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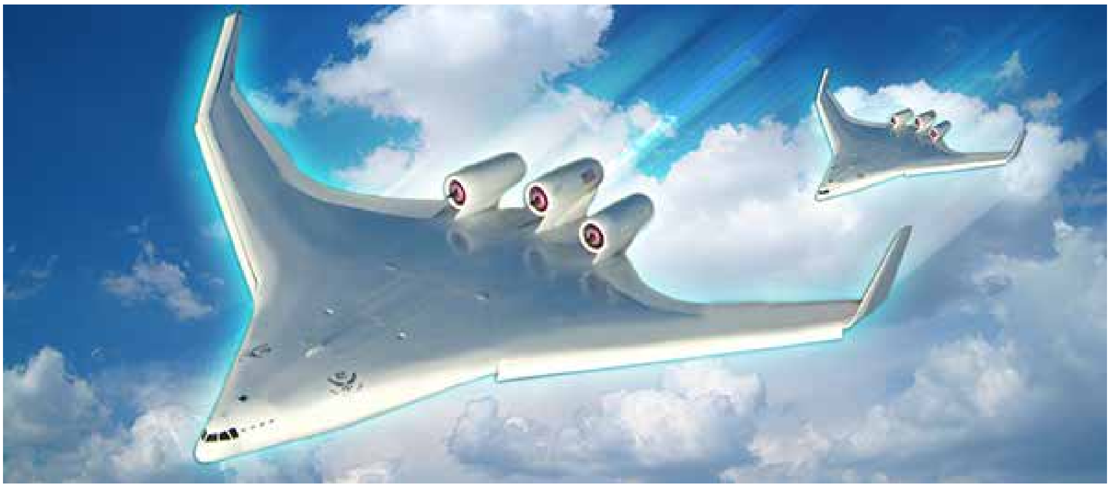
A Range-Balanced Force

An Alternate Force Structure Adapted to New Defense Priorities

Lt Col Peter Garretson, USAF



This article argues that external forces will drive the US Air Force to procure a very different force structure than the one currently postulated for the early 2030s. Specifically, the service will eventually settle on a structure for its combat air forces (CAF) dominated by longer-range strike platforms capable of remotely piloted operations—a "range-balanced force." The first section of the article describes the future environment and challenges that will shape the force structure. The second presents a range-balanced force better configured to meet these issues. The final section discusses how the Air Force might transition to the new force structure.

Many people believe that they can fairly well estimate the service's structure for the 2030s by looking at today's program force-extended. Although most expect some trimming of the overall numbers due to austere times, few think that the force structure will deviate markedly from a fleet dominated by manned, short-range fighters in general and the F-35 specifically, with well below 10 percent of the total fleet composed of bombers. According to this analysis, that future is very unlikely.

A convergence of significant forces will drive the Air Force to a different force structure, one similar to a range-balanced force outlined below. This argument is not prescriptive; rather, it proposes an alignment of forces that will take the service down a different acquisitions path. Beyond buying more long-range-strike bombers (LRS-B), these forces will likely feature two aircraft types not currently contemplated in Air Force budgets—a medium-range unmanned combat aerial vehicle (UCAV) and a long-range, optionally manned, general-purpose, blended-wing body (BWB) with a bomber variant. Should this be the shape of things to come, Airmen should embrace it now.

The Strategic Environment and Converging Forces of Change

A number of important factors will conspire to ensure that the Air Force's force structure of the future emphasizes long-range strike and autonomous capability in spite of internal resistance.[1] These include the following: a change in strategic guidance emphasizing antiaccess/area-denial threats and a rebalance toward the Asia-Pacific; the requirement to project power across the Asia-Pacific's vast distances; the public expectation of increased use of autonomous technology and the rise of a community of remotely piloted operators in the Air Force; the criticality of maintaining America's competitive advantage in its high-tech / air and space industrial base in the face of rising international competition; the Air Force's need to maintain value in the national security establishment to both cooperate and compete with the other services by maintaining its ability to control and exploit the air and space domains; and the Air Force's natural bureaucratic desire as an organization to protect its identity as a separate service and its freedom of action.

As a military service subordinate to civilian leadership and its direction, the Air Force sees the change in strategic guidance articulated in *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* as one of the most compelling forces acting upon it to revise its acquisition strategy. According to the new guidance, "*The U.S. military will invest as required to ensure its ability to operate effectively in anti-access and area denial . . . environments*. This will include implementing the Joint Operational Access Concept, . . . developing a new stealth bomber, [and] improving missile defenses. . . . While the U.S. military will continue to contribute to security globally, *we will of necessity rebalance toward the Asia-Pacific region*" (emphases in original).[2] As illustrated in figure 1, these expanding environments feature significant ballistic and cruise missile threats that put at risk close-in bases, carriers, tankers, and other high-value assets which underpin our fighter-heavy strike forces. In such environments, the Air Force must supply a "halt-hold" force at the highest end of the spectrum of warfare in theaters characterized by few air bases—all under missile threat.

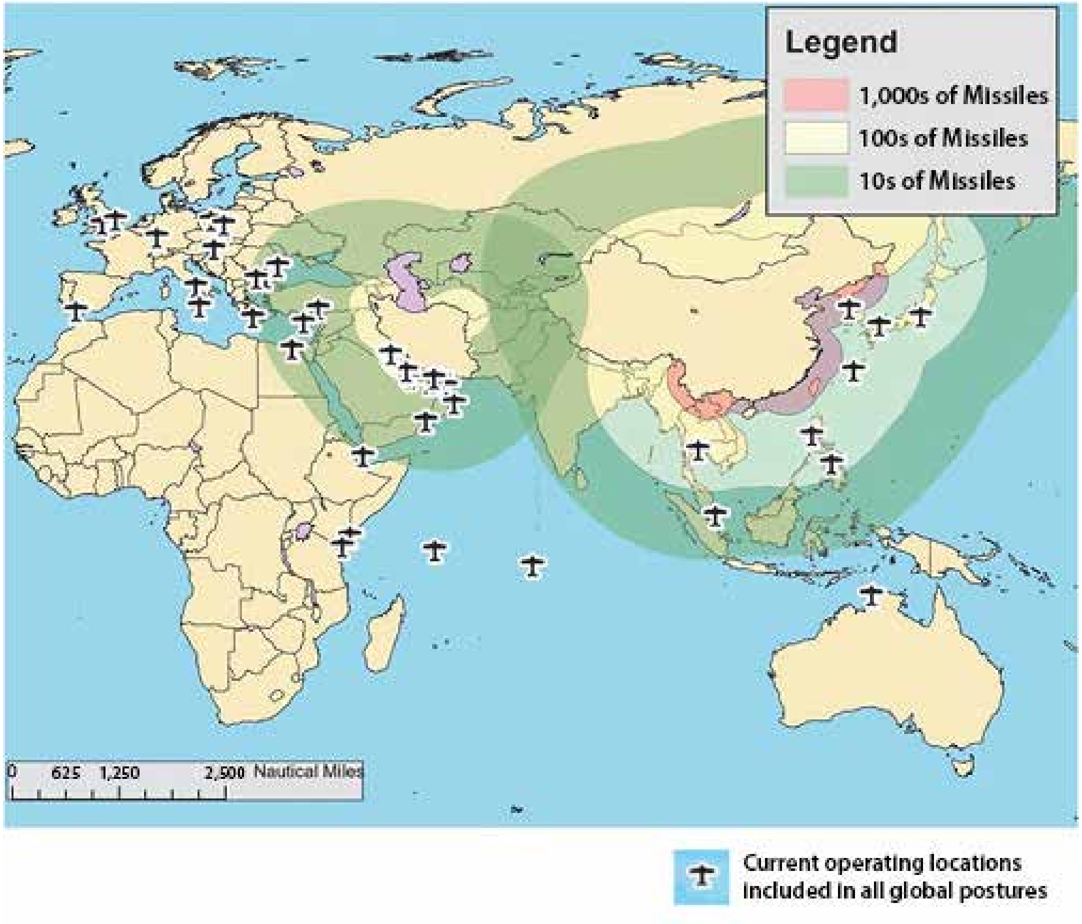


Figure 1. Iranian and Chinese missile threat, 2011. (From Lynn E. Davis et al., *U.S. Overseas Military Presence: What Are the Strategic Choices?* [Santa Monica, CA: RAND, 2012], fig. 3.1, p. 21, http://www.rand.org/content/dam/rand/pubs/monographs/2012/RAND_MG1211.pdf. Reprinted with permission.)

To remain relevant, the service will need a force structure that gives the United States a definite asymmetric advantage—the ability to function from long range. Individuals who make resourcing decisions will likely see the programmed structure—characterized by some 1,700 F-35s with a combat radius of barely 600 nautical miles (nm) unrefueled and only 100 LRS-Bs (despite their much greater range and payload)—as mismatched to the operational problems.[3]

The dangers articulated in the new defense strategic guidance are not considered principally land threats calling for a large, mobilized army. Further, the United States' airpower and industrial base can supply the necessary speed of response and overmatch to deter threats; threaten escalation; and flexibly engage, disengage, and impose costs. Consequently, the Air Force is in a strong position to argue for resources in preference to the other services. Under these conditions, resources would exist for new systems considered important, but we cannot expect the Department of Defense's (DOD) total "top line" to trend upward in our favor.[4] As occurred in the 1950s, the increase in the Air Force's top line will have to come from internal savings and funds taken from the other services, particularly the active component of the Army.

Pressure to move toward remotely piloted / autonomous systems constitutes another notable force acting on the Air Force. On 21 September 2012, the deputy secretary of defense signed DOD Directive 3000.09, *Autonomy in Weapons Systems*, the result of an 18-month effort across the Office of the Secretary of Defense (OSD) and the services to create a responsible but enabling policy for acquisition and use of weapons systems "that, once activated, can select and engage targets without further intervention by a human operator."[5] Evidently, many members of the external policy community and public at large have "seen the future" and expect the Air Force to move with greater speed toward more remotely piloted / autonomous platforms.[6] Not everyone agrees, of course. Reports such as Human Rights Watch's *Losing Humanity: The Case against Killer Robots* highlight broader societal concerns that the tremendous speed of progress, proliferation, and employment of increasingly capable remotely piloted / autonomous systems might compromise our highest values: morality and responsibility in war.[7] But the report itself is evidence of society's expectation that future conflict will feature "drone warfare." Regardless of whether or not these beliefs are accurate now or in the future, a strong force of public sentiment and popular culture will likely create space for remotely piloted / autonomous alternatives not currently in the Air Force's inventory.

Nor is the pressure entirely domestic. As noted by Peter Singer, author of *Wired for War*, "This robotics revolution is not just an American revolution."[8] Moreover, the Government Accountability Office reported that "since 2005, the number of countries that acquired an unmanned aerial vehicle . . . system nearly doubled from about 40 to more than 75. In addition, countries of proliferation concern developed and fielded increasingly more sophisticated systems."[9]

This external pressure will only strengthen as defense analysts watch non–Air Force parties such as the Navy N-UCAS and the French Dassault nEURon UCAV, scheduled to fly in 2012, doing what they think America's cutting-edge Air Force is "supposed to do." That pressure includes the OSD. Many people believe that the Air Force is dragging its feet and that remotely piloted / autonomous platforms offer the nation the advantages of usability, lowered risk, and lowered cost. "It's been like pulling teeth," said former secretary of defense Robert Gates in April 2008.[10] One can see the OSD's strong support for remotely piloted / autonomous systems in the secretary's statement during the roll-out of the new defense strategic guidance: "Lastly, as we reduce the overall defense budget, we will protect, and in some cases increase, our investments in . . . new technologies like ISR [intelligence, surveillance, and reconnaissance] and unmanned systems."[11] The OSD matched its rhetoric by releasing its new directive on autonomy, creating an initiative, and finding resources to accelerate the Navy's Unmanned Carrier Launched Airborne Surveillance and Strike development program.[12]

Pressure will also come from inside. For the first time, the Air Force is buying more RPAs—the Air Force's current term and method of operating remotely piloted / autonomous aerial systems—than fighters and training more RPA operators than fighter pilots.[13] These operators now constitute a significant community comfortable with the technology and its employment—a community that will seek a voice in policy and procurement. Given the conclusion of US combat operations in Iraq and the anticipated withdrawal from Afghanistan in 2014, the RPA community will naturally wish to adapt its technology and identity to high-end conflict. If not present already, a "critical mass" of RPA operators of ever-increasing rank will soon emerge within the Air Force, able to advocate internally for more investment in remotely piloted systems across the full spectrum of warfare.

The clear appreciation that our nation faces substantial challenges to its industrial competitiveness represents another critical external driver. The defense strategic guidance notes that the "Department will make every effort to maintain an adequate industrial base and our investment in science and technology."[14] The natural question for the military becomes, With regard to my national industrial base (and jobs and dual-use technology), what have you done for me lately? Aviation has been our best export industry and source of domestic innovation.[15] Its vibrancy and ability to produce the best systems worldwide underpin our military advantage and control of the air domain. But our industry confronts ever-stronger competition abroad, and our military acquisition's choices and timing of those choices will materially contribute to or detract from our nation's overall and long-term competitiveness across the entire aviation sector, as well as its ability to sustain our military advantage over the long term. Each service will have to demonstrate how investment in its deterrent posture improves the US position in the larger international market space and sustains the US economy by creating jobs at home. The latter is critical not only to maintaining our national aviation industrial-technical base but also to preserving congressional appropriations and support for Air Force modernization. A viable strategy links that modernization with US commercial industrial growth so that modernization enables and supports US competitiveness rather than detracts from it.

Threats to and solutions proposed by the Navy will also affect the Air Force's acquisitions. Carriers' vulnerability to the Chinese DF-21 missile highlights the Air Force's own vulnerability of short-range tactical air assets (stationed in the same theater) to similar threats. A decision by the Navy to purchase a long-legged, stealthy UCAV will certainly cause policy analysts, budget-waste cutters, and Congress to ask why the Air Force isn't buying the same platform.

The Air Force will also have to protect itself as an independent service. It cannot make these claims on the basis of tactical air-to-ground missions—only on its distinctive functions of long-range bombing and air superiority. Competence in tactical air-to-ground exists solidly in the Navy and Marine Corps and is proliferating via RPAs to the Army.

Long- and short-range aircraft are vulnerable to modern, highly capable surface-to-air missiles as well as enemy fighters and their supporting integrated air defense systems. The Air Force has attempted to mitigate this threat by modernizing to a fleet of fifth-generation fighters more survivable in this environment. Unfortunately, these highly capable fighters are critically dependent upon a system-of-systems that features a pair of Achilles' heels not easily remedied—tankers, which must be relatively close to the fight, and close-in air bases. Adversaries increasingly pursue "high value aircraft attack" capabilities and tactics to cripple our tankers and ISR. They can afford large numbers of ballistic and cruise missile systems to strike air bases and aircraft on the ground.

If one accepts supporting tankers and bases as the most vulnerable aspect of the manned-fighter system-of-systems, then a strategy of power projection based on an overcommitment to short-range manned fighters begins to appear less desirable. In general, a force structure overwhelmingly weighted toward a dual-role fighter-bomber is less adapted to the new defense priorities and likely inadequate. It imposes costs, risks, and issues because it forces the United States to operate from, build up, and defend bases inside the threat ring. Such a force structure comes with a substantial tanker bill, further elevating operational risk due to tanker vulnerability as high-payoff targets.

In an environment with the principal theater of concern characterized by significant distances, a greater mix of longer-range aircraft less vulnerable to these Achilles' heels will probably seem more credible and usable than a force structure dominated by a short-range fighter-bomber with short legs, small payload, and inferior performance as an air superiority fighter, compared to the F-22. However, this analysis is not hostile to manned multirole fighters. Like the intercontinental ballistic missile leg of the triad, manned fighters and their close-in bases throw an adversary on the horns of a dilemma. That is, if he does not plan to eliminate them, then they remain available for use; if he plans to eliminate them, then defeating them entails considerable cost (they become more costly if bases feature hardened shelters that drive an adversary to use unitary warheads). Also, in all scenarios short of high-end war, manned fighters offer a flexible option to posture and signal resolve. Foreign sales provide independent, strategic opportunities for partnership building and its benefits.

Nevertheless, one can realize the above-mentioned costs to an adversary and the aforementioned strategic partnership and signaling benefits with a lower proportion of short-range assets. The remaining assets will likely enjoy greater survivability with a larger, highly credible long-range-strike force that makes preemptive attack upon close-in fighter bases appear futile and unattractive. All of these points will conspire to ensure that the future force structure of the Air Force puts more emphasis on long-range strike and remotely piloted capability. But what might this future force look like?

Basics of the Convergent Force Structure

Currently, the projected composition of the CAF is approximately 2,300 total aircraft, overwhelmingly dominated by F-35s (a total buy of 1,763), with less than one-tenth (currently projected as 6 percent) long range and less than one-fifth capable of remotely piloted / autonomous operation (fig. 2).[16] Planned RPA acquisitions are nonstealthy and unsurvivable in a nonpermissive or contested environment.

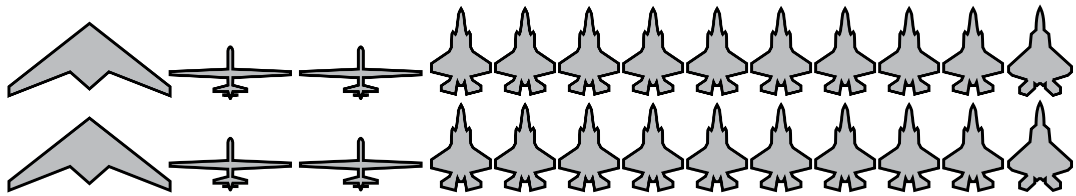


Figure 2. Rough approximation of basic elements of the program force-extended

A range-balanced force would seek to more evenly distribute the Air Force's investment among long-range (greater than 6,000 nm), medium-range (about 2,000 nm), and short-range (about 600 nm) aircraft (fig. 3). As a starting point, this analysis proposes a future force structure evenly distributed among one-third bombers, one-third medium-range UCAVs and one-third manned fighters, two-thirds of them capable of remotely piloted / autonomous operations. Figure 4 offers a visual representation of the approximate percentages of what such a force structure would look like, compared to the currently projected force in figure 2.

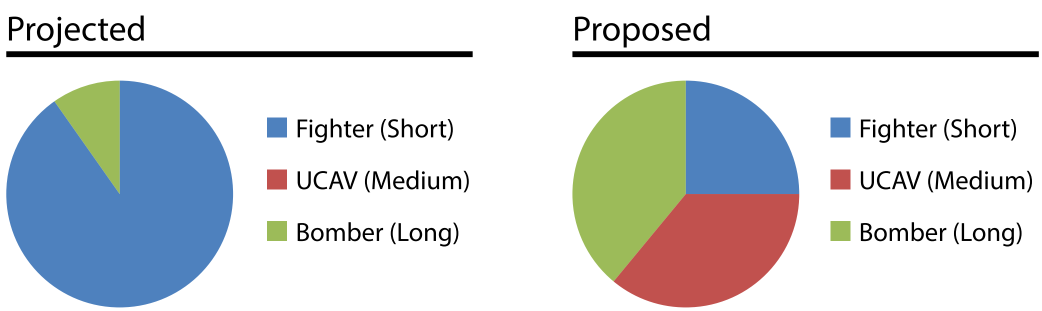


Figure 3. Ratios of range distribution

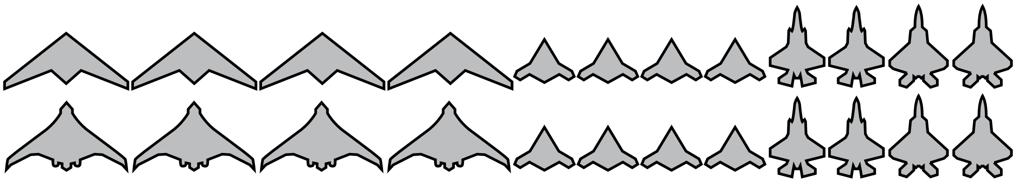


Figure 4. Proposed range-balanced force structure

This proposal involves a substantial reapportionment, creating a significantly more balanced force in terms of range. The change is quite dramatic: whereas the average unrefueled combat radius of the projected force is on the order of 814 nm, the range-balanced force boasts an average unrefueled combat radius closer to 2,208 nm.

The change in balance of manned versus remotely piloted/autonomous-capable systems is also noteworthy (fig. 5). The dominant feature of this new force is the "swing force" of a large number of medium-range (2,100 nm) UCAVs—probably X-47B descendants (fig. 6). An additional one-third of range-balanced forces consisting of optionally piloted long-range bombers would make fully two-thirds of the total CAF capable of remotely piloted / autonomous operations.

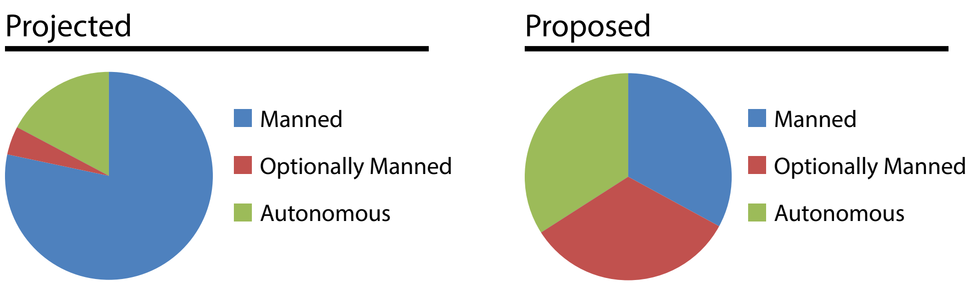


Figure 5. Manned versus remotely piloted / autonomous ratios

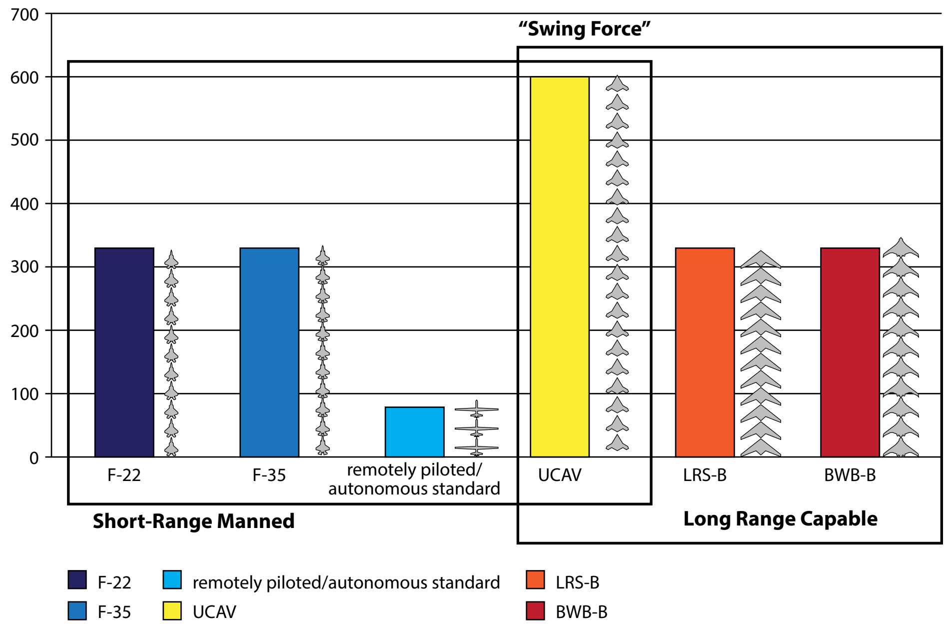


Figure 6. Range-balanced force structure at a glance

Longer-range aircraft are heavier and typically more expensive than other platforms. Assuming a relatively fixed Air Force acquisition budget or top line, an increase in the number of larger aircraft requires a slightly smaller total number of platforms procured. In this model, the CAF converges on 2,000 aircraft for its basic fleet (see fig. 6), with a composition in round numbers as follows:

- 330 F-22 Raptors
- 330 F-35s[17]
- 600 UCAVs (X-47B variant)
- 80 nonstealthy Reaper follow-ons
- 330 LRS-Bs
- 330 blended-wing-body bombers (BWB-B)

The exact numbers and proportions are not fixed, and within the basic structure of one-third long-range, one-third medium-range, and one-third short-range/manned aircraft, one has room to innovate and explore other options. However the beauty of simple numbers lies in their ability to communicate clearly to external audiences, and the appeal of a balanced force like the one described above is its flexibility to adjust and respond to the environment as necessary.

Transition to the New Force Structure

Acquisition

Acquiring these platforms in 2020 and completing the transition to the convergent force by 2035 would essentially mean a national commitment of approximately $32 billion in annual acquisition of approximately 133 aircraft per year (44.4 fighters, 44.4 UCAVs, and 44.4 bombers).[18] This number is less than the most recent peak of 180 aircraft in 2008 and substantially above the current annual buy of only 59 in 2011. An annual procurement budget of $32 billion for the CAF seems reasonable and within historical precedents in light of the fact that the DOD's total aircraft procurement budget is now about $40 billion (including the CAF, mobility air force [MAF], and sister services), coming close to $70 billion in the mid-1980s (constant 2012 dollars).[19]

Is a 2,000-Aircraft CAF Sufficient?

One can make a basic argument for sufficiency based upon commonsense criteria and commonsense risk. The defense strategic guidance of 2012 observes that the force structure should prove sufficient to deter and prevail in one conflict and deny objectives or impose unacceptable losses in a second region.[20] Our starting assumption holds that our nation will be principally interested in a force that provides credible deterrence with minimum cost and the smallest deviation from existing budgets. Barring a crisis, the nation will operate on momentum, assuming that since we are not in a major war, its overall investment must be more or less right as long as procurement matches the stated priorities and objectives. America will easily see that a range-balanced force will involve lower risk than one dependent for 90 percent of its combat power on a single short-range platform whose greatest vulnerability resides in the tankers, bases, and petroleum, oils, and lubricants facilities within the threat ring.

Since voters and many politicians will never have access to the complex models used by AF/A9 and OSD/CAPE, a number of them will make their evaluation based on open-source media and observable criteria.[21] The most obvious visible criterion involves examining the number of aircraft in our CAF, comparing it to that of potential challengers in each region, and making sure it is larger by some factor.

In this case, the Chinese People's Liberation Army Air Force is moving toward 1,700 combat aircraft in the 2020s with an expected composition of 500 Su-27s/30s, 500 F-10s, 300 F-7s/F-8s, 100 FC-1s/JC-17s, 250–300 ground-attack/long-range-strike platforms, and small numbers of its fifth-generation J-20.[22] Today, open-source documents estimate that Russia has approximately 1,800 combat aircraft (11 Su-35s, 16 Su-34s, 188 Mi-31s, 15 Su-30s, 226 Mi-29s, 281 Su-27s, 241 Su-25s, 639 Su-24s, 16 Tu-160s, 63 Tu-95s, and 117 Tu-22Ms).[23]

A range-balanced force of 2,000 aircraft (not counting the contribution of US allies) is appreciably more modern and at least 200 platforms larger than either the Russian or Chinese air force although smaller than both combined. Some individuals might consider this number inadequate since, as a global actor, the United States could face simultaneous contingency operations in more than one theater. The proposed force, however, is not obviously inadequate based on the simplest notion of mass of forces and certainly entails lower risk than the currently projected force, given its vulnerabilities and limitations. A range-balanced force gives policy makers the flexibility to determine if these numbers are sufficient, and five open weapons-systems production lines allow easy adjustment for increased production.

Affordability

Is such a radically different force affordable? A reasonable estimate suggests that it is. Assuming that aircraft cost scales with weight, a rough-order approximation derived by interpolating data suggests that the proposed force structure of 2,000 aircraft, composed of more platforms of larger size, admittedly increases costs by 15 percent over the projected force structure.[24] The major trade involves deep cuts to the overall number of F-35s to purchase a high number of UCAVs (approximately half the weight of the F-35) and fewer bombers of larger size.

Such a force would have significantly lower life-cycle costs—an unverifiable but certainly a plausible notion. Historically, the process of research, development, test, and evaluation (RDT&E) averages only 6 percent of such costs, and procurement only 28 percent. Operations and sustainment account for 66 percent of total life-cycle expenses for fixed-wing assets. The three largest categories include personnel (30 percent), fuel (17 percent), and base-level parts consumption (14 percent).[25] Since the range-balanced force appreciably increases the proportion of remotely piloted and optionally manned aircraft, some substantial portion of flying hours for currency training might be progressively reduced. As confidence in automation increases and specialization of the operators permits, the Air Force could move from an hours-based to a cycles-based maintenance construct and perhaps a lesser number of total pilots or pilots in the active component.

Depending upon the overall level of cuts, such a force structure might prove affordable within existing budget shares with internal trades. However, if the OSD and national security staff considered other Air Force programs vital and were unwilling to cut or reduce, trade-offs within the DOD as a whole might be more palatable. Assuming that this force structure better matches the strategic design of the president and secretary of defense, where might they realistically choose to make cuts or shift resources? Since the Navy and Marine Corps face the same issues, one could imagine a climate in which both the B and C variants of the Joint Strike Fighter were cancelled and re-placed on a one-for-one basis with an X-47B-variant UCAV. Since cost scales with weight and the X-47B is almost exactly half the weight of the F-35, such a move would likely provide considerable savings and improve the Navy's relevance at strategic ranges while supplying more persistent air support for the Marine Corps.[26] However, the most obvious adjustment would involve reallocating shares of the defense budget between the Army and the Air Force.

Figure 7 illustrates how the services' shares of the budget (total obligation authority [TOA]) have shifted over time, giving a historical perspective to bound the likely possibilities. Notice that, almost as a rule, the Air Force's and Army's shares move in opposite directions—when one increases, normally the other decreases. At present, because of two decade-long occupations, the Army commands the largest budgetary share (35 percent), far above its average of about 25 percent and all-time low of 23 percent. Today, the Air Force finds itself at an all-time low (23 percent) compared to its average of about 30 percent. Actually, 23 percent overstates Air Force resourcing. A significant portion of the service's budget passes through for intelligence functions such as the National Reconnaissance Office, over which the Air Force has no control. "Air Force Blue TOA"—the budget over which the service has control—is actually only 18 percent of DOD TOA. When the Air Force was ascendant in the strategic design of the national security strategy, it commanded better than 30 percent (as high as 35 percent) in the 1980s and above 40 percent (as high as 47 percent) in the 1950s and 60s. One can imagine a natural inversion of budget shares, whereby 12 percent of the defense budget shares were transferred from the Army to the Air Force. Twelve percent is likely the upper limit of cuts to the Army in TOA share—a reasonable number, given both precedent and strategic design. The president and secretary of defense explicitly state that "U.S. forces will no longer be sized to conduct large-scale, prolonged stability operations."[27]

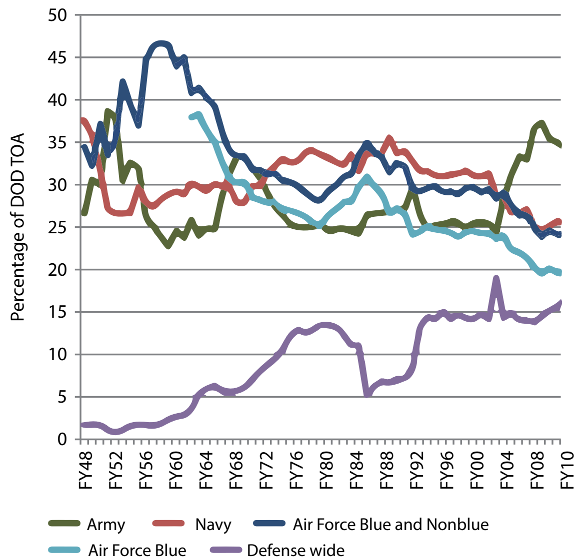


Figure 7. Service shares by total obligation authority. (From Briefing, Headquarters US Air Force Directorate of Strategic Plans and Programs, Washington, DC, derived from Office of the Under Secretary of Defense [Comptroller], *National Defense Budget Estimates for FY 2013* [Green Book] [Washington, DC: Office of the Under Secretary of Defense (Comptroller), March 2012]; Air Force Blue TOA: ABIDES 13PB and PFY files.)

Policy makers and DOD leadership might then decide to shift such a strategic capability to the Guard and Reserve. If the future security environment places a premium on mobility, then the same could be done with armor. The absolutely lowest limit for the active duty Army (excluding our commitments in Korea) might be an active force of 70,000 air-deployable light infantry—small teams similar to special operations forces and highly reliant on fires, mobility, command and control, and resupply from the air. Strategic planning would assume that such a force would not be expected to hold and occupy territory but to employ where friendly ground forces are present.

Advantages of the Convergent Force

A force so composed would have notable advantages over our current one. First, it represents a successful adaptation to concerns about the

Western Pacific / South China Sea, the Middle East / Arabian Gulf, and the vaster distances of the Indo-Pacific. Second, the substantial swing force of UCAVs allows operation in both penetrating air-to-ground strike and manned-autonomous teaming for air superiority, where it can serve as an off-board sensor and missile-carrying platform ("missile truck") for cooperative engagement. Such a concept of operations can rely on hard-to-jam line-of-sight low probability of intercept / low probability of detection data links and passive sensors rather than satellite communications. This ability of an autonomous system to serve as a "loyal wingman"—to operate seamlessly as part of a manned formation or strike package—provides a significant force multiplier for the manned fleet (fig. 8).[28]

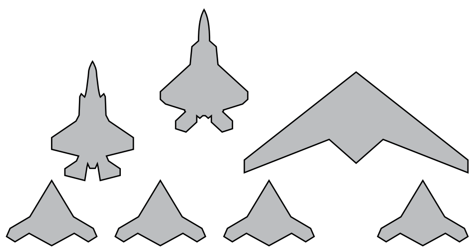


Figure 8. Manned–remotely piloted teaming or "loyal wingman"

Common purchase of the RPA platform by the Air Force and Navy would present new en route carrier-based staging concepts, reducing the complexity of setting up an air bridge in theaters dominated by water. The fact that a carrier-capable RPA requires sturdier landing gear would modestly degrade the ultimate range/payload, but the enhanced flexibility and other efficiencies in training and maintenance costs would make such an accommodation worthwhile. The probable high costs of RDT&E might also put the Air Force in a favorable position to influence the Navy's procurement decision, ensuring a better platform for the nation.

Third, inclusion of a less stealthy (but potentially quite survivable) BWB-B will measurably advance American aviation, probably allowing it to dominate commercial platforms for several decades. The BWB-B could piggyback on the National Aeronautics and Space Administration's (NASA) environmentally responsible aircraft (ERA) (fig. 9). The ERA seeks to build an optionally manned BWB cargo/airliner with double the range/fuel economy over current tube and wing designs at a size entirely consonant with a long-range bomber.[29] This project would advance the BWB airframe, structures, material, engine technology, and optionally manned technology as well as provide an indirect subsidy of our commercial airline business. The latter, in turn, will mean lower costs for the Air Force.[30] Pursued in collaboration with the ERA, a BWB-B would also serve as an industrial-base catalyst similar to previous projects. The latter included the 707 airframe, which offered utility both commercially and as a widely modified military variant, and the C-5 competition, which gave birth to the turbofan and modern wide-body intercontinental aviation for passengers and cargo. An ERA/BWB-B collaboration would also advance the Air Force's autonomous/RPA goals since the target design of the ERA is nearly identical to that of the MQ-L concept articulated in the service's *Unmanned Aircraft Systems Flight Plan*.[31] The MQ-L is the Air Force's vision of a large platform "leveraging autonomous, modular and open architecture technologies. The MQ-L will be capable of performing today's manned heavy aircraft missions with one common core airframe."[32] Conceptually closest to a B-52 replacement, the MQ-L, available in the 2020s, is an easily modifiable, flexible platform or "truck" capable of "air mobility, airlift, air refueling, [electronic warfare], [multiple intelligence] ISR, strategic attack, global strike, [close air support], air interdiction and humanitarian assistance operations."[33] Pursuit of an optionally manned BWB-B/MQ-L presents opportunities for a different hedge for survivability, relying more on electronic warfare and directed-energy self-defense.

Figure 9. NASA's environmentally responsible aircraft concept. (Reprinted with permission from NASA.)

Fourth, the proposed force structure offers improved flexibility. The grounding of any one platform due to a serious maintenance problem or vulnerability does not compromise the capability of the overall force in either air-to-air or air-to-ground combat. Having "loyal wingmen" and optional manning greatly increases the resilience of the force to attacks on connective data links. Further, there is no reason why bomber platforms could not also have an air-to-air role, serving as off-board missile carriers (holding many more "long-stick" [long-range] air-to-air missiles and relying on off-board cueing), standoff jammers (with much larger apertures and power), or users of directed energy for offensive counterair. The logical conclusion is that a more balanced force permits simple adjustment, depending on how the operational picture changes, and easily allows the Air Force to flex incrementally in one direction or the other to optimize the force.

Fifth, the heavy proportion of optionally manned LRS-B and BWB-B platforms greatly expands flexibility for how the service grows and manages pilots and crews. If done properly, fundamentals pioneered for the optionally manned LRS-B system (quad-redundant flight controls, mission-management systems, environmental systems, redundant communications, cockpit displays, and control stations) may be transferred to the BWB-B, and the UCAV could use the same control-station terminals. A BWB pioneered for the BWB-B would also likely make tanker and mobility variants attractive, allowing a single training pipeline to service two-thirds of the CAF and some significant portion of the MAF and making it easy to cross-flow aircrews between systems. Thus, the Air Force could have pilots with both manned ("air sense") and remotely piloted experience, creating substantial flexibility in rated management and better paths to leadership development. It would also enable an entirely different Guard/Reserve concept of operations. Consequently, the Air Force could rapidly shuttle missions to remote operators or retain a pool of avionics-qualified individuals as true reservists who need only complete a flight physical and altitude-chamber training to return to flying status.

Sixth, the advantages for our industrial base would be profound, permitting no fewer than five open assembly lines. In this proposed force structure, procuring the F-35 in lower numbers becomes attractive—principally to team with the UCAV. It also reopens the F-22 line, giving us no fewer than three concurrent fifth-generation tactical air lines. The UCAV and LRS-B purchases are large enough that we might consider encouraging licensed production by other contractors, as we did in World War II, to broaden the industrial base and allow faster procurement. The decision to pursue a BWB-B would significantly advance US commercial aviation. Inclusion of new platforms is a feature—not a mistake or unintended consequence—in the emerging political space as long as it remains rationally linked to strategy and jobs.

Finally, such a force provides an attractive option from a political perspective by making the Air Force appear both responsive and visionary. The story is simple, with simple numbers: a combat aircraft fleet of 66 squadrons and 2,000 aircraft, two-thirds of them capable of long-range strike and two-thirds capable of remotely piloted operation—something that any policy analyst or airpower advocate can explain quickly in simple terms. It gives the Air Force both competitiveness and a visionary role in the nation's industrial base. Moreover, it substitutes new projects and "spreads the wealth" across both defense contractors and congressional districts to the extent that it should allow scale-back of the F-35 overcommitment with the least pain.

Conclusion

According to this analysis, the force structure of the mid-2030s will not resemble what is presently in the program objective memorandum and program force-extended. The latter are deficient in long-range, survivable UCAVs but overcommitted to RPAs that can survive only in permissive environments and to short-range manned fighters that force the United States to operate inside threat rings. Careful examination would show that a convergence of forces will not let this stand.

If a range-balanced force represents the future, one way or another, the Air Force would do well to march resolutely toward a force structure that is clearly adaptive to current threats and easily articulated—one that offers a clear vision for the future of airpower. Such a structure will give policy makers the justification to secure required resources rather than attempt to maintain the current course, which would have to adapt at a future date. An early change to a range-balanced force would also let the service apply some degree of strategic planning to pursue all of the rationalizations and synergies that such a force could present. That path is preferable to arriving at something similar by cobbling together pieces without the benefit of thoughtful design and interoperability.

The rebalance toward the Asia-Pacific and the new defense strategy outline areas where we can establish priorities of investment. An Air Force proposal that seeks to adapt itself to this new reality while moving smartly forward by advancing remotely piloted aviation and providing a visionary, forward-looking strategy for the national dual-use air and space industrial base will probably be well received. This is especially true if it involves simple numbers and concepts that are easily communicated. A basic 66-squadron CAF of 2,000 aircraft composed of one-third bombers, one-third UCAVs, and one-third manned fighters fits that bill, and the convergent forces will probably take us there. If that is where the winds are blowing, let us not fight this jet stream of convergent forces but place ourselves in its tailwind, pick the range-balanced force as the guiding star, and move confidently toward the future. ✪

Notes

1. Opposing factors include resistance from the fighter community, the need to export fighters in the global market, the need for flexibility to adapt to black swans (unexpected, largely unpredicted events such as the terrorist attacks of 11 September 2001), the need for mass versus performance versus defense budgets, the risk of relying on networks in a contested cyber environment, and ethical considerations.

2. Department of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Washington, DC: Department of Defense, January 2012), 4–5, 2, http://www.defense.gov/news/defense_strategic_guidance.pdf.

3. "The Force behind THE FORCE," Air Force Association, slide 2, accessed 17 April 2013, http://www.afa.org/professionaldevelopment/issuebriefs/F-22_v_F-35_Comparison.pdf; Philip Ewing, "The Air Force's Simple, No-Frills, Advanced New Bomber," Military.com, 13 February 2012, http://www.dodbuzz.com/2012/02/13/the-air-forces-simple-no-frills-advanced-new-bomber/; and Dave Majumdar, "USAF's LRS-B Bomber Proceeds, but Is Completely Classified," Flightglobal, 21 August 2012, http://www.flightglobal.com/blogs/the-dewline/2012/08/usafs-lrs-b-bomber-proceeds-bu.html..

4. *Top line* is a business term for gross revenues, used in the Pentagon to denote the total budget given to a service or the total obligation authority.

5. Department of Defense Directive (DODD) 3000.09, *Autonomy in Weapons Systems*, 21 November 2012, 13, http://www.dtic.mil/whs/directives/corres/pdf/300009p.pdf.

6. This reflects my impressions after spending two years of intense engagement with think tanks, policy makers, and the press in the National Capital Region.

7. Human Rights Watch, *Losing Humanity: The Case against Killer Robots* (Washington, DC: Human Rights Watch, 2012), http://www.hrw.org/sites/default/files/reports/arms1112ForUpload_0_0.pdf.

8. Dr. Peter Singer, to the author, e-mail, 10 December 2012.

9. Government Accountability Office, *Nonproliferation: Agencies Could Improve Information Sharing and End-Use Monitoring on Unmanned Aerial Vehicle Exports* (Washington, DC: Government Accountability Office, July 2012), see "What GAO Found" (page following title page), http://www.gao.gov/assets/600/593131.pdf.

10. Secretary of Defense Robert M. Gates (remarks to Air War College, Maxwell-Gunter AFB, AL, 21 April 2008), http://www.defense.gov/speeches/speech.aspx?speechid=1231.

11. President Barack H. Obama, Secretary of Defense Leon E. Panetta, and Chairman of the Joint Chiefs of Staff Gen Martin E. Dempsey, "Defense Strategic Guidance from the Pentagon," news transcript (Washington, DC: Department of Defense, Office of the Assistant Secretary of Defense [Public Affairs], 5 January 2012), http://www.defense.gov/transcripts/transcript.aspx?transcriptid=4953.

12. DODD 3000.09, *Autonomy in Weapons Systems*.

13. AF/A8XC, to the author, e-mail, 10 December 2012; and Dan Parsons, "Air Force F-35s, Drones May Square Off in Budget Battle," *National Defense* 96, no. 699 (February 2012): 28–29, http://digital.nationaldefensemagazine.org/i/53735/29.

14. Department of Defense, *Sustaining U.S. Global Leadership*, 8.

15. "The Aerospace Industry in the United States," SelectUSA, accessed 28 February 2013, http://selectusa.commerce.gov/industry-snapshots/aerospace-industry-united-states.

16. "F-35 Lightning II Joint Strike Fighter (JSF), United States of America," airforce-technology.com, accessed 28 February 2013, http://www.airforce-technology.com/projects/jsf/; and Bruce Rolfsen, "Despite Problems, AF Plans to Stick with F-35," *Air Force Times*, 26 April 2010, http://www.airforcetimes.com/news/2010/04/airforce_f35s_041310w/.

17. A question arose about completely eliminating short-range, manned fighters, given their operational limitations, the most significant of which is limited range for the contingencies imagined. These aircraft maintain balance and allow operational flexibility in several ways. First, unlike remotely piloted systems, they do not face operational restrictions in national airspace, where laws or regulations require a pilot. Second, short-range assets can posture forward without extending a threat ring over unintended third parties. Third, manned aircraft signal a certain resolve and provide a trip wire. Finally, they offer resilience in case remotely piloted systems cannot keep up with the complexity of the operational environment or experience a compromise of either command and control or autonomy. A second question arose regarding cancelling the F-35 entirely and buying all F-22s or purchasing greater numbers of 4.5-generation fighters such as the Silent Eagle of F-16 block 60 rather than relying on significantly lower numbers of aircraft, depending on their stealth for survivability.

18. The following assumes that we could begin procuring our force in 2020 and wish to finish by 2035: 2,000 total aircraft / 15 years = a commitment to buy 133.3 aircraft per year from the 2008 high of 180 and current low of 59 (24 of which are MQ-9s): $6,216 million = 44.4 manned fighters each at $140 million (average of F-22 $143 million and F-35 $135 million) + $3,552 million = 44.4 UCAVs each at $80 million + $22,200 million = 44.4 bombers each at $500 million = $31,968 million = average annual acquisition costs for the CAF, 2020–35 versus $50,000 million = 100 bombers x $500 million + $238,005 million = 1,763 F-35s x $135 million = $288,005 million (not accounting for other CAF acquisitions and service-life extensions).

19. Industrial Analysis Center, Defense Contract Management Agency, presentation, subject: The Industrial Base, Aircraft Sector Industry Assessment, February 2012.

20. Department of Defense, *Sustaining U.S. Global Leadership*, 4.

21. AF/A9 is the Analysis Division of the Air Staff; OSD/CAPE is Cost Assessments and Program Evaluation under the Office of the Secretary of Defense.

22. Ashley J. Tellis, *Dogfight: India's Medium Multi-Role Combat Aircraft Decision* (Washington, DC: Carnegie Endowment for International Peace, 2011), 15–16, http://carnegieendowment.org/files/dogfight.pdf.

23. International Institute of Strategic Studies, *The Military Balance 2013* (London: International Institute of Strategic Studies, 2013). The numbers are summarized in *Wikipedia: The Free Encyclopedia*, s.v. "Russian Air Force," http://en.wikipedia.org/wiki/Russian_Air_Force.

24. The cost of an aircraft is roughly its weight in thousands of pounds x $0.65 million + $25 million. That calculation underestimates the known cost of the F-22 and F-35, but the comparison is still proportional. Legacy force structure is assumed to be 187 F-22s at 43.4 thousand pounds [43.4 x $.65 = $28.21 + $25 = $53.21/plane x 187 = $9,950]; 1,763 F-35s at 29.3 thousand pounds [29.3 x $.65 = $19.045 + $25 = $44.045/plane x 1,763 = $77,651]; and 100 LRS-Bs at 100 thousand pounds [100 x $.65 = $65 + $25 = $90/plane x 100 = $9000], a total of [$9,950 + $77,651 + $9000 = $96,601] $96,601 million. The proposed force is as reported above, with the BWB-B assumed to be 100,000 pounds empty weight, totaling $111,954 million with a ratio between the two of 115 percent.

25. Custom briefing requested by SAF/FMCC (Directorate of Cost Analysis), slide 16: "Cost per Flying Hours Discussion," 27 April 2011.

26. A significant objection is that the smaller buy of F-35s would push up the unit cost, eroding some of the savings for the UCAV.

27. Department of Defense, *Sustaining U.S. Global Leadership*, 6.

28. "Loyal wingman technology differs from swarming in that a UAS [unmanned aircraft system] will accompany and work with a manned aircraft in the AOR [area of responsibility] to conduct ISR, air interdiction, attacks against adversary integrated air defense systems (IADS), offensive counter air (OCA) missions, command and control of micro-UAS, and act as a weapons 'mule,' increasing the airborne weapons available to the shooter. This system is capable of self-defense, and is thus, a survivable platform even in medium to high threat environments. The loyal wingman UAS could also be a 'large' UAS that acts as a cargo train or refueling asset." Headquarters US Air Force, *United States Air Force Unmanned Aircraft Systems Flight Plan, 2009–2047* (Washington, DC: Headquarters US Air Force, 18 May 2009), 34, http://www.fas.org/irp/program/collect/uas_2009.pdf.

29. Guy Norris, "Future-Airliner Concept Contenders Reveal Design Surprises," *Aviation Week*, 16 January 2012, http://www.aviationweek.com/Article.aspx?id=/article-xml/AW_01_16_2012_p21-413463.xml#.

30. Critical new engine technology includes higher-temperature and adaptive-flow technology such as that being pioneered in the Air Force Research Laboratory's ADVENT and HEETE programs.

31. Headquarters US Air Force, *Unmanned Aircraft Systems Flight Plan*.

32. Ibid., 39.

33. Ibid., 40.

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The Growing Threat to Air Bases

Col Shannon W. Caudill, USAF
Maj Benjamin R. Jacobson, USAF

Wearing US Army uniforms, the attackers penetrated the air base's defenses under the cover of night. Armed with rifles, rocket-propelled grenade launchers, and suicide vests, the 14-man team began its deadly mission against an air base in Helmand Province, Afghanistan, jointly manned by the North Atlantic Treaty Organization's (NATO) International Security Assistance Force (ISAF). Hours of combat ensued, and the morning light revealed the destruction of six AV-8B Harrier jets and damage to two other aircraft; additionally, "six aircraft hangers [*sic*] suffered damage," and "six refueling stations were destroyed."[1] In the aftermath, 14 insurgents and two US Marines lay dead while eight coalition military members and one contractor were wounded. In September 2012, this insurgent operation constituted the most successful ground attack against NATO's ISAF air assets to date in the Afghanistan conflict.

Italian general Giulio Douhet famously noted that "it is easier and more effective to destroy the enemy's aerial power by destroying his nests and eggs on the ground than to hunt his flying birds in the air."[2] Douhet's observation still rings true, as demonstrated by the aforementioned attack on the Helmand air base. Indeed, poorly defended air bases will continue to be susceptible to organized ground assaults. Previously, the most successful post-Vietnam air base onslaught occurred during El Salvador's civil war in 1982, in which 100 insurgents attacked an El Salvadoran air force base, destroying five Ouragan aircraft, six UH-1Bs, and three C-47s while damaging five more platforms. Clearly, this "well-planned and executed operation . . . demonstrated the tactical superiority" of the insurgents against the government's base defense force.[3]

Protecting air bases and air and space assets in the future will become exponentially more complex and expensive due to the promulgation of technology, abundance of open-source information, and growth in adversary capabilities. Looking forward, we see that traditional threats such as airborne assault, indirect fire (IDF) through rockets and mortars, and direct attack by suicide squads will continue as staples of enemy action. Consequently, we must examine emerging threats that enable new modes of air base attack, including the development of precision munitions, the spread of remotely piloted vehicles (RPV), the proliferation of shoulder-launched surface-to-air missiles (SAM), an escalating insider threat, and other variants of a new technological bounty for terrorists and insurgents. The defense of air assets will become even more problematic in the face of a spectrum of threats enabled by technology and an accelerating insider threat. This growth and proliferation of technology will enable small groups to gain an even greater advantage against base defenders and air operators.

Certainly, Airmen need to thoughtfully consider the high probability of these emerging threats and the associated costs of ensuring continued operations. Formerly, a man and a rifle filled a gap in a sector of base defense. Well-defended air bases drive the enemy to explore alternative means of affecting air operations. Naturally, any rational actor desires the quickest, cheapest route to success after selecting a target. If he does not seek a spectacular attack designed to produce casualties and dramatic television footage (as espoused by groups such as al-Qaeda), then he will likely wish to impede air operations and bleed the base dry through harassment that produces casualties over time.

When examining the threat, however, we must constantly ask ourselves what the enemy will target because it is not necessarily aircraft on the ground. Targets and objectives depend upon the attackers, ranging from terrorist groups to conventional forces to special operations, and upon the political objectives and actual capabilities that they can bring to bear against an air base. In Vietnam, enemy forces found ground attacks against airfields a drain on their resources. As a result, they adapted to disrupt air operations rather than attack airfields directly because "whether the raids resulted in aircraft, facility, or runway damage, sortie rates were impaired. Standoff weapons [IDF in today's parlance], as well as various forms of command-detonated explosives, soon became the weapons of choice amongst the many belligerents engaged in conflict since the 1960s."[4]

The threat of terrorism has driven most base-defense operations to focus on the defeat of vehicle-borne improvised explosive devices (VBIED). Top-tier terrorist groups have long wanted headline-grabbing attacks that are big on visual imagery, shock, and body count. Images of the Marine barracks in Beirut, Lebanon, or the Air Force's Khobar Towers in Khobar, Saudi Arabia, became the adversary's desired outcome of an attack. We see the same intent at play in the Taliban's detonation of a truck bomb on the 10th anniversary of the terrorist attacks of 11 September 2001—a strike that wounded 89 people, including 77 Soldiers.[5] This article examines some of the more alarming threats—such as VBIEDs, which we expect the enemy to use in future attacks—and the emerging technology that could enable him to assail our air bases.

The Growing Precision of Indirect Fire

IDF has become the popular choice among insurgents for attacking an air base. Fired at a distance and often rigged to fire after the attacker has departed, it offers a degree of survivability. In Vietnam, Vietcong and North Vietnamese forces hit American air bases 475 times between 1964 and 1973, primarily with IDF, destroying 99 US and South Vietnamese aircraft and damaging 1,170.[6] In Iraq, insurgents used IDF to harass air bases, but it proved largely ineffective because of a poorly trained enemy and active external base defenses. In Afghanistan the enemy employed IDF not only to harass coalition forces but also to mask and cover ground attacks. On 22 August 2012, enemy forces even managed to damage the visiting aircraft of the chairman of the Joint Chiefs of Staff.[7]

Mortars and rockets, aimed at a base by someone with limited targeting information, rely on the technical expertise of the operator—factors that hinder their overall effectiveness. However, a new age in precision IDF weapon systems is now upon us. On 31 March 2011, Soldiers from the 4th Brigade Combat Team fired a 120 mm precision-guided mortar round from Forward Operating Base Kushamond, Afghanistan, hitting within four meters of the target.[8] Normally a mortar fires a "dumb" round—one that has no onboard guidance system. Over time this technology will likely spread to insurgent and terrorist groups, improving their ability to pick and choose targets with extraordinary accuracy and making aircraft as well as key facilities much more vulnerable.

Defeating this type of weapon system demands a truly integrated technological defense. Both America and Israel have pioneered defensive systems designed to counter the increased precision of IDF weapons. In Iraq, Joint Base Balad and other locations used a jointly manned Counter-Rocket Artillery Mortar system to defend against enemy IDF. The defense establishment will need to ensure a comprehensive defense system in the future because precision rounds will make base attack much simpler and give defending forces less margin for error. Furthermore, the capability of this defense technology is improving.

For instance, during the November 2012 Israeli conflict with Hamas in Gaza, militants launched more than 1,500 rockets at Israel, but that country's Iron Dome, a "portable anti-rocket system built to take down short-range missiles," intercepted about 400 of them.[9] This system may offer a template for a portable defense system for air operations. Should precision IDF rounds become part of the operational environment, our Airmen won't have the luxury of an enemy's incompetent firing of dumb rounds.

Remotely Piloted Vehicles

Personnel contemplating defense of an air base must consider the threat posed by RPVs by formulating a plan to tackle a range of remote threats, both ground and airborne. Who is cleared to engage such vehicles and with what weapons? For ground-based vehicles, the answer is more clearly defined and in line with established contingencies for VBIEDs; however, a defensive gap may exist in defending against airborne threats. The fact that we have yet to fully explore protocols for these defenses leaves a seam that a technologically savvy enemy could exploit. We must develop modeling, simulation, and defenses to account for these new threats before a protest group disrupts flying operations or—worse yet—before a terrorist organization uses RPVs for reconnaissance or attacks against our air assets.

The use of these vehicles (RPVs, robots, drones, etc.) is moving beyond exclusive military use. After all, civilians have flown remote-controlled airplanes since the 1930s. Today, though, the sophistication, range, and video capability allow civilians to access technology once reserved only for military and intelligence organizations. Take the case of a protest group called SHARK (Showing Animals Respect and Kindness). This group planned to use a Mikrokopter drone to videotape a live pigeon shoot as a means of deterring and interfering with a legal hunting outing. On 21 February 2012, SHARK set up operations at Broxton Bridge Plantation near Ehrhardt, South Carolina. Law enforcement officers and a local attorney tried to prevent the protest group from flying its drone, but the group flew anyway, only to have the drone shot down by hunters on the scene.[10]

This same technology is capable of carrying weapons or conducting reconnaissance for groups targeting an airfield—indeed, it has already done so. For example, although American policy makers have concerned themselves with al-Qaeda in recent years, Hezbollah has proven itself to have global reach and staying power. It is credited as the first terrorist group to pioneer the use of suicide bombers as a weapon of mass destruction, delivering large vehicle bombs to specific targets.[11] Hezbollah has recently shown technological prowess through its use of explosive-laden RPVs and missile technology, even managing to cripple an Israeli warship.[12] The success of the organization comes from its financial and logistical backing by Syria and Iran, the latter supplying advanced weapons and reconnaissance equipment.

Starting in November 2004, Hezbollah shocked Israelis by launching a remotely piloted surveillance plane, the Mirsad 1, that flew over Israeli towns and returned to Lebanon unharmed. At a Hezbollah rally, the organization's leader, Hassan Nasrallah, declared, "You can load the Mirsad plane with a quantity of explosive ranging from 40 to 50 kilos and send it to its target. . . . Do you want a power plant, water plant, military base? Anything!"[13] No doubt this technology will spread to other terrorist and protest groups over time.

To punctuate this point, examine the case of Rezwan Ferdaus, a 26-year-old US citizen. He was arrested on 28 September 2011, charged with plotting to attack the Pentagon and US Capitol with "large remote controlled aircraft filled with C-4 plastic explosives" and providing "material support and resources to a foreign terrorist organization, specifically to al Qaeda."[14] According to the Federal Bureau of Investigation, Ferdaus planned to couple his "aerial assault" by three explosive-laden drones with a ground attack that included "six people, armed with automatic firearms and divided into two teams." Ferdaus explained that "with this aerial assault, we can effectively eliminate key locations of the P-building [Pentagon] then we can add to it in order to take out everything else and leave one area only as a squeeze where the individuals will be isolated, they'll be vulnerable and we can dominate."[15]

Proliferation of Shoulder-Launched Surface-to-Air Missiles

A flying wing can realize mission success only by generating aircraft sorties, regardless of threats from the operational environment. Protecting aircraft from SAMs during takeoff, the most vulnerable phase of flight, is extremely challenging due to constraints on their maneuverability caused by weight and low altitude. Consequently, heavy transport aircraft and their valuable cargo, possibly munitions and/or passengers, present extremely tempting targets during takeoff. Conversely, aircraft on approach must maintain predictable speeds and flight paths. In either case, SAMs represent a threat to such aircraft. For instance, rebels in the current Syrian conflict allegedly possess some "fifteen to thirty SA-7 man-portable air-defense systems [MANPADS]" and have "reportedly shot down at least five rotary-wing and six fixed-wing aircraft," claiming at least one downed by a MANPADS.[16] According to the US Air Force Counterproliferation Center,

> Currently, 27 terrorist groups including Al Qaeda have confirmed or reported possession of MANPADS. Since 1994, there have been ten high profile attempts to target commercial aircraft with four being shot down—including one carrying the Presidents of Rwanda and Burundi. Furthermore, MANPADS fit Al Qaeda's mode of operation perfectly and are relatively easy to use, convenient to transport, widely available, inexpensive, and certainly lethal.[17]

As technologies developed by foreign competitors continue to advance and proliferate, tactics, techniques, and procedures for integrated defense will have to keep up with their employment. Recently the Russian-made SA-24 "Grinch" MANPADS proliferated to Venezuela, Libya, and Syria.[18] Of course, Libya's government has been deposed, and at this writing Syria remains in a state of civil war. The security of MANPADS in such war-strewn countries remains doubtful as potential black markets develop and instability attracts nefarious elements. The threat of MANPADS to future US and coalition forces as well as civilian airline operations will likely rise as these systems become more accessible in the fertile ground of civil war and insurgency.

The Expanding "Insider Threat"

For the foreseeable future, US and coalition forces will operate amid insider threats. In Afghanistan from 2007 to 2011, Pentagon statistics reveal a total of 42 attacks by members of the Afghan National Security Forces on US and NATO personnel, claiming the lives of 70 coalition troops and wounding 110 others.[19] One of the most egregious and horrific instances of an insider threat occurred on the morning of 27 April 2011, when an Afghan air force captain killed eight Airmen and one contractor at Kabul International Airport.[20] Another incident demonstrated how a determined and crafty suicide bomber could infiltrate a Central Intelligence Agency base in eastern Afghanistan and kill eight Americans.[21] This disturbing trend intensified in 2012 as uniformed Afghan security forces conducted 46 insider attacks against coalition forces, which killed 60 NATO personnel.[22]

More troubling still is the growing threat from within the ranks of American personnel. On 11 May 2009, five American military members were killed by a US Soldier at a military counseling center in Camp Liberty, Baghdad.[23] Shootings by a US Army psychiatrist on 5 November 2009 in Fort Hood, Texas, resulted in the deaths of 13 people and wounding of 32 others.[24] Clearly, the Department of Homeland Security is concerned about the threat that veterans could mount in the homeland, noting that veterans returning from Iraq and Afghanistan could be susceptible to recruitment by right-wing extremists.[25]

It is important to remember that one person can do a great deal of harm—witness the number of "lone wolf" incidents that have occurred. On 22 July 2011, for example, Anders Breivik, a Norwegian, set off a vehicle bomb near government buildings in Oslo, killing eight, and then massacred 69 people at a youth camp on the nearby island of

Utoeya.[26] On 20 July 2012, American James Holmes walked into a sold-out movie theater near Denver and began shooting; he killed 12 and wounded 58.[27] Trained and experienced US military members and veterans could wreak even more havoc. Whether stateside or overseas, commanders must ensure that they provide and exercise a comprehensive interior security plan—one that includes an aggressive psychological screening program to identify insider threats.

Obtaining Maps of Air Bases

Enemy forces planning a ground assault of an air base used to rely on collaborators who had access to the target base to facilitate the mapping of terrain and key facilities, as well as attain pace counts that enable IDF attacks. Today the information superhighway offers access to satellite imagery and other open-source information that make the job of a would-be attacker much easier. One such website, that of the Federation of American Scientists (FAS), describes itself as "an independent, nonpartisan think tank and registered 501(c)(3) non-profit membership organization . . . dedicated to providing rigorous, objective, evidence-based analysis and practical policy recommendations on national and international security issues connected to applied science and technology."[28] GlobalSecurity.org, an offshoot of FAS founded by John Pike, one of its former members, claims to be "the leading source of background information and developing news stories in the fields of defense, space, intelligence, WMD [weapons of mass destruction], and homeland security."[29] Its website features satellite images of military bases around the world, many of which the US government considers classified. Other sites, such as Google Maps, make available imagery and street maps. In sum, people now have a multitude of ways to acquire detailed maps of air bases that would facilitate attacks on those locations.

Social Media: Flash Mobs, Terrorism, and Networking Base Attacks

Instantaneous communications will dramatically improve the enemy's information operations and base attacks, allowing him to draw upon elements of a sympathetic local populace to create situations that embarrass an air base's leadership or overwhelm defenses. Thus, intelligence and law enforcement must stay one step ahead of an increasingly agile foe by becoming more adept in their collection efforts. Basic technology, such as cell phones, has affected society in unusual ways by creating unprecedented means for communicating and coordinating actions. Take for example the phenomenon of the "flash mob," a group of people summoned via cell phone, social media, and viral e-mails for the purpose of performing some sort of act at a specific location. The web and even commercials of telecommunications companies are replete with footage of benign flash mobs who appear in a public place to carry out some sort of unusual or artistic act, like freezing in one place or performing a coordinated dance routine. Although they do this in the name of entertainment, what happens when someone uses this same technology for nefarious purposes?

In the summer of 2011, for example, Philadelphia was hit with an epidemic of flash mobs organized to carry out robberies, assaults, looting, and chaos. This incident included random beatings of pedestrians, a rampage through a Sears store, and assemblages of hundreds of people at designated locations designed to choke traffic. Margaret Rock, editor at Multimedia.com in Chicago, offered the following: "I don't know why, but what started out as something used for good has shown its dark side."[30] Later that same summer, riots in London, Birmingham, Manchester, and elsewhere developed, causing security officials great concern. Scotland Yard identified and arrested nearly 3,000 people suspected of physically rioting or inciting violence across the country by using BlackBerry Messenger, Twitter, and Facebook.[31] According to one text, "If you're down for making money, we're about to go hard in east London."[32] David Cameron, British prime minister, observed that "everyone watching these horrific actions will be struck by how they were organized via social media. . . . So we are working with the police, the intelligence services and industry to look at whether it would be right to stop people communicating via these websites and services when we know they are plotting violence, disorder and criminality."[33]

The rapid pace of technological advancement has spread to every corner of the globe. Cell phones are now powerful computers in their own right, networking with other devices globally. Nowhere is this more apparent than in developing countries that had poor communications because of the cost of hard-wiring infrastructure for land lines. Cell phones now make that expense moot since towers and satellites allow such countries to plug into the global communications grid. As of 2008, 80 percent of the world's population had access to a cellular network, and by the end of 2006, developing countries bought 68 percent of the world's mobile phones.[34]

The same technology that enables global information sharing and advancement also supports the networking of terrorist and criminal groups. According to a new study by Israel's University of Haifa, al-Qaeda, Hamas, Hezbollah, and the like have invested in social networking such as Facebook and Twitter to recruit, raise funds, and gather intelligence. Prof. Gabriel Weimann, author of the study, argues that "today, about 90 per cent of organized terrorism on the internet is being carried out through social media" and that the latter is "enabling the terror organizations to take initiatives by making 'friend' requests, uploading video clips and the like and they no longer have to make do with the passive tools available on regular websites."[35]

How will this technology and social networking affect base security in the future? Protestors, mobs, and terrorist groups could easily be summoned with no prior notice to military intelligence or law enforcement, quickly assembling near a base's entry-control point or perimeter to protest, riot, or attack. In many instances, such areas would have only a handful of guards available to counter the assembled groups—a scenario that could easily overwhelm the few personnel on scene and escalate beyond their capacity to quell such action.

Cyber Attacks: A Potential "Easy Button" for Air Base Attack

Technological advances have pushed the US military into a "cyber force" largely dependent upon a network of computers and communications links to ensure not only the effective use of forces during contingency operations but also the day-to-day mission of force preparation and training. Thus far, insurgent forces have lacked the capability and training to conduct large-scale cyber attacks against military installations. However, that will likely change as state-sponsored terrorist organizations and insurgent forces partner to defeat a common enemy. Utilizing a cyber attack that affects air operations or base-defense sensors and cameras to facilitate a kinetic strike may be a cost-effective and efficient choice.

Attacks via cyberspace could result in degraded flight operations, as occurred at the Indira Gandhi International Airport when a malicious code, utilizing scripts specifically designed to exploit that system's weakness, shut down check-in counters and boarding gates and significantly affected operations.[36] A similar assault could disrupt air-traffic-control nodes, networked maintenance schedules, and training operations as well as threaten armed or unarmed RPVs operated by the Air Force and other government agencies. Take for example the recent hacking of a Department of Homeland Security drone as part of a bet between a Texas college professor and his students. For less than $1,000, these individuals successfully "spoofed" the RPV, effectively "re-missioning" it.[37] This low-budget academic prank demonstrates how easily an adversary or terrorist group could re-mission RPVs and turn them into flying missiles against an air base or other target.

Red Flag, the Air Force's combat-training exercise involving US and allied forces, has integrated cyber and space elements from Air Force

Space Command to address effects associated with attacks on cyber and space assets. At the March 2011 Red Flag, an Air Force official commented, "We know many threats around the world are working diligently to access, corrupt, or deny our use of [both unclassified and classified computer systems]."[38] Assets and personnel associated with integrated defense systems may also become targets. Further, adversaries might try to disrupt or manipulate the increasing use of cyberspace for communications, including encrypted radio transmissions, classified and unclassified messaging, and biometric identification systems at our access gates. A *Washington Post* investigation found that certain types of software platforms used by government and the private sector—including a Tridium company system called Niagara—are more vulnerable than others. Marc Petock, Tridium's vice president for global marketing and communications, noted that "some Defense Department facilities in the United States also depend on Niagara. That includes the giant Tobyhanna Army Depot in Pennsylvania" and some "high security" military facilities.[39]

The rapidly evolving cyber domain promises many benefits: reduced manpower requirements, increased efficiency, better targeting, and ease of access/use. However, these same technologies present significant opportunities for a clever and determined adversary to create a backdoor through which he can penetrate and defeat the entire security system.

Marrying Modern Technology with Special Forces

Not too long ago, planners at NATO bases concentrated on the USSR's plans to attack air bases. During the Cold War, the Soviets explored a number of ways to assault and disable bases, primarily by employing the Spetsnaz (special forces). A review of Spetsnaz airfield-attack profiles in declassified Cold War–era Central Intelligence Agency reports would prove useful because they provide insights into methods for direct strikes on these targets. These included the airdrop near an air base of 30 special operators, who then broke into "four operations teams, each team with specific responsibilities including capturing vehicles and personnel for the purpose of infiltrating the target [air base]," using SAMs and explosive devices to destroy aircraft.[40] Additionally,

> in a second method, a Spetsnaz company (approximately 10 teams of five to 12 men) operated against a heavily defended airfield. The company could not get closer than 2 to 3 km to the target. During the first night Block Strelas [three-tubed SAM launchers mounted on a tripod] were positioned as close as possible to either end of the field, and then attacks were initiated against pipelines, powerlines, communication lines, security personnel, and crews heading toward the airfield.[41]

This would disrupt airfield operations, create the impression that a larger Soviet force was in the area, and draw more NATO forces in for defense and away from the front lines. Imagine well-trained enemy special forces enabled by many of the aforementioned technological advances. Base defense would become incredibly difficult, and the complexity of countering the threat would escalate significantly.

Conclusion

Understanding and countering these growing threats will play a major role in the ability to project airpower effectively in the future. One solution—basing aircraft as far from hostilities as possible—strains aircraft and aircrews with longer flight times. However, it does not address the likely requirement that mobility aircraft land near or in the combat zone to support ground operations. Nor does remote basing speak to the technological means of attack through cyberspace, technologically enabled terrorists, or special forces hitting a presumably safe air base. Thus Airmen must conduct a truly full-spectrum threat analysis and take into account these potential vulnerabilities in force-protection planning.

Aircraft are extremely fragile. One well-placed mortar round can render several hundred million dollars' worth of aircraft worthless or can wipe out a barracks occupied by essential personnel such as pilots or aircraft technicians. The Air Force and coalition forces will have to make hard choices about base defense driven by mission requirements, economic constraints, and the rising threat posed by a determined enemy enabled by some of the aforementioned technology. Airmen and joint leaders must either stay abreast of these issues during the interwar period or risk the elimination and degradation of air assets at the onset of the next hard-fought campaign. ✪

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Lt Gen Frank Andrews and the Role of Airpower in Hemispheric Security

Johannes R. Allert

Gen Dwight Eisenhower had big shoes to fill when news concerning the death of Lt Gen Frank M. Andrews circulated throughout the Pentagon.[1] In his eulogy to the aviator, Gen George C. Marshall placed him in a select category that included the nation's few great captains.[2] Such high praise from someone with demanding standards directed toward an individual whose life was cut short so early in the war raises the question, What made Andrews so important? Although historians often designate him a proponent of an independent air force that would conduct strategic bombing or as Eisenhower's predecessor, they overlook his talent in conducting combined operations.[3] Compared to his fellow aviators, Andrews possessed over a decade's experience in the regular Army prior to earning his wings. A cavalryman by trade, he later served as a general's adjutant and received advanced training and education from the US Army's Command and General Staff School and the War College, making him a rarity among his fellow pilots.[4] This background had considerable bearing on his promotion to head the newly formed General Headquarters (GHQ) Air Force. Traditionally, historians emphasize the latter's role in the service's transition to independence but give short shrift to its vital participation in joint operations with Army and Navy forces.[5] Mobility exercises conducted throughout the country in the GHQ Air Force's first two years of existence demonstrated its importance, forcing aviators to come down to earth and recognize problems associated with combined operations in all types of weather involving a variety of air and land assets—aspects with which Andrews was familiar.

His experience and advanced training made him an exceptional leader with a diverse background and knowledge of Army tradition yet a forward-thinking individual who maintained a broad perspective and who understood the necessity for reform as a means of dealing with modern battle conditions. One sees this attitude in his assessment of armor tactics following the Army's Louisiana maneuvers in 1941. Serving as Marshall's G-3 (Operations), Andrews appreciated the need for mobility, speed, and firepower—elements vital for success in mechanized warfare. Upon conclusion of the maneuvers, he sided with armor proponents who advocated creation of the first mobile armored division independent from infantry or cavalry.[6] In a day and age when disciples of airpower incessantly preached aviation's superiority and decisiveness, Andrews's recognition of the value of armor in modern warfare demonstrated his multifaceted approach to combat, indicating his appreciation of integrated operations requiring versatility, flexibility, and responsiveness to threats. Airpower represents one facet of the force multiplier that, when implemented as a whole, makes it decisive. His ideas concerning modern warfare, whether on the ground or in the air, went against conservative norms.

Andrews's leadership proved crucial to bringing about revolutionary changes in the conduct of military operations in concert with airpower despite enormous resistance to change from political and military establishments.[7] Accordingly, in 1941 Marshall appointed him theater commander—the first Airman to hold this position—giving him responsibility for Caribbean Defense Command, which included Cuba, Puerto Rico, the Virgin Isles, Trinidad, the Panama Canal Zone, and the Galapagos Islands.[8]

Axis Threat and Hemispheric Security

The growing tide of war revealed the increasing presence of totalitarian elements from overseas who attempted to infiltrate Latin America. Impressed by fascism's rapid success in Europe, many individuals there believed that Great Britain would fall next. This movement made inroads when Sociedad Colombo Alemana de Transporte Aéreo (SCADTA), a German-owned and -operated air service, increased its presence throughout South America, specifically designing many of its aircraft for dual use in either a civilian or military capacity.[9] Later estimates from 1940 put the total number of miles flown by this airline at more than three million.[10] Reports from Panamanian authorities revealed that in excess of 1,200 German nationalists had recently established businesses and preferred renting apartments in lieu of hotel rooms.[11] Even Mexico was not immune. Covert agents spent large sums of cash entertaining officials and made inquiries about the regional geography, showing particular interest in the coastline.[12]

Fascist threats had now arrived at America's very doorstep, highlighting the military's inability to adequately protect the Panama Canal, which the Navy relied upon to shift assets economically from one ocean to the other. This situation underscored the irony that America's most vital point of defense lay outside its borders. Earlier military assessments publicized in *Time* magazine drew attention to the canal's vulnerabilities. Firstly, sabotage could damage or destroy the locks. Secondly, a carrier-launched strike could smash the locks or breach the dam located at Gatun Lake, thereby draining the water crucial for its operation. Lastly, enemy forces could establish a foothold in Latin America by launching a combined and systematic attack against military installations on the isthmus.[13] In the absence of naval assets, the best alternative clearly demanded expansion of the canal's defensive perimeter to 2,000 miles by utilizing airpower.[14] Confronting the possibility of a British defeat, the United States adopted a worst-case-scenario mentality, applying diplomatic, economic, and military measures to stem the tide.

Having served as Marshall's G-3 officer for a little more than a year, Andrews was directed to take command of air assets located within the Panama Canal Zone. Wasting no time, he conducted an extensive 6,000-mile inspection of air facilities throughout the theater, conferring with area commanders to determine needed improvements. Although construction of bases remained on schedule, enhancements to the theater's communication grid lagged considerably due to bureaucratic paperwork and conflicts among the various sectors.[15] Submitting his report to Lt Gen Daniel Van Voorhis, the theater commander, on 18 February 1941, Andrews listed seven principles:

1. Deny establishment of hostile bases in the Western Hemisphere.
2. Defeat adversaries by air action against their air assets and establishments.
3. Oppose the operation of any hostile air force through the use of airpower.
4. Operate against hostile land and naval forces that threaten vital US interests.
5. Operate in close coordination with ground forces.
6. Operate in close coordination with naval forces.
7. Operate in lieu of or in support of naval forces when the fleet is not situated to operate effectively against enemy forces.[16]

This action called for unified command and control of all Army air assets in the Caribbean.[17] Emulating the German Luftwaffe's tactics in Norway in May 1940, Andrews established the Army's first air-mobile strike force, combining infantry with air transport to respond instantly with a substantial force to any attack.[18] Appreciating England's air defense and its reliance on radar during the blitz, he patterned his newly formed Caribbean Air Force on that model.[19] However, because Andrews and Van Voorhis did not have a good working relationship, Marshall requested that the latter relinquish command early and promoted Andrews to theater commander.[20]

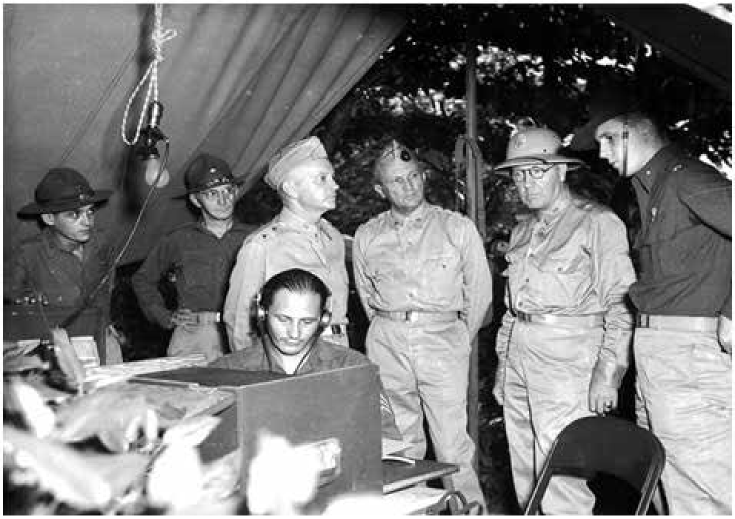
The American Lake

Upon taking charge of Caribbean Defense Command on 19 September 1941, Andrews encouraged the men under his command

> to shoulder together the burden of preparing yourselves for whatever eventuality time may bring. Whether your job is in the air or on the ground, it is this spirit of teamwork which has made possible the progress which has been made and which still must be made. World War II has clearly demonstrated that teamwork between air, ground and sea forces is the primary requirement for military success. May we ever keep in mind, in the Panama Canal Department and the Caribbean Defense Command, an appreciation of this fundamental principle.[21] (emphasis in original)

His promotion to theater commander proved significant for several reasons. Firstly, the command was the largest one at the time that involved both ground and air troops. Secondly, Andrews's assumption of command marked the first use of the policy of grouping all elements under an officer of a branch most likely to bear the brunt of operations in that area. Thirdly, for the first time, an individual from the Air Corps commanded a theater. Moreover, at no other time in American history had defensive operations included expansion to foreign countries.[22]

Andrews restructured his command by dividing it into three sectors: Panamanian, Puerto Rican, and Trinidadian. Sector commanders were responsible for defense and training in their respective areas. Recognizing the requirement for a strong air defense in the face of impending war, the general instituted fighter air patrols.[23] Aircraft patrolled frequently, especially on the Pacific side of the Canal Zone where Andrews believed that attacks on the canal would most likely occur. He ensured the presence of antiaircraft batteries on all the islands and requisitioned additional radar sets to cover the Pacific and monitor air traffic in Colombia.[24] With the help of Gen Harry Ingles, his chief of staff and an experienced signals officer, Andrews rectified the communications problem so that area commanders could speak to one another and with Andrews's headquarters. This action established a communications grid spanning the distant islands, including countries in Latin America.[25]



US Air Force File Photo

***Second from right*: Lt Gen Frank Andrews inspecting communications (Puerto Rico, 1941)**

In keeping with the philosophy of hemispheric defense, Andrews improved and expanded the numerous airfields in the Caribbean theater. On Marshall's behalf, he conducted a series of negotiations with Ecuadorian officials, establishing a base on the Galapagos Islands. Completed in late 1942, the airfield broadened the defensive perimeter of the Panama Canal, extended the range of aircraft over the Pacific Ocean, and closed gaps in the patrol route.[26] Andrews consistently demonstrated his knack for diplomacy by patiently negotiating with several other Latin American states, each with its own agenda, ultimately establishing an "American Lake" within the Caribbean theater.[27]

These alliances produced a defensive ring around the canal and maintained the southern air route vital for the support of Allied forces in North Africa once America joined the fray. Furthermore, his efforts to revitalize good relations with Latin American countries paid dividends in the long run—witness their consent to the deployment of US military assets to the region of Surinam, an area known for its bauxite, a valuable resource critical to the production of high-grade aluminum.[28]

Although efforts to complete defensive measures remained unfinished when the nation entered World War II, Andrews held two significant advantages. For one, possession of a unified command facilitated combined operations, demonstrating his understanding that the mission to guard the Panama Canal and the Caribbean demanded the use of all available assets. Additionally, his collegial relationship with Marshall eliminated any possibility of misunderstanding his commander's intent.[29] With Marshall's support, Andrews united all Army Air Corps assets under a single command to protect the approaches to the canal and monitor activities in Latin America.[30] Furthermore, he conducted productive mock exercises to maintain readiness.[31]

Operation Neuland: German Submarine Warfare in the Caribbean

Despite securing the Canal Zone, Andrews could not prevent early successes of the German U-boat campaign against Allied shipping in the Caribbean. Simultaneously defending the Panama Canal with scant resources and maintaining vigilance across the vastness of the Caribbean proved impossible. Compounding the problem was the fact that American naval strategy, concentrating on the Pacific, miscalculated the ability of the British Royal Navy to thwart attacks in the Atlantic. Furthermore, the Air Corps and Navy had continually grappled over coastal defense and were now paying the price for their intransigence.[32] Consequently, between February and May 1942, US forces suffered a temporary setback, losing 46 ships totaling more than 219,867 gross tons.[33]

Its Pacific Fleet at the bottom of Pearl Harbor and faced with demands to supply beleaguered forces in the Pacific, the Navy had few resources to spend chasing submarines, let alone assist the Air Corps.[34] Yet, that service remained critical of the Air Corps's performance in the Caribbean and initially declined to share intelligence or allow the Air Corps to fly beyond its jurisdiction.[35] Recognizing the need to maintain a semblance of unity and having learned from earlier experiences, Andrews publicly expressed a sense of cooperation between the two services while privately venting to Marshall.[36] However, this did not prevent others like retired Army colonel Hugh Knerr, Andrews's former chief of staff at GHQ Air Force, from speaking openly. Free from military censure, Knerr blasted the Navy's failure to support Andrews's mission in the Caribbean:

> The average sixty year old admiral contemplates the tortures of hell a lot more cheerfully than he contemplates being commanded by an Army general. The area around the Windward Islands is obviously an area that anyone responsible for the defense of the canal would like to know is being patrolled most carefully, but General Andrews has no authority to direct the patrolling. He supplies the bombers, but they cannot leave the ground without the permission of the admiral who shares the Navy sentiment that Army aviation stops at the shoreline.
>
> Pearl Harbor is a bloody monument to divided responsibility, but even now it remains a three way split command between Admiral Nimitz, the Navy's district commander, and Army airman Lt. General Delos Emmons. The simple solution to this never ending problem is to give absolute authority to one man in each theater of war.[37]

The protest had its desired effect, and the American public, many of whom had sons serving in harm's way, quickly clamored for a formal military investigation and urged cooperation.[38]

With the canal secure, Andrews quickly shifted his assets to address the U-boat menace. Having a unified air command helped. In an ironic twist, he relied upon the twin-engine B-18 Bolo, a lightly armed aircraft that he had lobbied against in favor of the B-17 Flying Fortress.[39] Initially, these aircraft proved ill equipped to deal with U-boats, and air crews—indoctrinated to fly at high altitudes—occasionally failed to spot their prey. Undeterred, Andrews ordered these aircraft retrofitted with low-altitude bombsights, radar, and depth charges. Most importantly, he instituted a rigorous patrol schedule conducted at lower altitudes and implemented square search patterns in relays after encountering the enemy.[40]

Adherence to the fundamentals paid off over time, reflected by the experience of Kapitänleutnant Werner Hartenstein. Attempting to repeat the success of the previous summer, Hartenstein and his U-156 returned on 2 March 1943 and experienced the difference firsthand. They did manage to escape but not before B-18s damaged the U-boat's fuel tanks, leaving an oily trail for the Navy's PBY flying boats to follow. They sank U-156 the following day.[41] Coincidentally, negative reaction to casualties suffered by the local population at the hands of the Germans meant that the Axis was also losing the ever-important battle of hearts and minds.[42]

Over time, American industrial production caught up with demand, making longer-range aircraft like the utilitarian B-24 Liberator more available. Eventually the Navy, in addition to adopting the British convoy system, assumed responsibility for antisubmarine patrols. Rewarded for his efforts, General Andrews was transferred to North Africa in November 1942 and given the task of uniting the disparate air assets throughout the Mediterranean and combining them into US Army Forces in the Middle East.[43]

Photo courtesy Cpl Charles Henry Allert

B-24D (serial no. 42-63800), attached to the 3rd Bomb Squadron, Sixth Air Force, remained in service throughout the war performing antisubmarine patrols in the Caribbean. Paint removal and replacement of standard propellers improved performance at lower altitudes, thus demonstrating the US military's adage of adapt, improvise, and overcome.

Proficiency through experience allowed the Air Corps to drive off attacks.[44] Andrews's insistence on the fundamentals recognized that numbers mattered and that the protection of ships was more important than sinking submarines. The latter operated best on the surface, so forcing them to remain submerged to evade aerial detection allowed vital Allied cargo to reach its destination safely.[45] Additionally, the absence of air conditioning made life aboard U-boats uncomfortable in the heat of the Caribbean. Prolonged subsurface operations depleted the submarine's batteries, prevented acquisition of fresh air, and diminished the crew's overall performance. Unable to surface and recharge batteries or obtain fresh air—even at night—for fear of detection by aircraft, the U-boats were forced to withdraw.[46]

The greatest challenge confronting Andrews involved synchronizing his operations between Army and Navy components that for decades remained thoroughly indoctrinated to operate within their own service standards. Fortunately, leadership, time, and the realities of the situation prevailed to the point that both services reconciled their differences.[47] However, the same cannot be said of the Axis, which failed to exploit initial successes due to disputes over naval strategy and a lack of cooperation among the military services.[48] Failure to develop what we today consider second-generation technology meant that U-boats sailing off to war in 1944 were essentially the same as those of 1940. By the time the revolutionary type XXI arrived, it was too late. Conversely, the Allies continually enhanced radar, communications, and weapons platforms.[49] Furthermore, Germany's failure to capitalize on initial efforts to influence political, economic, and social elements within Latin America culminated in a rejection of fascist power previously embraced in that region. Faced with Andrews's talent for adaptation, aggressive countermeasures, tact, diplomacy, and vigorous pursuit of a collaborative policy, Operation Neuland ceased after less than a year.

Conclusion

America's brief, limited experiences during World War I account in part for its slow maturation in aviation early in the next world war. A cultural mind-set that obsessed over the costs of defense, coupled with a preference for isolationism, resulted in significant developmental delays and deterred creation of a sound, unified aviation strategy. Despite previous training and education, American commanders were overwhelmed by the rapid expansion and complexities of a new global war that surpassed anything in their imagination. Thus, commanders sometimes made mistakes or miscalculations, revealing either personal imperfections or the limitations of technology; however, this process also separated the leaders who learned from their experiences from those who could not. The events of the Caribbean campaign demonstrated that General Andrews, although an advocate of airpower, did not confine its use merely to high-altitude precision bombing. The numbers vindicate the importance that he placed on combined operations. Historian Orlando Pérez notes the recording of more than 23,000 transits between July 1941 and June 1945, an average of 16 per day. The unhindered movement of troops and equipment between the Atlantic and Pacific proved invaluable to the Allied war effort.[50] Further, Andrews's antisubmarine campaign secured valuable bauxite in Surinam and the vital southern air route to Europe.

Unfortunately, his promotion to theater commander of Europe in February 1943 was short lived. Perishing in an aircraft crash in Iceland on 3 May 1943, Andrews never saw the fruit of his efforts.[51] In the wake of his death and hasty funeral arrangements, his nephew recalled promises from officials to honor the general's legacy at war's end.[52] Greater events transpired in the interim, however, quickly overshadowing his tragic end.

US Air Force file photo

Recovery of bodies from crash site in Iceland

In his essay "The Air War in Europe, 1939–1945," Richard Overy describes the air strategy instituted by the Allies in World War II as a "general strategy" which, unlike that of the Axis, did not limit its use or dilute its resources. Furthermore, he observes the current historical shift from emphasis on bombing campaigns to air operations, exemplified by Andrews's efforts in the Caribbean during 1941–42.[53] Airpower's significance lay not in its decisiveness but in its versatility, and Andrews was the first and foremost US commander to demonstrate this difference.

Granted, other great aviation leaders emerged during World War II, but none of them became theater commander in an active war zone.

Pigeonholing Andrews as a proponent of strategic bombing or as a crusader for air independence mirrors Overy's argument and overlooks the fact that his best talent lay in operational planning. The general understood that securing the Panama Canal, the natural resources in Latin America, and the southern air route to Africa were essential to hemispheric defense—more so than airpower itself. Only by emphasizing operational control and by maximizing technology, cooperation, and forethought could the Allies take this first step in the long road to victory. ✪

Notes

1. Associated Press, "Downed in Iceland: Plane of Commander of U.S. Forces in Europe Falls in Wild Spot, Staff Officers with Him; Methodist Bishop-Chaplain on Flight during Global Tour of American Bases; Gen. Andrews Dies in Iceland Crash," *New York Times*, 5 May 1943, 1.

2. DeWitt S. Copp, *Frank M. Andrews: Marshall's Airman* (Washington, DC: Air Force History and Museums Program, 2003), 26.

3. Despite all the accolades bestowed upon Andrews by contemporaries and historians alike, no major historical works about him exist. The crash of his B-24 destroyed not only the man but also many of his personal documents. In 2004 E. Thomas Woods began working on *Andrews: Life of a Leader*, in which he emphasizes the general's leadership and courage of conviction with regard to airpower. DeWitt S. Copp's books *A Few Great Captains: The Men and Events That Shaped the Development of U.S. Air Power* (Garden City, NY: Doubleday, 1980) and *Forged in Fire: Strategy and Decisions in the Air War over Europe, 1940–45* (Garden City, NY: Doubleday, 1982) offer the closest biographical sketch. Copp later published *Frank M. Andrews: Marshall's Airman* (see note 2), which highlights his aviation talents and leadership. He pays particular attention to the close relationship between Andrews and General Marshall and its impact on US preparedness. Separate articles by David T. Zabecki ("Frank Andrews Was the Architect of U.S. Air Power Who Might Have Commanded Allied Forces on D-Day," September 1998) and E. Thomas Wood ("The Man Who Would Be Ike: What If Frank Andrews Had Survived His 1943 Air Crash?," May/June 2010) for *World War II Magazine* emphasize Andrews's effective leadership and cooperative personality; however, they spend much time contemplating the "what ifs" had General Andrews survived. Conversely, H. O. Malone adeptly focuses on "what was" in "The Influence of Frank Andrews," *Air Force Magazine* 85, no. 2 (February 2002): 84–88, http://www.airforce-magazine.com/MagazineArchive/Documents/2002/February%202002/0202andrews.pdf. He credits the general's gradual commitment to an airpower strategy that would lead to establishment of the US Air Force. John Shiner demonstrates Andrews's role in organizing airpower militarily in "Birth

of the GHQ Air Force," *Military Affairs* 42, no. 3 (October 1978): 113–20. Shiner credits Andrews for his leadership and notes that he was well respected by ground and air staff alike.

4. James P. Tate, *The Army and Its Air Corps: Army Policy toward Aviation, 1919–1941* (Maxwell AFB, AL: Air University Press, 1998), 192.

5. Wireless to the *New York Times*, "Attack on Ponce Ends War Game: Puerto Rican National Guard Defends City as Marines Occupy Near-By Hills," *New York Times*, 4 March 1938, 24.

6. Christopher R. Gabel, *The U.S. Army GHQ Maneuvers of 1941* (Washington, DC: Center of Military History, US Army, 1991), 22–23.

7. Nelson Andrews, "Nelson Andrews Discusses Frank Maxwell Andrews," Leading Voices, Lipscomb University, 10 November 2010, audio clip, 55 min.,16 sec., http://leadingvoices.lipscomb.edu/commonground/Nelson_Andrews_Discusses_Frank_Maxwell_Andrews/.

8. George C. Marshall, "Letter to Lieutenant General Frank M. Andrews," 14 October 1941, *Marshall Papers*, no. 2-577, http://www.marshallfoundation.org/Database.htm.

9. Nazi Victories News Reports by Russell B. Porter, special cable to the *New York Times*, "German Propaganda in Colombia Seen as Winning Conservatives: Fifth Columnists among Influential Part of Community Developed—They Spread Nazi View That U.S. Is Helpless," *New York Times*, 17 August 1940, 7.

10. Central Intelligence Agency, *Importance to the US of Latin American Civil Air Transport*, historical file ORE 22-49 (Langley, VA: Central Intelligence Agency, October 1950), 11. Document declassified 21 July 1992.

11. Special Cable to the *New York Times*, "Ecuador Is Sifting German Activities," *New York Times*, 25 August 1940, 28.

12. Russell B. Porter, special to the *New York Times*, "Nazi Agents Found Busy in Mexico, Viewed as Threat to U.S. Defense: 5th Column Network Reported Sowing Hatred for U.S., Planning Sabotage and Opening Way for Aid to Invading Forces; Busy Agents Spend Freely; Army Officers Approached; Official Resistance Stiffened; Landing Fields Available; Major Threat to Defense," *New York Times*, 28 August 1940, 6.

13. This mirrored the various naval fleet exercises conducted during 1923–40 and involved both conventional and nonconventional tactics. See Albert A. Nofi, *To Train the Fleet for War: The U.S. Navy Fleet Problems* (Newport, RI: Naval War College Press, 2010), 52–55, 62–63. In 1930 the US Army published a field assessment of the Panama Canal: Joseph Hamilton Grant, *A Study of the Influence of Military Geography upon the Defense of the Panama Canal Zone* (Ft. Leavenworth, KS: Command and General Staff School, 1930), 36–39. See also "National Defense: The Strategic Geography of the Caribbean Sea," *Time* 36, no. 5 (29 July 1940): 37–39.

14. "National Defense."

15. Wireless to the *New York Times*, "Stresses New Bases in Canal Air Defense: Gen. Andrews Completes 6,000-Mile Tour of Inspection," *New York Times*, 30 January 1941, 11.

16. Kathleen Williams, *Air Defense of the Panama Canal, 1 January 1939–7 December 1941*, Army Air Force Historical Studies, no. 42 (Maxwell AFB, AL: Army Air Force Historical Office, 1946), 139–40, http://www.afhra.af.mil/shared/media/document/AFD-090602-096.pdf.

17. Ibid., 141.

18. "First Air Troops Formed in Panama: Specially Trained Battalion Organized as Aerial Vanguard of Swift-Striking Force; New Trend to Air Power: Military Aviators Believe Reinforcements Could Be Sent Quickly to Aid New Unit," *New York Times*, 27 July 1941, 24.

19. Copp, *Forged in Fire*, 117–18.
20. Copp, *Frank M. Andrews*, 18–19.
21. Williams, *Air Defense of the Panama Canal*, 197.
22. Daniel P. Hagedorn, *Alae Supra Canalem—Wings over the Canal: The Sixth Air Force and the Antilles Air Command* (Paducah, KY: Turner Publishing Co., 1995), 25–26.
23. Williams, *Air Defense of the Panama Canal*, 181.
24. Charles Morris Brooks, *Guarding the Crossroads: Security and Defense of the Panama Canal* (Colombia [?]: P & P Group, 2003), 158.
25. Karl G. Larew, "December 7, 1941: The Day No One Bombed Panama," *Historian* 66, no. 2 (June 2004): 284–85.
26. Paul H. Harrison, "Study of the U.S. Air Forces' Galapagos Island Base," 28 October 1947, http://www.galapagos.to/TEXTS/USAF1947.HTM.
27. Harold Callenderbalboa, "C.Z., Our Vital Ditch: Mighty New Defenses of Panama," *New York Times*, 18 May 1941, SM8.
28. C. H. Calhoun, special cable to the *New York Times*, "Latin America Backs U.S. Vigilance: Troops at Surinam Seen a Service of Good Neighbor," *New York Times*, 30 November 1941, E5.
29. Comparatively speaking, dialogue between Marshall and Andrews was cordial (see examples 2-062, 2-219, and 2-577) whereas with Eisenhower it was instructional (see examples 3-338, 3-339, and 4-172). Marshall's tone and candor indicate deference toward Andrews, who previously outranked him during Andrews's stint as chief of GHQ. Consider the fact that during the same period of time, Eisenhower was a major serving as MacArthur's aide. *Marshall Papers*, http://www.marshallfoundation.org/Database.htm.
30. Associated Press, "Army Air Forces Unified for Canal and Caribbean," *New York Times*, 15 June 1941, 34.
31. Copp, *Forged in Fire*, 196–97.
32. John F. Shiner, "The Air Corps, the Navy, and Coast Defense: 1919–1941," *Military Affairs* 45, no. 3 (October 1981): 113–20.
33. A. Timothy Warnock, *The Battle against the U-Boat in the American Theater*, US Army Air Forces in World War II (Washington, DC: Center for Air Force History, 1993), 13.
34. Hanson W. Baldwin, "Securing Orient Aid Routes Is Navy Job: Problem of Pacific War Supplies Is Held Greater Than That of Arming Britain across the Atlantic," *New York Times*, 27 January 1942, 13.
35. Ibid.
36. Copp, *Frank M. Andrews*, 10–11, 16.
37. "Army & Navy: Indictment of the Navy," *Time* 39, no. 22 (1 June 1942): 46, http://www.time.com/time/magazine/article/0,9171,790546,00.html.
38. "Letters to the Editor," *Time* 40, no. 12 (29 June 1942): 5.
39. CAPT Arthur H. Wagner and Lt Col Leon E. Braxton, *Birth of a Legend: The Bomber Mafia and the Y1B-17* (n.p.: Trafford Publishing, 2012), 160.
40. Hagedorn, *Alae Supra Canalem*, 70–73.
41. William Wolf, *Douglas B-18 Bolo: The Ultimate Look; from Drawing Board to U-Boat Hunter* (Atglen, PA: Schiffer Military History, 2007), 156–57.
42. C. H. Calhoun, special cable to the *New York Times*, "Submarines Plague Caribbean Coast: Their Forays Raise Storm of Hostility against Axis," *New York Times*, 2 July 1942, E4.
43. Copp, *Marshall's Airman*, 23.

44. Arthur Ferguson, *The AAF Antisubmarine Command*, Historical Study no. 107 (Maxwell AFB, AL: Army Air Force Historical Studies, April 1945), 213–15, http://www.afhra.af.mil/shared/media/document/AFD-090522-043.pdf.

45. Special cable to the *New York Times*, "Canal Defenses Stronger, Gen. Andrews Says; Calls Anti-Submarine Measures 'Successful,'" *New York Times*, 18 July 1942, 5.

46. Holger H. Herwig, "Slaughter in Paradise," *Naval History* 24, no. 1 (February 2010): 7.

47. A memorandum established an interservice committee on aerial antisubmarine warfare (ASW). The Air Corps relinquished its B-24s to the Navy, which agreed to pick up ASW duties. George C. Marshall, "Memorandum for the Commander in Chief, U.S. Fleet and Chief of Naval Operations," 15 June 1943, *Marshall Papers*, no. 4-014, http://www.marshallfoundation.org/Database.htm. Additionally, prior to formal agreement, both services were collaborating on ASW tactics. See LTC Clinton Burrows, A-2, "Monthly Intelligence Report," AAF Antisubmarine Command, New York, February 1943, 7, 18–19, 25–26, 30–32.

48. Herwig, "Slaughter in Paradise," 5–7.

49. Ibid., 4.

50. Orlando J. Pérez, "Panama: Nationalism and the Challenge to Canal Security," in *Latin America during World War II*, ed. Thomas M. Leonard and John F. Bratzel (Lanham, MD: Rowman & Littlefield, 2007), 71.

51. Milton Bracker, "The New Boss of the ETO: General Andrews, Flying Officer, Comes to the European Theatre of Operations via Panama and the Middle East," *New York Times*, 28 February 1943, SM10.

52. Andrews, "Nelson Andrews Discusses."

53. Richard Overy, "The Air War in Europe, 1939–1945," in *A History of Air Warfare*, ed. John Andreas Olsen (Washington, DC: Potomac Books, 2010), 50–51.

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Realizing Operational Planning and Assessment in the Twenty-First-Century Air Operations Center

How a Refined Planning Construct and Semantic Technologies Can Enable Delivery of the AOC's Last Unsupported Functions (Part 2)*

Wg Cdr Redvers T. Thompson, Royal Air Force, Retired

Part 1 of this article discussed the problems and failings to date of operational planning and assessment capabilities across all US government command and control (C2) domains and at all levels, including ad hoc processes, the paucity of information technology support tools, and limitations of data acquisition, correlation, analysis, and visualizations.[1] It then examined the number of these shortfalls that

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one could address through the employment of an evolutionary planning construct and methodology—Comprehensive Adaptive Planning and Execution (CAPE)—and utilization of abstract semantic operational plan models (OPM) as well as operational environment models (OEM) to realign data and enable automated reasoning and inferencing across those models.

This, the second part of the article, describes how modern semantic technologies can efficiently implement—as "services" within a service-oriented architecture—the CAPE methodology, OPMs, and OEMs as a highly practical and effective planning and assessment paradigm for the US Air Force's air operations center (AOC) of the twenty-first century. This paradigm will provide hitherto unavailable resources and capabilities to commanders, planners, assessors, and analysts for timely decision making and attainment of campaign objectives. Specifically, this part of the article addresses the solution technology involved in the generation and integration of semantic planning and environment models. It then turns to the proof-of-concept implementation undertaken in a particular operational C2 domain (i.e., the tactical assessment [TA] functions within a standard AOC). While describing the specific employment developed for the TA domain, the article shows how the solution approach could benefit and be applied in a cross-domain comprehensive approach to planning, execution, and assessment. After highlighting the solution benefits of enabling the unified and dynamic C2 that this approach can deliver, it offers some conclusions.

Solution Technology: Generating and Integrating Semantic Models

Semantic Modeling of Cross-Domain Operational Plans and the Operational Environment

Central to this proposed solution approach is the use of semantic domain models—data models characterized by the use of a formal language. The latter includes directed graphs (sets of nodes connected by edges that have a direction associated with them) in which the nodes denote concepts or entities in the world and the edges denote relationships between them. These models are precise specifications of domain concepts, which define how instance data relates to each other and to real-world categories of information. They can also include the ability to express information that enables users to interpret meaning (semantics) from the instances (i.e., the discrete data model elements). Such semantic models are fact-oriented (as opposed to object-oriented). Facts are typically expressed by binary relations between data elements, such relations usually taking the form of "triples": object <relation type> object (e.g., the Eiffel Tower <is located in> Paris). Typically, instance data explicitly includes the kinds of relationships between the various data elements, such as <is located in>. To interpret the meaning of the facts from the instances, one must know the general meaning of the relations (what does it mean to be located in?). Therefore, semantic domain models typically standardize such relation types.

Semantic models, therefore, are more than just object models or data models because they can change dynamically to accommodate growth of the domain or new knowledge based on reasoning. Furthermore, semantic models can provide a standard syntax that allows formalization of the domain—the first step toward machine-assisted understanding of that domain.

Consequently, from the perspective of cross-domain operational plans, semantic modeling enables the formalizing of knowledge in a machine-readable/processable format that spans strategy design, planning, execution, and assessment across the operational environment. Encoding this knowledge in a semantic model enables automated reasoning that supports a user-defined operational picture inclusive of the user's role and information needs across domains.

As outlined in part 1 of the article, this approach enables the development of a semantic representation of an OEM that, combined with a semantic representation of an OPM, positions the approach ideally for adaptive planning. These OEMs include taxonomies ranging from facilities, equipment, and organizations to an operational environment's "soft" factors (e.g., political, cultural, and social). These semantic OEMs have two main dimensions:

- A *stereotypical* OEM is modeled after widely used data and artifacts such as Modernized Integrated Database data, products from a joint intelligence preparation of the operational environment, and inputs from operational subject-matter experts. It is classified by type and then semantically defined using a series of semantic patterns in the form of dependencies, capabilities, and vulnerabilities. Also included for purposes of operational assessment (OA) are constructs that define possible mechanisms for the measurement and indication of the achievement (or otherwise) of plan elements. Representation of these definitions enables users to reason about and make inferences toward the state of specific OEM objects and the effect of that state on related objects throughout the operational environment.
- An *instantiated* OEM offers adversary and/or campaign specificity to the stereotypical OEM. It consists of data that represents a specific adversary, battlespace, or campaign and is populated as instances of the stereotypical constructs discussed above. One can populate the majority of the instantiated OEM from Modernized Integrated Database products; however, a small but critical part of the instantiated OEM comes from products generated by joint intelligence preparation of the operational environment. Operational-process definitions within CAPE's semantic model, as well as a user's planning domain and tools, would define the necessary tasks required for creation and maintenance of the instantiated OEM, along with available tools or services used to carry out these tasks. Once populated, the instantiated OEM is related to the OPM to complete a comprehensive semantic model.

Realization of CAPE and the Semantic Assessment Engine

An implementation of the CAPE methodology has been undertaken in the context of developing a planning and OA support system. For proof-of-concept purposes, the latter was deliberately limited to the TA function within the broader OA domain.[2] The resulting actualization of the approach outlined above—the semantic assessment engine (fig. 5)—is a system designed to implement semantic technologies to integrate and analyze data in relation to the OEM and OPM. It includes four primary components: the plan reader, ingestor module, ontology engine, and network analyzer. The engine is part of a larger "system" that makes up the entire assessment engine. Other components include the application server, database, web services, and user interface. The following sections elaborate on the designs of the modules and their contribution to the technical delivery of the semantic assessment engine.

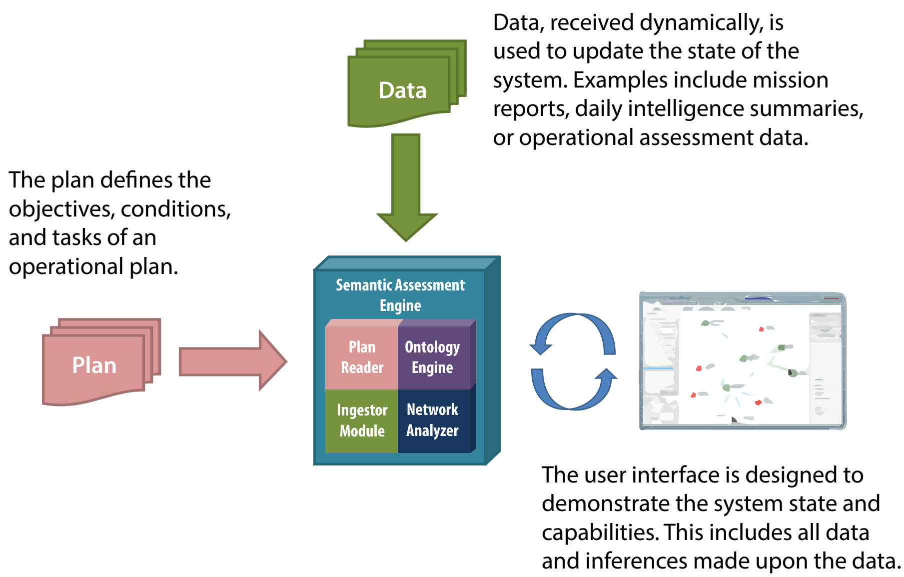

Figure 5. Semantic assessment engine

The engine begins by reading a plan based on extensible markup language from a current Air Force planning capability (e.g., Information Warfare Planning Capability or Strategic Worldwide Integration Capability) through the plan reader. It extracts plan elements and matches them with ontological structures in the OPM and OEM, categorizing them and establishing relations between the structures. The ontology undergoes an initial reasoning cycle to determine the possibility of making additional inferences to the plan. The engine checks plan entities for the presence of geographical, infrastructure, and physical dependencies and adds them to the system—for example, a hospital and power-distribution node acquiring a logical dependency due to their immediate geographic proximity (as shown in the center of fig. 2, part 1).

The ingestor module receives data from disparate sources and uses the semantic grounding mechanism—semantic patterns for actors, physical entities, concepts, and composites meshed with the relational types of capabilities, dependencies, and vulnerabilities—to identify and classify the information. The engine analyzes new messages against a set of known patterns and algorithms, and if it detects a match, passes the message data through a series of predetermined procedures for handling. Statistical data from planning or OA processes or a mission report message would fall under this category. If the data does not match any predetermined criteria, it passes to the natural language processor for data extraction—as one may find, for example, in the free-text narrative portions of a daily intelligence summary.

The natural language processor engine analyzes text by breaking down sentences or expression blocks into smaller, more manageable statements. It does so by moving statements from passive to active voice, breaking up conjunctions, and splitting up sentences based on overall complexity that includes elements such as subclauses or multiple time-manner-places (see table below).

Table. Conversion of complex to simple statement

Complex Statement	*Simple Statement*
Kennedy (subject-passive) was (aux-pass) killed (verb) in 1963.	1. Somebody (subject) killed (verb) Kennedy (object) in 1963.
Mary, John, and Joe were jumping and singing on the shore.	1. Mary was jumping. 2. Mary was singing on the shore. 3. John was jumping. 4. John was singing on the shore. 5. Joe was jumping. 6. Joe was singing on the shore.
Somebody observed local civilians traveling in the field to exchange weapons for large boxes of cigarettes.	1. Somebody observed local civilians. 2. Local civilians travel in the field. 3. Local civilians exchange weapons for large boxes of cigarettes.

Source: Attila Ondi and Anthony Stirtzinger, "Information Discovery Using VerbNet: Managing Complex Sentences," in *Proceedings of the 2010 International Conference on Artificial Intelligence, ICAI 2010, July 12–15 2010, Las Vegas, Nevada, USA*, 2 vols., ed. Hamid R. Arabnia et al. (CSREA Press, 2010), 268–76.

Extracting meaningful information from the simplified statements is an easier and more reliable task since the grammar elements more closely align with current pattern and grammar technologies.[3] General Architecture for Text Engineering breaks down sentences into their parts of speech.[4] VerbNet extracts and analyzes verbs, and WordNet—a comprehensive word database—processes all other parts of speech.[5] The extracted sentence elements then go to the semantic model to augment current definitions or provide new ones.

The ontology engine supplies the primary semantic processing for the semantic assessment engine by providing both comprehensive models of the plan and operational environment as well as the "state of the system." The Web Ontology Language (OWL)—chosen as the underlying model representation because of its good performance, expressivity, and metadata support—keeps all of this information. OWL's metadata support, which allows users to define their own properties, can extend and enhance the overall capabilities of the system, allowing for complex domain relationships. These user properties, combined with built-in OWL properties, offer a powerful platform for inferencing within a system. Examples of some of these properties include transitive and symmetric properties. A transitive property, for instance, states that for each property P, if P is a property of X and Y and if P is a property of Y and Z, then P is a property of X and Z. The preceding rule may apply to different situations; physical and logical dependencies represent one example with regard to assessment. That is, assume that site A has a critical dependency on site B and that site B has a critical dependency on site C. If site C is disabled, we can infer that sites A and B are both disabled.

Another powerful aspect of OWL is support for the Semantic Web Rule Language (SWRL), which allows users to extend properties and build complex expressions and statements for evaluating OWL ontologies.[6] For example, if entity X provides air defense cover and if Y is within X's engagement radius, then Y receives air defense cover from X. The semantic model leverages OWL and SWRL technologies to define the ontological framework. Constructs such as objects, properties, and SWRL rules are then implemented on top of these technologies to focus the domain model toward planning and assessment.

The network analyzer subsystem produces dynamic updates to the system and augments it by covering any inadequacies in the ontology models. The analyzer is implemented as a network graph that reflects the OEM and OPM as network nodes and edges. Entities in the semantic model are represented as network nodes, and the relations between the entities are graph edges (i.e., the links between them).

Further, this semantic-model-based approach readily permits the organization and presentation of data in well-formed, human-readable, and easily understandable formats. One can present hierarchical data in tree, graph, and a "line of effort" format while presenting more free-form data using concentric-viewpoint graphs. Additional visuals allow better understanding of the impact of decisions—take for example a hospital close to a high-value target. Using a standard scenario, analysts might not be cognizant of that relationship, but a means of detecting the potential link via the semantic models and a visual way of depicting the logical relationship can forewarn them of potential issues with the hospital (fig. 6).

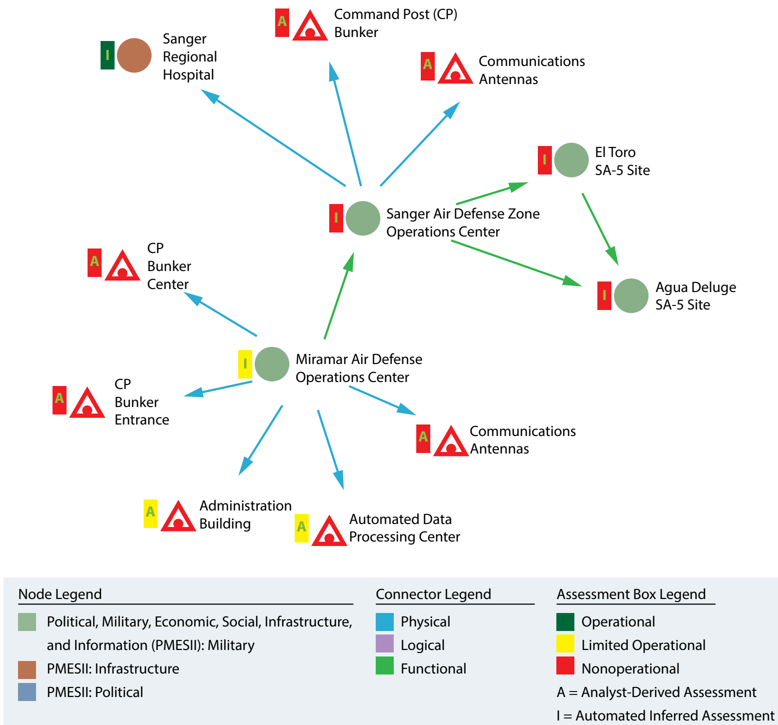

Figure 6. Visualization of OEM depicting entity states and relationships. The legend indicates the type of node and edge (link). Boxes adjacent to each operational environment node (circles) and subordinate facilities (triangles) provide related TA data. Box color indicates "system status" while the embedded "I" or "A" character indicates whether the status is "inferred" by the semantic assessment engine or formally "assessed" from within an analyst-produced battle damage assessment report.

Exemplar Solution Employment: Dynamic Tactical Assessment

Although the clear potential to employ CAPE's solution approach in cross-domain C2 at all levels of warfare was a foundational concept, the proof-of-concept implementation had to focus in on a particular operational domain. Toward that end, the exemplar case used the TA functions within a standard AOC. This section describes the specific employment developed for the TA domain and shows how the solution approach could benefit and be applied in the cross-domain comprehensive approach to the entire planning, execution, and assessment cycle.

An AOC's TA cell works directly with the operational assessment team in the strategy division:

> The purpose of TA within the AOC is to provide physical, functional and target system assessments that the [operational assessment team] will use to answer the following question, "Have our forces achieved the desired effects and ultimately, the JFACC's [joint force air component commander's] objectives?" The TA cell must be thoroughly familiar with JFACC objectives, the [operation plan], other component commanders' objectives, sortie allocation and target systems being analyzed.[7]

The TA cell uses existing targeting tools and databases, spreadsheets, e-mail, chat, and various other manual means to track mission completion and results to aggregate those results and report them to the operational assessment team. The cell will likely have responsibility for creating physical-damage and functional-assessment reports on specific target systems contained in battle damage assessment reports. Currently, the data-intensive TA processes require largely manual correlation of incoming data (e.g., mission reports, outside battle damage assessment [BDA] reports, etc.). Because of limitations in existing AOC systems, TA analysts must track mission changes and associate both mission results (from mission reports) and target statuses (from BDA reports) back to their corresponding strategy elements (e.g., tactical tasks) with no automated assistance.

Due to the overwhelming amount of incoming data, TA cells typically struggle to maintain awareness of mission results and target status changes and then report on their assigned target systems. They do very little, if any, in-depth analysis and make few recommendations beyond those based on a planned strike's not producing its direct effect on the target (i.e., a "reattack recommendation"). These limitations in current processes largely disappear with the employment of the semantic assessment engine, which will give the TA cell the following capabilities:

- Fully maintained relationships between plan and operational environment elements.
- Automated data gathering and correlation.
- Automated first-order evaluation of evidence against measures and indicators.
- Multiple ways to visualize information based on user roles.

Relationships between the Plan and Operational Environment

As discussed in part 1 and shown in figure 1, the CAPE construct is implemented in the OPM and can include all entities and relationships within a plan. For the AOC, one must remember that the "plan" isn't simply captured in a single artifact but in the dynamically evolving joint air operations plan, daily air operations directives, multiple joint integrated prioritized target lists, and daily air tasking orders, all of which provide the actual plan elements included and maintained in the OPM. One finds the planning relationships between objectives and tasks in the joint air operations plan and air operations directive, and the plan relationships between tasks and targets in the joint integrated prioritized target list. Finally, the air tasking order includes the planning relationships between targets and missions. All targets (i.e., a plan's *objects of action*) are also represented in the OEM as objects existing in the operational environment, along with any relationships between them.

Currently, because a singular AOC system does not maintain these relationships between the plan and operational environment, one must do manual reasoning across these different elements. The semantic assessment engine, however, dynamically updates models as information becomes available, and analysts can easily search the models for effects or allow the network analyzer to assist in reporting more complex indications of effects.

Relationships between elements of a plan and objects in the real world are not unique to air operations or even to military operations in general. Any structured plan (e.g., humanitarian assistance or stability operations) seeking to effect change in an environment can be represented by OPM and OEM interactions.

Data Gathering and Correlation

At present, the greatest challenge for a TA cell lies in acquiring, managing, and making sense of the large amount of data needed to assess tactical actions. New tools and databases have been developed to assist with data gathering and management for structured messages, but capability gaps remain with regard to parsing and correlating both structured and unstructured messages to the appropriate objects in the environment and associated plan elements. For example, a mission report for "mission X" arrives that depicts the results of a strike against "target Y." Because of the structured format of the report, it is relatively easy to correlate mission X and target Y to the associated tactical task through the associations maintained in the OPM and OEM. However, a daily intelligence summary—unstructured text—may also include information pertinent to the same tactical task. The semantic assessment engine's ingestor engine and its natural language processor engine can analyze this unstructured prose to extract relevant information, semantically relate it to model elements, and present it to the user. Therefore, the semantic assessment engine can automatically correlate both structured and unstructured text with little to no user interaction. These data-gathering and correlation capabilities inherent in the engine are applicable beyond the AOC environment, with many interagency organizations bogged down by the vast amounts of data that need processing and analysis. The semantic assessment engine speeds this process greatly by automating the basic correlation and processing of the information to allow users to concentrate on higher-level cognitive tasks.

Evaluation of Evidence

Well-developed operational plans include methods for evaluating those plans. *Measures of effect* and *measures of performance* are among the common terms used in the AOC. Collectively, these measures and indicators must be individually evaluated, based on incoming evidence contained in messages and other data sources.

In addition to basic correlation and parsing of messages, the semantic assessment engine assists the assessment analyst with the evaluation process. TA is primarily concerned with evaluation of the measures and indicators associated with tactical tasks, often requiring aggregation of results against a group of targets. The engine's network analyzer allows the analyst not only to see the results against individual targets and groups of targets but also to evaluate the relationships between directly affected targets and other objects in the operational environment. Again, the evaluation of evidence is not just an AOC TA cell issue. One must be able to compare new information against a standard measure in many endeavors across a myriad of operations and environment domains. Within the C2 domain, that ability remains critical to understanding whether desired effects are being produced.

Information Visualization

As explained in the section on solution technology, visualizing information is also an important aspect of this evolving capability. Despite the importance of processing information through the semantic assessment engine, it has only marginal benefit if it cannot present that information to the user. Figure 7 offers another example of a visualization developed to help commanders, planners, assessors, and analysts see the relationships between plan elements and objects in an operational environment as well as relationships between various domains and levels of a full campaign plan. This tactical-level visualization depicts a mission task with its assigned target and four facility elements within that target, along with color-coded assessment boxes (as described in the caption of fig. 6).

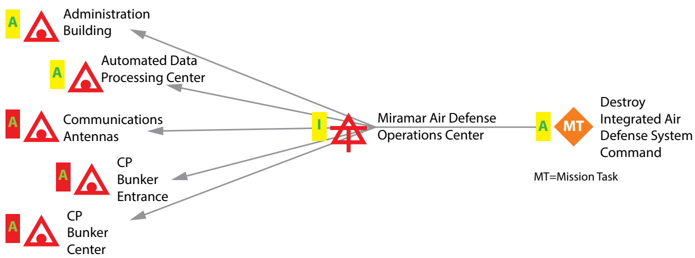

Figure 7. Visualization of both OPM and OEM elements

These types of views give all users additional ways of understanding information beyond the common tabular and tree views used on most systems today. The value of visualization lies in its utility to the user. Because of the semantic relationships maintained in an OPM and OEM, the options for visualizing the data contained therein are almost limitless. Views can be created for any level of war, instrument of power, or organization—based on the needs of each discrete user.

Solution Benefits: Enabling Unified and Dynamic Command and Control

Employment of CAPE's logical construct, semantic OPMs and OEMs, and the semantic assessment engine offers several significant benefits to the Air Force's C2 domain. The solution also has broad application across military, government, interagency, and coalition domains at all levels (strategic, operational, and tactical). Although this article has detailed only the initial proof-of-concept implementation for the AOC's

TA domain, at this writing, that implementation has been successfully extended to encompass the vast majority of the currently stated operational requirements for an AOC's higher-level operational assessment functionality. When combined with an analysis engine to reason across them, this demonstrated TA and OA functionality—along with the related semantic models that reflect the operational plan and environment—has clear potential to assist C2 planning, execution, and assessment in any domain.

This CAPE-based approach allows automatic generation of an OPM during operational design or plan development. The associated process identifies constituent objects of action, objects of effect, and causal links, enabling automatic creation of an initial plan-centric OEM if a broader, intelligence-prepared OEM does not already exist. Additionally, during later planning or subsequent operations, open-source information, intelligence reports, and/or TA and OA outputs update operational environment data within an OEM. When that data affects OEM entities and links identified as also existing in the OPM (i.e., within the plan), appropriate updates and warning flags can be generated for the user—whether analyst, assessor, planner, or commander.

The approach will also allow an operation's OPM, OEM, and their interactions to produce algorithms enabling multiple visualizations of an operation's plan, execution, assessment, and environment. For instance, they could highlight key relationships that must be managed for mission success (e.g., a planning visualization that helps cyber and air strike planners synchronize interdependent actions). Further, they can support complex analysis activities, such as an OA visualization that allows users to "drill down" through objectives, tasks, and associated measures and indicators to understand the underlying cause of poor performance against a particular objective.

Moreover, the solution approach takes full advantage of existing web services, databases, and other data sources. The approach does not require a new "system" with a unique architecture. Rather, the realized solution, using CAPE, semantic models, and the semantic assessment engine, was developed from the outset as web services within a service-oriented architecture, aimed at taking full advantage of any existing services within the current C2 domain.

At the time of submitting this article, this solution approach had been implemented as an advanced proof-of-concept demonstration for the Air Force Command and Control Integration Center under the umbrella name *Command and Control Toolbox*, that term representing the intention of developing a broad family of service-oriented-architecture-based tools for C2. In early October 2012, the center hosted a successful demonstration of the first of those intended tools—an integrated tactical assessment and operational assessment prototype capability, or Command and Control Toolbox for Assessment. Following that demonstration, the Air Force Targeting Center expressed interest in a potential Command and Control Toolbox for Targeting and Target Development. Similarly, Air Force Materiel Command expressed interest in the approach and a potential Command and Control Toolbox for Agile Logistics that could enable the dynamic integration of operations planning and associated logistics planning. Further, US Central Command has indicated that it would favor an operational transition of these concepts and their technical implementation to support combat assessment at the combatant command level.

Conclusion

This article has explained how the variability of extant planning and assessment constructs and terminology, data sources, analyst confidence, and the ability to readily understand and visualize operational schemes, plans, and evidence from the operational environment all form obstacles to effective campaign development and integration. Moreover, it has demonstrated how problems related to the access, collation, and analysis of related planning and assessment data compound those issues. It proposes that one address these current C2 deficiencies by utilizing CAPE, an evolutionary planning construct, and abstract semantic models of both operational plans and operational environments to realign and relate data as well as enable automated reasoning and inferencing across those models. With the CAPE-based solutions in play, cross-domain commanders and staffs, as well as interagency, coalition, and nongovernmental organizations, will be able to communicate operational meaning and intent in a more structured, well-understood way. Further, those solutions will open the door for technology to truly assist (through semantic reasoning) in operational design, plan development, execution, and assessment.

Given the appropriate tool support, an OPM can—in real time or as required by the user—interact with any or all available operational environment data or OEMs. For the first time, this would permit both interactive, real-time feedback during course-of-action and detailed plan development and high-fidelity strategic, operational, and higher-tactical war gaming. During operations, this approach would enable the realization of "living" plans through the constant interaction of the "living" OPM of the ever-morphing operational plan with streaming and changing outputs from the "living" OEM—constantly updated with data from both open-source and intelligence reports, execution data from live operations, and outputs of tactical-, operational-, and strategic-assessment processes.

The author believes that, just as there are few technological impediments to rapidly realizing this approach across all of the Air Force's AOCs and, indeed, the wider joint planning community, so should there be few impediments associated with interservice "operational culture." This is true primarily because the underpinning CAPE construct is a "best of breed" evolution of existing joint operational design and planning constructs, now having the innovative benefit of ontological definitions of, and syntax for, *all* elements of the construct—something sadly missing currently. Second, the use of a service-oriented-architecture-based implementation makes the solution set readily available to any and all domains yet gives each one the continued use of its existing planning systems and tools, from which it can simply import and "translate" the necessary artifacts.

Since several Air Force operations-support communities already recognize the potential of the Command and Control Toolbox, the author recommends similar expeditious consideration within the service's key operational C2 communities, particularly for Air Force forces and AOCs. This is especially prescient as the Air Force will imminently embark on the long-awaited replacement of its AOCs' current weapon system with the next-generation 10.2 weapon system, "intended to develop, field, and sustain modular net-centric [C2] applications and data management solutions for current and future C2 systems."[8] Therefore, if the AOC community, its weapon system program managers, and the Air Force Command and Control Integration Center's "capability integrators" can quickly recognize and endorse this solution approach, it is possible that the new AOC 10.2 weapon system could become the key program vehicle to "hosting" this service-oriented-architecture-based Command and Control Toolbox capability. In turn, this would allow the Air Force, after many, many years, to enable the effective delivery of both operational planning and assessment—the AOCs' last unsupported functions. Additionally, and more broadly, it would also allow the service to take the lead within the Department of Defense and joint community in making an innovative contribution to enabling unified and dynamic C2 appropriate for the twenty-first century. ✪

Notes

1. This article is an abridged, amended, and updated version of the following: Redvers Thompson, Anton DeFrancesco, and Phil Warlick, "Enhancing Command and Control (C2) Assessment through Semantic Systems" (paper presented at the 16th International Command and Control Research and Technology Symposium, Québec City, Canada, 21–23 June 2011), http://www.dodccrp.org/events/16th_iccrts_2011/papers/135.pdf.

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7. Air Force Tactics, Techniques, and Procedures 3-3.AOC, *Operational Employment—AOC*, 1 November 2007, par. 6.4.2.2.

8. "D—Command & Control Information Svcs (C2IS) & C2 Air Operations Suite (C2AOS)," FedBizOpps.gov, 1 February 2012, https://www.fbo.gov/index?s=opportunity&mode=form&id=bda84bb9831f39b6cc393aabc80a59d3&tab=core&_cview=1.

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Tanker Acquisition

A Systems Engineering Perspective

Maj Sarah Lynch, USAF
Dr. Alan R. Heminger
Lt Col Daniel D. Mattioda, PhD, USAF

A short examination of air refueling, specifically its past, present, and future, offers valuable insight into the developmental needs of this critical capability. This article seeks not only to showcase an appreciation for the roots of air refueling but also to highlight the requirement for sound systems engineering in conjunction with the creativity and willingness to take risks, as exhibited by our forefathers in the field. These attributes are vital to furthering air-refueling technologies and capabilities as well as refining the somewhat flawed tanker-procurement process employed today.

The Birth of Air Refueling

Lt Col Stanley Dougherty asserts that no aircraft in the US Air Force inventory can conduct responsive global power projection without air refueling; quite simply, tankers are the cornerstone of global reach—global power.[1] Early conceptualizations of air refueling consisted of daring, brute feats of bravery and courage. According to the Office of the Historian at Headquarters Strategic Air Command, the history of air refueling began in 1918 when Lt Godfrey L. Cabot, a US Navy Reserve pilot, began snaring cans of gasoline positioned on floats.[2] This undertaking was designed to test the feasibility of putting fuel on ships in such a way that aircraft could access it and refuel during transatlantic flights. On 2 October 1921, rudimentary flight refueling took place in Washington, DC, when a Navy lieutenant in the rear cockpit of a Huff-Daland HD-4 aircraft used a grappling hook to snatch a five-gallon can of gasoline from a float in the Potomac River. A Long Beach "publicity stunt" marked the first true "air-to-air" refueling on record when Wesley May, a wing walker with a five-gallon can of gasoline strapped to his back, climbed from a Lincoln Standard onto a JN-4 and then poured the gasoline into the tank of the second aircraft. In April 1923, two US Army Air Service de Havilland DH-4Bs demonstrated the feasibility of transferring fuel between aircraft by performing the first in-flight hose contact, all under the direction of Maj Henry H. "Hap" Arnold. Later that year, the Army Air Service conducted its first successful air refueling: Capt Lowell H. Smith, along with Lt John P. Richter, set new records for duration and distance, culminating in one flight of more than 37 hours—made possible by 15 hose contacts. In January 1929, the flight of the *Question Mark* established the practical value of air refueling and tested the endurance of both crew and aircraft. Commanded by Maj Carl A. Spaatz, the modified Atlantic (Fokker) C-2A remained airborne for an astonishing six-plus days until engine problems forced it to land. Two modified Douglas C-1 biplanes played the role of tankers, passing 5,700 gallons of fuel as well as oil, food, and water to the receiver aircraft over the course of 37 hookups.[3] Spaatz, who later became the first Air Force chief of staff, proposed that all future aircraft acquisitions be equipped for air refueling during manufacture.[4]

Spaatz was not alone in his unwavering support for the development of air-refueling capability. Giulio Douhet, the Italian airpower theorist, considered range the defining characteristic that distinguished airpower from land or sea power; in his eyes, extended range equated to strategic effect. During his tenure as Air Force chief of staff (1948–53), Gen Hoyt S. Vandenberg directed that all future tactical aircraft be capable of air refueling.[5] Further, Maj Gen Perry B. Griffith asserted that "no single innovation of recent times has contributed more to air power flexibility than the aerial tanker."[6] Gen Curtis E. LeMay was such a staunch proponent of air refueling that he declared, "If you gave us money for jet airplanes, I would buy tankers, not airplanes for MATS [Military Air transport Service, ancestor of Air Mobility Command]. . . . I think we would increase our combat capability more in that manner."[7] Dougherty affirms that air refueling still serves as a force multiplier by increasing the speed, range, lethality, flexibility, and versatility of today's airborne weapon systems through the extension of aircraft range to the limit of the aircrew.[8]

At this point, air refueling as we know it today began to develop. In 1948 Boeing proposed the flying-boom concept, and shortly thereafter Strategic Air Command procured the KC-97 (fig. 1). Next came the Dash 80 in 1954 and, finally, in 1957 the first of a generation of tankers still in use today—the KC-135A. Figure 2 depicts the legendary Dash-80 barrel roll, showing the wing inverted with the engines balanced precariously on top. Rumor has it that this particular demonstration was the impetus for proceeding with the purchase of the Dash-80 derivative of the Boeing 707—not the most objective or systems-engineering-oriented approach to procurement that the military tries to adhere to today!

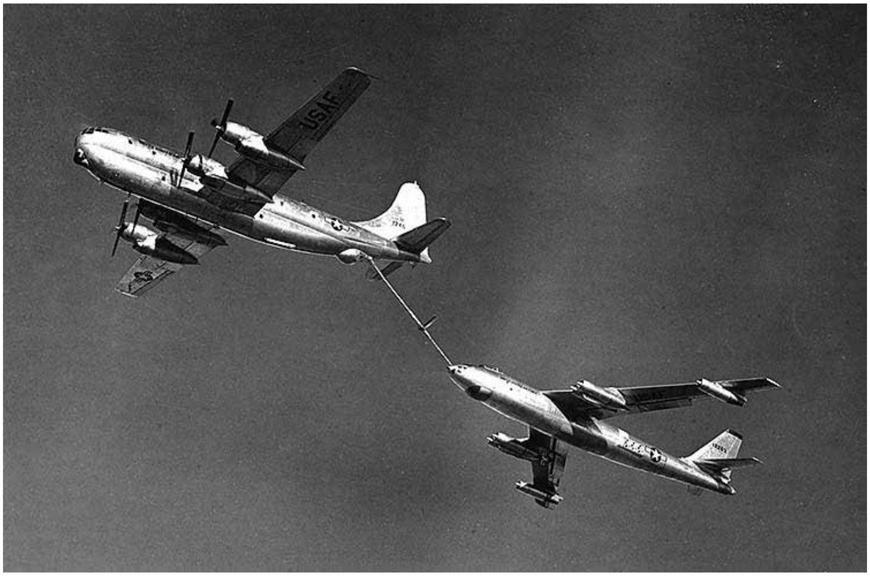

Figure 1. KC-97. (Reprinted from the National Museum of the Air Force, accessed 14 February 2013, http://www.nationalmuseum.af.mil/photos/media_search.asp?q=kc-97&btnG.x=30&btnG.y=8.)

Figure 2. The legendary Dash-80 barrel roll. (Reprinted with permission from Boeing Images, accessed 6 March 2013, http://boeingimages.com.)

Air Refueling Today

Air refueling alleviated strategic airlift's dependence on en route basing, dramatically increasing airlift's effectiveness and efficiency. Specifically, air refueling accelerates the operations of an air bridge—an airborne line of communications linking the continental United States and a combat theater—by reducing or even eliminating refueling stops. In 1991 during Operation Desert Storm, tankers enabled both additional speed and mass of attacks by concentrating combat power at a decisive place and time; they also afforded a vital margin of safety by providing airborne fuel reserves. Air Force officials at US Central Command emphasized the fact that the air campaign depended heavily upon these aircraft: "Tankers were the most critical limitation."[9] The tanker air bridge for Somalia in 1993, which extended nearly halfway around the world, proved that air refueling was a greater force multiplier than previously realized.

The North Atlantic Treaty Organization's (NATO) Joint Air Power Competence Centre (JAPCC) offers vital insight into the international perspective on the role of air refueling. According to the JAPCC, the primary air-refueling effect is "spatial or temporal extension of other air capabilities by providing additional fuel to airborne aircraft."[10] Second-order effects of this extension include enhanced flexibility, fewer operating locations, and increased payload capacity. Further, the JAPCC identifies the relevant measures of merit for the effect as reliably delivering the right amount at the right time in the right place. Consistent with Air Force doctrine, the JAPCC considers air refueling "an enabling or supporting effect instrumental to accomplishing ultimate air effects."[11]

Tanker Procurement and Systems Engineering

Despite the proven significance of air refueling in doctrine, more recent tanker procurement has proven controversial, and the acquisition process has not reflected its criticality. As Maj David Mazzara points out, "Despite its [significant contribution] to airpower, [air-refueling] technology has evolved little in the last 50 years. . . . The Air Force [still] uses the same basic refueling systems designed for Strategic Air Command (SAC) over a half-century ago."[12] Moreover, procurement of the current tanker fleet has occurred in a strikingly similar fashion for each platform: the Boeing 707 became the KC-135, the McDonnell Douglas DC-10 became the KC-10, and, most recently, the Boeing 767 finally became the KC-46. In essence, the procurement of tankers has followed a model of retrofitting an existing airframe for the purpose of the air-refueling mission. Maj Robert Basom emphasizes that

> an enormous advantage of . . . [proceeding in this fashion] is the cost savings, reaped from previous civilian research and development efforts. [An additional] advantage is time compression from design, flight testing, and operational delivery [since] the basic airframe has already received its air-

> worthiness certificate . . . [and only] requires . . . minor testing of the [added] air refueling . . . systems.[13]

On the other hand, the procurement process used thus far contradicts the very fundamentals of good systems engineering, which, according to the International Council on Systems Engineering, is

> an interdisciplinary approach . . . [that includes a] means to enable the realization of successful systems. [It reaches this goal by] defining customer needs and required functionality early in the development cycle, documenting requirements, [and] then proceeding with design synthesis and system validation while considering the complete problem. Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. [Finally, it] considers both the business and the technical needs of all customers with the goal of providing a quality product that meets . . . user needs.[14]

Thus, with respect to the field of air refueling, a good systems-engineering approach would suggest that all stakeholders come together to identify capability gaps that the Air Force, as the service provider, then seeks to fill for all of its customers.

A final point on the evolutionary progression of air refueling deals with the United States' enjoyment of a virtual monopoly on air-refueling assets since the mission's very inception. According to the 2012 *Air Mobility Master Plan*, the Air Force's fleet of tankers consists of 59 KC-10s and 414 KC-135s—well over and above that of any other nation in the world.[15] Hence, the service is the primary provider worldwide to Air Force, Navy, and Marine receiver customers, as well as to our coalition and NATO partners who need tanker support. This particular point may contribute to the US military's complacency in the technological and conceptual advancement of this critical mission set.

Air Mobility Command maintains that its overall goal calls for meeting global air-refueling requirements; it acknowledges, however, that those requirements are not expected to diminish in the coming years. In fact, they will most certainly increase over the next 25 years and thereafter, resulting in the need to fill an ever-growing gap in force extension. The two main reasons for this upward trend are the growing challenges of regional antiaccess/area-denial strategies together with the development and fielding of remotely piloted combat air systems, both of which will drive the demand for air refueling above and beyond its current level.[16]

Summary

The Department of Defense must not rest in its pursuit of advancements in the field of force extension. Future war-fighter issues such as antiaccess/area denial are sure to take a greater toll on our aging fleet of tankers, as well as intensify the existing requirement to close the widening force-extension gap. Basing future procurement decisions on sound principles of systems engineering is critical. More importantly, we must be willing to exhibit the bravery and courage of our forefathers in air refueling; only then can we develop effective processes to correct inefficient tanker-procurement practices, particularly in today's fiscally constrained environment. ✪

Notes

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16. Ibid., 142.

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Dr. Heminger (BA, University of Michigan; MS, California State University–East Bay; PhD, University of Arizona) is an associate professor of management information systems at the Air Force Institute of Technology, Department of Systems Engineering and Management. He has a background in networked collaborative work systems, strategic information management, and business process improvement. Dr. Heminger has undertaken research and consulting for Air Force and Department of Defense agencies, including Air Force Materiel Command, the Air Force Research Laboratory, the Air Force Center for Systems Engineering, Air Force Special Operations Command, the Air Force Office of the Chief Information Officer, the Air Force Communications and Information Center, the Defense Threat Reduction Agency, the 689th Combat Communications Wing, and the Defense Ammunition Center.

Lt Col Daniel D. Mattioda, PhD, USAF

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MacArthur's Airman: General George C. Kenney and the War in the Southwest Pacific by Thomas E. Griffith Jr. University Press of Kansas (http://www.kansaspress.ku.edu/), 2502 Westbrooke Circle, Lawrence, Kansas 66045-4444, 1998, 368 pages, $39.95 (hardcover), ISBN 978-0-7006-0909-3.

The assertion that the best history is biography seems especially true when the subject of the biography proved instrumental in the implementation of significant military operations during World War II, not to mention his major contributions to and influence on the postwar Air Force. One finds that story in *MacArthur's Airman* by Thomas Griffith Jr.

The book begins by recounting General Kenney's formative years in Nova Scotia, the son of parents whose rich ancestry included voyagers on the *Mayflower*. Although the author does not delve into the details of family problems, the sudden departure of Kenney's father suggests that such issues did exist. The future general attended the Massachusetts Institute of Technology but dropped out, claiming he was bored with school. Europe was preparing for war, and Kenney, influenced by air shows and aerobatic demonstrations common in the early twentieth century, joined the Army to fly airplanes. From that point on, Griffith discusses Kenney's career, his experience in World War I, and the events and associations that led to his assignment as the top air commander in the Pacific theater during World War II.

A forward-thinking man, Kenney was among the first to understand the true function of air superiority—to gain control of the airspace, not simply conduct operations in it. In fact, the author points out that Kenney's strategy, effectiveness, and advocacy for total air superiority may have influenced operations led by his counterparts in the European theater during the war.

Griffith provides a balanced view of Kenney, praising him for his management style, knowledge, and vision concerning the use of airpower, and for his relationship with Gen Douglas MacArthur. At the same time, he does not ignore Kenney's more controversial traits and positions, such as his racist attitude toward the Japanese, the controversy over the B-29, his disputes with Gen Henry "Hap" Arnold, and the constant quarrels with his Navy counterparts. Kenney could check his ego and decentralize decision making for tactical operations, but that same ego and quick temper hindered his relationship with the Navy and perhaps impaired some operational missions.

I found *MacArthur's Airman* a well-researched, well-written, and fairly detailed account of the air campaign in the Southwest Pacific. Some readers may wish to read the concluding chapter, a good summary of the book, before venturing into the chapters dealing with the air war. Readers seeking a biography strictly designed to entertain will probably be disappointed. Granted, the first three chapters offer details about Kenney's youth and early military career, but most of the book examines the air campaigns under his leadership. Those interested in military history will find it an excellent resource. In the introduction, the author points out that he does not intend to dissect individual air engagements and that readers should look elsewhere for that information; nevertheless, the air campaigns seem to receive thorough treatment.

As an Airman, I appreciated the discussion about air employment that made General Kenney a great success. His critique of close air support and acceptance of interdiction operations demonstrated his forward thinking. Moreover, Kenney's conduct of mobility operations and his use of engineering knowledge to push for better bomb fuses and the construction of new airfields to advance MacArthur's army revealed his innovative nature. Readers can also garner lessons and practices from the general's leadership abilities. I admire his management style as well as the trust he placed in the officers and enlisted men under his command.

All told, I enjoyed *MacArthur's Airman* and recommend it both to my fellow Airmen and to readers interested in military history in general. Though at times overshadowed by the European theater, the war in the Pacific was no less dynamic, producing one of the great airpower advocates of all time.

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America's School for War: Fort Leavenworth, Officer Education, and Victory in World War II by Peter J. Schifferle. University Press of Kansas (http://www.kansaspress.ku.edu/), 2502 Westbrooke Circle, Lawrence, Kansas 66045-4444, 2010, 304 pages, $39.95 (hardcover), ISBN 978-0-7006-1714-2.

In light of the recent academic debates regarding the value of professional military education (PME), Peter Schifferle has serendipitously produced a book that reminds us what PME can do for the nation. His work, which rightfully should be considered a companion to Timothy Nenninger's *The Leavenworth Schools and the Old Army: Education, Professionalism, and the Officer Corps of the United States Army, 1881–1918* (Greenwood Press, 1978), presents a balanced look at the role of the Fort Leavenworth school structure in the interwar period, with special emphasis on the Command and General Staff School. In doing so, he successfully depicts the education provided at Leavenworth as important to the Army's success in the Second World War.

Schifferle outlines the reopening of the Leavenworth school structure following the First World War and the predominant influence exerted by American Expeditionary Force veterans in shaping the postwar curriculum and teaching methodology, thus painting a nuanced picture of the interwar US Army. Rather than serve up the leisurely, ultraconservative institution often portrayed, he presents an officer corps grappling with an uncertain future in a time of fiscal austerity that—even in today's environment—American officers can only imagine. The author makes clear how Leavenworth's educational efforts fit into the Army's doctrine under the National Defense Act of 1920. Specifically, the education of regular officers was designed to provide the core framework around which a massive mobilization would take place in the event (assumed by many people) of another European war. Additionally, he depicts the schools as forward thinking and concerned with employing mobile warfare and breaking through static defensive fronts long before the successes of the German offensives of 1939 and 1940.

Schifferle addresses the notion that deciding how to teach is just as important as determining what to teach. In this regard, the degree to which Leavenworth embraced the applicatory method (graded problems, map exercises, and the like) was paramount. By taking great pains to refute the oft-mentioned critique of rigidity towards "school solutions," the author opposes the conclusions drawn by Jörg Muth in his book *Command Culture: Officer Education in the U.S. Army and the German Armed Forces, 1901–1940, and the Consequences for World War II* (University of North Texas Press, 2011). Schifferle's argument that students were not unduly burdened and stifled by overly constrictive adherence to these solutions is more much persuasive then Muth's.

Though a faculty member at the Command and General Staff College's School of Advanced Military Studies, the author does not engage in boosterism. He points to several clear shortcomings of Leavenworth's interwar approach—foremost the dearth of Supply Corps and Air Corps topics as well as the outsized resistance to a one-year (versus two-year) curriculum. Throughout, he presents alternate views to his conclusions in a complete manner—not the traditional "straw men" that some historians use.

Any PME graduate will read with interest descriptions of the intense pressure, late evenings, and stringent grading of the interwar period. In an era when reduced budgets limited the opportunity for officers to lead large formations, they attempted to compensate through PME. Obviously, *America's School for War* offers lessons for our own future. Overall, Schifferle's work is well presented, well researched, and instructional to anyone concerned with the development of PME or the interwar Army.

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Fast Tanks and Heavy Bombers: Innovation in the U.S. Army, 1917–1945 by David E. Johnson. Cornell University Press (http://www.cornellpress.cornell.edu), Box 6525, 750 Cascadilla Street, Ithaca, New York 14851-6525, 1998, 304 pages, $79.95 (hardcover), ISBN 978-0-8014-3458-7; 2003, 304 pages, $24.95 (softcover), ISBN 978-0-8014-8847-4.

Between World War I and World War II, Congress and the public largely ignored the US Army, starving it for funds and attention. Conventional wisdom holds that a small corps of professionals struggled mightily during those dark days to create modern doctrines for armored and air warfare. Although partially successful, these dedicated officers could not overcome the paucity of funding, and the Army entered World War II deficient in key weapons, such as heavy tanks that could challenge German Panthers and Tigers head-on as well as long-range escort fighters that could protect the Flying Fortresses and Liberators on their way to Berlin and back. Most importantly, the Army lacked a combined-arms doctrine that could integrate tanks and tactical aviation to best advantage.

David Johnson, a retired Army field artillery colonel and senior political scientist at the RAND Corporation, assails the conventional wisdom in *Fast Tanks and Heavy Bombers*. Yes, the Army was neglected and underfunded between the wars, but the intellectual blind spots of the men who developed Army doctrine prior to World War II had more to do with the Army's shortcomings than any funding shortfall. Choosing armor and airplanes as the two technologies that offered the most promise for changing the face of battle after World War I, Johnson finds that the two innovative weapons had both advocates and detractors during the interwar period. Visionaries could foresee hordes of tanks sweeping the battlefield or fleets of bombers flattening strategic targets in the enemy homeland, but the Army hierarchy remained wedded to the idea of a mass army with infantry at its core, with tanks and airplanes as supporting elements, albeit valuable ones.

The doctrines developed by the Army for using tanks and airplanes reflected this core understanding. Tank development was split between the infantry and the cavalry. The infantry wanted tanks to punch holes in enemy lines for foot soldiers. Modernizers in the cavalry saw tanks as mechanical horses, primed for exploitation of a breakthrough and raiding enemy rear areas, while traditionalists desperately defended the horse as a weapon of war. Neither foot nor horse soldiers envisioned tanks fighting tanks, instead seeing the new weapons in terms of their traditional missions (e.g., fast tanks with lighter cannons optimized for antipersonnel or antiobstacle attacks). Airmen saw bombardment aviation as the way to bypass the morass of the battlefield. Bombing could win the war by battering enemy industry and morale and, not incidentally, prove that airpower deserved a separate military service. Attack aviation on the battlefield realized neither goal and became neglected. Thus, long-range bombers with heavy defensive armament attacked precision targets by daylight—in short, fast tanks and heavy bombers.

By placing airpower and armor side by side, Johnson deftly illustrates the organizational, intellectual, and bureaucratic influences that go into the formulation of doctrine. The Army developed fast tanks and heavy bombers because it wanted to—not because of external constraints. As the present Department of Defense enters a period of fiscal austerity, it should keep Johnson's conclusions firmly in mind.

The author's research is thorough, plumbing multiple archives, service journals, memoirs, interviews, and official publications. His writing style is fluid and enjoyable to read. *Fast Tanks and Heavy Bombers* is almost entirely free of typographical errors but includes no illustrations. I highly recommend it.

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Death from the Heavens: A History of Strategic Bombing by Kenneth P. Werrell. Naval Institute Press (http://www.usni.org/), 291 Wood Road, Annapolis, Maryland 21402, 2009, 400 pages, $49.95 (hardcover), ISBN 978-1-59114-940-8.

Death from the Heavens is a detailed assessment of strategic air bombardment carried out by aircraft ranging from dirigibles, whose crew members literally tossed bombs down on London in 1917, to today's drones, launched to kill one terrorist wherever that enemy might be. At the end of the First World War, the four leading nations that fought on the western front were determined not to repeat the bloody trench warfare that had destroyed a generation of young men. France constructed a static row of fortresses along its border with Germany called the Maginot Line while Germany developed highly mobile ground forces aided by tactical aircraft to produce a blitzkrieg. Both Great Britain and the United States responded by relying on airpower. During the Second World War, although the Allied and Axis powers "made widespread use of air power, only the Americans and British employed strategic bombardment on a grand scale" (p. xiv).

The doctrine of strategic airpower requires the use of fleets of heavy, long-range bombers, their very existence expected to deter an aggressor. If that failed, however, "strategic bombardment strikes the enemy's homeland, bypasses its armed forces, and directly hits the source of power, be it physical targets, such as war industry, or population centers to destroy the will of the people to continue the conflict" (p. xv). Winston Churchill and Franklin Roosevelt endorsed the doctrine, and so-called bomber barons in Britain and the United States wholeheartedly supported and executed it, the Americans insisting that a landing in Normandy would be unnecessary.

Nevertheless, as author Kenneth P. Werrell reveals in this detailed examination of doctrine and execution, that promise exceeded its grasp. Despite the devastating bombardment of German and Japanese cities, what the people might have "willed" had no impact on the course of the war. Nor did it destroy the capacity of the enemy to continue the struggle: "Air power was important to Allied victory, but it was just one of several factors that won the war. . . . In hindsight it appears that the connection of air power with cutting technology, the romance of aviation, and the spotlight of wartime publicity gave the airman more credit than their actions deserve" (p. 125). Thus, Alexander de Seversky's *Victory through Air Power*, a classic example of wartime propaganda, proved to be a fantasy.

The author's assessment of the strategic bombing attacks on Germany and Japan seems certain to draw fire. Controversy continues to surround the firebombings of Hamburg and Dresden as well as the destruction of Hiroshima and Nagasaki. It arises not from the decision to attack legitimate military targets but from an attempt to end the conflicts by targeting population centers, thereby killing and maiming thousands of women, children, and the elderly. Although the morality of the strategic bombing of population centers remains debatable, the author notes that it should be kept in context:

> Moralists critical of strategic bombing should consider the results of the World War I Allied blockade that starved to death 800,000, certainly mostly women, children, and old men. . . . While this does not excuse the situation, it provides some context. That is, the great evil is not strategic bombing but war itself. . . . Is the death of some innocents worth the saving of the lives of some combatants or other innocents either directly or by shortening the conflict? (p. 154)

This practitioner and student of airpower much appreciates the author's going beyond the tenets of strategic bombing and the results achieved (or not achieved) to describe in some detail the "strategic delivery systems" (p. 300) from Germany's Gotha bomber of the First World War to today's stealth aircraft, and from Germany's V-2 rockets of the Second World War to today's four-stage Peacekeeper. Looking (more like glancing) at ballistic rockets that introduced a new means of delivering death from the heavens, Werrell gives short shrift to Germany's V-2 (the "V" not representing "Victory" but *Vergeltungswaffe*—a weapon of revenge). The V-2s, the author writes, were "only a terror weapon because they were deficient in reliability, accuracy, destructive capacity, range and numbers. . . . A wiser allocation of resources that emphasized . . . jet aircraft, surface-to-surface missiles, and proximity fuses, could have made the Allied air offensive more expensive (by destroying more bombers)" (p. 67).

The Allied strategic bombing campaign in the Second World War represents an excellent introduction to strategic airpower in the postwar years. Death and destruction from the heavens remain fundamental doctrine, especially as a deterrent. Today we possess advanced "explosive delivery systems," including intercontinental ballistic missiles, stealth bombers, and drones. However, Werrell concludes that "complete application of strategic bombardment is only applicable in total war, which nuclear weapons have made unthinkable, at least for nuclear-armed nations. Thus the practitioners have fallen short of the theorist's vision. The record during its first century reveals that strategic bombardment is a case study of promises unfulfilled" (p. 300).

This excellent, well-researched study is nicely balanced: six chapters address the prewar period, and the remaining five cover postwar events. At the end of each, the author offers his conclusions. The book includes source notes and an index as well as a number of photographs. Unfortunately, it lacks a bibliography although the notes mention documents for further study. *Death from the Heavens* is a major contribution that neither practitioners and nor students of airpower should overlook.

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Mission to Berlin: The American Airmen Who Struck the Heart of Hitler's Reich by Robert F. Dorr. Zenith Press (http://www.zenithpress.com), Quayside Publishing Group, 400 First Avenue North, Suite 300, Minneapolis, Minnesota 55401, 2011, 336 pages, $21.00 (hardcover), ISBN 978-0760338988.

In *Mission to Berlin*, Robert Dorr sets the goal of describing the personal experiences of American aircrews during a bombing mission to Berlin on 3 February 1945. Unfortunately, he diverges from that objective, devoting only about one-third of the text to this particular mission and the remainder to previous ones. As written, using vignettes to share these war stories, the book provides the reader with a history of missions flown and awards earned in various air battles over Germany and the occupied territories.

Digressions quickly frustrate the reader. The author commences the narrative with the early wake-up call of the flight crews, follows with a chapter about earlier missions, and then resumes the story of the Berlin mission in chapter 3, thus establishing the pattern for the remainder of the book. Although this technique is interesting, Dorr fails to follow through on his promise that "the reader is along for the ride on a harrowing mission" (back flap). One sees another example of this digressive tendency in his coverage of the B-29, which never served in the theater.

Furthermore, the book suffers from a lack of thorough proofreading, containing numerous errors—both factual and grammatical. For example, 1,437 bombers and 948 fighters took part in the mission, but the author evidently is at a loss regarding the precise number of aircrew members, referring to "fifteen thousand Americans" (dedication page) and to "fifteen thousand American bomber crewmembers" (p. 139). Spelling errors are both blatant ("ting [tiny] fragments") (p. 73) and puzzling: "Durkin was certain that the ail [*sic*] of the fighter appearing, standing on its tail, and then exploding had to be wrong" (p. 135).

Secondary and tertiary sources dominate the bibliography. Dorr documents interviews in chapter notes but does not include the time, place, or means of conducting them. Accordingly, certain data presented as factual as well as other information is difficult to verify. For instance, the author declares (without citation) that "nearly twenty thousand military pilots were killed in the United States during training" (p. 58) and that "three hundred thousand men trained in aerial gunnery schools during the war" (p. 87). Regarding the latter, other sources, such as the *Army Air Forces Statistical Digest, World War II*, list 309,236 men trained (see table 47, p. 64).

Granted, the anecdotal nature of the narrative makes for easy, pleasant reading. As a scholarly work, however, the book is lacking. As a general historical work, it offers the reader an overview of bomber and fighter missions in the skies over Europe. Additionally, the personal narratives and information about crew members who received the Medal of Honor emphasize the Air Force's proud heritage. Thus, in spite of the digressions, Airmen can still enjoy *Mission to Berlin*, whose grim stories of death and suffering will remind them of the sacrifices of those who saw the true face of war.

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Fighting for Afghanistan: A Rogue Historian at War by Sean M. Maloney. Naval Institute Press (http://www.usni.org/store/books), 291 Wood Road, Annapolis, Maryland 21402, 2011, 326 pages, $42.95 (hardcover), ISBN 9781591145097.

Dr. Sean Maloney's *Fighting for Afghanistan* has captured a sense of the emotions that take place in warfare with a tactical "ground eye" view of the actions of Canadian forces in southern Afghanistan in 2006. An associate professor at the Royal Military College of Canada, the author has a keen eye for detail as a historian but still provides his personal outlook and range of emotions during a particularly difficult time in the Afghanistan war. Obviously he was granted extraordinary access to both the planning and execution of operations, gaining the perspectives of both senior leaders and soldiers on the ground.

Several themes reverberate throughout the book, one of which involves the difficulty in fighting a war with coalition partners, each with disparate capabilities and objectives. The inability of Canadian forces to obtain air support—for lift as well as fire support—at critical times during engagements proved especially frustrating. The reasons were just as bothersome: prior political decisions by the Canadian government; the higher priority that special operations forces always received, regardless of need; caveats from different countries, which left aircraft idle; and bureaucratic red tape. All of these factors prevented the availability of needed support, which put lives at risk. Another theme, unity of effort, addresses disconnects caused by changes in the command structure to integrate the International Security Assistance Force and the American-led Operation Enduring Freedom in 2005–6. Such problems made the coordination and integration of operations difficult at best.

Dr. Maloney's access to troops on the ground offers insight into the good, bad, and ugly parts of warfare. He experiences the camaraderie of being part of a unit when he unwittingly shifts from observer to participant. The author earns his moniker as a *rogue historian* by writing, "How the hell can I write and lecture about this stuff if I haven't been exposed to it too???" (p. 266). Unfortunately, he also feels grief and a sense of loss when his comrades become casualties.

Dr. Maloney's extraordinary access to and familiarity with operations in Afghanistan are responsible for a possible weakness in the book. Specifically, readers will find the acronyms and level of operational detail hard to follow at times. No doubt this level of detail will prove valuable as a historical record, but it makes perusing the book more troublesome for nonmilitary individuals. Nevertheless, *Fighting for Afghanistan* is well written, well researched, and relevant for military audiences. For those who have served in Afghanistan, it will be particularly interesting.

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The Hump: America's Strategy for Keeping China in World War II
by John D. Plating. Texas A&M University Press (http://www.tamupress.com), John H. Lindsey Building, Lewis Street, 4354 TAMU, College Station, Texas 77843-4354, 2011, 320 pages, $34.95 (hardcover), ISBN 9781603442374.

Given the exploits of the strategic bombing campaign in Europe during World War II, it is not surprising that we hear or know relatively little about what was arguably the toughest flying environment encountered by and the most demanding air campaign executed by the US Army Air Forces (AAF)—the trans-Himalayan airlift known as the Hump. Without this air campaign, made successful through the sacrifice and loss of numerous aircraft and crews, we would have had no successful and equally demanding Berlin airlift. Much of our knowledge of it consists of anecdotal and personal stories of the pilots who flew the Hump—tales of events having scant connection to the strategic context in which they occurred. Author John D. Plating fills that void with *The Hump: America's Strategy for Keeping China in World War II*, a comprehensive and remarkably readable historical study of the world's first sustained combat airlift operation. An active duty airlift pilot with combat experience, Plating, who holds a PhD and serves as a professor at the US Air Force Academy, is more than qualified to pen such a book.

In his account of the Hump airlift, an operation often relegated to the periphery of airpower studies, the author describes factors that contributed to the unforgiving ruggedness of the environment endured by pilots flying the China-Burma-India corridor. For example, weather systems in that part of the world (consisting primarily of wind, turbulence, rain, and icing) were little understood, so forecasting proved impossible. Moreover, mountain wave turbulence had a devastating effect on aircraft fuselages. Lastly, the Hump pilots—commonly the least skilled of their pilot-training classmates—found themselves not only in combat the first time they sat at the controls but also under constant threat of attack by Japanese fighters who encountered no defenses.

From early 1942 until just after the surrender of the Japanese in 1945, the Hump airlift served as the best tangible expression of America's commitment to China. Working with a determined and stubborn Chiang Kaishek and Nationalist Chinese forces, President Roosevelt overcommitted American airpower that, at the beginning of the airlift, never envisioned meeting the Herculean monthly airlift tonnage goals set for the effort. Ultimately, this campaign beat back and defeated Japanese forces in China, allowing Nationalist forces, rather than the Communist troops of Mao Zedong, to accept the Japanese surrender.

The hubris regarding American airpower in World War II asserts that strategic bombing laid the foundation for efforts like the Hump airlift. In fact, the opposite is true. Airlift was "*the* precondition that had to be met to make possible all other Allied military action" (emphasis in original) (p. 1). The author's treatment of the airlift begins by introducing its architects—not only Roosevelt and Chiang but also Gen George Marshall, the Army chief of staff, and Gen Henry "Hap" Arnold, the AAF chief. Pressure from the top flowed through the command chain, and the officers leading the airlift, such as Brig Gen Thomas Hardin and Brig Gen William Tunner, felt the end of the whip. Tunner's experience in the China-Burma-India theater would later pay huge dividends during the second airlift battle, in Berlin, which occurred during the Cold War.

Plating's hypothesis in this work entails "investigat[ing] both the material and symbolic components of the airlift with an eye toward discovering whether the airlift really *did* keep the Chinese from surrendering to the Japanese before August 1945" (emphasis in original) (p. 9). He brings plenty of evidence to bear to support that premise. In doing so, he first lays out the origins of the airlift, followed by the reasons for its existence, and then an account of how it both failed and succeeded en route to attaining larger political goals. The author equivocates in the last 10 pages, however, qualifying his conclusions in accordance with how one perceives the airlift.

When the operation began, none of the people involved knew what they were doing. Plating describes this phase as "barnstorming" (see chap. 3, " 'Barnstorming' over the Hump: March to December 1942," pp. 73–104). Inexperienced pilots flew in a part of the world they knew little about. A lack of discipline and low morale conspired to make impossible the job of cast-out commanders who initially led the airlift. After they got a handle on what was going on, the next and most important phase ensued. During the 13 months from May 1943 through May 1944, airline executives and pilots joined the effort en masse, turning the fledgling campaign into a more efficient and eventually thriving one. The last phase, known as the "era of big business" (p. 71), made the airlift's operations resemble those of an experienced airline. Although problems with discipline and morale still existed, they had diminished significantly. The airlift systematically met its tonnage goals in spite of the weather, which never improved—an accomplishment that pleased both Chiang and Roosevelt (until his death) and exceeded most people's expectations.

Airpower scholars will find Plating's treatment of the Hump airlift worthy of study. He concludes the work by reiterating the five themes that tie the airlift's significance to the larger context: "airlift as an expression of airpower; the Hump as a dramatic feat of aerial logistics; the impact of the Hump in both theater and global war strategy; airlift as an expression of the 'national-ness' of airpower; and airlift as facilitating a paradigm shift in global logistics" (p. 241). Readers will certainly enjoy this book!

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