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Aerospace Power Journal Board of Reviewers

Prelaunch Notes

LT COL SCOTT G. WIERSCHKE, EDITOR

A Fond Farewell

Early in the production of this issue of *Aerospace Power Journal,* Col Eric Ash, the (now former) editor, was named commander and president of the Community College of the Air Force (CCAF) and had to leave the *Journal* rather abruptly. Fortunately for the *APJ* staff—and the Air Force—he leaves behind a strong and vital professional journal that is recognized as a major forum for the discussion of aerospace power. This reputation makes it easier to assemble journals in his absence, not to mention the fact that he had already written one last editorial for his successor (it follows these comments).

In his three years as editor, Colonel Ash produced 11 editions of *APJ,* including several that focused on important Air Force issues such as leadership, aerospace integration, support functions, and aerospace medicine. He expanded the *Journal*'s reach to company grade officers by establishing the *CGO Voices* page on *APJ*'s Web site and personally briefed every Air and Space Basic Course class that came through Air University during his tenure, giving each lieutenant his or her own copy of the *Journal.* Colonel Ash's extensive knowledge of our profession and stringent standards of scholarship have greatly improved *APJ.* Indeed, the Air Force leadership not only reads the *Journal* but also contributes articles.

The *APJ* staff wishes Colonel Ash the best in his new command. We will strive to meet and exceed the high standard he has set for the Air Force's professional discourse. The staff also congratulates CCAF on landing a top-notch commander who, we are sure, will take it to new heights of success.

A Note of Thanks . . .

It is with sad but heartfelt appreciation that *APJ* announces the retirement of Dr. Richard H. Kohn as a member of the Professional Journals Editorial Board. Former chief historian for the United States Air Force and professor of history at the University of North Carolina, Chapel Hill, Dr. Kohn is stepping down from *APJ* after more than six years of faithful service and dedicated support in order to concentrate on several projects and pending publications, including a book on presidential war leadership in American history. Dr. Kohn has made a great, positive impact on *APJ* and will truly be missed.

. . . and a Hearty Welcome!

Just as nature abhors a vacuum, seats on *APJ*'s editorial board cannot remain empty. Thus, *APJ* is pleased to announce the appointment of Dr. J. Douglas Beason, Colonel, USAF, retired, to the Professional Journals Editorial Board. Currently the deputy associate director for defense threat reduction at the Los Alamos National Laboratory, Dr. Beason, while on active duty, served as commander of the Phillips Research Site of the Air Force Research Laboratory, as a senior policy analyst in the White House Science Office, and as a member of the vice president's commission to study a US return to the moon, among many other important assignments. Dr. Beason, who has a PhD in physics and is a Fellow of the American Physical Society, has written more than 50 scientific and technical papers and has written or coauthored more than 30 novels and short stories. We welcome Dr. Beason to the *APJ* team.

Flight Lines

COL ERIC ASH, COMMANDER AND PRESIDENT, COMMUNITY COLLEGE OF THE AIR FORCE

The "Perception Transformation"

TRANSFORMATION IS A hot issue, but the one that really counts is the "perception transformation." Since the dawn of military history, perception has been a paramount factor in both the cause and termination of war. It rules morale, determining one's will to continue or discontinue the fight. Often more important than the reality it may or may not reflect, perception transcends rationality, influencing both genius and moron. It is key to deterrence and compellence, and it is the articulation of effects-based operations. Therefore, the ultimate strategy for any sea, land, air and space, joint, or coalition force is to transform the enemy's perception.

That strategy begins at home with our own perception transformation. Of course this is nothing new—Sun Tzu's advice in 500 B.C. was to know both the enemy and oneself. Proceeding further, however, we must transform our perception of the enemy as we also attempt to affect the enemy's perception of us. Post–Cold War enemies are getting smarter, exploiting vulnerabilities by breaking the "rules." The Air Force is also getting smarter about these enemies, realizing that for a vast percentage of the world, we are not the "good guys." Tremendous sacrifice on the part of America and its coalition partners is wasted if the end result is the wrong enemy perception.

How is a perception transformation engineered into the enemy? Traditional airpower has done it either directly or indirectly. Kill the enemy, and he has no perception. Sometimes, however, direct application is impossible, or political objectives (linked to perceptions) require indirect methods. Consider the possible perceptions of B-52 bombing, a method of airpower that can be either direct or indirect. First, one could take such bombing to mean that the Air Force has turned "serious," a common historical interpretation of the impact in Hanoi during the Christmas bombings of 1973. Or another perception could be that the Air Force considers the situation of minor importance and not worth risking more expensive aircraft, such as B-2 bombers. A third perception might be that the Air Force has run out of targets or has lost patience trying to bomb surgically. Finally, the enemy could even perceive that the Air Force is the evil tool of an enemy giant, employed to carry out indiscriminate punishment on innocents. We know better, but so what if we do, when the enemy has the wrong perception? As the Air Force gets better at fighting, it must equally improve its ability to transform perceptions.

A perception transformation involves not only our perception *of* the Air Force, but also our perception *within* the Air Force. Tunnel vision is the wrong perspective; it runs counter to integration. A transformed Air Force is a symphony of systems rather than a collection of soloists. Transformation normally conjures up thoughts of air and space, the Expeditionary Aerospace Force, information warfare, and sophisticated technologies, but the perception transformation means getting out of stovepipe perceptions and embracing integration in those and all areas. As General Jumper stated recently, "We are in ruts. . . . We have to bust some bureaucracies."

Sometimes we must bust our thinking in order to fight as a team and transform enemy perceptions. As the lead article by Ben Lambeth shows, we have not always done that perfectly, and despite great success over Kosovo, we still need improved integration in suppressing enemy defenses. We must be willing to embrace uncomfortable but progressive ideas about organization and technologies, such as the future role of unmanned aerial vehicles (UAV)—the focus area of this issue. Next to space, UAVs represent some of the greatest challenges, not only to bureaucracies but also to the cultural keel of the Air Force. Another challenge, as the "Red Team" piece by Col Timothy Malone and Maj Reagan Schaupp points out, is to understand how important self-criticism is in effecting a perception transformation—not just in war gaming but in the service as a whole.

Prior to September 2001, terrorism had been around for a very long time. In one tragic series of events, however, America's perception of terrorism transformed. Part of the Air Force's transformation journey in the twenty-first century now involves a new focus on terrorism and homeland defense, but it must also include a perception transformation within our own service to embrace new thinking about new technologies. We must transform into a more effectively integrated team in order to fulfill the strategy of creating a perception transformation within the mind of the enemy.

Ricochets and Replies

We encourage your comments via letters to the editor or comment cards. All correspondence should be addressed to the Editor, Aerospace Power Journal, *401 Chennault Circle, Maxwell AFB AL 36112-6428. You can also send your comments by E-mail to apj@maxwell.af.mil. We reserve the right to edit the material for overall length.*

BOOK REVIEW RESPONSE

After reading reviews of two of my books in recent issues of *Aerospace Power Journal*, I feel the need to respond. In Dr. James S. Corum's review of *The Nazis' March to Chaos: The Hitler Era through the Lenses of Chaos-Complexity Theory* (Summer 2001), he asserts that "only Great Britain seemed relatively immune to the European tendency toward totalitarian government in the 1930s." That leaves out Switzerland, Sweden, Holland, Belgium, Ireland, Norway, Denmark, and Finland, and discounts the Fascist movement as well as some appeasers' sentiments in Britain. No French government between the wars was "totalitarian," and the third of unoccupied France went under Fascistoid rule after military defeat. This book doesn't survey theories of European history, but, as the title indicates, it considers Nazism from a chaos/complexity perspective.

Exceptions to Dr. Corum's claim that resistance to mechanization at high levels in the *Reichswehr* and *Wehrmacht* is "unsupported outside of Guderian's self-serving memoirs" include F. W. von Mellenthin's *Panzer Battles, 1939–1945: A Study of the Employment of Armour in the Second World War;* Wilhelm von Thoma's and Hasso Manteuffel's comments in B. H. Liddell Hart's *The Other Side of the Hill: Germany's Generals, Their Rise and Fall, with Their Own Account of Military Events, 1939–1945;* Siegfried Westphal's *The German Army in the West;* and *The Rommel Papers,* edited by Liddell Hart.

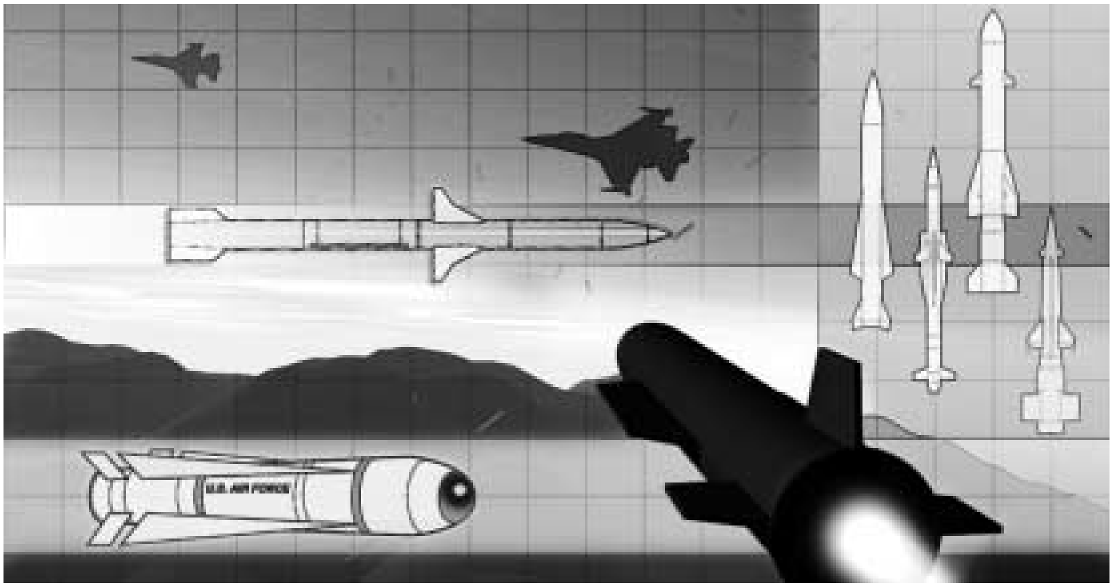
Additionally, although Dr. Corum faults me for not providing the reader with "clear conclusions," that would be apposite to the

Continued on page 103

Kosovo and the Continuing SEAD Challenge

DR. BENJAMIN S. LAMBETH

Editorial Abstract: Just as the attacks of 11 September 2001 refocused national attention on terrorism, so did the shootdown of an F-117 stealth aircraft over Kosovo in 1999 serve as a wake-up call for the Air Force to improve tactics, techniques, and procedures relating to the suppression of enemy air defenses. Dr. Lambeth paints a mixed picture of success and frustration during NATO's air war over Kosovo, pointing out systemic problems that the Air Force must address as it faces increased antiaccess challenges posed by intelligent enemies and threats from double-digit surface-to-air missiles.



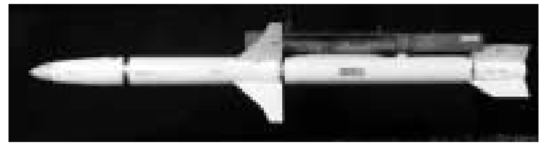
IN THE END, almost everyone acknowledged that the allied forces' use of airpower in the North Atlantic Treaty Organization's (NATO) air war for Kosovo in 1999 was a resounding success.[1] Yet, some troubling questions arose well before the war's favorable outcome over a number of unexpected problems along the way. Perhaps the most disturbing of these involved assessed deficiencies in the suppression of enemy air defenses (SEAD) in support of allied strike operations against the enemy's fixed and mobile targets.

Much of the surprise experienced by allied aircrews during their early, unsuccessful forays against Serbia's integrated air defense system (IADS) in Operation Allied Force may have stemmed from an overconfidence in the Air Force's SEAD capability, which had taken root in the aftermath of the highly effective

SEAD campaign during the opening days of Operation Desert Storm eight years before. At that time, Baghdad was protected by the heaviest concentration of air defenses of any city in the world after Moscow. Likewise, highly internetted, radar-guided surface-to-air missiles (SAM) and antiaircraft artillery (AAA) proliferated throughout the rest of Iraq. Accordingly, the coalition's initial SEAD attacks focused on neutralizing Iraq's radar-directed medium- and high-altitude SAMs with AGM-88 high-speed antiradiation missiles (HARM) so as to open up a sanctuary for coalition aircraft above 10,000 feet.[2] The underlying concept of operations entailed using a combination of tactical surprise and deception, from the very first moments of the campaign, to force the largest possible number of Iraqi SAM batteries to disclose their positions to the coalition's HARM shooters by activating their radars.[3]

During the first four hours of the war, coalition sensors logged nearly 100 radar emissions from Iraqi air defenses, resulting in the firing of more than 500 HARMs to useful effect during the first 24 hours. Consequently, Iraq's IADS operators quickly learned that activating their radars meant inviting a deadly attack. By the sixth day of the war, Iraqi SAM, AAA, and early warning radar emissions had dropped by 95 percent. Now that Iraq's air defenders were fully intimidated and loathe to activate their SAM acquisition-and-tracking radars, coalition SEAD operations moved from suppression to the physical destruction of enemy defenses, using general-purpose bombs, AGM-65 Maverick missiles, and CBU-87 cluster bombs.[4] Instead of rolling back the enemy's defenses sequentially, coalition planners attacked those assets simultaneously, neutralizing them in such a way that Iraq never recovered. For good reason, the US Air Force's *Gulf War Air Power Survey* later characterized the SEAD campaign as "one of the clear success stories" of the war.[5]

In marked contrast to the highly satisfying SEAD experience of Desert Storm, the initial effort to suppress Serbian air defenses in Allied Force did not go nearly as well as expected. The avowed objective called for neutralizing as many of Serbia's SAMs and AAA sites as possible, particularly its estimated 16 SA-3 Low Blow and 25 SA-6 Straight Flush fire-control radars. Another early goal involved taking out or suppressing long-range surveillance radars that could provide timely threat warnings to enemy troops carrying shoulder-fired, infrared SAMs such as the SA-7. Unlike the Iraqis, however, the Serbs kept their SAMs defensively dispersed and operating in an emission-control mode, prompting concern that they meant to draw NATO aircraft down to lower altitudes for easier engagement. Before the initial strikes, there were reports of a large-scale dispersal of SA-3 and SA-6 batteries from nearly all of the known garrisons. The understandable reluctance of enemy SAM operators to emit and thus render themselves cooperative targets made them much harder to find and attack, forcing allied aircrews to remain constantly alert to the radar-guided SAM threat throughout the war.[6] This situation also had the effect of denying some high-risk targets for a time, increasing force-package size, and increasing overall requirements for SEAD sorties.



AGM-88 high-speed antiradiation missile

Moreover, unlike the more permissive operating environment in Desert Storm, limitations to airspace availability typically made for high predictability on the part of attacking NATO aircraft, and prohibitions against collateral damage frequently prevented the use of the most tactically advantageous attack headings. Adm Leighton Smith, USN, retired, commander of NATO forces in Bosnia from 1994 to 1996, said that the resulting efforts to neutralize the Serb IADS were "like digging out potatoes one at a time."[7] Gen John Jumper, commander of United States Air Forces in Europe (USAFE) at the time,

F-16CJ firing HARM

later added that the combined air operations center (CAOC) could never get political clearance from NATO to attack the most troublesome early warning radars in Montenegro, which meant that the Serbs knew when attacks were coming most of the time.[8] In other cases, the cumbersome command and control (C^2) arrangements and the need for prior CAOC approval before attacking the fleeting IADS pop-up targets resulted in many lost opportunities and few hard kills of enemy SAM sites.

Navy EA-6B Prowler

The Allied Force Game Plan

Allied Force drew principally on 48 Air Force Block 50 F-16CJs and 30 Navy and Marine Corps EA-6B Prowlers to conduct the suppression portion of allied counter-SAM operations. Land-based Marine EA-6Bs, tied directly to attacking strike packages, typically provided electronic countermeasures (ECM) support for missions conducted by US aircraft. Navy Prowlers aboard the USS *Theodore Roosevelt* supported carrier-launched F-14 and F/A-18 raids and strike operations by allied fighters. Each of the carrier-based Prowlers carried two HARMs. In contrast, those operating out of Aviano Air Base, Italy, almost never carried even a single HARM, preferring to load an extra fuel tank because of their longer route to target. To compensate, EA-6Bs often teamed with HARM-shooting F-16CJs or with HARM-equipped German and Italian Tornado electronic-combat-role variants.[9]

The Air Force used EC-130 Compass Call electronic warfare (EW) aircraft to intercept and jam enemy voice communications, thus allowing the EA-6Bs to concentrate exclusively on jamming the enemy's early warning radars. RC-135 Rivet Joint electronic intelligence (ELINT) aircraft, which orbited at a safe distance from the combat area, validated the success of the latter efforts. The biggest problem with the EA-6B was its relatively slow flying speed, which prevented it from keeping up with ingressing strike aircraft and diminished its jamming effectiveness. On occasion, the jamming of early warning radars forced Serb SAM operators to activate their fire-control radars, which, in turn, rendered them susceptible to attack by a HARM. Accordingly, the enemy limited activation of his SAM fire-control radars to increase their survivability.[10]

SEAD operations conducted by F-16CJs almost invariably entailed four-ship formations, the spacing of which ensured that the first two aircraft in the flight always looked at a threat area from one side while the other two monitored it from the opposite side. That enabled the aircraft's HARM Targeting System, which provided only a 180-degree field of view in the forward sector, to maintain 100 percent sensor coverage of a target area whenever allied strike aircraft attempted to bomb specific aiming points within it. According to one squadron commander, the F-16CJs would arrive in the target area ahead of the strikers and build up the threat picture before those aircraft got close, so that the strikers could adjust their ingress routes accordingly. In so doing, the F-16CJs provided both the electronic order of battle and the air-to-air threat picture as necessary. The squadron commander added that enemy SAM operators got better at exploiting their systems at about the same rate the F-16CJ pilots did, resulting in a continuous cat-and-mouse game that made classic SAM kills "hard to come by."[11]

Evidently, the Serbs launched only a few SAMs against attacking NATO aircraft the first night. The second night, the enemy fired fewer than 10 SA-6s, none of them scoring a hit. Later during Allied Force, the Serbs fre-

RC-135 Rivet Joint aircraft

quently fired SAMs in large numbers, with dozens launched in salvo fashion on some nights but only a few launched on others. Although these ballistic launches constituted more a harassment factor than any serious challenge to NATO operations, in numerous instances allied pilots had to jettison their fuel tanks, dispense chaff, and maneuver violently to evade enemy SAMs that were guiding.[12]

Indeed, the SAM threat to NATO's aircrews proved far more pronounced and harrowing than media coverage typically depicted, and aggressive jinking and countermaneuvering against airborne SAMs frequently became necessary whenever the Serbs sought to engage NATO aircraft. Ten or more pilots operating in a target area might report a SAM shot as ballistic while the one pilot on whose helmet the missile was figuratively guiding would be actively reacting to it. Shortly thereafter, 10 pilots would recover to widely dispersed home bases and report nonthreatening ballistic launches, while only one would return with the evidence of a guided shot. Such episodes drove an initial impression among Allied Force leaders that "most" of the observed SAM shots were ballistic. Fusion of all the pertinent information and elimination of duplicate reporting, however, indicated that a substantial number of SAM launches, perhaps as many as a third, were guided.[13]

Indeed, Gen Wesley Clark, US Army, supreme allied commander, Europe (SACEUR), later reported numerous instances of near-misses involving enemy SAM launches against NATO aircraft. General Jumper added that a simple look at cockpit-display videotapes would show that "those duels were not trivial."[14] From the very start of NATO's air at-

F-117 Nighthawk stealth fighter

tacks, Serb air defenders also sought to sucker NATO aircrews down to lower altitudes to bring them within the lethal envelopes of widely proliferated man-portable air defense systems (MANPADS) and AAA emplacements. A common Serb tactic involved firing on the last aircraft in a departing strike formation, perhaps on the presumption that those aircraft would be unprotected by other fighters; flown by less experienced pilots; and low on fuel, which would limit their freedom to countermaneuver.

The F-117 Shootdown

It did not take long for the problems connected with the air war's SEAD effort to register their first toll. On the fourth night of air operations, an apparent barrage of SA-3s downed an F-117 at approximately 2045 over hilly terrain near Budanovci, about 28 miles northwest of Belgrade—marking the first combat loss ever of a stealth aircraft. Fortunately, the pilot ejected safely and, against formidable odds, was recovered before dawn the next day by a combat search and rescue team using MH-53 Pave Low and MH-60 Pave Hawk helicopters led by a flight of A-10s.

Afterward, this unexpected event occasioned a flurry of speculation regarding how it might have taken place. Experts at Lockheed Martin Corporation, the aircraft's manufacturer, reported that—unlike earlier instances of F-117 combat operations—the missions flown over Yugoslavia required the aircraft to operate in ways that may have compromised its stealthy characteristics. By way of example, they noted that even a standard turning maneuver could increase the aircraft's radar cross section by a factor of 100 or more. Such turns were unavoidable in the constricted airspace within which the F-117s had to fly.[15] Another unconfirmed report suggested that the RC-135 Rivet Joint aircraft monitoring enemy SAM activity may have failed to locate the SA-3 battery thought to have downed the F-117 and may not have relayed timely indications of enemy SAM activity to the appropriate C^2 authorities. Lending credence to that interpretation, Gen Richard Hawley, commander of Air Combat Command at the time, commented that "when you have a lot of unlocated threats, you are at risk even in a stealth airplane."[16]

Although the Air Force has remained understandably silent about the confluence of events it believes occasioned the F-117's downing, according to press reports, Air Force assessors concluded, after conducting a formal postmortem, that a lucky combination of low-technology tactics, rapid learning, and astute improvisation had converged in one fleeting instant to enable an SA-3 not operating in its normal, radar-guided mode to down the aircraft. Undoubtedly, enemy spotters in Italy reported the aircraft's takeoff from Aviano, and IADS operators in Serbia, as well as those in Bosnia and along the Montenegrin coast, could have assembled enough glimpses of its position en route to its target from scattered radars to cue a SAM battery near Belgrade to fire at the appropriate moment. The aircraft had already dropped one laser-guided bomb (LGB) near Belgrade, offering the now-alerted air defenders yet another clue. (The Air Force is said to have ruled out theories hinging on a stuck weapons-bay door, a descent to below 15,000 feet, or a hit by AAA.)[17]

Allegedly, at least three procedural errors contributed to the downing.[18] First, ELINT collectors reportedly could not track the changing location of the three or four offending SAM batteries. Three low-frequency Serb radars that could have detected the F-117's presence, at least theoretically, were not neutralized because US strike aircraft had earlier bombed the wrong aiming points within the radar complexes. Also, F-16CJs carrying HARMs and operating in adjacent airspace could have deterred the SA-3 battery from emitting, but those aircraft had been recalled before the F-117 shootdown.

The second alleged procedural error entailed an EA-6B support jammer that was operating too far away from the F-117 (80 to 100 miles) to offer much protection. Furthermore, it was out of proper alignment with the offending threat radars, resulting in inefficient jamming.

Last, F-117s operating out of Aviano had previously flown along more or less the same transit routes for four nights in a row (because of SACEUR's ban on overflight of Bosnia) to avoid jeopardizing the Dayton Accords. That would have made their approach pattern into Yugoslav airspace predictable. Knowing the direction the F-117s would take, Serb air defenders could have employed low-frequency radars for the best chance of getting a snap look at the aircraft. Former F-117 pilots and several industry experts acknowledged that the aircraft is detectable by such radars when viewed from the side or directly below. US officials also suggested that the Serbs may have gotten brief, nightly radar hits while the aircraft's weapons bay doors opened fleetingly.

In the immediate aftermath of the shootdown, heated arguments arose in Washington and elsewhere over whether US European Command had erred in not acting aggressively to destroy the wreckage of the downed F-117 in order to keep its valuable technology out of unfriendly hands and eliminate its propaganda value, which the Serbs made every effort to exploit.[19] Said Gen John M. Loh, USAF, retired, former commander of Tactical Air Command, "I'm surprised we didn't bomb it, because the standing procedure has always been that when you lose something of real or perceived value—in this case real technology, stealth—you destroy it."[20] Paul Kaminski, the Pentagon's former acquisition chief and the Air Force's first F-117 program manager during the 1970s, bolstered the case for at least trying to deny the enemy the wreckage. He noted that, although the F-117 had been operational for 15 years, "there are things in that airplane, while they may not be leading technologies today in the United States, [that] are certainly ahead of what some potential adversaries have." Kaminski added that the main concern was not that any exploitation of the F-117's low-observable technology would enable an enemy to put the F-117 at greater risk but that it could help him eventually develop his own stealth technology in due course.[21] Reports indicated that military officials had at first considered attempting to destroy the wreckage but opted in the end not to follow through because they could not have located it before civilians and the media surrounded it.[22] Those issues aside, whatever the precise explanation for the downing, it meant not only the loss of a key US combat aircraft, but also the dimming of the F-117's former aura of invincibility, which for years had carried incalculable psychological value.

Other Frustrations

The persistence of a credible SAM threat throughout the Kosovo air war meant that NATO had to dedicate a larger-than-usual number of strike sorties to the SEAD mission to ensure reasonable freedom to operate in enemy airspace. Thus, fewer sorties were available for NATO mission planners to allocate against enemy military and infrastructure targets—although the limited number of approved targets at any one time tended to minimize the practical effects of that consequence. Moreover, the Block 50 F-16CJ, which lacked the ability to carry the LANTIRN targeting pod, was never used for precision bombing at night because it could not self-designate targets.[23]

One of the biggest problems that confronted attacking NATO aircrews on defense-suppression missions was target location. Because of Kosovo's mountainous terrain, the moving-target indicator and synthetic aperture radar aboard the E-8 joint surveillance, target attack radar system (JSTARS) aircraft could not detect targets masked from view at oblique look angles, although sensors carried by the U-2 and the EC-135 Rivet Joint often compensated for this shortfall. The cover provided to enemy air defense assets by the interspersed mountains and valleys became a severe, complicating factor. Mitigating that constraint somewhat, the limited surveillance range of JSTARS caused by interposed ridgelines restricted E-8 operations primarily with regard to Kosovo, which harbored only a limited SAM threat (only one of the five SA-6 regiments and no SA-2s or SA-3s). Most of the enemy IADS targets lay outside Kosovo. Moreover, the U-2 and Rivet Joint typically performed well and did not suffer the same problems that sometimes plagued the E-8.[24]

By the same token, the Yugoslav IADS's extensive network of underground command sites, buried landlines, and mobile communications centers hampered the allied effort to attack that system's internetted communications links. This internetting used fused radar input, which allowed the acquisition and tracking of NATO aircraft from the north, and subsequently fed the resulting surveillance data to air defense radars in the south. This enabled the southern sector operations center to cue defensive weapons (including shoulder-fired man-portable SAMs and AAA positions) at other locations in the country that had no active radar nearby. That may have accounted, at least in part, for why the F-16CJ and EA-6B often proved ineffective as SAM killers since both employed the HARM to home in on enemy radars that normally operated in proximity to SAM batteries.[25] In all, well over half of the HARM shots taken by allied SEAD aircrews were preemptive targeting or so-called PET shots, with a substantial number of these occurring in the immediate area of Belgrade.[26] Many HARM shots, however, were reactive rather than preplanned, made in response to transitory radar emissions as detected.[27]

Yugoslavia's poorly developed road network outside urban areas also may have worked to the benefit of NATO attackers on more than a few occasions because the enemy's SAM operators depended on road transportation for mobility, and towed AAA tended to bog down when it left prepared surfaces and moved into open terrain. NATO pilots, therefore, studiously avoided flying down roads and crossed them when necessary at 90-degree angles to minimize their exposure time. By remaining at least five kilometers from the nearest road, they often negated the AAA threat, albeit at the cost of making it harder to spot moving military vehicles.

Whenever available intelligence permitted, the preferred offensive tactic entailed destruction of enemy air defenses (DEAD) attacks aimed at achieving hard kills against enemy SAM sites using Block 40 F-16CGs and F-15Es carrying LGBs, cluster bombs, and the powered AGM-130, rather than merely suppressing SAM radar activity with F-16CJs and HARMs.[28] For attempted DEAD attacks, F-16CGs and F-15Es would loiter on call near tankers orbiting over the Adriatic, rolling in on any pop-up SAM threats that might suddenly materialize.[29] Also, the unpowered AGM-154 Joint Standoff Weapon (JSOW), a near-precision glide weapon featuring inertial and Global Positioning System satellite guidance and employed by Navy F/A-18s, used its combined-effects submunitions to good effect on at least a few occasions against enemy acquisition-and-tracking radars.[30]

One problem with such DEAD attempts was that the data cycle time had to be short enough for attackers to catch the emitting radars before they moved on to new locations. One informed report observed that supporting F-16CJs were relatively ineffective in the reactive SEAD mode because the time required for them to detect an impending launch and get off a timely HARM shot to protect a striker invariably exceeded the flyout time of the SAM aimed at the targeted aircraft. As a result, whenever attacking fighters found themselves engaged by a SAM, they were pretty much on their own in defeating it. That suggested to at least some participating aircrews the value of having a few HARMs uploaded on selected aircraft in every strike package so that strikers could protect themselves as necessary without having to depend in every case on support from F-16CJs or EA-6Bs.[31]

The commander of the Marine EA-6B detachment at Aviano commented that allied SEAD assets had no single-solution tactic to employ against enemy systems: "If we try to jam an emitter in the south, there may be a northern one that can relay the information

EC-135 Rivet Joint aircraft with "hog nose" through a communications link and land line. They are fighting on their own turf and know where to hide."[32] He added that Serb SAM operators would periodically emit with their radars for 20 seconds and then shut down the radars to avoid swallowing a HARM.

In all, more than 800 SAMs reportedly fired at NATO aircraft, both manned and unmanned, over the course of the 78-day air war, including 477 SA-6s and 124 confirmed manportable infrared missiles.[33] A majority of the fixed SAMs were fired without any radar guidance. Despite that expenditure of assets, enemy fire downed only two NATO aircraft—the F-117 mentioned above and, later, an F-16—although another F-117 sustained light damage from a nearby SA-3 detonation and two A-10s were hit by enemy AAA fire but not downed.[34] Also, in two reported cases short-range, infrared-guided missiles hit A-10s, one of the missiles apparently striking the bottom of the aircraft, defusing itself, and bouncing off harmlessly.[35] US and NATO aircraft fired at least 743 HARMs against radars supporting these enemy SAMs.[36] Yet, enough of the Serb IADS remained intact—mainly the persistent AAA and MANPADS threat—to require NATO fighters to operate above a 15,000-foot floor throughout most of the air effort. Although allied pilots could effectively counter the older SA-7 with flares if they saw it in time, the SA-9/13, SA-14, SA-16, and SA-18 presented a more formidable threat.

The Balance Sheet for Kosovo

In the end, as noted above, enemy SAM fire brought down only two aircraft (both American), thanks to allied reliance on electronic jamming, towed decoys, and countertactics to negate enemy surface-to-air defenses.[37] However, NATO never fully succeeded in neutralizing the Serb IADS, and NATO aircraft operating over Serbia and Kosovo were always within the engagement envelopes of enemy SA-3 and SA-6 missiles—envelopes that extended as high as 50,000 feet. Because of that persistent threat, mission planners had to place such high-value surveillance-and-reconnaissance platforms as the U-2 and JSTARS in less-than-ideal orbits to keep them outside the lethal reach of enemy SAMs. Even during the operation's final week, NATO spokesmen conceded that they could confirm the destruction of only three of Serbia's approximately 25 known mobile SA-6 batteries.[38]

In all events, by remaining dispersed and mobile, and by activating their radars only selectively, the Serb IADS operators yielded the short-term tactical initiative in order to present a longer-term operational and strategic challenge to allied combat sorties. The downside of that inactivity for NATO was that opportunities to employ the classic Wild Weasel tactic of attacking enemy SAM radars with HARMs while SAMs guided on airborne targets were "few and far between."[39] Lt Gen Michael Short, the Allied Force air commander, later indicated that his aircrews were ready for a wall-to-wall SAM threat like the one encountered over Iraq during Desert Storm but that "it just never materialized. And then it began to dawn on us that . . . they were going to try to survive as opposed to being willing to die to shoot down an airplane."[40]

One may also explain the dearth of enemy radar-guided SAM activity, at least in part, by reports that the Air Force's Air Combat Command had conducted information operations by inserting viruses and deceptive communications into the enemy's computer system and microwave net.[41] Although US information operators probably could not insert malicious code into enemy SAM radars themselves, General Jumper later confirmed that Allied Force had seen the first use of offensive computer warfare as a precision weapon in connection with broader US information operations against enemy defenses. As he put it, "We did more information warfare in this conflict than we have ever done before, and we proved the potential of it."[42]

During Desert Storm, by means of computer penetration, high-speed decrypting algorithms, and taps on landlines passing through friendly countries, the United States reportedly intercepted and monitored Iraqi E-mail and digitized messages but engaged in no manipulation of enemy computers. During Allied Force, however, information operators allegedly succeeded in putting false targets into the enemy's air defense computers to match what enemy controllers were predisposed to believe. Such activities also supposedly occasioned the classic operator-versus-intelligence conundrum from time to time, in which intelligence collectors sought to preserve enemy threat systems that provided them with streams of information while operators sought to attack and negate them in order to protect allied aircrews.[43]

All of this raised basic questions about the adequacy of US SEAD tactics, suggesting a need for better real-time intelligence on mobile enemy SAMs. We not only needed to get that information to pilots quickly enough for them to act on it, but also needed to give them greater standoff-attack capability. The downings of the F-117 and F-16 were both attributed to breakdowns in procedures aimed at detecting enemy IADS threats in a timely manner and ensuring that pilots did not fly into lethal SAM envelopes unaware of them. Other factors cited in the two downings included poor mission planning and improper use of available technology. Although far fewer aircraft were lost during Allied Force than expected, these instances pointed up some systemic problems in need of fixing.

The Wages of Past Neglect

The unsettling SEAD experience of Allied Force sent a much-needed wake-up call to the Air Force's EW community. The survival tactics used to such maddening effect against NATO's aircrews by Serb IADS operators were first developed and tested in the no-fly zones of Iraq. Operations Northern and Southern Watch had steadily policed these zones ever since the coalition first showed the full extent of its capability against active SAM radars during the Gulf War. For that reason, they should have come as no surprise to the Air Force's mission planners. It is reasonable to expect more of the same as potential future opponents continue to monitor US SEAD capabilities and operating procedures, adapting their countertactics accordingly.

Thanks to Allied Force and to the heightened appreciation of possible IADS threats yet to come, Air Force leadership has acknowledged that it needs to make SEAD a renewed priority. As one general observed candidly regarding the frustrations of that experience, "There had to be about ten things that didn't go right. But the central issue is an overall lack of preparedness for electronic warfare."[44] Indeed, one of the first signs of that insidious trend manifested itself as far back as August 1990, when half of the Air Force's ECM pods being readied for deployment to the Arabian peninsula for Desert Storm were found to be in need of calibration or repair. Numerous later sins of neglect with respect to EW included Air Force decisions to make operational readiness inspections and Green Flag EW training exercises less demanding—decisions that naturally resulted in an atrophying of the readiness inspection and reporting of EW units, along with a steady erosion of EW experience at the squadron level. "Now," said the above-cited general, "they only practice reprogramming [of radar warning receivers] at the national level. Intelligence goes to the scientists and says the signal has changed. Then the scientists figure out the change for the [ECM] pod and that's it. Nobody ever burns a new bite down at the wing."[45]

Moreover, during the years since Desert Storm, the response time for engaging high-end SAM threats has grown *longer* rather than shorter, thanks to an absence of adequate planning and to the disappearance of a talent pool of Air Force leaders skilled in EW. One senior Air Force veteran of the Gulf War complained that "we used to have an XOE [operational EW] branch in the Air Staff. That doesn't exist any more. We used to reprogram [ECM] pods within the wings. They don't really do that any more."[46] During a subsequent colloquium on the Kosovo air war and its implications, former Air Force chief of staff Gen Michael Dugan attributed these problems to the Air Force's having dropped the ball badly in 1990, when it failed to "replace a couple of senior officers in the acquisition and operations community who [oversaw] the contribution of electronic combat to warfighting output. The natural consequence was for this resource to go away."[47] The challenge now confronting the Air Force leadership in this respect is to anticipate and, to the extent possible, preempt the emerging SAM threats of the early twenty-first century.

New Solutions

One palliative now on the horizon that portends a major boost in overall SEAD mission effectiveness is substantially reduced observability to enemy radars—an inherent design feature of the next-generation F-22 and F-35 (the latter previously known as the Joint Strike Fighter).[48] Once the United States fields these new multirole combat aircraft in sufficient strength toward the end of this decade, their much-reduced radar cross sections will enhance their survivability by shrinking the effective engagement envelopes of enemy radar-directed SAMs by 95 percent or more. Provided that proper tactics and some important operating limitations are respected, that will enable the F-22 and F-35 to fly in hostile airspace and reach effective weapons-release parameters undetected.[49]

Granted, as we have already seen in the arresting case of the F-117 shootdown over Serbia in 1999, such low observability to enemy radars will not render the F-22 and F-35 fully invisible along the lines of the fanciful Romulan cloaking device of *Star Trek* fame. It will be impossible to operate these successor-generation stealth aircraft with *complete* abandon in a high-threat SAM environment. On the contrary, pilots will have to fly even the F-22 and F-35 in specific attitudes to threat radars to preclude their detection and susceptibility to risk. As a senior Air Force officer cautioned two years before the F-117 downing, stealthiness "significantly reduces your vulnerable area, but it does not give you the freedom to ignore the threats."[50] At some aspect angles, even the stealthiest aircraft may be at least fleetingly detectable by surface radars. Moreover, they will continue to emit infrared signatures that an enemy can exploit.

Nevertheless, such advanced low observability by radar promises to reduce substantially the range at which an enemy's acquisition radars can detect ingressing friendly aircraft from various look angles, as well as complicate the tracking of any F-22 or F-35 momentarily detected by enemy sensors. This will have the net effect of narrowing significantly any defender's window of opportunity for successfully engaging and downing such aircraft. Thus, the F-22 and F-35 can operate in high-threat areas with less intense concern for surface-to-air defenses and can fly on headings and at altitudes aimed at maximizing opportunities for early target acquisition.

Indeed, when coupled with astute tactics based on accurate and timely threat intelligence, even the shaping and skin treatments of currently deployed stealth aircraft have rendered today's early warning and engagement radars, as well as the SAMs that depend on them, all but useless. The resultant ability provided to joint force commanders (JFC)—the ability to conduct precision attacks with near impunity—has imparted a new edge to US airpower. The F-117 and B-2, with their first- and second-generation stealth features, now allow JFCs to conduct vital operations in the most heavily defended enemy airspace that *no* number of less capable aircraft can perform at acceptable risk. The F-22 and F-35 will extend that capability to an ever-larger number of deployed US aircraft. Not only will such aircraft be able to produce strategic effects early in a war, but also they will increase the leverage of nonstealthy aircraft by negating enemy radar-guided SAM threats and thus provide those latter aircraft a safer envelope within which to operate over hostile terrain.

That said, however, JFCs in future contingencies will almost surely have to contend with threats of double-digit SAMs, namely the Russian S-300PM (NATO code name SA-10) and the comparably lethal SA-12 through SA-20, well *before* the F-22 and F-35 begin coming on-

F-22 Raptor

line in operationally significant numbers. The SA-10 and SA-12 are lethal out to a slant range of 80 nautical miles, five times the killing reach of the earlier-generation SA-3.[51] One SA-10/12 site in Belgrade and one in Pristina could have provided defensive coverage over all of Serbia and Kosovo. They also could have threatened Rivet Joint, Compass Call, and other key allied aircraft such as the airborne command and control center and the Navy's E-2C operating well outside enemy airspace.

Fortunately for NATO, the Serb IADS did not include the latest-generation SAM equipment currently available on the international arms market. Early, unsubstantiated reports, repeatedly denied by the Russian Ministry of Foreign Affairs, claimed that several weeks before the start of the bombing effort, Russia had provided Serbia with elements of between six and 10 long-range SA-10 systems, delivered without their 36D6 Clam Shell target-designation and tracking radars.[52] Had those reports been valid, even the suspected presence of such SAMs in the enemy's IADS inventory would have made life far more challenging for attacking NATO aircrews.[53] As Lieutenant General Short later commented darkly, "It would have profoundly changed the balance of the threat and our ability to maintain air superiority."[54] The inescapable message here is that the Air Force cannot afford to wait for the F-22 and F-35 deployments to help solve its SEAD conundrum. It must begin coming to effective grips now with this increasingly clear and present danger.

Beyond the stealthiness portended by the F-22 and F-35, another promising avenue for dealing with emergent SAM threats may lie in the realm of nonkinetic alternatives. To offer but a glimpse into the more intriguing possibilities in this respect, General Jumper remarked after Allied Force that although information operations remained a highly classified subject about which little could be said, the Kosovo experience suggested that "instead of sitting and talking about great big pods that bash electrons, we should be talking about microchips that manipulate electrons and get into the heart and soul of systems like the SA-10 or the SA-12 and tell it that it is a refrigerator and not a radar."[55] Some of the more cutting-edge variants of first-generation offensive cyber warfare, reportedly tested successfully in Allied Force, suggested the feasibility of taking down enemy SAM and other defense systems in ways that would not require putting a strike package or a HARM on critical nodes to neutralize them. Toward that end, Gen Hal Hornburg, current commander of Air Combat Command, recently reiterated the importance of looking beyond familiar solutions to this looming threat in certain portions of President George W. Bush's "axis of evil," where the United States might find itself engaged militarily: "We don't just need jammers and we don't just need Block 50s. . . . We need an array of capabilities. . . . I am looking for kinetic and non-kinetic solutions. I am looking, for example, for space to be able to get down to an SA-10 and convince it to launch all missiles right now or to deny it from launching their missiles right now."[56]

Finally, an emergent concern prompted by the less-than-reassuring SEAD experience in Allied Force was the need for better capabilities for accommodating noncooperative enemy air defenses and, more specifically, countering the novel tactic whereby enemy SAM operators resorted to passive electro-optical rather than active radar tracking. That tactic prompted Maj Gen Dennis Haines, who at the time served as Air Combat Command's director of combat weapons systems, to spotlight the need for capabilities other than relying on radar emissions to detect SAM batteries, as well as the need to locate and identify enemy SAM sites more rapidly when they emitted only briefly.[57] As one looks farther down the road, the ultimate answer to this and related challenges may entail not only continuing to get better at traditional SEAD mission applications, but also moving increasingly toward developing more sophisticated concepts of operations and fielding associated new technologies. The latter include unmanned aerial reconnaissance platforms such as Global Hawk; armed, uninhabited combat air vehicles; and possibly space systems, with a view toward rendering SEAD and DEAD either missions of last resort or unnecessary altogether. □

Notes

1. This article is based upon the author's book *NATO's Air War for Kosovo: A Strategic and Operational Assessment,* MR-1365-AF (Santa Monica, Calif.: RAND, 2001).

2. John D. Morrocco, "Allies Attack Iraqi Targets; Scuds Strike Israeli Cities," *Aviation Week and Space Technology,* 21 January 1991, 20–22.

3. The F-4G did most of the actual HARM shooting, with jamming support provided by EF-111s, EC-130s, and EA-6Bs. The allies also utilized Marine F/A-18s heavily on opening night to back up the SEAD campaign with preemptive HARM attacks.

4. Capt Dan Hampton, "Combat Defense Suppression: The F-4G/F-16C Wild Weasel at War," *USAF Fighter Weapons Review,* Summer 1991, 4–6.

5. Thomas A. Keaney and Eliot A. Cohen, *Revolution in Warfare? Air Power in the Persian Gulf* (Annapolis: Naval Institute Press, 1995), 119.

6. Dana Priest, "NATO Unlikely to Alter Strategy," *Washington Post,* 26 March 1999.

7. Quoted in Dana Priest, "NATO Pilot Set to Confront Potent Foe," *Washington Post,* 24 March 1999.

8. Gen John Jumper, "Oral Histories Accomplished in Conjunction with Operation Allied Force/Noble Anvil" (Washington, D.C.: Air Force Studies and Analysis Agency, n.d.).

9. Robert Wall, "Sustained Carrier Raids Demonstrate New Strike Tactics," *Aviation Week and Space Technology,* 10 May 1999, 37.

10. Robert Wall, "Airspace Control Challenges Allies," *Aviation Week and Space Technology,* 26 April 1999, 30.

11. Tim Ripley, "Viper Weasels," *World Air Power Journal,* Winter 1999/2000, 102. The standard F-16CJ weapons loadout consisted of two AGM-88 HARMs and four AIM-120 advanced medium-range air-to-air missiles (AMRAAM).

12. Richard J. Newman, "In the Skies over Serbia," *U.S. News and World Report,* 24 May 1999, 24.

13. Comments on an earlier draft by Headquarters USAFE/IN, 18 May 2001.

14. Cited in "Ground Troops Lauded," *European Stars and Stripes,* 6 August 1999; and "Jumper on Air Power," *Air Force Magazine,* July 2000, 41.

15. James Peltz and Jeff Leeds, "Stealth Fighter's Crash Reveals a Design's Limits," *Los Angeles Times,* 30 March 1999.

16. "Washington Outlook," *Aviation Week and Space Technology,* 3 May 1999, 21. Asked whether the aircraft's loss was caused by a failure to observe proper lessons from earlier experience, Hawley added, "That's an operational issue that is very warm."

17. Eric Schmitt, "Shrewd Serb Tactics Downed Stealth Jet, U.S. Inquiry Shows," *New York Times,* 11 April 1999. In subsequent testimony before the Senate Armed Services Committee, F. Whitten Peters, then the secretary of the Air Force, did confirm that enemy SAMs had downed the aircraft. See Vince Crawley, "Air Force Secretary Advocates C-130, Predators," *Defense Week,* 26 July 1999, 2.

18. See David A. Fulghum and William B. Scott, "Pentagon Gets Lock on F-117 Shootdown," *Aviation Week and Space Technology,* 19 April 1999, 28–30; and Paul Beaver, "Mystery Still Shrouds Downing of F-117A Fighter," *Jane's Defence Weekly,* 1 September 1999.

19. To bolster their case, some people noted that when an F-117 had crashed earlier at an air show near Baltimore in 1998, the Air Force had thoroughly sanitized the area and hauled off the wreckage to prevent its most sensitive features from being compromised.

20. Quoted in Vago Muradian, "Stealth Compromised by Not Destroying F-117 Wreckage," *Defense Daily,* 2 April 1999.

21. Ibid.

22. On 2 April, the Yugoslav government announced its intention to hand over pieces of the downed F-117 to Russian authorities. Robert Hewson, "Operation Allied Force: The First 30 Days," *World Air Power Journal*, Fall 1999, 18. For the record, the Air Force immediately put F-15Es on alert to destroy the wreckage with AGM-130s after confirmation of the F-117 downing, but by the time the service could positively determine the wreckage location, Cable News Network was on the scene, and collateral-damage issues precluded the attack. Comments on an earlier draft by Headquarters USAF/XOXS, 9 July 2001.

23. *LANTIRN* stands for *low-altitude navigation and targeting infrared for night*.

24. Comments on an earlier draft by Headquarters USAFE/IN, 18 May 2001.

25. Wall, "Airspace Control Challenges Allies," 30.

26. Brig Gen Randy Gelwix, "Oral Histories Accomplished in Conjunction with Operation Allied Force/Noble Anvil" (Washington, D.C.: Air Force Studies and Analysis Agency, n.d.).

27. Wall, "Airspace Control Challenges Allies," 30.

28. The AGM-130 could be fired from a standoff range of up to 30 nautical miles. It featured Global Positioning System satellite guidance, enhanced by terminal homing via man in the loop through live video feed data-linked to the attacking aircraft from the guiding weapon.

29. The Block 50/52 F-16CJs used for defense suppression were equipped to carry the AGM-65 Maverick missile, but they did not employ that munition in Allied Force because the pilots, given their predominant focus on making the most of the AGM-88 HARM, had not sufficiently trained for its use.

30. Gelwix, "Oral Histories." JSOW was employed only infrequently during Allied Force. Many of the targets assigned to the Navy were inappropriate for attack by the AGM-154's cluster-bomb variant because of collateral-damage concerns, lengthy timelines associated with attacks against mobile targets, and the munition's lack of a precise-impact timeline. William M. Arkin, "Fleet Praises JSOW, Lists Potential Improvements," *Defense Daily,* 26 April 2000.

31. Lt Col Philip C. Tissue, "21 Minutes to Belgrade," US Naval Institute *Proceedings,* September 1999, 40.

32. Michael R. Gordon, "NATO to Hit Serbs from 2 More Sides," *New York Times,* 11 May 1999.

33. "AWOS Fact Sheet," Headquarters USAFE/SA, 17 December 1999. See also William M. Arkin, "Top Air Force Leaders to Get Briefed on Serbia Air War Report," *Defense Daily,* 13 June 2000, 1.

34. David A. Fulghum, "Kosovo Report to Boost New JSF Jamming Role," *Aviation Week and Space Technology,* 30 August 1999, 22.

35. "Washington Outlook," *Aviation Week and Space Technology,* 20 September 1999, 25.

36. "AWOS Fact Sheet."

37. In all, US aircraft expended 1,479 ALE-50 towed decoys during Allied Force.

38. Comments on an earlier draft by Headquarters USAFE/IN, 18 May 2001.

39. Tim Ripley, " 'Serbs Running Out of SAMs,' Says USA," *Jane's Defence Weekly*, 2 June 1999.

40. Interview with Lt Gen Michael Short, USAF, PBS *Frontline*, "War in Europe," 22 February 2000. Serb IADS operators may have been able to trade short-term effectiveness for longer-term survivability because allied aircraft typically could not find and successfully attack fielded Serbian forces and other mobile ground targets. Had they been able to do so and kill enemy troops in large numbers, the Serb army's leadership would have insisted on a more aggressive air defense effort. That would have enabled NATO to kill more SAMs but at the probable cost of losing additional friendly aircraft.

41. David A. Fulghum, "Serb Threat Subsides, but U.S. Still Worries," *Aviation Week and Space Technology,* 12 April 1999, 24.

42. "Jumper on Air Power," 43.

43. David A. Fulghum, "Yugoslavia Successfully Attacked by Computers," *Aviation Week and Space Technology,* 23 August 1999, 31–34.

44. Quoted in David A. Fulghum, "NATO Unprepared for Electronic Combat," *Aviation Week and Space Technology,* 10 May 1999, 35.

45. Ibid.

46. Ibid.

47. Quoted in "Washington Outlook," *Aviation Week and Space Technology,* 23 August 1999, 27.

48. On potential F-35 SEAD applications in particular, see Edward H. Phillips, "LockMart Eyes F-35 for AEA/SEAD Use," *Aviation Week and Space Technology,* 18 March 2002, 32–33.

49. As the principal designer of the B-2 wrote several years ago with respect to these limitations, stealth in practice is a combination of low observability and *tactics,* the latter entailing close attention to mission doctrine, maneuver, sensor operation, and weapon application in addition to relying on the aircraft's inherent low-observability properties. "When appropriate tactics are employed," he added, "survivability will be assured with or without supporting ECM." By implication, when appropriate tactics are *not* employed, the survivability of a nominally stealthy aircraft is anything but assured. John Cashen, "Stealth (and Related Issues)" (paper prepared for a conference on "Control of the Air: The Future of Air Dominance and Offensive Strike," sponsored by the Australian Defense Studies Center, Canberra, Australia, 15–16 November 1999), 4.

50. Quoted in David A. Fulghum, "Expanding Roles May Shield F-22," *Aviation Week and Space Technology,* 6 January 1997, 43.

51. David A. Fulghum, "Report Tallies Damage, Lists U.S. Weaknesses," *Aviation Week and Space Technology,* 14 February 2000, 34.

52. Zoran Kusovac, "Russian S-300 SAMs 'in Serbia,' " *Jane's Defence Weekly,* 4 August 1999.

53. Serbian president Slobodan Milosevic reportedly pressed the Russians hard for such equipment repeatedly, without success. Deputy Secretary of State Strobe Talbott later stated that the Clinton administration put the Yeltsin government on the firmest notice that any provision of such cutting-edge defensive equipment to Yugoslavia would have a "devastating" effect on Russian-American relations. Michael Ignatieff, *Virtual War: Kosovo and Beyond* (New York: Henry Holt and Company, Inc., 2000), 109.

54. Quoted in Christopher J. Bowie, *Destroying Mobile Ground Targets in an Anti-Access Environment,* Analysis Center Papers Series (Washington, D.C.: Northrop Grumman Corporation, December 2001), 4.

55. "Jumper on Air Power," 43.

56. Gen Hal M. Hornburg, USAF, presentation to the Air Force Association National Symposium, Orlando, Fla., 14 February 2002.

57. Robert Wall, "SEAD Concerns Raised in Kosovo," *Aviation Week and Space Technology,* 26 June 1999, 75.

The "Red Team"

Forging a Well-Conceived Contingency Plan

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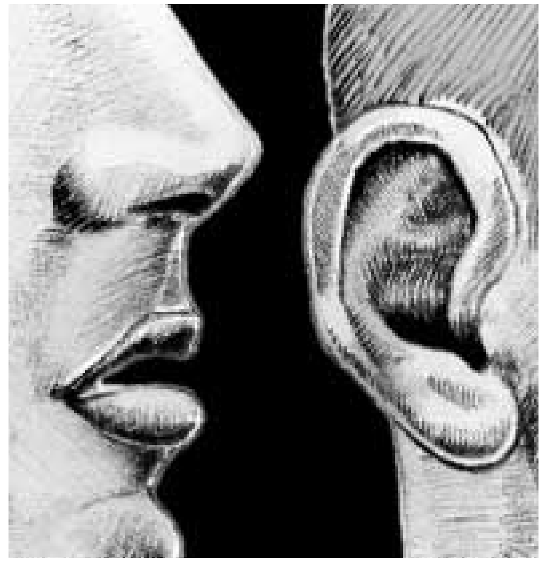

Editorial Abstract: Independent peer review by recognized experts is crucial to the production of any quality product, whether a professional journal or war plan. Colonel Malone and Major Schaupp discuss evolving efforts to use "Red Teams" to incorporate this kind of review into the crisis-action planning process. Employing such teams at critical phases during both the planning itself and the mission rehearsal of completed plans will yield more robust and vetted war plans.

THROUGHOUT THE lengthy planning effort for Operation Allied Force in 1998–99, allied leaders and planners widely adhered to a significant assumption. When the order arrived to execute the operation—on the very eve of hostilities—that assumption continued to prevail. But as the days of the aerospace campaign stretched into weeks and then months, the allies recognized their assumption for the fallacy it was—namely, that President Slobodan Milosevic of Yugoslavia would capitulate after a "modest set of punitive air strikes," which were designed to achieve only limited objectives while demonstrating the North Atlantic Treaty Organization's resolve in ending the crisis in Kosovo.[1]

Reflecting upon this misjudgment years later, the current commander of the 32d Air Operations Group (AOG)—the same organization that had largely planned and orchestrated Allied Force—asked his analytical team a pointed question regarding the prewar planning and analysis for Allied Force: had anyone conducted an in-depth analysis to determine whether two days of bombing would achieve the objectives? Analysts had modeled the initial Allied Force attacks, but they had focused on aircraft attrition and potential damage—not on whether the attacks would achieve the overall objectives. So the answer was "no." During the planning that took place prior to Allied Force, no group had the task of systematically examining the emerging plan from the enemy's perspective. No team was assigned to diligently unearth the plan's shortfalls or oversights—or to thoroughly war-game the various courses of action (COA) while planners considered and developed them.[2] Thus, the plan's execution went well only until the enemy "got a vote"—after which the air war over Serbia continued for a frustrating 78 days.

The Red Team

What if an enemy, "Red," announced his intended reaction to a "Blue" campaign plan before Blue executed it? What if Red obligingly pointed out the flaws in Blue's plan that he intended to exploit and revealed several hidden weaknesses of his own? Surely, once Blue optimized his strengths and protected his vulnerabilities, the operation would stand a much greater chance of success.

Furthermore, what if representatives of the press and the public confided to Blue planners the elements of the operation that concerned them most as well as those with which they might take issue? What if national leadership explained in advance some of the "wrenches" they might throw into the works during execution? What if senior war-fighting commanders and higher headquarters staffs worked alongside the planners to ensure correct understanding of every facet of their guidance and answered the planners' key questions? If all these pieces of information were synthesized into the plan during the planning process, the plan would have a better chance of surviving any contingency.

Of course, no enemy will ever knowingly provide such insight to the opposition. Nor can the multitude of military agencies and civilian groups, whose decisions and views so heavily influence military operations, reveal their changes of mood, mind, and policy in advance. But a "Red Team" that studies, simulates, and role-plays the enemy and outside agencies during crisis action planning (CAP) can go far toward providing exactly that sort of perspective. In this context, we offer the following working definition of *Red Team: a group of subject-matter experts (SME), with various, appropriate air and space disciplinary backgrounds, that provides an independent peer review of products and processes, acts as a devil's advocate, and knowledgeably role-plays the enemy and outside agencies, using an iterative, interactive process during operations planning.*

If conducted effectively, "Red Teaming" can yield a closely synchronized planning staff, drive more complete analysis at all phases, and ultimately deliver a better plan of operations into the hands of a war-fighting commander. An effective Red Team can pinpoint key Blue decision points, identify planning shortfalls, show deviations from doctrine, reveal overlooked opportunities, and extrapolate unanticipated strategic implications. Just as important, good Red Teaming can determine how clearly Blue planners understand the tasks that higher headquarters have given them and indicate whether they must request additional, specific guidance for planning critical facets of the operation.[3]

The concept of Red Teaming is far from new. It has been used (under that name and others) in government, military, and civilian circles in a variety of contexts, though none exactly like the one described in this article. In the business world, Red Teaming usually means a peer review of a concept or proposal. In government circles, it is normally associated with assessing vulnerabilities of systems or structures, especially within the information-warfare arena.

The military services, especially the Army and Navy, have long used elements of the Red Teaming process, particularly war games *(Kriegspiele),* to think through campaigns.[4] The Army defines *war game* as follows: "A disciplined process, with rules and steps, that attempts to visualize the flow of a battle. The process considers friendly dispositions, strengths, and weaknesses; enemy assets and probable COAs; and characteristics of the area of operations."[5]

Additionally, the Air Force Doctrine Center's *Aerospace Commander's Handbook for the JFACC [joint force air component commander]* mentions the notion of Red Teaming COAs, although it provides no further details.[6] Some elements of Red Teaming are as basic and intuitive as a pilot "chair-flying" a mission before execution.

The Red Teaming process examined in this article begins with the most applicable elements of the traditional war game and then incorporates the concepts of peer review and vulnerability assessment applied to the CAP process at several levels. Toward that end, we offer the following as a practical definition of the *Red Teaming process: An iterative, interactive process conducted during CAP to assess planning decisions, assumptions, COAs, processes, and products from the perspective of friendly, enemy, and outside organizations.*[7]

Team Composition and Preparation

In his article describing a notional "Silver Flag," Col Bobby Wilkes identifies an important initiative: "Develop a cadre of experts equipped with appropriate resources—*in-house red-team expertise*" (emphasis in original).[8] Because a Red Team will conduct a comprehensive review of Blue planning products and processes, the selection of team members is critical. A commander should gather his or her Red Team from *functional aerospace disciplines that apply to the operation in question*.

For example, Gen Gregory S. Martin, commander of United States Air Forces in Europe (COMUSAFE), tasked his command's first Red Team to assess an offensive air and space campaign. After analyzing requirements and considering the restrictions imposed by the "need to know," the Red Team leader formed the team with SMEs from the following areas:

- air operations and strategy
- command and control (C^2)
- joint operations
- logistics
- space operations and strategy
- intelligence, surveillance, and reconnaissance (ISR)
- combat search and rescue
- information operations and information warfare
- law
- politics

Additionally, to emphasize the focus on enemy leadership decisions and reactions to the Blue campaign, the team included two opposing forces (OPFOR) experts and one specialist in integrated air defense systems, all from the intelligence career field.

A prime consideration in forming the Red Team is the Blue planners' acceptance of Red as a valid, value-adding group. Two requirements will facilitate this Blue "buy-in." First, the commander should make it clear that the Red Teaming effort is *his or her own initiative,* explaining the intent and highlighting expected benefits to the planning process. This will mitigate a natural resistance on the part of the planners to have outsiders "picking at" their plan. Second, Red Team members must have *credibility,* which comes only with expertise and experience. If some Red Team members blatantly fall short of this prerequisite, their Blue counterparts will be skeptical of any insights they claim to have about the operation.

When possible, the commander should draw Red Team members from sources external to the Blue planning organization. Although this may seem intuitive, it is not always easy to accomplish. Most organizations that have the necessary experts are usually fully employed—indeed, the Blue planning organization itself is a perfect example. A commander may be tempted to dual-hat his or her own Blue planners as Red Team members; after all, what better people to assess a plan than the ones most intimately familiar with it? But this seemingly workable solution is fatally flawed: one of the prime benefits of Red Teaming is an *independent* review of Blue products and reasoning—a second set of eyes on the plan. Try as it might, even the most talented planning group cannot discern its own oversights—if it could, those oversights would not occur in the first place. As concerned as Blue planners must inevitably be with the details, it is sometimes difficult for them to stand back and see the big picture.

In the case of USAFE's initial Red Team effort, the team leader and most of the team members came from the Warrior Preparation Center (WPC) in Einsiedlerhof Air Station, Germany. Others were drawn from Headquarters USAFE. One Red Team member (the ISR expert) had to be pulled from the Blue planning group since no other expert in that discipline was readily available.

The exception to the rule that Blue planners should not be Red Team members occurs when one considers a Blue "internal Red Team." The chief of a Blue planning effort may believe it valuable to designate a small, organic Red Team that would involve itself in the day-to-day details of planning. Such a team, although not able to provide a wholly independent look from outside the planning process, nevertheless will realize some of the benefits of Red Teaming by periodically cross-checking others' work, playing devil's advocate to others' assumptions or decisions, and "murder-boarding" emerging planning products.[9] One finds an example within an air operations center (AOC), in which Combat Operations Division personnel might conduct a peer review of the work of the Combat Plans Division and vice versa. The increased familiarity that Combat Operations personnel would gain with the plan they might have to execute is an added benefit in this case.

In addition to the Red Team, use of a "White Cell" enhanced and controlled USAFE's Red Teaming effort (fig. 1). This cell includes several senior participants who provide oversight and adjudication during the formal Red Teaming events.[10]

Two of the pivotal White Cell positions are the facilitator and senior mentor. The facilitator ensures that the discussion remains relevant and on schedule and that all participants follow the rules of engagement (ROE). The senior mentor, typically a retired general officer, provides the valuable perspective of experience to the Blue planning chief and staff.

When one considers the overall mission of the Red Team—generating a more effective plan—it becomes clear that the team is not consistently "Red." At times, rather than challenging Blue reasoning, its members will provide assistance to the planners, offering another perspective or additional information. This is especially true of the senior mentor, a vital participant in the process although not technically a member of the Red Team. This periodic functional shift on the part of the Red Team—from devil's advocate to planning partner—does not detract from the overall effort. On the contrary, it broadens the range of thinking and contributions of the entire group, enhancing the planning effort.

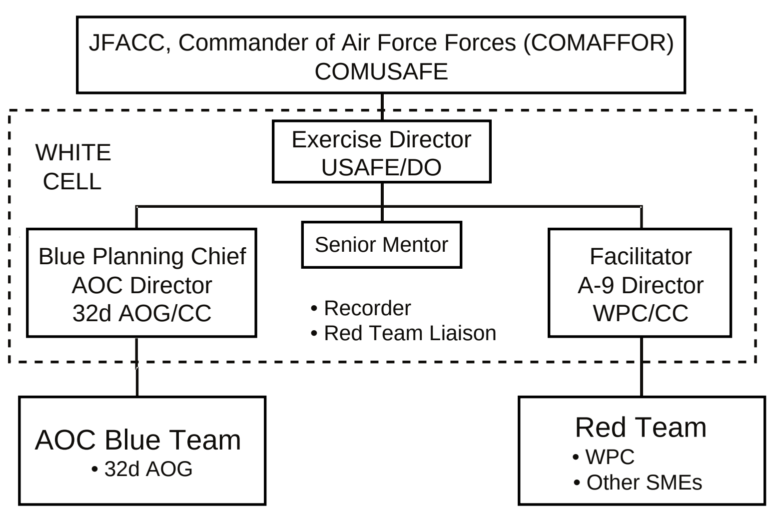

Figure 1. Red Teaming Command and Control

Once the Red Team is identified, its focus should turn to preparation. The team should anticipate engagement in an iterative, interactive series of events that closely parallels the stages of the CAP process.[11] Therefore, team members should immerse themselves in learning everything they can about what has gone before in the crisis at hand and what the enemy and other adversaries are thinking. Joint Publication (Pub) 5-00.2, *Joint Task Force Planning Guidance and Procedures*, provides a list of actions that planners should accomplish to prepare for war gaming during COA analysis.[12] Since the scope of Red Teaming is significantly broader than that of COA war gaming, the USAFE Red Team prepared its own preparatory checklist, based on the joint publication's guidance (table 1). Neither exhaustive nor necessarily applicable at every step, the checklist nevertheless proved useful to the command's first Red Teaming event.

Table 1

Red Team Preparations Checklist

Establish secure location away from distractions

- Access to Secret Internet Protocol Router Network (SIPRNET), Joint Deployable Intelligence Support System (JDISS), and Unclassified but Sensitive Internet Protocol Router Network (NIPRNET)
- Maps and overlays
- Office supplies

Gather necessary reading material and data

- Chairman of the Joint Chiefs of Staff (CJCS) warning order and directives
- Combatant commander warning order
- Other major command or higher headquarters guidance
- Relevant message traffic (intelligence reports, etc.)
- Combatant commander's assessment
- Relevant briefings or documents produced to date in the planning process
- Relevant publications (joint pubs, planning guides, etc.)
- C^2 diagrams or task-organization information
- Blue COAs under consideration
- Country studies
- Enemy order of battle

Prepare to role-play the enemy and other adversaries

- Review country studies
- Study enemy doctrine and force disposition
- Identify C^2 infrastructure and decision-making processes
- Identify enemy centers of gravity (COG)
- Identify Blue COGs as seen by enemy
- Identify enemy's limiting factors (LIMFAC)
- Identify enemy commander's key decision points
- Determine enemy's anticipated COAs
- Study the political environment

Understand the overall situation and Blue planning progress

- Review assessments, orders, messages, and other products
- Identify and assess Blue assumptions
- Identify Blue LIMFACs
- Identify known, critical events in the operation
- Identify Blue commander's key decision points
- Convene a Red Team meeting to review elements of the crisis

Red Team Rules of Engagement

As the Red Team prepares to integrate into the planning effort, it must acknowledge a simple fact: very few people perceive a review and assessment of their efforts as benign. Even assistance, which is ultimately what the Red Team provides, is often not welcome, especially when it comes from people unknown and external to the Blue planning team. To mitigate this friction, the Red Team should meet with the Blue planners as early as possible to explain a number of critical points about a Red Teaming effort. The following ROEs should apply to every Red Teaming event throughout the process:

- The commander's perceived intent *should not limit innovation* (e.g., drive certain COAs).
- Red Teaming events are meant to be interactive, *candid discussions* reminiscent of the flight debrief after a mission.
- The principle of *nonattribution* is in effect.
- Participants should *remain objective* in their contributions to the effort; personal agendas or personality conflicts are not welcome.
- Participants should stay professional—no fighting in public.

The first item in this list addresses a problem that can be insidious and deadly to a well-developed plan: the natural tendency to favor a war-fighting commander's perceived intent in developing COAs. Too often, a planning staff presents the commander with several COAs, knowing full well that all but the perceived favorite are throwaways. As a result, staffers sometimes spend little time seriously developing the COAs.

As the Red Team moves into action, its ability to gain the confidence and trust of the Blue planners is absolutely critical. Failure in this area will lead to Red Team failure. One cannot overstate the importance of avoiding an "us against them" relationship between Blue and Red. Again, the commander's early buy-in and influence in this area, as well as adherence to the ROEs outlined above, will pay large dividends to the process. When this groundwork is laid successfully, the Blue team will understand why the OPFOR, for instance, is doing its utmost to simulate a realistic, hostile enemy.

Timing Red Teaming Events

The timing of Red Teaming events can play a crucial role in planning success. Ideally, the commander should form a Red Team *as early in the planning effort as possible*. USAFE's first Red Teaming event took place when the planners were in CAP, phase five, after selection of the COA. In the after-action review, everyone agreed that the event had occurred too late in the cycle and would have proven more valuable to the planners had it taken place earlier. Consequently, COMUSAFE tasked the Red Team to determine the best time for Red Teaming events. He also directed them to determine how many events should take place during the CAP process.

The Red Team members determined that they should become involved no later than the start of CAP, phase three (receipt of a warning order). This phase involves planning that can benefit greatly from Red Teaming efforts, as outlined below. Such efforts will yield well-thought-out COAs for the commander to consider. The further the planning effort proceeds without an integrated Red Team, the more diminished the value of Red Teaming.

Crisis Action Planning, Phase Three

The Red Team has two primary opportunities to engage during phase three: mission analysis and COA analysis (designated "COA War Game" in fig. 2). Mission analysis is the first step in the operational planning process in which command and staff actions lead to the development of the commander's guidance. To support the formulation of that guidance, a commander will task subordinate staff echelons (such as a joint planning group or JFACC staff) to provide staff estimates on any number of subjects.[13]

The initial warning order from the supported commander establishes command re-

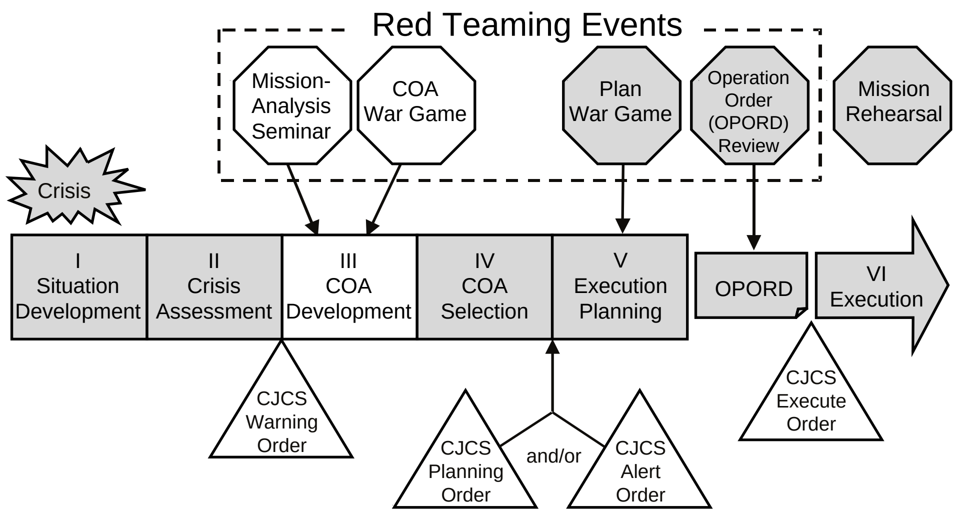

Figure 2. Red Team Opportunities during CAP, Phase Three

lationships, identifies the mission, and provides other planning constraints critical to the planning effort.[14] During the Blue planners' efforts to formulate a response to their tasking, the Red Team ideally would hold a mission-analysis seminar to conduct a peer review of the following:

- Understanding of tasking and guidance from higher headquarters, *both specified and implied*
- Assumptions that influence the staff estimate
- End state
- Mission statement
- Use of available resources to answer tasking

Mission-Analysis Seminar. This seminar follows a murder-board format. Depending upon the mission at hand, planning progress, and time available, the following items represent one possible agenda:

- Blue crisis update
- Blue briefing on its understanding of the flow of tasking (top-to-bottom) to date
- Blue briefing on its assigned *mission-analysis* task (i.e., its staff-estimate assignment)
- Blue briefing on its answer to the staff-estimate tasking
- Red Team huddle to formulate assessment
- Red Team assessment of Blue progress
- Facilitator consolidation of "take-aways" and taskers
- Commander (or Blue planning chief) assignment of taskers
- Mission-analysis seminar's after-action review

Establishing detailed ROEs for interaction during the event (such as allowing the Red Team to ask substantive questions during Blue briefings or requiring it to wait until the assessment phase) is left up to the event planners—but they should certainly agree upon the rules beforehand.

After defining the format, one should set the seating arrangement. Keeping in mind that Red Team events are intended as informal forums, it is important that Red and Blue participants interact with one another with as little obstruction as possible, as reflected in the seating arrangement for the first USAFE Red Teaming event—a war game (fig. 3). For the mission-analysis seminar, seating need not be divided as strictly between Blue and Red.

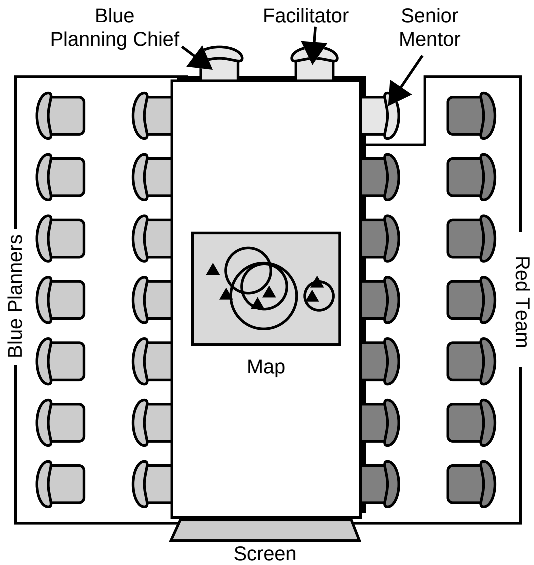

Figure 3. Seating for USAFE Red Teaming Event

During the seminar, Red Team members with appropriate expertise should bring to the attention of Blue planners any oversights, alternatives, or additional resources that the planners did not consider. The Red Team should always keep in mind the ROEs outlined above, and Blue planners should remind themselves that everyone is working toward a more effective plan. The fruits of this labor are the take-aways, taskers, and "due-outs" that the Blue planning chief assigns to his or her planners. Obtaining such results may entail more work, but if they are based upon valid insights, it will be worth the effort.

COA War Game. The second opportunity for Red Team engagement in phase three, possibly the most valuable in the entire planning cycle, comes during COA analysis. Such analysis begins after the mission analysis is complete and the commander provides the appropriate guidance.

At the same time, the joint force commander (JFC) may issue further planning guidance based upon staff estimates. Such guidance will further refine and focus the planners' efforts in developing COAs by giving clear commander's intent, end state, and priorities (among many other matters found in Joint Pub 5-00.2).[15] With this information, Blue planners can quickly begin to develop the plan in accordance with their instructions.

As the various COAs begin to take on some structure and completeness, the commander must determine the best time for Red Team engagement in a COA war game. This decision may involve a trade-off. On the one hand, if Red Team members engage too early in a COA's development, they will naturally find many holes in it—simply because Blue planners have not had time to complete their work. On the other hand, waiting until the planners have put every finishing touch on their draft COA could result in time wasted if the COA war game leads to significant redirection for the planners. A commander must use his or her best judgment for this decision. During this time, the internal Red Team (described earlier) might prove valuable in keeping planners on track.

Another consideration is that different COAs often develop at different paces. It may be valuable for the Red Team to conduct a COA war game on a substantially developed COA while other planning cells continue to work on alternative COAs. Joint Pub 5-00.2 discusses the COA war game at some length, defining it as "a conscious attempt to visualize the flow of a battle, given [joint task force] strengths and dispositions, enemy assets and possible COAs, and the [joint operations area]. It attempts to foresee the action, reaction, and counteraction dynamics of an operation."[16] The entire description is well considered and adds great value to the understanding of the COA war game. Three additional notes merit further discussion.

First, the joint publication emphasizes the importance of the planning group's having a devil's advocate who doesn't mind challenging authority.[17] Although it does not identify who that should be, the Red Team clearly is the proper entity since it can assemble experts to make valid challenges to the planning group.

Second, the publication mentions the "action, reaction, counteraction" flow of a war game—something long established in Army planning circles.[18] It is precisely here that the OPFOR experts who role-play the enemy prove invaluable. These specialists should have studied the enemy's C^2, decision-making process, doctrine, key decision points, LIMFACs, and COGs to provide as realistic a portrayal of the enemy as possible. Because the WPC Intelligence Division trains personnel who act as OPFORs during their normal exercise duties, they became the OPFOR role players for the USAFE Red Team. During the COA war game, portrayal of the enemy should be kept at a high—almost strategic—level. More detailed war gaming will come later, during the "plan war game" in phase five. For example, one could now set forth an enemy's decision to conduct information operations by portraying the conflict in a certain light in the press, while the enemy's deployment of tactical surface-to-air missiles should wait until the plan war game.

Third, Joint Pub 5-00.2 states that "the most detailed form of wargaming is modern, computer-aided modeling and simulation [M&S]" and that this "can provide a possible choice for the best COA."[19] The COA war game lends itself very well to automation. Increasingly sophisticated and accurate computer simulations can provide a detailed perspective that more traditional "pen-and-paper" war games cannot duplicate. However, use of M&S requires expertise in the appropriate simulations as well as considerable setup time in order to build the appropriate databases. In order to plan ahead for future requirements and reduce M&S lead times, the WPC—with the support of Checkmate (Headquarters Air Force's strategic-analysis team) and the Air Force's analytical community—is preparing to support future COA war games using M&S tools.

Other war-game tools include maps and a synchronization matrix. The latter is useful for recording the functional areas addressed, by phase of the operation, to ensure that no stone is left unturned (e.g., whether or not logistics was considered during phase two).

The seating previously shown in figure 3 is designed for this type of war game. The format should be an *action-reaction-counteraction* type.[20] That is, when Blue planners have described a certain set of actions that Blue commanders and forces will conduct, the OPFOR can consolidate and present the enemy's reaction, whereupon Blue planners must counteract these (possibly unconsidered) Red moves. It is important that Blue representation at the war game include planners from all appropriate functional areas so that a broad range of issues can be addressed and assessed during the event. All participants should adhere to the ROEs outlined above for maximum productivity in this and other sessions.

One major benefit that occurs during COA war gaming is *determining the logistical feasibility of a COA before selection* (M&S tools exist to facilitate this endeavor). An Air Force senior mentor recently observed that far too many COAs find their way into the hands of a JFC before the Joint Operations Planning and Execution System (JOPES) has processed the corresponding time-phased force and deployment data (TPFDD).[21] Consequently, commanders have selected some COAs, only to have subsequent planning reveal them as logistically infeasible.

As COAs develop enough to undergo comparison and ranking to determine which will be recommended to the JFC, the Red Team role changes somewhat. At this point, the team should play devil's advocate and lend expertise to determine whether Blue planners have considered everything. The Red Team *should not*, however, recommend that a certain COA be top ranked or suggest that a given COA is "good" or "bad." Such input and decisions are exclusively the purview of Blue planners. If the Red Team has done its job well, the planning team will know which COAs are solid and which are not. When the commander's estimate is transmitted, the information it contains will be much more thoroughly planned as a result of the Red Teaming process.

As anyone who has ever been involved in planning an operation knows, actual planning activity hardly ever neatly mirrors the CAP process as shown in the joint publications. Planning is iterative and constant; when a phase ends, planners must often revisit activities in that phase, based upon new information or new guidance. Once the commander's estimate is sent, planners do not simply stop work, take a deep breath, and wait for higher headquarters to select a COA—they continue developing their plan.

Crisis Action Planning, Phase Five

Execution planning, which occurs during this phase, begins with a planning or alert order and entails detailed planning to execute the approved COA.[22] Planners also transform the COA into an executable OPORD. Two points during this phase provide the next significant opportunity for Red Teaming events (fig. 4): a war game of the detailed plan and a review of the written documents. The Red Team can conduct a plan war game before or after completing a review of the OPORD and other written documents.[23]

The plan war game differs from phase three's COA war game in several respects. First, planners have developed the plan based upon a *selected* COA. Therefore, the objective of this event is to refine that COA into the best possible plan, as opposed to considering the merits and feasibility of a given COA. (However, if significant flaws in the COA emerge, this should be brought to light.)

Attendees should include all the primary members of the Blue planning staff. Their attendance will yield another prime benefit of the Red Teaming process: *ensuring that the Blue planners and staff are synchronized in their thinking about all facets of the plan*. Even during the earliest Red Team efforts in USAFE, it was clear that one of the greatest benefits of the plan war game was a shared understanding between Blue planners in different cells or at different levels.[24] For example, in a Master Air Attack Plan (MAAP) discussion midway through a war-game session, two senior Blue planners realized that the targets built into the MAAP did not exactly match those identified in the Joint Integrated Prioritized Target List. They agreed that this significant discrepancy came to light only because of the Red Teaming effort.

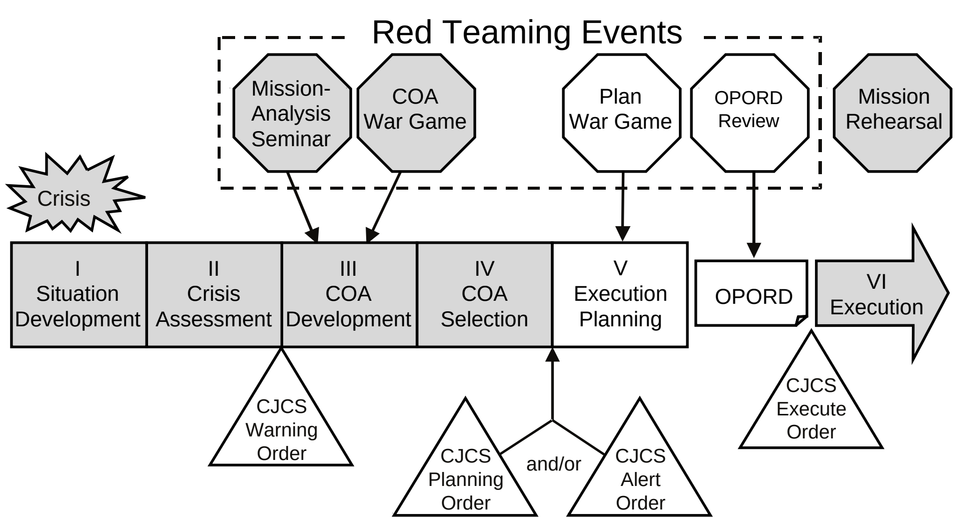

Figure 4. Red Team Opportunities during CAP, Phase Five

In a plan war game, the Red Team focuses more on operational-level enemy actions and "what ifs" involving outside agencies (versus strategic-level actions, as in phase three). Has a joint search and rescue center been established? Are the ROEs adequate? What country clearances are required for overflight? What if the enemy employs his assets in a way not considered? Such are the issues with which the plan war game is concerned.

An interesting phenomenon often emerges during this type of Red Teaming event. Although the Red Team does not conduct an evaluation, the plan is evaluated nevertheless. Normally, Blue planners identify the flaws in their reasoning or planning quite candidly, without being asked. Sometimes they explain a shortfall or oversight that *otherwise would have gone unnoticed*.

Figure 4 shows that the OPORD review follows CAP, phase five; however, reviews could and should take place throughout the planning process when written documents are in a sound draft format. The Red Team can do a review either as a seminar or independently. During this review, the team should determine whether the OPORD or plans are complete (including all annexes), intact, understood by subordinates, and ready for transmission or presentation to higher headquarters.

Additionally, the Red Team should determine whether the OPORD as written *is consistent with previous products and briefings as well as with the guidance and intent of higher headquarters*. Occasionally, "planning momentum" will result in a plan's undergoing slight, almost imperceptible, deviation as planning proceeds. This always originates in the details—"down in the weeds"—but can affect a plan significantly as it moves through its iterations. Is the final OPORD consistent with the commander's estimate? Is it consistent with other briefs to higher headquarters in the interim? Does it answer the commander's original intent and guidance? The Red Team should remain alert to discrepancies in these areas.

Mission Rehearsal

As a plan approaches execution, the final event in preparing the staff to execute the plan is a *mission rehearsal* (fig. 5), whose purpose is to "prepare commanders, staffs, and assigned forces for known crisis operations. . . . Typically,

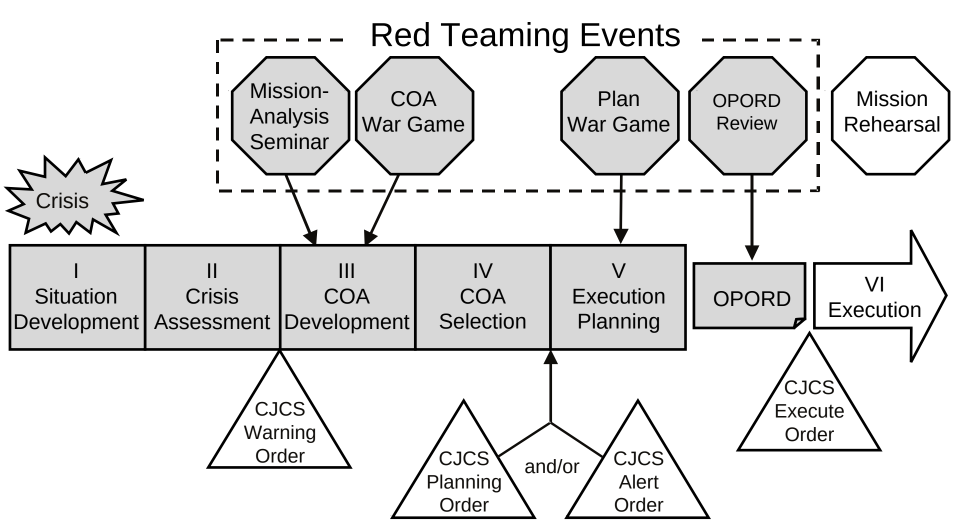

Figure 5. Mission-Rehearsal Opportunities

a rehearsal program will employ [command-post exercises and computer-assisted exercises] . . . as time permits."[25] Rehearsals can take many forms but likely will include the entire planning and operations staffs as they conduct the myriad processes required to orchestrate and execute the air and space campaign successfully. Although mission rehearsal is not considered a Red Teaming event, members of the Red Team should certainly be involved in it, possibly as observer trainers for the Blue planners.[26]

Conclusions

USAFE's early Red Teaming efforts will continue to evolve. Development of the commander's Red Team becomes more focused with each effort. One thing is already clear—Red Teaming adds great value to contingency planning. It would likely do the same for deliberate planning. Air and space staffs should consider the doctrine already in place, as well as the ideas expounded here, with a view toward making Red Teaming a staple of the planning process.

Field Marshal Helmuth von Moltke's adage "no plan survives contact with the enemy" is true.[27] But through Red Teaming, a plan can be refined *after* each contact with a Red Team. This process is valuable because it brings a contingency plan, together with the reasoning and information behind it, under the scrutiny of a well-simulated *enemy*. Better still, the Red Team can imitate outside agencies, higher headquarters, and even "Murphy's Law." A plan that survives this kind of treatment should be healthy indeed. To modify Gen George S. Patton's famous quotation, "A good plan, well rehearsed, is better than a perfect plan unrehearsed."[28] □

Notes

1. *Air War over Serbia: Aerospace Power in Operation Allied Force* (U) (Washington, D.C.: Headquarters United States Air Force, 2000), 5.

2. This discussion relies upon the definition of *war game* found in *The Official Dictionary of Military Terms,* comp. the Joint Chiefs of Staff (Washington, D.C.: Science Information Resource Center, Hemisphere Publishing Corporation, 1988): "a simulation by whatever means of a military operation involving two or more opposing forces, using rules, data, and procedures designed to depict an actual or assumed real-life situation."

3. Lt Gen S. B. Croker, USAF, retired, chief of staff of the Air Force senior mentor, memorandum to Gen G. S. Martin, Headquarters United States Air Forces in Europe (USAFE), subject: Comments on Red Team Exercise, 3–4 January 2002, 5 January 2002.

4. For an excellent history of war gaming, see Lt Col Matthew Caffrey Jr., "Toward a History-Based Doctrine for Wargaming," *Aerospace Power Journal* 14, no. 3 (Fall 2000): 33–56.

5. Field Manual (FM) 101-5, *Staff Organizations and Operations,* 31 May 1997, 5–16.

6. Air Force Doctrine Center Handout (AFDCH) 10-01, *Aerospace Commander's Handbook for the JFACC,* 27 June 2001, 15.

7. The Warrior Preparation Center developed this definition in anticipation of USAFE's first Red Teaming event.

8. Col Bobby J. Wilkes, "Silver Flag: A Concept for Operational Warfare," *Aerospace Power Journal* 15, no. 4 (Winter 2001): 55.

9. *Murder-boarding* is defined as a critical review of a document, briefing, or plan accomplished in a trial-jury format. (Its euphemism is "review by committee.")

10. For the global war on terrorism, COMUSAFE has been designated as the theater JFACC and COMAFFOR. As part of his AFFOR staff, COMUSAFE designated the WPC commander as the A-9, responsible for mission rehearsals and analysis. The A-9 serves as the Red Team leader.

11. Joint Pub 5-00.2, *Joint Task Force Planning Guidance and Procedures,* 13 January 1999, fig. IX-10.

12. Ibid., fig. IX-19.

13. Ibid., p. IX-40.

14. Ibid., pp. IX-17, IX-18.

15. Ibid., p. IX-40.

16. Ibid., pp. IX-45, IX-46, fig. IX-19.

17. Ibid., p. IX-46.

18. Ibid.

19. Ibid., pp. IX-46, IX-49.

20. See FM 101-5 for an excellent description of the war-game format.

21. Croker.

22. Joint Pub 5-0, *Doctrine for Planning Joint Operations,* 13 April 1995, III-14.

23. In order to maintain consistency with the CAP process as defined in the joint publications, this article uses the term *OPORD* to include the primary written planning documents such as an OPORD, joint air operations plan, operations plan, and concept plan.

24. Croker.

25. Chairman of the Joint Chiefs of Staff Manual (CJCSM) 3500.03, *Joint Training Manual for the Armed Forces of the United States,* 1 June 1996, V-3.

26. For more information on mission rehearsals, contact the Warrior Preparation Center at WPC / grpCC@wpc.af.mil.

27. Quoted in Edward S. Miller, *War Plan Orange: The U.S. Strategy to Defeat Japan, 1897–1945* (Annapolis: Naval Institute Press, 1991), 333.

28. Joint Pub 5-0, III-1. Based on his wartime experience, General Patton observed, "A good plan executed violently now is better than a perfect plan next week."

Maintaining Friendly Skies

Rediscovering Theater Aerospace Defense

LT COL LESTER W. GRAU, USA, RETIRED
DR. JACOB W. KIPP

Editorial Abstract: As Pearl Harbor did in 1941, the 11 September 2001 terrorist attack brought home the catastrophic consequences of an insufficient homeland aerospace defense. This is not a new issue. The history of the Cold War is replete with attempts to build effective aerospace defenses for the United States and Soviet homelands as well as for the theater armed forces of both superpowers. Grau and Kipp chronicle this history and recommend steps for improving US theater and homeland aerospace defenses.

WORLD WAR II began with the catastrophic failure of US air defenses over Pearl Harbor and in the Philippines. While the United States invested major resources in air defense and conducted a campaign of air-raid drills and blackouts, no serious air threat to the continental United States emerged during the war. One Japanese floatplane did manage to bomb California after being launched off a long-range submarine. Late in the war, the Japanese launched high-altitude balloons loaded with incendiary devices into the Pacific jet stream with the expectation that the balloons would float into the Pacific Northwest and their incendiary devices would cause forest fires. The incendiary balloon effects were marginal.[1] In the European and Pacific theaters, however, new aerospace threats created new challenges to the defense. In Europe, Hitler's vengeance weapons *(Vergeltungswaffen)* radically recast the problem of air defense for England. A solution to Hitler's pilotless ramjet V-1s involved both offensive and defensive responses—bombing launch sites, seizing launch sites, coordinating radar stations with day and night interceptors, and flak batteries. There was no suitable answer to counter the German V-2 ballistic missile, save seizing the launch areas themselves. The Germans fired over 3,000 V-2s against England, France, and Belgium in late 1944 and early 1945. These terror weapons were Hitler's answer to the Allied air campaign against German cities and could deliver one ton of explosives to a range of 240 kilometers (km) against an area target—such as a large city. In the Pacific, desperation drove the Japanese to employ extreme measures. Kamikaze pilots made their first suicide attacks against American ships during October 1944, as the American campaign moved to retake the Philippines. These attacks continued to the end of the war, and while modern conventional air defenses inflicted heavy casualties, enough kamikazes got through to their targets to inflict serious losses on US naval ships and personnel. The United States countered the Japanese low-tech, high-science balloon assault, mentioned above, with consequence-management measures (additional firefighters and smoke jumpers) and a total news blackout on the results of the attacks. Events in Europe and the Pacific were harbingers of things to come, although the situation changed radically with the advent of atomic weapons.

The atomic attacks on the cities of Hiroshima and Nagasaki contributed to the end of the war and were supposed to usher in a time when a US nuclear monopoly would restore America's strategic invulnerability. This period of invulnerability proved short. The USSR detonated its first atomic bomb in 1949 and had already built a strategic, nuclear-capable bomber—the Tu-4, a copy of an American B-29 that had landed in the Soviet maritime provinces. The destructive power of nuclear weapons rose geometrically, and nuclear weapons and ballistic missiles were joined to allow for short, intermediate, and intercontinental nuclear strikes. The nuclear-tipped missile challenged the monopoly of manned bombers in nuclear war. In a relatively short time, the air-defense mission evolved from its focus on causing attrition against massed bomber attacks to intercepting single and small groups of planes to stopping ballistic missile attacks. The rapid technological development of offensive weapons posed a serious challenge to air defenders.

In the first few decades of the Cold War, the Soviet Union acquired atomic and then nuclear weapons far more rapidly than expected and began building a strategic air force to deliver the weapons. In response, the United States and Canada deployed an integrated continental air-defense system based on a combination of US Army missiles, Navy early warning stations, and Air Force early warning stations and interceptor aircraft. Soviet intercontinental bombers were the primary threat that motivated the creation of this system. The Nike Ajax and Nike Hercules missile systems provided the Army missile component under the Army Air Defense Command (ARADCOM). Continental/National air defense went hand-in-hand with national civil defense measures such as air-raid drills, evacuation plans, and fallout shelters.

Until the 1970s, Nike sites, manned by regular and National Guard batteries, protected key cities and installations throughout the United States while the Air Force protected the space in between. Nike Hercules sites, manned by US Army missileers, continued to guard the skies in the Federal Republic of Germany and the Republic of Korea until 1984.

By the 1960s, however, the chief strategic threat to the United States had shifted from manned bombers to ballistic missiles. Confronted by expanding arsenals on both sides and sobered by the experience of the Cuban missile crisis, the United States and the Soviet Union moved towards strategic arms control in lieu of the deployment of full-blown but marginally effective systems of ballistic missile defense (BMD). These systems employed nuclear warheads, and the defense priorities for their use vacillated. The focus shifted between protecting urban centers from Soviet attack and defending the retaliatory capabilities of the United States, and included varying concerns about a possible attack from China. Urban Americans became anxious with a nuclear defense strategy that would destroy inbound enemy nukes by detonating their own defensive missiles' nuclear warheads overhead. There were also considerable political arguments and technical problems to complicate the development process. Additionally, the overhead detonation of nuclear weapons to defend missile silos would create their own electromagnetic pulse that could be a problem for the very radars and the silo-based missiles they were defending.

Meanwhile, the strategic nuclear theory shifted over time and included concepts like massive retaliation, mutually assured destruction (MAD) and deterrence, and the Strategic Arms Limitation Talks (SALT) I and II. The SALT agreements limited launchers but did not preclude a technological arms race to improve delivery systems, such as reduced circular error probables (CEP) and multiwarhead missiles. The arms-control process did, however, lead to a radical shift in the priority given to national aerospace defense. As a result of the Antiballistic Missile (ABM) Treaty of 1972, the United States developed the Safeguard ABM system and deployed a limited number of missile interceptors around its intercontinental ballistic missile (ICBM) silos in North Dakota while the Soviet Union deployed its limited ABM assets around its national command authority in Moscow. Three years after signing the ABM Treaty and only a month after activating its ABM complex in North Dakota, the United States closed the site. National air defense lost its strategic priority and became solely the business of interceptor aircraft working for North American Air (now "Aerospace") Defense Command (NORAD). Units of the Air National Guard flew much of this air-defense mission.

In 1983 President Ronald Reagan revived national interest in aerospace defense by proposing the Strategic Defense Initiative (SDI). Its goal was to advance technology in order to create an effective shield against ballistic missiles. SDI explored a wide range of ground-based and space-based advanced technologies for sensors, guidance, and destruction, but the program did not advance beyond research and development. However, it did stir an emotional national debate over the feasibility and wisdom of seeking such a defense against an attack by the Soviet Union. Critics accused the administration of seeking a "first-strike" capability that would undermine the arms control regime and a strategy of deterrence. Technical experts opposed the program they called "Star Wars," implying that so complex a system was more a work of science fiction than prudent national defense. They maintained that SDI was unlikely to function with the degree of perfection necessary to be effective in a war against the Soviet Union. Proponents spoke of the logic of saving American lives and of restoring the strategic invulnerability that had been disrupted by the appearance of nuclear weapons, intercontinental delivery systems, and the Cold War. A few supporters defended the initiative as an exercise in competitive strategy, which would force the Soviets to engage in massive investments in offensive and defensive systems at a time of growing strain on the Soviet national economy. Ironically, since the program was one of research and development, the SDI probably did serve to end the Cold War—not as a technological threat, but as a strategic indicator that the United States was not about to launch an imminent attack on the USSR. This gave President Mikhail Gorbachev some room to maneuver, which he used to begin strategic disengagement in carrying out pressing domestic reforms to bolster the Soviet economy. The air-defense failure that allowed Mathias Rust to land a light plane just off Red Square provided Gorbachev the justification for an assault on the privileged position of the Soviet military. The Reagan and Bush administrations embraced this opportunity, and arms control played a vital role in ending the Cold War with the Intermediate Missile Forces (IMF) Treaty, the Conventional Forces in Europe (CFE) Treaty, and the Strategic Arms Reduction Treaty (START).

Now, over a decade after the end of the Cold War, the United States is considering a national BMD—based on a missile intercept capability. The proliferation of weapons of mass destruction (WMD) and the spread of ballistic missile technology are the two factors that have driven the current debate. The marriage of the ballistic missile with nuclear, chemical, or biological warheads has ceased to be the privilege of major powers and is now within the reach of smaller and less stable states. It would be prudent to examine the prior experience and lessons learned about theater air defense before fielding such an expensive and important system. Most of the ARADCOM missile men who manned the stateside Nike Ajax and Nike Hercules sites have retired, and many of the lessons learned in their air-defense missile units are lost, forgotten, or archived. However, there are other sources of material available on the subject. The Soviet Union also operated a national air-defense missile, interceptor aircraft, and BMD system. Much of that system remains intact in Russia, in successor republics, and in military client states. Interviews with Soviet and Russian air-defense officers and Russian open-source material on the subject help provide a comparison between the two national air-defense systems, imparting potential lessons for a new national missile defense system.

Defending the Continental United States

The explosion of the first Soviet atomic bomb in 1949 and the outbreak of the Korean War in 1950 provided the impetus for the creation of a continental air defense. The Army, Air Force, and Navy formed a massive system to detect, identify, attack, and destroy the strategic bombers of a hostile and nuclear-capable Soviet Union. The Army's initial effort was the formation of the Army Antiaircraft Command (ARAACOM). This command deployed early warning radar throughout the United States and antiaircraft gun battalions around 23 critical areas in the United States. In 1954, ARAACOM began deploying Nike Ajax missile battalions to replace the antiaircraft battalions. ARAACOM changed its name to USARADCOM in 1957 and then shortened it to ARADCOM in 1961 to reflect the change to missile defense. Along the way, the Army lost the early warning radar sites to the Air Force. The Army maintained a point air-defense capability around 22 population and industrial centers with 250 surface-to-air missile (SAM) batteries. Combat readiness was high since 25 percent of the batteries were always on combat alert. The Air Force conducted area defense of the rest of the United States using interceptor aircraft and a few Bomarc unmanned ramjet winged interceptors based at 10 sites.[2]

The Nike Ajax missile was a two-stage missile with a solid-fuel booster motor and a liquid-fuel sustainer motor. It had a range of 50 km, or 31 miles, and could reach targets at a height of 80,000 feet. It could fly at Mach 2.3, or 1,750 miles per hour (mph), and employed a high-explosive warhead. By 1958, the Army had developed and begun deploying the new Nike Hercules—the Nike Ajax had been replaced and was out of the Army inventory by 1964. The Nike Hercules was an improvement over the Nike Ajax in that it was a two-stage, solid-fuel system, had an increased range of 160 km (100 miles), and could engage targets at a height of 150,000 feet. It could fly at Mach 3.3 (2,500 mph) and had a high-explosive and variable-yield nuclear warhead that could also be used against surface targets.[3] The Nike Zeus (fig. 1) was tested as an antiballistic missile and as an antisatellite weapon (both missions envisioned the use of nuclear warheads). Although it was never fielded, it evolved into the Spartan missile and was deployed briefly as part of the Safeguard ABM system in North Dakota in 1975.

Figure 1. Nike Zeus, Hercules, and Ajax missiles

As the Soviet ICBM threat grew, the Army planned to counter it through deployment of Nike Zeus, then Nike X, then Sentinel, and finally the Safeguard missile systems. The Army's first ICBM target intercept was in 1962. The Safeguard system centered around two missiles—the Spartan and the Sprint. The Spartan was a solid-fuel, three-stage missile designed to destroy ICBMs outside Earth's atmosphere. It had a 460-mile range, was effective up to an altitude of 340 miles, and carried a nuclear warhead. The Sprint was a two-stage, final-defense missile. It was shot into the air by a gas piston before its booster rocket fired. It had a 25-mile range and flew to an altitude of 10,000 feet. It also carried a nuclear warhead. The Army planned 12 Safeguard sites and began construction of the first site in North Dakota in 1970. In 1972, the Soviet Union and United States ratified the interim agreement on the limitation of strategic offensive arms, commonly called SALT I. That agreement limited the number of ABM sites to two per country; the United States chose to defend the sites of Washington, D.C., and the missile fields in North Dakota. Congress, however, withheld funding for the Washington, D.C., site. A protocol on the treaty then limited each country to one ABM site. The Grand Forks, North Dakota, site was completed and declared operational in October 1975—and closed one month later.[4]

The United States chose to rely on the nuclear strategy of MAD rather than an ABM defense. Since the United States decided not to defend itself against missiles, it also decided not to mount an all-encompassing air defense against aircraft. ARADCOM was deactivated in 1974, and the US Army was out of the continental air-defense business. NORAD continued to provide air defense using Air Force and Air National Guard interceptors.

Defending the Soviet Union

The Soviet military had five services—strategic rocket forces, ground forces, air-defense forces, air forces, and the navy. The Soviet ground forces, air force, and navy had their own tactical air-defense systems, but these were used for point defense of important installations and sites. PVO Strany, the Soviet National Air Defense Force, was founded in 1948 and provided a layered air-defense umbrella over the entire Soviet Union. The air-defense forces consisted of intercept aviation, missile troops, and early warning forces.

Since the National Air Defense Force was a separate service, it trained its own pilots, radar technicians, and missile men. Training facilities included 14 commissioning academies (six surface-to-air missile, three fighter-aviation, and five radio-electronics for air defense) where candidates were prepared for service as air-defense officers. The commissioning

Figure 2. MiG-25 (Foxbat)

academies were, in effect, engineering universities that specialized in a particular system and involved four to five years of engineering theory and application studies. For example, the SAM academy at Dnipropetrovsk in the Ukraine spent four years training officer candidates to serve on a specific SAM system. Graduates of this academy expected to serve their careers working with this system.

The Soviet PVO Strany was organized into armies that were responsible for particular air-defense regions. These regions covered the entire country and presented a missile-heavy perimeter defense on likely aviation approaches. A typical air-defense army was divided into missile and interceptor aviation corps, and each corps had three to five regiments. The MiG-25 (Foxbat [fig. 2])[5] and MiG-31 (Foxhound [fig. 3]) were the interceptor aviation corps's primary aircraft. The corps would manage the air-defense battle when its interceptor aviation was engaged. However, missile units would initiate the battle by intercepting incoming enemy aircraft at maximum range. Usually, interceptor aircraft had their own sector of responsibility.

Figure 3. MiG-31 (Foxhound)

A missile regiment would control groups and battalions of different types of missiles. Long-range area protection was provided by the S-200 (SA-5 Gammon) (fig. 4) and the S-300 (SA-10 Grumble) (fig. 5). They were always deployed in groups comprised of two to five battalions. One of the group's battalions was always on full combat alert. Groups with five

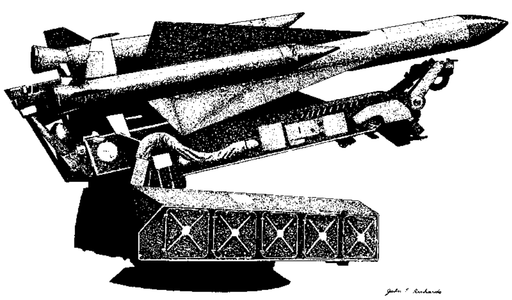

Illustration by John Richards

Figure 4. S-200 (SA-5 Gammon)

battalions were automatically upgraded to regiments. These regiments protected key areas such as Moscow and Leningrad. Point-defense missile systems such as the medium-range V-75 Dvina (SA-2 Guideline) (fig. 6) and the short-range S-125 Neva (SA-3 Goa) were deployed only as battalions. If PVO Strany were guarding an important location, it would position the SA-2 and SA-3 battalions near the protected

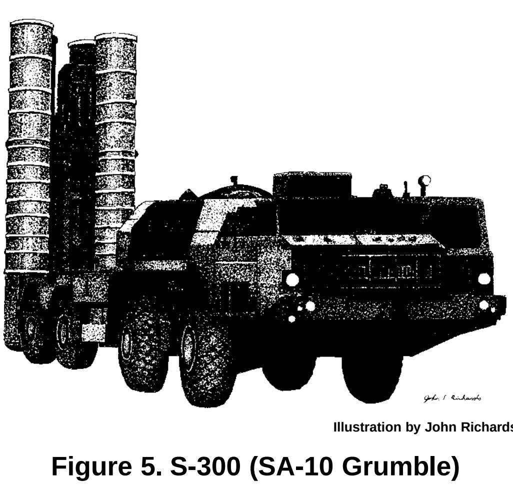

Illustration by John Richards

Figure 5. S-300 (SA-10 Grumble)

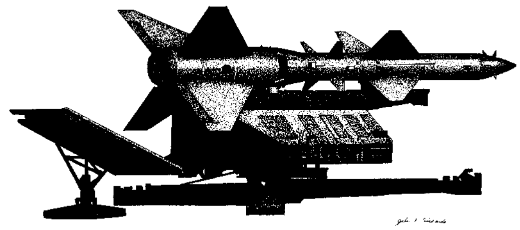

Illustration by John Richards

Figure 6. V-75 Dvina (SA-2 Guideline)

area and place the SA-5 battalion where it could cover the approaches to the farthest extent possible. Depending on the value of the area, it would establish a single-belt, double-belt, or triple-belt protection area. Air-defense interceptors would cover sectors outside the missile sector but could fly into the missile sector in an emergency. The layered air-defense-missile defenses were designed to engage enemy aircraft at the maximum possible range, reengage surviving aircraft with medium-range missiles, and then attack the last survivors with short-range, air-defense missiles. Antiaircraft guns were often included in many defensive sectors to provide a close-in air defense.

The SA-5 SAM system was the backbone of the PVO Strany. Its liquid-fueled missile, assisted by four jettisonable booster rockets, was capable of engaging targets as low as 30 meters to as high as 40 km (25 miles). The maximum effective intercept range of the later models was 300 km (186 miles), but they could fly and engage at greater distances. The minimum intercept range of 7 km (four miles) is due to its booster burn time and jettison requirements. The SA-5 carried a high-explosive or nuclear warhead and had a 96 percent probability of kill when it was properly sited, manned, and employed within its operating parameters. The nuclear warhead was designed for use against massed aircraft. The SA-5's primary targets were AWACS aircraft, cruise missiles, cruise-missile carriers (like the B-52), jamming aircraft (like the RC135), the F-15, the F-16, and the SR-71. There have been eight versions of the SA-5. Early versions, such as those deployed by Libya in 1986, were readily defeated by electronic countermeasures (ECM). Later versions have improved guidance packages with electronic counter-countermeasures (ECCM).[6]

The S-300PS (SA-10 Grumble) is a low-to-medium-range mobile missile system. It has four single-stage solid-propellant missiles that are housed in reusable launch / shipping canisters which are mounted on a dedicated transporter-erector-launch vehicle. The missile launches vertically, with an intercept altitude ranging from 20 meters to 40 km. The maximum intercept range for aircraft is 150 km and for ballistic missiles 40 km. The SA-10 can intercept cruise missiles, aircraft, as well as ballistic missiles at a speed of 3,000 meters per second (6,710 mph). It has a high-explosive warhead and the potential for a nuclear warhead.[7] It is a moderately expensive system. An SA-10 complex outside of Moscow suffered a major explosion and fire on 8 June 2001, and the subsequent destruction of three of its launchers and 13 missiles represented a loss in excess of $17 million.[8]

The Soviet Union exported its missile systems and missilemen throughout the Cold War. Using the experience gained in various local wars, they were able to test and improve their equipment. Being aware of the support Israel received from the United States, Egypt turned to the Soviet Union for assistance after experiencing defeats in 1956 and 1967. Soviet military advisers had been in Egypt since 1957 but began arriving in force following the June 1967 war.[9] The Soviets arrived in civilian clothing and served in Egyptian uniforms without rank or other identifying markings.[10] They came to train the Egyptians on their new Soviet equipment but also flew combat air patrols and manned modern air-defense systems while Egypt refitted its equipment and retrained its personnel.

The Egyptian armed forces were completely refitted with Soviet tanks, aircraft, air-defense systems, and other tools of war. The air-defense systems included the improved V-75 (SA-2 Guideline), S-125 (SA-3 Goa), ZUR 9M9 (SA-6 Gainful), and Strela 2 (SA-7 Grail).[11] The Soviets sent a separate air-defense division with 27 battalions of S-125 and ZUR 9M9 missiles.[12] The Soviets also devised cheap and effective ways to defeat Israeli technology. For example, the Israeli Air Force had received the deadly US AGM-45 Shrike and other antiradiation missiles designed to lock onto a radar transmission, follow the radar beam to its source, and destroy the radar. The Soviets had studied the very effective Shrike while they were supporting North Vietnamese air defense in Vietnam. On 18 April 1971 the Israeli Air Force launched 72 Shrike missiles against Soviet-manufactured radars located in the Suez Canal Zone—only one Israeli antiradiation missile hit Egyptian radar. The Soviets had simply packed the area with radars and turned them all on. Faced with too many targets and choices, the missiles failed to lock on to a single radar.[13]

Soviet/Russian Missile Defense

When the Soviet Union signed the SALT I Treaty, it chose to build its ABM sites around Moscow and Leningrad. When the United States decided not to build its site around Washington, D.C., the two nations renegotiated the 1974 protocol, and the Soviet Union canceled its Leningrad site. However, the Soviet Union remained committed to its Moscow ABM site despite the decision by the United States to close its single remaining Safeguard site. The Soviets built and maintained a two-layered ABM defense around Moscow, which consisted of silo-based long-range A-350 (ABM-1 Galosh [fig. 7]) three-stage, solid-fueled interceptor missile and follow-on interceptor missiles. These were silo-based, high-acceleration interceptors designed to engage targets within the atmos-

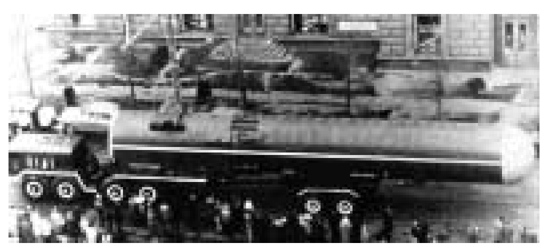

Figure 7. A-350 (ABM-1 Galosh)

phere, above-ground reusable launchers, and associated radar. There were up to 100 launchers in this system.[14] The Soviets formed an antimissile defense force that was separate from the regular PVO Strany.

The Soviets were concerned with the survivability of their forces and continued to develop air-defense systems for their ground forces, air force, and navy. The tactical ballistic missile threat required a mobile defense. The Soviets developed the S-300V (SA-12a Gladiator [fig. 8] and SA-12b Giant), a multistage missile that is launched from tubular canisters on the back of the tracked or wheeled launch vehicle.

Figure 8. S-300V (SA-12a Gladiator)

Theater Aerospace Defense: Contemporary Options and Historical Experience

The world has clearly changed from when the United States and the Soviet Union confronted each other during the Cold War with sufficient nuclear power to eliminate each other and do serious collateral damage to the rest of the planet. Russia still has a large, powerful nuclear arsenal, but the open hostility that existed between the communist and capitalist blocs has disappeared. Although serious issues remain between Russia and the United States, none are apparently so serious that both nations are willing to risk annihilation for their resolution. Clearly, the MAD strategy is strategically irrelevant. Some Russian civilian analysts have proposed moving from MAD to mutually assured protection (MAP) on the basis of cooperation in the development of theater and national aerospace defense systems.[15] Russian military analysts have noted the continued irrationality of general nuclear exchange but have also spoken of the risks posed by the escalation of local conflicts into nuclear ones.[16] Three summers ago the armed forces of the Russian Federation ran Zapad-99, a large-scale exercise in which Russian forces countered simulated aggression in the Baltic region. With limited conventional forces, the Russian high command introduced theater nuclear forces to achieve escalation domination in a local war, a strategy in keeping with Russia's draft military doctrine.[17] At the same time, the United States and Russia continued to explore the problem of theater missile defense, even as they argued over the prudence of modifying the ABM Treaty. Russian attention has focused on the problem of aerospace defense against precision strike and its supporting systems, typified by the greatly enhanced reconnaissance, electronic warfare, and precision-guided munitions capabilities demonstrated during the Gulf War.[18] Russian authors stress the need for a wide range of measures to protect air-defense sites from these systems as the only cost-effective solution to their perceived threat.[19] The most outspoken Russian proponents of the revolution in military affairs have noted "the increased role and changing function of aerospace defense" and a shift in aerospace defense capabilities to effectively engage air- and space-based, long-range, precision- strike platforms. V. I. Slipchenko, an air-defense expert and former research coordinator at the Military Academy of the General Staff, anticipates the appearance of such systems in the 2010–20 time frame as part of what he calls *sixth-generation* or *post-nuclear* warfare.[20] Slipchenko also foresees a major program in the United States for "non-strategic aerospace defense," based upon the proliferation of WMDs and delivery systems.[21]

The rest of the world has not stood still. To the extent that their budgets and technology allow, other nations have entered—or are trying to enter—the nuclear club and are building or buying their own nuclear delivery systems. Nations such as Belarus, China, France, Germany, Greece, India, Iran, Iraq, Israel, Italy, Japan, North Korea, Pakistan, Russia, South Korea, Syria, Taiwan, and the Ukraine are building or buying their own BMD systems. Whether or not the United States builds an effective antiballistic missile system will have little impact on preventing other nations' development of missile and antimissile programs. Iran recently demonstrated the ability to mount a sustained barrage of ballistic missiles against Iraq by firing 66 Scuds from 17 launchers over a three-hour period.[22] During the same period, Russian specialists announced the sale of an advanced Scud missile with an optical guidance capability that would achieve greater accuracy during its terminal stage of flight.[23]

How will the United States protect itself against attacks upon its homeland? Ballistic missiles represent only one such strike system. Many state actors could develop a range of air- and sea-launched cruise missiles capable of carrying WMDs. They could also engage in the covert delivery of WMDs by land, sea, or air. An information attack could come from a state or nonstate actor using information technology to attack critical systems via the Internet. At what point, or following what event, does the president authorize the employment of nuclear weapons? Will the president retaliate with a nuclear strike following the loss of Seattle? Will the president promise to retaliate against any hostile nuclear actions by any other nuclear-capable country with an overwhelming return nuclear strike? How will the United States respond to the destruction of its nuclear-attack ballistic missiles by another country's antiballistic missiles? What is the nuclear threshold today, and how do other nations know how far they can go before they have crossed it? What is the new US nuclear strategy?

Without firm answers to these questions, a limited continental antiballistic missile system might seem prudent for the United States in dealing with rogue nuclear powers and maverick launches from other powers' strategic arsenals. Such a system would have to provide a working system that can protect the United States so that the limited use of nuclear-armed ballistic missiles would prove unlikely to succeed. This system should also be affordable and avoid setting off a nuclear arms race that would make such a limited system irrelevant. Technologically, problems remain, such as with the kinetic-energy hit-to-kill technological challenges. In the past, the technological answer adopted by both powers to the problem of hitting a bullet with a bullet (hit-to-kill technology) was to use nuclear warheads on SAMs. The difficulty with using nuclear warheads, aside from creating a cloud of radioactive fallout over one's own country, is the resultant electromagnetic pulse (EMP) generated by the nuclear detonation. It would likely knock the bulk of electronic systems off-line immediately, including the air-defense systems needed to fight a follow-on attack. Reliable, nonnuclear antiballistic warheads are desirable but difficult to design. Other nuclear-capable countries may find the hit-to-kill technology too difficult and may stick to nuclear warheads for their SAMs and missile-defense systems.

The problem has outgrown the scope of just homeland defense. The United States continues to deploy forces abroad, and the protection of those forces is a major issue. The hardware and technology of theater ballistic missiles (TBM), rather than ICBMs, have become the focus of modern missile proliferation, and the former has become theater weapon of choice. During Desert Shield, the United States had a difficult time keeping the coalition together when Israeli cities became the target of Iraqi Scud attacks. The possibility of an Iraqi warhead armed with chemical munitions hitting Israel raised the prospect of an Israeli retaliatory attack against Baghdad itself. The speedy deployment of US Army Patriot missile (fig. 9) batteries to Israel was the US response to this political-military risk. TBM defense had suddenly become a critical strategic issue.

Figure 9. Patriot Missile Launch

Another issue concerns deployed US forces: under what terms and conditions will the United States feel compelled to use tactical nuclear weapons to contain or restore the situation in-theater? This almost happened on the Soviet side. The most casual student of history is aware of how the United States and the Soviet Union approached the nuclear threshold over the issue of Soviet nuclear missiles in Cuba in October 1962. Few people are aware of just how close the superpowers were to the initiation of nuclear war. In addition to the detected medium-range ballistic missiles, the Soviet internationalists had also brought, undetected, operational tactical nuclear systems into the theater. Although the medium-range missiles potentially threatened the United States proper, the short-range tactical missiles were the ones more likely to be used on the battlefield.

Gen Issa Pliyev was the overall Soviet commander at the time, and he operated under the pseudonym of General Pavlov. Washington was not aware of the presence of these tactical nuclear weapons and delivery systems in Cuba. Nor did the United States know that General Pliyev had already received the authority to use the tactical nuclear weapons in case the Americans attacked when he did not have communications with Moscow. During the height of the missile crisis, Castro asked Nikita Khrushchev to launch a first strike against the United States. Khrushchev was not ready to initiate a nuclear exchange on Castro's behest, but the danger still existed. On 27 October, while piloting a USAF U-2 reconnaissance aircraft over Cuba, Maj Rudolf Anderson Jr. was shot down and killed by a Soviet V-75 air-defense missile. Fortunately, he was to be the sole combat casualty of the crisis—but it could have been different. The American fleet was off the shores of Cuba, and only 36 R-12 medium-range ballistic missiles were at launch positions. Of these, only half had been fueled, and none of them had their nuclear warheads attached. For the US command, it was the optimum time to launch an air strike to destroy the missiles while jamming Cuban and Soviet radar and communications. This option was strongly argued to President John Kennedy.[24] If it had been executed, it would have presented General Pliyev with the option of employing his tactical nuclear weapons against the US fleet cruising off Cuba's shore. The catastrophic loss of thousands of US sailors and marines would have undoubtedly led to nuclear exchange between the superpowers.[25]

Survivability of air-defense assets is another issue. Mobility is a valuable attribute to a SAM system, though not absolutely essential for survival. Since the Gulf War, the United States and Britain have conducted a protracted effort against Iraqi air defenses—which still survive. The Serbian forces were able to preserve much of their air defenses despite the concerted NATO campaign. Political targeting restraints on offensive aerospace operations will most probably be a part of future conflicts. This will create opportunities for even small air-defense systems to engage in a strategy of withholding forces in order to preserve an "aerospace defense in being," to act as a future check on the tactical employment of precision-strike forces in a theater campaign.

Conclusions

What lessons from the United States and Soviet Union theater-air-defense-systems experience can be applied to a future missile defense? There are undoubtedly many technological lessons, but the primary lessons are listed below:

1. National nuclear policy is central to BMD. In the absence of a peer competitor, intent upon military confrontation and possessing an arsenal that could threaten the survival of the United States, a full-blown aerospace-defense system seems unlikely. Proliferation of WMDs and delivery systems among rogue states will likely increase pressure for the deployment of a limited theater and continental ABM system.

2. National air defense was more efficient and cost-effective when conducted by a separate air-defense service. Interservice rivalry was eliminated, and the army, navy, and air force were left to perform their primary jobs. However, the antimissile problem has now spread beyond homeland defense, and theater ballistic missile defense (TBMD) is now a major concern for all the services. Until last year, the National Defense Strategy pursued the ability to "fight and win two separate conflicts simultaneously" but failed to address homeland defense. While the new strategy is somewhat murky, homeland defense is clearly a key component of the National Defense Strategy.

3. Missiles are a primary component of air defense and need to be designed for both area and point defense. A national missile defense will require long-range area-protection missiles and short-range point-defense missiles. Cruise missile defense is as essential as BMD. Electronic warfare and information warfare will figure prominently in future struggles between offensive and defensive systems and are likely to have an increasingly decisive influence on the outcome. Radar is vital in detecting, acquiring, and tracking targets. Ground-based radars are restricted in coverage due to terrain masking, Earth's curvature, and other factors. Space Based Radar (SBR) will be necessary to provide area coverage for the large North American theater.

4. Redundancy and effective command, control, communications, and information management are keys to a reliable air-defense system. However, with the growth of multiple warheads and decoys, a space-based weapon designed to destroy a missile during launch makes increasing sense. The compressed decision cycle minimizes human participation in making the attack decision, and relying exclusively on artificial intelligence is fraught with peril.

5. Nuclear warheads remain a viable but troublesome method of destroying hostile aircraft and missiles for nations that lack a precision-intercept capability. The real-time disruption of defensive radars by the nuclear detonation's electromagnetic pulse and the long-term environmental effects continue as problems.

6. The National Guard has played a significant role in national air defense in the past, and the total force is even more vital now to theater aerospace defense.

7. While hostile aircraft and cruise missiles still constitute a major threat to homeland safety, the sad experience of 11 September 2001 awakened the nation to the reality that normally peaceful activities, processes, and technologies can be transformed into weapons of terror.

8. Mobile antiballistic missile systems are now available and are more survivable than fixed-site missile launchers.

9. Air defense is as much a military-political issue as a military-technical one. It can influence positively or negatively the ability to deter aggression and retain the support of allies. Its utility to the na-

tion must be self-evident and above dispute to guarantee a sustained program.

10. No military-technical solution to aerospace defense can be expected to provide an absolute solution against a thinking opponent intent upon using force to achieve his ends. Every measure will encourage countermeasures. One cannot achieve an indefinite technological superiority but can only gain and continually work to retain the technological edge.

At present several positions on homeland BMD remain under debate. The Clinton administration had supported modifying the ABM Treaty to allow the deployment of 100 interceptors in Alaska to counter modest projected ballistic missile threats from North Korea or Iran. Such a limited system would go hand-in-hand with US efforts to promote TMD against these same threats, and technical experts projected the deployment of such a limited system by 2005. The limited BMD system would involve ground-based interceptors; upgraded intercept and early warning radars; enhanced battle management/command, control, and communications; and space-sensor technology.

That option was apparently preempted by the December 2001 announcement of a US decision to withdraw from the ABM Treaty. Russia had hinted that this action would bring a series of responses from Moscow that would negate other arms-control agreements, such as START II, the Intermediate-Range Nuclear Forces (INF) Treaty, and the Treaty on Conventional Armed Forces in Europe (CFE). So far that has not happened. The Russian government has even called for further sweeping reductions in strategic offensive weapons as part of START III negotiations. President Vladimir Putin specifically mentioned a figure of 1,500 warheads—a cut well below the 2,500 that the Department of Defense proposed for START III.

Republican leaders in the US Senate and the Bush administration had favored complete and unilateral abandonment of the ABM Treaty and a full national program for homeland BMD. Indeed, this option is what Russian opponents of the modification of the ABM Treaty had suggested was the long-range US objective. The problems associated with this option remain the same as those raised in the past over national BMD. It is still unclear whether an effective and credible system is technologically feasible. There is also uncertainty about the consequences on global nuclear proliferation that would result from abandoning the national policy of strategic arms control. Advocates of this position see Russian opposition as irrelevant because of their military and technological decline. They tend to ignore the risks associated with possible Russian responses, such as changes in launch regime, replacing single-warhead systems with multiple independent reentry vehicles (MIRV), or a decreased cooperation in controlling ICBM and warhead proliferation—especially with China. The realization of any of these possible consequences could adversely affect strategic stability, raise the costs of national BMD, and make the mission itself far more challenging.

The Bush administration's deliberate disengagement from Russia during its first few months indicated they considered Russia's emotive clinging to great-power status as something that remained in the way of national defense progress. Russia should no longer expect any special relationship with Washington on the basis of old and obsolete arms-control arrangements. Putin, however, neither backed down from nor compromised Russia's position on the ABM Treaty, calculating that the tension between the United States and Western Europe over unilateral withdrawal from the treaty would lend political support and legitimacy to the Russian response, potentially lead to US concessions on strategic arms control, and foster closer geopolitical ties between Russia and China. President Putin may have calculated correctly, as the Bush administration found itself explaining its plans to its European allies and trying to derail deeper cooperation between Moscow and Beijing in Eurasia as part of an antihegemony pact. The Putin-Bush relationship warmed substantially after a bilateral summit in Slovenia in June 2001, and discussions turned to creating a mutually agreed-upon strategic framework that would replace Cold War arms control and provide a broader framework for cooperation. In addition, United States–Russian relations warmed substantially after the events of 11 September 2001, when both nations recognized terrorism as a common enemy. A November 2001 summit in the United States demonstrated joint consensus to cut strategic offensive weapons but failed to reach agreement on abandoning the ABM Treaty.

In December 2001, President Bush announced that the United States would exercise the option for unilateral withdrawal from the ABM Treaty under the impact of "extraordinary events" that adversely affect "its supreme interests."[26] That withdrawal will become effective in June 2002. At present, Russia and the United States are engaged in talks about a new strategic framework, which could help provide future stability. However, a recent newspaper article has complicated progress on the reduction of offensive strategic nuclear systems and Russian acceptance of abandonment of the ABM Treaty. On 10 March 2002, the *Los Angeles Times* published an article citing a classified report to Congress, in which Russia was identified as one of the seven states targeted by the United States in its nuclear strategy.[27] While the report said that Russia was no longer an "enemy" and stressed the absence of "ideological sources of conflict," it noted the size of the Russian nuclear arsenal. The review looked toward the development and integration of nonnuclear and nuclear capabilities to combat threats posed by hostile states possessing WMD or to counter unexpected developments.[28] On the eve of his visit to the United States to discuss the new strategic framework, Russian Defense Minister Sergei Ivanov warned of the serious risks generated by the absence of a mutually agreed-upon concept of strategic stability. That concept must be the foundation upon which the new strategic framework can be based. Ivanov's proposal involved written guarantees that a proposed US BMD system would not seek to become strategic—it could not negate the offensive capabilities of a radically reduced Russian strategic arsenal.[29]

The final position had opposed any modification of the ABM Treaty and any deployment of a national BMD system. Its supporters had seen strategic arms control as an end to itself and were unconvinced that the emerging nuclear threat from rogue states could be deterred. In their view, the ABM Treaty should have remained untouched regardless of changes in the international security environment. Part of the value of the treaty had been symbolic, fostering a perception of shared vulnerability to make common efforts against the proliferation of WMDs more appealing. With the official expansion of the nuclear club during the last years of the Clinton administration to include Pakistan and India, one might reasonably ask just what advantages such a posture would provide. On the other hand, it seems to be the only possible approach that could generate a multinational effort to woo North Korea away from its ongoing attempts to develop nuclear weapons and delivery systems. This position represents a significant portion of the US arms-control community. They warn that the abandonment of an arms-control framework may actually move other states to view the acquisition of WMDs as appropriate and timely in the post–Cold War environment.[30] Russian arms-control specialists seem less convinced that a strategy of negotiation will be able to protect Russian interests.[31]

Over the next few months, a fundamental choice will be made regarding missile defense. It is prudent to understand that this choice will initiate a wide range of measures and countermeasures with complex technical, military, and political consequences. Ironically, this decision-making process is happening at the same time when many security analysts have had to shift their focus away from nuclear issues to new threats posed to the national infrastructure, population, and homeland by terrorist acts and information warfare by nonstate actors using low-tech delivery of weapons with mass effects. □

Notes

1. American air combat experience in World War II accrued a wealth of experience in defeating national air-defense systems over Germany and Japan in support of massive strategic bombing campaigns. By the time the United States entered the war and deployed strategic bombers to England and North Africa, the struggle between the strategic air offensive and air defense had already gone through several radical shifts in the correlation of forces. When the war began, airmen, soldiers, and statesmen tended to believe that airpower would be decisive. If unleashed, the bomber would always get through, and terror attacks would wreak havoc on a national economy and morale. The Battle of Britain demonstrated that a national air-defense system could be created and managed to send swarms of fighters against daylight attackers. Over the next two years the so-called "wizards' war" raged between Allied strategic aviation and the German air-defense system. In the battle over Germany, the US Army Air Forces and Royal Air Force developed advanced technologies to disrupt German sensors and thereby its ability to control the air. Germany engaged in its own countermeasure efforts until it was overwhelmed. Germany, having lost the strategic bomber war, countered with new challenges to British air defense from 1944 to 1945 in the forms of the pilotless, pulse-jet V-1 cruise missile and the V-2 ballistic missile. Air defense and other countermeasures reduced the effectiveness of the V-1 attacks, but no countermeasure, short of denying the Germans launch sites, could stop the V-2s. The struggle between offensive airpower and air defense has been a feature of every war since then—and continues in the aerospace environment.

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3. Displays at US Army Air Defense Museum, Fort Bliss, Texas.

4. Ibid.

5. Hereinafter, NATO designations and code names for Soviet military systems will be presented parenthetically.

6. Steven J. Zaloga, *Soviet Air Defence Missiles* (Surrey, England: Jane's Information Group Ltd., 1989), 98–109.

7. A. G. Magritskiy, *Zenitnaya Raketnaya sistema S-300* (S-300 Air Defense Missile System), (St. Petersburg, Russia: Nevskiy Bastion), 7; Valentin Valentinov, "There are no equals to the system," *Vestnik protivovozdushnoy oborony* (Air Defense Herald), December 1993, 12–14; N. Markov, S. Zhukov, and V. Yepifanov, "The S-300V Surface-to-Air Missile System," *Tekhnika i vooruzheniye* (Technology and Armaments), January 1993, 46–48.

8. "Government commission to find out causes of SAM launch pad blast in Moscow region," *Agentstvo Voyennykh Novostey*, 13 June 2001, available from http://www.militarynews.ru/fel_l/enews.asp?id-64157.

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10. Igor Timofeyev, Yakov Borovoi, and Ivan Menshikov, "War on the Day of Atonement: 15 Years On: Facts, Opinions, Lessons," *New Times* (in English), no. 45 (November 1988): 18.

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12. Ibid., 66–67.

13. Makhmut Akhmetovich Gareev, *Esli zavtra voyna?. . .*(If war comes tomorrow?. . .) (Moscow: VlaDar, 1995), 142–43.

14. Department of State and Department of Defense, *Soviet Strategic Defense Programs* (Washington, D.C.: Government Printing Office, 1985), 7–9.

15. V. A. Gelovani and A. A. Piontkovskiy, *Evolyutsiya kontseptsiy strategicheskoy stabil'nosti (Yadernoe oruzhie v XX i XXI veke)* (Evolution of the concept of strategic stability: Nuclear weapons in the 20th and 21st centuries) (Moscow: Institut sistemnogo analiza RAN/Institut sotsial'noy informatiki MAIPT, 1997), 80–102.

16. Makhmut A. Gareev, *If War Comes Tomorrow? The Contours of Future Armed Conflict* (London: Frank Cass & Co., 1998), 70–93.

17. "Voyennaya doktrina Rossiyskoy Federatsii" (The Military doctrine of the Russian Federation) *Krasnaya zvezda* (Red Star), 9 October 1999, 4.

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20. V. I. Slipchenko, *Voyna budushchego* (Future war) (Moscow: Moskovskiy Obshchestvennyy Nauchnyy Fond, 1999), 82–87.

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26. "Washington to Withdraw from ABM Treaty," *Associated Press*, 12 December 2001. The ABM Treaty contains the following provision for withdrawal: "Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from the Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests." See Department of State, *Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems*, 26 May 1972, on-line, Internet, 4 April 2002, available from http://www.state.gov/www/global/arms/treaties/abm/abm2.html.

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Partnering for Hemispheric Security

A Combined Regional Operations Center in Brazil

Lt Col Merrick E. Krause, USAF

Editorial Abstract: Brazil is crucial to maintaining the security and stability of South America, a continent vital to the defense of the Western Hemisphere. Colonel Krause presents a provocative proposal for building a stronger alliance with Brazil through a combined regional operations center. Such a center could yield productive partnerships with both Brazil and other nations in the region, as well as facilitate multinational security cooperation in the heart of South America.

A U.S. government surveillance plane flying over northern Peru identified a small aircraft carrying American missionaries as a possible drug flight and passed the information to the Peruvian Air Force shortly before a Peruvian fighter jet shot it from the sky Friday morning, U.S. sources said.

—*Washington Post,* 22 April 2001

Our role was to help countries identify planes that failed to file flight plans. . . . Our role was simply to pass on information. . . . I want everybody in my country to understand that we weep for the families whose lives have been affected.

—President George W. Bush, 22 April 2001

THIS ARTICLE PRESENTS a proposal to facilitate multinational security cooperation in the heart of South America by providing arguments that support the establishment of an experimental combined regional operations center in Brazil. Led and hosted by Brazilians, this center would serve as a centerpiece for the coordination of intelligence sharing and operational responses to illegal overflights of the Amazon or other violations of national borders or sovereignty. Although this concept is not a comprehensive strategy alone, it provides promise for a productive, beneficial partnership with Brazil and other nations in the region.

Drugs, crime, and terrorism walk hand in hand. However, recent technological advances plus renewed efforts at cooperation with South American allies present unique opportunities to advance regional coordination in support of sovereignty and security issues. Brazil stands as a linchpin in South America because of its economic and political strength, strategic location, and emerging capability to monitor and control its borders in the Amazon frontier. Therefore, building on the opportunities for partnership and the utilization of modern technology, this article seeks to answer the question of how one might maximize the effectiveness of Brazilian surveillance efforts to achieve benefits and reach security goals for Brazil, its neighbors, and the United States. Toward that end, it briefly reviews the security situation and concerns of the Brazilian government; addresses Brazilian interdiction capabilities, particularly air interdiction, and outlines the concept of an experimental combined regional operations center; and concludes with a cost-benefit analysis, a sample concept of operations (CONOPS), and a discussion of the future potential for a regional operations center.

Security Issues

Important interests shared by the United States and South America—such as counternarcotics, counterinsurgency, and anticrime operations; border enforcement; and state security—would benefit from more detailed and secure regional coordination. Although the United States has a history of working with South American countries in drug-interdiction programs, the tragic failure of the US-Peruvian process that occurred in April 2001 (see above) forces all nations in the hemisphere to review partnership options and evaluate possibilities to increase effectiveness and accuracy in intercepting narcotics and reducing transnational criminal activities.

Several US agencies coordinate with South American nations, but Brazil's defense policy and the Brazilians' unique capabilities for air control and surveillance operations are keys to stabilizing the Amazon Basin. As the largest, least populated, and centrally located frontier in South America, the basin is important for its strategic location, natural resources, and waterways.

Creating a partnering arrangement among Brazil, the United States, and selected neighboring states would further the objective of achieving collective security goals. Indeed, key directives made by the Brazilian government to implement its national defense policy include "contribut[ing] actively to the construction of an international order based on the rule of law which provides regional and worldwide peace, . . . contribut[ing] to the strengthening, expansion and consolidation of regional integration, . . . [and] expand[ing] exchange programs with the Armed Forces of friendly nations."[1]

The emergence of the Brazilian Amazon Surveillance System (SIVAM) project—a multifaceted, integrated control system coming on-line in 2002—presents an opportunity for cooperation and the creation of trust among regional neighbors, Brazil, and the United States. The goals of such a collaboration might include increasing border security; reducing drug, arms, black-market, and currency trafficking; inhibiting the movement of insurgents; and increasing regional stability to stem the illegal cross-border migration of civilians or guerilla combatants. Successful collaboration would encourage long-term regional stability, enhance transparency in knowledge sharing, improve security for participating states, and reduce drug and criminal trafficking in the region.

The security situation in South America is generally defined as a consequence of international crime. Terrorism, narcotrafficking, money laundering, and insurgent activities contribute to security concerns throughout the region. The largest, most visible partnership attempt to control some of these negative activities is Plan Colombia, the Colombian government's counterdrug plan supported by the United States. However, this and other indigenous antidrug efforts in South America have caused both a migration of drug-transit routes to the Amazon area, particularly through western Brazil, and the spillover of Colombian insurgents (fig. 1).[2] The narcotrafficking situation not only raises concerns about national security and territorial sovereignty for the Brazilians, but also affects the security of neighboring countries.

Repeated violations of Brazil's sovereignty by unauthorized overflights of its territory present a national security problem that the Brazilian government can respond to in one of three ways: (1) address the issue directly with international cooperation, (2) ignore the threat imposed on Brazilian sovereignty due to border violations, or (3) minimize the impact of such incursions through the unilateral use of military or police force. This situation is complicated by the fact that the majority of overflights involve narcotics and arms smuggling, as well as by the logistics and leadership of drug cartels and guerillas. Given the presence of transnational criminal activities, ignoring or minimizing their impact is not an optimal response. Indeed, this example of the globalization of crime affects many states and renders some frontier borders meaningless. Furthermore, the inability of neighbors to control sparsely populated border areas, except at specific entry points, makes the Brazilian situation even more difficult.

Although surveillance efforts are ongoing in the Amazon Basin, particularly along the border with Colombia, there is little transnational integration and insufficient real-time command and control (C^2) to interdict traffickers or other threats efficiently. Indeed, the lack of both C^2 and substantive cooperation among countries in the Amazon region is particularly apparent on the sparsely populated Colombian border and westernmost portion of the Amazon Basin. While Brazil attempts to secure its Amazon territory, the United States continues to support the $7.5 billion Plan Colombia with a contribution of $1.3 billion, as well as assist with intelligence sharing, radar-installations support, and surveillance in Colombia and neighboring countries. However, bilateral agreements with countries in the region, not multilateral coalitions or treaties, have dominated the conduct of US policy regarding the collective drug trade.[3]

The situation in Colombia, which involves refugees, internal unrest, rebellion, organized

Figure 1. Drug-Transit Routes and Insurgent Border-Crossing Areas in the Western Amazon Basin

crime, and narcotrafficking, continues to concern the United States. Obviously, this instability also threatens Colombia's neighbors. Brazil, the premier regional power with the largest economy in South America (and the fifth largest in the world), appears to be affected at its weakest point: the broad and largely unpopulated Amazon Basin frontier.[4] Brazilians especially fear that Plan Colombia will cause Colombia's guerillas, fueled by cocaine money, to spill into the Amazon territory.[5] Moreover, Brazil's size, population, influence, power, and location make it a critical partner with the United States in any successful regional counterdrug strategy over the long term.

In some respects, one finds a noninterventionist theme in Brazilian politics. Basing their views upon a historic tendency that eschews intervention in the affairs of other states, particularly military action, and upon a belief that state sovereignty is sacrosanct, many Brazilians oppose Plan Colombia and a US military presence in Colombia. This attitude also inhibits the Brazilian government from intervening in Colombian affairs, even to support the legitimate government of Colombia against rebels on Brazil's borders. Moreover, even though Brazil fought alongside the United States in the Italian campaign of World War II, currently it is not extremely active either in peacekeeping or in supporting the United States militarily. Lastly, Brazilians are certainly concerned with the problems that narcotrafficking, other transnational threats, or territorial violations portend. A prevalent opinion among many Brazilians holds that US demand and consumption are principal drivers for the drug trade. Indeed, some Brazilians also suspect, unfortunately, that narcotics may mask sinister American intentions regarding Amazonian minerals, territory, and biodiversity.

This last concern—that America has an unstated objective of establishing a military presence in the Amazon—is apparent but not persuasive.[6] Several Brazilian military and civilian personnel conveyed this sentiment directly although it is uncertain how many influential governmental officials really believe it. In any case, in the calculus of some Brazilian officials, their country requires a robust surveillance system; an increased, armed presence in the Amazon; and an aircraft carrier to protect their territory from all potential threats to its sovereignty.[7]

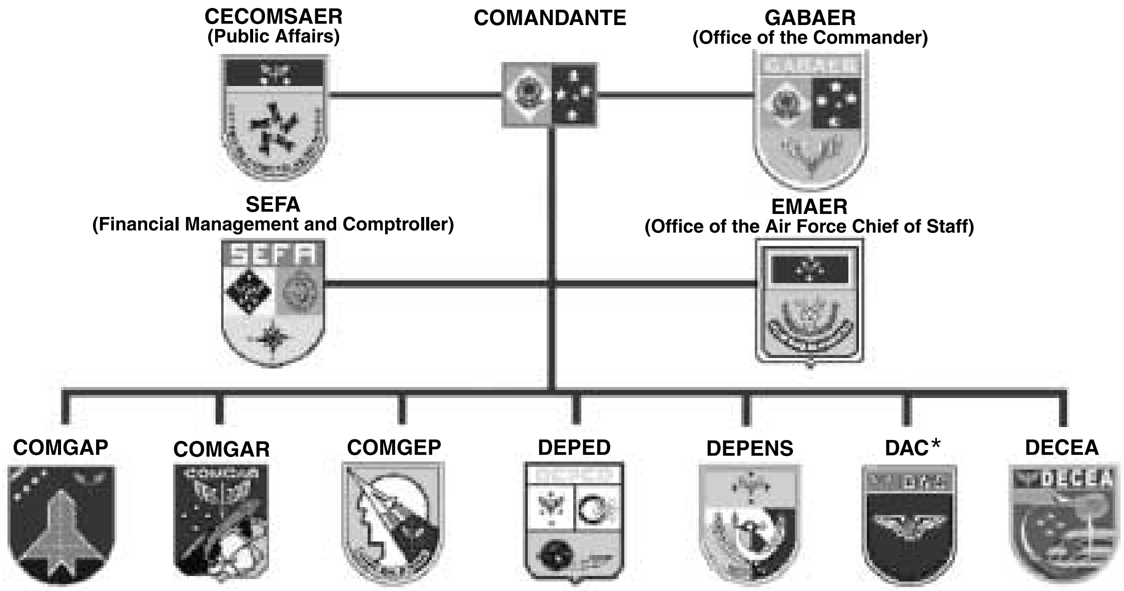
The Brazilian government's first objective in national defense is "to guarantee sovereignty while preserving the Nation's territorial integrity, heritage and interests."[8] Criminal or insurgent elements in countries neighboring Amazonia, however, threaten Brazilian sovereignty—not the United States. Currently, Colombian rebels use Brazil's Amazon region for trade and as a rear-supply area. Peruvian drug traffickers have been known to transit Brazil's borders to avoid capture because the 1,000-mile border with Colombia is largely uninhabited and uncontrolled. Moreover, criminal corruption and drug trafficking, which crosses the Brazilian border from Bolivia and Venezuela, create further concerns about regional instability that complicate the Colombian and drug situations. Furthermore, some Brazilians fear that US-trained Colombian troops pose a threat when they confront narcotraffickers and rebels close to Brazil's border,[9] rightly perceiving this threat as destabilizing. Finally, Brazil has its own burgeoning drug problems, especially those involving elements in Brazil that supply cocaine-precursor chemicals to Colombian drug-processing labs.[10]

Interdiction Capabilities

In an effort to control its borders, Brazil's congress produced legislation in 1998 enabling the Brazilian air force, the *Força Aérea Brasileira* (FAB), to intercept and shoot aircraft that illegally enter Brazilian airspace. Although Brazil has neither ratified nor begun enforcing this law, unified C^2 and the cooperation of bordering governments will permit more efficient drug interdiction.[11] Colombia presently enforces similar shoot-down policies.[12] However, the previously mentioned downing of a civilian missionary plane by the Peruvian air force, resulting in the death of a woman and her child, has caused Brazilian political support for intercept-and-kill authorization to erode.[13]

Because of the vastness of the Amazon region, air is the most efficient medium for broad surveillance efforts, interdiction, or rapid insertion of ground forces. The controlling authority of FAB, a separate service maintained under the Brazilian Ministry of Defense, is the *Comando da Aeronáutica* (COMAer), which has three major commands (MAJCOM)—the *Comando Geral do Ar* (COMGAR), which protects Brazilian airspace and supports other military services and governmental agencies; the *Comando Geral de Apoio* (COMGAP), which controls logistics; and the *Comando Geral de Pessoal* (COMGEP), which controls FAB personnel issues—and four other MAJCOM-level organizations: the *Departamento de Pesquisa e Desenvolvimento* (DEPED), which supervises research and development; the *Departamento de Aviação Civil* (DAC), the regulatory agency of Brazilian civil aviation; the *Departamento de Controle do Espaço Aéreo* (DECEA), which controls Brazilian airspace; and the *Departamento de Ensino* (DEPENS), which controls FAB's schools and educational facilities (fig. 2).

COMGAR organizes its air assets into three air forces, a training command, and seven regional air commands. FAB, whose 800 aircraft



*Note that the Brazilian Congress is considering a bill aimed at establishing the National Civil Aviation Agency (ANAC) to replace the current DAC, which, since its inception, has been run by the Brazilian air force. ANAC would come under the direct control of the Ministry of Defense.

Figure 2. FAB Organizational Chart (From "Aeronautica," 12 November 2000, on-line, Internet, available from http://www.aer. mil.br/Conheca/index.htm. The commandant's biography is also linked to this chart.)

make it the largest air force in South America, contains several *Esquadrões* (squadrons) assigned to task-defined groups.[14] The largest of these include *Grupo de Aviação* (GAV—fight, attack, and rescue); *Grupo de Defesa Aérea* (GDA—airborne intercept); *Grupo de Transporte* (GT—airlift and air refueling); and *Grupo de Transporte de Tropa* (GTT—troop and airborne transport).[15]

Brazil has numerous aircraft available for drug interdiction as well as sovereignty-monitoring and -protection missions. Brazil uses the F-5F and Embraer AMX A-1 as primary fighters and the Super Tucano as the primary trainer.[16] It also maintains various transport aircraft and helicopters suitable for use in and around the Amazon. Emerging capabilities—part of an initiative to modernize FAB—include eight recently ordered EMB 145 RS "remote sensing" aircraft that will comprise a capable airborne-surveillance system. The EMB 145 RS features a synthetic aperture radar that can provide 24-hour, all-weather ground surveillance,[17] which will help expose drug traffickers and illegal miners in Amazonia.[18] Additionally, five new EMB 145 airborne early warning and control (AEW&C) aircraft provide onboard C^2, signals intelligence, and surveillance.[19]

The EMB 145 RS is part of Brazil's most significant emerging capability—SIVAM, an ongoing series of civil and military instrumentation projects that integrate air, land, and river surveillance. The system is "considered to be primarily a surveillance project for use in curbing the trafficking of illegal narcotics."[20] The System for the Protection of the Amazon (SIPAM), closely aligned with SIVAM, is an integrated Brazilian military C^2 program that leverages the SIVAM components. The key ground components of the SIVAM system include 19 fixed and six mobile radars intended to detect low-flying aircraft in Brazil.[21] Brazil plans to use the EMB 145 AEW&C as a patrol aircraft and as a support aircraft for counterinsurgency missions.[22] However, until the implementation of overflight and international agreements, integration of these systems will be restricted to Brazilian airspace.

In addition to the capabilities described above, the Brazilian Ministry of Defense has made a considerable commitment to protecting Brazil's sovereign territory. The FAB plans to spend $3–5 billion to purchase new fighter aircraft, particularly the Embraer AMX, and it will refurbish 100 combat jets. Brazil also has a ground complement of 22,000 troops (of its total of 220,000) permanently stationed in the Amazon; furthermore, it has dedicated 180 police officers, 18 patrol boats, two airplanes, and a helicopter to securing the Colombian border.[23] The Brazilian government's substantial efforts in the Amazon indicate the high priority of territorial integrity as well as internal and regional stability. However, little precedent exists for the sharing of near-real-time information among comprehensive international military or law-enforcement alliances, or for executing time-critical actions against criminals or insurgents.

Unfortunately, Brazil's approach—investing heavily in the SIVAM/SIPAM projects and attempting to secure its borders from within—is necessary but not sufficient to assure long-term sovereignty. Because of the lack of regional linkage among Brazil and its neighbors, efforts to control vast borders and reduce criminal, drug, and refugee flows are uncoordinated. Perhaps the tradition of limited security cooperation with other states in the region is a matter of trust. However, the emerging SIVAM capability and ongoing US partnering arrangements in South America may provide an entrée to a Brazilian-hosted operations center for monitoring and integrating counternarcotic, counterinsurgent, and law-enforcement efforts.

At present, the United States provides military advisors, training, and equipment—including radars, communications gear, weapons, and helicopters—to Colombia. Modest US assistance also goes to Bolivia, Peru, and Brazil. The United States provides technical support to several countries in Latin America through radar-surveillance assistance and airborne-warning flights, and C^2 through the Joint Interagency Task Force East (JIATF-East) for counterdrug assistance. However, comprehensive counternarcotics and security efforts are not *regionally* coordinated in real time through a single command center or a single agency in any one country. The limited, bilateral approach to law-enforcement, counterdrug, and counterinsurgency efforts, therefore, is not as optimized or efficient as a more integrated approach.

Since no combined regional operations center exists to assist in data fusion and C^2 from the SIVAM system or other surveillance efforts throughout the region, benefits of SIVAM/SIPAM to the Brazilians and spin-off benefits to regional neighbors and the United States are abridged. Therefore, since the United States already interacts with nations in the region for air and counternarcotics surveillance and interdiction efforts, a new strategy of cooperation with the Brazilian government may increase the efficiencies and productivity of established efforts. A new regional strategy yields a recommendation that the United States should support the Brazilians in the establishment of a combined regional operations center and forge agreements to conduct and coordinate real-time, multinational drug and security efforts through that center.

Its large air force and robust surveillance capability put Brazil in a unique position to provide regional coordination for integrated, international counterdrug interdiction and territorial security. With US support, regional cooperation based upon integrated defenses may achieve buy-in and increased efficiency. For example, in November 2001 the Colombian government inaugurated a $25 million radar, built under Plan Colombia, to intercept drug flights in rebel-held areas. This is the fifth such radar in Colombia, manned by US-trained Colombian personnel.[24] Given the outstanding potential of the SIVAM/SIPAM radar system, particularly if used cooperatively with other radars and C^2 systems in neighboring countries, and given a program of combined operations for air interdiction and narcotrafficking, the achievement of lasting regional effects may indeed be possible.

The Brazilian government has already approached Guyana, Suriname, Venezuela, Bolivia, and Peru to discuss information exchanges, anticipating that SIVAM/SIPAM will become operational in July 2002.[25] The concept outlined here moves a step further than information sharing, however, in that it includes an integration effort using an Amazon regional operations center in Brazil, based upon combined air operations center (CAOC) models in Saudi Arabia, Turkey, and Italy.

In this conceptualization of a combined regional operations center, a Brazilian general officer would command a Brazilian center. Representatives from partnering neighbors as well as US interagency representatives and technical advisors could contribute by working together at the central data-fusion location (fig. 3). Initially, non-Brazilian colleagues could be liaison officers, with an option to move forward to a truly integrated operations center in the out-years. As host, Brazil would provide access to the command facility, and an existing SIVAM/SIPAM regional integration station could host the first combined-operations-center experiment. Other resources would reside in the already planned SIVAM/SIPAM program, except for communications links with neighboring countries and the United States. The latter could assist with financing and provide some equipment and training for the operations center, as well as coordinate with the JIATF-East for interdiction activities. United States Southern Command (USSOUTHCOM) could further contribute by temporarily assigning personnel to the operations center and by coordinating with other agencies to assign advisors.[26] Indeed, the United States could offer outstanding CAOC experience, most recently from Operation Enduring Freedom, to facilitate a combined regional operations center in Brazil.

Various US agencies, including the State Department, Drug Enforcement Agency, and USSOUTHCOM are already actively involved in counterdrug operations throughout the region in an attempt to foster stability in the affected countries during periods of internal stress caused by narcotrafficking.[27] These American efforts involve diplomatic, economic, and military strategies. Regarding Colombia and other bordering countries, objectives of the US counternarcotics policy provide for enhancement of the Colombian government's (host country) intelligence capabilities; eradication of coca, amapola, and heroin and development of alternative crops; interdiction; and strengthening of Colombian (host country) law-enforcement agencies and

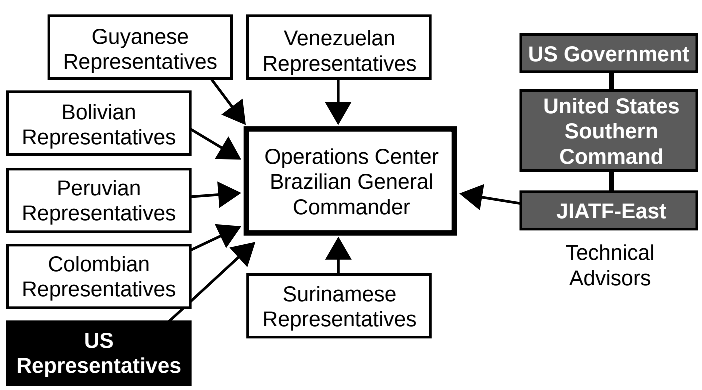


Figure 3. Example of Combined Regional Operations Center Staffing

the administration of justice.[28] The US military's involvement in counterdrug actions presently includes assisting with surveillance, training, advisors, and intelligence sharing; providing interagency assistance; and making selected foreign military sales.

After initial agreements with Brazil, in order to move forward with a regional cooperation effort, the US government might encourage reciprocal regional overflight and other cooperative security agreements among participating countries. An ideal regional interdiction alliance for the Amazon would require overflight, pursuit, and perhaps shoot-down / force-down coordination in an antidrug operations charter. The combined regional operations center would provide the C^2 and data fusion to enable effective interdiction operations in the Amazon. An international Counternarcotics Oversight Council, chaired jointly by US and Brazilian representatives, could negotiate rules of engagement and organize operations-center establishment efforts; it could also be expanded to include further cooperative regional-security issues.[29] This council could provide oversight for the establishment and conduct of the center's operations. A Brazilian FAB general would command the proposed combined multinational center while Brazilian officers, US technical advisors, contractors, and multinational representatives would assist in staffing. Hot phones and, eventually, data links would connect the center to the partner governments to exchange knowledge and provide rapid resolution and confirmation of pursuit or intercept status.

Cost-Benefit Analysis

The benefits of investing in an Amazon international regional operations center under Brazilian command include increased regional cooperation, integration of diverse interdiction efforts, and enhanced regional stability. Increased cooperation would facilitate transparency and regional integration of interdiction activities. Spin-off effects would include the encouraging of dialogue among participating countries through legitimate military efforts under the control of civilian governmental agencies, as well as improved trust among nations in South America. Additionally, emphasizing US teamwork rather than a perceived imperialistic, American-led effort might cause *pátria* and national pride to increase domestic Brazilian support. Finally, the United States would offer partnership—not intervention—in Brazil, which might serve to reduce Brazilian concerns over US participation in Colombia.

Risks to the regional-operations-center approach include misuse or proliferation of US technology, possible affronts to national sensitivities, and domestic / regional power struggles. Indeed, combined-operations-center technologies are expensive and subject to misuse if regional infighting occurs (an unlikely event) or if corruption creeps into the information-sharing system. Moreover, regional or internal power struggles may affect negotiations, but any integration provides a positive step in a regional effort and supports potential expansion in the future. However, proper diplomatic and technical agreements might mitigate these challenges.

Concept of Operations

The CONOPS includes detection, decision / interception, and action phases. First, the SIVAM / SIPAM system, either through an airborne or ground sensor, detects an illegal flight or suspected drug trafficker. Second, the surveillance asset relays the target's location and other pertinent details to the operations center. Brazilian commanders, US advisors, and regional representatives coordinate a real-time strike. Airborne assets scramble to intercept the flight or helicopter / ground / riverborne assets converge at its landing point. If assets are beyond communication range, AEW&C relays orders to a forward strike team, interdiction riverboat, or forward aircraft. Third, the operations center can direct Brazilian fighter planes to follow or force the target aircraft to land. If it lands in Brazilian territory, airborne assets fix the location.

If the illegal flight attempts to evade the interceptors, the center may authorize them to destroy it. If the illegal flight crosses into a neighboring country, Brazilian fighters can pursue the aircraft to mark the landing spot (depending upon treaties), or the illegal flight will be passed to controllers in the neighboring country, who then vector their own interception (fig. 4).

Potential for the Future

Beyond counternarcotics interdiction, a combined regional operations center can provide a model for a future data-fusion command post that addresses multiple-agency concerns. For example, integrating available sensors can leverage existing technologies to fight a more regionally focused and efficient drug war. However, as the concept of the center develops beyond the immediate concern of narcotics trafficking and security operations, possible ancillary uses include the integration of future orbiting or airborne environmental sensors in Brazil, cartographic uses for sensors on Embraer aircraft, and border refinement and mapping. Indeed, either Brazilian sovereignty or an interagency antinarcotics effort could provide the impetus for the detailed mapping of the Amazon itself, in addition to its usefulness as a scientific endeavor. The center could foster regional cooperation, enhance Brazilian leadership, and encourage more unity in the Western Hemisphere—the possibilities are tremendous for international cooperation through the exploration of advanced data-fusion applications.

Conclusion

Mutual interests and modernized C^2 efforts in Brazil may open a window of opportunity for partnership with the United States.

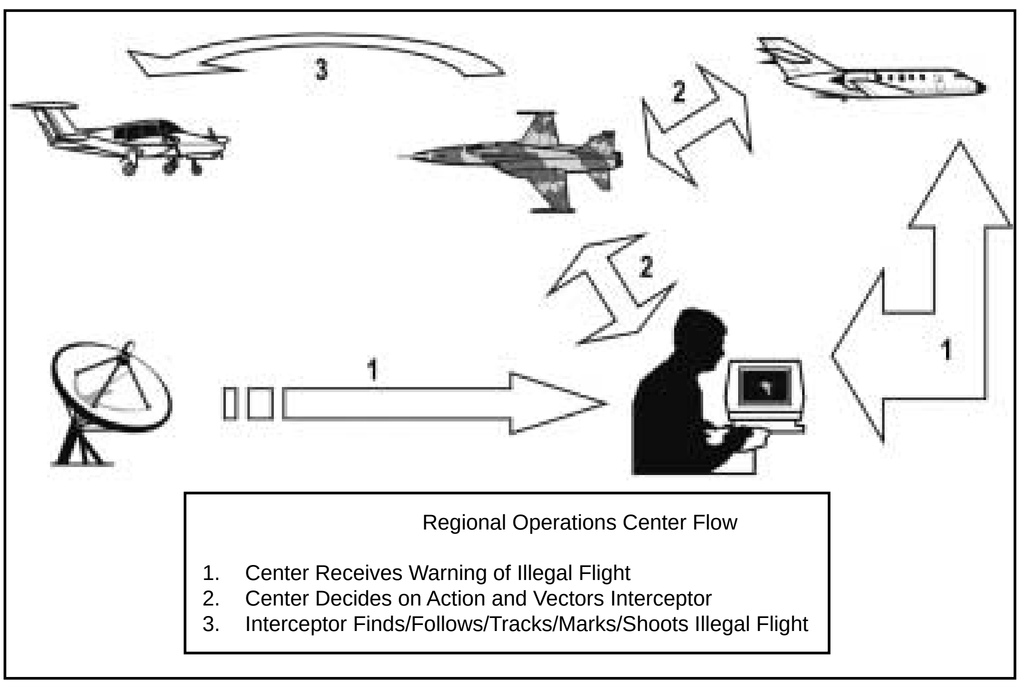


Figure 4. Example of Operations Center CONOPS

The concept of a combined regional operations center discussed in this article provides an avenue for experimenting and building trust, as well as fighting real transnational threats such as narcotrafficking, criminal activities, border violations, and insurgent activities. As a confidence-building measure and regional-security cooperation effort, establishing such a center promises to be a win-win situation that advances the interests of both Brazil and the United States and strengthens hemispheric security. □

Notes

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Unmanned Combat Aerial Vehicles

Dawn of a New Age?

COL ROBERT E. CHAPMAN II, USAF

Editorial Abstract: The use of unmanned combat aerial vehicles in the skies over Afghanistan is just beginning to awaken the Air Force to the enormous potential of these aircraft. In this informative article, Colonel Chapman summarizes current developments regarding these vehicles and gives us a glimpse into their possible employment in the future.

THE DEPARTMENT OF Defense (DOD) has recently accelerated efforts to develop unmanned combat aerial vehicles (UCAV)—aircraft that can launch, attack, and recover without crew members aboard. Advocates contend that an array of technologies has now matured to the point that fielding an operational UCAV is both feasible and desirable. UCAV proponents project significantly lower acquisition costs, as well as operations and support costs. Such projections are particularly attractive in the current fiscal environment, in which all military services urgently need to replace aging capital equipment. Proponents further contend that a reusable vehicle capable of delivering precision munitions could significantly lower the cost per target killed below that of the current generation of standoff weapons.

Background: Why a UCAV?

Over the last decade, the combined airpower of the US military has proved instrumental in favorably deciding military actions in Iraq, Bosnia, and Kosovo. American airpower in all its forms constitutes a unique and decisive military advantage no other nation can match. However, growing concern exists within the national security community that this advantage may be eroding. A number of potential adversaries are pursuing advanced weapons systems that could deny or restrict America's future ability to project combat power abroad. Of particular concern are increasingly lethal integrated air defense systems (IADS) and mobile

surface-to-surface missile systems. Many analysts believe that the United States must develop means to counter those threats if it is to maintain its ability to project decisive combat power abroad. UCAVs could offer one option to combat the worldwide proliferation of these access-impeding weapons.

Potential Advantages

Although airmen have long recognized the promise of UCAVs, thus far they have remained beyond the grasp of developers.[1] Recent advances in technology, however, have prompted many national security planners to reevaluate UCAV feasibility.

Cost per Target Killed. Advocates assert that UCAVs employing direct-attack munitions could reduce costs per kill well below that of current standoff systems—cruise missiles, for example. During Operation Desert Fox, a 70-hour joint military operation ordered by the president in December 1998 to destroy military and security targets in Iraq, Navy ships fired more than 325 Tomahawk cruise missiles, and Air Force B-52s launched more than 90 AGM-86C conventional air launched cruise missiles (CALCM).[2] These weapons carry warheads weighing 1,000 pounds and 2,000 pounds, respectively.[3] Alternatively, proponents argue that reusable UCAVs could achieve the same effect at far less cost by delivering 1,000-pound and 2,000-pound joint direct attack munitions (JDAM) guided by the Global Positioning System (GPS) (table 1). UCAV proponents argue that the cost-per-kill contrast becomes even greater when one considers procurement, operating, and support costs of the associated launch platforms. The cost implications for future military operations will merit examination once detailed UCAV data becomes available.

Design. UCAV proponents contend that removing the operator from the weapons-delivery vehicle confers design advantages over manned aircraft. First, since vehicle loss does not pose an inherent risk to human life, design margins can be reduced below the traditional 150 percent design load factor traditionally used for manned aircraft.[4] Lower design margins lead to reductions in structural weight.

Table 1

Tomahawk/CALCM/ JDAM Unit-Cost Comparison

	Tomahawk	*CALCM*	*JDAM*
Warhead	1,000 lb	2,000 lb	1,000/2,000 lb
Unit Cost	$600,000	$1,160,000	$21,000

Sources: "Tomahawk Cruise Missile," United States Navy Fact File, 28 November 2000, on-line, Internet, 6 March 2002, available from http://www.chinfo.navy.mil/navpalib/factfile/missiles/wep-toma.html; and "AGM-86B/C Missiles," USAF Fact Sheet, n.d., on-line, Internet, available from http://www.af.mil/news/factsheets/AGM_86B_C_Missiles.html. JDAM cost is for tail-kit modification to existing Mk 83 and Mk 84 conventional bombs (response to inquiry, Office of the Secretary of the Air Force, Weapon Systems Liaison Division, 14 May 2001).

Second, the elimination of pilot-support systems, such as egress mechanisms and environmental controls, also reduces weight and complexity. Collectively, these savings can result in smaller vehicle sizes.

Operation. UCAV proponents cite several potential operational advantages over manned systems, pointing out that smaller vehicle sizes yield greater range and endurance. Additionally, smaller vehicles possess inherent survivability advantages because radar cross-section and infrared signatures are reduced. They argue that the absence of the cockpit, typically a large area of radar reflectivity and a significant contributor to radar signature, would further enhance UCAV survivability. UCAV advocates assert that smaller vehicle sizes may have even greater survivability implications in the future as new detection and tracking technologies mature (e.g., long-wave infrared and vortex-generation detection, which exploits airflow disturbances caused by aircraft).

Finally, without the risk of aircrew loss, vehicle attrition becomes less onerous from both a moral and a political standpoint. One could task UCAVs for high-risk, high-payoff missions without attendant risk to human life. As a result, UCAVs could expand the range of coercive options available to both civilian and military leaders.

Potential Contributions to an Air Campaign

UCAV proponents argue that a fleet of low observable (LO) UCAVs could contribute to the success of an air campaign in a number of ways. First, UCAVs could provide a powerful "day one" force enabler by conducting destruction of enemy air defenses (DEAD) and suppression of enemy air defenses (SEAD) missions. DEAD, the physical destruction of known elements of an enemy's IADS, plays an essential role in the success of a general air campaign by creating a survivable environment for the nonstealthy strike aircraft that comprise the bulk of America's aviation force structure. Second, UCAVs could be used to supplement deep-penetration strike aircraft, such as the B-2 and F-117, by conducting conventional attacks against strategic fixed targets and enemy centers of gravity. Although the Air Force currently operates LO platforms capable of conducting this mission, the Navy does not. A carrier-based LO UCAV could provide naval aviators with a long-sought, survivable, day-one, deep-strike capability. Finally, operating as part of a general air campaign, long-loiter UCAVs could provide a persistent presence to rapidly strike time-critical targets such as mobile surface-to-surface missile systems or armored vehicles out of garrison.

UCAVs might also play an important role in low intensity conflict or contingency operations. Low observability, long endurance, and the absence of pilot support are ideal attributes for long-duration missions in hostile or contested airspace. Proponents envision UCAVs conducting armed-reconnaissance missions, patrolling the skies over hostile territory, and holding enemy targets at risk in a manner similar to missions currently ongoing over Iraq as part of Operations Southern Watch and Northern Watch.

Additionally, UCAVs might reduce demands on support assets such as combat search and rescue (CSAR) forces. These scarce resources, characterized by DOD as high-demand/low-density assets, are tasked with the hazardous mission of recovering downed aircrew members. In the event of a UCAV loss, CSAR efforts would be unnecessary. Reducing rescue requirements directly lowers the risk of CSAR force attrition. Lastly, UCAVs could enhance a theater commander's ability to maintain a robust air campaign in the presence of chemical or biological agents because these vehicles would obviate the inefficiencies imposed by aircrew physiological-support requirements in such an environment.

Notional Concept of Operations

The potential application of UCAVs to the DEAD/SEAD mission is of particular interest to the services. The Air Force characterizes this mission, a subset of air superiority, as both high risk and high payoff. Successful destruction or suppression of enemy air defenses is a paramount concern in the execution of an air campaign.

DEAD missions are typically characterized by short-decision timelines and target systems consisting of mobile, relocatable, and fixed components. The DEAD mission is notoriously hazardous because weapons employment typically requires the launching of aircraft to operate within the lethal envelopes of enemy surface-to-air missiles. Frequently, DEAD aircraft must intentionally stimulate enemy systems by placing themselves at risk in order to employ antiradiation missiles.

Most national security analysts agree that the DEAD/SEAD mission is both critical and inadequately addressed. Lt Gen Michael Short, USAF, retired, who served as joint force air component commander for Operation Allied Force and commander of NATO's Allied Air Forces Southern Europe, cited the need for additional DEAD/SEAD capability as one of the principal lessons learned from the recent Kosovo air campaign.[5] Many national security professionals are hopeful that UCAVs will become an affordable solution to the DEAD/SEAD shortfall.

However, some defense analysts contend that UCAVs will lack the utility and effectiveness of manned aircraft. They question whether these vehicles can provide the same level of adaptive decision making and responsiveness to mission changes that manned aircraft provide. Moreover, UCAV critics raise doubts regarding their affordability, based on still-emerging technology, and question whether their operational value will justify the cost. The Defense Advanced Research Projects Agency (DARPA) has embarked on two demonstration projects that directly address these concerns—the UCAV Advanced Technology Demonstration (ATD) and the UCAV-N ATD, a naval version.

Unmanned Combat Aerial Vehicle Advanced Technology Demonstration

The UCAV ATD (fig. 1) is a joint effort between DARPA and the Air Force. Led by DARPA, the program seeks to demonstrate the technical feasibility of a UCAV system that can effectively and affordably prosecute SEAD and strike missions.[6] ATD aims to design, develop, integrate, and demonstrate both critical and key UCAV technologies, processes, and system attributes. Critical technology areas to be explored include adaptive autonomous control; advanced cognitive-aids integration; secure and robust command, control, and communication; and compatibility with the integrated battle space.[7] As they pursue specific objectives (table 2), UCAV ATD program officials hope to define the design elements of an operational UCAV system and develop life-cycle cost models that will include 80 percent confidence estimates of acquisition as well as operations and support costs.[8]

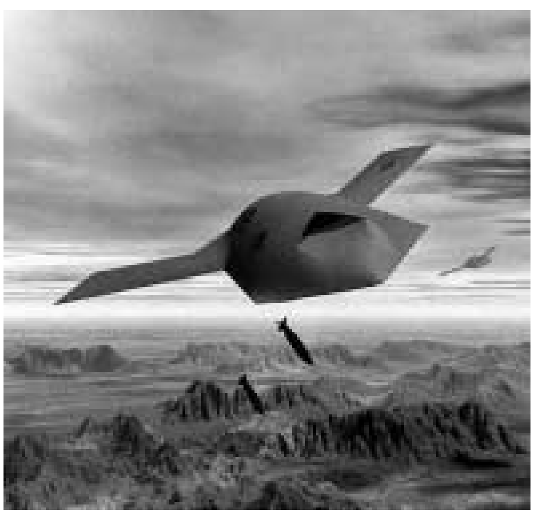


Figure 1. UCAV ATD (From briefing, subject: DARPA/USAF Unmanned Combat Aerial Vehicle Advanced Technology Demonstration Program Overview and Status Update, July 2000)

Table 2

UCAV ATD Program Objectives

- Develop and demonstrate a low-life-cycle-cost, mission-effective design for a SEAD/strike unmanned aerial vehicle (UAV).
- Develop a reconfigurable control station for multiship operations.
- Develop robust/secure command, control, and communications, both within line of sight and beyond line of sight.
- Evaluate human/computer function allocation, dynamic mission planning, and management approaches.
- Evaluate off-board/onboard sensor integration, weapon targeting, and loadouts.
- Demonstrate human-in-the-loop detection, identification, location, real-time targeting, weapons authorization, weapons delivery, and target-damage indication.
- Continue refinement of the operational SEAD/strike UCAV design and assessment of its projected effectiveness and affordability.

Source: Briefing, subject: DARPA/USAF Unmanned Combat Aerial Vehicle Advanced Technology Demonstration Program Overview and Status Update, July 2000.

UCAV System Description

UCAV ATD efforts are focused on maturing and validating technologies that could eventually form the basis of an operational UCAV weapons system. Designers are conducting numerous design trade studies and constructive analyses aimed at optimizing UCAV effectiveness and affordability. To validate design elements of an operational UCAV, program officials are developing a UCAV Demonstration System (UDS)—not an operational prototype but a set of tools to assist in the definition of a suitable operational weapons system. However, it is possible that a number of UDS elements eventually could be iteratively refined and incorporated into an operational UCAV design. UCAV ATD efforts are distributed among three distinct segments: air vehicle; mission control, including communications architecture and operator interface; and supportability, including operator training, vehicle maintenance, and logistics.

Air Vehicle Segment. The demonstration air vehicle, designated X-45, is a tailless stealth platform that designers believe would be suitable for survivable deep-penetration missions. With an overall length of 27 feet and a wingspan of 34 feet, it is smaller than manned fighters carrying comparable payloads. The relatively small size of the vehicle, coupled with its internal weapons carriage, would provide an operational vehicle with a distinct advantage in its ability to avoid detection by threat systems.

The demonstration aircraft will have an empty weight of approximately 8,000 pounds and will be powered by a single business-jet-class engine (nonafterburning). Designers have selected the Honeywell F124 engine as the power plant for the first two vehicles. Program officials believe that this engine, designed to produce 6,300 pounds of thrust,[9] will propel the vehicle to approximately 480 nautical miles per hour at 40,000 feet and provide a flight duration of about 90 minutes. The engine face is fully shrouded by a serpentine inlet for signature reduction. A yaw thrust-vectoring nozzle, derived from previous UAV programs, enhances flight-control authority. Program officials believe that many X-45 design details could transfer directly to an operational vehicle.

Program officials are looking ahead to an operational UCAV optimized for DEAD but possessing the inherent ability to penetrate an advanced IADS and attack fixed targets. This vehicle concept features the ability to carry a variety of conventional payloads. Primary payload options for each of the two internal UCAV Operational System (UOS) weapon bays could include six 250-pound GPS-guided small smart bombs, eight Low Cost Autonomous Attack System (LOCAAS)[10] submunitions, two advanced antiradiation missiles, or one Mk-83 1,000-pound JDAM. Loads could be mixed between bays to enhance operational flexibility. Program officials contend that the system's weapons capabilities will allow it to conduct attacks against 80 percent of projected enemy target sets. An operational vehicle might also incorporate other weapons currently in development. Among these are an information-operations/electronic-attack payload and a directed-energy payload. Other weapons-bay options include an intelligence, surveillance, and reconnaissance payload; supplemental fuel; or countermeasures dispensers.

Designers also envision that an operational UCAV will feature a robust avionics suite. To accomplish the DEAD mission, the air vehicle will be equipped with electronic-surveillance measures. The components could precisely geo-locate targets of interest by triangulating received signals using time-difference-of-arrival techniques. Program officials believe that a flight of three cooperatively targeting UCAVs will be capable of determining an emitting threat radar's position to within roughly 50 meters. Using its high-resolution synthetic aperture radar (SAR), the vehicle could then map the area of interest to determine precise target locations. From the resulting SAR image, one could compute coordinates with sufficient accuracy to enable employment of GPS-based weapons. Cooperative operations between both UCAVs and manned systems could occur through ultrahigh frequency (UHF), Link 16, and satellite communications. Finally, to enhance supportability and facilitate long-term storage, designers envi-

sion that an operational vehicle's flight controls and secondary systems would be electrically powered, thus eliminating traditionally maintenance-intensive hydraulic systems.

Mission-Control Segment. Using commercial, off-the-shelf hardware, program officials are developing a reconfigurable mission-control system that could ultimately serve as an integrated command, control, and intelligence node with links to a wide array of national- and theater-intelligence sources. The trailer-based system features both line-of-sight communications and a satellite relay for beyond-line-of-sight mission control. By employing a layered command-and-control architecture modeled after the Internet, designers believe that the mission-control system will eventually provide sufficient situational awareness and decision aids to enable a single operator to control up to four vehicles simultaneously. Transferring the decision-aiding software from ground-based consoles to the air vehicle will be one of the key challenges in the demonstration.

Supportability Segment. The supportability segment aims to minimize both the operating costs and footprint of the system. Central to the program's design philosophy is the capability for long-term system storage. Program officials project that operational UCAVs, with wings detached, could be housed in their own sealed, deployable storage containers (fig. 2) for up to 10 years. The containers would be powered to allow humidity control and vehicle diagnostics. Networked connections would allow maintainers to monitor vehicle health and configure onboard software. The transportable containers would increase the UCAV's deployment options beyond system self-ferry, with a single C-17 carrying up to six containerized UCAVs. As part of the demonstration effort, the contractor will construct two full-scale UDS vehicle containers.

Program officials contend that long-term system storage not only is viable, but also is capable of yielding significant life-cycle cost savings. One area of potential cost savings lies in operator-proficiency training. Unlike pilots of manned aircraft, UCAV operators would receive no direct sensory inputs on vehicle performance—the control console would synthetically generate all performance cues. Consequently, program officials believe that modeling and simulation can effectively provide substantial portions of operator training. Virtual proficiency training could substantially reduce the number of actual training flights required, yielding a corresponding reduction in the vehicle's operating and support costs. Significant savings could accrue from reduced personnel costs, a sizable contributor to operating and support costs. One would need a full complement of unit personnel only when UCAVs operate at wartime flying rates. As a result, program officials are

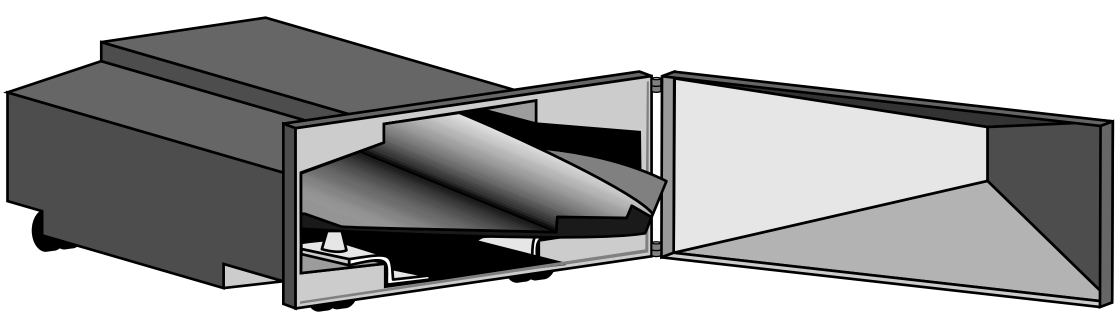


Figure 2. Artist's Conception of Vehicle Storage Container (From briefing, subject: DARPA/USAF Unmanned Combat Aerial Vehicle Advanced Technology Demonstration Program Overview and Status Update, July 2000)

exploring unit-manpower concepts based on up to 80 percent manning by Reserve personnel. Preliminary analysis indicates that a UCAV squadron could achieve a reduction in operating and support costs of at least 75 percent, compared to costs associated with an F-16 squadron equipped with high-speed antiradiation missiles, the Air Force's current DEAD workhorse.

UCAV ATD Program Structure

Officials contend that the three-phase UCAV ATD program (fig. 3) will allow decision makers to determine the technical feasibility and fiscal prudence of pursuing an operational UCAV weapons system. Each phase contains a series of performance-based milestones that determine the efficacy of proceeding to the next phase. If one can meet these milestones, DARPA and Air Force program officials believe that the UCAV ATD could form the foundation for a follow-on, low-risk engineering, manufacturing, and development (EMD) effort that might yield an operational weapons system.

Since entering phase two in March 1999, program efforts have focused on UDS design development. As part of that task, Boeing, the prime contractor, will build two demonstrator systems, each consisting of an X-45A air vehicle, mission-control system, air-vehicle container, and associated system-support equipment. The X-45A demonstration air vehicles will be constructed in a manner consistent with the LO design details envisioned for operational vehicles, including external, signature-driven surface characteristics and internal structural layout; however, they will not fully incorporate LO materials, treatments, or apertures. A number of

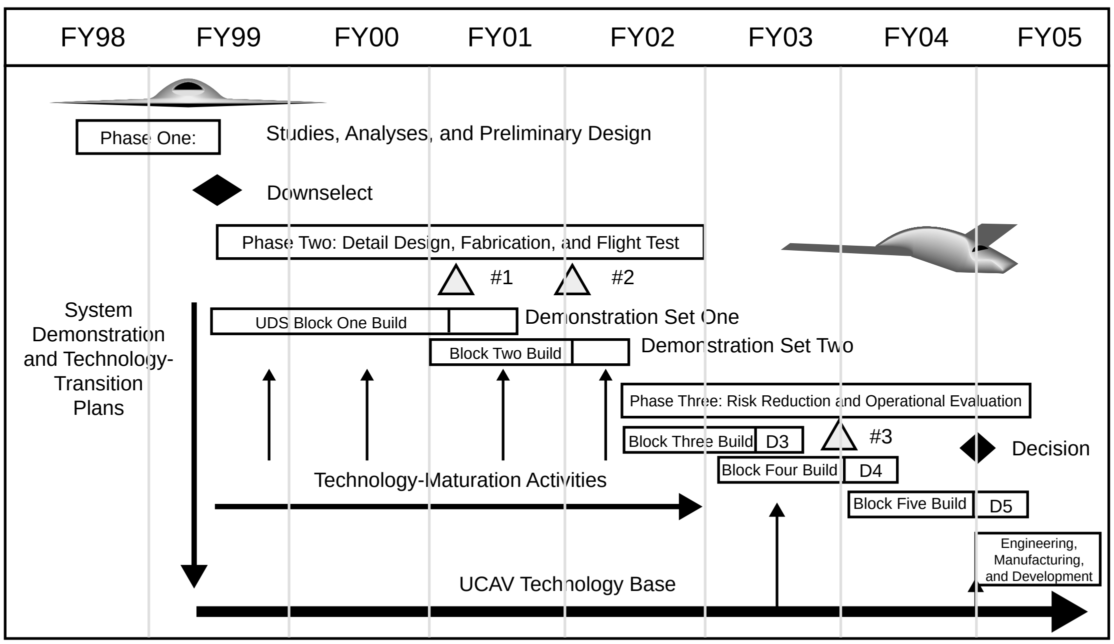


Figure 3. UCAV Transition Plan (From briefing, subject: DARPA/USAF Unmanned Combat Aerial Vehicle Advanced Technology Demonstration Program Overview and Status Update, July 2000; and *Department of Defense Report on Unmanned Advanced Capability Combat Aircraft and Ground Combat Vehicles* [Washington, D.C.: Department of Defense, March 2001])

planned simulator, ground, and flight tests will demonstrate system maturation.

Once the flight-test phase begins, initial emphasis will be on validating basic vehicle-control concepts using a single air vehicle with line-of-sight UHF links. Early flight tests will focus on navigation; exploration of operator-interface options; contingency management, such as the loss of off-board communication signals; and distributed control procedures to transfer vehicle control between two noncollocated ground-control stations.[11] A second flight-demonstration period will utilize two X-45As to demonstrate multivehicle control for both basic flight and mission tasks. Flight tests are intended to validate intervehicle control using the Multifunctional Information Distribution System/Link 16 architecture. Flight-test period two is scheduled to culminate in a full mission demonstration consisting of preemptive DEAD employment against a simulated enemy surface-to-air missile site.[12]

If phase two proves successful, program officials hope to enter a third phase of the UCAV ATD, currently forecast to begin in October 2003. That phase would focus on risk reduction and operational evaluation to facilitate a low-risk entry into EMD between 2005 and 2007, depending upon funding profiles provided.[13] During phase three, program emphasis would shift from validating technical feasibility to exploring operational utility. Program officials acknowledge that their key technical challenge in this phase will entail achieving higher levels of onboard vehicle autonomy and cooperative targeting by migrating the intelligent, decision-aiding software developed for the mission-control station onto the air vehicle's mission-management system. From an operational perspective, program officials see their greatest challenge as achieving seamless UCAV interoperability with a strike package consisting of manned aircraft.[14]

Part of phase three would include construction of a third demonstrator system featuring the X-45B air vehicle, which would incorporate all LO design elements envisioned for the UOS to allow for in-flight signature validation and evaluation of LO maintainability. Additional periods of simulation, ground, and flight test are planned, eventually culminating in a full mission demonstration during which several X-45s will operate in conjunction with manned aircraft as part of a joint strike force.[15] If the demonstration proves successful, DOD officials believe that initiation of an EMD effort in 2007 might yield an initial operational capability in fiscal year 2015.[16]

Naval Unmanned Combat Aerial Vehicle Advanced Technology Demonstration

The UCAV-N ATD (fig. 4), a joint effort between DARPA and the Office of Naval Research, seeks to demonstrate the technical feasibility of a UCAV system that can effectively and affordably provide persistent, sea-based SEAD, strike, and surveillance capability.[17] The program proposes to extend knowledge gained from the UCAV ATD into the maritime environment and examine aspects of UCAV operations unique to the Navy.

UCAV-N program goals for SEAD and strike are virtually identical to those of the Air Force program. UCAV-N program officials wish to leverage the results of the Air Force UCAV program to avoid duplication of effort. They characterize the interplay between the

Figure 4. Artist's Conception of a Naval UCAV on Approach (Reprinted, by permission, from Northrop Grumman Corporation)

two programs as "almost a leader-follower relationship" and plan to explore only those areas that are significantly different in their naval applications or those emerging areas that promise advantages to both programs.[18]

UCAV-N System Description

Like the Air Force UCAV, the UCAV-N will conduct both preemptive and reactive DEAD missions as well as strike missions against fixed, relocatable, and mobile targets. The UCAV-N differs significantly from the Air Force version in three areas. First, it has adopted a 12-hour endurance goal to facilitate both maritime and battle-area surveillance. Second, the system must operate, launch, and recover in the crowded and confined carrier environment. Moreover, it must do so without imposing costly modifications to the ship's layout or disrupting the well-established routine of the carrier's operating cycles. Finally, the UCAV-N vision includes daily peacetime flight operations with no provision for long-term, dormant system storage. Again, like the Air Force UCAV, UCAV-N ATD efforts are distributed among three segments—air vehicle, mission control, and supportability.

Air Vehicle Segment. Designs for the demonstration vehicle have not been finalized. Contractor teams are still defining their vision for an operational UCAV-N and designing an appropriate demonstration system. Some general vehicle characteristics, however, are emerging. As in the case of the Air Force UCAV, UCAV-N contractor teams are pursuing tailless, LO platforms optimized for high-altitude, subsonic cruise and featuring an internal weapons carriage. Senior program officials anticipate contractor proposals for an aircraft with an empty weight of 10,000 to 15,000 pounds.[19] Weapons payload is likely to exceed 4,000 pounds.

Program officials also anticipate that both contractor teams will propose designs that take off and land from a large-deck carrier in the same manner as conventional aircraft. UCAV-Ns likely will perform catapult-assisted takeoffs and arrested landings, although the teams have considered short-takeoff/vertical-landing options. The program's goal is for operational UCAV-Ns to integrate seamlessly with manned flight operations. Ideally, UCAV-N launches and landings would be staggered so as to minimize conflict with manned aircraft, but program officials maintain that the vehicle must land and clear the arresting cable within 45 seconds, as manned aircraft must do. Within the Navy, many aviators remain skeptical of the UCAV's ability to integrate with manned flight operations and have expressed concerns regarding potential disruptions and safety hazards to sailors and equipment on deck. Clearly, service support for the UCAV-N will be predicated largely on the ability of program officials to allay these concerns.

Mission-Control Segment. Carrier integration of the mission-control system represents a unique UCAV-N design challenge. Many elements of vehicle control, particularly tactical control elements such as those required in SEAD and strike profiles, will be common to the Air Force UCAV, but recovery aboard ship is a unique and challenging UCAV-N issue. Notionally, one can achieve basic vehicle navigation, including entry into the carrier's traffic pattern, using onboard GPS equipment. Once established on final approach, glide slope and azimuth information—necessary for precise, all-weather landings—could be obtained through a shipboard-relative GPS, a developmental system that computes relative carrier motion.

System designers are constructing a number of redundant control nodes intended to ensure that UCAV-Ns will be able to recover aboard a carrier safely. During the final portion of a UCAV-N's landing approach, cancellation authority would reside in several man-in-the-loop links. UCAV-N operators stationed both in the carrier air traffic control center and the mission-control station would be able to command a wave off, as would the landing-signals officer on deck. Through the shipboard-relative GPS communications link, that officer would be able to monitor a wide array of flight data, including relative vehicle position, velocity, acceleration, glide-slope deviation, airspeed, angle of attack, and sideslip.

Designers are also addressing the challenge of maneuvering UCAV-Ns on deck after a successful arrested landing. Among the available deck-handling technologies, the most promising concept appears to be equipping dedicated UCAV-N maintenance personnel with a wireless, hand-held control device to input real-time commands to the vehicle. Essential system characteristics include positive control and redundant shutdown capabilities, which would protect sailors working on deck.

Supportability Segment. Unlike the Air Force program, the UCAV-N program does not include integrated storage and shipping containers. Program officials envision that UCAV-Ns will fly daily to provide real-time surveillance for the battle-group commander. This operating concept poses a significant supportability challenge—namely, conducting daily flight operations in the harsh marine environment without the need for routine restoration of LO airframe components. Developing LO materials appropriate for the naval environment has impeded previous efforts to field an LO naval aircraft. Even in land-based stealth programs, signature maintenance has imposed a significant supportability burden. Program officials hope to leverage development efforts for the joint strike fighter to achieve an affordable and supportable stealth vehicle.

UCAV-N ATD Program Structure

Much like the Air Force UCAV ATD, the UCAV-N ATD is a three-phase program that, according to officials, will allow decision makers to determine the technical feasibility and fiscal prudence of pursuing an operational maritime UCAV weapons system. Each phase consists of performance-based milestones used to determine the efficacy of proceeding to the next phase. As in the case of the Air Force program, DARPA and Navy program officials hope that UCAV-N ATD success will warrant entry into a low-risk EMD effort that could yield an operational weapons system.

In phase one of the program, begun in July 2000, program officials are refining operational-system concepts; identifying critical technologies, processes, and system attributes; developing a system-maturation plan; and defining demonstration-system requirements. These officials plan to incorporate lessons learned from the Air Force UCAV program and align the program to enable further cooperative efforts.

Planned UCAV-N efforts in phase two entail risk-reduction activities, including designing, developing, and flight-testing a UCAV-N demonstration system. One of the primary objectives of the phase-two trials involves validating the control-and-communication attributes required to launch and recover a UCAV-N on a carrier deck. Program officials seek to maintain a competitive environment by retaining both contractors through at least the end of this phase.

If phase-two efforts prove successful, program officials anticipate entering a yet-to-be-defined third phase—risk reduction and operational evaluation—as a precursor to a possible EMD effort. Although an appropriate decision point for EMD entry remains undetermined, these officials continue to explore potential EMD options. One planning constraint is that the timeline for UCAV-N development is wedded to that of the lead Air Force UCAV program. If the latter achieves its development milestones as forecast, program officials believe it would be possible to begin a UCAV-N EMD effort in 2010, possibly resulting in a fielded system by 2015.[20] Additionally, a number of aircraft producers in the United States and Europe are reportedly pursuing UCAV development efforts (table 3).

Technical Challenges and Concerns

Both DARPA and service officials characterize the UCAV and UCAV-N as high-risk, high-payoff programs. Consequently, program officials have instituted a number of measures to monitor and manage risk. Of particular concern to developers are systems-integration issues such as seamless compatibility with other battle-space information systems; a secure and

Table 3

Selected UCAV Demonstration/Development Programs

Program	*Country*	*Manufacturer*	*Description*	*Empty Weight (lb)*	*Maximum Takeoff Weight (lb)*	*Projected Weapons*
European Aeronautic Defense and Space Co. (EADS)	European Consortium	EADS Military Aircraft	LO surface-attack UCAV	9,923	18,078	Internal carriage of various conventional munitions
Aeronef Validation Experimentale (AVE)	France	Dassault Aviation	Subscale demonstrator of LO surface-attack UCAV	77	132	N/A
Swedish Highly Advanced Research Configuration (SHARC)	Sweden	Saab Aerospace	LO surface-attack	unknown	11,023	Internal carriage of various conventional munitions
Unannounced Program	USA	Lockheed Martin	Aircraft-launched, LO UCAV designed to attack air defense elements	unknown	unknown	One or two small bombs or nonlethal payloads (e.g., high-powered microwaves)
Pegasus	USA	Northrop Grumman	Contractor-funded demonstrator to explore LO UCAV carrier suitability	3,835	5,500	Internal carriage of two 500 lb conventional bombs
Weaponized RQ-1B Predator	USA	General Atomics	Medium-altitude, armed reconnaissance vehicle for real-time targeting of armored vehicles	950	2,250	Two AGM-114 Hellfire C anti-missiles

robust communication capability; and adaptive, autonomous operations.

Battle-space integration, pivotal to UCAV success, will require network-integrated software capable of supporting multisensor cooperation, dynamic networking, and autonomy. As an example, both programs intend to incorporate off-board sensor data from highly classified national technical means. Specifically, designers hope to exploit signals intelligence from overhead collectors in real time and use this data to provide tactical cueing for UCAV weapons. This effort is both critical and challenging.

Secure and robust communications represent another key to program success. Jam-proof low probability of intercept and detection (LPI/D) communications links are vital. System developers are working to create a survivable and fault-tolerant network architecture in response to information-warfare threats.

Graceful system degradation—the ability of a system to tolerate faults and retain at least partial functionality—is also a key concern. At a minimum, the vehicles must maintain coordinated flight in the event of communications loss. Failure to fully resolve this issue in previous UAV programs has contributed to UAV accident rates 10 to 100 times higher than manned-aircraft rates.[21] Onboard prognostics and health management will be essential to achieving high-confidence fault anticipation and isolation. Similarly, within the mission-control system, fault detection and localization will become key issues.

Finally, within the mission-control system, integration of advanced cognitive aids presents a major challenge. Creating intelligent onboard decision aids to enhance the operator's situational awareness will be a fundamental requisite if developers are to achieve multiple-vehicle control by a single operator in a dynamic mission environment. Such intelligent autonomy is highly desirable because it avoids the necessity of streaming video and corresponding high-bandwidth requirements.

In solving these technical challenges, designers must devise solutions that permit interoperability of UCAV operations with manned aircraft. In the case of the UCAV-N, the requirement to develop a ship-suitable design increases the complexity of the task. The technology appears feasible at this early stage, but a myriad of technical details and an unknown number of unidentified challenges remain unresolved.

Affordability

Accurately projecting the cost of an operational UCAV system is difficult. Both the Air Force and Navy UCAV demonstration projects are still relatively immature and include many unknowns. Cost estimates based on manned-aircraft programs are unlikely to yield satisfactory results based on differences in the design approach and operating concepts. By the end of phase three—risk reduction and operational evaluation—however, Air Force UCAV program officials hope to develop life-cycle cost models that will bound acquisition as well as operations-and-support costs within an 80 percent cost-confidence band.[22] The UCAV program's affordability goal is to achieve a recurring unit-flyaway cost of one-third that of an Air Force joint strike fighter—about $10–12 million—and a 20-year operations-and-support cost of 25 percent that of an F-16 Block 50. Similarly, UCAV-N program officials hope to achieve a unit-cost goal of one-third that of a Navy joint strike fighter—about $11–15 million—and a 20-year operations-and-support cost of one-half that of an F/A-18C.

At present, cost estimates are imprecise and, in the case of the UCAV-N, proprietary. However, one can draw several conclusions, based upon previous manned and unmanned aircraft programs. First, avionics will represent a significant portion of total vehicle cost. As a result, UCAV unit cost will be particularly sensitive to user requirements for sensor-suite (primarily radar and electronic support measures [ESM] equipment) capability. Accommodation of a surveillance requirement is likely to be a significant cost driver since it will require a more robust radar capability than that required for SEAD and strike missions. Second, DOD's acceptance of UCAVs will be predicated largely on reductions in total operating costs over those of alternative systems. Contributors to these costs include training, maintenance, logistics, and long-term support. Program officials believe that total operating costs of the UCAV and UCAV-N will be far below those of manned platforms, in part because of their simulator-based operator-training concept. Simulator training would significantly reduce the number of training flights required, yielding significant savings through reductions in costly maintenance work hours and consumables such as fuel, tires, and spare parts.

Procurement Quantity

As is true for any weapon, UCAV and UCAV-N acquisition quantities will be largely a function of their perceived operational effectiveness, survivability, and affordability as compared to alternative systems. Determination of a prudent fleet size requires effects-based analysis, including detailed examination of lethality against anticipated targets and survivability issues such as threat capabilities, threat density, and frequency of engagement. With regard to UCAV and UCAV-N, the present fidelity of performance projections is insufficient to support a production or fleet-sizing decision. However, program officials are generating an array of cost estimates based on sizing excursions of fewer than 300 aircraft of each type.

If the vehicles enter production, one approach entails initially fielding a small fleet of UCAVs and UCAV-Ns, perhaps 10–20 of each, thereby providing users with a limited operational SEAD capability while enabling them to refine requirements and operational concepts. Lessons learned could be incorporated in subsequent block development. This approach resembles the one planned for the Global Hawk program.

Conclusion

If an operationally effective UCAV can be fielded affordably, many people believe it could serve as one of the key building blocks of military transformation. Compared to other power-projection systems, UCAVs have the potential to reduce total ownership costs substantially and perhaps offer one method of easing the impending funding challenges faced by the services in replacing their aging equipment fleets. Additionally, removing humans from a vehicle that maintains the stealth and precision of manned systems could expand power-projection options available to political and military leaders. These characteristics are well suited to combating the growing antiaccess threat posed by rapidly proliferating, advanced surface-to-air and surface-to-surface weapons.

UCAV prospects appear promising, but feasibility, operational effectiveness, and affordability remain unknown. Several critical system attributes, such as adaptive autonomy as well as secure, robust, and networked communications, remain areas of high risk and need resolution. Both the UCAV ATD and the UCAV-N ATD will explore these issues in detail. By the end of the demonstrations, program officials hope to bound these unknowns sufficiently to allow a low-risk entry into a formal EMD effort. However, we cannot yet precisely quantify the cost and schedule risks associated with fielding an operational system. Until we resolve these outstanding issues, any resource and force-structure decisions predicated upon fielding an operational UCAV fleet would be premature. □

Notes

1. Development of unmanned aircraft began with the "Kettering Bug" in World War I. From 1971 to 1979, DOD attempted several UCAV development projects in the form of the Ryan BGM-34A/B/C. Budget constraints and system-capability shortfalls led to termination of these efforts.

2. DOD news briefing, Gen Henry H. Shelton, 19 December 1998, on-line, Internet, 7 March 2002, available from http://www.defenselink.mil/news/Dec1998/t12201998_t1219coh.html.

3. Additional information on DOD standoff weapons is available in Christopher Bolkcom and Bert Cooper's *Missiles for Standoff Attack: Air-Launched Air-to-Surface Munitions Programs,* CRS Report RL30552 (Washington, D.C.: Congressional Research Service, 9 May 2000).

4. In this case, design margin refers to the additional load-bearing capability required above the design's load limit to prevent structural failure. DARPA program officials are designing both the Air Force and the Navy UCAV, subsequently discussed, to a design limit of 125 percent.

5. Lt Gen Michael C. Short, USAF, retired, "Lessons Learned from Allied Force and Implications for the QDR [Quadrennial Defense Review]," lecture, DFI International Aerospace Power Seminar Series, Washington, D.C., 14 November 2000.

6. Management and funding responsibilities will pass from DARPA to the Air Force, beginning in fiscal year 2003. The terms *DEAD, destructive SEAD, lethal SEAD,* and *SEAD* are sometimes used interchangeably within DOD. In UCAV ATD parlance, SEAD encompasses both preemptive and reactive DEAD.

7. "Unmanned Combat Air Vehicle Advanced Technology Demonstration White Paper," final draft (Saint Louis, Mo.: Boeing Corporation, 7 December 2000).

8. Ibid.

9. Frank Bokulich, "TRW Builds PTO [Power Takeoff] for F124 Turbofan," *Aerospace Engineering,* June 2000, on-line, Internet, available from http://www.sae.org/aeromag/techupdate_6-00/09.htm.

10. LOCAAS is an advanced-development program that intended to develop a technology base for future low-cost laser radar (LADAR) sensor submunitions. As currently envisioned, LOCAAS incorporates an autonomously powered maneuvering airframe with a LADAR sensor and a multimode warhead. The submunition is optimized to perform broad-area search, identification, and destruction of a range of ground, mobile, and fixed targets.

11. “Unmanned Combat Air Vehicle Advanced Technology Demonstration White Paper.”

12. Ibid.

13. *Department of Defense Report on Unmanned Advanced Capability Combat Aircraft and Ground Combat Vehicles* (Washington, D.C.: Department of Defense, March 2001).

14. “Unmanned Combat Air Vehicle Advanced Technology Demonstration White Paper.”

15. Ibid.

16. *Department of Defense Report on Unmanned Advanced Capability Combat Aircraft and Ground Combat Vehicles*.

17. As in the case of the UCAV ATD, UCAV-N ATD program officials use the term *SEAD* to encompass both preemptive and reactive DEAD. Briefing, John Kinzer, deputy program manager, UCAV-N ATD, Office of Naval Research, to American Institute of Aeronautics and Astronautics 2000 Missile Sciences Conference, subject: UCAV-N, 9 November 2000.

18. Ibid.

19. Geoff S. Fein, “Naval UCAV Development Program Progressing in Early Stages,” *Inside the Navy* 14, no. 2 (15 January 2001).

20. *Department of Defense Report on Unmanned Advanced Capability Combat Aircraft and Ground Combat Vehicles*.

21. Jefferson Morris, “Despite Rosy Future, UAVs Still Have Some Growing Up to Do, Report Says,” *Aerospace Daily,* 27 April 2001.

22. “Unmanned Combat Air Vehicle Advanced Technology Demonstration White Paper.”

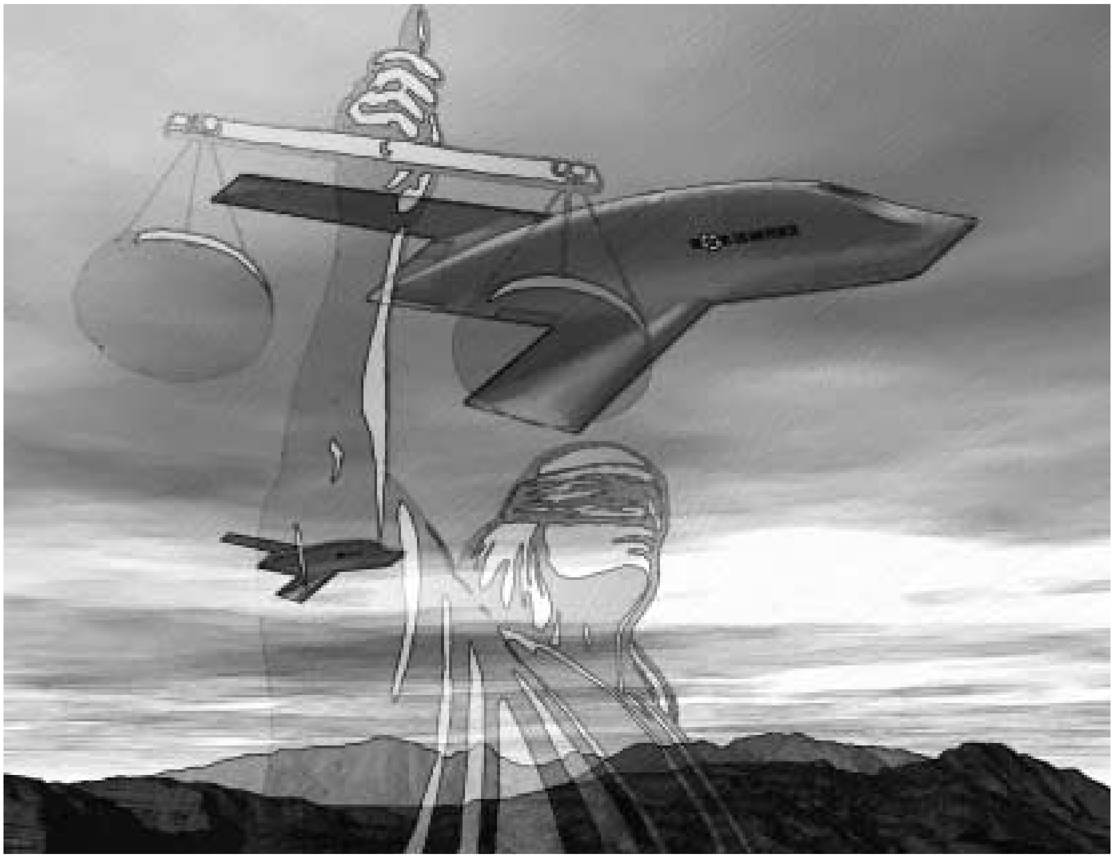
Aerospace Power *Chronicles*

Aerospace Power Chronicles continues to provide our readers outstanding articles that stimulate and promote new ideas. For example, “Examining the Reconstruction of Egyptian Morale during the Aftermath of the 1967 Six Day War: An Arab Perspective” by Lt Youssef H. Aboul-Enein, USN, gives us an appreciation of the experience of many people in Egypt, as well as a better understanding of this key US ally. Using both a sociological and military perspective, the author explores the ways in which the Egyptian people rebuilt their morale after the Six Day War. In “Planning to Win: A Study in Strategy and Operational Art,” Lt Col John P. Hunerwadel, USAF, warns that our current military superiority does not guarantee our safety, as the events of 11 September 2001 plainly show. We must focus on winning the war we’re in and intelligently use all the tools available to us—including those for planning.

We have also posted two new discussion topics in our “Current Issues” section. In “Intelligence Preparation of the Battlefield,” TSgt John Dyson takes the lead in the discussion, declaring that “Security Forces do not need intelligence of enemy forces (which is the prime mission of aerospace intelligence personnel), but need simple information regarding local threats to the base.” And Lt Col Steve Suddarth inquires about Air Force Materiel Command’s definition of “transformation” in “AF Transformation of Research, Development, Acquisition, and Logistics.” Log on and join in the discussions.

As always, you can find these and many more articles of interest on-line at http://www.airpower.maxwell.af.mil.

Luetwinder T. Eaves
Managing Editor
Aerospace Power Chronicles



Editorial Abstract: Rumors that Mullah Mohammed Omar had been "in-the-sights" of an armed, uninhabited (or unmanned) combat aerial vehicle (UCAV) early in the Afghan campaign and was not attacked due to legal wrangling at command headquarters sparked questions about who really makes decisions on the battlefield. These questions will become more important as UCAVs proliferate in both US and foreign militaries. Colonel Lazarski explains the legal implications of these powerful weapons and urges the United States to aggressively lay the groundwork for operating UCAVs in the international airspace environment.

Legal Implications of the Uninhabited Combat Aerial Vehicle

LT COL ANTHONY J. LAZARSKI, USAF

You've got to put a surrogate brain in that airplane. And that's not going to come cheaply or easily.

—Gen Ronald R. Fogleman

CLARENCE "KELLY" JOHNSON, the legendary founder of Lockheed's Skunk Works and creator of the SR-71 and U-2, predicted in 1944 that the future of military aviation would belong to unmanned aerial vehicles (UAV).[1] That time is almost upon us (fig. 1). Currently, the United States Air Force, Army, Coast Guard, Marine Corps, and Navy possess and operate some type of UAV.

The United States has used UAVs during Operations Desert Storm, Deny Flight, Deliberate Force, and Allied Force, and continues to use them over the skies of Iraq, Bosnia, Kosovo, Korea, and, most recently, over Afghanistan in support of Operation Enduring Freedom. Today, UAVs primarily perform the traditional missions of reconnaissance and surveillance. The next generation of UAVs—uninhabited combat aerial vehicles (UCAV)—will perform an array of offensive and defensive operations, including suppression of enemy air defenses (SEAD), close air support (CAS), defensive counterair (DCA), offensive counterair (OCA), and air interdiction (AI).

During World War II, Gen Henry H. "Hap" Arnold, in coordination with Gen Carl A. Spaatz, developed a plan to use stripped-down B-17s (BQ-7)(fig. 2), loaded with 22,000 pounds of high explosives and equipped with

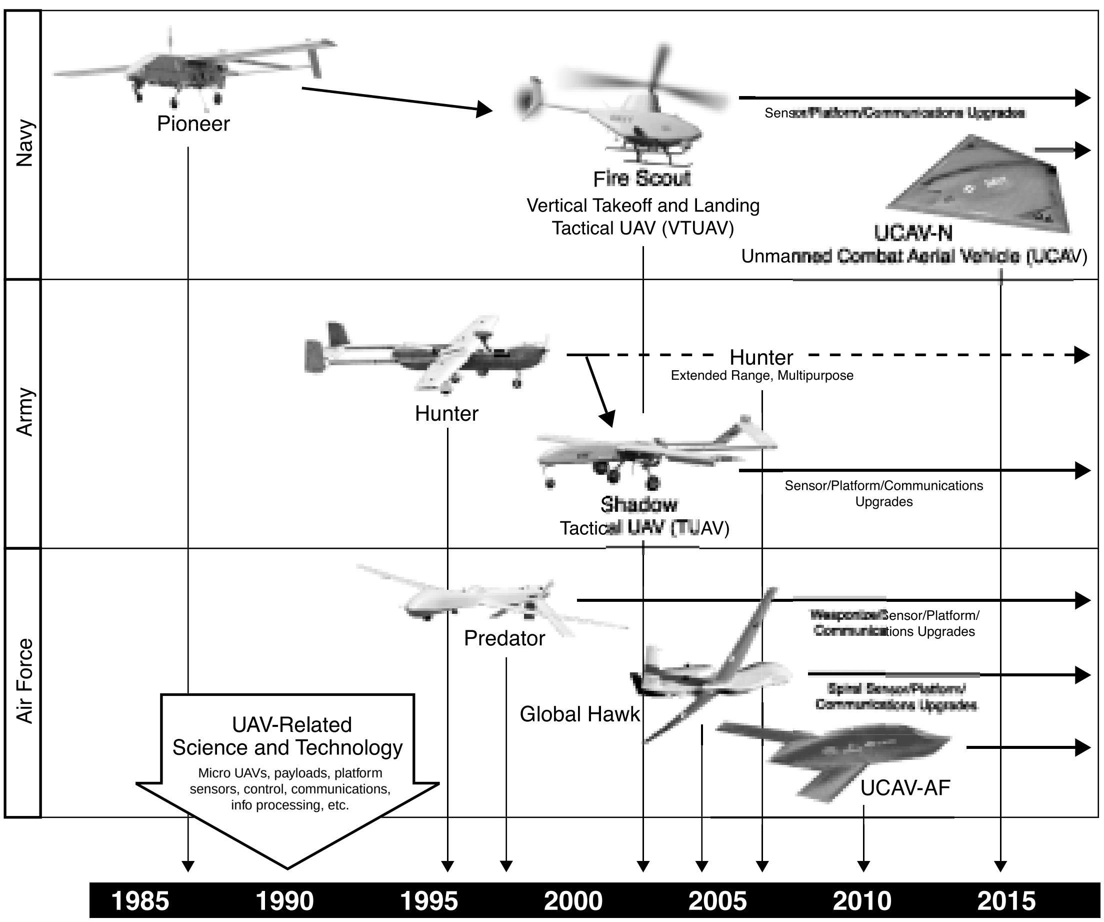


Figure 1. UAV Evolution

radio-controlled autopilots to destroy new, heavily defended German V-weapon launching sites.[2] Labeled Project Aphrodite, this plan used BQ-7s as primitive forms of UCAVs. A crew of two (pilot and autopilot technician) would execute the UCAV's takeoff, arm the explosives, turn control over to the mother ship (cruising at 20,000 feet) by engaging the radio-controlled autopilot, and then bail out over the United Kingdom. Four B-17s were launched on 4 August 1944—one aircraft exploded over the United Kingdom, killing its crew, and the final three failed to reach their targets. General Arnold's vision of a UCAV would be placed back on the drawing board for another 45 years until another general officer in command of combat air forces envisioned the development of an armed UAV.

When Gen John P. Jumper, the current Air Force chief of staff, was the commander of Air Combat Command, he asked the Air Force to develop and demonstrate a weaponized UAV with the ability to find a target and eliminate it.[3] The platform chosen was the Predator (fig. 3)—a surveillance-and-reconnaissance UAV with over 600 missions in support of NATO operations in Bosnia.[4] On 16 February 2001 the Predator made history by successfully launching the first missile from a UAV. The Hellfire-C laser-guided missile struck a stationary tank, marking the Predator's evolution from a nonlethal reconnaissance asset to an armed, highly accurate tank killer.[5] Today's Air Force envisions the UCAV as an affordable weapon system that can execute lethal strike missions by exploiting the design and operational freedoms of relocating the pilot outside of the vehicle.[6] UCAVs, by design, can be smaller, stealthier, and have a higher maneuver-and-endurance capability than current combat aircraft. This paradigm shift could decrease the cost of air combat, increase airpower capabilities, and reduce risk to the human operator on UCAV missions.

Figure 2. B-17 UCAV (BQ-7)

Figure 3. Predator UAV with Hellfire-C

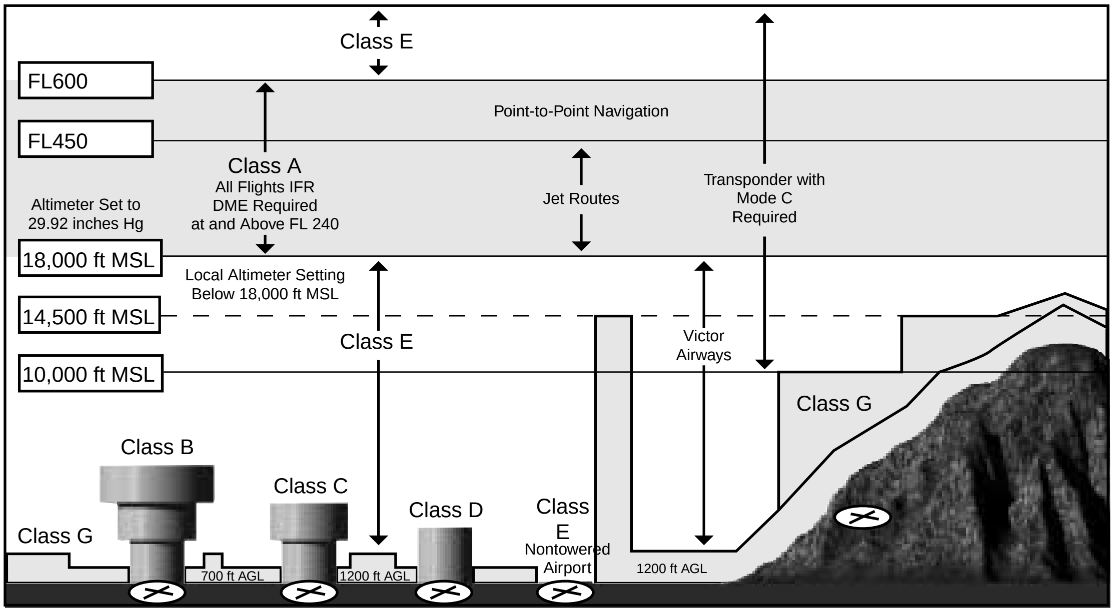
According to the Defense Advanced Research Projects Agency (DARPA), one doesn't need technical miracles to make a UCAV work. The Boeing Company's Phantom Works Division is drawing on its extensive experience and resources in the areas of manned strike aircraft; weapon systems; surveillance-and-reconnaissance systems; and command, control, communications, and computer technologies.[7] The challenge is integration—command and control (C^2) and human-machine interface.[8] However, integration is not the last hurdle. Before the United States develops, deploys, and employs UCAVs, it must address the legal issues involved. Specifically, the United States must consider the rules that govern flight operations in national and international airspace, the Laws of Armed Conflict (LOAC), and rules of engagement (ROE). If these issues are not addressed, the law may shoot down the UCAV before it ever sees combat.

Before the legal issues can be addressed, it is necessary to understand the nature of a UCAV and the operational plans for this *revolution in military affairs* (RMA). The Department of Defense (DOD) has on the drawing board, or is testing, UCAVs that can laser-designate targets; conduct SEAD; and attack heavily fortified, high-value targets with enough speed and stealth to survive.[9] UCAVs are an extension of the UAV, both of whose development is driven by mission requirements—the ability to conduct effective air operations in any environment with minimum risk to friendly forces. These operations must also be cost efficient. UCAVs currently in prototype or on the drawing board are projected to cost up to 65 percent less to produce and 75 percent less to operate and maintain than future manned combat aircraft (fig. 4).[10] UCAVs will range in wingspan from a few feet to 150 feet and will possess maneuver and endurance capabilities that far exceed the limits of the human pilot. UCAVs will have sleek, radar-absorbing bodies; sophisticated onboard computer systems; and the capability to conduct offensive and defensive combat operations.[11] UCAVs can and will be containerized for easy storage and deployment. Container interfaces will allow for periodic maintenance monitoring and software updating of the vehicle inside.[12] By taking the aircrew out of the cockpit, the United States can avoid what is being called a *Gulf War syndrome*—a total intolerance by the population of the United States for any casualties. Uninhabited aircraft are a continuation of the great American tradition of substituting technology for human beings.[13] UAVs have taken on reconnaissance and surveillance roles, with UCAVs soon to follow in combat-attack operations.

Figure 4. Future Design

The first legal area the United States must address before it commits to building a wing of UCAVs involves the rules that govern flight operations in national and international airspace. The major areas of concern for UCAV flight operations deal with airspace procedures and C^2. Detailed coordination with the Federal Aviation Administration (FAA) and the International Civil Aviation Organization (ICAO) is required before any UCAV flight operations can take place in the United States or in international airspace. These organizations will have to develop new procedures prior to the commencement of routine UCAV operations.

In the United States, the national airspace system is broken down into several classes of airspace specifically designed for the safe operations of all aircraft (fig. 5).[14] The FAA restricts most UAV flight operations to special-use airspace and prohibits UAVs from flying over populated areas. UAV flight operations into uncontrolled airspace are restricted to flights in perfect weather conditions, and local air-traffic administrators must be given a 30-day notice.[15] These restrictions severely limit the UAV units' participation in training deployments and exercises. During the calendar year 2000, the FAA issued 20 authorizations to fly UAVs in civil airspace (outside special-use airspace).[16] Following the events of 11 September 2001, the United States redefined "homeland defense" and ways in which the government/military will participate in that defense. Manned fighter and reconnaissance aircraft are engaged in day-to-day operations, but officials have been



AGL: Above Ground Level
IFR: Instrument Flight Rules
MSL: Mean Sea Level
DME: Distance Measuring Equipment

Figure 5. United States National Airspace Classification

reluctant to discuss UAV or UCAV operations over major US cities and their sharing of airspace with civilian air traffic. This reluctance may be due to their unfamiliarity with UAV/UCAV capabilities, their inability to find written UAV/UCAV procedures for operations in the United States, and/or their fear of what happens if UAV/UCAV control is lost. One of the lessons these officials learned during Operations Deliberate Force and Allied Force was that manned aircraft and UAVs must be deconflicted by time, altitude, and/or location to avoid a potential midair collision.[17] While advances in the civilian and commercial UAV market have helped in negotiations with the FAA for the integration of operational UAVs in national airspace, UCAV operations have been completely ignored.[18] The US military's increasing reliance on UAVs, coupled with the rapid pace of UCAV development, requires the US aviation community to rewrite the rules regarding UAVs and to draft and publish rules and regulations governing the use of UCAVs in national airspace. The future of homeland defense and the ability of the United States to project power will depend on published procedures, both at home and internationally.

Internationally, the ICAO and other nations are operating under many of the same lack of procedures as the FAA and the United States when it comes to UAVs and UCAVs. In 1998 the ICAO and civilian UAV community made history when a miniature autonomous aircraft, the Aerosonde *Laima*, made the first transoceanic flight from Canada to Scotland in less than 27 hours.[19] In 2000, Global Hawk, a US UAV, won the Collier Trophy for the year's greatest aerial achievement in astronautics—the first transpacific flight of a UAV (fig. 6).[20] UAVs such as Global Hawk operate at altitudes above 65,000 feet where commercial traffic does not fly, simplifying the international coordination process.[21] However, little progress is being made with regard to other types of military UAVs, and no progress is being made in regard to UCAVs. The latter,

Figure 6. Global Hawk UAV

which are military aircraft, should be treated as state aircraft in accordance with the Chicago Convention. Although the convention does not define *state* aircraft, it does suggest that the term is determined functionally by use of aircraft such as those in military, customs, and police services.[22] As the development of UCAVs progresses, these aircraft will be able to fly directly from the United States to the contingency operation. The ICAO needs to codify its *due regard* procedures for uninhabited aircraft flying in international airspace. This step is important for both civil safety and military operations.

The Chicago Convention codified the principle that each nation maintain full sovereignty in its airspace.[23] Therefore, flight operations into a nation's sovereign airspace require that nation's approval. The United States must proactively engage potential coalition partners and develop agreements for the use of UCAVs in their national airspace. These agreements need to include provisions for airfield, training, and combat operations. If procedures are not negotiated and in place prior to the start of a contingency, delays in the deployment and employment of UCAVs will occur and may have grave consequences on the outcome of future contingency operations.

C^2 procedures for UCAVs are the final area of concern for both national- and international-flight operations. Those procedures are defined by the dependence of the machine on ground control—not by the technological aspects of how the ground controller communicates with and controls the machine. C^2 procedures are broken down into three types: *autonomous, semiautonomous,* and *full ground control*. Autonomous C^2 procedures require only a ground-control interface during takeoffs and landings. The UCAV's navigation and other mission tasks are preprogrammed so that onboard computers can autonomously take care of all combat operations. Semiautonomous C^2 requires ground control during critical portions of flight such as takeoff, landing, weapons employment, and some evasive maneuvers. Full ground control requires a continuous ground C^2 input during all phases of the UCAV's flight. In the United States, the FAA requires that all UAVs operating outside of special restricted areas have certified pilots at the controls and that the UAVs be under either semiautonomous or full ground control (fig. 7).[24] The ICAO and coalition partners may impose similar restrictions. These conflicts need to be resolved prior to deployment and should be considered in the development of the UCAV.

Another critical aspect of C^2 for UCAVs is the concept of a safe mode. Because a UCAV

Figure 7. X-45 Mission Control Console

will be carrying some type of weapon during at least half of its flight profile, procedures need to be developed and legal arrangements negotiated to cover emergency operations. Just like aircraft, UCAVs can experience engine problems, loss of communication, and weapon malfunctions. Unlike manned aircraft, UCAVs must be programmed with precise instructions and procedures to follow. These instructions and procedures may include a preplanned orbit point to regain communications and control, a preplanned self-destruct point, or an autonomous recovery-and-landing option. The potential for loss of life increases significantly in the case of armed, pilotless aircraft. These issues are being addressed at the UAV Battlelab at Eglin Air Force Base, Florida.[25]

Once the legal issues concerning national- and international-flight operations have been resolved, the United States needs to examine potential conflicts with the LOAC, also known as Law of War, which are derived from two main sources: customary international law and treaty law.[26] UCAV operations have potential conflicts with the two LOAC principles of *discrimination* and *humanity*.

The principle of discrimination (Protocol 1 of 1977 to the Geneva Conventions of 1949, Article 48) requires the parties of the conflict to distinguish between civilians and combatants; distinguish between civilian objects and military objectives; and direct operations against military objectives only.[27] Therefore, an attacker must not employ weapons that would cause excessive collateral damage. Technology has legitimized precision warfare and criminalized collateral death and destruction resulting from the use of lethal force.[28] This has in turn placed limits on using any system that could deliver lethal force. During Operation Allied Force, NATO bombs were believed to have killed approximately 500 civilians.[29] In a June 2000 report, Amnesty International concluded that NATO had violated the LOAC principle of discrimination by failing to provide effective warning to civilians who were in or near a targeted facility; failing to refrain from attacking a target if civilians were known to be in or near the target; and failing to suspend an attack once it became known that civilians had been hit.[30] Amnesty International also concluded that requiring NATO aircraft to fly above 15,000 feet made it difficult for pilots to see whether civilians were near a target.[31] A lethal and, as of yet, unproven UCAV with autonomous or fully adaptive controls poses significant accountability problems and is sure to be challenged by groups such as Amnesty International. Prior to the UCAV's first employment, extensive testing must be conducted and documented to the world, proving the accuracy and reliability of the aircraft's systems. All UCAV weapon systems must undergo this type of scrutiny until they gain worldwide acceptability as discriminating weapons.

The principle of *humanity* or *unnecessary suffering* prohibits the employment of any kind or degree of force that is not necessary for the purposes of war.[32] Listed under the principle of humanity are examples of lawful and unlawful weapons. The legal status of UCAVs as lawful weapons comes under scrutiny due to the 1988 Intermediate-range Nuclear Forces (INF) Treaty that was signed by the United States and the Soviet Union. The INF Treaty prohibits the United States and former Soviet republics from deploying ground-launched cruise missiles with ranges between 500 kilometers (km) and 5,500 km.[33] Some critics feel that UCAVs could be considered cruise missiles or nuclear-capable launch vehicles specifically prohibited under the INF Treaty. If the United States developed a ground-launched UCAV that was not expected to return to base, it could be considered a cruise missile and therefore prohibited by the INF Treaty. By example, in 1999 DOD considered acquiring and deploying Harpy, an Israeli UCAV, for use during Operation Allied Force. However, since the Harpy was essentially a cruise missile with a 32-kilogram warhead and range of up to 600 km, the United States abandoned the project due to its potential violation of that treaty's restrictions.[34] In contrast, current and projected UAVs and UCAVs have flight profiles that preclude them being characterized as cruise missiles. DOD is currently investigating the legal status of UCAVs with respect to the INF Treaty and the Reduction and Limitation of Strategic Offensive Arms Treaty (usually referred to as the Strategic Arms Reduction Treaty [START]).

The Missile Technology Control Regime, an international treaty that regulates the exportation of UAVs, poses another potential problem for the United States and its coalition partners. Under this treaty, the signatory nations agree to limit the risks of proliferation of weapons of mass destruction (WMD) by controlling transfers that could make a contribution to the development of WMD delivery systems.[35] These guidelines specifically exclude manned aircraft but include the export of uninhabited aerial aircraft and related technology.[36] This would require the United States to be the sole operator of UCAVs if the other coalition partners did not independently possess the technology. Despite the regulations of the Missile Technology Control Regime, many nations continue to independently develop UAV technology and subsequently employ UAVs. By 2002 Italy will acquire six Predator UAVs from a team comprised of General Atomics, a US UAV manufacturer, and Meteor, an Italian company.[37]

ROEs are the final legal issue that must be addressed before deployment and employment of UCAVs. Their effective use requires the establishment and understanding of common ROEs to provide guidance for their application. Standing ROEs (SROE) are approved by the president and secretary of defense (SECDEF) and maintained by the Joint Chiefs of Staff (JCS).[38] Each commander in chief (CINC) augments SROEs as necessary to authorize certain actions or place limits on the use of force. Specific ROEs need to be written regarding the use of UCAVs. The most critical area that must be addressed is the authorization to release or fire weapons.

During combat, pilots must satisfy the current ROEs and meet a specific list of criteria before employing weapons on a target. Some of these criteria would typically include positively identifying the target and minimizing collateral damage; furthermore, there must not be any known malfunctions with the aircraft or the weapons that could preclude the weapons from functioning normally. The pilot makes the final choice in a rapidly changing environment and is ultimately responsible for the result. The American public and the international community hold individuals and organizations accountable for their decision to use force.[39] The same will be true for UCAVs.

As discussed earlier, there are three types of C^2 for UCAVs—autonomous, semiautonomous, and full ground control. The fully autonomous mode presents the most problems legally due to a lack of a human-in-the-loop. The UCAV must be sophisticated enough and reliable enough to assess the situation, apply the current ROEs, and deliver the weapon. The last two types of C^2 pose little problem by maintaining a human-in-the-loop for authorization to release. The human controller makes the decision to release the weapon, based on the current ROEs and situational awareness gained from onboard systems as well as an integrated air-and-ground picture. The UCAV and weapon are controlled through impact. Full accountability rests on the ground controller and, potentially, the ground-control team. Legal and moral issues arise when the UCAV malfunctions and collateral damage occurs. A chain of accountability must be in place for these instances. This chain may lead all the way back to the initial operational test and evaluation. The public will question the reliability of the system and, in the end, the use of all UCAVs in the future. It is imperative that we be cautious in making the leap to UCAVs. The United States should begin with total ground control and progress to a fully autonomous mode (fig. 8). The selection of types of missions and targets is critical in the beginning stages of UCAV development. The United States needs to build confidence that a robot airplane would use the same caution that a human being would use when deciding to employ ordnance.[40] As the system matures, technology should allay fears and cultural opposition.[41] ROEs can be modified as world opinion

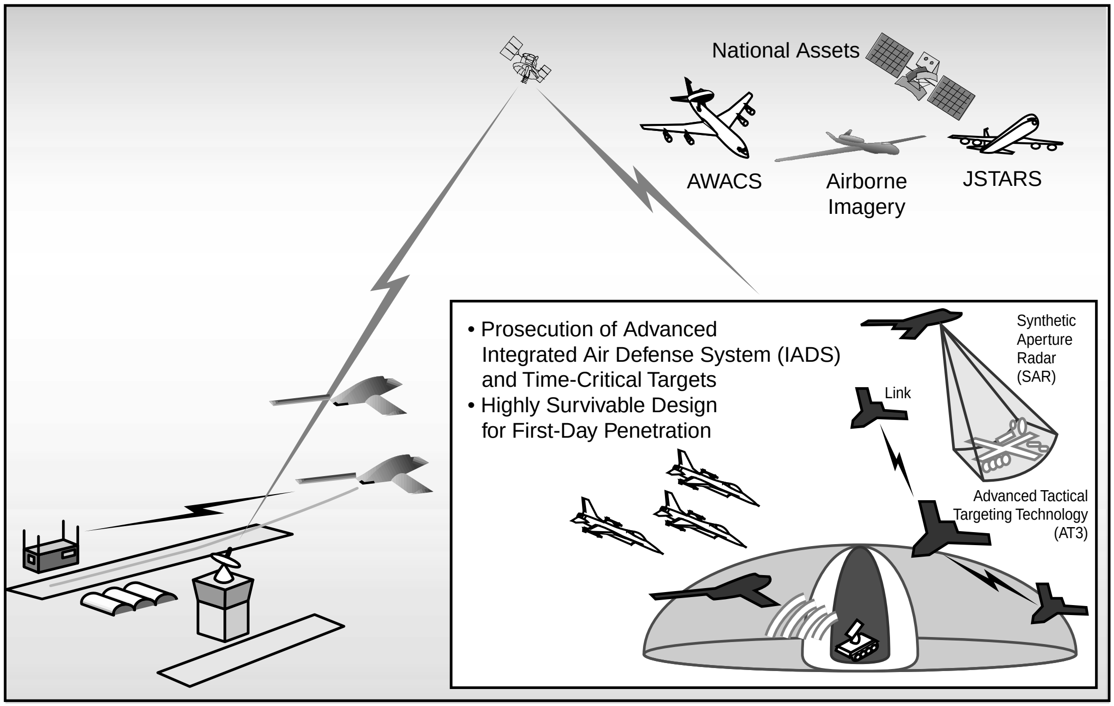


Figure 8. UCAV Concept of Operations

and cultural bias begin to accept the concept of automated warfare.

The United States must be ready and able to employ all its assets, including UCAVs, in homeland defense and international operations. To that end, the United States must begin the necessary efforts to proactively prepare itself and its coalition partners, legally and operationally, for the future employment of UCAVs. Those efforts must address UCAV flight operations in national and international airspace and ensure that UCAV operations meet all the principles of LOAC and the treaties to which the United States or our coalition partners are signatory. Finally, very conservative ROEs must be specifically developed for the initial use of UCAVs to ensure their international acceptance until the system matures and its employment become routine. In spite of the potential reduction in friendly casualties and a significant savings in national treasure, UCAVs may never see combat if these critical issues are not specifically and satisfactorily addressed. □

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An army of sheep led by a lion is more to be feared than an army of lions led by a sheep.

—Arab proverb

PIREP

Editor's Note: PIREP *is aviation shorthand for* pilot report. *It's a means for one pilot to pass on current, potentially useful information to other pilots. In the same fashion, we intend to use this department to let readers know about aerospace-power items of interest.*

Future Missions for Unmanned Aerial Vehicles

Exploring Outside the Box

MAJ EARL "DUKE" ODOM, USAF*

Editor's Note: Established by Gen Ronald R. Fogleman when he was chief of staff, the Air Force's Unmanned Aerial Vehicle (UAV) Battlelab became operational on 1 July 1997 as part of the original six Air Force battlelabs. The battlelab concept emerged from the Air Force's long-range planning effort and the publication of Global Engagement: A Vision for the 21st Century Air Force. *The mission of this battlelab is to rapidly identify and demonstrate the military worth of innovative concepts that exploit unique characteristics of UAVs to advance the Air Force's combat capability. (See the UAV Battlelab Web site at https://intranet.eglin.af.mil/UAVB.)*

THE AIR FORCE'S UAV Battlelab (UAVB) has conducted or is conducting numerous initiatives that demonstrate the military utility of relevant functions that will keep the United States poised to exploit the unique capabilities of the UAV. As UAV mission areas expand from intelligence, surveillance, and reconnaissance (ISR), battlelab initiatives remain on the leading edge, focused on demonstrating increased combat capability. This article briefly identifies some of those accomplishments—the results of exploring outside the box.

The transition of UAVs from ISR platforms to multimission vehicles is a natural progression, just as it was with manned aircraft. Almost unlimited potential exists in areas other than ISR, and the UAVB is defining that potential. For example, the battlelab completed the Global Positioning System (GPS) airborne-pseudolite initiative, which demonstrated the ability to mitigate hostile jamming of GPS receivers while providing them the means to continue to navigate without primary satellite reception.[1]

The battlelab also accomplished its combat-identification initiative, which addressed concerns of fratricide and the ability of the war fighter to identify friendly players and locations. The UAV's situational-awareness data link tied the receivers to a network that included connectivity to properly equipped ground forces; thus, pilots of F-16 aircraft could receive information about the location

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of friendly troops, which aided them in making attack decisions.

Another initiative known as Spotter showed the military worth of integrating an infrared pointer into a UAV to illuminate targets at night for attack aircraft that employ night-vision goggles. A resounding success, Spotter defined a requirement for an infrared zoom laser illuminator / designator on future Predator UAVs.

Weather UAV, an ongoing initiative that gives UAVs the ability to perform periodic, automated pilot-report weather reporting, addresses a requirement of the Office of the Secretary of Defense's *Unmanned Aerial Vehicle Roadmap, 2000–2025:* "The reporting of basic meteorological conditions can and should be made an integral part of all future sensor systems acquired for UAVs."[2] The initiative allows for the gathering of weather information in denied and data-sparse areas, enhancing the ability to make informed attack decisions. The sensor on board the Predator UAV reports back via satellite communications and inserts the data into the Nonclassified Internet Protocol Router Network (NIPRNET), which allows access by meteorological and oceanographic centers, air operations centers (AOC), and operational squadrons. This vital information can help determine required sensors for planned attacks, orbit locations for tankers, release ranges, and so forth.

The UAV to Fighter Imagery Relay (UFIR) initiative demonstrated the military utility of using UAVs as communications relays to transfer imagery tasking from an AOC directly to aircraft cockpits and then relay battle-damage-assessment imagery back to the AOC. The Air Force conducted UFIR in conjunction with the United Kingdom's Extendor Operational Concepts Demonstration, an effort to provide "bent-pipe" relay to and from ground forward air controllers (FAC) via UHF or VHF radio.[3] The technology utilized in this initiative can provide a common imagery capability in all tactical platforms, including the F-16, F-15E, and B-1B, as well as Army, Navy, and coalition assets.

Finally, the UAVB has embarked upon a robust initiative called Forward Air Control UAV, a large-scale plan to mount a communications suite composed of FM-UHF-VHF-capable radios, the situational-awareness data link, an imagery-transfer module, and a beacon locater on UAVs for the purpose of augmenting tactical air control parties and airborne FACs. This will allow UAVs to perform three major areas of the FAC mission—air interdiction, close air support, and combat search and rescue—as well as perform target tracking, marking, and / or illumination of designated targets of interest.

Future areas of concentration at the UAVB include suppression of enemy air defenses (SEAD) and detection of tactical missile launches. The battlelab also has developed the "electronic-warfare picket," which entails using UAVs for SEAD "umbrella coverage" by utilizing their payloads, transferring information to larger aircraft or processing centers, or launching expendables from UAVs or other platforms.

Cobra Hawk, currently on the drawing board, will allow UAVs to relay basic information about enemy launch-site positions after a missile launch. The UAVB is also collaborating with the Air Expeditionary Force Battlelab on an initiative that will allow detection and characterization of battlefield lasers. Other planned efforts focus on the cutting edge of the unmanned combat air vehicle, involving advanced technology demonstration led by the Defense Advanced Research Projects Agency. All of these initiatives show that the UAVB seeks opportunities to provide risk mitigation with respect to command and control and concepts of operation, while continuing to bring innovation and technology to the war fighter. □

Notes

1. A pseudolite (PL) is a small satellite transceiver that transmits information to enable a GPS receiver to continue to navigate when standard GPS satellite signals are not available. A PL can be either airborne (APL) or ground based (GPL). In essence, it is a lightweight satellite that can be used in the lower atmosphere or on the ground.

2. *Unmanned Aerial Vehicle Roadmap, 2000–2025* (Washington, D.C.: Office of the Secretary of Defense, April 2001), 23, par. 4.2.

3. Bent-pipe communications entail configuring two radios on a platform "back-to-back" on frequencies A and B, respectively. In this configuration, a transmitter (e.g., a ground station) can broadcast on frequency A, have the transmission go through the relay, and talk to a receiver on frequency B (e.g., a fighter or FAC).

APJ Vortices

There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things.

—Niccolò Machiavelli

Future Employment of Unmanned Aerial Vehicles

1st Lt Jeff Mustin, USAF*

If a man's trust is in a robot that will go around the earth of its own volition and utterly destroy even the largest cities on impact, he is still pitiably vulnerable to the enemy who appears on his doorstep, equipped and willing to cut his throat with a penknife, or beat him to death with a cobblestone. It is well to remember two things: no weapon is absolute, and the second of even greater import—no weapon, whose potential is once recognized as of any degree of value, ever becomes obsolete.

—J. M. Cameron

Unmanned systems are the future of aerospace.

—Jerry Daniels, the Boeing Company

WHEN THE JOINT Strike Fighter Program announced its winner, I vividly recall hearing the evening news anchor extol the virtues of the F-35 and then comment that, due to the success of unmanned aerial vehicles (UAV), that fighter may well be the last manned aircraft produced for the US military. About two weeks later, Boeing's Jerry Daniels reaffirmed that statement (see above). Indeed, the press, public, policy makers, and war fighters have all witnessed the maturation of UAV and unmanned combat aerial vehicle (UCAV) technology. Although UAVs have been in operation for decades,

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their ability to provide real-time intelligence, surveillance, and reconnaissance (ISR) built momentum in Operation Desert Storm and gained additional clout throughout numerous missions in Operations Allied Force and Enduring Freedom. Little doubt exists that UAVs employ a continually maturing technology that demonstrates its usefulness on the battlefield. However, will UAVs really make manned fighter aircraft obsolete? What role will they play in future combat, given their limitations and unique capabilities? The Air Force needs to answer these questions as it looks to the next generation of warfare. Before we consider the actual capabilities of manned versus unmanned aircraft, we should examine the relationship between technology and combat in order to define the former's effects on UAV employment.

> *The United States has a strategy based on arithmetic. They question the computers, add and subtract, extract square roots, and then go into action. But arithmetical strategy doesn't work here. If it did, they would already have exterminated us with their airplanes.*
>
> —Gen Vo Nguyen Giap

During Desert Storm, Cable News Network painted a picture that revolutionized combat, etching images in the public's mind of smart weapons slicing through chimneys and Maverick missiles guiding their way through the night to kill tanks. The technological revolution showcased in Desert Storm has done anything but slow down. The past decade has seen substantial increases in many technologies, from satellite-guided assets such as the Joint Direct Attack Munition (JDAM) and Joint Standoff Weapon to integrated Inertial Navigation System/Global Positioning System (GPS) layouts in aircraft navigation. Without question, the relationship between technology and warfare is a fluid mixture, certain to stir up some debate. As history shows us, however, the only sure factor is that the progression of war-fighting technology always leads to effective and/or economical countertechnologies or tactics. This cycle has occurred throughout the history of warfare.

Take the knight of the Middle Ages, for instance. Highly trained and paid, he was a lone ranger, noted both for his armor and weapons. Becoming a knight required years of apprenticeship and training, and the price was heavy (not unlike modern-day pilots). But the invention of the crossbow changed everything. With one small arrow, a common farmer could topple a mighty knight with impunity. This innovation was considered so disgraceful that the Church of England attempted to outlaw the crossbow, and in 1139 Pope Innocent II declared it "hateful to God and unfit for Christians."[1] The mighty knight, with all his training and bravado, now faced a lethal threat from relatively untrained peasants armed with a weapon that effectively and inexpensively countered his training and costly materials. One can easily substitute the F-15 for the knight and the antiquated MiG-21 for the farmer, and then arm the MiG-21 with a helmet-mounted cueing system that allows the pilot to target the AA-11 at high off-boresight angles. Any fighter pilot knows what kind of problem at the merge that would represent. Like the knight, the fighter pilot is susceptible to an effective, inexpensive threat. Such is the cycle of technology in combat.

Radar constitutes another example of this technology cycle. Developed by scientists during World War II to detect approaching airplanes, radar proved its worth in the Battle of Britain. Early warning of approaching airplanes allowed beleaguered British Spitfire and Hurricane pilots to save gas by knowing exactly when and where to expect the attack. When the fight was upon them, they could focus their planes and concentrate firepower, giving them a huge advantage over their Luftwaffe counterparts.[2]

Now the primary method of detecting aircraft, radar for years has inspired planners to contrive techniques to defeat it. On the one hand, in the decades since its inception, many electronic countermeasures (ECM) systems were developed to avoid radar detection, including chaff, various forms of jamming, bin masking, terrain-bounce counterradar, and radar decoys.[3] On the other hand, electronic counter countermeasures (ECCM) such as detection and angle tracking; passive ranging; reduction of ground clutter and sidelobe interference; beam forming; and broadband, multifrequency operation were then invented and refined to reestablish the dominance of radar as the primary means of detection.[4]

The United States raised the stakes and established a benchmark in deception when it fielded the F-117, but even that aircraft is not invincible or invisible to radar. In fact, many radars operating on varied frequencies are rumored to have shown better success at picking up stealthy aircraft,[5] as are other technologies in development. The Russians have admitted that they tested the wreckage of an F-117 lost over Yugoslavia to strengthen their air defense network against stealth aircraft, with varying degrees of success.[6] Whether or not the F-117 is survivable in five years misses the point. Instead, the lesson learned is the inevitable downfall of technology in combat. The technological benchmark in warfare consistently resets, and there has yet to be a technology that cannot be countered.

> *Some revolutions have a short shelf life. What seems unique at the time tends to become the norm.*
>
> —Brig Gen David Deptula

The late Col John Boyd established a hierarchy of people first, followed by ideas, and then technology—invariably in that order.[7] This overarching concept, essentially a synthesis of the aforementioned historical lessons of combat and comprehension of thought, can apply in many arenas but perhaps in military circles most of all. Humans developed technology to serve human functions. Essentially, it is a slave to that hierarchy. In a linear capacity, technology has shown some success at reasoning capability in applications such as chess. Chess, however, is linear, two-dimensional reasoning; warfare is not. As Murphy's Laws of Combat proclaim, "Professional soldiers are predictable, but the world is full of amateurs," a humorous way of identifying war as nonlinear thought. Nonlinear reasoning in a fluid, dynamic environment is solely the domain of the human mind. As such, technology remains secondary to the human capacity to reason and is vulnerable to the same reasoning principles.

This next lesson learned, then, is not that technology is useless in combat or life—far from it. Technology has uses, but, unlike the human mind, they are specific in purpose. Technology supports warfare—it does not wage warfare. Using Boyd's hierarchy, humans conduct warfare by applying nonlinear reasoning to establish political will; develop tactics, techniques, and procedures; and manipulate technological innovation to assist in the implementation of those ideas and see them to fruition. As such, the human mind—not the computer chip—truly wages war.

One sees this in the realm of asymmetric warfare. Again, thanks to Colonel Boyd, one can define asymmetric warfare as the violent placement of strength upon weakness, as opposed to symmetric warfare, in which strength battles strength.[8] Asymmetric warfare comes in many shapes and sizes, from terrorists to guerrilla warriors to special operations teams. Its consistent virtue is the sudden and unexpected application of power that results from a combination of stealthy surprise and massing of forces almost instantaneously against an enemy. One must note that this stealth need not take the shape of radar-evading aircraft only. Instead, deception of any sort constitutes a true stealthy attack.

Asymmetric warfare is nonlinear by nature. As such, it allows smaller forces to fight effectively against larger, more cumbersome opponents by massing firepower rapidly to strike at weaknesses. This use of massive force at a single point of vulnerability represents the strength-upon-weakness principle that makes asymmetric warfare successful. Such warfare hinges upon accurate intelligence, fluid maneuver in the battle space, and surprise. It allows smaller forces to combat their enemies effectively and can also constitute the ability to fight inexpensively. The attack on the USS *Cole* demonstrated the ability to cripple a billion-dollar US Navy ship with an inflatable boat filled with explosives. Another example might include a theoretical infection of refugees with a strange virus in an attempt to harm an enemy military. Interestingly, the astute student of asymmetric war would do well do study the criminal behavior of organized crime and bank robbers. Aside from the ethical discussion of legality, they present excellent case studies in the disproportionate use of sudden force to achieve a specific result.

> *I am advising a man on how best to employ light infantry and horse cavalry in the attack against Taliban T-55 (tanks), mortars,*

> *artillery, personnel carriers and machine guns—a tactic which I think became outdated with the invention of the Gatling Gun.*
>
> —Declassified Commando Report,
> Operation Enduring Freedom

Such disproportional use of force means that enemies with inferior technology but keen intellect can create and sustain a synergistic effect powerful enough to combat a superpower such as the United States. They do so by attacking our troops and inflicting casualties; hence, they try to win the mental battle by testing our political will, a potential American weakness, while avoiding economic or technological confrontations, which, historically, are American strengths. Asymmetric warfare attempts to negate our technological advantage. As Dr. Linda Beckerman explains,

> When the form of warfare employed by both sides is linear, then Technical Superiority gives a decided edge. It raises the value of the constant k in the basic equation for linearity $Y = kX + b$. Thus in the Battle of Crecy, the long bow gave the British a decided advantage, despite being vastly outnumbered by the French. Technical superiority as a way of obtaining decisive advantage in linear warfare works fine so long as the other side is also employing linear warfare. Fortunately, Saddam Hussein was using linear warfare in Desert Storm, so our linear efforts paid off. However, he has since learned his lesson and has become decidedly non-linear, and the effectiveness of our efforts has dropped.[9]

The bottom line is that a technological advantage does not preclude asymmetric warfare and, in fact, if conflict is inevitable, probably invites it due to the lack of linear options for potential foes. Theoretically, a pure form of asymmetric war could offer victory by superior cunning or "winning hearts and minds" without achieving a single victory on the traditional field of battle. Again, our analogy of bank robbers comes into play—many robberies occur and achieve the desired result without any application of force. By inducing fear and coercing submission, the mere threat of force wins the mental battle and, therefore, the war.

This does not insinuate that symmetric or more traditional forms of warfare are gone forever. We must still take large, conventional threats seriously. Asymmetric war shows us yet again that our people and ideas—not technology—create true war-fighting capabilities. Technology, then, serves to support those ideas that can be construed as a strength or weakness—or, in many cases, both a strength and a weakness simultaneously—that both combatants can leverage. The combatant who manipulates these ideas more rapidly, operating inside the opponent's observe-orient-decide-act (OODA) loop, as conceived by Colonel Boyd, will prove more successful.[10] The capacity to process data and rapidly make decisions is the foundation of the ability to fight. Technology is only as powerful as the human-derived political will behind it and only as lethal as the tactics with which one employs it and the skill that implements it. The human mind is the true war-fighting power.

UAV advocates quickly point out that because the UAV has a human in the loop, it retains the lethal edge. True, UAVs such as Predator retain human-in-the-loop principles, which enhance their tactical capacity to function in a dynamic environment. A significant difference exists between having a human in the loop and one in the cockpit, however. The primary difference lies in the ability to relay information to the human for processing. UAVs simply do not have the capacity to absorb, process, and relay the same amount of data as a pilot in the cockpit, who can maintain 360-degree situational awareness (SA) with his or her radar, wingman, and eyesight.

Pilot training represents one of the best examples of what might seem a semantic difference. When first teaching students to fly using instruments only, the Air Force deprives them of the ability to see anything else. They can still read the altimeter and airspeed, and they still have navigation aids available to them. In fact, they have all the same tools available to sustain flight and SA except their eyesight to process data from the outside world. Invariably, students suffer from a lack of positional awareness. They are cognizant of altitude and airspeed, but their general concept of position is that they are in a cloud—and that's about all they know. To return vision to them, even for a moment, restores their SA. The reason for this is simple: when flying instruments, students look through the proverbial "soda straw," flying with a limited field of view. Restoring vision serves to broaden their scope, and students thus regain their ability to maintain awareness. With training, one can overcome this, but pilots—more specifically, fighter pilots—always have better SA when they use their vision to maintain a broad field of view concerning the circumstances of their airplane.

UAVs simply do not provide a field of view broad enough to execute some combat missions. The Predator's sensors, for example, are optimized with a 45-degree or greater look-angle and minimum slant range, placing the UAV within three nautical miles of the target.[11] Much like a cockpit pilot flying with an instrument hood, the external pilot of the UAV understands the aircraft's attitude and altitude and can gain some awareness through sensors. He or she can take pictures, view thermal images, and can even view simulated images of the flight path. Even with this capability, the vision out of the sensor suite is limited and narrow. The external pilot lacks the overarching awareness provided by 20/20 vision—not to mention a cranium on a swivel beneath a bubble canopy.

This does not preclude UAVs from having roles; nor does it suggest that UCAVs should not carry weapons. Instead, one should note that they are support assets, limited in function because of their inability to absorb data and reason. Used within those limits, they can be very successful. The Air Force should use UAVs and UCAVs because their unique capabilities blend well with its missions. UAV loiter time, for example, can far exceed that of piloted aircraft. On the one hand, in the eyes of policy makers, the risk to a cockpit pilot (i.e., of becoming a casualty or prisoner of war) detracts from manned operations. On the other hand, we have shown that in certain situations a pilot in the cockpit has the edge because of his or her superior ability to reason, maintain SA, and subsequently take the fight to the enemy. The line between combat effectiveness and risk to the shooter is often as fine—and controversial—as the one between warriors and policy makers themselves. We seek to answer the questions about cost-benefit analysis that define this doctrinal compromise. To do so, we must first identify those strengths and weaknesses inherent to this piece of technology so that we can leverage their capability to a greater degree.

> *I think there's no doubt UAVs have come of age. The Predator UAV we have deployed around the world has done superb work for us. We see UAVs like Global Hawk that have stayed airborne for long periods of time. I think these will eventually replace manned reconnaissance aircraft. We will eventually have a conventional bomb-dropping capability also. This will come with time. Certainly nothing is technologically impossible, but we will see over time the utility of replacing all the aircraft. It's hard to replace the gray matter that is inherent in every human being. There's no computer that can do it quite that well yet.*
>
> —Gen John P. Jumper

> *The complementary nature of unattended vehicles with manned systems is something we have become more and more comfortable with.*
>
> —Secretary of the Air Force James G. Roche

UAVs have established roles as effective ISR assets. From the days of Buffalo Hunter in Vietnam to Enduring Freedom in Afghanistan, the maturation of the UAV as a signals intelligence (SIGINT), imagery, battle damage assessment (BDA), and data-relay platform has been impressive. As the tempo of conflicts has increased, the capacity to loiter over extended periods has helped sustain fluid operations by providing more of the real-time intelligence necessary to make accurate decisions in dynamic environments. The inherent plausible deniability of an unmanned vehicle provides great promise for strategic reconnaissance as Global Hawk begins to take flight. The necessity of real-time BDA for Army artillery is far too hazardous for manned assets but perfect for UAVs. The adventuresome undertaking of collecting SIGINT on surface-to-air missile (SAM) sites is also well suited for unmanned assets.

Whether UAVs will inherit all battlefield surveillance and reconnaissance remains to be seen. The Predator UAV, optimized as a

medium-altitude, fair-weather asset, has received criticism in the past for problems with its anti-icing capability and lack of communication, but one can attribute some of these concerns to the growing pains of a maturing system. However, it does not perform low-altitude reconnaissance well. The United States has lost 20 Predators, many of which were forced into enemy threat envelopes by poor weather or the desire to take a closer look.[12] Obviously, it presents a visual target during the day. At night, visual detection is limited, but radar and noise signature are still available. Additionally, UAVs are not the swiftest assets in the battle space. At maximum operational airspeed, a Predator takes 30 minutes to travel 50 nautical miles—an obscene figure that creates a serious liability when one tries to retask missions or get electrons on mobile targets.[13] Future variants might have a better top speed, but higher speeds usually create aerodynamic penalties for loiter time, one of the UAV's biggest assets. To an extent, higher speeds can also make aircraft more visible to radar and susceptible to threats.

Perhaps the UAV's most significant weakness in surveillance issues is, again, the lack of overarching awareness. A human in the cockpit (a very quiet cockpit) can provide a broad field of view in which to direct narrow sensors. Although high-altitude UAVs can do this, they cannot always extract the detail required by the intelligence community. Low-altitude, noise-sensitive manned assets have a better chance of obtaining this data in detail, especially at night. UAVs lack the overarching SA to look at the battle space and understand where they should focus their sensors. This is acceptable for performing specific surveillance of fixed targets, but moving targets could prove elusive. Higher-flying assets could direct UAV sensors to help alleviate this problem, but simply providing a human in the cockpit enhances the broad field of view and bypasses the need for data link. This presents numerous risks to manned assets, but the intelligence community will simply have to weigh the manned risk against the desired collection capability. As such, it is unlikely that unmanned assets, despite their success, will completely encompass all ISR functions in the next decades.

> *Obviously we don't plan to stem armored attacks with a few Predators with Hellfires on them, but for those fleeting, perishable targets that present themselves as they did in Kosovo, this is a great opportunity to close the loop [and reduce the time] between tracking, targeting, and engaging [mobile targets].*
>
> —Gen John P. Jumper

This brings us to the UCAV, which takes the UAV concept, with its inherent ISR capability, and adds weapons. How the weapons will be employed in the future remains to be seen. We do know, however, that we need to give UAVs in strike roles specific targeting jobs because of their aforementioned reliance and limited capacity to absorb and reason rapidly in the battle space.

The UCAV's ability to collect data and perform limited strike functions is an old military concept with a new wrinkle. If we truly leverage UCAVs to fulfill their potential, we can liken them to airborne snipers. Using a set of eyes to look through a rifle scope and provide BDA, intelligence, and a "specific lethality" (to borrow a term from James Webb's speech to the Naval Institute) on a tactical level has been a part of military operations for decades, if not longer.[14] A UCAV's ability to provide a limited, focused "God's-eye view" removes the risk to the shooter and provides a lethal, clandestine capability for accurate, if not precise, strike capability. It is also an excellent platform for lazing weapons and performing instantaneous BDA in this "elevated sniper" capacity. By providing real-time imagery, it allows a remote user to identify potential targets and, if warranted, eliminate the target. Interestingly, surveillance and target identification do not always lead to killing the target because doing so compromises the capability for intelligence collection. Much like a sniper, however, a UCAV can maintain surveillance until someone decides to attack.

Exploiting UCAVs in precision-strike roles does not mean that tactical aircraft no longer need to drop iron on targets. A Predator UAV is not going to roll down the chute on a column of tanks; nor can it rapidly react to close with and strike mobile targets. A UCAV or its operator would have extreme trouble with receiving or issuing a nine-line text message or with constructing a talk-on close air support (CAS) strike in close quarters while maneuvering in a high-threat environment from a remote site with limited view. Data link is available, but even a low probability of intercept signals could compromise positions and become susceptible to jamming or deception. This problem is exacerbated when common tactical issues such as communication and data-link jamming are factored into the equation. GPS coordinates and weapons are coming of age, but coordinates become difficult to use when targets decide to move. Furthermore, GPS munitions are accurate, not precise—an important distinction. They are not the munitions of choice for "no collateral damage" targets. The United States is attempting to alleviate this problem through enhanced precision guidance, but this capability remains to be fielded, and GPS jamming could render such additions merely theoretical. Using UCAVs against fixed targets or as airborne snipers has vast potential.

One fact worth noting about UAVs is that all of the military services are using them. Although most services have always had some ability to perform autonomous tactical reconnaissance, the addition of missiles on the wings could theoretically cross some time-honored boundaries. Interservice parochialism has long held that the Air Force would use fixed-wing, forward-firing assets; the Army would maintain rotary-wing, forward-firing airframes; and Special Operations Command would utilize propeller-driven CAS support and rotary-wing assets with no forward-firing capability. The Hellfire missile currently employed by the Predator is the property of the US Army, which has long worked with snipers in the field. The fact that all services now operate UAVs could open the floodgates for operating UCAVs as well. Thus, the Army might decide to conduct autonomous CAS, which would threaten the Air Force's control over the mission. Although a UCAV would never prove as effective as an A-10, the Army might consider a 70 percent solution "good enough," especially considering the autonomy and reduced interaction. Imagine a Predator platoon deploying with a Ranger battalion and the ways of implementing those forces.

Much has been made of UCAVs performing suppression of enemy air defenses (SEAD) functions. Although UCAVs could prove useful in collecting SIGINT for distribution to the shooters and their battlefield-surveillance capability could help identify mobile sites for targeting or real-time threat updates, actually integrating UCAVs into "weasel" missions might be tricky. There is a very credible upside. The prospect of removing the potential for casualties or prisoners of war created by the dangerous, high-risk mission of offensive SEAD appeals to policy makers and removes a great deal of stress from commanders. Obviously, not too many suicidal fighter pilots exist either, but, again, dealing with SAMs is not a linear matter. UCAVs could definitely be used to attack fixed SAM sites with conventional weapons; at the same time, a JDAM could perform this function from a great distance with little-to-no threat to the pilots. The question of whether a UCAV could survive in such a serious threat environment is worth additional analysis and evaluation.

The fact that one can optically guide and use visual commands to project various SAMs into their terminal phase circumvents the more traditional radar warning receiver (RWR) spike and most forms of electronic warning. Although in theory we could detect the infrared launch plume, multiple launches typically associated with SAM traps and multiple electronic warnings might still make visual, "stealthy" launches lethal. The capacity to process the deception and data launched at the airplane from all aspects, possibly using different guidance systems, is beyond the capability of technological reasoning. Therefore, UAVs with limited scope and awareness would find it difficult to survive in this arena.

A UAV's survival might seem trivial since it is unmanned, but the Predator's price tag of $3.2 million per unit makes it attritional, not expendable.[15] Although far less expensive than a manned asset, it is less capable. As such, we could theoretically utilize UCAVs against high-risk targets, with an important caveat. If they are successful, then the employment was justified, but we must understand that, against an even slightly robust integrated air defense network, UCAVs might not survive and thus fail to eliminate lethal targets. If the latter occurs, we must have both the political will and the tactical capability to use manned assets against those targets.

> *One of the most significant military lessons of the Vietnam War was that control of the air over an enemy's homeland must be wrested from him by men specifically trained for that purpose. On the face of it, that would sound like a redundant statement. After all, hasn't the same lesson been learned from all the previous wars of the twentieth century? Of course it has, but recent technological preoccupations somehow seem to have blinded us to the importance of the man in the cockpit, and to the fact that air-to-air combat boils down to the man and his tactics against the other man and his tactics.*
>
> —Lou Drendal, *And Kill MiGs*

In the words of one fighter pilot, trying to fly air-to-air combat in a UAV would be "like having a knife fight in a phone booth looking through a toilet-paper tube. You can try and flail all you want, but eventually you are going to die." Air-to-air combat, more than any other type of aerial engagement, will long remain the domain of the fighter pilot. Simply put, all the targets are mobile, and SA is hard enough to maintain using a 360-degree field of view within the cockpit. Undoubtedly, a UAV would bring greater G limits and maneuverability to a dogfight, but that is what missiles are for. The fighter aircraft employs the missile based upon the broad SA of the pilot and his or her refined SA via onboard sensors, a capability with which UAVs will struggle. Many proponents would argue that turning aerial combat is a thing of the past, but this argument has existed for 50 years. Current missile technology has improved, and beyond visual range (BVR) combat is tactically preferable to a confrontation at the merge. However, rules of engagement do not always allow BVR shots, preferring a more conservative visual identification, and missiles, like all forms of technology, can go "stupid" and fail. The need still exists for manned aircraft to turn and fight with other aircraft.

Nevertheless, UAVs might serve some function in aerial combat. Simply put, their ability to loiter makes them excellent sensor platforms for SIGINT issues. Giving them air-to-air radar capability would allow tactics of remote-radar data link or missile launches beyond visual range, which could be guided by the UAV's radar beam. This type of deception increases potency through the masking of our own force composition. Other tactical uses, such as "seeing eye" long-range visual identification or support of combat air patrols, both domestically and abroad, could enhance the fighter pilot's SA while increasing the life span of manned assets. Although UAVs will never fully inherit the air-to-air role, they can provide useful assistance in the accomplishment of that mission.

UAV technology is maturing rapidly, and, as with most new weapon systems, it will continue to progress as funding allows. Comparing the evolution of UAVs to that of airplanes can be instructive. Initially, airplanes

were attached to the Army, which did not know how to leverage their capabilities effectively, so it limited them to scout and patrol roles. Eventually, some creative pilots fired guns and threw grenades from the cockpit, thus giving birth to the fighter aircraft. Like those early aircraft, UAVs are a new technology which current doctrine is attempting to refine as that technology comes of age.

> *We also need to keep in mind that we cannot defeat the determination of terrorists to die for their country with unmanned attack systems, because we will never win the psychological superiority necessary to defeat the leaders of such efforts.*
>
> —Maj Gen William Nash, USA, Retired

Leveraging UCAV capability will be essential to future combat. History has shown us that technology has inherent weaknesses, such as the capacity to function in asymmetric, nonlinear environments. Consequently, we must be careful about placing too much faith in unmanned vehicles. For specific missions and purposes, they show great promise. Using them as ISR platforms and airborne snipers would maximize their strengths and provide excellent integration with manned assets. The notion that UCAVs could replace humans in warfare echoes of something out of a science-fiction novel. I think back to the time when a general told me that the movie *Star Wars* taught us three lessons: there will always be fighter pilots, there will always be fighter-pilot bars, and the dive toss never works. He was right. □

Laughlin AFB, Texas

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What's So Special about Special Operations?

Lessons from the War in Afghanistan

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WATCHING THE WAR in Afghanistan and listening to speculation about future US moves, one hears a lot of discussion about US special operations forces (SOF). The consensus seems to be that these forces are tailor-made for the unconventional nature and uncertainty of this war. Every war is unique, but if the uncertainty and chaos of the current war are characteristic of future conflicts, it is important to consider potential lessons from SOF's success. Lessons learned by SOF over the last two decades and demonstrated in Afghanistan provide some signposts for future conventional forces and the ongoing transformation of the US military.

Lesson One

You don't know what you need until you need it. A wide range of capabilities in effective quantities is a good hedge against tomorrow's threat.

Predicting the future is an enterprise with a very poor record unless predictions are so broad as to be useless for setting priorities. The takedown of Manuel Noriega in Panama did not look like any mission the United States had prepared for during the 1980s. Combat in Somalia, the Balkans, and now Afghanistan has differed from the set-piece armored battle Saddam Hussein presented to the coalition in Kuwait and Iraq. Yet, for the most part, the US military force built for the NATO / Warsaw Pact and Korean theaters has provided the right conventional and specialized forces, in sufficient numbers, to fight these conflicts. In each one, SOF provided the commander a critical edge by supplying a variety of niche capabilities and the ability to develop new capabilities rapidly. In the large, conventional conflict of the Gulf War, SOF capabilities proved strategically crucial, though not tactically decisive. SOF's biggest contribution may have been preventing Israel from attacking Iraq in reaction to the latter's Scud missile attacks against Israel. Offensive Israeli involvement in the war could have fractured the coalition, but this alliance demonstrated its resolve to defend Israel and defeat the Scud threat by deploying recognized, elite

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forces and allocating hundreds of sorties to hunt Scud launchers aggressively. Although the number of Scuds killed may be in dispute, the result is not. Israel remained on the sidelines, and the coalition held.

In Afghanistan, SOF began by waging an unconventional warfare (UW) campaign—a mission that has remained low on US Special Operations Command's (USSOCOM) priority list for the last decade.[1] The utility of UW as part of the national strategy seemed low, and threat scenarios requiring these skills seemed unlikely. Yet, the skill sets needed to wage UW—from the Army, Navy, and Air Force—have fitted the conditions in Afghanistan.

Lesson Two

Network-distributed may be more effective than network-centric warfare. The best way to speed up the observe, orient, decide, act (OODA) loop is to shorten it by getting it into the field.

Much of the work in transforming future US military capability focuses on command and control—getting more and better information to the commander so he or she can see and direct the battle. Although this is important, it is also very challenging if the concept requires collecting and passing information to headquarters, analyzing it, and then passing direction back to the battle. John Boyd's description of the OODA loop in command and control makes this point. Both human action and the mechanical passing of information consume critical time in the cycle. Centralizing control of the battle means that these actions are multiplied at each echelon of command. Field observation and orientation are passed to higher levels of decision making, where another cycle takes place until they reach the command authority. Decisions and actions then repeat at each level in return until they arrive at the battlefield.

One must synchronize and centrally direct a battle against large, conventional forces—those that mass and move relatively slowly. A battle against small, independent, and mobile formations may change too rapidly to allow centralized control in detail. The lesson from Afghanistan is that, with clear mission orders and appropriate technology, each tactical element can become a command, control, and *execution* node, greatly shortening the OODA loop while still allowing the passing of information on tactical actions and results to higher levels for operational and strategic analysis.

SOF personnel have proven uniquely suited for this networked, distributed warfare. Special forces (SF) teams with embedded Air Force air-control elements provide a tactical force with a broad range of skills and the maturity to execute mission orders without detailed oversight. They can move, shoot, and communicate while employing supporting fires from any source—land, sea, or airpower from US or coalition forces. SOF teams can do this because they are interoperable.

Lesson Three

Interoperability comes by interoperating regularly, routinely, and often. No royal road exists.

Forging an interoperable force is a big job. Interoperability in equipment requirements and design is only a start. Real interoperability requires constant testing and training not only to work out equipment problems, but also—and more importantly—to work out the human problems of command, control, and communications as well as unit tactics.

USSOCOM and its predecessors have spent the last 20 years forging a joint team with interoperable service components. SOF personnel jointly conduct virtually all training above the individual skill level. This training program is tough, extensive, and expensive, but it has succeeded in forging a truly interoperable team. SOF communications link SOF service components—and extend to parent service forces as a result. SOF personnel conduct operations with elements from all services directly integrated in tactical formations—from SF or SEAL teams with integral Air Force air-control elements to tactical helicopter formations combining Army and Air Force aircraft.

This makes SOF ideal for the kind of chaotic and diffuse warfare that probably awaits us in the future. Fighting this kind of war requires coordinated, dispersed teams—not traditional massed forces. In this kind of war, a defined battlefront or safe rear area may not exist.

However, the most probable conflict is not the only type of conflict—and may not represent the most significant threat to the nation. Organized, heavy enemy forces remain a threat in some theaters, and heavy, combined-arms air and surface assets may still be the force of choice for fighting them. The challenge of these conflicts lies in adapting the fundamental lessons learned from Afghanistan to local conditions.

Lesson Four

Existing forces are nothing more than tools to provide the commander with combat capability. This capability and the ability to employ it are what matters—not the specific tool.

The war in Afghanistan has seen Army, Navy, and Air Force helicopters, fighters, and long-range bombers providing interdiction and close air support to US, allied, and associated forces fighting from foot, horseback, high-mobility multipurpose wheeled vehicles (HMMWV), or light armored vehicles (LAV). The joint special operations team has been the key to linking these forces into an effective, interoperable tool to achieve the joint force commander's objectives. But *interoperable* does not mean *identical*. Each of these disparate forces brings particular capabilities as well as definite strengths and weaknesses to the fight.

The Air Force's long-range bombers provide large weapons loads, precision, and endurance. Navy fighters provide forward forces in-theater, precision, and reconnaissance. AC-130 gunships provide endurance; immediate, direct fire support; and real-time overwatch of operations. Army and Marine conventional forces provide quick-reaction firepower and the ability to secure ground. The only important criterion for the joint force commander and troops on the ground is their ability to use these capabilities effectively.

Lesson Five

The "tooth to tail" ratio may no longer be a relevant measure of merit because it draws an artificial distinction between integral elements of US combat power.

If the only "teeth" in Afghanistan were the few hundred SOF personnel and aviators who initially engaged the Taliban and al Qaeda, then the tooth-to-tail ratio was minuscule. Tens of thousands of US personnel flew reconnaissance, ran ships, moved logistics, processed intelligence, and moved information to support those few hundred troops at the sharp end. However, precisely because of that intricate and massive support structure, the few hundred troops on the ground were able to topple the Taliban regime in a few months with almost no US casualties. That same support structure allowed the US military to reach halfway around the world; commence combat operations in an unexpected, austere theater within weeks; and succeed on an extremely chaotic battlefield.

The only relevant measure of merit is the effectiveness of the entire US force structure. Is there enough "tail" to support full use of US teeth? Is the United States building enough of the "enablers" (tankers; airlifters; airborne warning and control system [AWACS] aircraft; joint surveillance, target attack radar system [JSTARS] aircraft; unmanned aerial vehicles [UAV]; communications bandwidth; information analysis capabilities; etc.) to allow effective employment of the latest generation of "shooters"? Does the force provide a complete capability worth the cost in people and materiel?

Lesson Six

Human beings are more important than hardware.

The war in Afghanistan and the larger global war against terrorism are wars of people. The key to defeating the Taliban and al Qaeda lies in coordinating and supporting the Afghan opposition forces in their fight for their country. The language skills, cultural orientation, maturity, and adaptability of SOF enabled the joint force commander to effectively co-opt Afghan anti-Taliban forces and incorporate them into his campaign. Their success is a result of human action and initiative in employing an extremely wide range of hardware—from horse cavalry to joint direct attack munitions (JDAM)—to conduct the campaign.

Fundamentally, the global war against terrorism—indeed, any war—is about individuals. The war on terrorism features few traditional military targets, such as large military formations or key national infrastructure. The first step in conducting this war is to determine *who* the enemies are (either an individual or a group of individuals) and *what* we want them to do—or not do. The second step is to determine *how* we can get them to do our will (e.g., co-opt, persuade, coerce, or kill them). The United States will need a range of tools—political, military, economic, legal, and informational—to exploit these individuals' vulnerabilities and achieve national objectives.

The final lesson from the war in Afghanistan may be that the revolution in military affairs has already happened.

Like most revolutions, this one went from the bottom up—not from the top down. While the generals debated how to mandate a revolution, the captains and majors quietly implemented one. Despite a decade of downsizing, parts of the US military have learned to exploit networked information and precision weapons to conduct real-time, coordinated, and precision joint/combined operations against an enemy dispersed over complex terrain in a chaotic theater on the other side of the world. Troops have learned to use a networked, distributed force of coordinated but independent joint combat elements with a wide range of capabilities. They have demonstrated that command, control, communications, computers, intelligence, surveillance, and reconnaissance (C^4ISR) can be fused and focused directly on a small, effective formation at the tip of the spear, allowing US forces to apply the right tool at the right time in the right place. Ultimately, this capability will prove itself more important than raw firepower. □

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Note

1. "[Unconventional warfare encompasses] a broad spectrum of military and paramilitary operations, normally of long duration, predominantly conducted by indigenous or surrogate forces who are organized, trained, equipped, supported, and directed in varying degrees by an external source. It includes guerrilla warfare and other direct offensive, low visibility, covert, or clandestine operations, as well as the indirect activities of subversion, sabotage, intelligence activities, and evasion and escape. Also called UW." Joint Publication 3-05.5, *Joint Special Operations Targeting and Mission Planning Procedures*, 10 August 1993, GL-13, on-line, Internet, 5 March 2002, available from http://www.dtic.mil/doctrine/jel/new_pubs/jp3_05_5.pdf.

Ricochets and Replies
Continued from page 7

essence of chaos/complexity. Such dynamics are not bulletizable or reducible either to checklists or the "KISS" principle. As with turbulence in aerodynamics, hydrodynamics, air conditioning, and meteorology, the challenge lies in trying to discern patterns amid apparent pandemonium and to frame equations, coefficients, and/or algorithms that describe ranges of phenomena. The alternative is to develop a broad sensitivity to the irreducible turmoil of combat presented, for example, by Gen Erwin Rommel in *Infantry Attacks*, Ernest Swinton in *The Defense of Duffer's Drift*, or Cecil Lewis in *Sagittarius Rising*.

The review of *Right Backed by Might: The International Air Force Concept* by Col Phillip S. Meilinger, USAF, retired (Winter 2001), also faults my not addressing subjects outside my stated focus. That having been well examined by others, I tried to steer close to the title.

The citing of factual errors is correct regarding the following: B-52s didn't fly from the Philippines in Linebacker II; and the Casablanca Conference was in January, not February, 1943. But while Dien Bien Phu in 1954 wasn't in Laos, it wasn't in North Vietnam then but in Tonkin, unless one accepts Ho Chi Minh's 1945 declaration rather than the Geneva Conference of 1954 as the point of North Vietnam's inception.

Further, views differ on Ike's nuclear threats in early 1953—for example, Maurice Matloff, in *American Military History*, who saw a general threat being offered to Moscow and Pyongyang, North Korea; Burton I. Kaufman, in *The Korean War: Challenges in Crisis, Credibility, and Command*, who saw no direct threat being made to China; and Timothy J. Botti, in *Ace in the Hole: Why the United States Did Not Use Nuclear Weapons in the Cold War, 1945 to 1965*, who saw increased Chinese flexibility at Panmunjom, North Korea, as being "probably influenced by rumors that the administration had let circulate around the Far East that the U.S. was stationing more atomic bombers in Okinawa." Others saw the stately and visible progress of an atomic cannon across the Pacific as a crucial influence.

My comments on the relative intensity of the Gulf and Serbian air campaigns are those of an outsider, based on a broad impression of a tangle of apples and oranges in a matrix full of differential elements like volume of ordnance delivered, hits scored, numbers and types of targets, criteria and selection processes, density of infrastructure, propinquity of targets to elites and general publics, camouflage, target hardness, air defenses, and so forth. A worthy topic for Boydian—or post-Boydian—analysis? Or perhaps that has already been done.

Roger Beaumont
College Station, Texas

CORRECTION

I just finished reading the Spring 2002 edition of *Aerospace Power Journal*. As the NORAD deputy inspector general (soon to be the USSPACECOM and NORAD inspector general), I jumped immediately into those articles on homeland security. Homeland defense is a growth industry, thanks to the events of 11 September 2001. That said, it bothers me immensely when one of our "bright and shiny" action officers at the Air Staff still refers to NORAD as North American *Air* Defense Command instead of North American *Aerospace* Defense Command. Of course I refer to Lt Col Michael Champness's article in the Spring issue and his glaring error on Air Force doctrinal definitions. My USSPACECOM brethren feelings are hurt.

Stay the course.

Check 6!

Col Dan Phillips, USAF
Colorado Springs, Colorado

Editor's Note: APJ *is to blame for this error, not Colonel Champness. During our editorial process,* *we define all acronyms used in an author's original submission and mistakenly used the old "air" designation instead of "aerospace" in defining NORAD. So our apologies and thanks to Colonel Phillips for the correction.*

AIR MOBILITY ARTICLE OVERDUE

Once again, Dr. David R. Mets is almost a lone voice in the wilderness in his attempts to keep the discussion and study of airlift and air mobility in play ("Between Two Worlds: Fodder for Your Professional Reading on Global Reach and Air Mobility," Spring 2002).

I would offer an additional thought—one that concerns Southeast Asia / China-Burma-India (CBI) operations in World War II. Although Dr. Mets mentions the Hump airlift as a key event, he doesn't note the air commandos' use of gliders and paratroops in Operation Thursday, which used airlift as the only source of resupply to American, Chinese, and British combat units in the field in Burma. Such resupply was pioneered by Tenth Air Force and, later, the Combat Cargo Task Force; Maj Gen Claire Chennault also used airlift to keep his widely distributed Fourteenth Air Force units in business once Air Transport Command had delivered the goods across the Hump. I am of the opinion that, although the historical treatment of Army Air Forces transport units which served in the CBI theater is not nearly proportional to their contributions and service, their work in airdrop and aerial delivery of cargo laid the groundwork for much of what became "tactical" airlift as used / refined in Korea, Vietnam, and any number of contingencies as well as humanitarian and disaster-relief efforts.

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Net Assessment

A poor appetite for good books eventually leads to intellectual malnutrition.

Striving for Air Superiority: The Tactical Air Command in Vietnam by Craig C. Hannah. Texas A&M University Press (http://www.tamu.edu/upress), John H. Lindsey Building, Lewis Street, 4354 TAMU, College Station, Texas 77843, 2002, 176 pages, $29.95.

This book is both enlightening and disappointing. Beginning with the former, Hannah's thesis is that during the first two decades of the nuclear era, Tactical Air Command (TAC) failed to concentrate on the missions specified for it by the War Department in 1946. The reason was an "identity crisis" brought about by the dominance of nuclear deterrence in national security policy that led TAC to become a mini-Strategic Air Command in order to survive. Although this is not a new theme, Hannah gives the problem a sharper focus by concentrating only on TAC's traditional air-superiority mission.

Hannah demonstrates that after the F-86 Sabre jet, which had been so successful in Korea, subsequent "fighters" were designed as long-range interceptors to shoot down Soviet nuclear bombers at long range with radar-guided or heat-seeking missiles. Or they were designed as fighter-bombers (more accurately called bomber-fighters) whose primary capability was delivering nuclear ordnance. He effectively shows, even to the novice, that the design requirements for interceptors, "bomber-fighters," and air-superiority fighters are very dissimilar. As a result, the United States entered the struggle in Vietnam ill equipped to handle challenges from a small North Vietnamese air force equipped with outdated air-superiority fighters—but fighters nonetheless.

Hannah also effectively demonstrates that because TAC concentrated on its twin nuclear missions (long-range bomber interception and nuclear-weapons delivery), there was very limited training in air-to-air combat. Not only was there not much training in these kinds of turning engagements, when training did occur, it was against similar aircraft flown by US pilots using US tactics. Dissimilar air combat training (DACT) was not used until after the Vietnam War.

Observations about aircraft-design parameters and pilot-training missions would normally make for very dry reading. Much to his credit, Hannah brings the subjects to life with well-chosen vignettes from Vietnam combat veterans that aptly illustrate his points. This makes for a "good read."

Turning to the disappointments in the book, readers' misgivings will begin with the title. TAC was not in Vietnam. TAC was stateside, in the business of structuring, training, and equipping the forces that it supplied to combatant commands, such as Pacific Air Forces in the case of the conflict in Vietnam. Admittedly, this is a minor gaff but a gaff nonetheless—and one not likely to favorably impress the knowledgeable reader.

Much more important are two fundamental flaws in the book. The first is that Hannah seems unsure of the audience for whom he writes. At times he appears to be writing for the novice, as in chapter two when he spells out some of the most basic principles of aerospace engineering as a prelude to explaining why interceptors, bombers, and fighters require dissimilar designs. However, he quickly lapses into three pages of complex mathematical formulae (Hannah has a degree in aeronautical engineering) that are not needed to make his points and are meaningful only to readers with Hannah's mathematical background. Strangely, in this same chapter, he fails to explain the importance of wing loading but in later chapters talks about it as if readers were thoroughly familiar with the subject.

The second fundamental flaw is found in what Hannah doesn't do. He does not even try to explain why virtually the entire national security apparatus developed nuclear myopia in the 1950s and 1960s. The reader is left with the impression that reckless decisions by cost-cutting politicians and Air Force bomber barons were the root of the problem. Of course, the truth is that the post–Korean War force-structure decisions were reckless only in hindsight. The idea that the threat of US nuclear weapons could deter most wars and quickly end wars not deterred permeated most of the defense establishment—civilian and military. Nuclear weapons were quite reasonably seen at that time as the basis for a "revolution in military affairs" that would make conventional military forces obsolete. Everyone wanted to get into the nuclear business—the Navy with its carrier airpower and submarines, the Army with its missiles and an "atomic cannon," and, of course, Tactical Air Command.

It seems to this reviewer that when Hannah fails to address the "why" of America's nuclear myopia, he has ignored at least half of the story—perhaps the more important half. What is left is a short but very enlightening thesis outlining design differences among different types of aircraft and illustrated with some very interesting vignettes about how difficult it was to seize control of the air over North Vietnam with the wrong kind of aircraft.

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Serenade of Suffering: A Portrait of Middle East Terrorism, 1968–1993 by Richard J. Chasdi. Lexington Books (http://www.lexingtonbooks.com/home.shtml), 4720 Boston Way, Lanham, Maryland 20706, 1999, 288 pages, $65.00.

Wayne State University academic Richard Chasdi's first book is a scholarly look into a quarter century of terrorism in the Middle East. One of the pivotal missions of foreign area officers (FAO) is to give field commanders an extra edge in force-protection matters. This book, which discusses the evolution of many terrorist groups in the region, will help in the classification of different types of terrorism. The author offers a balanced description of Islamic militant, Palestinian radical, and Jewish extremist groups, comparing and contrasting them. Furthermore, the descriptions of terrorist organizations as theocentric, ethnocentric, and ideocentric will aid FAOs in articulating the types of groups operating in an area.

Chasdi's second chapter is a study of what stimulates action in terrorist organizations. Some stimulants are more direct, such as the Israeli invasion of Lebanon in 1982. Others are key dates, commemorations that Palestinian, Jewish, and Shiite radicals exploit to make a political statement. Chapter four is an excellent historical discussion that outlines each terrorist group, starting with *Al-Ikhwan al-Muslimeen* (the Islamic Brotherhood), founded in 1928 by Hassan al-Banna as a sociopolitical party in Egypt. This organization is the blueprint for many Islamic groups throughout the region. Another group, *Hamas*, is the offshoot of the Muslim Brotherhood in the Palestinian Occupied Territories. The author also discusses the key founders of these organizations in this useful chapter, the best and most worthwhile in the book.

Chasdi peels back the Palestinian movement's different factions, many of whom espouse different views on how to gain independence. The discussion of the Syrian-backed *Al-Saiqa* (Thunderbolt) and the Iraqi-sponsored Arab Liberation Front demonstrates how regimes wish to manipulate the Palestinian cause to enhance their regional influence in the Arab world. *Serenade of Suffering* ends with counterterrorism tips from both long- and short-term perspectives. Middle East FAOs will benefit from reading this volume.

Lt Youssef H. Aboul-Enein, USN
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Clausewitz and Chaos: Friction in War and Military Policy by Stephen J. Cimbala. Praeger Publishers (http://www.greenwood.com/imprints/index.asp?ImprintID=I8), 88 Post Road West, Westport, Connecticut 06881-5007, 2000, 240 pages, $68.00.

This book is yet another endorsement of Clausewitz's military theory—specifically, his descriptive analysis of friction in war. It attempts to draw contours between "classical" Clausewitzian military theory and contemporary chaos theory. Thus, it is the union of two schools of thought—one that has stood the test of time and acquired nearly biblical prestige in military and political circles, and one that is struggling to make a mark. Stephen Cimbala may appear to be putting new wine in old wineskins, but the old skins still work fine.

The author's message is clear that friction has always been part of strategy, politics, and war. It is still a fundamental reality of those processes and will remain so in the future. As Clausewitz noted, it is the difference between "war on paper" and war. Depending on one's perspective, friction both plagues and benefits deterrence, crisis management, and peace operations. Friction applies to revolutions in military affairs. Despite programmatic attempts to argue otherwise, technology cannot eliminate friction or even accommodate it. This is because friction breeds friction. Although some technologies may address some forms of friction, they will produce other friction in the process.

For example, a classic national endeavor involves eliminating political friction militarily, military friction economically, or economic friction politically. Then, of course, one finds many variations on that theme. Historically, however, the result is more friction, sooner or later. Cimbala points to various historical case studies to prove the point. In addition, he focuses on present-day conflicts to argue that friction is here to stay.

Readers looking for a solution to this dilemma will be disappointed, and rightly so. No solution exists. Cimbala argues that soldiers and politicians alike must always appreciate the existence of friction and its importance in all activities. Simply knowing that friction exists can help predict its effects—and, hopefully, plan accordingly.

All this may be no more profound or illuminating than Clausewitz's original description, and Cimbala may be guilty of overstating the obvious and making the simple more complex—thus adding friction himself. Moreover, purist Clausewitz disciples, no doubt, will look for inaccurate interpretations and applications. *Clausewitz and Chaos,* however, is effective in making the reader think about friction, and that, after all, is Cimbala's purpose.

Col Eric Ash, USAF
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The Russian Way of War: Operational Art, 1904–1940 by Richard W. Harrison. University Press of Kansas (http://www.kansaspress.ku.edu), 2501 West 15th Street, Lawrence, Kansas 66049-3905, 2001, 368 pages, $39.95.

In the summer of 1941, the Red Army was nearly annihilated during the opening phases of the Nazi invasion of the Soviet Union. Poorly led, improperly deployed, and in the midst of reorganizing and reequipping, even the finest and most lavishly equipped Soviet formations fared poorly in their initial confrontations with the German army. Yet, following the catastrophes of 1941, the Red Army recovered and was able to conduct ever more complex and effective operations, ultimately grinding down the *Wehrmacht*.

Sheer weight of numbers—both human and material—certainly played a part, but the stereotype of the "Soviet juggernaut" is only part of the story. This significant, major study is more concerned with examining the intellectual and theoretical roots of this remarkable resurgence. Harrison has produced a concise, thoroughly researched examination of the development of "the operational art" in tsarist Russia and the Soviet Union. In the author's own words, this study strives to illuminate "the rich heritage of operational thought and practice accumulated by the Soviet army and its imperial predecessor" (p. 1). The result is an exceptionally readable and convincing "intellectual history" of an army.

Systematic study of the operational level of war—defined in Soviet parlance as "the connecting link between strategy and tactics" (p. 2)—is essentially a twentieth-century phenomenon. Dramatic advances in the practice of war, including the expansion of armies, increased weapons range and lethality, and the advent of modern command and control, necessitated changes in military thought. The author convincingly argues that operational art represents "a distinctly Russian response" to these challenges.

Harrison develops a series of quantitative "indices"—number of troops engaged, length of front, depth of operation, and duration. He argues that significant increases across several indices amounted to a qualitative change in the military art and that the Soviets developed new terminology and concepts to confront this change. His excellent narrative traces the development of Russian/Soviet operational thinking from the Russo-Japanese war through military symposia and war games on the eve of Operation Barbarossa. The intellectual underpinnings of the sophisticated, multifront operations of the later years on the eastern front emerge clearly as Soviet thinkers developed the theory of the "deep operation" in the mid-1930s.

Harrison's account richly details the role of the theorists and their ideas, but he does not neglect the context within which this theorizing took place. He deftly analyzes the effect of combat experience in the Civil War, the Polish-Soviet conflict, the Spanish Civil War, and (most notably) the Stalinist purges of the late 1930s. While highlighting the sophistication of the Soviet theory of the deep operation, he also emphasizes the human cost of the purge and the heavy price paid by the Red Army in dealing with the resulting frequent, politically motivated reorganizations. Students of military reform may greatly benefit from studying this account.

The author is somewhat less successful in his rare forays into comparative history. He attempts to distance his discussion of Russian and Soviet operational art from parallel developments in Germany, notably blitzkrieg, on the grounds that "blitzkrieg is, at heart, a *strategy* for waging war, while operational art is subordinate to strategy" (emphasis in original, p. 268). This represents a seriously outdated view of blitzkrieg. More recent scholarship on German combined-arms warfare has effectively discredited the idea of "blitzkrieg strategy," and the comparisons between Soviet and German operational practice are far more complex than Harrison allows.

The author's research is thoroughly grounded in the military-theoretical literature of the period. It is filled with insights into the formulation of doctrine, the problems of military transformation, and the role of professional military education. At the same time, one emerges with an appreciation of the importance of individual reformers and the social dynamic within the officer corps. *The Russian Way of War* is a most important study and should be mandatory reading for all students of the operational art.

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The Few: Summer 1940, the Battle of Britain by Philip Kaplan and Richard Collier. Sterling Publishing Co., Inc. (http://www.sterpub.com/sterling.htm), 387 Park Avenue South, New York, New York 10016-8810, 2001, 224 pages, $21.95.

Although I love reading about the Battle of Britain, when I first picked up this book, my initial, mixed reaction was, "Great, another Battle of Britain book." There always seems to be yet another study of arguably the greatest air battle of all time. Unfortunately, many of them just rehash old information. Although this one was released in 1989 under the title *Their Finest Hour: The Battle of Britain Remembered*, it is still refreshing to find a book with enough of a clever slant to make the reading worthwhile and refreshing.

The authors have done a fantastic job of presenting the Battle of Britain to the reader. Philip Kaplan is the author of several books, including *Little Friends, Round the Clock, Wolfpack, Fighter Pilot*, and *Bombers*, while Richard Collier authored *The Sands of Dunkirk, The General Next to God, Eagle Day, D-Day*, and *Duce!* These two men have combined their knowledge to create a very readable and attractively presented book. Not only is it well written, but it also contains over 100 wartime and current photographs—both black and white and color—of the battle's men, machines, and significant locations.

Although *The Few* can in no way be considered a definitive work on the Battle of Britain, it does contain fascinating facts and anecdotes. Throughout, the authors creatively weave stories of the pilots, the people who supported them, and the civilians who witnessed the battle. We find great quotations from both sides of the conflict as well as personal stories, such as Geoffrey Page's account of being shot down and severely burned in his Hurricane. The book offers a wealth of good, well-articulated, historical information (e.g., the birth of British radar). It also tells of German airmen killed on the ground by British soldiers and gives due credit to the highest scoring Allied unit of the battle—the Polish 303d Squadron.

As a Joint Doctrine Air Campaign Course instructor, I was very interested in the authors' presentation of the Germans' operational-level conduct of the battle. Anyone who has ever studied this battle surely comes away with the notion that the Germans were never quite sure of their overall strategic- and operational-level objectives. German intelligence officers admit that they made little or no distinction between key Fighter Command airfields like Biggin Hill, Tangmere, and Manston and minor airfields in southern England. Likewise, quotations from high-ranking officers clearly reveal the Germans' indecisiveness and operational ineptitude. The 60-year-old question regarding actual German invasion plans remains clouded: for example, on 2 September, Reichsmarschall Hermann Göring admitted to Gen Kurt Student, commander of all airborne troops for Operation Sea Lion, that Hitler did not intend to invade England. "I don't know," shrugged Göring, "There'll be nothing doing this year at any rate." The authors also accurately portray the Germans' intelligence efforts for what they were—ineffective, inaccurate, and subject to the political whims of the moment.

The Few is a good coffee-table book, one I recommend both to anyone moderately interested in this key period of history and to the scholar more familiar with the battle. An attractive and informative book, it will certainly be a welcome addition to any library on the Battle of Britain. Perhaps somebody can convince Kaplan and Collier to write a sequel—but from the German perspective.

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Cold War Strategist: Stuart Symington and the Search for National Security by Linda McFarland. Praeger Publishers (http://auburnhouse.com/praeger.htm), 88 Post Road West, Westport, Connecticut 06881-5007, 2001, 240 pages, $62.00.

Never read the liner notes. They inevitably promise more than the author delivers. On occasion, the author commits the liner-note sin, and this book is a case in point.

McFarland claims that Symington (1901–88) began moving from cold warrior to dove in the middle of his Senate career when he started to become aware of Central Intelligence Agency (CIA) and administration deceit in Southeast Asia: “Symington evolved from a Cold Warrior who rarely questioned Pentagon decisions to a distinguished Senator who became not only less enchanted with policy makers but even suspicious of them. This was the most striking characteristic of his long public career” (p. 4). Unfortunately, the argument does not stand up to a reasonably close reading of the author’s own evidence. Rather, her Symington is a consistent partisan, liberal-Democrat cold warrior. Symington’s approach to foreign affairs, including Vietnam, was always win or withdraw but never half-step. That’s the position of a hawk, not a dove.

Also, although her argument is that Symington became disenchanted with covert activity over time, she specifically says that his shocked reaction at public revelations about CIA wrongdoing during the Nixon-era secret wars in Laos and Cambodia was at least in part a pose. He was more provoked by the Nixon administration’s disregard for the Senate than by the wars. He had been receiving the classified briefings during the Johnson administration and had knowledge of a long-standing pattern of CIA behavior. In fact, he approved of it until he got tired of Johnson’s dilatory approach to the Vietnam War (p. 157).

So, the book has problems with its logic. Oddly, the flaw does not weaken the work all that much. McFarland compensates by diligent research into a long-neglected career. The book offers more than enough to justify a new look at the senator from the Air Force.

So who was Stuart Symington if he wasn’t the cold warrior who eventually saw the light of reason and peace? For one thing, he was a hardheaded businessman whose specialty was turning around failing companies. His success in business brought him into the Truman administration, where he served as undersecretary for air and first secretary of the Air Force; later on, he also held a couple of other subcabinet positions.

As secretary of the Air Force, he fought for 70 groups as opposed to Truman / Johnson’s 48. He also tried to get the Air Force a larger share of the minuscule (less than $15 billion) defense budgets of the late 1940s. He was a good cold warrior whose planes made the Berlin airlift a success. And he wanted B-36s to carry the bomb. He had no noticeable aversion to the United States attacking monolithic communism while it had the nuclear upper hand. Consistently, he had a habit of exaggerating both the Soviet threat and the weakness of the American military, especially the Air Force. Furthermore, he was among the first to get the military into missile development and to advocate arms reduction, but never at the expense of preparedness.

He broke with Eisenhower and Truman because he regarded them as miserly in supporting the defense budgets. He was against limited wars from Korea through Vietnam and highly critical of Ike’s action in Suez. Symington was one of the originators of the “missile gap” charge that Kennedy played so well against Nixon in 1960. And he was a party loyalist.

He decided in 1952 to run for the Senate against an isolationist. He won, served four terms, and made a minor run for the Democratic presidential nomination in 1960. He ran for the Senate despite Truman’s endorsement of the Pendergast candidate in the Democratic primary. In the Senate, he was in on the Army McCarthy hearings, and for much of the time served on Foreign Affairs and Intelligence, among other committees.

The big question I had about this book was whether it was an intellectual history with authorial insights into Symington’s change and what it means for others similarly situated. Would it reveal Stuart Symington as an anomaly, or is this a pattern shared by many cold warriors? Why does Symington matter enough to justify the labor that went into this volume? I had hoped that it would provide more insights into the thought processes of Symington, a representative cold warrior. Unfortunately, *Cold War Strategist* is close to straight narrative. Probably, the sources limit the approach: the bibliography is full of sources that filter out the real person. Interviews, press releases, secondary works, and official or semiofficial letters give public views instead of private ones. This book is a public biography of one element—foreign affairs—of Stuart Symington’s robust public life. It ignores his domestic political concerns, which were extensive. McFarland’s book is good for what it does, but that is not what it intends or what a biography should do. Unfortunately, the two available full biographies date from Symington’s presidential campaign of 1960, so McFarland’s is the definitive work on his foreign policy. Fortunately, even with its occasional lapses of interpretation, it does provide a well-researched and readable examination of the foreign-policy career of a long-time cold war liberal.

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Bomber Harris: His Life and Times: The Biography of Marshal of the Royal Air Force Sir Arthur Harris, the Wartime Chief of Bomber Command by Henry Probert. Stackpole Books (http://www.stackpolebooks.com/Stackpolebooks.storefront), 5067 Ritter Road, Mechanicsburg, Pennsylvania 17055-6921, 2001, 432 pages, $34.95.

History records Arthur Harris as Bomber Harris, one of the most controversial figures of World War II. The wartime commander of Britain's Bomber Command, Harris personified the controversial area bombardment of German cities from early 1942 to Nazi capitulation in May 1945. Both during the war and afterwards, some people vilified this bombing policy as immoral and strategically misplaced while others argued that it was one of the war's exigencies, designed to bring the conflict to conclusion faster than a slogging ground fight would have, sparing the deaths of additional noncombatants. For 60 years, Harris's strong personality and his command's central role in area bombing have made him a focal point of debate regarding the air war. His wartime service has received abundant attention from historians and memoirists alike, to the point that Harris the man has become captive and caricature to the conflict's larger portrait. In this generally fine biography, Henry Probert, a retired air commodore, sets out to rediscover the person of Arthur Harris and to contextualize his Bomber Command days around Harris's "earlier life, both in the RAF [Royal Air Force] and as a family man," and his long life after the war (p. 15). In this task, Probert mostly succeeds, although in the process he does not tackle many of the controversies surrounding either Harris or area bombardment.

Harris was born in 1892 and spent his early childhood in India. After attending an English boarding school, he made his way in 1910 to Rhodesia, where he helped run various agricultural concerns. The outbreak of war in 1914 brought him into military service and away from southern Africa, although nostalgia for youth forever after labeled him a Rhodesian in his own mind. With the help of family connections, Harris garnered a commission in the RAF. During the Great War, he served as a pilot on the western front, where he became a disciple to the great promise of aerial bombing as a better, swifter substitute to bitter trench fighting in the conduct of war. In the 1920s, Harris served in various flying capacities in India and the Middle East, where the RAF was busy policing Empire territory. In the 1930s, he served in both operational and staff billets, including a stint as the deputy director of plans in the Air Ministry. This duty led to his service as the RAF lend-lease representative in Washington during the time Britain was at war but America was not. He left the United States in January of 1942, became commander in chief of British Bomber Command in February, and began the core of his wartime service.

Harris helped lift Bomber Command from a demoralized nadir following the bombing war's early frustrations. His attention to detail, diligent focus, and forceful advocacy not only cheered the British public but also offered an example to the US Eighth Air Force, with which Harris's command conducted the Combined Bomber Offensive. Harris contended with the challenges of bombing accuracy, crew morale, equipment upgrades, and diversions from strategic bombing as well as tasks ranging from mine laying to tactical support of the Allied invasion of Normandy. By war's end, Bomber Command's contributions to victory were clear, but its place in memory was less secure as Allied public opinion recoiled at the stark horror of bombing cities in Germany. As a result, Harris became a kind of national embarrassment, and the public embraced his legacy with great ambivalence.

Not independently wealthy, Harris returned to southern Africa to become a founder and director of Safmarine, a fledgling but ultimately successful marine line connecting Cape Town to London and New York. By the early 1950s, he was back in England, financially better off, and settled for good. He lived a generally modest and unassuming life, only later emerging to take a more active part in numerous RAF functions and Bomber Command reunions. Harris died in 1984 at the age of 92.

Probert's approach to Harris is largely descriptive. His treatment of Harris's life before the war, the dissolution of his first marriage, and the course of his second union do indeed serve his purpose of painting a person beside the portrait of Bomber Harris. Moreover, the author's care in relating Harris's postwar life as family man and country gentleman is the book's major contribution to the broader literature. With access to private family scrapbooks and surviving Harris intimates, Probert is able to complete the circle of Harris's life as no one else has done.

But analysis suffers from this stress on description. Probert does not delve into many issues surrounding the efficacy of area bombardment in World War II. Although those issues have ample voice in the literature, the value of biography is the intersection of person and policy. In his obligatory treatment of the planes, people, techniques, and effects of bombing, Probert misses an opportunity to tackle these issues with nuance and doggedness within the context of Harris's personality. Rather, he relies on standard sources and methods to arrive at standard conclusions about the air war. Nowhere, for instance, does he refer to recent scholarship on bombing efficacy drawn from German sources, relying instead on the published writing of Albert Speer and the Allied bombing surveys after the war. Beyond that, Probert does not examine a central matter of the bombing: that it was at its most effective role when diverting German resources to defense. This was not the measure of airpower that prewar theorists had used, nor was it the yardstick that wartime commanders generally employed to gauge the value of bombing. Probert's descriptive approach largely misses a chance to explicate this doctrinal paradox. All books have limits, of course, but these oversights are weaknesses.

Still, this biography is the new standard for Harris, replacing Dudley Saward's *Bomber Harris*. Probert set out to write a book "both critical and sympathetic" and worried that some readers might find his judgments "too kind" to Harris (p. 15). He is probably right on both counts. But his book does a nice job of teaching us about Harris the man, which is the biographer's first obligation.

Dr. Tom Hughes
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Henry L. Stimson: The First Wise Man by David F. Schmitz. Scholarly Resources Books (http://www.scholarly.com), 104 Greenhill Avenue, Wilmington, Delaware 19805-1897, 2001, 222 pages, $60.00 (hardcover), $19.95 (softcover).

To the extent he is remembered at all, Henry L. Stimson (1867–1950) probably is most often recalled for declaring that "gentlemen do not read each other's mail," a sniffy observation which accompanied his 1930 directive to close the US State Department's cryptography office (aka "the Black Chamber"). That unfortunate and undeserved obscurity has been happily diminished by David F. Schmitz's excellent new biography *Henry L. Stimson: The First Wise Man*.

A generation unfamiliar with Stimson might be surprised to learn that this successful New York attorney-turned-public-servant held senior appointments under nearly every president from Theodore Roosevelt to Harry S. Truman. A lifelong Republican, Stimson served as secretary of state (1929–33) for one president (Herbert Hoover) and secretary of war for three others, two of them Democrats (William H. Taft [1911–13]; Franklin D. Roosevelt, and Harry S. Truman [1940–45]). Along the way, he fought as an artillery officer in World War I and held appointments as a presidential envoy to revolution-plagued Nicaragua (1927) and as governor-general of the Philippines (1927–29). Even a partial list of his accomplishments constitutes an impressive resume: reforming the War Department on the eve of World War I; inaugurating what later became known as the Good Neighbor Policy toward Latin America; guiding US mobilization for World War II; helping to shape wartime strategy; overseeing development of the atomic bomb; and influencing the formulation of postwar military and foreign policy.

Making extensive use of Stimson's personal papers and diaries, Schmitz offers a judicious, insightful, and sometimes provocative study of a remarkable public figure. He makes two major arguments: (1) that Stimson played a major role in America's transition from traditional imperialism and isolationism to internationalism and world leadership and (2) that Stimson—for good or ill—personified certain key strengths and weaknesses in twentieth-century American foreign policy. Few would dispute the first point. As noted above, over a period of some 40 years, Stimson ably served no fewer than six presidents in positions of great trust and responsibility.

Schmitz's second assertion explains the subtitle of his book. Drawing on an earlier study of post–World War II foreign-policy makers (Walter Isaacson and Evan Thomas's *The Wise Men: Six Friends and the World They Made: Acheson, Bohlen, Harriman, Kennan, Lovett, McCloy* [New York: Simon and Schuster, 1986]), Schmitz depicts Stimson as "the first wise man"—that is, as the progenitor of the line of imposing figures who shaped US foreign policy in the 1950s and beyond while shuttling between corporate board rooms, Ivy League faculty clubs, and senior, nonelective posts in the national-security establishment. According to Schmitz, both Stimson and his successors (basically the same group collectively and memorably referred to by David Halberstam as "the best and the brightest") shared a number of important characteristics: high intelligence, impressive dedication to public service, a somewhat narrow worldview, and the unswerving assurance they were always right. In Stimson's case, those tendencies were reinforced by a strong sense of noblesse oblige and, as was common among privileged men of his day, a no-less-strong belief in the inherent superiority of white, Anglo-Saxon, Protestant males. To his credit, Stimson also possessed a sense of the limits of American power, a trait not always exhibited by the policy makers who followed him.

There is much to be said for examining major historical episodes through the medium of biography. By humanizing the past, biographies can help inspire us to learn more about events that otherwise might appear hopelessly dull and irrelevant. Of course, biography is not without its dangers, chief among them the inflation of the subject's relative importance and exaggeration of his or her personal virtues or flaws. David Schmitz avoids those pitfalls with perhaps two exceptions. To describe Stimson as *the* architect of American victory in World War II appears excessive (pp. 172, 196). On the other hand, without direct evidence to corroborate such a claim, it seems unfair to attribute Stimson's leading role in the wartime internment of Japanese-Americans purely to prejudice against "nonwhite people and all non-European cultures" (pp. xv, 146).

But these are minor and isolated lapses in an otherwise balanced account that manages to be both learned and fast moving. This is a wise book about a wise and important man.

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Black Cross, Red Star: The Air War over the Eastern Front, vol. 2, **Resurgence** by Christer Bergström and Andrey Mikhalov. Pacifica Military History (http://www.pacificamilitary.com), 1149 Grand Teton Drive, Pacifica, California 94044, 2001, 232 pages, $39.95.

The eastern front consumed over half of the German Luftwaffe's frontline strength from June 1941. It also was the scene of some of the most significant air action of World War II. The Red Air Force (VVS) recovered from its near-total annihilation in the summer of 1941 to become a vital part of a powerful combined-arms team that defeated the German military. Yet, among the vast outpouring of World War II histories is but a tiny handful of works focusing on the eastern front in the "third dimension." We are fortunate, therefore, to welcome the second installment of a multivolume series examining, in great detail, the air war on the eastern front, 1941–45. It is a story that needs telling and retelling.

In many ways, this volume tells it well and has much that is new to offer. It covers the critical battles before Moscow in December 1941–January 1942 through the ambitious Soviet counteroffensive and the subsequent German stabilization of the front line, culminating in the German victories on the Kerch peninsula and at Kharkov. The narrative concludes with the conquest of the Crimea, which clears the way for Operation Blue, the major German drive during the summer of 1942, to be covered in a future volume. Throughout, the courageous efforts of the VVS to close the training, technical, and tactical gap with the Luftwaffe are well covered. The book also contains excellent accounts of the "secondary" fronts since air action around Leningrad or opposite Army Group Center hardly slackened during this period. The chapter devoted to the Demjansk and Kholm airlifts, in which the Luftwaffe kept a cutoff German force of over 100,000 men resupplied for months, is one of the highlights of the volume.

The work masterfully combines the combat experiences of both Soviet and German airmen into a coherent narrative. For years, historians and general readers were aware of the exploits of a number of the German ace fighter pilots, such as Hannes Trautloft, Hermann Graf, and Anton Hackl, fighting in the Soviet Union. This work certainly gives them their due, providing much new and enlightening information in the process. Perhaps the book's most significant contribution lies in finally recognizing the achievements and sacrifices of the airmen (and airwomen) of the VVS. In some cases, the authors have been able to fully reconstruct both sides of an air battle, nearly 60 years after the event—certainly a remarkable example of historical detective work. Indeed, one wishes that the footnotes and bibliography had been a bit more detailed. Simply listing a citation as "VVS-Karelian Front documents" or "Luftwaffe Loss Reports" is not adequate if future scholars wish to follow in the footsteps of such excellent research.

One might criticize this volume for its overwhelming focus on the sharp end of individual aerial combats and its near-total neglect of many other facets of the air war on the eastern front. Examinations of intelligence and logistics are almost entirely absent from the narrative. Discussion of the airpower theory and doctrine of both air forces, as in volume one, is cursory and oversimplified. The strategic and operational direction of the air war is scarcely discussed. For example, Luftwaffe chief of staff Hans Jeschonnek, who exerted enormous influence on the Luftwaffe's force structure and operational employment, is never mentioned. The achievements of Gen A. A. Novikov, whose innovative command arrangements on the Volkhov front in early 1942 set the pattern for the recovery of the VVS, are given a few scant paragraphs. Field Marshal Walther von Brauchitsch is misidentified as the chief of the Army High Command (OKH), and Adolf Hitler's role is reduced to providing "daily outbursts of fury" (p. 44). The book is very effective at communicating the details of air engagements and the exploits of the individual aviators. It is less successful at placing these operations into some kind of larger strategic and operational context.

In terms of its production values, this volume is an enormous improvement over its predecessor. Photographic reproduction and paper quality are much improved, and the book contains a number of color side-view paintings of Soviet and German aircraft that are nothing short of spectacular. This is a most worthwhile study—narrowly focused, attractively presented, and filled with much new information on an aspect of World War II that is still poorly understood in the West.

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My War: A Love Story in Letters and Drawings by Tracy Sugarman. Random House (http://www.randomhouse.com), 201 East 50th Street, New York, New York 10022, 2000, 191 pages, $30.00.

Reminded by his wife June of the commemoration of the 50th anniversary of D day in the United States and Europe, Tracy Sugarman, who served as a naval officer aboard a troop transport during the Normandy invasion, asks her, "Whatever became of our letters and drawings from the War?" The discovery of these items, unscathed in their attic, marks the beginning of the touching tale that brings together personal highlights of World War II in the magnificent book *My War: A Love Story in Letters and Drawings*. Sugarman left his life as an art student at Syracuse University and joined the armed services, as did thousands of Americans. Answering the call to arms after the attack on Pearl Harbor, young American men and women from all walks of life clamored to serve their country. For the first time, a kid from Yazoo City, Mississippi, met an Italian-American from New York City, and the diversity that is America would be brought together and represented in the landing craft that carried them to the beaches of Normandy.

My War contains the earthy, touching, and heartfelt correspondence between Sugarman and his wife (now deceased). Many readers will identify with these letters and drawings as Sugarman reveals both the tragic and comic aspects of life in World War II. He writes about the long hours on troop transports, seasickness, all-night poker games, and, of course, the shenanigans of liberty call. As Lt Tracy Sugarman, USNR, on board LST-491, prepares to take part in D day, he writes to June, "I believe with all my heart there must be finality this time. I pray to God that someone, anyone will take the lead and save a score of generations from the shame and disgust of winning and losing the same war again."

Sugarman could have been any solider or sailor forward-deployed in a hostile situation. His letters remind me of men and women I encountered in Bosnia, West Africa, and the Persian Gulf, where sailors found a private corner to E-mail or actually write their loved ones. I recommend that you read the book that Stephen Ambrose, acclaimed World War II historian, calls "one of the most compelling accounts of the war I've ever read."

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Luftwaffe Colours, vol. 1, sec. 3, **Jagdwaffe: Blitzkrieg and Sitzkrieg: Poland and France, 1939–1940,** by Eric Mombeek with J. Richard Smith and Eddie J. Creek. Classic Publications (http://www.classic-books.co.uk), Friars Gate Farm, Mardens Hill, Crowborough, East Sussex TN6 1XH, England, 2000, 93 pages, £12.95.

Well-known Belgian researcher and author Eric Mombeek and Classic Publications of England have produced a series of books about aircraft markings of the *Jagdwaffe*, the Luftwaffe's fighter arm. If *Blitzkrieg and Sitzkrieg* is any indication of the quality of the other books in this series, it will likely be a very profitable endeavor.

Although this 93-pager contains hundreds of pictures, drawings, and color plates, it is by no means a coffee-table book. Mombeek takes the reader on a fast but enjoyable trip inside the Luftwaffe during part of the period before the invasion of Poland—the so-called *Sitzkrieg* in France. He adds combat reports, personal accounts, the birth of night-fighting units, serviceability rates, and breakdowns of the Luftwaffe's organizational and command structure, all of which make the book both informative and interesting. For those of us who have never heard of it, Mombeek also discusses the history of the *Kunstflugstaffel*—the German national aerobatic team, formed in 1938.

The publisher has spared no expense in printing very rare and seldom-seen photographs throughout the book. In addition to pictures of Luftwaffe personalities, pilots, and crews, the book includes photographs and color plates of Luftwaffe aircraft; rare unit, national, and individual aircraft markings; and unique camouflage patterns that disappeared before the Battle of Britain. It was refreshing to see these markings in color for the first time, bringing to life images seen only in black and white for the past half century.

Blitzkrieg and Sitzkrieg does an excellent job of filling a specialized niche in the literature—perhaps better than any other book of its type. Artists and modelers will be especially happy with the information they find here, as will readers looking for unique pictures, accurate color schemes of Luftwaffe aircraft, and markings of units and / or individual aircraft. This is a first-rate effort, and I look forward to reading the other books in this series.

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Russian Strategic Nuclear Forces edited by Pavel Podvig. MIT Press (http: / /www-mitpress.mit.edu), Five Cambridge Center, Cambridge, Massachusetts 02142-1493, 2001, 620 pages, $45.00.

This Russian study, the first on nuclear weaponry, will interest both arms-control advocates and historians. Since it was written with Russian source information, its perspective differs from that of other texts on nuclear arms, such as the *Nuclear Weapons Databook Series* by William Arkin and others, published by the Natural Resources Defense Council. Adding to the intrigue of *Russian Strategic Nuclear Forces*, it is banned in Russia, and the team's notes and computer disk were seized by the FSB, successor to the KGB. The translators have done an outstanding job of producing a readable gold mine of data. Like many other Russian texts, this one relies on drawings rather than pictures, but this idiosyncrasy does not lessen its worth.

Rather than merely collecting data, this study describes the history and evolution of weapons and weapons systems and provides a comprehensive look at the development, deployment, and testing of weapons. For example, the release sequence for nuclear weapons is well described and shows how the Soviet Union maintained its alert posture. Some gaps, however, need to be filled in. Although the book addresses the Russian weapons-development complex, with its labs and production facilities, it includes scarce data on national nuclear-weapons storage sites, which hold most of the Russian inventory.

Some arms-control controversies of the 1970s and 1980s may undergo debate once again when data in this book is added to that released by the United States. For example, the SS-16, a mobile ICBM of SALT II fame, was deployed and then removed after the SALT Treaty was signed. The other mobile systems—the SS-14 / SS-15—which the Western powers were never sure about, were built and tested but not deployed. Other issues, such as how many SS-20s the Soviets were going to deploy before the Intermediate-Range Nuclear Forces Treaty eliminated them, are left open by the Russian authors.

The book covers all air, naval, and air defense forces. One finds no great surprises in any of the data, but much of it confirms Western suspicions about Soviet forces and weapons development. An additional chapter devoted to nuclear tests lays out a chronology of how the Soviets developed their bomb. The chapter on peacetime nuclear explosions and industrial uses of nuclear explosions will add to Western understanding of Soviet developments in this twilight area between national security and economic development.

The authors have aided Western readers by cross-referencing Soviet systems designations with those used by the United States and NATO. An appendix traces Russian nuclear defense policy and equipment to the year 2000, and maps help to pinpoint facilities once so secret that their names were banned in the USSR. This well-documented book should spur additional research in America's national security community as comparisons are made and the history of the Cold War and strategic arms control is analyzed.

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Best of Intentions: America's Campaign against Strategic Weapons Proliferation by Henry D. Sokolski. Praeger Publishers (http: / /www.greenwood.com / imprints / index.asp?ImprintID=I8), 88 Post Road West, Westport, Connecticut 06881-5007, 2001, 184 pages, $19.95 (softcover).

Don't be fooled by this book's thin size, its soothing green color, or the strangely incongruous photo of a bulldozer on its cover—this small gem packs a mighty wallop. With great economy of prose and penetrating insight, Henry Sokolski distills the roots, foundations, and implications of American policies designed to counter the proliferation of strategic weapons since World War II. In its recounting of this story, his book is a powerful and disturbing reminder that the unstated but foundational assumptions or unintended consequences often leave the most enduring legacy of any policy. But by culminating with specific, useful guidance on crafting the next campaign against weapons proliferation, *Best of Intentions* goes beyond simply warning today's policy makers to avoid these common inconsistencies and pitfalls.

Sokolski has struggled long and hard with nonproliferation issues during his career both inside and outside the government. A former military legislative analyst in the Senate and deputy for nonproliferation policy for Secretary of Defense Dick Cheney from 1989 to 1993, Sokolski now heads the nonprofit Nonproliferation Policy Education Center in Washington, D.C. His book reflects these years of solid effort and presents mature, well-honed arguments that will prove useful to newcomers and experts alike. *Best of Intentions* is divided into seven chapters and provides the most important of its source documents in five appendices. Sokolski includes a short chapter that describes and analyzes each of the five major US nonproliferation efforts since 1945: the Baruch Plan, Atoms for Peace Initiative, Nuclear Nonproliferation Treaty (NPT) of 1968, proliferation-technology control regimes, and Defense Counterproliferation Initiative. Of course, much of this is familiar ground, but Sokolski's seasoned judgement has enabled him to strip away the chaff yet very clearly and succinctly lay out the goals, resulting policy, and fruits of the policy for each of these major initiatives. For example, Sokolski shows how assumptions in the late 1940s and early 1950s that nuclear weapons would provide "an unqualified advantage to the aggressor" drove US policy makers to conclude that the spread of even a small number of nuclear weapons "would inevitably lead to war" (p. 14). These assumptions were the foundation for both the Baruch Plan and the Atoms for Peace Initiative. In the Baruch Plan, they were the most important rationale for removing the Soviet Union's veto power in the United Nations Security Council and for making the stringent inspection regime operational in the Soviet Union *before* the international authority established full control over the US nuclear arsenal. In a similar way, these exaggerated fears that growth in the superpowers' nuclear arsenals (vertical proliferation) would inevitably lead to aggressive nuclear war contributed to the Eisenhower administration's failure in the Atoms for Peace Initiative to appreciate the danger of spreading the capability to produce fissile material to other states (horizontal proliferation).

In particular, Sokolski emphasizes how the last three major initiatives flowed directly out of the previous approach and were designed to correct the perceived weaknesses in that approach. He traces the roots of the NPT to two sources: the Irish Initiative and finite deterrence. Sokolski labels the 1958 Irish Initiative at the United Nations as the "first NPT bargain": "Weapons states should not furnish nuclear weapons to nonweapons states, and nonweapons states should refrain from trying to acquire them" (p. 43). Beginning in the late 1950s, the first NPT bargain was undercut by the emergence of a new concept known as finite deterrence—the idea that states with very small nuclear arsenals can effectively deter attacks by states with larger nuclear arsenals by threatening to retaliate against the attackers' cities. Sokolski also shows that it is a small step from finite deterrence to the concept of "nuclear rights" or the notion that states deserve to be compensated for forgoing nuclear-weapons development. Rather than the "grand bargain" emphasized by many analysts, Sokolski sees the NPT as a quite inconsistent mixing of these two positions. He questions the benefits of finite deterrence and peaceful nuclear power while highlighting the weakness of the International Atomic Energy Agency (IAEA) inspection regime. Sokolski then explains how these weaknesses in the NPT moved the United States to create proliferation-technology control regimes beginning in the 1970s. When India (even though it had not signed the NPT) used "civilian" US, Canadian, and Western European reprocessing as well as heavy-water technology and hardware to create the "peaceful" nuclear device it detonated in May 1974, the United States responded by creating the Nuclear Suppliers Group (NSG), a secret and explicitly discriminatory regime. As Sokolski explains, the NSG was just the first of these new discriminatory control regimes. During the 1980s, the United States spearheaded efforts to create the Australia Group for control of chemical and biological weapons and the Missile Technology Control Regime to control aerospace technology and hardware transfers. But by the 1990s, the weaknesses and inconsistencies in these technology control regimes triggered the final major initiative that Sokolski examines: the Defense Department's Counterproliferation Initiative (CPI) of December 1993. He explains how initiating the CPI meant the United States was questioning the fruit of nonproliferation and recognizing at least some inadequacies in all previous nonproliferation efforts. The CPI caused bureaucratic squabbling, particularly between the State Department and Defense Department, until the National Security Council stepped in to broker a set of definitions in January 1994 that limited the scope of the CPI to a subset of all US nonproliferation efforts. The CPI thus evolved from a wide range of offensive and defensive measures designed to counter a variety of strategic military technologies to a more narrow focus on ensuring that US forces are capable of deterring and prevailing against enemies armed with nuclear, biological, and chemical weapons as well as the ballistic missiles to deliver them.

In his final chapter, "The Next Campaign," Sokolski examines how future nonproliferation efforts might be made more effective. He begins by using some of the major themes that emerge from his case studies to critique current nonproliferation efforts. Sokolski sees the concept of finite deterrence as a major determinant of the shape of the Agreed Framework of 1994, under which the United States indicated that North Korea should receive a set of light-water nuclear reactors in return for remaining subject to IAEA inspections. He is very critical of the agreement and questions whether finite deterrence is a sound way to assess the North Korean nuclear threat or whether key premises of the NPT remain sound in the post–Cold War era. Likewise, Sokolski sees disturbing parallels between the Baruch Plan and current US policy toward proliferation activities in Iraq and Iran. As the United States designs future nonproliferation campaigns, Sokolski calls for policy makers to consider several general and specific principles. To the extent possible, these campaigns should attempt to distinguish between safe and dangerous activities; include timely warning criteria; sharply limit unsafe dual-use exports; promote marketlike, case-by-case approaches to supplier control regimes; and recognize and deal with the relationship between vertical and horizontal proliferation. Sokolski emphasizes the linkages between the last issue and the NPT by reiterating that viewing the relationship between vertical and horizontal proliferation through the lens of the Irish Initiative is "sound" but that viewing it through the finite-deterrence lens is "quite frightening" (p. 107). Sokolski closes with a strong appeal for the United States "to explicitly distinguish between progressive and illiberal regimes, something no previous nonproliferation initiative has yet done. More important, the next campaign should work in a fashion that actually promotes progressive over illiberal rule" (p. 111). In the wake of the terrorist attacks of 11 September 2001 on the World Trade Center and the Pentagon, US nonproliferation efforts must also focus directly on the most dangerous and least deterrable threat: the axis of evil between states armed with nuclear, chemical, or biological weapons, such as Iraq, and terrorist networks, such as al-Qaeda.

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Three Wings for the Red Baron: Von Richthofen, Strategy, Tactics, and Airplanes by Leon Bennett. White Mane Books, P.O. Box 152, Shippensburg, Pennsylvania 17257-0152, 2000, 240 pages, $39.95.

Leon Bennett's *Three Wings for the Red Baron* is intriguing and effective. A mix of history, scientific/mathematical analysis, and military studies, it is written for the student of each of these disciplines rather than the aeronautical engineer. Bennett explains the technical material in a manner easily understood but in enough detail to reveal the salient points—specifically, the impact of technology on tactics, organization, and doctrine. His book is a study of triplane technology in the First World War with respect to one of the greatest legends to have used it—Baron Manfred von Richthofen.

Clearly, the triplane was not a superior type of fighting machine—at least in the form built by Spad, Curtiss, or Sopwith—because it was too slow. Yet, the greatest ace of the war chose the Fokker triplane, eventually losing his life in it. Bennett analyzes the Fokker's design and performance, bringing to light some of the potential rationale for Richthofen's decision and exploring the mystery of his death.

The book does not delve deeply into Richthofen's personality but touches on it enough to suggest how it influenced the famous ace's decision making. He was both intellectually and physically strong and capable. Although experienced and a keen tactician in air-to-air combat, he could also overcome miscalculations with talent. This trait may have applied to the triplane decision to some extent, although it turns out that his choice may not have been all that wrong.

The significant story of Richthofen goes beyond dogfights and comparisons of kills. No doubt his impact as a leader on Luftwaffe organization, doctrine, and training was far greater than the effect his kills had on the supply of Allied pilots. This book discusses those areas to a limited extent and is finely tuned to the specifics of early aircraft design in relation to aerial tactics. It reflects significant research and includes hundreds of figures and pictures. Overall, *Three Wings for the Red Baron* is a great read for airpower enthusiasts and a valuable contribution to the literature on the first air war.

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Devil Dogs: Fighting Marines of World War I by George B. Clark. Presidio Press (http://www.presidiopress.com), P.O. Box 1764, Novato, California 94948, 1999, 463 pages, $24.95.

George Clark's *Devil Dogs* provides a thorough retelling of the role of the Marine Corps in the Great War. The author, a military historian and former marine, begins with a concise description of events leading up to American involvement in the war and the Marines' effort to live up to the motto First to Fight. Maj Gen George Barnett, commandant, led the corps in a crash expansion program, establishing new training centers at Paris Island, South Carolina (the spelling officially changed to "Parris" in 1919), and the village of Quantico, Virginia. By June 1917, the first unit—the 5th Marine Regiment—was ready for overseas service. The core of the 4th Marine Brigade, this regiment served with distinction throughout the war.

At first, Army leadership opposed active participation by the corps in the growing American Expeditionary Force (AEF). Gen John J. Pershing, AEF commander, and other AEF officers feared that the Marine Corps would be unable to provide resupply or replacements as it suffered losses in battle. Pershing grudgingly accepted the corps on the condition that it be aligned with Army units. Thus, the 4th Brigade was assigned as one of three infantry brigades in the Army's 2d Infantry Division, which went into battle in June 1918 at Verdun, France. Although considered a relatively quiet zone, Verdun was the scene of some hard fighting for the soldiers and marines of the 2d Division. The infusion of fresh American troops on the front lines had an immediate and telling impact on the resolve of their German opponents. American marksmanship, far superior to that of the war-weary French troops, had an especially demoralizing effect on the "Boche." One German soldier, found dead in the fortifications facing the Americans, lamented in an unposted letter, "The Americans are savages. They kill everything that moves."

The author goes on to describe the Battle of Belleau Wood, perhaps the best-known Marine Corps action prior to World War II, devoting a full 145 pages to this epic confrontation. Although I commend Clark's attention to detail, his insistence on documenting minor unit actions (often at the platoon and squadron levels) sometimes makes it difficult to follow the overall flow of the battle. Maps complement the narrative, but the book could use more of them, with more details.

The author then follows the 4th Brigade through the battles of Soissons and Blanc Mont, the Saint-Mihiel offensive, the Meuse River campaign, and occupation duty in defeated Germany. An illuminating final chapter provides valuable information on the "other" marines (not in the 4th Brigade) who served in France during World War I. Here Clark briefly describes the activities of Marine aviators, women marines, and marines who served directly with the US Army in staff and command positions. He also examines the experiences of the 5th Marine Brigade, which arrived in France in September 1918—too late to see combat.

Making extensive use of unit histories, as well as letters and diaries of the marines and soldiers involved, Clark paints a nuanced picture of life (and death) on a World War I battlefield. Indeed, he is at his best in recounting the daily brutality of combat in the trenches and no-man's-lands. Although some details may be lost by the time the reader turns the final page, in the end the payoff makes the effort worthwhile. An outstanding read, well organized and thorough, *Devil Dogs* is an important and essential contribution to military history.

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Around the World in 175 Days: The First Round-the-World Flight by Carroll V. Glines. Smithsonian Institution Press (http://www.si.edu/sipress), 750 Ninth Street NW, Suite 4300, Washington, D.C. 20560-2300, 2001, 208 pages, $29.95.

I had the very good fortune to meet both Col Carroll V. Glines and one of his subjects, Maj Gen Leigh Wade. Both had two great blessings in common: long, hands-on experience with flying and the longevity to have witnessed much of the first century of aviation. Additionally, Glines is blessed with a wonderful prose style that makes everything he writes both interesting and highly readable. General Wade was one of the pilots on the round-the-world flight, and my engaging afternoon with him in 1982 made me eager for even more of the story. Much has been written about that great adventure, and only a person with Glines's vast expertise and writing competence could hope to add to that literature in a significant way.

More a historian of aviation than of military airpower (notwithstanding his full career as an Air Force pilot), Glines has also authored such books as *Bernt Balchen: Polar Aviator;* several works on Gen Jimmy Doolittle; *Chennault's Forgotten Warriors: The Saga of the 308th Bomb Group in China; Roscoe Turner: Aviation's Master Showman;* a work about global circumnavigation by air; and too many others to mention here. *Around the World* is an adventure story, to be sure, but it is thoroughly documented and meets high scholarly standards.

Readers of *Aerospace Power Journal* will want to add this book to their reading lists, perhaps more for the sake of recreation than for their education as air warriors/scholars. But in a general way, *Around the World* will add to their databases on the foundations of American airpower by adding insights into its development, even in the midst of the great Billy Mitchell controversies. The trip took place on the eve of Mitchell's court-martial, when the conventional picture paints interservice relations at their very worst. Yet, the Navy's freely given support for the great Air Service achievement was not only outstanding, but also essential to its success. Gen Mason Patrick, then at the helm of the Air Service, prominently recognized that support. Patrick's flyers probably spent as many of the 175 nights aboard naval and Coast Guard vessels as they did ashore, and the refueling and maintenance services proved crucial. Too, when Maj Frederick Martin, the flight's leader, and his mechanic crashed in the Alaskan wilds, major search-and-rescue efforts came from many sources.

Martin led the flight of four Douglas Air Cruisers westbound out of Seattle, notwithstanding the headwinds they would generally have to face. He dropped out soon after the departure, and for 10 days his fate was unknown. Capt Lowell Smith, who had participated in the world's first air-to-air refueling only a year before, assumed command and received instructions from General Patrick to proceed with the mission, notwithstanding the loss. The remaining three Cruisers proceeded along the Aleutian Islands with frequent stops at the many ships deployed along the route. Although they flew in daylight, they had little help from instruments, often were out of sight of the surface below, and had no landmarks that would show them the way. Nonetheless, they made it across the Pacific.

Relations between the United States and Japan were not good, in part because of American legislation in 1924 that restricted immigration by Orientals. Though the worst was yet to come, the trip through the Japanese islands was difficult but ultimately successful. As the three surviving aircraft passed along the coast of Southeast Asia, one lost an engine and had to make a forced landing. The movement of the aircraft to a place where a new engine could be delivered and installed in the plane was a saga in itself.

Up to that point, the aircraft flew with pontoons for water landings, but those were replaced by wheels for the flight across the Asian subcontinent and thence to France and the United Kingdom. Three made it to the British Isles and were refitted with pontoons for the transatlantic voyage. Soon after going out over the ocean, though, the crew led by Leigh Wade (then a lieutenant) made a second forced landing. He got his plane, dubbed the *Boston*, down in relatively good shape. A British warship quickly found Wade and his crewmate, Henry H. Ogden, and made a futile attempt to tow the airplane back to land. After the flyers arrived on land, they hustled back across the Atlantic and met the remaining two aircraft in Nova Scotia. General Patrick had dispatched another Douglas Cruiser, *Boston II,* to that province so that Wade and Ogden could complete the trip to Seattle. Once back in North America, the adventure became a publicity tour that finally ended in Seattle.

Carroll Glines has done a superb job of researching and writing this new account of the famous flight. He has spent a lifetime studying the secondary sources about this event and has thoroughly explored the primary unpublished sources as well. I highly recommend *Around the World* to *APJ* readers who desire an evening of entertaining reading that will also yield insights into the nature of flying in the formative years of the 1920s.

Dr. David R. Mets
Maxwell AFB, Alabama

American Volunteer Fighter Pilots in the RAF, 1937–43, Classic Colours American Eagles, sec. 1, by Tony Holmes. Classic Publications (http://www.classic-books.co.uk), Friars Gate Farm, Mardens Hill, Crowborough, East Sussex TN6 1XH, England, 2001, 128 pages, £16.95 (softcover).

The Classic Colours American Eagles series of four "sections," written by Tony Holmes and Roger Freeman (sections two through four), is a noteworthy undertaking designed to appeal to the World War II buff who wants a concise history of the topic and lots of photographs and color profiles of aircraft. In section one, Holmes certainly lives up to this idea. His topic is the countless Americans who served in the Royal Air Force (RAF) from 1937 to 1943. Although Holmes does not account for more than a fraction of them, he uses their experience as a unifying theme to recount the story of the development of the RAF during those critical years. His descriptions are brief, and he tends to focus too much on a few specific Americans, but the reader does come away from this colorful volume with a better idea of the scope of American involvement with the British air arm. The book's greatest contribution is not the summary-like narrative, however, but the illustrations. Holmes includes over 150 photographs of both men and machines, as well as 30 beautifully done color profiles of aircraft—mostly Hurricanes and Spitfires. The pictures and profiles of aircraft are accompanied by comprehensive sidebars that trace the history and fate of both the pilots and the particular machine. The fact that many of the photos have not been previously published adds to the value of the book. Overall, Holmes has produced a volume that, though far from a definitive history of Americans in the RAF, briefly tells the story of their service, relates the development of the RAF, and supports this account with an extraordinary number of photographs and color profiles. *American Volunteer Fighter Pilots in the RAF, 1937–43* is a worthwhile addition to any collection of books about World War II.

Brig Gen Philip D. Caine, USAF, Retired
Monument, Colorado

Flak: German Anti-Aircraft Defenses, 1914–1945 by Edward B. Westermann. University Press of Kansas (http://www.kansaspress.ku.edu/printbytitle.html), 2501 West 15th Street, Lawrence, Kansas 66049, 2001, 448 pages, $45.00.

Despite my initial impressions of the title, *Flak* is not a dull book about "all you ever wanted to know about flak but were afraid to ask." Quite the contrary, Westermann weaves a splendid overview of the historical significance of flak. He starts with World War I—including prominent figures and important technical information—and carries this concept through the interwar years to World War II.

Flak doesn't stop there. Westermann also takes the reader into the economic impact of flak gun and ammunition production on the Nazi Germany war machine. His thorough research of German, British, and American archives helps illustrate the political turmoil that the leadership of Germany, Bomber Command, and the US Army Air Corps experienced as their respective fortunes regarding flak waxed and waned through the war. Westermann uses crew member interviews to take the reader into the bombers themselves as those men recount the nightmarish missions when they were under attack by flak.

Wait! There's more! *Flak* isn't just about flak. Westermann goes to great lengths to paint the full picture of Germany's air defense capabilities in World War II. Germany's air defense was dependent not only on flak but also on many other players, such as fighter aircraft, dummy installations, other deception measures, searchlights, and smoke batteries. All of these were key elements during Germany's six-year air defense campaign. His research of German documents is extensive, and he clearly lays out for the reader how all of these parts figured into the German war machine. He further illustrates the impact of manpower shortages, ammunition shortages, public opinion, political maneuvering, and the chaos and frenzy of war, as well as the effect that all of these had on the fate of flak during the course of the war.

In fact, during his research, Westermann uncovered extensive Bomber Command and US Army Air Corps documentation that detailed flak losses and flak damage to Allied bombers. While neither Ally came out and directly said it, Westermann's research and the wording of the countries' reports clearly indicate that German flak had a significantly larger impact on the Allied bomber campaign than was credited by the Allies—yes, even greater than the impact of fighters! Even the German reports tacitly drew the same conclusions, despite widespread belief that German fighters made the greater contribution.

Flak was a faithful friend; a hated enemy; a comforter to civilians as bombs rained on their cities; a scapegoat during bad times; and, in the end, the only remaining, steadfast defender of the German skies as German fighter aircraft succumbed to dwindling numbers and sporadic fuel shortages. The important lessons learned from the German air defense campaign—including tactical deception, employment of air defense assets, and implications of industrial capacity—are detailed by *Flak* and are as equally applicable today as they were almost 60 years ago. Air campaign planners would do well to give this book a read!

Flak is a wonderfully written book. It makes a magnificent read for the World War II history buff who wants something to read on an offbeat but engaging topic. It's a terrific research tool for anyone looking into the workings of a comprehensive World War II air defense system. It is also a great primer for air defense tactics and doctrine, with application even to today's air campaigns. I highly recommend this "two-thumbs-up" book!

Maj Paul G. Niesen, USAF
Maxwell AFB, Alabama

Matthew B. Ridgway: Soldier, Statesman, Scholar, Citizen by George C. Mitchell. Stackpole Books (http://www.stackpolebooks.com), 5067 Ritter Road, Mechanicsburg, Pennsylvania 17055-6921, 2002 (originally published by Cathedral Publishing, Pittsburgh, Pennsylvania, 1999), 231 pages, $15.95.

Gen Matthew B. Ridgway has gone down in our military history as one of our greatest leaders. This recognition is based not just on his military service and combat performance but also on his entire life. Dr. George C. Mitchell, journalist, diplomat, and educator, has taken advantage of his personal relationship with General Ridgway and his access to the extensive documentary record to produce an authorized biography that is a compact evaluation of this extraordinary man.

Courage, character, and commitment were Ridgway's hallmarks. The author illustrates these by presenting four distinct sections that correspond to the title. In each he relates many aspects of Ridgway's life and career with just enough detail to convince the reader of this man's uniqueness. Many of these observations deserve to be, and have been, the subject of book-length examinations. Through a judicious use of Ridgway's own written and spoken words, one sees the world through his eyes and is educated in a timeless sense that is apropos in this or any other age.

On the subject of liberty, Ridgway tells us, "Admission to the Hall of Freedom is not free. The entry fee is high. The charge for remaining there is higher yet. The liberty, which is ours . . . is challenged still." He continues, "We should expect to pay a price, to make a sacrifice, to retain those treasures. Measured against their loss, no price would be too high to pay, no sacrifice too heavy to endure" (p. 134). Although spoken at a different time, under different circumstances, these words are instructive and inspiring to us as we face the scourge of global terrorism that threatens us today. This book is full of similar inspirations that will strengthen the heart of service members and embolden them to perform their duties to the fullest measure.

Airmen may be interested to read Ridgway's thoughts during the mid-1950s when the Air Force, Navy, and Army were in direct competition for limited available resources. Although he held airpower in great esteem, his words reveal a belief in the importance of a strong Army: "There is still one absolute weapon—the employment of which dominates every consideration of National Security—the only weapon capable of operating with complete effectiveness—of dominating every inch of terrain where human beings live and fight, and of doing it under all conditions of light and darkness, heat and cold, desert and forest, mountain and plain. That weapon is man himself" (p. 134). Words like these transcend all manner of warfare, in any age, and should be appreciated by all—no matter the color of one's uniform.

Another inspirational aspect of Ridgway's life is the manner in which he professed his opposition to those policies he felt were detrimental to this country. Whether it was his disagreement over the budget cuts that threatened national security or our involvement in Vietnam, Ridgway opposed policies in a forceful manner that left no doubt regarding his position on the issues while maintaining his loyalty to the chain of command and the concept of civilian primacy over the military. One may disagree with Ridgway's position on any number of issues, but one must respect the way in which he went about his duties both in and out of uniform.

This book is appropriate for the rucksack or flight bag of any service member looking for an easy reference during hard duty. It is well written and conveniently organized. The only distraction was the misidentification of a recent Army chief of staff in one of the book's photos. That faux pas aside, this book is entertaining, educational, and highly recommended as a worthy investment of one's time and effort.

Command Sgt Major James H. Clifford, USA
Fort Gillem, Georgia

NATO's Air War for Kosovo: A Strategic and Operational Assessment by Benjamin S. Lambeth. RAND (http://www.rand.org/publications/MR/MR1365), 1700 Main Street, P.O. Box 2138, Santa Monica, California 90407-2138, 2001, 276 pages, $20.00 (softcover).

NATO's Air War for Kosovo is an important contribution to the study of air warfare. Ben Lambeth's characteristically clear prose, thoroughness, and objectivity fill an important gap left by the failure of the US Air Force's Air War over Serbia Study to produce an unclassified volume. Lambeth's book, together with the unclassified volumes of the *Gulf War Air Power Survey* (Washington, D.C.: Government Printing Office, 1993) and the single-volume *Deliberate Force: A Case Study in Effective Air Campaigning* (Maxwell AFB, Ala.: Air University Press, 2000), provides general readers with official or at least semiofficial examinations of three of the four major US air campaigns of the 1990s—Desert Storm (1991), Deliberate Force (1995), Allied Force (1999), and the ongoing air-control campaign against Iraq (1992–present).

The focus of *NATO's Air War for Kosovo* is Allied Force, the air campaign conducted from 24 March through 9 June 1999 to halt and reverse the excesses of Slobodan Milosevic's rule over Serbia's southernmost province of Kosovo. In the first two chapters, Lambeth nicely outlines growing international frustration with the harshness of Serbian military actions in Kosovo during the late 1990s. This frustration centered on the Serbian military's always cavalier and increasingly intentional killing of unarmed ethnic Albanian civilians as part of its operations against the nationalist Kosovo Liberation Army. When diplomacy failed to bring Milosevic to heel in the winter of 1998–99, NATO launched its air campaign. Lambeth lays out the ensuing operational details of Allied Force in three chapters, focusing predominantly on bombing operations and their related planning, targeting, and command and control (C^2) activities. Reflecting the hesitancy and differences within the alliance, Allied Force began as a desultory campaign of about 400 sorties per day, aimed at a restricted target list of enemy air defenses and military forces. But by the end of May, the operational tempo had reached 900 sorties per day, and the target list had expanded to include infrastructure targets such as bridges and power plants, civil-government facilities, and economic and manufacturing installations. Many of the latter were "crony" targets—facilities chosen for attack in part because members of Milosevic's inner circle of friends and supporters owned them. In total, NATO air forces launched 38,004 combat sorties, of which 10,484 were strikes against targets in Serbia, Kosovo, and Montenegro, and 18,439 of which were aerial tanker and airlift sorties in support of combat and humanitarian-relief operations. The three remaining chapters of the book examine the strategic implications of the war from different perspectives—namely, the effect of the bombing on Milosevic's decision making, lapses in strategic planning, and implications for air-warfare theory.

Lambeth's focus on bombing operations and supporting activities is hardly surprising, given his background as one of only a handful of civilians who have flown a wide range of fighter-aircraft types (over 20), some during exercises and some during actual operations. A prolific writer, he has published dozens of articles and books on air warfare over the past two decades. He knows the world of air combat, its language, and its focus areas. Consequently, his discussion of the phases and salient features of Allied Force is energetic and broad, ranging from the combat debut of B-2 bombers and the large-scale use of unmanned aerial vehicles to examinations of more sensitive issues, such as the F-117 shootdown and the bombing of the Chinese Embassy in Belgrade. Lambeth does not pull punches. For example, he credits the F-117 shootdown to the Serbs' tactical innovation in the presence of American tactical predictability and cites disjointed American intelligence procedures for the embassy debacle. He gives equally objective treatment to other issues, such as collateral damage, inadequate suppression of enemy air defenses, and initial errors in management and control procedures for allied airspace. Taken together, these chronological and topical discussions provide a concise reference for the flow and dynamics of the salient elements of the Allied Force combat experience.

Likewise, the strategic analysis in *NATO's Air War for Kosovo* hits the most obvious high points of Allied Force. Lambeth's assessment of the bombing campaign's relative role in forcing Milosevic's capitulation is comprehensive. The bombing, as he points out, was only one element in a broad front of diplomatic, economic, and military pressure brought to bear on Milosevic. But he declares unequivocally that the air campaign gave both credibility and force to the other elements: "Had it not been for Allied Force and its direct effects, the additional stimuli would never have materialized. As [Gen Wesley J. Clark, supreme allied commander, Europe,] later remarked, 'The indispensable condition for all other factors was the success of the air campaign itself' " (p. 82).

In a complementary discussion, Lambeth considers the essential elements of the strategy debate, which focused on three issues—gradualism, the insertion of NATO ground forces, and targeting doctrine. NATO civilian leaders, as Lambeth relates, had strong reasons for insisting that operations be intensified and expanded slowly, mainly in the hope that the alliance would find Serbia's breaking point at the rock-bottom levels of military commitment and political risk. Consequently, alliance leaders only reluctantly allowed NATO airmen to bring in reinforcements and expand the range of targets when the campaign seemed to bog down in the face of unexpected Serbian resilience. Reflecting the same conservatism, NATO political leaders, notably President Bill Clinton, also eschewed a "ground option" publicly and emphatically at the start of the campaign, relenting in principle only after it began to drag on. The confrontation over targeting doctrine found its focus in the relationship between General Clark and his principal air subordinate, Lt Gen Michael Short, USAF. At the onset of operations, Clark directed Short to focus on suppressing Serb air defenses and attacking Serb military units in the field. Short pressed for an expanded target list but got it only when the campaign stagnated. Still, Clark never relinquished detailed control of targeting to his air expert, a source of great friction between the two. Lambeth relates that General Clark's "aggressive micromanagement was met by frustrated and increasingly transparent passive-aggressive rebellion against it [by Short]" (p. 190). This perception of open conflict (which, by many accounts, is accurate) does not speak well of the cohesion and professional discipline of NATO leadership, even within American ranks.

Of course, Lambeth's study does have some limitations. Although it generally includes all facets of air operations, it focuses upon the strike aspects. Lambeth gives only minimal coverage to space support through brief discussions about systems and the use of space-gathered data to provide real-time, in-cockpit information to B-52s and B-1s in flight; enhance battle damage assessment; and improve search and rescue capabilities. Similarly, he does not fully examine air mobility, despite the fact that nearly twice as many mobility sorties were flown during the conflict than strike sorties. He does praise both the irreplaceable ability of C-17s to move the Army's Task Force Hawk into Albania and the stress that Allied Force placed on the Air Force's tanker fleet, supposedly designed to handle two major theater wars. But Lambeth also overlooks the Herculean work of US Transportation Command and Air Mobility Command, which delivered forces and materiel on time despite nonexistent or rapidly changing deployment plans, US European Command's imprecise use of movement priorities, and the convoluted and incomplete C^2 arrangements made for air mobility by General Short and other theater commanders.

Likewise, Lambeth does not address support issues, although force-beddown challenges, malpositioned munitions, airspace-access problems, uncertainties in obtaining diplomatic overflight clearances, and so forth rendered the success of Allied Force nearly as much the product of logistical and staff-support miracles as of bombs placed on target. In fairness, Lambeth states up front that he will focus on an operational- and strategic-level analysis of the planning, execution, and assessment of bombing operations. The point here is that the restricted focus of the treatment provides the opportunity and some initial help for further study, and it suggests that a better title for the book might have been *The Conduct and Value of Bombing Operations during the War for Kosovo*. All that said, *NATO's Air War for Kosovo* is the logical first read for anyone interested in Allied Force in particular and its implications for the future of air and space warfare in general.

Col Robert C. Owen, USAF, Retired
Embry-Riddle Aerospace University
Daytona Beach, Florida

Touch and Go

In this section of "Net Assessment," you will find additional reviews of aviation-related books and CD-ROMs but in a considerably briefer format than our usual offerings. We certainly don't mean to imply that these items are less worthy of your attention. On the contrary, our intention is to give you as many reviews of notable books and electronic publications as possible in a limited amount of space. Unless otherwise indicated, the reviews have been written by an APJ *staff member.*

America's Airports: Airfield Development, 1918–1947 by Janet R. Daly Bednarek. Texas A&M University Press (http://www.tamu.edu/upress), John H. Lindsey Building, Lewis Street, 4354 TAMU, College Station, Texas 77843, 2001, 240 pages, $39.95 (hardcover).

Most of us know of the relationship between civil airfields and military interests. In this book, Professor Bednarek, once an official Air Force historian, has provided a thorough treatment of airport development and management in the first four decades of flight. *America's Airports* is the first study to delve deeply into the experimentation and innovation that formed municipal airports. She describes the trend from local boosterism development to federal and military investment in airfields throughout the nation, especially in the late 1930s, when the demands of World War II required federal attention. She not only discusses the complex local and federal relationships but also investigates legal and city-planning issues.

The Best of *Wings* Magazine by Walter J. Boyne. Brassey's, Inc. (http://www.brasseysinc.com/index.htm), 22841 Quicksilver Drive, Dulles, Virginia 20166, 2001, 256 pages, $27.50 (softcover).

Walter Boyne, one of America's premier aviation writers, has collected an interesting mix of his articles previously published in *Wings* magazine. Boyne has earned his credentials in nearly 40 books and, by his account, 600–700 articles on aviation. This collection includes accounts of some unusual aircraft of the past 90 years, including Howard Hughes's H-1 and the Boeing B-9. It also relates the building of some great military aircraft such as the Boeing B-52 and McDonnell F-4. Readers who like airplanes will enjoy, perhaps again, the fascinating writing of this knowledgeable author. Particularly useful is the preface, which gives a snappy account of the periodical publishing history of aviation.

The Technological Arsenal: Emerging Defense Capabilities edited by William C. Martel. Smithsonian Institution Press (http://www.si.edu/sipress), SI Building, Room 153, Washington, D.C. 20560-0010, May 2001, 284 pages, $29.95.

In an informative compendium of essays, William Martel, professor of national security affairs at the Naval War College, attempts to bridge the gap in understanding between high-technology aficionados and laymen with respect to emerging defense technologies. *The Technological Arsenal* reviews the Department of Defense's (DOD) technology-development programs in the areas of directed energy, military targeting and effects, and command and control. Focusing on technologies that could yield operational weapon systems between 2010 and 2020, the editor does not attempt to address all new technologies under development at DOD. Instead, the book concentrates on those technologies that are mature enough for initial system development to have begun, such as the airborne laser. The experts who have contributed to this work do a superb job of laying out the many technical challenges inherent in the development—and eventual employment—of lasers for various missions, high-power micro-waves, advanced cruise missiles, nonlethal weapons, space-operations vehicles, unmanned aerial vehicles, computerized command-and-control architectures, and information-warfare systems.

The technology-savvy reader may be disappointed at the lack of technical description in most of the essays, but each contains a good bibliography for further study. Overall, *The Technological Ar-*

senal does a fine job of educating the reader on how the future of warfare might look.

Technology and Security in the Twenty-First Century: U.S. Military Export Control Reform by John J. Hamre, Jay C. Farrar, and James A. Lewis. CSIS Press (http://www.csis.org/pubs/index.htm), Center for Strategic and International Studies (CSIS), 1800 K Street, NW, Washington, D.C. 20006, May 2001, 76 pages, $21.95.

Export control of military-critical technologies has been an important, albeit unsung, instrument for protecting US national security for most of the twentieth century. Tight controls and complex licensing procedures were utilized to keep the most advanced technologies, mostly developed by US defense industries, out of the hands of potential adversaries during the Cold War. However, in today's globalized economy, in which defense industries do not lead the development of the most important technologies, the 1970s-era export-control procedures still in place today can potentially damage US national security. This report by the CSIS Military Export Control Project examines the problem in depth and makes recommendations on how to change the export-control regime to expedite the useful transfer of ubiquitous technologies, while ensuring the interoperability of weapons systems with our allies and keeping those truly military-specific technologies away from potential adversaries. This report is recommended for anyone interested in export control and technology issues.

India's Emerging Nuclear Posture: Between Recessed Deterrent and Ready Arsenal by Ashley J. Tellis. RAND (http://www.rand.org), 1700 Main Street, P.O. Box 2138, Santa Monica, California 90407-2138, 2001, 885 pages, $40.00 (hardcover), $25.00 (softcover).

This comprehensive text outlines how India developed nuclear weapons, what threat scenarios it uses, and what political forces drive its nuclear arsenal. It also discusses the models that Indian decision makers may use to develop this arsenal in the future. By examining territorial flash points and the strategic environment India faces on the subcontinent, Tellis explores various force options in light of technical and budgetary limitations. He also argues that it is time for the United States to reexamine its ties with and policies towards India and attempt to build on past pronouncements to support a more stable region that now has nuclear weaponry. Anyone whose specialty is India and/or the proliferation of nuclear weapons should study *India's Emerging Nuclear Posture*.

Understanding Information Age Warfare by David S. Alberts et al. Command and Control Research Program (CCRP) Publications (http://www.dodccrp.org), c/o EBR, Inc., 1595 Spring Hill Road, Suite 250, Vienna, Virginia 22182-2216, 2001, 312 pages, free from Web site or to government offices.

Need to know about war in the computer age? This detailed primer explains the importance and possibilities of the latest technology. Not only does it show concepts, theories, hypotheses, and models, but also it recommends ways of getting and keeping a military advantage. The authors explain the physical, information, and cognitive worlds; their relationships; and the way modern war works in those areas. They also point out the value of information in war, from the writings of Sun Tzu and Clausewitz to current and future sources of data. We must avoid the uncertainty of war and use modern tools as force multipliers for quick victory at the lowest cost. Detailed models, comparisons with traditional systems, and exercise examples all aid the reader's comprehension by explaining the use of information-age tools, organizational structures, and decision processes. A fount of knowledge for the computer illiterate and an update for the computer savvy, *Understanding Information Age Warfare* calls for aggressive planning, investment, and coordination of these tools.

Maj Herman Reinhold, USAF
Yokota AB, Japan

Lightning Rod: A History of the Air Force Chief Scientist's Office by Dwayne A. Day. Chief Scientist's Office, United States Air Force, Washington, D.C., 2000, 310 pages.

Starting with the famous bond between Gen Hap Arnold and Dr. Theodore von Kármán, Dwayne Day uses the history of the Air Force Chief Scientist's Office to chronicle the relationship between the Air Force's leadership and the science and technology community. Since the establishment of the position of chief scientist in 1950, 29 interesting and diverse individuals from academia, industry, and the government have served as the principal science and technology advisor to the chief of staff and secretary of the Air Force. Day gives us a synopsis of the life and career of the individuals who have filled this important role, as well as a taste of the political and technological environment in which they served. In this volume, we see that the relationship between Air Force leadership and its chief technology advisor has been sometimes effective, sometimes tumultuous, and sometimes ineffective, depending upon the personalities involved and the atmosphere at the time. *Lightning Rod* will be of most interest to avid Air Force historians or science and engineering officers curious about how technology decisions are made at the highest levels of the Air Force.

Silent Heroes: Downed Airmen and the French Underground by Sherri Greene Ottis. University Press of Kentucky (http://www.uky.edu/UniversityPress), 663 South Limestone Street, Lexington, Kentucky 40508-4008, 2001, 248 pages, $24.00.

Action . . . suspense . . . valiant heroes and heroines fighting evil foes! Sherri Ottis's inspiring book has it all, telling the tale of rescue groups created (and often betrayed) in France who risked all to save downed Allied airmen in World War II. Readers will relish its accounts of both the greatest tragedies—the courageous patriots caught, tortured, and killed—and the greatest successes—the bravery and planning that saved over 5,000 young lives. Like *Schindler's List*, *Silent Heroes* could be a great movie that tells of little-known heroes who saved many lives amidst tragedy. And its excellent bibliography and footnotes give readers the opportunity to learn more about these heroes. Forget dry history books and fictional thrillers. The real people and true courage of *Silent Heroes* will appeal to a wide audience.

Maj Herman Reinhold, USAF
Yokota AB, Japan

The Great Snafu Fleet: 1st Combat Cargo/344th Airdrome/326th Troop Carrier Squadron in World War II's CBI Theater by Gerald A. White Jr. Xlibris Corporation (http://www.Xlibris.com), 436 Walnut Street, 11th Floor, Philadelphia, Pennsylvania 19106-3703, 2001, 276 pages, $28.79 (hardcover), $18.69 (softcover), $8.00 (E-book).

We have very few accounts of the magnificent airpower performances in the China, Burma, and India (CBI) theater of World War II, partly because of very weak archival resources. Gerald White not only combed the archives but also interviewed the participants and examined privately held records to produce this magnificent account of the gallant C-47 squadron that operated as both the 1st Combat Cargo Squadron and later as the 326th Troop Carrier Squadron in 1944 and 1945, delivering supplies and personnel in Burma and China. Operations in this often-forgotten part of the global war forged tools the Air Force would use in future airlifts. In the foreword, Gen Ronald R. Fogleman, retired Air Force chief of staff, points out how hard it was to provide lift when "our airlift capability was largely what could be appropriated from civilian airlines for the duration." Still, our airmen prevailed, thus adding to the luster of American airpower.

An idea not coupled with action will become no bigger than the brain cell it occupied.

—Arnold H. Glasgow

Mission Debrief

Aerospace Power Journal is always looking for good articles written by our readers. If you've got something to say, send it to us.

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As the professional journal of the Air Force, *APJ* strives to expand the horizons and professional knowledge of Air Force personnel. To do this, we seek and encourage thought-provoking articles. Please submit yours to the Editor, *Aerospace Power Journal*, 401 Chennault Circle, Maxwell AFB AL 36112-6428, or electronically to apj@maxwell.af.mil.

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The Editor

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Dr. Benjamin S. Lambeth (BA, University of North Carolina at Chapel Hill; MA, Georgetown University; PhD, Harvard University) is a senior staff member at RAND. He served previously in the Office of National Estimates at the Central Intelligence Agency. A civil-rated pilot, he has flown in more than 35 different types of fighter, attack, and jet trainer aircraft with all of the US services and eight air forces worldwide. In 1989 he became the first US citizen to fly the Soviet MiG-29 fighter and the first Westerner invited to fly a combat aircraft of any type inside Soviet airspace since the end of World War II. His book *The Transformation of American Air Power* (Cornell University Press, 2000) won the Air Force Association's Gill Robb Wilson Award in arts and letters for 2001. A member of the Council on Foreign Relations and the Board of Reviewers of *Aerospace Power Journal*, he was recently elected as an honorary member of the Order of Daedalians, the national fraternity of US military pilots.

Col Timothy G. Malone (USAFA; MS, Embry-Riddle Aeronautical University) is commander of the Warrior Preparation Center, Einsiedlerhof Air Station, Germany. He has served in a variety of operational, command, and staff positions, including commander of the 87th Flying Training Squadron at Laughlin AFB, Texas, and deputy commander of the 4th Operations Group, Seymour Johnson AFB, North Carolina. He was also part of the initial F-15E cadre at Luke AFB, Arizona. After completing a National Security Fellowship at Harvard University, he served on the Joint Staff, J-7, Washington D.C., as chief of the Joint Doctrine Branch. Colonel Malone is a graduate of Squadron Officer School, USAF Fighter Weapons School, and Air Command and Staff College.

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Lt Col Merrick E. Krause (USAFA; MAS, Embry-Riddle Aeronautical University; MA, School of Advanced Airpower Studies; MA, National War College) is Senior Military Fellow at the Institute for National Strategic Studies, National Defense University. Previous assignments include F-4E aircraft commander and flight leader, Moody AFB, Georgia, and Seymour Johnson AFB, North Carolina; F-15E instructor and evaluator pilot for the 4th Tactical Fighter Wing, Seymour Johnson AFB; mission commander during Operations Desert Shield/Storm and Desert Resolve; test project officer, chief of weapons, Strike Eagle test flight commander, and instructor and evaluator pilot at the Air Warfare Center, Nellis AFB, Nevada; and chief of aerospace campaign strategy and the CENTCOM/SOUTHCOM team, Checkmate Office, Air Staff, Pentagon, Washington, D.C. A command pilot with more than 2,800 flying hours and 216 combat hours, Lieutenant Colonel Krause is also a graduate of the USAF Fighter Weapons School.

Lt Col Lester W. Grau, USA, retired (BS, University of Texas at El Paso; MA, Kent State University), is a military analyst for the Foreign Military Studies Office (FMSO) of the US Army Training and Doctrine Command at Fort Leavenworth, Kansas. He has held a variety of command and staff positions in the continental United States, Europe, and Vietnam, including deputy director, Center for Army Tactics, and chief, Soviet Tactics Instruction Branch, Army Command and General Staff College (CGSC); political and economic adviser, Headquarters Allied Forces Central Europe, Brunssum, the Netherlands; and diplomatic courier, Moscow. He has published over 80 articles and studies on Soviet and Russian tactical, operational, and geopolitical subjects. Colonel Grau's academic degrees are in international relations, and he is a graduate of the US Army Defense Language Institute (Russian) and the US Army's Institute for Advanced Russian and Eastern European Studies. His military education includes Infantry Officers Basic and Advanced Courses, USA CGSC, and USAF Air War College. He has authored and coauthored several books: *The Bear Went over the Mountain: Soviet Combat Tactics in Afghanistan* (1996), *The Other Side of the Mountain: Majahideen Tactics in the Soviet-Afghan War* (coauthored with Ali Jalali, 1998), and *The Soviet-Afghan War: How a Superpower Fought and Lost* (2001). He is currently working on a book about the recent wars in Chechnya.

Dr. Jacob W. Kipp (BS, Shippensburg State College; MA, PhD, Pennsylvania State University) is a senior analyst with the Foreign Military Studies Office (FMSO) of the US Army Training and Doctrine Command at Fort Leavenworth, Kansas. He taught Russian history in the History Department at Kansas State University until 1985 when he joined the FMSO Soviet Army Studies Office. Dr. Kipp is an adjunct professor of history with the University of Kansas and teaches in the Soviet and East European Studies Program. He has served as the American editor of *European Security* for 10 years and is now founding-editor emeritus. He is an expert and has written much on Russian/Soviet and East European military history, particularly the impact that technology had on the evolution of their military strategy and doctrine. He has also written extensively on Russian aviation and aerospace topics. He edited and contributed an introductory essay to the translation of A. A. Svechin's *Strategy* (1992) and was the coeditor of a collection of essays on *The Future of the Soviet Military* (1993). He also edited and contributed an introductory essay to the translation of V. K. Tirandafillov's *The Nature of Operations of Contemporary Armies* (1993), and translated M. A. Gareev's *If War Comes Tomorrow?* (1998). Dr. Kipp was awarded the Ira C. Eaker Award in 1988.

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