 (accessed 26 January 2009).

[24] Tom Vandenbrook, "Report: UAV Maker Falls Behind War Needs," *Defense News*, 23 September 2008, http://www.defensenews.com/story.php?i=3737173&c=AME&s=TOP and Sue C. Payton, Assistant Secretary of the Air Force (Acquisition), to Honorable John J. Young, USD AT&L, "Request for Air Force Waiver to Procure MQ-1B Aircraft," 31 July 2008.

[25] US Government Accountability Office (GAO), *Defense Acquisitions: Assessment of Select Programs,* GAO-08-467SP, (Washington DC: United States GAO, March 2008), 158.

[26] Summation of comments from Colonel (Army) Randy Rotte, Deputy Director of Army Aviation, in Grace V. Jean, "Army, Air Force to Operate Drones in Tandem," *National Defense*, December 2008.

acquire sufficient resources to support most or all of the Army's relatively independent brigade combat teams, meaning a requirement for 35 companies. It makes sense that Army special ops forces would also acquire organic Sky Warrior capacity or use conventional companies to augment special operations, but there is no information available to suggest which one of these scenarios will occur. The Air Force's robust acquisition of MQ-1Bs and MQ-9s for its special forces would suggest the former option as opposed to the latter is more likely.

A disconnect exists between the Army's currently-approved force structure and its projected doctrinal method of employing its forces. The Army's approved program of record for the Sky Warrior is 11 companies of 12 MQ-1C aircraft with accompanying five ground-control stations, support equipment, and personnel. With the Army's shift to combat formations centered on the brigade combat team (BCT), the number of notionally independent battlefield units shifted from 11 active divisions to 35 BCTs. Army doctrine suggests Sky Warrior employment will support one or more BCTs, with a division and corps in the chain of command leading to a C/JFLCC. The Army has recognized this and has stated a requirement, currently unfunded, for 35 Sky Warrior companies to ensure sufficient, independent BCT support. Failure to achieve the required number of companies will require a reassessment of the projected BCT employment concept.[27] Further, the lack of required forces could reduce the flexibility of the proposed system due to both the reduction in airframes as well as pool of personnel, operators, and maintainers available to support deployed operations. Finally, failure to support each BCT with a company indicates that all projected Army requirements will not be filled with the current 11-company force structure. As a result, an open question remains as to whether the Air Force has a requirement to fill the perceived support gap.

Contractors. As with legacy aviation systems, contractors will have a future presence on the battlefield supporting the Sky Warrior, but the question is, "to what

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http://www.nationaldefensemagazine.org/archive/2008/December/Pages/Army,AirForcetoOperateArmedDronesinTandem.

[27] Major Scott Dickey, "The Brigade Aviation Element: Providing the Brigade Combat Team with the Ability to Plan and Synchronize Aviation Assets into the Ground Commander's Scheme of Maneuver," (masters diss., US Army Command and General Staff College, 2007), 20-32 and Colonel Robert Sova, Director Army UAS Center of Excellence, "Unmanned Aircraft Systems" (briefing, Armed UAS Conference, Washington, DC, 28 October 2008).

degree and in what roles"? Currently, a combination of military and contract civilian personnel provide operations and maintenance support for the early-model Sky Warrior units.[28] The rate of reducing contractor involvement will depend on the slope of Sky Warrior system maturity, which should be better than Predator and Reaper if the Army and General Atomics leverage the developmental and operational experiences from those systems.[29] For rapid reaction to unforeseen events, reduction in the *need* of contractor personnel will increase the relative performance of Sky Warrior companies in some of the hedging scenarios shown in table 2. The Army is planning a future shift to an all-military force with a minimum level of contractor-support personnel in primarily engineering and field-support roles. The Army Aviation Command at Fort Rucker is analyzing the makeup of each company in terms of quantity, type, and skill of personnel for operations and maintenance. Framing this analysis is the expected steady-state and surge sortie rate of each company.

Operators. Supported by an air vehicle with an automated flight control system, the Army is building a responsive training pipeline whose fundamental constituency, enlisted personnel, is relatively plentiful. The Army utilizes enlisted personnel for its mission commanders, unmanned-aircraft-operator and sensor-operator positions for all of its systems, though officers and warrant officers provide overall unit leadership.[30] Automated control mechanisms facilitate this structure by allowing a programmatic "point-and-click" approach to operating the UAV as opposed to flying the aircraft with a stick and rudder. In addition to possible safety benefits, the system's high degree of automation should reduce the required training time to develop an operator when compared to a conventional pilot. The Army is projecting a little over 34 weeks to graduate an enlisted Sky Warrior operator from its UAV school at Fort Huachuca, AZ, of

[28] Colonel Robert Sova, Director Army UAS Center of Excellence, "Unmanned Aircraft Systems" (briefing, Armed UAS Conference, Washington, DC, 28 October 2008) and Colonel Robert Sova, Director Army UAS Center of Excellence "UAS Component Analysis – Human Element, U.S. Air Force Research Institute" (briefing, Air Force Research Institute Training, Fort Rucker, AL, 11 December 2008).

[29] US Government Accountability Office (GAO), *Defense Acquisitions: Assessment of Select Programs,* GAO-08-467SP, (Washington DC: United States GAO, March 2008), 158, "MQ-1C Warrior," *Global Security.org,* and Kimberly Kasitz, "First Sky Warrior Aircraft for Army ER/MP Program Takes to the Air," General Atomics Aeronautical website, 15 April 2008, http://www.ga-asi.com/news_events/index.php?read=1&id=31&page=2.

[30] Army Field Manual (FM) 3-04.15, *Multi-service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems*, August 2006, I-7.

which 9 weeks will be a common UAS operator course. In this respect, this concept could provide a significant uncertainty hedge as the Army adopts both a common GCS and a training system with core elements applicable to all of their systems. Theoretically, operators could shift between UAV systems on the battlefield if the need arose, or more holistically across the Army to support changing requirements.

Though advantageous for sustaining a robust pipeline for replacements, the Army's reliance on enlisted personnel operating an automated control interface may or may not affect the adaptivity of the overall system. With increased automation of the pilot (and presumably sensor) interface, Army operators will likely give up some of the flexibility of piloting the UAV by using automated systems. Through training and drill, however, the mission sets shown in table 3 are well within the scope and capability of operator and machine. The missions will require not only flexibility over the battlefield, but also familiarity and training with the supported division and/or brigades. Missions in conjunction with special forces or other government agencies could require specialized piloting to accomplish specific tasks that are not amenable to a preconceived, automated routine. In addition, using the Sky Warrior companies as modular packages for humanitarian missions or in counterinsurgency operations with other countries seems probable based on Air Force requests and Army announcements on future UAS employment.[31] Operating in foreign air space outside of the division and brigade control systems is something that will have to be considered when building the control system's automation software and designing the UAO training. Calling these issues "limiting" factors in terms of adaptivity and flexibility may be a red herring, though only time will tell. Even special forces supporting Air Force and Army units have standardized training and tactics. If a requirement exists for these types of tactics, acquiring the capability via software systems and operator training is only one of many possible solutions.

Maintenance. The Army is attempting to build a robust, predominately soldier-based maintenance capability. Each 12-aircraft company's support element is expected

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[31] Kris Osborn, "New Missions Seen for Army UAVs in 2009," *Defense News,* 12 December 2008, http://www.defensenews.com/story/php?i=3861135&c=AME&s=AIR and Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem," *National Defense,* December 2008, http://www.nationaldefensemagazine.org/archive/2008/December/Pages/Army,AirForcetoOperateArmedDronesinTandem.

to have approximately 50 to 52 soldiers consisting of predominately maintainers and some supply personnel.[32] This level is analogous to Air Force Predator and Reaper teams of 48 and 73 maintenance technicians for 10 and 11 aircraft, respectively.[33] Manning these teams will be soldiers with a single core UAS maintenance military occupational specialty (MOS). Although they will possess different levels of skill and proficiency, the Army plans to train every maintainer to the same standard in performing organizational-level maintenance on all facets of the system's aircraft, ground-control stations, and communications equipment. Further, all Army UAS maintainers will receive common core maintenance training in addition to UAS-specific type training.

In investing the time it takes up front to building multi-faceted technicians, the Army is gaining outstanding battlefield and deployment flexibility at the expense of a slow training pipeline. On a specific battlefield within a combat aviation brigade (CAB), maintainers from other UASs can provide surge support, attrition backfills, and other forms of complementary assistance as required. Not all UAS maintainers will be able to rapidly transition between UASs due to experience and skill, but the existence of a single career field will ensure some degree of technical depth on the battlefield. For global, modular, semi-independent Sky Warrior operations, CABs have a greater degree of flexibility when deploying personnel from the brigade's population of UAS maintainers, as opposed to relying only on personnel immediately assigned to the Sky Warrior company, for example. Finally, Army-wide shortages of maintainers on a critical UAS can be mitigated through on-the-job or schoolhouse training of core UAS maintenance personnel with MQ-1C-specific training courses.

Interoperability

The Sky Warrior system is inherently interoperable, at varying degrees, with other services' as well as some allies. At its core, the Tactical Control Data Link and ethernet systems will enable various levels of interoperability between Army and other service component systems. Further, the adoption of the NATO control standard in its One

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[32] Sergeant Major (SM) Donald R. Sanders (Command SM , US Army Aviation Center of Excellence, Fort Rucker, AL), interview by the author, 18 Dec 2008.
[33] Chief Master Sergeant Robert Stout, Nevada Air National Guard, to author, email, 6 April 2009.

System Ground-Control Station expands this net even further to include, eventually, NATO allies and possibly other close allies such as Japan and Australia.[34] The level of interoperability, however, does not necessarily extend to actual control of the aircraft from another platform. For example, some Army systems (such as the Apache) will have purpose-built modifications and associated employment concepts that feature the ability to take control of a Sky Warrior from its GCS.[35] However, other systems such as Air Force ground-control stations will have a reduced degree of interoperability that extends only to some data-sharing due to differences in software, hardware as well as training and employment concepts.[36] In this respect, even though complete level 4 or 5 interoperability is possible between, for example, an Air Force ground-control station and a Sky Warrior, fundamental differences in the vehicle control mechanism and concepts between the services greatly complicate the problem.[37] In addition, C2 of completely interoperable forces becomes exceedingly problematic unless communications and interactions between units are robust. Maintaining and troubleshooting a system in which the cockpit and aircraft are connected only electromagnetically is difficult enough in one service, as will be described in chapter 3. There are certainly no doctrines, policies, or regulations to facilitate inter-service and inter-allied maintenance of UAVs flown over a

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[34] "AAI's One System Ground Control Station Automatically Launches and Lands Sky Warrior UAV," *Shephard,* 13 October 2008, http://www.shephard.co.uk/news/381/aai-s-one-system-ground-control-station-automatically-launches-and-lands-sky-warrior-uav/ and US Government Accountability Office (GAO), *Defense Acquisitions: Assessment of Select Programs,* GAO-08-467SP, (Washington DC: United States GAO, March 2008), 157-8.

[35] Bettina H. Chavanne, "Block III Apache Takes Control of UAVs," *AviationWeek,* 15 February 2009, http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=defense&id=news/aw021609p1.xml.

[36] Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem," *National Defense,* December 2008, http://www.nationaldefensemagazine.org/archive/2008/December/Pages/Army,AirForcetoOperateArmedDronesinTandem.

[37] Per FM 3-04.15, NTTP 3-55.14, ATTP (I) 3-2.64, *UAS Multi-Service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems*, August 2006, chapter 3, para. 2.a. "Joint UAS Levels of Interoperability:
• Level 1 - Indirect receipt/transmission of UA [unmanned aircraft] related payload data.
• Level 2 - Direct receipt of ISR/other data where "direct" covers reception of the UA payload data by the RVT when it has direct communication with the UA.
• Level 3 - Control and monitoring of the UA payload in addition to direct receipt of ISR/other data.
• Level 4 - Control and monitoring of the UA, less launch and recovery.
• Level 5 - Level 4, plus launch and recovery functions."

common network. Thus, translating the promise of interoperability to practical reality will require rigorous evaluation and development of support processes.

Sortie-Generation Capabilities

A system's inherent sortie-generation capability, both in a steady state and surge mode, is a key indicator of its flexibility in supporting predicted and unpredicted events. A flexible system, sized to meet multiple levels of operational requirements, can form the basis of an effective hedge against uncertainty. Typically, the purchased hardware and software will have an inherent sortie-generation rate based on the designed and actual reliability of the system.   Beyond the inherent hardware characteristics, however, sortie-generation rates depend on multiple variables to include sustainment support; operations and maintenance manpower; duration of the generation effort and a multitude of other factors. With a design that accounts for these variables, the average generation rate can stabilize at or near the inherent capability of the system. Surges are possible and even specified in capability requirements documents, but the wear and tear of surge operations on man and machine will typically require a period of recovery after a given time.

For UASs, the disconnected cockpit or ground-control station (GCS) adds a level of complexity to the system since the aircraft-generation rate and corresponding GCS capability, in a sustained or surge mode, should be matched to ensure an effective, efficient use of resources. Too few GCSs could mean that a surge is not possible unless additional assets become available for short time periods. In contrast, an oversized aircraft fleet relative to the desired number of sustained sorties and corresponding number of assigned GCSs is an inefficient use of resources unless planners anticipate high battlefield losses. Further, operations and maintenance personnel, not to mention C2 and sustainment systems, are all considerations when developing a system solution to a desired sortie-generation rate.   Detailed analysis of a system's total capacity is generally done with Monte Carlo (or other) simulation methodologies like the Air Force's Logistics Composite Model, for example, but is not yet complete for the Army.[38] In developing aircraft programs with clear historical antecedents, utilizing the ancestral systems' mature performance as a baseline of minimum system capability is standard in acquisitions and

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[38] Sergeant Major (SM) Donald R. Sanders (Command SM , US Army Aviation Center of Excellence, Fort Rucker, AL), interview by the author, 18 Dec 2008.

will be the methodology used in this analysis. Thus, probable *minimum* Sky Warrior sortie-generation capacity will be deduced assuming broad system characteristics and performance analogous to Predator UAV and GCS hardware and software performance.

Steady State. Assuming performance and sustainment levels at or exceeding the Predator, GCS, and associated support equipment, Air Force heuristics and models can deduce the probable sortie-generation *capacity* of the hardware the Army has programmed for each company. Based on this analogy and ignoring operator limitations, the steady-state sortie capacity of a single Sky Warrior company should be approximately six Air Force-equivalent 24-hour combat air patrols (CAPs).[39] Combat loads, actual use and other factors will drive variations in the actual sortie length, which according to projections could go beyond 30+ hours. In addition, if the Sky Warrior experiences a reduction in scheduled engine maintenance--the most time-consuming part of the Predator repair cycle--and all other maintenance performance and supply indicators stay approximately the same as historical Predator historic norms, Sky Warrior-*steady-state* CAPs could exceed six, with seven or eight CAPs being feasible. Each company, however, will have five GCSs thus creating the upper limit of what each company can produce without sourcing external GCSs (see discussion below on this possibility). This upper limit seems prudent for steady-state operations given the complexity of developing reliable supply lines for the Army's operations from austere locations and the resulting need for cannibalization of aircraft to provide spare parts. Combat attrition will play into Army operations as well, given the Army's intent to fly below 25,000 feet.

The system supporting the Sky Warrior will likely enhance the Army's ability to sustain its steady-state (and surge) operations. In case of accidents or casualties combat aviation brigade leadership can redirect maintenance personnel to the Sky Warrior company, assuming that it retains the higher priority relative to the other UASs. In addition, the Army logistics systems, if appropriately structured, can leverage existing global contractor logistics support as well as Defense Logistics Agency sustainment paths set up for Predator and Reaper components with which it has commonality. Similarly, existing field representatives and engineering service personnel can service both Air

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[39] Technical Sergeant Michael P. Kretser, "Modeling Predator MQ-1 Logistics" (master's thesis, Air Force Institute of Technology, March 2008), 41-2.

Force and Amy equipment, when conditions feature co-location or allow migration of the contractors between sites. Finally, the Army can leverage common tools, support equipment, and a myriad of other items already created or proven for the Air Force programs to reduce costs as well as increase availability of the common resource pool.

Surge. Based on current equipment make-up and operating concept, the number of available Sky Warrior surge CAPs is likely to be equal to the max steady state due to GCS availability. Like a conventional aircraft unit, the ability of a Sky Warrior unit to surge for a specific time period will depend on equipment and operator availability within or in the immediate vicinity of the unit. Availability of stockpiled spare parts and consumables, endurance of soldiers, as well as rate of resupply will dictate the duration of the surge. However, unless arrangements are made to gain access to additional ground-control stations at will define the upper margin of surge CAPs. Alternatively, given the high levels of interoperability planned for between Army platforms, it might also be possible to launch additional aircraft into the air and pass control of them to other platforms such as battlefield Apaches.[40] This action inherently adds some risk to the process, but it is feasible based on Predator experiments in which they were sent autonomously to specific points on the battlefield to ensure no interruption in target servicing.[41] Another option would be a multiple aircraft control-type ground-control station, which the Air Force has successfully operated for many years.[42] While these solutions are technically feasible, both are problematic due to the inherent complexity associated with having to coordinate more takeoffs, landings, and handoffs of Sky Warriors as well as the increased density of vehicles within the airspace. Also, limited local control frequencies as well as ground data terminals may or may not affect a unit's ability to surge, depending on location-specific circumstances.

From a global-surge perspective, the Army's concept of operations is in reality no different from other aviation units. On-call units could rapidly deploy to new theaters,

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[40] Bettina H. Chavanne, "Block III Apache Takes Control of UAVs," *Aviation Week,* 15 February 2009, http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=defense&id=news/aw021609p1.xml.

[41] Lt Col Christopher Plamp, former 15 Reconnaissance Squadron (MQ-1) commander, to author, email, 6 April 2009.

[42] "Ground Control Station," General Atomics brochure, http://www.ga-asi.com/products/pdf/GCS.pdf (accessed 2 April 2009).

redeploy within a theater or even meet up with pre-positioned equipment at airfields. Timeframes from notice of a warning order to actual operations will vary depending on level of alert and status of equipment used, whether packed up or pre-positioned. The Air Force's Predator US natural disaster on-call package, deployable within 72- hours of notification, with operations beginning 24-hours after, serves as a model for what may be feasible. Higher levels of alert are possible, though, depending on expected roles and missions of the unit. Beyond alert units, however, non-deployed Army units are not expected to be immediately deployable unless they were due for deployment or on alert for some specific reason. Rather, non-deployed units, hardware, and personnel, will reenter the rest-and-refit cycle that is part of the standard Army deployment system. Interrupting this cycle for sudden deployments will have a corresponding negative effect on future personnel and equipment readiness.

Several features of the Army's planned system should enhance the surge sortie-generation capability of Sky Warrior companies but will depend heavily on the brigade combat team and aviation brigade to plan for and execute ad hoc operational and sustainment plans. The planned common ground-control station (GCS) among all Army UAV platforms provides the possibility of displacing other, lesser capable UAVs from their GCSs, to add Sky Warrior sorties. While clearly not optimal, non-deployed assets in the United States could be deployed to support ad hoc expansion of a company's sortie requirements. Further, this factor promises a common supply stream and opportunities to cannibalize parts between different UASs within a combat aviation brigade, if required. Since the MQ-1C significantly outclasses other Army UASs and will be supporting division-commander objectives, one can assume that it probably would have priority in all such actions. The Army's single UAS maintainer system ensures that there will be at least some MQ-1C-qualified maintenance personnel support in the other UASs who can assist as required. Appropriately staffed and empowered C2 nodes, such as the BAE could garner the effects of these advantages and add tremendous surge capacity and flexibility in the Army's system.[43]

Hedging Analysis

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[43] Major Scott Dickey, "The Brigade Aviation Element," 9, 15, 20-32.

Strategic Reserve Capable of Being Rapidly Expanded: Meets intent with issues. The Army's projected UAS construct offers significant advantages for maintaining and expanding a strategic reserve. C2 of the system is more than adequate to control the expansion of forces as required, both from a staff and field level. At the field-level, the Army's system of creating battlefield task forces to control ad hoc organizations is sufficient for incorporating additional units or parts of units into the scheme of maneuver. Further, training concepts for operators and maintainers appear robust enough to facilitate rapid expansion. In this vein, the Army's attempts to generate UAS operators and maintainers should create a pool of both cadres that can be shifted as required between weapon systems as priorities dictate. To accommodate this sort of reserve concept, the training pipeline will need a surge capability to provide UAS-specific training courses.

The Army's desired force structure for Sky Warrior provides significant strategic reserves, but its actual programmed force structure and choice of manufacturer could limit availability. The Army requires 35 companies of Sky Warriors to support its brigade combat teams, but its currently approved program is 11 companies, one for each combat aviation brigade. Given the brigade combat team-focus of Army land operations, the proffered division-support role of the companies stands out as a potential chokepoint in which demand will outstrip supply. Future funding of the desired Army program will dictate whether this issue is mitigated or not.[44] Production problems at General Atomics and potential competition for the same manufacturing resources with the Air Force and foreign customers serve as chokepoints for attempting to create a responsive, expandable manufacturing base. Finally, after the initial production run, it seems unlikely in an era of reduced defense spending that Congress would fund a "warm" production line capable of being turned back on to increase available forces or make good battlefield attrition. However, foreign military sales may provide a mechanism for keeping the line open indirectly.

Expanded Reserves of SOF: Meets intent with issues. The Army's C2 and sustainment construct may facilitate the creation of expanded reserves of special

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[44]John T. Bennett, "Support Signaled for More C-17s, UAVs, Small Ships," *DefenseNews,* 23 January 2009, http://www.defensenews.com/story.php?i=3916373&c=AME&s=TOP.

operations forces (SOF), but several questions remain unanswered. The Army's (and SOCOM's) plans for the Sky Warrior purchase are unclear, and additional information is needed to determine the impact of an Army SOF-specific acquisition, if it takes place. From an equipment standpoint, the SOF units (as well as reserves) will require appropriately-cleared personnel and/or modified ground-control stations, airframes, and specialized equipment. The Army could build, as one option, a dual conventional/non-conventional capability into some non-SOF units as part of a standard mission set. Sky Warrior companies seem flexible enough to shift between SOF and direct battlefield support roles or serve as the basis for the creation of SOF-specific companies. There may be a limiting factor, however, in that the non-SOF Warrior companies do not seem pre-disposed to perform modular, small-unit SOF operations absent a larger CAB C2 and support presence. A designated secondary SOF mission for one or more companies may provide the impetus for the conventional forces to develop SOF C2 battlefield support procedures. Finally, the Army's robust maintenance and operator training programs seems capable of accommodating additional training throughput.

Rapidly Upgradeable Lethality and Sortie Rate: Meets intent with issues. Though the Army is fielding an inherently flexible and upgradeable UAS, the service's method of employment limits its sortie rate. With the aircraft's multiple payload bays and under-wing hardpoints combined with the ground-control station's flexible architecture, airframe and GCS lethality could be upgraded relatively easily as new weapons are developed. Despite the flexible hardware designs, companies will be sortie-rate-limited due to scarcity of GCSs on the battlefield.   Alternatively, the Army's creation of a common UAS maintainer and operator skill set as well as a common GCS could expand the ability of a CAB to marshal its internal UAS resources to expand the sortie rate capacity of the Sky Warrior companies. Such an effort would require extensive C2 and foresight to adequately plan and execute.

Rapid Inter-theater Movement: Does not meet intent. The Sky Warrior does not represent a significant improvement over legacy systems in terms of inter-theater mobility. The Sky Warrior company's concept of operations does not require it to move significantly faster than the ground units its supports. The Army has not designed its UAS companies to shift between theaters any faster than required to support its

accompanying ground units. As a result, the Army does not have a global C2 system in place to shift Sky Warrior companies rapidly between theaters on a modular basis. Rather, the system will depend on normal Joint and internal Army C2 procedures for deploying units for "normal" ground operations in theater. Further, even under independent modular operations, shifting between theaters will likely be no faster than legacy Predator systems and will ultimately depend on external transportation, most likely airlift. Ad hoc, independent deployments could take place, if required. The equipment makeup of the company will require it to travel with all of its heavier equipment (ground control stations, UAVs, satellite dishes) when shifting from one location to another. As discussed later, this characteristic will contrast with the Air Force concept.

Long-range Systems Operable From Bases Outside the Region: Does Not Meet Intent. The Army Sky Warrior system is not an inherently long-range system due to its relatively slow speed, communication links, and lack of C2 for this mission construct.   Designed to stay over targets for extended periods, its long loiter times resulting from fuel and aerodynamic efficiency provide the basis of its designed force-multiplier capability. Further, its communication control links will normally extend only a couple hundred nautical miles, though over-the-horizon operations are possible via satellite communications. The focus of a Sky Warrior company typically extends to the immediate battlefield in support of a division and subordinate brigade combat teams, with C2 doctrine and communications links set up to facilitate this primary mission. While ad hoc arrangements can be created, if required, the system is not currently optimized or intended to provide long-range support of external ISR missions. In this respect, the Army is not establishing standardized sustainment systems to support a deployed, independent Sky Warrior company separated from its combat aviation brigade for long periods. Improving interoperability with Air Force global C2 and sustainment systems could provide the basis for an expanded, standardized Army role in joint missions of this type, but aerodynamic realities will inevitably prevent any real range improvements. Finally, the Army's use of enlisted operators rather than certified pilots may hinder their ability to operate over foreign, non-battlefield airspace when conducting missions from countries bordering the area of interest or operations.

Detection/surveillance Capable of Identifying Combatants from Non-Combatants: Meets intent. The Sky Warrior supports identification of combatants and non-combatants. In this respect, its improved electro-optical/infrared (EO/IR) and synthetic aperture radar (SAR) as well as other classified reconnaissance and surveillance capabilities (and presumably operator training) will provide improved performance in this area relative to older systems. The lack of adequate communications gateways for transmitting information may hamper the use of reachback intelligence services in the US to assist in this endeavor. This argument presumes the need to use external services whereas the Army's internal intelligence assets combined with limited external support may be sufficient to meet organic Army objectives. Given the Reconnaissance, Surveillance, and Target Acquisition (RSTA) and manned-unmanned teaming concepts proposed by the Army, as well as the immediate availability of intelligence support on the battlefield via its internal C2 nodes, it appears that the Army's system meets the intent of this requirement. If the Army expands its missions to include non-organic customers external to the battlefield, internal and external C2 node interoperability will be the keys to ensuring Army operators can support this requirement.

System Interoperability: Meets intent. The Army designed the Sky Warrior to support interoperability at all three levels: intra-service, inter-service, and inter-allied. The most robust capability will be, initially, intra-service as the Army takes internal steps to modify its other equipment to support multi-level interoperability to facilitate its mission set. Additionally, the Army will likely expand its doctrine and regulations to facilitate this activity while ongoing war lessons and testing continue to shape its operational concepts. With regard to inter-service interoperability, C2 and equipment issues remain whereby the Army will achieve some interoperability initially with expanded capability later. Continued discussions between the Army and the Air Force with regard to roles and responsibilities, on the battlefield and off, will provide the end state for required interoperability. In this respect, UAS interoperability is an open action item for the Army and Air Force Warfighter talks and received substantially greater

attention upon direction from DOD.[45] Inter-allied cooperation should follow similar

paths through NATO and other channels.

[45] Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem," *National Defense,* December 2008,
http://www.nationaldefensemagazine.org/archive/2008/December/Pages/Army,AirForcetoOperateArmedDronesinTandem.

Table 4. Army Sky Warrior UAS Analysis of Support for Hedging

Hedging Characteristic	C2	Sustainment
Strategic reserve capable of being rapidly expanded	No issues. Army's "task force"-based construct allows rapid absorption of projected reserves	1 Robust operator and maintenance training concept & projected pipeline offers potential for rapid expansion 2. Funded force structure inadequate for BCT-based ops.
Expanded Reserves of SOF and other highly-trained low-intensity warfare units	C2 construct (if not already created) needs to be developed if the Army uses conventional companies in dual-SOF roles on the battlefield.	1. Sustainment training pipelines appear adequate to support SOF. 2. Army, SOCOM Equipment requirements may already have
Systems capable of being rapidly upgraded in terms of lethality and sortie rate	1. Employment method limits rapid sortie rate expansion 2. Robust CAB C2 could allow rapid upgrade of sortie rate by harnessing interoperability of maintainers and operators within a CAB.	1. Interoperability, system modularity, and improved design allow rapid upgrade in lethality 2. Limited battlefield GCSs and Sky Warrior-trained operators provide upper limit of sortie capability/surging 3. Army's training concept & high degree of GCS interoperability may provide sortie increase

Source: Author's Original Work

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Table 4. Army Sky Warrior UAS Analysis of Support for Hedging (continued)

Assessment	Hedging Characteristic	C2	Sustainment
Meets intent with issues	Strategic capable of being rapidly moved between theaters	1. Army Sky Warrior companies designed to support and move in conjunction with supported ground units 2. Army does not have an effective C2 system to shift Sky Warrior companies rapidly between theaters.	1. Inter-theater movement no faster than normal airlift of legacy UASs 2. Entire footprint including all GCSs travels as a single company.
Meets intent with issue	Long-range systems operable from outside the region	1. Army's Sky Warrior battlefield focus is short, not long, range 2. Army does not have C2 infrastructure to support long-range ops	Sky Warrior and communication links are not inherently long range by design or intent.
	Detection/surveillance capable of identifying combatants and non-combatants	System C2 will likely support the requirement.	Hardware systems represent an evolutionary, at least, improvement in detection and surveillance capability.
Meets intent with issues	System Interoperability (Intra-/inter-service, inter-allied)	1. C2 of employment concept expected to support battlefield intra-service interoperability 2. Inter-service (and inter-allied) common operating procedures, tactics etc. should facilitate theater and even global interoperability	1. Hardware and system architecture is designed to support interoperability at all three levels. 2. Training system structured to support and enable interoperability

Source: Author's Original Work

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Assessment
Does not meet intent.
Does not meet intent
Meets intent
Meets intent

CHAPTER 3

USAF UAS Vision: "Now Say Again, What is It We're Doing?"

"Technical innovation and organizational change proceed at different rates, driven by different impulses, and it is easy enough for a fatal dissonance to persist between the two." [1]

　　Edward Luttwak, Senior Fellow, Center for Strategic and International Studies

"Our greatest strength [remote-split operations] is our greatest weakness." [2]

Major Jason S. Rabideau, MQ-1/-9 Operations Officer

　　　The Air Force has provided theater and tactical battlefield ISR--and a growing amount of offensive counter-land--support to the Army and joint force commander (JFC) since 2003. The use of UASs with this endeavor has been a case study in the perils of attempting to adopt a novel technology during a war while struggling with structural changes. The Air Force's chosen method for meeting tactical battlefield ISR support uses UAVs similar to the Army's, but its C2 and sustainment construct has been radically altered through the course of the war. From 2001 to 2003, the Air Force used a forward-deployment concept executing line-of-sight and beyond-line-of-sight operations that were similar to the concept the Army proposed for the Sky Warrior. After 2003, the Air Force switched to a technologically innovative, though complex, concept known as remote-split operations (RSO) that shifted a majority of the aircrew back to the US by connecting ground-control stations to forward aircraft using satellite and computer networks. While offering significant employment advantages, the C2

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[1] Edward N. Luttwak, *The Logic of War and Peace* (Cambridge, MA: Belknap Press of Harvard University Press, 2001), 235.
[2] Major Jason S. Rabideau (432d Aircraft Maintenance Squadron Operation Officer, Creech AFB, NV), interview by the author, 16 Jan 2009.

and sustainment challenges increased as rapidly as the system's potential flexibility and complexity grew. To this end, the Air Force had to develop entirely new doctrine, policy, and procedures to manage and maintain its global UAS air power network, to harness its theoretical efficacy, and to justify its complexity. Its efforts to do so, however, were halting and yielded questionable results.

Various organizations in the Air Force's Predator/Reaper UAS system have struggled to maintain the momentum of its rapid expansion in the face of perceived bureaucratic, wartime resistance. Leadership oversights, interservice rivalry, and the realities of war have hampered the Air Force's attempts to mature its UAS network. Cursed by its own propensity to field new, novel technologies, the Air Force was unprepared for the rapid expansion of ISR requirements when the wars in Iraq and Afghanistan shifted into large-scale counterinsurgency operations. In addition, UASs on the scale that the Air Force employed represented a sharp, pilot-intensive step away from its traditional manned platforms. Though more efficient in its use of pilots, the system required a minimum of seven crews for one 24/7 wartime combat air patrol (CAP), and the system could create CAPs significantly faster than the Air Force could produce crews. Further, the physical separation of the pilot's ground-control station from the battlefield created a perceived gap in the Air Force's empathy and support for ground forces. Finally, at the height of the counterinsurgency in 2006, Army battlefield units and Central Command demanded more Air Force ISR than its system could produce. Eventually in 2008, the SECDEF removed both the Secretary and Chief of Staff of the US Air Force for, among other reasons, perceived failings to institute desired improvements in the system and expand the Air Force's global and in-theater UAS ISR capability. Subsequently, the new CSAF, General Schwartz, has moved to normalize Air Force UAS operations to mature the system rationally.

Employment

Missions. Born in the exigencies of GWOT, the Air Force's chosen employment methodology leverages a novel network architecture to maximize global flexibility and concentration of UASs in support of national and combatant commander objectives. Validated for use in May 2002, remote-split operations (RSO) describes the methodology of flying UASs in an area of responsibility from the United States

using electromagnetic rather than physical connections facilitated by a Defense Information Systems Agency-supported computer network.[3] The generic RSO concept is shown in figure 2. The global strategic effect of using RSO is something I refer to as *hydratic airpower convergence*: *the ability to rapidly concentrate and replenish air power effects at any given moment and location via a global-network architecture that controls multiple UASs, based separately or together, from autonomous locations using electromagnetic-based C2 protocols.* In effect, by separating the ground control stations from the battlefield and networking them, a single station's UAV control capability expanded from a few hundred kilometers to the entire globe.

The mythical and formidable Hydra, spawned appropriately in our context by the Greek god of the winds, Typhon, serves as the ancient mythological inspiration of the effect produced by a remote-split operations UAS system. The Hydra had multiple heads capable of attacking a single target, and the heads would grow back as they were chopped off. Even after the destruction of one head, the others could converge on the threat to destroy it. The Greek hero Hercules defeated the beast only when he successfully severed every head and subsequently cauterized each neck stump to prevent re-growth. The RSO system evinces the same hydratic ability to "re-grow" and concentrate effects.   Even if a "head"-i.e. air vehicle- is destroyed over the battlefield, it can be rapidly replaced by airborne or ground spares connected to a mission-ground-control station (GCS) located in relatively invulnerable locations in the US.[4] The RSO hydra also can mount sustained, convergent attacks or missions at the same point from multiple, autonomous control locations in the US using aircraft in theater. Thus, the system's efforts can be rapidly converged at specific points on the battlefield with C2 and sustainment processes that can attach any mission-ground control-station (brain) to an aircraft (or head) via an electromagnetic neck. The most vulnerable part of the system is the UAV above the overseas battlefield and is replaceable via airborne or

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[3] Richard J. Newman, "War from Afar," *Air Force Magazine,* August 2003, 60.
[4] The Missions Control Element (or simple "mission") ground-control station flies the aircraft through the entirety of the mission profile with the exception of takeoff and landing. The Launch Recovery Element (or launch/recovery team) handles takeoffs and landings with pilots, maintenance, and equipment in the theater of operations. All of the component parts of the system are further explained in follow-on sections.

ground spares. Ultimately, defeating the system, like the mythical Hydra, requires the severing and subsequently "cauterizing" the electromagnetic neck (or network) by destroying the network or signal path.

Figure 2. Air Force MQ-1/MQ-9 Remote Split Operations Graphic
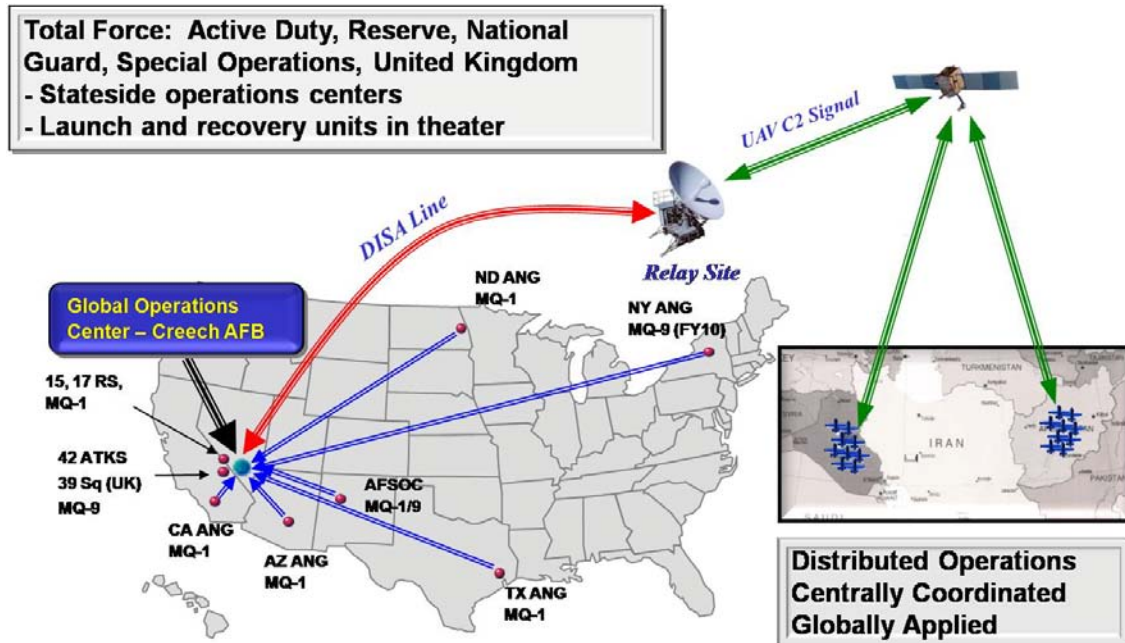
Source: Adapted from graphic in Colonel Eric Mathewson, US Air Force HAF/A2 DCS ISR, "Air Force ISR in a Changed World: ISR Transformation, the Importance of Jointness and AF Unmanned Aircraft Systems," (briefing at C4ISR Conference, Washington D.C., 17 October 2008).

In theater, at the end of the electromagnetic tether, the operational or tactical battlefield roles flown depend on the UAS employed and the situation. The platforms' various primary and secondary missions, in order, are shown in tables 5 and 6.

Table 5: MQ-1B Predator Functions and Tasks

MQ-1 Functions	Tasks
Reconnaissance / Surveillance	"…systematically observing air, space, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means."
Target Acquisition / Air Interdiction (AI)	Self explanatory / AI: "…destroys, disrupts, diverts, or delays the enemy's surface military potential before it can be used effectively against friendly forces, or otherwise achieve its objectives."

Sources: MQ-1 Adapted from AFTTP (I) 3-2.64 "Multi-service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems," II-5, August 2006 and Task definitions from AFDD-1, Air Force Basic Doctrine, 17 November 2003, 44, 55.

Table 6: MQ-9 Reaper Functions and Tasks

MQ-9 Functions	Tasks
Strike / Attack	Counterland operations?
Target Acquisition	Self Explanatory
Reconnaissance / Surveillance	"…systematically observing air, space, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means."

Sources: Adapted from AFTTP (I) 3-2.64 "Multi-service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems," August 2006, II-5 and Definitions from AFDD-1, Air Force Basic Doctrine, 17 November 2003, 55.

Global C2. Born through trial and error during the course of the GWOT, C2 of RSO's operational and sustainment elements is haphazard and generally creates its own friction, which tends to reduce the flexibility promised. The efficiency and effectiveness of the system depends on a global footprint featuring a system of tightly-connected, but loosely-controlled and monitored, systems to operate even a single CAP

tactically within a theater.   To this end, the Air Force has utilized a mixture of old and new organizational constructs for C2 of the operational and sustainment elements of the system while many of the interfaces remain undefined or outside of conscious Air Force control. A summary of the organizations' responsibilities and current command relationships follow:

1. Overseas launch and recovery elements (LREs) deploy as expeditionary squadrons that generate aircraft for CONUS mission-ground-control stations. These units report administratively and operationally through "normal" theater channels in an air expeditionary group or air expeditionary wing that "owns" the airfield up through the Air Force component commander and C/JFACC respectively.

2. Independent expeditionary aircraft maintenance squadrons and elements support assigned UAVs and ground control stations for both the mission and launch ground-control stations on their respective bases.

3. ACC coordinates acquisition of bandwidth on commercial satellites to carry all signals to and from the battlefield, while contractor personnel assigned to the aircraft maintenance squadron at the satellite relay site coordinate/troubleshoot with the service providers

4. CONUS and overseas CONUS (OCONUS) satellite relay sites--as shown--are controlled and maintained by a single aircraft maintenance squadron for all active duty, national guard, Royal Air Force, and even Global Hawk squadrons. One additional relay site is set to expand the global satellite coverage of the RSO network to the Pacific region but who will be charge of each relay site has not been determined.

5. Defense Information Systems Agency (DISA) monitors and controls the "hard" communications lines—typically fiber--from the satellite relay sites back to the bases on which mission GCSs operate. The Air Force buys the service from DISA.

6. From a DISA connection point at a base to a mission-ground-control station compound, the base's communication squadron maintains the fiber and equipment to push the control signal, but maintenance or operations units monitor the signal.

7. At the interface control points between the GCSs, their compounds, and the DISA node, the interfaces are maintained by informal collaboration of an aircraft

maintenance squadron, base communications squadron, and contractors…who all work for different organizations with little Air Force guidance.

8. The C/JFACC has operational control of the mission ground-control stations via in-CONUS Air Expeditionary Squadrons, Groups, and Wings at both active duty and Air National Guard locations. The air expeditionary wing at Creech Air Force Base exercises tactical control over the CONUS National Guard units on behalf of the C/JFACC per the current deployment order. Administrative control of the CONUS wings and subordinate units remain with the assigned Air Force major commands through intervening numbered Air Forces as required. [5]

9. A base's civil engineering organization maintains the electricity, building air conditioners, and normal infrastructure required by MCE GCS compounds to operate.

While organizationally confusing, this system "works" to a high degree, with CONUS mission GCSs executing combat air patrols in-theater providing the most compelling evidence. However, as noted by all levels of command, the loose, ill-defined, and friction-inducing C2 mechanisms are overcome through personal intervention as well as ad hoc and informal relationships, as opposed to defined processes. [6]

Mirroring the service's organizational setup, the Joint Staff and Air Force have limited doctrine, policy, or regulations concerning global C2 of the Air Force's RSO system. The only analogous system to the global RSO system capability offered by the Air Force is the "supported/supporting" relationship US Transportation Command's air mobility assets have with other combatant commanders. [7] Exceptions include US Strategic Command's apportionment of assets between combatant commands and LRE equipment deployments, which all fall under existing guidance. [8] Nevertheless, gaps in

[5] Captain Ed Ekpoudom, 432 Air Expeditionary Wing Public Affairs, "Predator, Reaper Unit Becomes Air Expeditionary Wing," *Space Daily,* 11 June 2008, www.spacedaily.com/reports/Predator_Reaper_Unit_Becomes_Air_Expeditionary_Wing_999.html.

[6] Col Chris Chambliss (432d Wing Commander, Creech AFB), interview by the author, 16 January 2009 and Maj Jason S. Rabideau (432d Aircraft Maintenance Squadron Operation Officer, Creech AFB, NV), interview by the author, 16 January 2009.

[7] Lemay Center Handbook 10-2, *Air and Space Commander's Handbook for the COMAFFOR,* 20 May 2008, 37-59.

[8] Steve Calicutt, Special Executive Service, US Strategic Command/J8, Director, Capability and Resource Integration (briefing Armed UAS Conference), 28 October 2008.

the systems C2 guidance are perceived to exist from the field and staff perspectives and include the following:

1. Lack of doctrine to define and describe the roles and responsibilities of the CONUS UAS air expeditionary wing construct.

2. Lack of doctrine to define network sustainment and operational C2 relationships between active duty UAS and Air National Guard reserve UAS air expeditionary wings.

3. Lack of doctrine, regulations, and procedures governing support of multiple combatant commands by a single CONUS air expeditionary wing

4. Lack of doctrine and regulations governing C2 relationship between more than one active duty in-CONUS air expeditionary wing, to include SOF air expeditionary groups or wings that utilize the Air Force's UAS network.[9]

5. Lack of doctrine and regulations governing the sustainment of RSO-communications-network-interface components and facility systems that are critical to the operation of the UAS RSO system but are not attached to traditional Air Force end-items such as aircraft or C2 systems. These items include facility air conditioners and black boxes at the relay site that convert UAV control signals to DISA-network formats.

6. Lack of doctrine and regulations defining maintenance C2 of the UAS network communications hardware and interfaces--by what procedures, and to what standards

7. Lack of doctrine and regulations defining maintenance and operations C2 relationships between conventional active duty, special operations forces, and Air National Guard CONUS expeditionary wings and forward launch/recovery elements.

The last issue deserves an expanded explanation since, unlike traditional platforms, C2 of basic remote-split operations maintenance and sortie generation requires a global perspective accompanied by guidance and resources. UAS mission-ground-control stations are connected to their engine, control surfaces, and payloads via the electromagnetic neck of the RSO hydra. Under the current system, however, the in-CONUS expeditionary wing commanders have no authority over their own wartime

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[9] Col Kenneth Kilmurray (HQ ACC/A8U, Langley AFB), interview by the author, 20 November 2008.

sortie-generation effort, only the availability and performance of their mission-ground-control stations. Rather, the CONUS expeditionary wing commander has to *coordinate* with the forward launch and recovery elements via an unofficial C2 node called the Global Operations Center (GOC). The GOC is owned by the Creech active-duty expeditionary wing commander and supports C/JFACC's air operations center planning efforts by coordinating the schedule of the forward UAVs, ground-control stations, and communications pathways with all CONUS expeditionary wings. Although it has no explicit doctrinal or regulatory maintenance or sustainment authority, the GOC has to monitor sortie generation and RSO equipment and network status since the wing commander has implied responsibility over much of the effort.[10]

The system, as currently constructed, violates both unity of command and effort at the most basic, tactical level for sortie generation as well as system maintenance. For example, mission ground-control stations are connected to their aircraft via common software and equipment configuration requirements that also drive aircrew and maintenance procedures and training. Changing either the ground-control station or UAV configuration is the equivalent of switching everyone to driving on the left hand side of the road: it either has to be done instantaneously or very methodically with maximum communication and a centralized plan. Centralized C2 of the process via a defined, empowered global-operations-center-like structure is a prerequisite for this level of coordination. Ideally, coordination, communication and some measure of control from the Global Operations Center and a single lead CONUS expeditionary maintenance group would coordinate the required software or hardware change, equipment move, and other activities. Realistically, a myriad of rear and forward commanders, with typically little or no knowledge of remote-split operations maintenance requirements interfere with all of these actions because they view the CONUS wing's involvement as improper under conventional Air Force policies and procedures.[11] The resulting self-induced friction reduces the flexibility of the system and its ability to upgrade components rapidly to meet mission demands. Ironically,

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[10] Chambliss (432d Wing Commander, Creech AFB), interview by the author, 16 January 2009.

[11] Maj Jason S. Rabideau (432d Aircraft Maintenance Squadron Operation Officer, Creech AFB, NV), interview by the author, 16 January 2009.

however, the Air Force is providing temporary maintenance manpower to perform these non-traditional C2 roles, indicating at least tacit support of the need for the level of C2.[12] The challenge now is codifying the informal procedures created in this effort.

Air Force written C2 guidance for the RSO global network sustainment is inadequate in depth and scope, but there are signs of improvement. For example, the Air Force maintenance instruction provides only one section that addresses RSO. In it, the Air Force instructs major commands (MAJCOMs) to develop debrief procedures for RSO, which Air Combat Command has evolved with the field units over several years.[13] Even this guidance is inadequate since three different MAJCOMs—Air Combat Command, Air National Guard, and Air Force Special Operations Command-- all operate a nominally common pool of UAVs over a single network. As a result, the forward launch and recovery maintainer, even with informal agreements between maintenance units, never knows whether (1) a debrief from the entire flight will arrive or (2) what format the debrief will be in if it does arrive. Under these circumstances, finding root causes of maintenance problems is problematic resulting in decreased sortie rates and mission effectiveness due to intermittent and unresolved problems. In addition, no guidance exists for C2 of the network or monitoring the health of a majority of the components in the network. As a result, Creech Air Force Base expeditionary maintenance personnel, in combination with some temporary duty personnel, have developed an unofficial network sustainment C2 function to oversee sortie generation as well as system health and modifications. Air Combat Command has begun addressing some disconnects in the system's management.[14] Emphasis on normalizing UAS operations by the Chief of Staff, General Schwartz, should add further impetus to this process at all staff levels.[15] This is especially important due to

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[12] Col Michael Stickney (432 Maintenance Group Commander, Creech AFB), interview by the author, 15 Jan 2009.

[13] Air Force Instruction (AFI) 21-101, *Aircraft and Equipment Maintenance Management,* 29 June 2006, 73 and Air Combat Command Supplement to Air Force Instruction (AFI) 21-101, *Aircraft and Equipment Maintenance Management,* 24 April 2007, 20, 87-90.

[14] Chief Master Sergeant Edward Torres (432 Aircraft Maintenance Squadron Chief, Creech AFB), interview by the author, 16 Jan 2009.

[15] General Norton A. Schwartz, Air Force Chief of Staff, "Keeping the Promise" (address, 24th Annual Air & Space Conference and Technology Exposition, Washington, D.C.), 16 September 2008, http://www.af.mil/shared/media/document/AFD-080916-083.pdf.

the involvement of multiple MAJCOMS. Recent attempts to transfer sustainment information flow to the operator C2 systems may also improve sustainment C2, if formal guidance follows.

   Theater C2. When an RSO system combat air patrol is assigned to a specific combatant commander or subordinate joint force commander, a C2 element such as the Combined Air Operations Center (CAOC) oversees the sortie's execution. In this role, the CAOC communicates with the CONUS Global Operations Center, mission-ground-control station and theater launch and recovery element as well as battlefield customers. As with legacy aircraft, the CAOC conducts analysis and planning associated with distributing available CAPs according to the joint force commander's priorities with "external" non-Air Force user requests considered relative to those priorities. Unlike legacy systems, the CAOC plans are subject to the combined availability of theater aircraft and launch/recovery crews, CONUS mission-ground-control stations and crews in multiple active duty and national guard expeditionary wings, and the communications network and components which the RSO system overlays. The Global Operations Center, in conjunction with mission and launch units, conduct long-term, daily, and ad hoc planning supporting CAOC requirements. For emerging challenges or opportunities, a CAOC can coordinate with the forward locations and Global Operations Center to generate ad hoc surges at specific forward sites as well as shift operations in-theater due to weather or battlefield conditions.

   In the counterinsurgencies in Iraq and Afghanistan, demand for ISR is almost limitless while resources are not, which requires robust C2 to use assets effectively and efficiently. Ground commanders, and all customers, generally receive an apportionment of the available Air Force UAS assets for very specific times. The relatively slow air speed of the Predator and Reaper--a natural design tradeoff with its extreme loiter times--prevents rapid repositioning and retasking of battlefield assets. Effective RSO system C2 to plan known operations as well as to shift real-time sensor information and airframe control as required can mitigate this design limitation somewhat. Further, UAS combat air patrols can orbit the battlefield to take advantage of developing situations, depending on aircrew, aircraft, and GCS availability. Similarly, depending on launch/recovery team resource and communication

availability, focus can be shifted intra-theater or globally by merely switching the communication for one CONUS mission-ground-control stations to another. However, hydratically converging the assets in this matter, as noted previously, requires robust *global* C2 to support the *theater* operation. The lack of joint doctrine, regulations, and procedures leaves open doubt as to whether the existing GWOT system can be (1) recreated for future conflicts; (2) adapted to service multiple combatant commanders with competing priorities; or (3) expanded to include an additional active duty CONUS expeditionary wing without creating a central controlling mechanism.

SOF forces, which contribute niche capabilities to counterinsurgencies, are dependent on the conventional RSO network and even forward LRE maintenance to launch individual sorties, but they desire further independence. Air Force special operations UASs, dependent on conventional launch/recovery maintenance units and/or contract maintainers, are managed through the combined air operations center air tasking order process or under a combined/joint forces special operations component commander, depending on the command relationships and requirements in theater. However, special operations UAS forces will likely rely on the conventional UAS network to overlay their C2 system if they continue to utilize RSO.[16] This will require formal documentation of their responsibilities to and expectations from the network, to include priority of communications pathways.

Under general conditions, planning the servicing combat air patrol requests from other services, especially the Army, are handled via documented, though evolving, C2 channels. Land, maritime, and special operations functional commanders have C2 elements that communicate these requests to the combined air operations center through existing joint processes.[17] The C/JFC provides the overarching

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[16] Major Ryan White (3 Maintenance Operations Squadron Commander, Cannon AFB, NM), interview by the author, 4 April 2009.

[17] Chairman of the Joint Chiefs of Staff, *Joint Concept of Operations for UAS*, March 2007, vii provides a CONOPS for "…capabilities-based planning, integration, and employment of unmanned aircraft systems (UAS) into joint military operations. It provides higher level guidance while acting as a reference tool for the joint operator and planner." and is undergoing revision. FM 3-04.15, NTTP 3 AFTTP(I) 3-2.64 *Multi-Service Tactics, Techniques, and Procedures for the Tactical Employment of Unmanned Aircraft Systems*, August 2006; FM 3-60.1, MCRP 3-16D, NTTP 3-60.1, AFTTP(I) 3-2.3 *Multi-Service Tactics, Techniques, and Procedures for Targeting Time Sensitive Targets*, April 2004; and

apportionment decision for available ISR assets and will also utilize the assets to prosecute his own priorities separate from the components specific requests. Air liaison officers, with or without ISR experience, may or may not be assigned to field units of other services to help process requests and advise ground commanders on the most effective and efficient use of available UAS assets. For normal ISR requests, the process time can range from 24- to 72-hours. In an emergency, support can be rapidly sourced from standby combat air patrol missions or diverted from previously-scheduled ones. Similarly, ground-attack and close-air-support requests--which UASs may administer--can happen on a tighter timeline, if needed immediately or scheduled in advance of known operations via the normal air tasking order cycle.[18]

In a counterinsurgency operation, the need for rapid ISR response for units below the division and brigade level has resulted in a reexamination of the C2 system that circumscribes the process of requesting ISR. From an Air Force perspective, the Army's process for forwarding requests from their lowest units up through the division and corps results in delays. Further, the Air Force believes that it can still meet requirements even if a request comes through during the 72-hour air tasking order process. The Air Force has also pointed out that the combatant commander determines priorities as well as some requirements, resulting in diminished availability of assets for prosecuting Army targets. In contrast, the Army perceives that the joint process, which the Air Force follows, is simply not responsive enough to meet the localized ISR needs of a counterinsurgency fight even when followed perfectly. The process is not the fundamental issue, however. Rather, the issue is the availability of ISR--and specifically UAS ISR--assets to prosecute targets. The anecdotal question, which the former SECAF and CSAF were unable to answer to the SECDEF's satisfaction, was, "why, after 6 years of war, are UAS and other ISR platforms still low density/high demand assets?"

Acquisition

JP 3-09.3 *Joint Tactics, Techniques, and Procedures for Close Air Support (CAS),* 3 September 2003 provide additional guidance on C2 of UASs.

[18] Air Force Doctrine Document (AFDD) 2-1.3, *Counterland* Operations, 11 September 2006. 27-8.

The Air Force RSO system structure is considerably more intricate than even "normal" UAS weapon systems. RSO encompass multiple, independent hardware components connected by a series of communications links, with no central sustainment management. The three primary hardware components are the unmanned aerial vehicle (UAV), ground-control station; and line-of-sight and beyond-line-of-sight satellite links. See appendix B for a complete set of specifications for the MQ-1 Predator and MQ-9 Reaper as well as the ground-control stations. The analysis below will describe characteristics of the ground-control stations and UAVs that affect the adaptivity and flexibility relative to the overarching hedging requirement. With regard to communications, the infrastructure can be less tangible, in many cases, than the other RSO components, i.e. bandwidth. The system is complex and consists of many elements owned, operated, and/or maintained by multiple organizations. An analysis of this phenomenon will follow and use the same theme as the analysis of the UAVs and ground-control stations. Finally, the RSO system also contains other support elements to include distributed common ground control stations (DCGCS) and other support units for intelligence analysis and exploitation. The discussion below does not evaluate these parts of the system, and, instead, assumes they are external "users" of the data produced by the RSO arrangement. Certainly, issues with a DCGCS will affect the ability to analyze and distribute the surveillance and reconnaissance gathered by UASs. Nevertheless, launching a UAV does not depend on DCGCS availability; minimum support can still be provided to external customers by the UAS if the DCGCS is unavailable.

Hardware. See appendix A. for a complete set of proposed specifications for the MQ-1B Predator and MQ-9 Reaper.

For UAVs, the Air Force employs a mixed force of Predators and Reapers in ISR and ground-attack roles, respectively. The platforms have complementary capabilities and can perform each other's primary function either fully or, in part, as evidenced by their design characteristics listed in appendix B. The low cost, multi-mission capability of both UAVs and their efficient aerodynamic designs synergize with RSO's inherent flexibility. Though relatively slow compared to modern jets, with loiter times of approximately 24 hours the Predator/Reaper can execute a myriad of

primary and secondary tasks for multiple customers and are limited only by fuel and ordnance. Even if a Predator/Reaper mission expends its entire ordnance load on a long mission, however, both UAVs can "buddy-lase" targets for other ground-attack platforms, for example. The UAVs relatively slow speeds, however, prevent rapid battlefield repositioning. For ISR, both systems have an electro-optical/infrared (EO/IR) turret primarily, though additional payloads such as synthetic aperture radar and signals intelligence pods are added, as required. Normal tradeoffs of payload and performance take place as more equipment is added. On-board-data systems can transmit to receivers directly beneath them to users on the ground or via their satellite control signal to global users. For both aircraft, the same pathways can be altered rapidly to allow UAV control to be swapped, in-flight, between CONUS mission-ground-control stations to accommodate changing mission needs, mission emergencies, or other contingencies.[19]

Fundamental Air Force ground-control-station design choices produced varying degrees of adaptivity and flexibility that, in turn, created both challenges and opportunities inherent in the system. First, although it has some degree of automation, an aircrew must still fly the UAV from the ground control station using normal aircraft control mechanisms, as well as perform takeoffs and landings. As a result, the Air Force has to source personnel that are able to "fly" in the traditional sense, though initial work is underway to determine if this necessarily has to be a conventional pilot.[20] The requirement for a pilot or "pilot-like" individual creates a demand for Predator/Reaper system-specific mission and launch/recovery training pipelines from an already limited pool of aviators. Most pilots do not maintain both launch/recovery and mission qualifications due to the inability of mission crews to stay current on launch/recovery operations. On the flip side, with substantial control over the UAV, the aircrews have more flexibility in performing tasks that would be outside the

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[19] Loiter times will depend on external stores loaded. Department of Defense, *UAS Roadmap 2007-2032,* (Washington DC: Office of the Secretary of Defense, 10 December 2007), 65, 73.
[20] Sig Christensen, "Air Force looks to keep more pilots grounded," *ExpressNews,* 23 December 2008, http://www.sanantonio.com/military/Air_Force_looks_to_keep_more_pilots_grounded, and General Norton A. Schwartz, Air Force Chief of Staff, "Keeping the Promise" (address, 24th Annual Air & Space Conference and Technology Exposition, Washington, D.C.), 16 September 2008, http://www.af.mil/shared/media/document/AFD-080916-083.pdf.

programmed capability of an automated UAS. Second, the basic GCS interface software is not compatible with the new NATO standard (see chapter 2 discussion) since the Air Force began buying its ground control stations prior to the standard's development. Efforts to gain access to the software to pursue modification have made marginal progress due to contractual issues associated with the prime contractor's proprietary rights over the software.[21] Finally, the Air Force has multiple GCS configurations with varying degrees of mobility and capability. With respect to the mobility issue, many of the GCSs are now in a so-called fixed configuration sans a mobility shelter and placed inside buildings. Reduced-capability launch and recovery ground-control stations have been acquired to take over the forward mission. The flexibility to open additional forward sites and tailor the UAS has correspondingly diminished.[22] Finally, the ground-control station for the Predator and Reaper have only small hardware differences in addition to easily-adjusted software loads. As such, the ground-control station design adds internal flexibility if extraordinary steps need to be taken for surges, emergencies, or other reasons.

The Air Force's changing wartime requirements as well as its legacy choice of General Atomics as its primary contractor for the Predator and Reaper yielded mixed results in creating a responsive production capacity reserve. Wartime necessity has led the Air Force to take extraordinary steps to rapidly field additional UAS capability, which, while largely successful, will have long-term fleet-sustainment impacts. For example, the Air Force fielded the Reaper two years earlier than planned to meet mission needs, and it has been effective in meeting mission requirements.[23] The system, as fielded, lacks configuration standardization, complete testing, and sustainment technical data that will have long term impacts on fleet availability and readiness. To field the Reaper early, the contractor was able to leverage common assembly processes with the Predator and the basic Reaper platform. While this seems advantageous, it points to the fact that the DOD and indeed the Federal Government

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[21] Major Kathryn M. Nelson, ACC/A8U, to author, email, 29 January 2009.

[22] Major David Hood (former Predator/Reaper Operations Officer), interview by the author, 9 April 2009.

[23] MQ-9 Reaper Hunter/Killer UAV." *Defense Update*. http://defense-update.com/products/p/predatorB.htmm (accessed 4 April 2009).

does not have an overarching authority to define production priorities for the company.[24] Foreign purchases of the UASs outside of the DOD's Foreign Military Sales program add another drain on the system that is outside government control.[25] Finally, both Government Accountability Office and Office of the Secretary of Defense (OSD) documents state or imply that the contractor's existing manufacturing base cannot meet DOD requirements.[26] This argument is somewhat questionable, however, as the services' requirements have changed erratically to meet wartime conditions, with corresponding production impacts. In this respect, there is no evidence to suggest that the DOD has requested or paid the company to maintain an adaptive--and probably *economically inefficient*--manufacturing base in the face of changing requirements.[27]

Communications Infrastructure. Analogous to the nervous system for the RSO hydra, the Air Force's UAS communications infrastructure offers a means to rapidly expand sortie production by one or more airframes but is dogged by C2 and sustainment questions. Born in the face of a wartime increase in UAS demand, the system is theoretically very expandable, assuming hardware, aircrew and maintenance availability, with adjustable bandwidth through the entire system. The availability of bandwidth is, in fact, a constant issue. The system requires matching capacity of multiple underground/sea fiber systems--owned variously by the Air Force, Defense Information Systems Agency, and commercial providers--with the capacity of the hardware and satellite relay systems. Management of this process is done by Air

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[24] Ann Roosevelt, "Pentagon Nixes Air Force as UAS Executive Agent," *Defense Daily,* 17 September 2008, http://findarticles.com/p/articles/mi_6712/is_54_235/ai_n29381052/, US Government Accountability Office, *Greater Synergies Possible for DOD's Intelligence, Surveillance, and Reconnaissance Systems,* GAO-07-578SP, (Washington, D.C.: Government Printing Office, May 2007), 2-3, 15, and US Government Accountability Office, *Unmanned Aircraft Systems: Additional Actions Needed to Improve Management and Integration of DOD Efforts to Support Warfighter Needs ,* GAO-09-175, (Washington, D.C.: Government Printing Office, November 2008), 19.

[25] For example, Italy purchased their Predators outside of the Foreign Military Sales system. Ludovico Chianese, Colonel, Italian Air Force, "Predator Command and Control: An Italian Perspective," *Air and Space Power Journal,* Fall 2007. http://www.airpower.maxwell.af.mil/airchronicles/apj/apj07/fal07/chianese.html.

[26] Tom Vandenbrook, "Report: UAV Maker Falls Behind War Needs," *Defense News*, 23 September 2008, http://www.defensenews.com/story.php?i=3737173&c=AME&s=TOP and Sue C. Payton, Assistant Secretary of the Air Force (Acquisition), to Honorable John J. Young, USD ATL, memorandum to "Request for Air Force Waiver to Procure MQ-1B Aircraft," 31 July 2008.

[27] US Government Accountability Office, *Unmanned Aircraft Systems: Additional Actions Needed to Improve Management and Integration of DOD Efforts to Support Warfighter Needs ,* GAO-09-175, (Washington, D.C.: Government Printing Office, November 2008), 19.

Combat Command but is also subject to either inputs or actions from other Air Force major commands as well as joint (theater J6 and A6 staff communications directorates) actors in the system. This alphabet soup is an indicator of the lack of clear control over the system. In this respect, there is no global C2 of the RSO system's communications backbone--analogous to the Air Force's Network Control Centers, for example--for daily operations, though the Global Operations Center at Creech provides some measure of control. The novelty of the technology early on also created problems in sustainment of small-production-run black boxes crucial to the operation of the system. Reliability of the boxes somewhat offset this issue, but creating and sustaining a repair-and-manufacturing base to either mitigate occasional breakdowns or enable rapid expansion is problematic.[28] In the end, while heroic in its ingenuity, the RSO communication system lacks the configuration rigor of systems carrying aircraft control signals, with a corresponding increase in operational and safety risk.

Opening of multiple satellite relay sites to ensure satellite coverage around the globe is one path to mitigating the problems associated with the small runs of communications infrastructure. Of course, this alludes to the fact that the system is dependent on infrastructure, which takes time to build, configure, and test. As a result, the system has gaps in its global signal coverage that can be mitigated by rapid deployment of a satellite link (i.e. the Predator Primary Satellite Link (PPSL)) and the cryptology and mission black boxes to an overseas area with a commercial or DISA fiber node. Alternatively, the Air Force would have to send mission GCSs and aircrew forward to attempt to operate in beyond-line-of-sight modes. While both are theoretically possible, neither one is being actively planned for in terms of purposeful equipment acquisition. Thus, future emergencies, prior to the completion of the network, would have to be executed ad hoc.

Despite sustainment issues and teething problems associated with novel growth, the system is fundamentally adaptable, which is an indicator of a much darker control issue. In fact, the Global Hawk piggybacks on the same network and concept, though with different interface hardware, to operate its systems. Within this adaptivity lurks

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[28] Master Sergeant John Sander (432 Aircraft Maintenance Squadron Communications Infrastructure, Creech AFB), interview by the author, 16 Jan 2009.

the problem of system stability and control adequacy. In this respect, the Predator/Reaper programs do not have a master engineering design outlining interface, hardware, power, and all other requirements associated with large-scale integrated networks. Since all components are connected in a network, unforeseen failures compromise system integrity. Further, system maintenance has not been analyzed resulting in a plethora of ad hoc procedures based on engineering assessments of specific problems, as opposed to a system-wide analysis of all complementary processes.[29] The dissociative character of network ownership, divided up among multiple agencies, also serves to reduce oversight of the system and its unique needs. Given that UAV control signals, in addition to surveillance and reconnaissance feeds pass through the infrastructure, the lack of control and corresponding high degree of adaptivity may or may not be appropriate. The addition of specific processes and disciplined engineering controls throughout the network will reduce the speed in which the network can be modified or enlarged.

The lack of an end-to-end hardware and system acquisition and sustainment manager for the RSO system and its components limits the amount of system monitoring and control possible, thereby increasing potential operational risk. One significant problem is the classification of the communications infrastructure and equipment as either communication-electronics (CE) or aircraft equipment. Some hardware such as the satellite relay is classified as CE equipment, which results in different staff management, funding, and sparing priorities relative to the other aircraft and GCS in the system. More importantly, the CE equipment is maintained according to a less rigorous standard as compared to aircraft equipment. As a result, the key links carrying eight or more aircraft control signals at once are maintained to lesser standards as compared to that of the other parts of the system. This can be acceptable if analysis shows that the reduced standard meets overall system reliability requirements. Air Force maintenance data systems do not collect and headquarters do not analyze system-wide performance and reliability data, however. Thus, it does not appear possible to perform the required analysis. Further, key components in the system, such as

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[29] Major David Hood (former Predator/Reaper Operations Officer), interview by the author, 9 April 2009.

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communication interface line replaceable units, are not tied to an end-item such as a UAV or ground-control station. As a result, ordering and provisioning spares, normally based on end-item reliability projections and performance, is problematic. However, Air Combat Command has acknowledged these historic problems, which are complex, and is working with other agencies to correct them. [30]

Force Structure

System. The employment flexibility inherent within an RSO-networked system capable of delivering hydratic airpower convergence is evident. The force structure required to deliver effects is not. In this respect, specifying a total number of combat air patrols (CAPs) that the system can deliver globally, which has been the Air Force and DOD's habit, is of limited value to defining the overarching force structure required. Specifying the required CAPs defines only the number of CONUS mission ground-control stations and aircrew required to produce the requisite CAPs as well as the size of the training pipeline. It does not define the number of launch/recovery teams that will be supported; total number of aircraft and launch/recovery ground-control stations required; forward maintenance and ops launch/recovery crews required; and breadth of underlying communications infrastructure and satellite network. In this respect, the flexibility of the system is limited only by the investment DOD and the Air Force are willing to make in communications infrastructure and developing forward airfields that can be populated/resupplied with aircraft, spares, launch/recovery ground-control stations, and trained personnel. A minimum infrastructure investment must be made at each forward site, regardless of its CAP capability. So, at a minimum, general employment decisions based on economics have to be made. The required force structure "in being" must be closely matched to both existing operational requirements and to the number and general location (narrowed down to the hemisphere) of possible contingent responses to unforeseen occurrences in order to harness the power of RSO.

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[30] Master Sergeant John Sander (432 Aircraft Maintenance Squadron Communications Infrastructure, Creech AFB), interview by, 16 Jan 2009 and "MQ-1/9 RSO Maintenance," powerpoint briefing, 13 February 2008 located in HQ ACC/A8UC email to author, 13 February 2008.

Assuming the presence of adequate C2, an RSO network requires specification of the total number of combat air patrols (CAPs); total number of forward sites; and geographic range of required satellite coverage at least to harness its inherent flexibility. Until Air Force senior leadership put out direction on 22 January 2009, the Air Force had to guess about its required force size and structure based on theater and Joint Staff guidance. In their January letter, the Secretary and Chief of Staff of the US Air Force directed that fifty CAPs be fielded by the fourth quarter of fiscal year 2011.[31] Fifty CAPS serves as an effective basis for developing the requirements for trained crews as well as partially right sizing the aircrew-training pipeline. Supporting the overarching system requirement, Air Combat Command's employment concept features ten deployed launch/recovery teams capable of up to five combat air patrols each. In addition, the Command preliminarily defined the standard CONUS mission squadron size of six ground-control stations, five primaries and one spare/surge/training. Two relay sites, located in Europe and the Pacific and connected back to CONUS mission ground-control stations via communications lines, would be capable of 50 or more RSO combat air patrols each. Each forward site will also be equipped with a satellite relay for beyond-line-of-sight options in-theater, similar to the Army's Sky Warrior company concept. Basing concepts for the CONUS mission-ground-control stations is still in work, but one idea spreads bases across active duty, Air National Guard-active duty associate, and AFSOC units with precise locations beyond existing operating sites to be determined.[32] Presumably, DOD or the Joint Staff via a future Joint Requirements Oversight Council (JROC) decision in the future will pass judgment on whether the Air Force's preferred force structure meets both GWOT and post-GWOT political (unit basing and procurement) and defense requirements. If not, the post-conflict force structure will look like the GWOT-developed force structure, regardless of what the National Security Strategy says.

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[31] Honorable Michael B. Donley, Secretary of the Air Force, and General Norton A. Schwartz, Chief of Staff of the Air Force, to MAJCOM Commanders and HAF 2-letters, memorandum 22 January 2009.
[32] Lt Col Kenneth Kilmurray, HQ ACC/A8U, to author, email, 9 February 2009.

Hardware. The Air Force is still determining the quantity and type of UAVs it needs as well as ground-control station, mission and launch/recovery, requirements. The Air Force has only recently defined the 50-CAP requirement, but it has not gained approval for its overarching employment concept that would drive the number and mix of Predators and Reapers. Instead, various actors in the system are, even as this paper is written, jockeying to shape the flavor and size of the fleet. The Air Force, as part of the Fiscal Year (FY) 2010 budget process, has submitted a request that features no Predator production, in any variant, and, instead, transfers all funding to Reaper production. The Predators in the inventory would presumably be flown to the end of their useful lives. Disagreeing with this assessment on the grounds of cost, OSD has directed the Air Force to procure the more capable MQ-1C and pursue conversion of its existing B-models to a C-model standard.[33] From the Army perspective, the Air Force's efforts are viewed with trepidation as the move to the Reaper, which is not classified as a primary ISR mission platform, will reduce the available surveillance in support of Army battlefield maneuver units.[34] In addition, configuring a manufacturing base to be responsive to Air Force battlefield needs under conditions in which there is no clear production plan or employment concept is problematic at best and has downstream sustainment consequences. In this respect, acquiring launch/recovery spares kits and developing depot repair capacities become difficult with unclear force-structure decisions. Since kits typically lag airframe delivery, the mid-term impact on establishing forward sites is murky.

Contractors. The Air Force's varied usage of contractors reflects its responses to challenges associated with attempting an unplanned weapon-system surge in a war. Due to rapid fielding with inadequate documentation and testing, contractor support is sometimes required to maintain many of the components of the RSO system. This

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[33] Lt Col Kenneth Kilmurray, HQ ACC/A8U, to author, email, 9 February 2009. Honorable John J. Young, ,USD STL, to Secretary of the Air Force and Secretary of the Army, memorandum entitled "Predator/Sky Warrior Acquisition Decision Memorandum," 19 May 2008 and Honorable John J. Young, Jr., USD ATL, to Assistant Secretary of the Air Force (Acquisition), memorandum entitled "Air Force MQ-1B Predator Procurement Waiver Request," 28 October 2008.

[34] Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem," *National Defense*, December 2008. http://www.nationaldefensemagazine.org/archive/2008/December/Pages/Army,AirorcetoOperateArmed DronesinTandem.

forces the Air Force to either risk maintaining the equipment organically with inadequate data or sustain a contractor capability. Even when data exists, however, the rapid wartime fielding of greatly-expanded number of both Predators and Reapers has exceeded the availability of active duty and Air National Guard maintainers and, in some cases, aircrew to meet immediate and long-term combat and training demands. Similarly, due to a lack of direction on the conventional and special operations forces employment concept, the Air Force cannot quantify its required UAS maintenance force structure for either ground-control stations or aircraft. [35] As a result, contractors serve as a useful hedge to unforeseen requirements, albeit not as responsive as active duty personnel and subject to the limitations of the existing contract. [36]

Contractor use, when structured appropriately and in concert with military forces, has effectively supported RSO flexibility, though with some limitations. For example, the Air Force maintains a conventional rapid-response military maintenance capability that can set up a site within 72 to 96 hours and typically sustain it for up to 120 days afterwards. [37] During that 4-month window, contract options can be turned on and personnel acquired to backfill military positions in theater, allowing the rapid response team to return and reset. For many operational situations, this response time is more than adequate and the cost inexpensive relative to attempting to add more manpower slots to the Air Force in a time when costs are skyrocketing. If already in-theater, the contract system can also be flexible in terms of altering steady-state and surge requirements as well as actually moving contractors to different sites for changing operational requirements. As has been seen in GWOT operations, however,

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[35]Col Michael Stickney (432 Maintenance Group Commander, Creech AFB), interview by the author, 15 Jan 2009.; "MQ-9 Reaper," *GlobalSecurity.org,* http://www.globalsecurity.org/military/systems/aircraft/mq-9-program.htm (accessed 3 April 2009) and US Government Accountability Office (GAO), *Defense Acquisitions: Assessment of Select Programs,* GAO-08-467SP, (Washington DC: United States GAO, March 2008), 139-40.

[36] Per MQ-1/-9 ACC Contract Program Manager, the Air Force adheres to J**oint Pub 5.0 - P. IV-30 which states "**In any operation where significant reliance on contracted support is anticipated, the JFC and Service component commanders must ensure the requisite contract planning is completed and appropriate controls/guidance are in place in accordance with DOD Instructions 3020.37, *Continuation of Essential DOD Contract Services During Crises*, and 3020.41, *Contractor Personnel Authorized to Accompany the US Armed Forces*." Mr. Jim Denkert, MQ-1/-9 ACC Contract Program Manager, to author, email, 12 January 2009.

[37] Col Michael Stickney (432 Maintenance Group Commander, Creech AFB), interview by the author, 15 Jan 2009.

the flexibility desired by the C/JFACC outstripped the capability of the contract, in some instances. Due to the nature of the system, structuring contract options to be as adaptive or flexible as an active-duty military force in-being is prohibitively expensive, though not necessarily impossible.[38]

A specific challenge for the Air Force in using its contracting mechanism is matching availability of long-lead manufactured items and aircrew with activation of contractor LRE teams. Theoretically, a contract can provide nearly infinite reserves, limited only by funds and availability of civilian technicians. Unclear force-structure planning limits contract effectiveness and flexibility due to the equipment, spares, and tools that must be purchased well in advance of contract execution. Civilian teams need to be equipped with long-lead (greater than 120 days) aircraft, spares, equipment and tools that must be stockpiled and managed awaiting use. Even if aircraft are available, the Air Force acquires spares kits awaiting deployment through purposeful funding and planning, sometimes years in advance, due to manufacturing times, to support a requirement. Similarly, equipment and tools do not magically appear, and it can be difficult to obtain unique items that are already in high demand for ongoing operations.[39] Using the rapid-reaction team's equipment is a poor option, because once a crisis is over, another could almost certainly occur unless defense planning provides some sort of ceiling on numbers of sites. Finally, each Air Force launch/recovery team needs sufficient aircrews, normally not civilian, to run the team, but no system-wide plan exists yet that defines the number that the squadrons must support. Air Combat Command is attempting to define it, however.[40]

The Air Force Special Operations Command's (AFSOC) acquisition of UAS forces serves as a poignant lesson on how RSO's flexibility can be frittered away unless an appropriate balance is struck between contractor and military capability. In 2006, to facilitate special operations in Central Command, the Air Force Chief of Staff transferred six combat air patrols worth of equipment to a SOF squadron that operated

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[38] Mr. Jim Denkert, MQ-1/-9 ACC Contract Program Manager, interview by the author, 12 January 2009.
[39] Major Jason S. Rabideau (432d Aircraft Maintenance Squadron Operation Officer, Creech AFB, NV), interview by the author, 16 Jan 2009.
[40] Lt Col Kenneth Kilmurray, HQ ACC/A8U, to author, email, 9 February 2009.

within Air Combat Command's RSO network. Only operations manpower accompanied the transfer, however, which meant that AFSOC had to rely on ACC maintenance to sustain its forward launch/recovery and mission ground-control station equipment for several years. AFSOC obtained some military maintenance positions in 2009 to build a quick-reaction force and will use contractors for new launch/recovery and mission ground-control station operations as well.[41] These added positions should significantly increase AFSOC flexibility.

Operators. A significant advantage provided by RSO is efficient use of resource-constrained pilots and sensor operators. With the exception of small forward launch/recovery deployments, all of the Air Force crews are in the US, resulting in no lost time associated with deployment transit times as well as rest and recuperation. In this respect, the Air Force system can provide "24/7" CAP coverage over a theater or battlefield with fewer personnel than if entire units deployed forward together. This characteristic reduces the demand on the Air Force pilot pool and training system as compared to a forward-basing construct, all other things being equal.[42] Further, the networked infrastructure of the system as well as physical proximity allows units to provide overlapping, backup, and surge crew and CAP coverage as required for mission accomplishment. flying training unit (FTU) personnel, for example, can fly combat missions from home station to maintain their combat experience and improve instruction, while also serving as an additional reserve of MCE aircrew in the event of extreme emergency. Similarly, the location of the squadrons in the US means that overhead command and staff positions in the stateside groups and wings can contribute to flying combat missions, both regularly and during surges. The Air Force hopes to leverage all of these advantages as well as other potential improvements to sustain a pipeline capable of supporting the 50-CAP end state of UAS RSO. It's worth noting, however, that permanent round-the-clock operations takes a toll on man and machine and would not necessarily be done unless the exigencies of war dictated it.

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[41] Mr. Major Ryan White (3 Maintenance Operations Squadron Commander, Cannon AFB, NM), interview by the author, 4 April 2009.

[42] Richard J. Newman, "War From Afar," *Air Force Magazine,* August 2003, 60-1, http://www.airforce-magazine.com/MagazineArchive/Pages/2003/August%202003/0803war.aspx.

From a macro-perspective, the 50-CAP plan is a double-edged sword for RSO training, as it provides better but not complete information on training requirements. The numbers of crews required to execute a combat air patrol become deceptively easy to calculate, though difficult to fill. In the aggregate, for active duty squadrons, the Air Force standard is ten crews per wartime round-the-clock combat air patrol. Current manning of seven crews per combat air patrol is considered a surge number with no margin for error and has resulted in extreme hardships for many crews and their families, as well as reducing staff to less than critical levels. Potential increases in operational and safety risk as well as decreases in member retention result in these circumstances. Air National Guard units need higher crew ratios due to the part-time nature of some of their crews, though many were mobilized for up to 2 years during GWOT. Long term, the training burden on a flying training unit due to Air National Guard crews is less, however, because there is less turnover than in active duty units. Additional crews are also needed to fill the flying training units and critical overhead functions that ensure safe operations and oversee the welfare of the assigned personnel. The number, therefore, required for 50 combat air patrols will be considerably more than 500 aircrews or over a 1000 pilots and sensor operators.

Uncertainties associated with maturing the RSO system during the GWOT have created havoc in defining operator requirements. One Predator squadron commander noted that there is no accurate guidance as to what the squadron should be *capable of doing*, only to execute what it *can do* with its existing cadre of aircrew. Currently, there is neither an RSO nor a combat air patrol plan. Mission execution and training new crews dominate operations. Forward launch/recovery sites also leverage the same pool of manpower for a steady stream of aircrew backfills to go in and out of theater as part of typical rotations. Since mission crews cannot normally stay launch/recovery proficient and sustain the RSO mission, launch/recovery crew training (2-3 weeks) requires careful orchestration of mission requirements and flying training unit (FTU) class schedules and capacity. The FTU can conduct ad hoc classes, but such a requirement merely adds more strain to a system typically operating at capacity. Since there is no guidance on the number of forward sites required for the system or what source they should come from (active duty, National Guard, or special operations),

maintaining a reserve of mission-ready crews to support pop-up requirements is problematic at best. Instead, even with the existence of on-call equipment and maintenance forces, the RSO system's flexibility is hostage to the lack of a definitive overarching plan driving squadrons to pre-train on-call aircrew. Air Combat Command plans to correct these issues, but the lack of definitive, codified direction in the form of Declared Operational Capability statements and mobility requirements that tie to anticipated contingencies prevents the units from operating efficiently…and possibly effectively.[43]

Wartime requirements have driven the Air Force to consider unusual, and in one sense, radical steps to meet the 50-CAP requirement. Predator/Reapers have two-person crews, a pilot and a sensor operator. Pilots can originate from three sources: pilots (and sometimes navigators) previously trained on other weapon system; pilots who are assigned to UASs for their first flying assignment following undergraduate flying training; and non-pilot/navigator UAS operator officers. The first source has been the mainstay of the Predator/Reaper system, whereas the latter two are experimental alternatives driven by unfilled wartime demands. In this respect, as noted by the commander of the UAS wing at Creech AFB, the latter two efforts attempt to satisfy demand for pilots that cannot be met within the Air Force's current force-structure limits. To this end, soon after becoming the Air Force Chief of Staff in September 2008, General Norton Schwartz, directed the service to find additional sources of operators to ensure an adequate sustainment pipeline and mitigate the need for draconian personnel policies to keep positions filled. Both alternative sources are controversial and represent somewhat of a departure from General Schwartz's predecessor, General Moseley, who did not pursue the same path. While General Moseley would not consider non-rated operators, he did initiate study of the possibility of sending pilots to UASs directly from undergraduate pilot training (UPT).[44]

[43] Lt Col Robert Kiebler ((15th Reconnaissance Squadron Commander, Creech AFB, NV), interview by the author, 16 Jan 2009.
[44] AFNEWS, "SECAF, CSAF stress back to basics," *Air Force Link,* 13 August 2008, http://www.af.mil/news/story.asp?id=123110751, Honorable Michael B. Donley, Acting Secretary of the Air Force, "A Time of Transition" (address, 24th Annual Air & Space Conference and Technology Exposition, Washington, D.C.), 15 September 2008,

Schwartz then created an experimental pilot program for non-rated officers and significantly sped up application of the direct-assignment-from-UPT option. Opinion varies across the Air Force as to the potential efficacy of either effort. As noted by the 15th Reconnaissance Squadron commander, neither program will yield a "complete" UAS pilot for some time since they will require more squadron instruction compared to an experienced pilot who transfers into UASs. In addition, many questions exist as to the career track of personnel, either rated or unrated, tied to nothing but UASs in what is still predominately a manned-system Air Force. Nevertheless, there is consensus, at all command levels, that attempting both programs is worthwhile due to shortages.[45]

In addition to pilot shortages, Air Force enlisted sensor operators are also in short supply, but impending changes in the character of the training pipeline should mitigate the problem somewhat. In the right hand seat of the GCSs, the Air Force utilizes an enlisted aircrew member to operate the UAV's sensors, to include the electro-optical/infrared "ball." In the past, enlisted sensor operators were actually intelligence personnel, and their mandatory training included imagery analysis first and then UAS-specific aircrew training. The resulting training pipeline did not meet the expanding needs of the Air Force because of the sheer length of time required. As the shortages grew more acute in both active duty and air National Guard units, leaders pointed out that the imagery-analysis portion of the training was a legacy requirement with little value in the combat missions being flows. As such, the Air Force CSAF is evaluating a proposal to create a UAS Sensor Operator career field, effectively separating it from the intelligence world and shortening considerably the training pipeline.[46] Although this would fill cockpits, unintended consequences of the career field shift could create problems for the larger UAS system as well as other reconnaissance platforms. In this respect, creating the new career-field will reduce the

http://www.af.mil/library/speeches/speech.asp?id=400, Michael Hoffman, "Air apparent: Are enlisted airmen next to pilot UAVs?" *Air Force Times,* 22 December 2008, 14-16, and General Norton A. Schwartz, Air Force Chief of Staff, "Keeping the Promise" (address, 24th Annual Air & Space Conference and Technology Exposition, Washington, D.C.), 16 September 2008, http://www.af.mil/shared/media/document/AFD-080916-083.pdf.

[45] Lt Col Robert Kiebler (15th Reconnaissance Squadron Commander, Creech AFB, NV), interview by the author, 16 Jan 2009.

[46] Michael Hoffman, "UAV sensor operators may get their own AFSC," *Air Force Times,* 2 February 2009, 11.

number of imagery analysts that the Air Force has in its collective pool. Thus, the move may reduce the Air Force's capacity to analyze the increased data flow that the change will likely generate, thereby moving the problem downstream. As with the rest of RSO, the Air Force will have to balance needs and requirements in search of a sustainable, effective average that meets customer requirements.

Maintainers. The Air Force has substantial maintenance forces on paper. In addition to the contractor support mentioned above, the Air Force has five active-duty military maintenance teams for the MQ-1 and MQ-9 respectively. Each team is capable of efficiently supporting up to ten and eleven aircraft, respectively, with expected steady-state generation rates of five sorties per day.[47] Future plans, noted below, are to attempt to cross-train the maintainers to allow seamless transfers as well as possible on-site support of both weapon systems. In addition, each weapon system has one team of ground communications maintainers who can support a CONUS-based mission ground-control station farm of between eight and ten modules each. The Air National Guard's (ANG) five Predator/Reaper units, while possessing some aircraft maintenance capability, do not have complete maintenance teams able to deploy independently. Instead, ANG units have provided home-station and deployment backfills in both the leadership and technician levels. Further, each ANG unit--except one--has a mix of blue-suit and contractor GCS maintenance support for mission ground-control stations flying Title 10 wartime missions. As noted by one ANG commander, however, the ANG units were not manned to a specific requirement. Rather, they were manned according to available resources, leaving open the question of whether the units are right-sized or not to support the required missions.[48]

In reality, Air Force military aircraft maintenance capability is a paper tiger in terms of depth and limits the flexibility of RSO. One key problem has been that Air Force manpower is organized around a peacetime or large-unit construct, a la the Cold War, in which ranks and grades are determined hierarchically as if the *whole* unit operates as though it were a single organism. Thus, each non-commissioned officer position will have an "optimally" efficient number of airmen subordinate to it on paper.

[47] Chief Master Sergeant Robert Stout, Nevada Air National Guard, to author, email, 6 April 2009.
[48] Lt Col John Keen, California Air National Guard, to author, email, 7 April 2009.

Air Force UAS launch/recover teams require minimum ranks of maintainers to operate legally according to codified safety and quality procedures, however. This has led to inefficient, but necessary use of non-commissioned officers (NCO) to meet technical standards. This is especially important, as will be discussed below, since the system discards its experience base every 3 to 4 years. The net effect is a system which has a sufficient number of manpower positions to fill out a set of launch/recovery teams, but insufficient technical experience due to lack of NCOs. Alternatively, the NCOs enter an onerous deployment cycle, reducing morale and retention. Efforts by Air Combat Command to increase the number of NCOs in each maintenance unit should mitigate this problem in the next few years. [49]

The Air Force does not have a specific UAS career field and, instead, relies on cross-training aircraft maintenance personnel--originally assigned to manned aircraft--to sustain the systems, in addition to contractors. As a result, nearly all new UAS maintainers must be trained on the system from the ground up, and once they leave the unit it is unlikely that they will return. The net effect is to reduce the availability of deployment teams. For example, for a five-team Predator maintenance group, only three teams worth of personnel are actually or close to fully trained. The remaining two teams are being trained; returning to their original weapon system; or unavailable for a myriad of other administrative reasons, such as leaving the Air Force. Of course, this does not mean that three teams of personnel are available to deploy. Rather, at least part of one trained team (if not the whole thing) must be available at home station to train new personnel. Typically, the other two teams are deployed forward or swapping out in theater. Some options are available to improve personnel availability, to include ANG augmentees as well as in-theater on-the-job training. Nevertheless, an Achilles heel exists in RSO flexibility: the fact that a launch/recovery team must still deploy to set up and/or operate sites.

Assuming adequate operator and equipment support, the Air Force's ability to rapidly hedge emerging situations is determined by maintenance-personnel availability. The Air Force would like to shift to an all blue-suit aircraft maintenance force to

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[49] Mr. Howard Beizer, ACC/A1MPP, to author, email, 9 April 2009.

improve the situation. This shift could enhance maintenance flexibility due to increased availability of trained personnel and improve the efficiency of the training process. As part of the FY10 budget formulation, the Air Force considered transitioning to an all-blue-suit maintenance force, but competing priorities prevented it from dedicating the resources to do so.[50] Of course, it is unclear whether the decision made was correct because the launch/recovery requirement, which would have driven the maintainer force structure, has never been stated. Despite the 50-CAPguidance, the Joint and Air staffs have not solidified the number of launch/recovery sites that must be supported; their required alert posture; and whether a mix of contractor/military maintainers meets projected hedging requirements. An experiment is underway to determine the feasibility to dual-train specific maintenance specialties such that they can seamlessly shift back and forth from both Predator and Reaper.[51] At the expense of a longer on-the-job training cycle, the measure would increase availability of maintenance personnel for deployments, if applied system-wide.

Like UAV aircraft maintenance, the force maintaining the RSO network and associated communications equipment is not structured according to a systematic plan associated with a requirement. As with aircraft maintainers, military ground communications maintenance personnel suffer from the ill effects resulting from the lack of a UAS or aircraft-specific career field and carry a similar training burden. Unlike aircraft maintainers, ground communications personnel deploy forward on launch/recovery teams as well as maintain the GCS compounds in the US. In this respect, the launch/recovery teams can support up to three GCSs each but are inefficiently manned (due to NCO quality review requirements) to effectively accomplish this role. In contrast, the mission GCS compound teams can support up to ten ground control stations and home-station satellite links on an around-the-clock wartime footing when fully staffed and trained. However, the onerous training burden stemming from a lack of a UAS communications specialty reduces the effectiveness of

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[50] Lt Col Eric Froelich, HQ USAF/A4LY, Chief UAS/ISR Sustainment, AF/A4LY, to author, email, 16 April 2009.
[51] Lt Col Eric Froelich, HQ USAF/A4LY, Chief UAS/ISR Sustainment, AF/A4LY, to author, email, 16 April 2009 and Col Michael Stickney (432 Maintenance Group Commander, Creech AFB), interview by the author, 15 Jan 2009.

the mission ground-control-station team. Further, experience from GWOT has shown that the local and global RSO mission networks have to be monitored and managed--an additional ill-defined tasking that simultaneously overlaps multiple, traditional organizational boundaries.[52]   As a result, while the Air Force may get to a 50-CAP goal, the capability of its system to flex is unclear due to a mismatch between system requirements and sustainment capability.

Interoperability

Intra/inter--service. Air Force Predator/Reapers have varying degrees of interoperability with other services' systems, though the Army and Air Force have jointly moved to improve the situation. In conjunction, OSD has issued direction to improve the situation. Air Force systems can share full-motion video as well as some additional data with Army systems now, but further communications are not possible due to technological issues. In February 2007, based on lessons learned as well as ongoing operational issues on the battlefield, the Chiefs of Staff of the Army and Air Force directed that the Army's Training and Doctrine Command and the Air Force's Air Combat Command establish a working group to enhance connectivity, communications, tactics, and procedures.   As a result, among other actions, both services are seeking technological solutions to enhance future data-sharing.[53] To this end, the Air Force has installed the Tactical Control Data Link (TCDL), which is used by the Army, on the Reaper.[54]

Until recently, any interoperability of the Sky Warrior and Predator/Reaper programs reflected more of the systems' common manufacturer as opposed to a systematic desire or joint plan on the part of the two services. In spring 2008, the Undersecretary for Acquisition, Technology, and Logistics (ATL) directed both services to enhance commonality of key subsystems to include data links and electro-

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[52] Major David Hood (former Predator/Reaper Operations Officer), interview by the author, 9 April 2009.

[53] Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem," *National Defense*, December 2008. http://www.nationaldefensemagazine.org/archive/2008/December/Pages/Army,AirorcetoOperateArmed DronesinTandem.

[54] "MQ-9 Reaper Hunter/Killer UAV," *Defense Update,* http://defense-update.com/products/p/predatorB.htmm (accessed 4 April 2009).

optical/infrared sensor balls, which in addition to reducing costs and improving logistics would enhance battlefield interoperability. AT&L directed the Air Force to improve the interoperability of its chosen ground-control station by adopting the same NATO standard interface architecture used by the Army.[55] Further, through guidance issued at various times in 2008, the AT&L directed the Air Force to switch purchases away from the MQ-1B to the MQ-1C, though a waiver was granted for FY09 due to pressing GWOT requirements and inability of the manufacturer to meet the changing requirement. Instead of a large purchase, ATL directed the Air Force to buy five MQ-1Cs to facilitate transition of the service to that variant.[56] The Deputy Director for Unmanned Warfare advised that ATL's direction is based on a perception that transitioning the Air Force to the more reliable and capable MQ-1C would streamline acquisition, battlefield logistics, and interoperability.

While acknowledging the need for enhanced interoperability at some level, the Air Force has open issues regarding OSD's ATL direction that could slow the drive to interoperability. Not the least of its concerns is the difficulty in modifying its existing operator and maintenance training as well as logistics pipelines to add another air vehicle variant. In addition, no Air Force commanders or staff officers interviewed thought there would be a need for interoperability beyond sharing situational awareness links and remote viewing of full motion video pictures, which the service is already working to improve.[57] The 432d Wing Commander as well as an active duty Predator combat reconnaissance squadron commander pointed out the possible difficulty in maintaining dual qualification in both the MQ-1B and C airframes.[58] The differences in engine and performance of the two aircraft are not negligible and will have to be

[55] Honorable John J. Young,, USD ATL, to Secretary of the Air Force and Secretary of the Army, memorandum entitled "Predator/Sky Warrior Acquisition Decision Memorandum," 19 May 2008 and Honorable John J. Young,., USD ATL, to Assistant Secretary of the Air Force (Acquisition), memorandum entitled "Air Force MQ-1B Predator Procurement Waiver Request," 28 October 2008.
[56] Honorable John J. Young, USD ATL , to Assistant Secretary of the Air Force (Acquisition), memorandum entitled "Air Force MQ-1B Predator Procurement Waiver Request," 28 October 2008.
[57]Col Chris Chambliss (432d Wing Commander, Creech AFB), interview by the author, 16 January 2009 and Lt Col Kenneth Kilmurray (HQ ACC/A8U, Langley AFB), interview by the author, 20 November 2008.
[58] Col Chris Chambliss (432d Wing Commander, Creech AFB), interview by the author, 16 January 2009 and Lt Col Robert Kiebler (15th Reconnaissance Squadron Commander, Creech AFB, NV), interview by the author, 16 January 2009.

studied. Even with only some differences, adoption of a new variant now may stress the aircrew and maintenance-training systems further, possibly limiting potential return on investments. ATL's direction to adopt the NATO ground-control station standard, while explicitly not directing a change in operating concept, poses some difficulty in execution. In this respect, the Air Force does not own the data rights to the ground-control station operating system, which makes it difficult and potentially expensive to modify. Further, if obtaining these rights is infeasible, the Air Force's options may be limited to a new ground-control station, which may or may not make sense under existing financial constraints and operational requirements.[59]

Inter-allied. While not using the NATO ground-control station interface standard yet, the Air Force is actually highly interoperable with several of its current allies. Great Britain, for example, purchased the Reaper, to include the Air Force-style ground-control station. The Royal Air Force is actually using the US' RSO network to fly its missions, as well as maintaining US aircraft alongside Air Force personnel.[60] Similarly, other countries such as Italy have purchased General Atomics systems and similar equipment from the US, which affords a high degree of interoperability with other major allied partners.[61] Thus, while a common standard for all is certainly a worthy goal, limited budgets within many of the NATO and non-NATO allies may hinder adoption. Ironically, the adoption of a new standard by some countries may, therefore, reduce overall interoperability in the near- to mid-term. In addition, since each of these countries is using the same supply chain that leads back to one company, any decision by the Air Force to move to a different system, interface, or otherwise could have unintended consequences with respect to its allies. Ultimately, NATO and other close US allies will have to determine not only an interface standard but also common employment concepts to ensure that the overall level of required interoperability is reached.

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[59] Major Kathryn M. Nelson, ACC/A8U, to author, email, 29 January 2009.

[60] Staff Sgt. Zachary Wilson, AFCENT Combat Camera News Team, "Airmen demonstrate unmanned aircraft not merely 'drones'," *Air Force Link,* 25 March 2009, http://www.af.mil/news/story.asp?id=123141439.

[61] Col Ludovico Chianese, Italian Air Force, "Predator Command Control," *Air and Space Power Journal,* 2 August 2009, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj07/fal07/chianese.html.

Sortie Generation

  Steady State. Due to its networked RSO architecture, the steady-state sortie-generation capacity at a specific location represents a balance between available forward UAVs and CONUS ground-control stations and crews. Limitations in aircrews, mission ground-control stations and available RSO communications bandwidth define the total-system steady-state capacity. In this context, the flexibility and adaptivity of the system, therefore, rests on the infinite number of combinations of launch/recovery UAVs and equipment that can be deployed around the globe, which mission ground-control stations can exploit near simultaneously. Assuming static short-term aircrew numbers due to the training cycle, the degree of system flexibility then boils down to investment in UAVs, launch/recovery equipment, spares, and maintenance crews. In the past, the Air Force has placed sufficient numbers of UAVs and launch/recovery ground-control stations at each forward location, as well as maintenance/logistics capability, to allow increases in steady-state generation for a period-of-time. In contrast to a surge, this allows the C/JFACC (or whomever) to focus on a specific tactical area as efforts elsewhere wax and wane, without wholesale shifting of forces around the battlefield. In support of changing conditions, equipment can be stationed around the globe in a war-reserve status and activated quickly as required. The inherent power of such a system is the reduced lift requirement associated with having to transport and house large numbers of mission crews as well as their ground-control stations. For example, to launch twelve combat air patrols, the RSO system needs only three to four launch/recovery GCSs forward and the twelve mission GCSs can stay in the states, instead of having to send everything forward.

  Modeling and real-world experience have led to heuristics of the expected performance of the Predator over time. Using this rationale, the combat air patrol capacity of a specific forward site based on MQ-1Bs alone is approximately 50 percent of the total number of aircraft at the site. [62] Assuming reasonable parts sustainment as well as maintenance and aircrews, the site can continue nearly indefinitely in this context. To obtain this consistent level, sufficient mission-ground-control stations must

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[62] Technical Sergeant Michael P. Kretser, "Modeling Predator MQ-1 Logistics" (masters thesis, Air Force Institute of Technology, 2008), iv.

be dedicated to flying combat air patrols from that location. In general, each mission ground-control station can fly approximately 22 of 24 hours each day, which matches the typical sortie length of the Predator. The other two hours are dedicated to maintenance of the mission-ground-control station and UAV requirements at the forward site.

The Reaper has done somewhat better based on improved engine performance, though it has experienced teething difficulties associated with early fielding. A rough heuristic for Reaper sortie performance--developed based on initial deployment performance--is equal to about two twelve-hour sorties with three aircraft per day consistently, though some scheduled maintenance might reduce the number to one longer sortie per day for short periods of time.[63] As with the Predator, collocating increasing numbers of Reapers results in economies of scale and a corresponding reduction in marginal resources to produce additional sorties. Long-term, the performance of the Reaper will need further modeling to determine system capacity.

Surge. The RSO network's inherent ability to surge rapidly and adaptively using either prepositioned or deploying UASs at specific location or locations around the globe is the key manifestation of its hydratic convergence capability. If an LRE UAS team and equipment is already in place at the point of need, the global force or a smaller subset of the combatant commander's apportionment of mission-ground-control stations can surge aircraft as quickly as they can be launched. The surge duration and number of aircraft launched will depend on available UAVs, launch/recovery ground-control stations, spares, and crews at the site. Models and experience indicate that about 80 percent of a site's Predators can be surged for periods of up to a week with no perceptible decline in long-term health of the forward fleet. Similar performance or better, based on improved characteristics overall, can be expected from the Reaper. For the mission ground-control station, the surge involves a refocus of effort--updated intelligence briefs and the like--from one location to the other, assuming all 50 CAPs are currently in use. The aircrew requirement for surge is the same as steady state, and

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[63] Chief Master Sergeant Robert Stout, Nevada Air National Guard, to author, email, 6 April 2009.

the ability to refocus the effort almost instantly provides tremendous flexibility to a combatant commanders and civilian leadership.

If the equipment is not pre-positioned and/or crews are not in place at the time of the requested surge, the required launch/recovery package has to be moved intra- or inter-theater. Relative to moving the mission and launch/recovery team forward, the lift payoff with RSO comes about when the number of combat air patrols flown RSO-style exceeds the number of launch/recovery ground-control stations required to launch the aircraft for the mission-ground-control stations back in the states. For example, if only lift factors are considered and if it takes two launch/recovery ground control stations (one primary and backup) to launch two combat air patrols, one could argue that the RSO system does not provide additional flexibility to justify its complexity since it's just as easy to lift two mission ground-control stations (assuming they are in mobile containers) to the theater along with aircrew. Beyond that point, however, the two launch/recovery ground-control stations can easily accommodate the launch and recovery of three combat air patrols. Under such conditions, RSO operations result in reduced lift requirements in addition to reduced forward footprint of aircrew that can be rapidly re-tasked to other global missions once the surge is completed.

Besides launch/recovery sustainment posture and mobility, the limiting factor for exercising the maximum surge capability of the RSO system is C2. The mechanism that would govern rapid reallocation of available combat air patrols from one combatant commander (COCOM) to another is unclear. When all UASs report to a single COCOM, shifting mission ground-control stations forces rapidly is relatively easy to manage. In Central Command, the Combined Air Operations Center and the CONUS Global Operations Center shift the focus of the mission-ground-control station between the Iraqi and Afghanistan theaters to account for weather and operational requirements with relative ease. As the 432 Air Expeditionary Wing (AEW) Commander remarked, however, how does one CONUS air expeditionary wing commander support and deconflict competing requests and priorities from two COCOMs simultaneously, both doctrinally and procedurally? The commander also pointed out that the Air Force was just beginning to consider the question as well as exactly how to codify his wing's planning and execution relationship with another,

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future active-duty UAS AEW connected to the same RSO network.[64] An Air Combat Command UAS staff officer echoed these sentiments.[65] In this respect, even without guidance and structure, the system has proven flexible enough to deal with complex, global problems, albeit inefficiently. At all levels there was general agreement that until doctrine and procedures are developed, planning and execution will be ad hoc and subject to increasing levels of self-induced friction as units activate in the UAS network piecemeal. In a stark warning from one operations officer, "we are one additional UAS wing away from system collapse due to undefined roles and responsibilities."[66] The comment punctuates the contention that the inherent power of the RSO system to surge globally cannot be harnessed without effective C2 methodologies and processes.

Hedging Analysis.

Strategic Reserve Capable of Being Rapidly Expanded: Meets intent with issues. Elements of the Air Force UAS RSO network could offer significant reserve capacity that promulgates hydratic convergence capability. From a communications standpoint, the Air Force is planning substantial reserves of infrastructure to ensure the RSO system can mobilize to meet global demands. Further, the early incorporation of Air National Guard units into the basic UAS remote-split operations concept provides a significant strategic reserve for post-GWOT contingencies. In addition, the planned equipment structure of each mission squadron provides one combat-air-patrol-reserve-surge capacity, at least, per squadron. The flexibility in the network allows rapid standup of the reserves dependent only on launch/recovery placement and equipment availability. Tentative plans to establish a capability of ten launch/recovery teams manned by military personnel for fast reaction and backed up by contractor options provides substantial reserves of maintenance personnel, though with acknowledged flexibility limitations.

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[64] Col Chris Chambliss (432d Wing Commander, Creech AFB), interview by the author, 16 January 2009. A review of possible doctrinal command relationships indicate that the AEW structure OPCON to two separate COCOMs does not seem feasible based on how a UAS Wing using remote-split operations executes its mission. Rather, a supported/supporting relationship with multiple COCOMs makes more sense for the long term with Transportation Command serving as a model. Lemay Center Handbook 10-2, *Air and Space Commander's Handbook for the COMAFFOR,* 20 May 2008, 37-59.

[65] Col Kenneth Kilmurray (HQ ACC/A8U, Langley AFB), interview by the author, 20 November 2008.

[66] Major Jason S. Rabideau (432d Aircraft Maintenance Squadron Operation Officer, Creech AFB, NV), interview by the author, 16 Jan 2009.

Despite substantial conceptual reserves, systemic C2 problems will reduce the viability of a rapidly expandable strategic reserve. The Air Force's existing C2 system, though still maturing, is able to call forth capacity within units already in the RSO network. In contrast, rapidly (or even slowly) activating new units is difficult due to the amorphous nature of the C2 system. For example, what are the responsibilities of a new active-duty wing within the RSO system? Will it manage a portion or the entire network, or is it subordinate to a lead air expeditionary wing, a numbered air force, or some other functional command structure? While the problem is not unsolvable, the Air Force's failure to define a standardized C2 and organizational construct for RSO--even a trial one—unnecessarily complicates addition of new units.

In terms of sustainment, the lack of a solidified system-employment plan prevents development of an effective strategic reserve capacity of pilots and maintenance personnel, as well as hardware. The Air Force's ongoing efforts to resolve its UAS aircrew shortages and accompanying training chokepoints will ensure the system's long-term success as equipment deliveries catch up. Similar to aircrew issues, the inefficient UAS maintenance manpower structure, subject to the legitimate requirements of Air Force resource challenges, will not be capable of rapidly deploying or sustaining ten military launch/recovery teams in the field. Ongoing attempts to cross-train personnel between Predator and Reaper as well as continued use of contractors and Air National Guard personnel provide avenues for resolving shortages. Paralleling the personnel sustainment challenge, the Air Force's investment in the highly-complex-RSO system with little systems engineering oversight has clouded future sustainment requirements and the Service's ability to cope. The addition of a second relay site in the Pacific region and possible relay sites in CONUS may expand the industrial base as well as internal equipment reserves. Finally, the Air Force shares the same primary contractor with the Army, other government agencies, and some foreign militaries. While this situation is not by definition a problem, the lack of a single government agency providing priority to the contractor on equipment and spares delivery is. Future efforts by OSD to consolidate some Army and Air Force acquisitions may improve this situation.

Expanded Reserves of SOF: Meets intent with issues. In addition to dedicated special operations Predator/Reaper assets, the UAS RSO network construct has the *capability* to provide substantial special operations force (SOF) reserves, but C2 and sustainment issues dissipate the effectiveness of the capability. Conceptually, conventional UAS forces, both forward launch/recovery and mission teams, can rapidly switch to meet SOF surge requirements. Further, in GWOT, conventional active duty and air National Guard units flew SOF or SOF-support missions regularly, security clearance issues notwithstanding. In addition, SOF forces would likely use the same global RSO communications infrastructure.[67] Nevertheless, no doctrine or regulation exists to describe or dictate C2 responsibility for mission ground-control station SOF forces within an integrated, global UAS network. For example, in the network, will the Global Operations Center make planning and execution decisions with respect to managing SOF control-signal priorities based on higher-headquarters guidance?

Complementing incomplete C2 guidance, sustainment issues hamper the Air Force's realization of the RSO network's advantages for creating substantial reserves of SOF UAS capability. The Air Force has only recently sourced AFSOC military maintenance personnel for a rapid-reaction LRE force, and it will take some time to build the capability. The Air Force has also delegated RSO UAS debrief procedures to the MAJCOMs and has not yet addressed RSO system maintenance boundaries and responsibilities. This lack of control is palpable as the SOF forces, in essence, use a UAS network "owned" and managed by conventional forces. In addition, as they have done in the GWOT, conventional mission-ground-control stations could be flying SOF aircraft, or vice versa. Without either Air Force guidance and controls or a series of robust inter-command agreements, monitoring and sustaining the network to support the SOF mission becomes problematic. Further, conventional mission ground-control station UAS squadrons do not have planning guidance about their responsibilities with respect to supporting SOF in terms of processes, equipment configurations, and security.

Rapidly Upgradeable Lethality and Sortie Rate: Meets intent with issues.

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[67] Major Ryan White (3 Maintenance Operations Squadron Commander, Cannon AFB, NM), interview by, 4 April 2009.

The Air Force's system can rapidly surge at specific points globally by concentrating internal resources through hydratic convergence with appropriate C2 and forward footprint. UAVs in an RSO network can rapidly surge one or more launch/recovery location by refocusing mission ground-control stations to maximize sorties based on operational need, but this will depend on effective C2 to orchestrate. The upper limit of a sortie surge is the lesser of the following: available mission ground-control stations that can be tasked or refocused; sortie rates of location or locations at a point; and communications capacity. Effective global C2, which doesn't currently exist in doctrine, policy, or regulations, is required to refocus the mission ground-control stations and coordinate the surge with forward sites. Similarly, if the network is supporting more than one COCOM, surges in support of one command will need a referee in the form of a process or higher chain of command to define which COCOM has the priority. Given the rapidity at which mission ground-control stations can refocus and launch/recovery teams can shift to surge, the JCS or other mechanism seemingly needs to be prepared, doctrinally and physically, to provide real-time guidance or delegate precise rules of engagement.

Absolute RSO system sortie rate is dependent upon crew and equipment availability. Since each ground-control station is normally occupied the majority of a given day (>22 hours/day) flying a combat air patrol, expanding absolute sortie rates depends on adding more ground-control stations, aircraft, and communications links, as well as accompanying air- and support crew. Improved training and equipment production pipelines are required to provide what is necessary to expand. Alternatively, with the right type of ground-control station and aircraft software, units can launch more sorties semi- or fully autonomously over the battlefield to reduce the effects of long transit times or provide more visibility over specific areas. Although increasing sortie rates, the tradeoff for this technique is increased air traffic, reduced UAV control, and subsequent risk associated with losing aircraft from in-flight collisions, undetected mechanical problems, and enemy actions. [68]

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[68] Lt Col Christopher Plamp, former 15 Reconnaissance Squadron (MQ-1) commander, to author, email, 6 April 2009.

Although it is possible to upgrade the network and its components lethality rapidly, the RSO network's C2 of sustainment makes upgrades painful and unnecessarily complicated. Separate administrative chains of command of personnel maintaining the RSO network and attached equipment serve to disrupt and slow upgrades due to lack of clear roles and responsibilities. In practice, the Global Operations Center (GOC) has coordinated system upgrades for the whole system. In this role and without specific administrative authority, the GOC eventually develops a solution that is sub-optimized due to local preferences as opposed to system needs.[69] To manage upgrade of an RSO network component, the various elements of the sustainment system must be able to, in the worst case, systematically upgrade the mission ground-control stations (GCSs), launch/recovery GCSs, aircraft, and communication infrastructure all at once or relatively quickly. In this respect, upgrades typically reduce the overall flexibility of the network, as compatibility between elements of the system is disrupted temporarily during the upgrade. In some cases, a degree of backward compatibility between the old and new modification mitigates the problem. Ideally, the Air Force would designate an agency to centrally manage and control the propagation of upgrades to maximize efficiency and minimize mission impact.

System capable of being rapidly moved between theaters: Meets Intent with Issues. Although constrained by the availability of airlift if starting from scratch, the RSO system offers substantial inter-theater mobility if capacity is thoughtfully set up. Demonstrating hydratic convergence, the RSO system can rapidly shift focus between theaters, if its C2 can shift mission GCS communication links to unused or surge sortie capacity at a forward site in another area of responsibility. Ideally, to realize this phenomenon, skeletally manned launch/recovery crews facilitate sortie generation awaiting deployment of a full crew when needed. This methodology makes sense in areas such as Africa or South America, where requirements pop up occasionally but not consistently. Alternatively, the Air Force can send on-call launch/recovery teams from CONUS or from one theater to the next, as required. This

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[69] Major Jason S. Rabideau (432d Aircraft Maintenance Squadron Operation Officer, Creech AFB, NV), interview by the author, 16 Jan 2009.

can be complicated if an attempt is made to move a contractor-maintained forward site. Typically, either the effort can be made to fit within the bounds of the existing contract or on-call military personnel can be used as a stopgap. If launch/recovery (LRE) capability is unavailable immediately, moving Air Force LRE teams is somewhat faster than a non-RSO system since a majority of the mission ground-control stations remain in the US. Finally, as with RSO surges, effective C2 with appropriate authority must be present to transfer control from one COCOM to another and to manage the moves as well as line up mission ground-control stations for control.

Long-range Systems Operable from Bases Outside the Region: Meets intent with issues. The RSO UAS network has reach that is effectively global due to its unique characteristics, but individual operations are still subject to the range limitations of the equipment at the forward site. Both the Predator and Reaper aircraft are designed to loiter over battlefields or targets for long periods, but there are corresponding tradeoffs in speed and range. Thus, when operated by a launch/recovery-ground-control station only, the UAVs communication and control links will normally extend active control only a few hundred nautical miles even with beyond-line-of-sight. The small logistics footprint of a launch/recovery team might, however, allow it access to airfields closer to the area of interest than might otherwise be possible with a non-RSO UAS system, thus extending its range. In contrast, when launch/recovery teams are prepositioned, the system's virtual reach is nearly global, depending on available satellite footprint. With the construction of relay sites in the Pacific and US for Asian and Western Hemisphere operations, the footprint will extend through a majority of US global theaters. With their unique communications infrastructure, Predator/Reaper intelligence feeds can transmit directly to battlefield customers below the aircraft or through the AF systems controlling the signal in the US via the satellite link. Nevertheless, the UAV, unless on a one-way mission, limits the range of the system.

Detection/surveillance Capable of Identifying Combatants from Non-Combatants: Meets intent. The Air Force RSO UAS system supports identification of combatants and non-combatants. Tactical experience codified in formal Tactics, Techniques, and Procedures (TTP) guides and incorporated into formal and squadron

training ensures systematic incorporation of best practices into operator culture.[70] In this respect, the Predator and Reaper's proven electro-optical/infrared and classified reconnaissance and surveillance capabilities support the requirement and are continually upgraded based on battlefield experience. Reachback intelligence services, military and government civilian, participate in this endeavor, utilizing RSO's integral communications gateways for transmitting the information.

System Interoperability: Meets intent with issues. Predator and Reaper have a small degree of interoperability at all three required levels, and improvement efforts are underway. Interoperability improvements are awaiting definition of requirements at all three of these levels. The Air Force can provide some interoperability--basic imagery and data--to a growing number of other services' and allied platforms. The Service's effort is handicapped by the legacy-ground-control-station interface architecture and rapid advances in the underlying technology. OSD efforts to improve DOD-wide interoperability may drive ground-control station interoperability as well as increased airframe commonality. Continued discussions between the Army and the Air Force with regard to roles and responsibilities, on the battlefield and off, should provide the end state for required interoperability. Whether Air Force ground-control stations are ultimately able to take control via RSO of Army UAVs on the battlefield appears doubtful and possibly unnecessary based on perceived operational scenarios. Inter-allied cooperation will depend on this same requirements definition. If the Air Force, through some means, adopts the NATO standard interface per OSD direction, the inter-allied interoperability could increase. Lack of C2 and doctrine outlining the dynamics of such interactions, however, will limit the effectiveness of the modification.

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[70] Lt Col Christopher Plamp, former 15 Reconnaissance Squadron (MQ-1) commander, to author, email, 6 April 2009.

Table 7. Air Force Predator/Reaper RSO UAS Analysis of Support for Hedging

Hedging Characteristic	C2	Sustainment
Strategic reserve capable of being rapidly expanded	1. Use of spare capacity within existing units poses no additional C2 problem. 2. Creating new units as part of the RSO network is problematic due to lack of doctrine, policy, procedures on adding and managing reserve units into the system.	1 Communications and GCS plans as well as AD & ANG units offer significant reserve capacity 2. Pilot and maintainer shortage on top of difficulties in right sizing a training pipeline prevent full use of available equipment. 3. Utilization of same primary contractor as Army problematic
Expanded Reserves of SOF and other highly-trained low-intensity warfare units	1. RSO employment concept and C2 potential are deal for generating internal reserves to support SOF 2. Lack of guidance for C2 of SOF forces in an RSO network problematic	1. Substantial internal reserves facilitate support potential 2. Lack of organic maintenance capability hinders independent deployment of SOF assets 3. Conventional units do not have
Systems capable of being rapidly upgraded in terms of lethality and sortie rate	1. Hydratic convergence inherently allows rapid point sortie rate increases 2. Lack of C2 guidance adds unnecessary friction for convergence 3. No systemized C2 guidance &	1. Absolute system sortie rates crew and equipment-dependent (via increased production etc.) 2. Improved training pipelines and/or reserve system required to rapidly upgrade sortie rates from

Source: Author's Original Work

Table 7. Air Force Predator/Reaper RSO UAS Analysis of Support for Hedging (continued)

Hedging Characteristic	Sustainment	Assessment
Strategic capable of being rapidly moved between theaters	1. Hydratic convergence possible if system LRE capacity is pre-positioned in strategically important locales. 2. C2 covering inter-theater transfer of MCE GCS focus not definitized. 3. Air Force mission is rapid, response	Inter-theater movement no faster than non-RSO UAS systems since MCE GCSs do not move	Meets intent with issues
Long-range systems operable from outside the region	RSO has global reach but C2 is an unclear amalgam of theater and local wing controls without global authorities or responsibilities.	RSO communication links are inherently long range but the UAVs are not.	Meets intent
Detection/surveillance capable of identifying combatants and non-combatants	System C2 supports the requirement with evolving TTPs and extensive, sometimes real-time reachback capability	Systems undergoing constant upgrades based on wartime feedback and tech improvements to enhance system performance	
System Interoperability (Intra-/inter-service, inter-allied)	1. C2 of employment concept expected to support battlefield intra-service interoperability 2. Inter-service (and inter-allied) common operating procedures, tactics etc. should facilitate theater and even	1. Hardware and system architecture is designed to support interoperability at all three levels. 2. Training system structured to support and enable interoperability	Meets intent with issues

Source: Author's Original Work

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Assessment
Meets intent with issues
Meets intent with issues
Meets intent
Meets intent with issues

CHAPTER 4

Comparing Apples and Oranges?

Given that a uniquely right strategy and force structure are rarely identifiable even in historical retrospect, it is obvious that there can be no demonstrably right strategy and force structure for the future.[1]

Colin S. Gray, *Explorations in Strategy*

…assessing the relative strategic effectiveness of an innovation can be important not only for the promotion of the innovation, but for the proper formulation of strategy.[2]

Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military*

This chapter will answer the following fundamental question: "Which services' UAS concept is more effective for meeting the National Security Strategy and National Defense Strategy hedging requirements?" The analysis in chapters 2 and 3 made an absolute comparison of the Sky Warrior and Predator/Reaper UASs in isolation against the proposed hedging criteria presented in chapter 1. The results, side-by-side, from these analyses are shown in table 8. With no inherently "right" and "wrong" answer, the assessments of "meets intent," "meets intent with issues," and "does not meet intent," enabled qualitative judgments of degree of compliance. In the analysis below, the UASs will be reevaluated relative to each other in achieving the criteria. In these evaluations, the judgments made are simply "Air Force" and "Army" according to which system is a relatively *better* hedge with "tie" used to denote no basic distinction in relative capability.

The following ideas provided context to the comparative analysis and results. First, the intent behind each system differs in ways that naturally affect, positively or not,

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[1] Colin S. Gray, *Explorations in Strategy* (Westport, CT: Praeger, 1998), 112.
[2] Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 147.

the value of the systems as a hedge. The Army's Sky Warrior UAS maintains a battlefield focus, whereas the Air Force's RSO-based UASs have global, theater, and battlefield ISR responsibilities. See chapters 2 and 3 for a discussion of the rationale behind the systems and the origin of their configuration. Second, the C2 for the tactical employment of the services' UASs for ISR missions is undergoing revision by an interservice committee. Since the US is unwilling to accept the current level of ISR support, however, it is rapidly building up the existing Air Force UAS force structure and laying the foundation for an independent, somewhat complementary Army version. Finally, some capability overlap is unavoidable between the services and, perhaps, even desired. The relative ability of a service's UAS to provide a hedge for all potential battlefields or theaters based on the quality of their C2 and sustainment of their chosen deployment and employment schema is, therefore, interesting from a strategic, operational, and tactical perspective.

Providing further context, the Army has not fielded its UAS yet, with the exception of spiral employment of some pre-production-model Sky Warriors to meet emergency GWOT requirements. As a result, the Air Force system in being, for the most part, is being compared to a system that many could argue has not been fully tested developmentally or in the heat of battle. Nevertheless, the Army's *planned* concept, with some battlefield experience, serves as the basis of comparison here since the Army proposed it, in part, due to the Air Force's perceived inability to provide adequate amounts and control of intelligence, surveillance, and reconnaissance (ISR) or reconnaissance, surveillance, and target acquisition (RSTA) coverage for its field units. Whether the Army's system meets its needs as well as national security objectives is, therefore, germane in the sense that it represents an expenditure of manpower and equipment that, in a perfect world, could have gone to the Air Force for expanding its UAS force structure. Though the Army resources would no longer be available under the general Air Force pool, these "lost" resources' ability to meet national security hedging objectives is still interesting since the Air Force will have implicitly fewer resources. In this respect, the national objectives will still have to be fulfilled, and the Army UAS companies may, in fact, be called upon to participate separately from their combat aviation brigades (CABs) to meet uncertain global requirements. Further, there is no

guarantee that the Army UAS system will meet US needs and may require Air Force UAS ISR support to fill in the gaps. Thus, understanding whether the Army system is substantially better, worse, or the same in terms of capability to meet the hedging criteria is a legitimate concern. Finally, since both sets of resources will no doubt find themselves in the same theater and battlefields, understanding relative capability is crucial to ascertaining their combined value.

Table 8. Army and Air Force Hedging Capabilities Comparison

Hedging Scenario	Category	Army	Air Force
Strategic reserve capable of being rapidly expanded	Strategic reserve	Meets intent with issues	Meets intent with issues
Expanded reserves of special operating forces and other highly-trained low-intensity warfare units	Strategic reserve	Meets intent with issues	Meets intent with issues
Systems capable of being rapidly upgraded in terms of lethality and sortie rate	Adaptive system	Meets intent with issues	Meets intent with issues
Systems capable of being rapidly moved between theaters	Adaptive system	Does not meet intent	Meets intent with issues
Long-range systems operable from bases outside the region	Adaptive system	Does not meet intent	Meets intent with issues
Detection and surveillance systems capable of identifying combatants from non-combatants	Adaptive system	Meets intent with issues	Meets intent
System interoperability (Inter-/ intra-service and inter-allied)	Strategic reserve & adaptive system	Meets intent with issues	Meets intent with issues

Source: Author's Original Work with Information Taken From Tables 4 and 7

Hedging Capability Comparison

Strategic Reserve Capable of Being Rapidly Expanded: Army

Result: The Army's planned system is capable of expanding its reserves more quickly than the Air Force's existing one due to its effective sustainment and lack of friction within its relatively simple C2.

More-responsive production is a joint problem for the services due to their shared primary contractor. The OSD Acquisition Technology and Logistics (ATL) efforts to

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find cost savings by having the Services work towards greater system interoperability could improve the feasibility of a responsive manufacturing line to feed the services' strategic reserve. Though cost remains the driving factor, manufacturing flexibility and ease of scaling-up production could result if the contractor refocuses on at least a single model Predator due to ATL decisions, though the Air Force would still employ the Reaper as well. The contractor would, however, have to improve upon its past manufacturing performance to harness the promised efficiencies of consolidation. In contrast, ATL's direction for the Air Force to pursue a common ground-control station (GCS) interface may open up alternate sources of supply for the GCS, thereby expanding potential production capacity.[3] If ATL's efforts are unsuccessful, determining the effect on the contractor's ability to surge production capacity for each service is unclear. For purposes of this analysis, the presumed negative or positive effects of ATL's efforts will be assumed equal. If the effort succeeds, from a reserve-manufacturing standpoint only, the potential resource savings, better asset prioritization, and ease of scaling up or sourcing different manufacturing lines will better serve the nation's strategy. Unintended consequences like disruption of ongoing UAS operations and an increased burden on strained Air Force training pipelines could result, however.

By sharing the same production source, the relative merit of each service's UAS concept with respect to hedging boils down to C2 and sustainment of their chosen employment concept. The Air Force's global RSO system is inherently expandable. The RSO communications network will have built-in reserve capacity, and active duty and Air National Guard units will have additional depth that will serve as a strategic reserve. The lack of structure in terms of doctrine, policy, and regulations for its C2 and sustainment systems, however, generates self-induced friction that reduces its capability to use its inherent reserve capacity or expand. With respect to sustainment, the Air Force does not have the force structure and training pipeline in pilots and maintainers to expand its system, internally or externally. Contractors can mitigate the maintenance issue, however. In addition, Air Force capacity will increase as additional, funded training

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[3] The author assumes that the contractor would not license manufacture of the Predator or Reaper by alternate sources, and there is no guarantee that such a move would expand production significantly over internal improvements anyhow.

courses come on line in 2009 and beyond. An approved UAV plan in terms of quantity and type would enable the Air Force, in the short and medium term, to rationalize its training pipelines for steady state and surge operations. In contrast, C2 of the Army's non-complex, CAB-based employment concept does not impede the rapid integration and employment of an expanding strategic reserve. In fact, the Army's robust UAS-focused sustainment system, as currently planned, offers a flexible way to expand the reserve of both operators and pilots rapidly, assuming hardware can be sourced.

Expanded Reserves of SOF: Tie

Result: The service's C2 and sustainment systems, despite some issues, have the capability to support expansion of reserve special operations forces (SOF).

Augmenting its existing SOF UASs, the Air Force has substantial internal reserves of conventional Predators and Reapers that can (and are) used in support of SOF. C2 and sustainment issues hamper the effectiveness of the effort, however. Notionally, the Air Force's RSO system allows for rapid stand-up of additional SOF CAPs, as required, assuming availability of launch/recovery sites. RSO's unstructured C2 system is a drag on doing this rapidly, but the concept is feasible and proven. Air Force Special Operations Command's (AFSOC) nascent military launch/recovery maintenance capability, however, casts a shadow on the AFSOC's ability to set up new sites quickly. All the same, slower, less flexible contract options could provide substantial reserves for long-term deployments. Further, continued use of non-SOF aircraft and maintainers for SOF purposes may grow unfeasible over time as AFSOC undertakes unique modifications of its UAVs. In addition, the lack of Air Force-level guidance on RSO maintenance creates friction for non-SOF launch/recovery teams launching sorties for SOF mission crews. Like the Air Force, the Army's C2 and sustainment mechanisms need greater maturity before they can effectively create SOF reserves with conventional forces. The Sky Warrior's combat aviation brigade-based C2 and sustainment system may or may not provide the flexibility to allow entire companies to be detailed--rapidly-- to SOF duty on separate deployments.

Though possible, the Army is not explicitly planning for this mission set yet, which, like the Air Force, introduces friction into attempts to utilize non-SOF forces in this role. From the sustainment perspective, its planned system appears to offer

substantial capacity to source existing operators and maintainers for SOF duty. Similarly, the training pipelines and concepts seem to have the necessary depth to create more throughput. Providing sustainment support for units detailed to SOF without prior planning might prove problematic, though not insurmountable as an obstacle. Finally, specialized SOF UAV and ground-control station modifications and requirements might also prove troublesome, but Army efforts to maximize interoperability of its UASs may mitigate this issue.

Rapidly Upgradeable Lethality and Sortie Rate: Tie

Result: The Army is limited in surging by its employment concept, whereas systemic flaws in C2 of its RSO system limit the Air Force.

The services have different challenges with respect to upgrading their lethality and sortie rate, but the aggregate effect on both services appears to be broadly equal. With similar degrees of adaptivity in the design of their ground-control stations, UAVs, and communication links, each service can accommodate a wide-range of lethality upgrades as technology improves. The Air Force's disjointed C2 system, however, is not structured to support rapid upgrades of hardware and software across its network.

With respect to sortie-rate improvements, the Army's employment concept and C2 of the Air Force's complex RSO system hamper the degree to which the systems can grow internally. For the Army, the lack of a networked system of control fundamentally limits the number of sorties that one site can launch and control due to the number of GCSs. Extensive interoperability of its UAVs with other platforms such as the Apache may increase the number of systems it can keep in the air, though at increased risk. Facing the opposite problem, the Air Force employment system can, theoretically, hydratically converge its mission ground-control stations to surge as many aircraft at a specific site as the forward maintenance and operations crews can sustain. Nevertheless, the C2 system does not support full use of the capability. The many separate chains of command that oversee the units connected to the RSO network as well as the network itself lack doctrine, policy, and regulations, which limit the degree that the system can be surged. Ad hoc measures have worked in CENTCOM-only operations, but the presence of only one supported combatant commander (COCOM) simplifies the problem. Future

expansion of UAS support for multiple COCOMs will exacerbate the issue without additional guidance.

Rapid Inter-theater Movement: Air Force

Result: The Air Force use of the remote-split operations concept enables it to shift focus rapidly between theaters, while the differences in mobility footprint are probably not substantial due to the size of the Reaper and its ground-support infrastructure.

On the surface the net difference between the Army and Air Force is sometimes, though not always, small in shifting a UAS force form one theater to the next. As both services' systems can fly soon after reassembling the UAV after shipment, the only fundamental difference would appear to be based on the speed of their transportation mechanisms. In comparing Predator and Sky Warrior companies, however, the Air Force has a slight advantage in reduced lift requirements (and probably speed) since most of its GCSs are in the US. Due to the size of the Reaper, the teardown/buildup time required for the much larger, more-complicated UAV marginalizes the advantage, however. For the purposes of this discussion, the author assumes that both services require the same base-level support such as security, supply lines, and fuel, which either external organizations or ad hoc arrangements will provide.

Given the lack of clear difference in physical mobility, the services' employment constructs provide the best barometer for gauging the relative merit in this metric. Functionally established for a division's battlefield support, the Army's Sky Warrior companies are tied to the C2 systems of their division, CAB, and supported BCT. Shifting a single company from one theater to the next would ordinarily be tied to the movement of the larger unit that the company is established to support. Although the movement of forces is possible to support external customers, there is some question whether this will happen and if the Army is going to plan for it.[4] In contrast, the Air Force's RSO system has the C2 and technical capability to shift CAPs rapidly *back and forth* between theaters. Although a resource-intensive solution in terms of UAVs, sites can be supplied with substantially more aircraft than steady-state operations require,

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[4] Richard J. Newman, "War From Afar," *Air Force Magazine,* August 2003, www.airforce-magazine.com/MagazineArchive/Pages/2003/August%202003/0803war.aspx, 60-1.

allowing levels of effort to shift between theaters. The Central Command Coalition Forces Air Component Commander (or CFACC) has employed this concept repeatedly between Iraq and Afghanistan to account for changing local conditions. Sustainment factors such as maintenance and launch/recovery crew sizes, as well as spares replenishment, will determine if the refocusing of effort will be of limited or extensive duration. Similarly, setting up bare-bones launch/recovery operations at sites around the globe, together with skeletal maintenance and operations crews (perhaps contractors) or use of on-call military teams, would allow rapid responses to temporary or even permanent requirements in multiple combatant commands. Doctrine, policy, and regulations for C2 and sustainment, however, do not exist to leverage systematically this capability, though ad hoc arrangements are feasible. Ultimately, even with C2 and sustainment issues, the Air Force system is more capable than the Army's at inter-theater movement due to the basic philosophies and mission requirements of the services.

Long-range Systems Operable from Bases Outside the Region: Air Force

Result: Both systems are limited by the relatively short range of their chosen UAVs, but the Air Force's RSO system provides virtually "global reach" which can be utilized to extend the range of effects of its UASs.

Both the service's UAS concepts are limited by the range of the UAV they employ, though the Air Force RSO system does have some benefits for long-range actions. The control of the aircraft from mission ground-control stations in the US technically means that the Air Force is operating the UAVs outside of whatever region they are employed. Nevertheless, a launch/recovery team is still required at a base sufficiently close enough to the region. Operating the control stations from the US also reduces forward presence of air and maintenance crews. In addition, the reconnaissance and surveillance footage provided by the Predator/Reaper, if controlled via RSO, can be transmitted directly back to the US and other customers, whereas the Army might not have this capability when deployed forward. The Air Force system, with its reduced forward footprint, might deploy surreptitiously to the region more easily than the equivalent Army system, offering a "virtual" improvement in range. While there is no substantive difference between the two concepts due to their dependencies on similar

UAV designs, RSO gives joint force commanders options to extend the range of systems designed from the ground-up with endurance--not range--in mind.

Detection/surveillance Capability of Identifying Combatants from Non-combatants: Tie

Result: Both Air Force and Army meet intent with no further comment required over and above the descriptions in their respective chapters.

System Interoperability: Army

Result: The Army's planned Sky Warrior system will have high degrees of interoperability by design, whereas, the Air Force's older designs are less interoperable, though upgrades are being pursued.

The Sky Warrior program is more interoperable than Air Force counterparts due to its employment concept and relatively recent design effort. With a primary capability of so-called "Manned-Unmanned Teaming," the Army drove the design of the Sky Warrior's underlying software and hardware to be as interoperable as possible. This interoperability is substantial and extends to multiple Army platforms and, to lesser degrees, with equipment from other services and possibly NATO allies. In contrast, the Air Force's "legacy" hardware software system component design did not start out with the intent or requirement to have extensive intra-, inter-, or allied service interoperability. Rather, battlefield GWOT experience and economics drove the requirement. Despite Office of the Secretary of Defense desires, efforts to increase interoperability have been problematic, and resolution of the issue with final decisions by the Air Force on a course of action will take some time.

Further Observations

A common theme evident in the evaluation of the Air Force system is the lack of doctrine, policy, and/or regulations for C2 and sustainment of and within its RSO network. Notionally, on a cocktail napkin, the Air Force RSO concept with supporting technology is extremely adaptable and flexible. The resulting integration of the system in time of war has been difficult, however, due to the unique nature of the system as well as its complexity. Further, the massive increase in capacity made possible by this technology has been a double-edged sword as the Air Force has found it difficult to feed its hydra with air crew and maintainers. To repeat Edward Luttwak's observation at the

beginning of Chapter 3, *"Technical innovation and organizational change proceed at different rates, driven by different impulses, and it is easy enough for a fatal dissonance to persist between the two."*[5] Similarly, Stephen Rosen's arguments on the difficulty in fielding new technology and organizational constructs in wartime seem to be playing out in the Air Force's RSO system.[6] However, the firing of the Chief of Staff of the Air Force as well as compelling wartime needs for GWOT seems to have increased the focus on these issues, with some progress being made for both C2 and sustainment. Chapter 5 will analyze the Air Force system more closely, focusing on its organizational history to determine why the system developed in the form portrayed in this analysis.

Table 9. Army and Air Force Hedging Capabilities Comparison Result

Hedging Scenario	Army	Air Force	Comparison
Strategic reserve capable of being rapidly expanded	Meets intent with issues	Meets intent with issues	Army
Expanded reserves of special operating forces and other highly-trained low-intensity warfare units	Meets intent with issues	Meets intent with issues	Tie
Systems capable of being rapidly upgraded in terms of lethality and sortie rate	Meets intent with issues	Meets intent with issues	Tie
Systems capable of being rapidly moved between theaters	Does not meet intent	Meets intent	Air Force
Long-range systems operable from bases outside the region	Does not meet intent	Meets intent with issues	Air Force
Detection and surveillance systems capable of identifying combatants from non-combatants	Meets intent	Meets intent	Tie
System interoperability (Intra-/inter-service and inter-allied)	Meets intent with issues	Meets intent with issues	Army

Source: Author's Original Work with Information Taken from Table 8

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[5] Edward N. Luttwak, *The Logic of War and Peace* (Cambridge, MA: Belknap Press of Harvard University Press, 2001), 235.
[6] Stephen P. Rosen, *Innovation and the Modern Military,* 180-1.

Though not addressed directly above, a key difference between the services' UASs is sustained capability to produce a given quantity of CAPs and the importance of that measure of merit. The Air Force can produce more UAV sorties with a similar force structure on average when employing RSO than the Army can without. All other things being equal then, the Air Force can more efficiently use assigned equipment. But are we answering the wrong question? The answer assumes that efficiency is the more important measure of merit. While Secretary Gates lambasted the Air Force for not producing sufficient *quantities* of CAPs, arguably the Army's complaint was that the Air Force could not produce the ground-effects it desired. Clearly, the Air Force did not sufficiently pursue expansion of ISR capability despite repeated requests from the Secretary of Defense and field commanders. However, other factors were at play that cloud whether the question was about quantity. In this respect, as admitted by all sides, the process for requesting ISR support, UAS or otherwise, was not keeping pace with the counterinsurgency fight in which both services were engaged. In addition, JCS validation of the forward-based Army UAS system and mission provides compelling evidence that the Army is seeking control of ISR assets to improve qualitative performance and not just quantity of missions. After all, why not just mirror the RSO system and even leverage its existing communications network to rapidly field increased numbers of assets? Rather, the Army chose a different path that moved the mission operators forward to leverage perceived advantages the service believes it will get from personal battlefield interaction. The RSO system could almost never meet this requirement without robust liaisons and/or communications with lower-echelon Army units.

Besides the differences between the services' UASs, the common technical lineage and overlapping capabilities present numerous opportunities for collectively improving hedging potential if accompanied by process improvements. The efforts of OSD and the individual services to improve interoperability and compatibility of UAVs and GCSs provide the foundation for future teaming to meet battlefield and global requirements. For example, with interoperability enhancements, Air Force US mission ground-control stations could be used to assist an Army battlefield surge or vice versa. Of course, contentious process issues such as battlefield airspace control when Sky Warrior-sized UASs are employed by the Army at altitudes up to 25,000 feet must be

resolved to ensure both services can function effectively together and independently. This teaming will further depend on flexible, adaptive C2 requirements, appropriately prescribed in joint doctrine, regulations, and codified lessons learned to ensure such teaming does not have to be purely ad hoc. Although many of these issues are unresolved, both services as well as OSD are working towards improving the assorted processes as part of the Army and Air Force Warfighter talks and other forums.[7]

To justify the required technical modifications and procedures, there will have to be a need born of the battlefield or predicted by analyses. What seems more feasible is continued integration of the respective service's sustainment systems. One service's UAV fleet, for example, could serve as a virtual reserve for the other service, depending on national mission need. Similarly, pursuing commonality on all component levels as much as possible will expand the available spares pool and lower costs. Training--especially maintenance--offers yet another area of efficiency where successful integration will yield flexibility to meet uncertain joint requirements.

Summary

The scorecard in table 9 and follow-on observations do not strictly explain which system is the "best" means to achieve the National Security and National Defense Strategy uncertainty hedges. If the answer were a linear summation of the results of each comparative category, the Army's *planned* system and the Air Force's *existing* system are in a virtual dead heat. Readers could easily debate the relative importance of the different hedging scenarios considered when performing the analysis, however. In this respect, the preeminent hedge characteristic needed to support an emerging conflict for different scenarios will vary in degree if not substance each time. In addition, the different categories clearly affect each other--with improved system interoperability impacting SOF reserves, for example. Nevertheless, when evaluated against the hedging scenarios, the systems tied for efficacy, but the results could change as fielding and system maturity progress. As changes are made, the results should be judged in light of

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[7] Grace V. Jean, "Army, Air Force to Operate Armed Drones in Tandem," *National Defense Magazine,* December 2008.
http://www.nationaldefensemagazine.org/archive/2008/December/Pages/ArmyAirForcetoOperateArmed DronesinTandem and Kris Osborn and Michael Hoffman, "Finally Ground Rules for Air Ops," *Defense News,* 19 October 2008, http://www.defensenews.com/story.php?i=3723662.

the strategic requirements of both the current and future wars, embodied in the strategy for GWOT and the national strategies, respectively. As such, the reader can view this paper as a lens with which to continue to evaluate the relative value of the two systems.

CHAPTER 5

Why Did We Come to This Corner of the Strategic Maze?

Where there is no vision, the people perish: but he that keepeth the law, happy is he. [1]

King James Bible

The deductive analysis of the Army and Air Force systems showed that both systems could serve equally well as a hedge in support of national security objectives. This was somewhat surprising for several reasons. The Army has historically been poor at developing and fielding UASs, but the evidence indicates the Sky Warrior will likely succeed. In fact, although measured against hedging criteria that had a distinctly "global focus" with an emphasis on flexibility and adaptivity, the Army's ground-centric Warrior did as well as the Air Force's Predator and Reaper. In contrast, the Air Force has a long history of UAS advocacy, innovation, and even a successful deployment in Vietnam. [2] However, as shown in the analysis, preventable C2 and sustainment issues reduced the effectiveness of both Predator and Reaper UASs as hedges. But, recent changes seemed to be improving the situation. In an effort to improve UAS fielding and employment in the future, the question now becomes. "Why did the analysis yield these results?"

Army Assessment: Civilian Guidance Reverses 40 Years of Traditional Failure

The Sky Warrior will likely perform well as a division/brigade UAV and, to an extent, as an instrument to support a strategic hedge. This UAS benefits from an excellent systems acquisition process and the use of an airframe based on the proven I-gnat Predator designs, both of which have extensive battlefield experience. Thus**,** the Sky Warrior is not really a technologically innovative weapon system as opposed to an evolution of successful designs. The innovation is the way in which the Army is building

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[1] Proverbs 29:18. *King James Bible*.
[2] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services: A Comparative Study of Weapon System Innovation" (PhD diss., Johns Hopkins University, June 2000), 51, 219-306, 407-500.

mutually supportive C2 and sustainment processes to support its primary battlefield mission. In the battlefield support role, the UAS' planned operational capability, sustainment, and interoperability greatly exceed that of its brigade-level predecessors in ISR and other roles. While not meeting the criteria of two of the scenarios examined, the Sky Warrior UAS will have substantial capability even with the limitations noted. (See table 4 for a summary of the hedging analysis from above.) The failure of the system to meet the long-range and rapid inter-theater mobility hedging requirements is due to the ground-centric approach to the UAS design, as opposed to any fault in the technology of the system itself. Indeed, a more relevant observation is that the baseline UAV is capable of readily improving its rapid inter-theater mobility performance with adjustments to its C2 and sustainment systems.

If the Sky Warrior continues down its current path, the Army will overcome its systemic organizational issues to successfully field a brigade-level UAV. Since World War II, the Army's primary failure in fielding UASs lay in the service's inability to designate a centralized proponent for the systems that was strong enough bureaucratically and technically.[3] In June 2003, the Army resolved the problem by naming the Aviation Branch and specifically Fort Rucker's Army Aviation Center as the proponent for Army UASs. The move placed the UASs within a branch capable of competing bureaucratically with the powerful combat arms branches of infantry and armor. In addition, it ensured UASs would be managed by the aviation community via a single-system manager within Training and Doctrine Command.[4] By design, the single manager would overcome historic failures and successfully incorporate the other branches' requirements into UAS designs without sacrificing its viability as an aviation system.[5] Further, assigning Sky Warriors to a combat aviation brigade while supporting engaged brigade combat teams ensures the assets can be simultaneously managed by

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[3] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 620-23.

[4] MG(P) John M. Curran, "UAV Systems: Aviation Branch Assumes Proponency," *Army Aviation Association of America,* Summer 2003, http://www.quad-a.org/Archives/0311.htm and Lieutenant General Anthony R. Jones, Deputy Commanding General, Chief of Staff, to Commander, U.S. Army Aviation Center and Fort Rucker and Commander, U.S. Army Intelligence Center and Fort Huachuca, memorandum, 25 Jul 2003.

[5] Colonel Robert Sova, Director Army UAS Center of Excellence, "UAS Joint Integration Panel" (briefing, AAAA Unmanned Aircraft Systems Symposium), 9 December 2008, http://www.quad-a-org/Symposiums/08UAS/Presentations/Sova%20COL%20.ppt.

aviators and responsive to ground commanders. The structure also sustains long-term UAS advocacy by experienced senior ground and aviation commanders.

External civilian influence appears to be the predominant reason the Army overcame its fractured organizational structure to produce a successful UAS. According to one study of UAV history, "The Army has always wanted a UAV to solve the age-old problem of seeing over the next hill, but has been unable to overcome its fractured structural dynamics long enough to field a useful system."[6] What drove the Army to get past these issues: the ascension of Secretary of Defense Donald Rumsfeld and his subordinate political appointees and the Global War on Terror. Contrary to Stephen Rosen's theory of military innovations resulting from intraservice competition, after over 40 years of UAV misfires, it was unlikely the Army was going to field a viable UAV without blind luck or extensive external stimulus. Secretary Rumsfeld placed tremendous pressure on the Army to transform itself into a much lighter and effective force even before the wars in Afghanistan and Iraq.[7] The Army reacted by reorganizing with a focus on efficient use of limited manpower that leveraged technological innovations. UASs clearly fit into this picture with their force- multiplying ISR capabilities. To this end, the transfer of UAS management to the Aviation Branch centralized a previously disjointed acquisition organization. Initial combat in Afghanistan and Iraq provided added impetus for the Army to revamp its internal structure for UAS development and employment. The Sky Warrior brigade UAV concept resulted in 2003. This series of events provides credence to Barry Posen's assertion that civilian intervention--"helped" by a war--is sometimes necessary to provoke military doctrinal change.[8] The effect of interservice competition on Sky Warrior development is addressed below.

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[6] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 620.

[7] MG(P) John M. Curran, "UAV Systems: Aviation Branch Assumes Proponency," John Hendren, "Army Holds Its Ground in Battle With Rumsfeld," *Los Angeles Times,* 29 November 2002, downloaded from GlobalSecurity.org at www.globalsecurity.org/org/news/2002/021129-sbct.htm and Mackubin Thomas Owens, "Rumsfeld, The Generals, and the State of US Civil-Military Relations," *Naval War College Review* 59, no. 4 (Autumn 2006), 77-9.

[8] Barry R. Posen, *The Sources of Military Doctrine* (Ithaca, NY: Cornell University Press, 1984), 224-7 and Owen Reid Cote, "The Politics of Innovative Military Doctrine: The US Navy and Fleet Ballistic Missiles" (PhD. Diss., Massachusetts Institute of Technology, 1996), 384-95.

Air Force Assessment—Lack of "Intellectual Mastery"[9]

By 2009, the Air Force had invested in an adaptable and flexible UAS well suited as a strategic hedge but did not integrate its peculiar C2 and sustainment requirements adequately within the larger institution. As discussed in chapter 4, the Service's RSO system is viable as a strategic hedge as it at least "meets intent with issues" in all seven categories. Turning the prism the other way, however, in six of the seven categories the system only "meets intent with issues" reflecting historically inadequate C2 and sustainment development. From 2002 to 2005, the RSO network grew slowly to meet increasing ISR demands as the Iraq and Afghanistan insurgencies grew. Organizational friction built up as the Air Force added capacity without making substantial changes to its UAS and C2 and sustainment systems. Indeed, although the Air Force's total UAS flight hours doubled between 2002 and 2005, the Army produced more UAS hours with Shadow, Hunter, and Warrior variants by 2005 and continued to do so through 2007.[10]

The Air Force did not have sufficient trained aircrew, equipment and supporting processes to accelerate production. By 2005, the Air Force was aware of the integration issues and even noted the problems in its UAV Strategic Vision.[11] Many of the issues remained unresolved by 2007 despite wartime pressures, and the Army out-flew the Air Force by approximately 40,000 UAS-hours (including small UASs).[12] In the words of Thomas Erhard's analysis of technological innovations, the Air Force had internally developed and adopted RSO, but failed to obtain intellectual mastery to ensure organizational success. In other words, the Service did not increase its UAS' "combat

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[9] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 15.

[10] Briefing, UAS Task Force, HQ AF/A2, subject: "Air Force and Army UAS," 9 March 2009., Colonel Eric Mathewson, US Air Force HAF/A2 DCS ISR, "Air Force ISR in a Changed World: ISR Transformation, the Importance of Jointness and AF Unmanned Aircraft Systems," (powerpoint presentation given at C4ISR Conference, 17 October 2008) and US Government Accountability Office, *Unmanned Aircraft Systems: Additional Actions Needed to Improve Management and Integration of DOD Efforts to Support Warfighter Needs*, GAO-09-175, (Washington, D.C.: Government Printing Office, March 2008), 9.

[11] Air Force Print News (AFPN), "Air Force releases UAV strategic vision," *Air Force Link,* 24 March 2006, http://www.af.mil/news/story.asp?id=123017981 and AFD-060322-009, "U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision," 2005, and Adam N. Stulberg, "Managing the Unmanned Revolution in the US Air Force," *Orbis,* Published by Elsevier Limited on behalf of the Foreign Policy Research Institute*,* Spring 2007, 254 http://www.af.mil/shared/media/document/AFD-060322-009.pdf.

[12] Adam N. Stulberg, "Managing the Unmanned Revolution in the US Air Force," 252-64 and Briefing, UAS Task Force, HQ AF/A2, "Air Force and Army UAS," 9 March 2009.

effectiveness or efficiency relative to competing systems by taking advantage of the novel system's unique characteristics, and through full integration of the system into standard operating practices."[13]

Intraservice Issues. Intraservice bias did not significantly slow RSO's initial development, but marrying the Predator to the Air Force culture required the CSAF to lead the system's integration. Internally, the Air Force had no systemic organizational or cultural bias against UASs. Since Hap Arnold, the Service has been on the leading edge of UAS development and operational employment, though with a mixed record of success.[14] With regard to Predator, the Chief of Staff of the Air Force (CSAF), General Fogleman, actively campaigned to gain control of the program and subsequently developed UAS squadrons. He did this in recognition of the importance of UASs and a desire to take the program from the Army. Fogleman's status as CSAF enabled him to line up senior-officer support and manipulate the service's organizational structure and funding streams to the initial benefit of the nascent UAS squadrons. In this regard, Fogleman acted as a heterogeneous engineer successfully merging the Predator into an Air Force system dominated by fighter, bomber, and mobility communities, all competing for a shrinking defense budget.[15] However, as described below, he planted the seeds for later internal UAS stagnation when he assuaged his Joint partners by agreeing to fund the program from within the Air Force.[16] Nevertheless, his engineering effort resulted in a kind of technological momentum through 2002 for UASs that helped set the organizational conditions necessary for the development of RSO.[17] Fogleman's efforts also did not create a senior advocate within the Air Force who could oversee development and management, pre-RSO and afterwards. As a result, when the RSO system's technological momentum significantly slowed due to limitations in its C2 and

[13] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 12-3.

[14] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 31, 407-10, and Adam N. Stulberg, "Managing the Unmanned Revolution in the US Air Force," 251-7.

[15] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 541-53.

[16] John Law, "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion," in *The Social Construction of Technological Systems,* ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch (Cambridge, MA: The MIT Press, 1989), *114*-5.

[17] Thomas P. Hughes, "Evolution of Large Systems," in *The Social Construction of Technological Systems,* ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch (Cambridge, MA: The MIT Press, 1989), 58-9 and Richard J. Newman, "War From Afar," *Air Force Magazine,* August 2003, www.airforce-magazine.com/MagazineArchive/Pages/2003/August%202003/0803war.aspx, 60-1.

sustainment, the sitting CSAF--General Jumper initially followed by General Moseley--was the only one that had the influence to correct significant problems.[18]

After 2002, the Air Force appeared poised to integrate UASs completely into its organizational fabric. Several factors served to slow this integration, however. First, General Fogleman had retired in 1997 and subsequent CSAFs through General Moseley in 2008 did not necessarily champion the program as ardently as he had. Thus, under the Air Force's so-called "monarchic" organizational structure that was subject to the strong centralized authority of the CSAF, the radical changes necessary to mature RSO did not take place.[19] Fundamental changes such as operator and maintainer UAS career paths and training were not addressed, and the program moved ahead largely on the momentum imparted to it in the late twentieth century. This was not entirely the service's fault, however. The Joint community did not establish overall UAS ISR requirements or allocate them by service before the GWOT or after the overseas insurgencies expanded. As UAS ISR requests grew, however, no single Air Force organization below the Chief could make the required structural changes to significantly change processes, internally shift assets, or advocate for external assistance to correct RSO problems.

Interservice Competition. Interservice rivalry led the Air Force to acquire Predator and to shape its employment, which significantly affected the maturation of its RSO system. In the late 1990s, the Army Chief of Staff blessed the Air Force Predator concept of operations, which explicitly aligned the UASs to the Air Component Commander and not the ground commanders for direct tasking. Army concurrence with this agreement or the Air Force's lead designation was not complete, as many officers feared that it would not adequately support their tactical ISR requirements. Army bitterness was assuaged somewhat when it obtained Air Force concurrence to field its own limited Predator system, though it never exercised the option. Further, the Army further acquiesced as it sensed that it could obtain the tactical ISR mission essentially for free when Fogleman funded Predator and a new C2 system allowing some Army control of in-flight UAVs. The C2 system never developed, however, and the Army lost all

[18] Thomas P. Hughes, "Evolution of Large Systems," 73.
[19] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 29, 74.

control of the Predator.[20] Thereafter, until the advent of wartime supplemental funding, the Air Force matured the Predator system at its own expense, but the effort competed with the service's fleet modernization efforts and, by definition, against other services' priorities. Budget constraints of the Clinton and even Bush administrations would have required substantial internal Air Force tradeoffs to improve remote-split operations C2 and sustainment. With successive CSAFs through General Moseley focusing on F-22 fielding and fleet modernization, hard internal choices and efforts to obtain additional joint resources beyond marginal growth of UASs were unlikely without external inputs. [21] Pressure from the Army and eventually civilian leadership would provide that stimulus.

Leadership Distractions. By 2005, the Air Force was fully aware of the limiting factors or "reverse salients" in the RSO technological system, but its leadership failed to move rapidly enough to correct them.[22] General Moseley, who became CSAF in September 2005, inherited a host of problems with the RSO system that his predecessor, General John Jumper, had uncovered in 2005. General Moseley would have been hard-pressed to fix all of the issues that were identified as well as execute other service priorities. In fact, he focused on obtaining DOD executive agency for UAS acquisition; establishing a UAS weapon school; and fixing the broken theater-ISR-request process, accurately believing that Joint-request processes were part of the problem.[23] However, Moseley did not execute any substantial changes in the UAS C2 and sustainment system with regard to expanding the pilot pipeline to match equipment deliveries. Further, a problematic strategic nuclear force, continued aging fleet issues, and multiple public

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[20] Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 53, 546-53, and Adam N. Stulberg, "Managing the Unmanned Revolution in the US Air Force," 253.

[21] Mackenzie Eaglen, "Airmen vs. Modernization: The Air Force Budget Dilemma," *The Heritage Foundation,* 18 May 2007, http://www.heitage.org/Research/NationalSecurity/bg2037.cfm and Thomas P. Erhard, "Unmanned Aerial Vehicles in the United States Armed Services," 552-3.

[22] "Reverse salient" is defined as one or more critical problems that slow or stop the expansion of a technological system. Thomas P. Hughes, "Evolution of Large Systems," in *The Social Construction of Technological Systems,* ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch (Cambridge, MA: The MIT Press, 1989), 73.

[23] AFNEWS, "Officials discuss executive agency for UAVs," *Air Force Link,* 15 April 2007, http://www.af.mil/news/story.asp?id=123048908, AFNEWS, "General [Lieutenant General Deptula] provides clarification on UAV use," *Air Force Link,* 25 April 2007, http://www.af.mil/news/story.asp?id=123050533, and Kris Osborne, "Finally Ground Rules for Air Ops," *Defense News*, 15 September 2008, http://www.defensenews.com/story.php?i=3723662.

relations gaffs beset General Moseley.[24] He also embarked on efforts to stand up a

"Cyber Command" and reverse a recently completed operations and maintenance

reorganization despite more pressing issues with the immediate war.[25] Further, he vetoed

ideas on using non-pilot/navigator and enlisted UAS operators, though he initiated efforts

to examine the use of recent pilot training graduates as UAS pilots.[26] Thus, when

ordered to surge UAS ISR in the summer of 2007, the Service executed a series of

draconian personnel actions to keep Predator/Reaper-trained personnel in their ground-

control stations. Although a success in terms of the efforts of field and staff personnel,

the surge's execution reflected the Air Force's failure to mature its UAS remote-split

operations system.

       Civilian Intervention. Similar to the catalyst for Army UAS reorganization,

civilian intervention by a Secretary of Defense compelled the Air Force to pursue policies

more conducive to UAS operations. With a mandate to provide a "fresh direction" to the

GWOT, Secretary Gates refocused the services' efforts on winning the ongoing

insurgencies and reduced emphasis on potential future wars with large conventional

competitors. The Air Force appeared to resist the redirection due to threats to its

traditional fleet and perhaps misdiagnosed the fundamental reasons for lack of UAS ISR

growth, leading the Secretary to vent his frustrations publically.[27] In June 2008, Gates

relieved Moseley and Wynn for what he said later was only the Air Force nuclear force

problems, but evidence indicates that the public UAS disagreement contributed to the

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[24] In terms of gaffs, for example, General Moseley was mentioned, though not charged, in the $50 million dollar public relations contract scandal for the Thunderbirds among other issues. Jonathan Karl, "Two Top Air Force Officials to Leave," *ABCNews.com,* 5 June 2008, http://blogs.abcnews.com/rapidreport/2008/06/two-top-air-for.html.

[25] AFNEWS, "Air Force leaders to discuss new Cyber 'Command," *Air Force Link,* 5 December 2006, http://www.af.mil/news/story.asp?id=123028524, and AFNEWS, "CSAF's Scope cites maintenance, logistics reorganization," *Air Force Link,* 13 December 2007, http://www.af.mil/news/story.asp?id=123110751, General Michael Moseley, Chief of Staff of the Air Force, to "ALMAJCOM/CC, DISTRIBUTION C," memorandum entitled "Reorganization of Wing Maintenance and Logistics," 7 December 2007, and General Michael Moseley, Chief of Staff of the Air Force, to "ALMAJCOM/CC, DISTRIBUTION C, USAFA/CC," memorandum entitled "Wing Reorganization Implementation Planning," 21 February 2008.

[26] Jim Hodges, "Relief for strained pilots," TSJOnline.com, August/December 2008, http://www.tsjonline.com/story.php?F=3607762.

[27] "Bush replaces Rumsfeld to get 'fresh perspective,' *CNN.com,* 9 November 2006, www.cnn.com/2006/POLITICS/11/08/**rumsfeld**/index.html and Michael Hoffman, "Gates Issues Calls for More UAVs, Fresh Thinking," *Defense News,* 21 April 2008, http://www.defensenews.com/story.php?i=3490138.

decision.[28] By the time its leaders were relieved, the Service was scrambling to maintain its existing surge for the long term and build a system to sustain it.[29] Almost immediately, the new CSAF and Secretary of the Air Force stopped the cyber command stand-up and the maintenance reorganization as well as a number of other Moseley programs. In the subsequent months through 2009, the new CSAF, General Schwartz, introduced an experimental non-rated operator system, created a new enlisted sensor-operator career field, and established an environment that sought to normalize outstanding RSO C2 and sustainment issues.[30]

Separate Paths, Common Summary

For both the Army and the Air Force, intervention by the sitting Secretary of Defense reintegrated their UAS programs and organizational structures with the administration's political objectives. Prior to 9/11, Secretary Rumsfeld applied significant pressure on the Army to transform into a leaner organization capable of leveraging technology to mitigate smaller force structures. For this new force, the Army needed significant airborne tactical ISR capability, and UASs fit part of this bill. Lessons from the Iraq and Afghanistan wars perpetuated this belief. As a result, the Army took steps to innovate its unsuccessful UAS acquisition and management policies. Breaking a 40-year tradition of failure, this reorganization facilitated a massive surge in UAS ISR and led to the successful initial steps for its Sky Warrior. In the Air Force's case, the service had developed the novel RSO system internally to enhance the flexibility and

[28] Michael Hoffman, "Gates: No More Cuts to US Air Force Personnel," *DefenseNews,* 9 June 2009, http://www.defensenews.com/story.php?i=3570646.

[29] Bruce Rolfsen and Michael Hoffman, "War strains supply of Predator pilots," *AirForceTimes,* 2 April 2008, http://www.airforcetimes.com/news/2008/04/airforce_uav_pilots_040108w/, General Norton A. Schwartz, Air Force Chief of Staff, "Keeping the Promise" (address, 24th Annual Air & Space Conference and Technology Exposition, Washington, D.C.), 16 September 2008, http://www.af.mil/shared/media/document/AFD-080916-083.pdf, and Karen Walker, "Air Force Firings: The Right Decision," *DefenseNews,* 9 June 2009, http://www.defensenews.com/story.php?i=3570572.

[30] AFNEWS, "SECAF, CSAF stress back to basics," *Air Force Link,* 13 August 2008, http://www.af.mil/news/story.asp?id=123110751, Honorable Michael B. Donley, Acting Secretary of the Air Force, "A Time of Transition" (address, 24th Annual Air & Space Conference and Technology Exposition, Washington, D.C.), 15 September 2008, http://www.af.mil/library/speeches/speech.asp?id=400, Michael Hoffman, "Air apparent: Are enlisted airmen next to pilot UAVs?" *Air Force Times,* 22 December 2008, 14-16 and General Norton A. Schwartz, Air Force Chief of Staff, "Keeping the Promise" (address, 24th Annual Air & Space Conference and Technology Exposition, Washington, D.C.), 16 September 2008, http://www.af.mil/shared/media/document/AFD-080916-083.pdf.

adaptivity of UASs. The powerful CSAF, however, failed to champion the necessary organizational changes and resource reallocations to implement the concept effectively once it had reached a reverse salient that stymied its effectiveness. In this respect, General Moseley's aims of preserving resources for other priorities ran counter to Secretary Gates' desires to surge UASs for overseas insurgencies. Gates ultimately intervened; removed General Moseley for problems with the nuclear fleet and other issues; and installed new leadership that modified the UAS C2 and sustainment systems of Predator and Reaper. While interservice and intraservice organizational factors were at work in each case, civilian intervention was required to re-integrate and innovate the services' military doctrines. Barry Posen's theory on military innovation seems most applicable here.[31]

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[31] Barry R. Posen, *The Sources of Military Doctrine ,* 13, 226-7. Note: "Military doctrine" as used here and by Posen "…deals explicitly with military means. [and answering the questions] *What* means shall be employed? and *How* shall they be employed?" p. 13.

CONCLUSION?

The task of identifying the need for new military functions and capabilities…is
very different than the search for military efficiency. If the future is uncertain, it
pays to be flexible. [1]

        Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military*

      The object of this analysis was to determine which of the respective Army and Air Force's UAS solutions was optimal or at least represented a "better" solution relative to the National Security and Defense Strategies…and why. Multiple contextual factors framed the canvas on which the solutions to this question were painted to include the original intent of the respective services' systems, as well as projected future improvements for each. In this respect, the Army created (or intends to create) a ground-centric UAS whereas the Air Force employed complex, jack-of-all-trade systems intended to satisfy the needs for the joint force commander (JFC) as well as all of the organic and functional components. Of course, the Army system is still under development and has not been fielded in great numbers, whereas the Air Force system already has a substantial record of performance. These and many other variables provided inputs to the calculus that sought to derive a best solution from the foggy, nonlinear combination and interaction of those factors. The analytical method employed attempted to penetrate the fog using the criteria associated with strategic hedging.

      The examination revealed that the Army's Sky Warrior UAS equaled the Air Force's RSO UAS with respect to supporting national strategic hedging requirements. But the results were not necessarily a prediction of future performance. Ironically, the Air Force's RSO concept is potentially more flexible and adaptive than the Army's ground-centric system, but RSO's potential is sometimes overwhelmed by problems in C2 and sustainment systems structured to support manned, not unmanned, aircraft. Similarly, the Army's organic ground-focus for Sky Warrior, while essentially correct,

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[1] Stephen P. Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca, NY: Cornell University Press, 1991), 257…

artificially limits the *potential* capabilities to provide additional means to support national strategy hedges. In neither case are the results static, however. For example, the Air Force's ongoing attempts to restructure its UAS C2 and sustainment systems may enhance its UAS' effectiveness as a hedge significantly. Similarly, the quality of the Army's ongoing Sky Warrior fielding effort will refine the evaluation of how well the UAS supports the ground units, as well as its relative value as an independent, national hedge against uncertainty. Thus, over time, the relative value of the service's UASs as strategic hedges will change. The methodology presented in this analysis provides one means of calculating that value at waypoints in the journey to field both systems.

In determining "why" the systems performed the way they did in the analysis a common primary theme emerged: civilian intervention helped remedy disconnects between political goals and the service's means. In the case of the Army, Secretary Rumsfeld forced the Army to lean out its force structure while leveraging technology to maintain combat effectiveness. The Army responded by correcting long-standing organizational deficiencies and embarking on a successful UAS surge for Iraq and Afghanistan as well as the initiation of the promising Sky Warrior program. Later in the war after Secretary Rumsfeld was removed, Secretary Gates intervened with the Air Force to force it to surge as well as restructure its C2 and sustainment systems to substantially increase non-surge UAS ISR capability. Secretary Gate's dissatisfaction with Air Force leadership on the UAS and other issues eventually led to General Moseley's removal. The new Chief of Staff of the Air Force (CSAF) instituted multiple changes to improve the effectiveness to the Air Force's UAS system, and his efforts were included in the previously discussed hedging analysis.

Recommendations

OSD and JCS. Office of the Secretary of Defense (OSD) and the Joint Chiefs of Staff (JCS) should provide *explicit* guidance to the services on the number of CAPs that they are required to support *and* the manner in which they will be expected to support them. The terms "insatiable" or "nearly unlimited" are typically used to describe the demand for ISR, but the reality of organizing, equipping, training, and employing military forces requires a reasoned, quantitative demand. Although Gates has set a 50-CAP goal by 2010, this guidance is incomplete given the physical characteristics of both

services' systems and capability overlaps. For example, the JCS should determine if the Army Sky Warrior is going to be expected to serve needs beyond ground-centric operations, to what extent, and how often. Similarly, the Air Force needs to know what its expected level of UAS ISR support will be for Army divisions and brigades, even those with Sky Warrior capability, in addition to its global JFC missions by theater. Indeed, both services need to know the global requirement--even if unfunded. In this respect, an unfunded requirement can drive further innovation in systems that, in the early stage of their development, may be moldable to produce more CAPs. Specific requirements for expected flexibility and responsiveness also need to be levied to ensure the services can program adequate C2 and sustainment. Further, OSD should continue efforts to improve interoperability as well as promote both joint acquisition programs and rational manufacturing and logistics processes to meet collective DOD needs. In the end, if OSD provides a clear vision, the services can harness innovation across the spectrum of organizing, training, and equipping its limited resources to meet most strategic requirements.

Air Force. The Air Force's visionary RSO UAS system serves as a cautionary tale on the pitfalls of implementing radical technologies in wartime. Conceived to produce UAS-based ISR support efficiently, "details" such as doctrine, policy, and/or regulations that bind the UAS' C2 and sustainment capabilities and define their interface to the rest of the Air Force need to be refined or, in many cases, created. The Air Force can more effectively harness the system's inherent adaptivity and flexibility with a simultaneous bottom-up and top-down transformation of these details. These efforts should range from joint and service-specific doctrine to basic sustainment metrics for monitoring system performance. The Air Force needs to leverage the experience of the men and women fighting so that future generations have a roadmap on how to fight the next COIN war. Indeed, a robust feedback process should periodically review not only the performance of the unmanned *aircraft* but the performance of the unmanned aircraft *system*. Improvement efforts have been underway, but the common theme expressed by multiple personnel commanding, controlling, and sustaining the system was that the pace of reform was inadequate to meet wartime needs. Paradoxically, even though the war is providing invaluable system-improvement lessons, harvesting this information lags the

need. Thus, the Air Force should systematically design, test, and modify the UAS' C2 and sustainment processes to hedge against an adaptable enemy in advance of the need. Given the CSAF-approved vision to 2047 for Air Force UASs, the need for creating *useful and long-lasting* RSO C2 and sustainment processes and procedures is evident.

Improving a system to some degree will not necessarily entail increased cost, though many perceive that it will. In this respect, in improving the present system, the *perceived* question will be (and has been) whether the Air Force can mitigate the opportunity costs in the combat and mobility air forces associated with expanding support to UASs using the same pool of resources. This study demonstrates inefficiencies in the Air Force's C2 and sustainment systems that have nothing to do with making a resource decision at the expense of either the combat or mobility air forces. Reducing the effects of friction by providing guidance to the field and clearly outlining command responsibilities, for example, while a difficult staffing challenge, may be no more expensive than altering a regulation. The resulting efficiencies at the local level improve system performance and ensure the system is ready as a hedge. Such improvements are not a panacea, however. The lack of aircrew for cockpits in an Air Force constrained by congressionally-established force levels limits its ability to produce the desired product. Nevertheless, serious evaluation of alternatives such as the ongoing test of non-rated UAS pilots may provide at least partial solutions to seemingly intractable problems. Willingness to consider these solutions in a systematic attempt to improve customer service perhaps characterizes the difference between the current Secretary of the Air Force and CSAF as opposed to previous ones.

Army. The Army's UAS system suffers not from doubts about its future success in supporting its primary mission but from its self-limiting potential to do more. The Army is developing robust UAS with C2 and sustainment systems with potential to be very responsive to its ground elements. In the DOD-approved program, the Army will field UAV companies to support C/JFLCC campaign objectives. The Army's internal measure of merit for effectiveness of this system will be the UAS's ability to support the combined-arms units of the brigade combat team (or other Army unit) when performing the functions in table 2. Whether the Army's UAS companies should be limited to just these ground-centric missions is a debate that will no doubt rage as long as there are

additional external requirements for airborne ISR. With the high degree of interoperability planned by the Army for the Sky Warrior, expanding its role to support of some non-ground centric UAS missions is very feasible. While ad hoc support of such taskings is possible, even rudimentary construction of doctrine, regulations, and sustainment structures to facilitate support of these missions would conceptually improve the depth of the nation's hedge against future conflicts. Refining joint processes to facilitate Sky Warrior support of the C/JFACC in much the same way Marine air assets do today would further facilitate this mission expansion. These joint processes should address any peculiarities associated with Sky Warrior C2 within a theater to include airspace control--over the immediate battlefield and beyond--as well as explicitly define how (or when) the UASs are included on the daily air tasking order. The current Army-Air Force Warfighter talks may yield substantial progress in all of these areas.

Future Analysis. This evaluation does not address a key area: analysis of the reconnaissance and surveillance (RS) data and images to produce intelligence. Rather, the focus was on so-called "target servicing," which entails having a UAS overhead of the area of interest in the reconnaissance/surveillance role gathering information. The analysis of the data to produce intelligence then takes place immediately by the user, or through other so-called reach-back channels, on the battlefield or in the US. The ultimate customer service of the system, therefore, is not simply having a UAS overhead, but rather a measure of the quantity, quality, and timeliness of the intelligence delivered to the user, on the battlefield or elsewhere. If information delivery takes place immediately via a communication link and little analysis is needed, simply ensuring the system is available and operational meets the requirement. The complicating mechanism, however, is when the images require extensive analysis. The overarching effectiveness of both services' UASs, therefore, depends on the capacity of the system's C2 and sustainment to provide the UAS *and* intelligence analysis. Expanding the UAS' network to include the C2 and sustainment of these organizations and processes will greatly enhance the utility of a system analysis.

Better quantitative modeling could also enhance this analysis. The Air Force Institute of Technology, at the behest of a field unit, already executed a quantitative evaluation of the capability of the launch/recovery sortie-generation capability of the

Predator.[2] Simulations that are substantially more refined and models of all the Air Force and Army's UAS C2 and sustainment systems could naturally feed into an analysis of the strategic merit of the systems. In the end, the judgment of strategic merit for a UAS will be a qualitative assessment, but the problem should be bounded by quantitative analysis.

Closing Remarks

Fielding an advanced weapon system is a difficult undertaking under any circumstance; doing it during a war in response to unplanned needs while planning for the next war exacerbates the task. Both the Army and Air Force reacted to wars they did not plan for with complementary, and in some ways, competing solutions to provide more UAS ISR for theater and battlefield customers. In the face of the Air Force's understandable inability to satisfy nearly unlimited demands, the Army's decision to develop its own organic, division-level UAS was a pragmatic move to provide some dedicated support to its ground-centric mission. On the other hand, the Air Force translated an adaptive, flexible concept into a complex, but capable solution. Harnessing the RSO construct was, for some time, a bridge too far for the Air Force's leadership and processes, which were tied to manned aircraft. In perceiving the question as a zero-sum game with dire consequences to existing force structure, key Air Force leaders, while correct in their concern, missed the point. They did not understand that internal solutions might be possible with existing resources and that refining the immature RSO system offered additional options to increasing system performance. With the installation of a new CSAF and SECAF, the Air Force's UAS challenges are at least under evaluation and, in some cases, well on their way to a joint solution. Ensuring that Army UASs can function as a hedge to future uncertainty, even in non-ground-centric roles, is a task that both services should take on for the greater, national good.

With this new spirit of joint cooperation, the question remains as to whether the spirit of innovation in both programs will continue. According to Owen Reid Cote, interservice competition over budgets or other issues is a powerful source of doctrinal

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[2] See the following thesis for more information: Technical Sergeant Michael P. Kretser, "Modeling Predator MQ-1 Logistics" (master's thesis, Air Force Institute of Technology, March 2008).

innovation, and its absence is a corresponding source of stagnation.[3] The source of Air Force and Army competition has often been either limited budgets or--as in the existing Predator/Reaper versus Sky Warrior debate--disagreements over roles and missions.[4] With respect to the FY10 budget, Secretary Gates' war-inspired focus on UASs has stimulated both the Army and Air Force to continue to expand their fleets to meet his 2011 goal of 50-CAPs in addition to ground-centric ISR requirements.[5] In this respect, although other larger defense programs are being cut, UASs remain well-funded for both services. Ultimately, however, the Air Force may have to significantly decrease conventional force structure to man UASs without increased automation. This could provoke conflict as the Air Force seeks to maintain a force capable of taking on future powers such as China. Further, even in the absence of budget cuts, the Army's OSD-approved "intrusion" into medium battlefield altitudes up to 25,000 feet as well as large-scale use of equivalent UASs seems like a recipe for future conflict. Combined with Gates' penchant for removing intransigent service (Army and Air Force) senior leadership, the probable budget and missions debates seem to provide ample motivation for both services to at least maintain their pace of UAS innovation. Whether Gates and his successor can harness the budgetary and roles/missions conflicts as catalysts for innovation remains to be seen. [6]

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[3] Owen Reid Cote, "The Politics of Innovative Military Doctrine: The US Navy and Fleet Ballistic Missiles" (PhD. Diss., Massachusetts Institute of Technology, 1996), 389-90. 393.
[4] Conrad C. Crane, *American Airpower Strategy in Korea 1950-3,* (Lawrence, KS: University Press of Kansas, 2000), 60-2, Richard G. Davis, *The 31 Initiatives: A Study in Air Force-Army Cooperation,* Air Staff Historical Study(Washington DC: Office of Air Force History, 1987), 2-3, 5, 77-9, and Ian Harwood, *Interservice Rivalry and Airpower in the Vietnam War*, 102-15.
[5] "Gates Lays Out Key FY 2010 Budget Recommendations," *Defense Industry Daily,* 6 April 2009, http://www.defenseindustrydaily.com/Gates-Lays-Out-Key-FY-2010-Budget-Recommendationsand William Matthews, "$83.4B for 2009: The Last Supplemental?" *DefenseNews,* 10 April 2009, http://www.defensenews.com/story.php?i=4034386&c=AME&s=TOP.
[6] Owen Reid Cote, "The Politics of Innovative Military Doctrine: The US Navy and Fleet Ballistic Missiles" (PhD. Diss., Massachusetts Institute of Technology, 1996), 389-90. 393.

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APPENDIX A

Unmanned Aerial Vehicles Performance Characteristics

Figure A1. MQ-1C Sky Warrior Performance Characteristics

Characteristics:

MQ-1C			
Length	28 ft	Wing Span	56 ft
Gross Weight	3200 lb	Payload Capacity	800 lb/500 lb external
Fuel Capacity	600 lb	Fuel Type	JP-8
Engine Make	Thielert diesel	Power	135 hp
Data Link(s)	BLOS	Frequency	Ku-band
	LOS		C-band (TCDL)

Performance:

Endurance	40 hr w/250 lb payload	Maximum/Loiter Speeds	130/60 kt
Ceiling	25,000 ft	Radius	162 nm/648 nm w/SATCOM
Takeoff Means	Runway	Landing Means	Runway
Sensor	EO/IR/laser rangefinder/ laser designator	Sensor Make	TBD
	SAR/MTI		TBD

Source: Reprinted from Department of Defense, *UAS Roadmap 2007-2032,* (Washington DC: Office of the Secretary of Defense, 10 December 2007), 66.

Figure A2. MQ-1B Predator Performance Characteristics

Characteristics:

MQ-1 B			
Length	27 ft	Wing Span	55 ft
Gross Weight	2250 lb	Payload Capacity	450 lb
Fuel Capacity	640 lb	Fuel Type	AVGAS
Engine Make	Rotax 914F	Power	115 hp
Data Link(s)	BLOS	Frequency	Ku-band
	LOS		C-band

Performance:

Endurance	24+ hr clean 16 hr w/external stores	Maximum/Loiter Speeds	118/70 kt
Ceiling	25,000 ft	Radius	500 nm
Takeoff Means	Runway	Landing Means	Runway
Sensor(s)	EO/IR	Sensor Model(s)	AN/AAS-52
	SAR		AN/ZPQ-1
Weapons	2xAGM-114		

Source: Reprinted from Department of Defense, *UAS Roadmap 2007-2032,* (Washington DC: Office of the Secretary of Defense, 10 December 2007), 65.

Figure A3. MQ-9A Reaper Performance Characteristics

Characteristics:

MQ-9A			
Length	36 ft	Wing Span	66 ft
Gross Weight	10,500 lb	Payload Capacity	*3750 lb
Fuel Capacity	4000 lb	Fuel Type	JP
Engine Make	Honeywell TPE 331-10Y	Power	900 SHP
Data Link(s)	BLOS	Frequency	Ku-band
	LOS		C-band

* Up to 3000 lb total externally on wing hard points, 750 lb internal.

Performance:

Endurance	24 hr/clean 4–20 hr/external stores	Maximum/Loiter Speeds	230/120 kt
Ceiling	50,000 ft	Radius	1655 nm
Takeoff Means	Runway	Landing Means	Runway
Sensor(s)	EO/IR/ laser rangefinder/ laser designator	Sensor Model(s)	MTS-B
	SAR/MTI		AN/DAS-1
Weapons	4×500 lb class or 10×250 lb class		

Source: Reprinted from Department of Defense, *UAS Roadmap 2007-2032,* (Washington DC: Office of the Secretary of Defense 10 December 2007), 73.