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Air War Plans Division 1
The Air Plan That Defeated Hitler

ASPJ STAFF

In August 1941, four men, all former instructors at the Air Corps Tactical School (ACTS) at Maxwell Field, Alabama, reported to the Air War Plans Division (AWPD) in Washington, D.C., to lay the foundation for a comprehensive, strategic air war plan. Lt Col Hal George called upon Maj Laurence Kuter, Maj Ken Walker, and Maj Haywood S. Hansell Jr. to answer a request from President Franklin D. Roosevelt for a "production plan to defeat our enemies"—one that would outline specific air requirements for industrial mobilization should the United States become embroiled in a war. After nine days, the team delivered a briefing to Gen Henry Arnold and Gen George C. Marshall that specified production requirements for 13,083 bombers; 8,775 fighters; 2,043 observation and photographic aircraft; 2,560 transports; and 37,051 trainers—an astounding total of 63,512 aircraft. Although these numbers were impressive, the planners exceeded Roosevelt's tasking by recommending a strategy for prosecuting the war against the Axis powers. That strategy assumed that airpower could achieve strategic and political objectives in a fundamentally new way.

Building upon untested airpower theories (taught throughout the 1930s at ACTS) that relied upon self-defending, high-altitude daylight bombers, the team first envisioned a strategic defensive in the Pacific theater while prosecuting an all-out air war against Germany. Air forces would concentrate for 18 months before launching an intensive six-month air campaign against Nazi Germany. The forces that had assembled at bases in Great Britain would focus on industrial target systems—the "industrial web"—that supported the German war effort. Electrical power, rail and canal transportation, petroleum production, and other industries formed the backbone of any industrial power. The AWPD staff also recognized that the German Luftwaffe would mount a strong defense. Consequently, the enemy air force became an "intermediate objective of overriding priority." Allied strategists later incorporated elements of AWPD-1 into AWPD-42 and the plans for the Combined Bomber Offensive that commanders used to prosecute the air war against Germany.

To Learn More . . .

Biddle, Tami Davis. *Rhetoric and Reality in Air Warfare: The Evolution of British and American Ideas about Strategic Bombing, 1914–1945.* Princeton, N.J.: Princeton University Press, 2002.

Cate, James Lea, and E. Kathleen Williams. "The Air Corps Prepares for War, 1939–41." In *The Army Air Forces in World War II.* Vol. 1, *Plans and Early Operations, January 1939 to August 1942.* Edited by Wesley Frank Craven and James Lea Cate. 1948. New imprint, Washington, D.C.: Office of Air Force History, 1983.

Faber, Lt Col Peter R. "Interwar US Army Aviation and the Air Corps Tactical School: Incubators of American Airpower." In *The Paths of Heaven: The Evolution of Airpower Theory.* Edited by Col Phillip S. Meilinger. Maxwell AFB, Ala.: Air University Press, 1997.

Hansell, Haywood S., Jr. *The Air Plan That Defeated Hitler.* Atlanta, Ga.: Higgins-McArthur/Longino & Porter, 1972.

Murray, Williamson. "Strategic Bombing: The British, American, and German Experiences." In *Military Innovation in the Interwar Period.* Edited by Williamson Murray and Allan R. Millett. Cambridge: Cambridge University Press, 1996.

A Word from the Chairman

Understanding Transformation

GENERAL RICHARD B. MYERS, USAF
CHAIRMAN, JOINT CHIEFS OF STAFF

Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after changes occur.

—Giulio Douhet

WHEN THE BOMBS fell on Pearl Harbor in 1941, they shattered more than the silence of a peaceful Sunday morning; they destroyed the illusion that the US military forces were safe at home. During the three and a half years that followed, a world war transformed the US armed forces into a first-rate military. The urgency of fighting a global conflict propelled the genius of Americans to make this transformation a reality.

In a similar manner, September 11th shattered the illusion that Americans are safe at home. Today, we have the same imperative to transform our military forces in order to defeat the new threats of the twenty-first century and protect our nation. Transformation cannot wait—it must take place as we wage the War on Terrorism. President Bush summed up this challenge: "It's like overhauling an engine while driving 80 miles per hour. Yet we have no choice."[1]

If the US armed forces are to meet the President's expectations, those in uniform must have a common understanding of what transformation is and what it is not. Understanding transformation requires appreciating past transformation efforts and the current security environment. This article does not replace the detailed description of our approach to transform the joint force found in the new *Joint Vision*. Instead, it offers insight into the foundation of transformation and its corresponding intellectual, cultural, and technological aspects.

Insight from the Past

The history of the US military is a history of the nation's armed forces evolving to meet new threats and opportunities. During the Civil War, Generals Grant and Lee exploited the telegraph for theaterwide information-sharing and the railroad network to give their forces theaterwide mobility. During World War I, General Pershing incorporated the airplane to benefit US ground maneuver units and gain information on enemy formations and positions.

A more contemporary example of transformation is how President Eisenhower refocused the nation's defense establishment as the United States entered the Cold War. He adopted the *New Look* strategy to meet the dual risk of deterring nuclear war and containing communist expansion. His administration fielded strategic nuclear forces to deter a Soviet nuclear attack on the US homeland. His administration also developed tactical nuclear forces, like the Army's Honest John missile, to counter the Warsaw Pact's massive armies aimed at the heart of Europe. For four decades, US military planning, organization, and training focused on this dual threat of the Soviet Union and Warsaw Pact. As the threat did not change much, the US military's mental agility to anticipate other challenges remained underdeveloped.

With the collapse of the Soviet Union and the fall of the Berlin Wall, the US military sought to redefine its focus and strategy. The Base Force and Bottom-Up Review of the early

1990s guided US forces away from the "Fulda Gap" mentality. Defense planning, however, remained threat driven. US military forces were organized, trained, and equipped to handle the task of conducting two nearly simultaneous regional conflicts against predetermined, conventional, predictable adversaries.

The Twenty-First-Century Security Environment

The 2001 *Quadrennial Defense Review (QDR)* marked a complete departure from Cold War planning. In this document, the Defense Department articulated a more sophisticated appreciation of the twenty-first-century strategic environment, the challenges to US interests, and what military capabilities are needed. Today, the threats to US interests go beyond Iraq and North Korea. During the past decade, political, ethnic, social, and historical factors have given rise to a range of conflict and crisis—from ethnic fighting to mass starvation to massacres. Disparities in economies, resources, and populations remain powerful motivators for future intrastate and interstate strife. Likewise, religious and cultural differences may arise that reflect ancient hatreds and cause additional crises around the globe.

Belligerents motivated by this wide array of influences now have access to modern conventional arms markets, a sophisticated industrial production infrastructure, and advanced communications. Advanced production capabilities also mean that hostile nations and agents may have access to weapons of mass destruction—chemical, biological, radiological, and nuclear. In addition, the global three-trillion-dollar communications network allows previously isolated groups to communicate instantly on a worldwide scale. It also gives them access to a wide array of information and intelligence, at little relative cost. The past US monopoly on the latest and most sophisticated capabilities is gone.

The current and future security environment is further complicated by the presence of nonstate actors who frequently transcend political borders. As such, they confound conventional diplomacy. Some of these nonstate organizations are cooperative and sympathetic to US security objectives—such as humanitarian aid organizations. Others, such as al Qaida and terrorist organizations, are hostile and directly threaten US interests.

In the 2001 *QDR*, the Defense Department recognized that US defense strategy must emphasize capabilities-based forces to meet such challenges. These forces must be able to rapidly project forces, and sustain them, over great distance into inhospitable and adverse environments. US forces must be capable of rapidly developing intelligence on enemy capabilities, vulnerabilities, intentions, and centers of gravity. US forces must be capable of precision engagement. US command-and-control networks must direct dispersed US and coalition forces to gain massed fires and effects.

Secretary Rumsfeld summed up the task ahead when he said the US military must be prepared "to defend our nation against the unknown, the uncertain, the unseen, and the unexpected."[2] To meet this broad and all-encompassing task, America's joint team must transform into a capabilities-based force.

Transformation . . . What It Is NOT

First, transformation is *not* just about technology. It's not about wheeled or tracked vehicles, stealthier aircraft, or the types of missiles on submarines. It's not about twentieth-century forces being renamed with twenty-first-century titles. Such approaches risk reducing important concepts into a budget drill. These mind-sets inspire service program managers to declare their program as "transformational" and therefore safe in the budget process. This singular mentality reduces transformation efforts into rear-guard actions to defend rice bowls.

Second, transformation is *not* just about seeking revolutionary changes in the conduct of warfare. Sudden and dramatic changes do occur. Nuclear weapons and stealth technology are examples of previous remarkable changes. Revolutionary changes, however, should not be the sole focus of our transformational ac-

tivities. Silver-bullet solutions to meet future defense requirements are rare.

Finally, transformation is *not* a new concept. As mentioned previously, the US military has been transforming for two centuries. Military historians can point to how Gens Dwight Eisenhower, Carl "Tooey" Spaatz, and Holland "Howling Mad" Smith plus Adm Chester Nimitz transformed American fighting forces during World War II. Fifty years later, Gens Fred Franks, Chuck Horner, and Walt Boomer, together with Adm Stan Arthur, also transformed the way US ground, air, and maritime forces were employed during Desert Storm.

After the terrorist attacks in September 2001, transformation has taken a new urgency. We must accelerate our efforts to gain transformation's potential for our new security environment. We can't wait until the War on Terrorism is finished. The joint team needs transformation's agility and responsiveness to defeat those who threaten our nation, our citizens, and our liberties. The United States no longer has the luxury of time to prepare.

Transformation . . . What It IS

Transformation is a process and a mind-set—not a product. Adopting a transformational mind-set means applying current fielded capabilities—in the current environment—to accomplish any assigned mission. In today's fluid and dynamic world, no service's core competencies can accomplish the mission alone. Transformation is about creating joint competencies from the separate service capabilities. Transformation is specifically about uniting unique service capabilities into a seamless joint framework to accomplish the joint force commander's objectives.

Stated another way, transformation is about demonstrating flexibility, dexterity, and adaptability to anticipate how the joint force can master unexpected challenges. To understand this, war fighters must understand transformation's intellectual, cultural, and technological elements.

This understanding of transformation starts with the intellectual element. The most important breakthroughs will take place between the ears of war fighters and planners. Soldiers, sailors, airmen, marines, coast guardmen, and DOD civilians must know their units' technical and operational capability. Joint leaders must comprehend the joint force commander's intent and adapt their capabilities—sometimes in an unanticipated environment—to fulfill that intent. They must understand not just the *probable* employment of their unit—they must appreciate its *possible* employment. Commanders should draw on their previous experience—not just repeat past endeavors. In some cases, transformation may mean reaching beyond doctrine—because doctrine may not have described the specific scenario faced by the war fighter. As a result, transformation involves taking operational risk.

That's not to say military professionals should be reckless. Rather, commanders and leaders must take educated and calculated risks. They must weigh the options—to include the option of doing nothing—in the context of the ultimate objective. Transformation also means encouraging and rewarding subordinates to do the same. That carries an obligation not to punish subordinates when they try something creative and fail.

During the Second World War, Gen George Kenney personified transformation's intellectual element. He adapted the capabilities of the Fifth Air Force in the Southwest Pacific theater to meet Gen Douglas MacArthur's objectives. In one example, during August 1943, Kenney employed six squadrons of B-25s to strafe and bomb the Japanese airfield at Nadzab in advance of an airborne assault. He then used the A-20 Havoc to lay a smoke screen to shield the paratroopers as they descended on the airfield. This innovative use of bombers (to strafe) and attack aircraft (to lay smoke) allowed the US forces to quickly seize the airfield. Kenney comprehended the potential of his forces and employed them in an imaginative way. Kenney matched his forces' capabilities to the mission and environment—rather than trying to make the environment fit his preconceived notions. Stated another way, Kenney motivated his units

Gen George Kenney personified transformation's intellectual element. He adapted the capabilities of the Fifth Air Force in the Southwest Pacific theater to meet Gen Douglas MacArthur's objectives. He employed B-25s (above) to strafe and bomb a Japanese airfield and A-20 Havocs (below) to lay a smoke screen to shield paratroopers as they descended on the airfield during an airborne assault. This innovative and imaginative use of his forces' potential allowed Kenney to match their capabilities to the mission and environment—rather than trying to make the environment fit his preconceived notions. Stated another way, Kenney motivated his units to perform as the mission required—not as their habit patterns dictated.

to perform as the mission required—not as their habit patterns dictated.

Transformation's second element is cultural—it involves the operating culture within and among military units and services. American military cultures are reinforced by tested checklists and proven tactics, techniques, and procedures. It's a comfortable environment of known quantities, familiar faces, and common verbal shorthand. Transforming the US military means operating in new ways and sometimes with untested procedures. When a new idea surfaces, we should avoid dismissing it because *we never did it that way before*. The new idea may not work—but we should first evaluate the concept on its merits. This will require commanders and war fighters to rely on their judgment. Success in embracing the required cultural change will be driven by the degree of trust and confidence among joint war fighters.

In the past, the trust and confidence among service components made the difference in combat. Gens "Fighting Joe" Collins and Pete Quesada demonstrated what is possible when warriors extend trust across components' boundaries. Following the breakout at Saint-Lô, Fighting Joe and Quesada created a shortcut in the targeting procedures to support VII Corps's exploitation of the fluid battlefield. Quesada took some of his pilots, gave them an FM radio, and had them ride with the lead Army tanks. In the process, they reduced the role of the upper chain of command. Collins and Quesada delegated the target approval to the lowest level—to the warriors facing the enemy.

No one told them they had to do this. These commanders assumed risk in their operation. After all, Quesada and Collins didn't have approved procedures or prescriptive doctrine. Instead, they demonstrated flexibility and adaptability. They succeeded because they trusted each other's judgment and experience. As a result, they accomplished the mission with far fewer American casualties.

This is just one example of what S. L. A. Marshall observed after the Second World War—"*Improvisation is the essence of initiative in*

all combat" (emphasis added).[3] To succeed in the crucible of combat often requires warriors to adopt innovative approaches. As the joint team comes together, such original concepts will only succeed if there is trust among the service components.

Technology is the third element of transformation's foundation. For fiscal year 2003, the Department of Defense has requested nearly $128 billion for current and future weapon systems and capabilities. The Defense Department must invest in the right capabilities that reinforce its ability to perform the unexpected and master emerging challenges of the twenty-first century. To be successful in the future, these capabilities must allow joint commanders to integrate our service capabilities—not force commanders to deconflict them.

In the past, joint warfare was segregated warfare. Desert Storm is an example of a successful campaign that had sectored operations. Air operations kicked things off and lasted 38 days. When ground combat began, US marines attacked in a path along the Kuwait coast; the Arab coalition forces assaulted the middle sector while the US VII Corps and XVIII Airborne Corps swept around the western flank. Close air support sorties were flown during the ground war, but they were employed beyond the sight of the troops they supported. These are a few examples of how we segregated and sequenced our efforts. It was not integration—it was deconfliction.

In the future, the joint war fighters must meld component capabilities into a seamless joint framework. The key to this effort will be shared information among the components. That's what Quesada and Collins did by having an aviator with a radio accompany the lead tanks. Transformational technologies are an area of great promise for integrated information-sharing across service boundaries. Such technological solutions, however, must be applied in an environment of trust.

Interoperable and integrated command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) suites are critical. Joint ISR will allow our commanders to "watch" the enemy. Enhanced joint command and control will allow joint commanders to make decisions faster with other members of the joint force. It allows for horizontal and vertical integration of plans and operations at all levels. The issue is not moving data faster—the issue is moving the right data to the right people. Then, components gain the insight needed to fulfill the commander's intent in an unpredictable environment. Improved joint C4ISR will allow US forces to exploit a decision cycle—to observe, decide, and act—faster than an adversary. History is pretty clear: The side that does this ***faster***—wins.

Improved C4ISR connectivity is more than a military issue. It must extend to information- and knowledge-sharing with other federal agencies and with US coalition partners. The War on Terrorism has demonstrated that all instruments of national power perform best when they have access to the best available and most complete information.

Investing in the right new capabilities requires the Defense Department to ensure that new systems are "born joint" in order to share information with the other services' systems. The US military must avoid buying technologies that bolster a service-centric vision. Such an approach risks segregating the battlefield. To ensure that the systems are born joint, the Joint Chiefs of Staff are developing a joint operations concept to better describe how we will operate across the range of military operations and to better evaluate how individual service capabilities fit into the joint operational framework.

The Way Ahead

A liberally educated person meets new ideas with curiosity and fascination. An illiberally educated person meets new ideas with fear.

—Adm James Stockdale

Joint professional military education (JPME) is an ideal place for the intellectual, cultural, and technological mind-set changes we need to inspire our transformation efforts.

JPME must reinforce within the US military—both in the officer and senior noncommissioned officer ranks—the mental agility to understand service and unit capabilities and match them with the mission at hand. A revamped JPME system must foster an ability and a desire to look forward and anticipate future conflict, which is much different than the ability to look back and recite past solutions. A transformed JPME must teach our leaders not what to think, but how to think, and it must foster a culture that accepts intelligent, calculated risk. Most importantly, JPME must inculcate a culture of understanding and trust among the leaders of the services and agencies.

A transformed JPME requires reforming our intermediate and senior service schools, incorporating new and focused education for our general and flag level officers, and offering joint educational and training opportunities for those who have not received it before—our junior officers and senior NCOs. These reforms will proceed beyond formal education and training opportunities and include how the US armed forces "grow" senior general and flag officers. Joint task force commanders and regional combatant commanders must have an array of leaders with a full understanding of how to integrate the joint team *prior* to a crisis, when the lives of servicemen and women are at risk and the mission's success hangs in the balance.

The idea that JPME must match the demands of the new security environment is not a new one. When President Theodore Roosevelt accelerated the transformation of the US armed forces from a frontier army and coastal navy at the turn of the twentieth century, he and his Secretary of War Elihu Root placed a premium on the education of the officers who would lead the new forces. The Roosevelt administration matched their procurement of 16 new battleships by expanding West Point and starting the Army War College to educate the officers who would lead the force. Following this model, we know that current and future commanders must have the same intellectual capital to match the technological marvels this nation provides for its defense.

The end result of transformation is a dramatically better joint force. Joint operations will function best when service capabilities are integrated in a seamless operation. Understanding, trust, and confidence among war fighters; intelligent risk taking; and forward-looking leaders who anticipate future conflict are vital to making this happen. Investing in the right technology, such as improved Joint C4ISR, will also prove essential to ensuring that personnel at all levels have the information to reduce the boundaries among organizations.

The new *Joint Vision* document defines in further detail the security environment, the military tasks, and the pillars of transformation, but this article complements that effort by defining transformation's foundation—its intellectual, cultural, and technological elements. These elements will give US joint forces the best tools to ensure the security of our nation.

I challenge the readers of *Air and Space Power Journal* to build on what I've written here. Give me your ideas of how transformation applies to our nation's maritime and joint forces. If you think you know a better way to define the potential and promise of transformation—put that in writing also. Send me a copy of what you write—I will get back to you. By all means, do not sit on the sidelines and think that others are responsible for transforming our forces to meet the challenges of the twenty-first century. Your ideas can and will make a difference. □

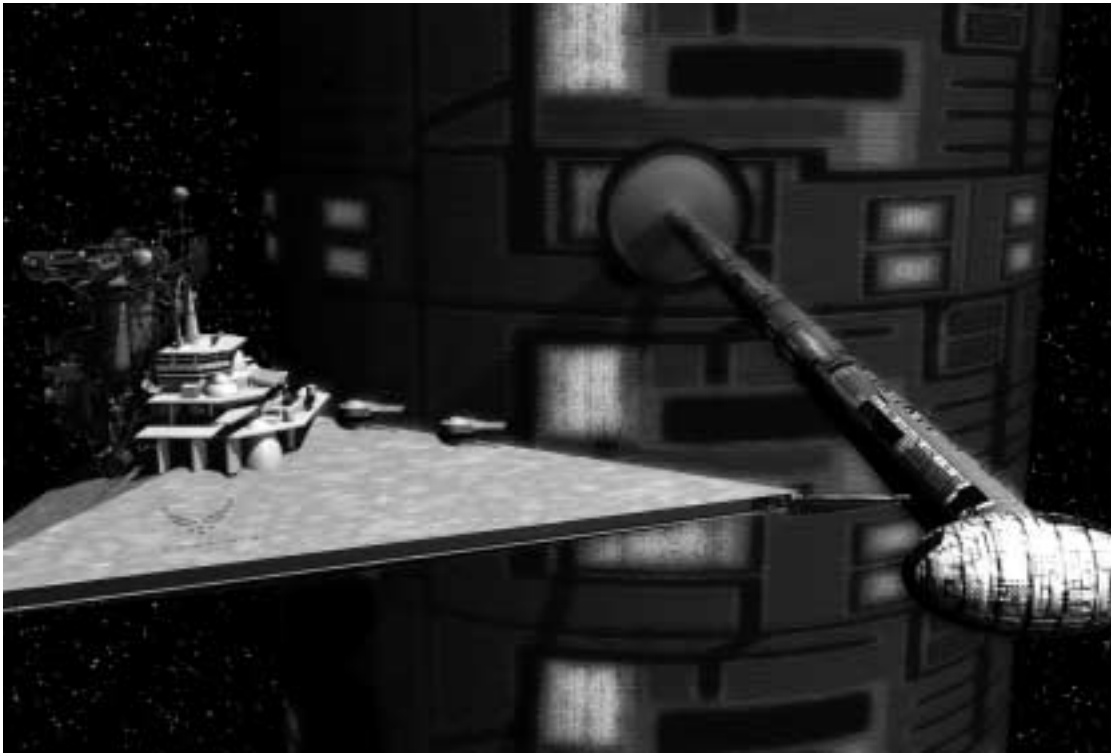
Notes

1. President George W. Bush, remarks to The Citadel, Charleston, S.C., 11 December 2001.
2. Secretary of Defense Donald Rumsfeld, "Transforming the Military," *Foreign Affairs*, May/June 2002.
3. Brig Gen S. L. A. Marshall, *Men against Fire: The Problem of Battle Command* (1947; reprint, Oklahoma City: University of Oklahoma Press, 2000).

Developing Space Power

Building on the Airpower Legacy

HON. PETER B. TEETS*



TODAY WE FACE a challenge to our nation's security perhaps greater than any other since the dawn of the Cold War. Unfortunately, this ugly threat of terrorism will not disappear anytime soon, and the global war on terrorism in which we are engaged will last years—perhaps lifetimes. There are other threats too. Today, our nation's armed forces may be on the eve of yet another call to duty in the Middle East. We in the military-space business are part of the nation's war-fighting team, and we will make a vitally important contribution to any conflict that we face.

In our work to deploy and maintain our nation's space capabilities, we must remember that more than just money or schedules is at stake. Lives and victory hang in the balance. We need to step up the intensity of discipline in our operations and ensure that we do all we

*This article is based upon remarks delivered by the author at the Air Force Association Space Symposium in Los Angeles, California, on 15 November 2002.

can to maximize the effectiveness of our space capabilities to meet national-security needs. The work we are doing now will make a very real difference in the outcome of our war on terrorism.

Coincident with the present national-security challenge, the Air Force has been given another challenge: the responsibility as the Department of Defense's executive agent for space. I believe that these two challenges are intertwined and that the Air Force's proud legacy of developing airpower over the last century can point the way to success for us all in space. We have heard—and will continue to hear in the months to come—that we are getting very close to celebrating the centennial of flight. In the relatively short span of military history in which we have wielded airpower, it has gone from a mere afterthought in military matters to center stage—and has become, arguably, the decisive form of combat power. How did we develop the capabilities of airpower for national-security needs? What did we do right? What did we do wrong? And—the real question for today—how can we apply those lessons of airpower to our development of space power as we move, as an air and space force, further into the twenty-first century?

I believe we can distill the success of airpower into three guiding principles that will serve as beacons to guide us as our nation's space power matures: (1) gain and maintain control of the high ground, (2) apply capabilities of the new medium to all conceivable forms of war fighting, and (3) develop a new professional culture. Our greatest successes with airpower have occurred when we adhered to these principles. Our greatest failures have occurred when we ignored them. We need to take the legacy lessons of airpower forward with us as we work to shape our space activities to secure America's future.

Gain and Maintain Control of the High Ground

Controlling the high ground has been a rule of warfare ever since the dawn of time. But as war fighting moved from Earth's surfaces into the air, the military advantages of control of the high ground became even more pronounced. We have traditionally kept air supremacy because we have a very rigorous and aggressive doctrine of control of the air. The first thing we do in any military campaign or combat operation is gain mastery of the skies and deny those skies to the adversary. A rigid adherence to this principle explains the amazing fact that we have not lost an American soldier on the ground to attack by enemy aircraft in 50 years. But it has also been true that an adversary confronted by superiority in the air will do his best to deny that control to the greatest extent possible. This drive to deny control of the high ground is nothing new.

For example, consider a story from the earliest days of airpower at work. At five o'clock in the afternoon, Brig Gen Fitz John Porter lifted off in his craft on a solo reconnaissance mission, which began without incident. He conducted his observations, noting the enemy positions and locations of heavy equipment. But then, due to circumstances beyond his control, he strayed too close to enemy lines. The adversary seized this opportunity to deprive General Porter of his high ground. First came the small-arms fire and then came the artillery. General Porter summoned every bit of his airmanship to put the craft back down safely on friendly territory—and he did. The date was 11 April 1862.

Yes, General Porter's observation balloon had broken free of its moorings, and he nearly lost his life by almost falling out of the gondola while maneuvering the balloon's hydrogen valve to change his altitude at the right moment to land on friendly ground. On the surface, this may seem an insignificant event from a conflict we normally consider outside the history of airpower. But the implications echo far into the future. General Porter had seized the high ground of the air—in the most primitive of fashions perhaps—but effectively nevertheless. The Confederate troops on the ground, aware of the valuable reconnaissance information he was gaining for the Union forces, seized the opportunity to try to deny him the high ground. It was truly one of the

first examples of the tug-of-war for control of the air. And it was the start of a long tradition of adherence to the principle of controlling the high ground, of gaining and maintaining air superiority in the face of a determined adversary—the most central tenet of air-campaign operations today.

How must we apply this principle to space? Look at what we have been able to accomplish using space: collection of all kinds of intelligence, precision navigation, weapons delivery, and communication and transmission of information to users worldwide. How much time will pass before an adversary, realizing the tremendous benefit we gain from our space capabilities across the spectrum of war fighting, will seize an opportunity to deprive us of them? How long will we continue to assume 0 percent losses to our space systems during hostilities?

The need to continue our thinking about space control is not just doctrinal rhetoric but military reality. Controlling the high ground of space is not limited simply to protection of our own capabilities. It will also require us to think about denying the high ground to our adversaries. We're paving the road of twenty-first-century warfare, and others will soon follow. What will we do five years from now when American lives are put at risk because an adversary uses spaceborne imagery collectors, commercial or homegrown, to identify and target American forces? What will we do 10 years from now when American lives are put at risk because an adversary chooses to leverage the Global Positioning System—or perhaps the Galileo constellation—to attack American forces with precision? The mission of space control has not been at the forefront of military thinking because our people have not yet been put at risk by an adversary who uses space capabilities. That will change. The Space Commission members had these sorts of events in mind when they warned us about the possibilities of a "Space Pearl Harbor." Not only do we need to think about the mission and implications of space control, but also it is fundamentally irresponsible of us *not* to. Space is the ultimate high ground. Our military advantage there must remain ahead of our adversaries' capabilities, and our own doctrine and capabilities must keep pace to meet that challenge.

Apply Capabilities of the New Medium to All Forms of War Fighting

In the earliest days of airpower, there existed an unfortunate tendency to aim far too short of this ambitious mark. At first people believed that the airplane could do nothing to change the course of war fighting. One recalls the story of the British cavalry commander who wanted even friendly aircraft as far from his forces as possible because they frightened his horses. Indeed, President Calvin Coolidge, upon receiving a request from the War Department to buy more aircraft, replied, "Why don't we just buy one airplane and let the pilots take turns flying it?"

But eventually military leaders began to integrate air capabilities into war fighting—unfortunately, due more to dire lessons learned than to vision. It started small: first as reconnaissance and then as support to ground operations in the form of close air support. Next it expanded to long-range interdiction and ultimately to the strategic strike and global mobility roles we knew in the Cold War and Operation Desert Storm. Perhaps the ultimate use of airpower happened during Operation Allied Force over Kosovo, where it strongly motivated the adversary to surrender. Noted British military historian John Keegan captured the significance of that campaign when he said, "Now there is a new turning point to fix on the calendar: June 3, 1999, when the capitulation of President Milosevic proved that a war can be won by airpower alone."[1]

What a shift in the history of warfare! In a mere several decades, the exploitation of a new medium produced completely new war-winning capabilities. This, then, is the principle of applying the capabilities of a new medium—not only integration into other existing forms of warfare, but also development of entirely

new ones conceivably capable of winning wars on their own.

How do we apply this principle to space? At its earliest stages, space power was treated much as airpower was in its earliest days—relegated to a relatively small reconnaissance role for a small set of strategic users. Clearly, we have made significant progress since then at integrating space capabilities into land, sea, and air operations. Achieving effective integration is still the primary challenge we face today. We are not there yet, and we need to keep working it hard. But if we limit our efforts only to applying space technologies to existing modes of war fighting, we have undershot. If space capabilities in the form of overhead imagery help platoon leaders on the ground direct their squads, then that is good. If space capabilities in the form of precision navigation guide an F/A-22 and its bombs to target, then that is good too. But if that is all they do, if that is all we envision space can do over the next few decades, then we have missed the boat. It is no different than all the ways our armed forces once found for airpower to support ground operations—and do no more. Are there ways we can scarcely imagine today of space capabilities supporting global strike operations? Are there ways we can use those capabilities to affect the decision-making cycle of an adversary or produce other effects to achieve campaign objectives in ways air, land, and sea forces cannot?

Finding answers to these tough questions is one of the main reasons Brig Gen Simon P. "Pete" Worden is working for Lt Gen Brian A. Arnold in the new Space and Missile Systems Center's Office of Transformation. One challenge General Worden is taking on is the rapid demonstration of responsive launch—finding ways to get a vehicle rapidly off the pad to any orbit on short notice. It is easy to see how such a responsive capability could be useful for rapid constellation replenishment and sustainment. But we must leave it to General Worden's—and others'—imagination to find additional ways to employ such a capability to achieve desired war-fighting effects.

I suspect the day will come when space capabilities alone will achieve a campaign victory—as was the case with airpower over Kosovo on 3 June 1999. It is possible that we can no more perceive what such a victory would look like than military leaders of World War I could envision the Kosovo conflict of 1999. But everything we have learned about capabilities in a new medium—especially our own experiences with airpower—tells us that day is coming.

Develop a New Professional Culture

The professional culture we see in our Air Force today developed from the blending of several profound influences: the love of technology and a new frontier, perhaps personified best by none other than the Wright brothers; the vision of airpower as a decisive form of war fighting, as espoused by legendary figures such as Gen Henry "Hap" Arnold, Gen Curtis LeMay, and Gen William "Billy" Mitchell; and adherence to the belief that airpower must be centrally controlled by airmen who understand its unique capabilities and uses, as espoused in our doctrine today. All these traits have combined to produce the airpower professionals who, today, wield airpower with devastating effectiveness.

How shall we apply this principle—the need to develop a new professional culture—to space? The Space Commission gave us a strong push in this direction. Gen Lance W. Lord, commander of Air Force Space Command, has described the significant progress we are making towards developing our future space professionals. But all of us must think about the implications of this step. We are not talking about creating a mere career field or sculpting a field of expertise. We are talking about an entirely new breed of war fighters who will ultimately transform the scope of war fighting in the same way airpower professionals have done in the past century. This development and nurturing process entails great responsibility on our part.

At the end of the day, adhering to this principle of developing a new professional culture—a space cadre—may prove the most decisive of them all. Every technological capability in the world will prove useless unless we have the leadership, vision, motivation, and skills to employ those capabilities effectively. We cannot produce these qualities overnight. It will take time to nurture and develop this space cadre and allow it to mature—just as it took time for the cadre of airpower professionals before it.

Implications and Conclusion

These three principles will guide us as we work to shape our nation's space capabilities. But there is one more lesson to learn from this discussion. The United States wields airpower more effectively than any other fighting force in history precisely because it has embraced these three principles. We jealously gain and maintain control of the air even though others may try to deny us that control. We aggressively apply airpower in every conceivable manner to achieve our war-fighting objectives, from global vigilance to global reach to global strike. We proudly and actively support and nurture a culture of airpower professionals. We do all this better than anyone else.

We must do the same in space! If we do not pursue control of space, then someone else will. If we do not exploit space to the fullest advantage across every conceivable mode of war fighting, then someone else will—and we allow this at our own peril. If we do not develop a new culture of space professionals—a new form of war fighter—then someone else may do so first, with dire consequences awaiting our first engagement with such an adversary. Our success at wielding airpower has come with a realization that we need to do it before—and better than—anybody else. Let us do the same for space.

As both Air Force members and air and space professionals, we have great reason to be proud of the legacy of airpower. We also should know, better than anyone else, both the challenges and rewards of exploiting a new medium in the interests of national security. This is an exciting time to be working to shape our space activities to secure America's future.

Each of us also faces a challenge. Military officers need to think the new thoughts, to find ways to control the new high ground of space, and to conduct war fighting in space effectively. They need to lead and inspire those who follow them and develop a new generation of air and space professionals who, when their time comes, will shape the future. People in industry need to combine the resources of today with a spirit of innovation—to produce the technologies we will need tomorrow to preserve our nation's security. Regardless of our responsibilities, we all have a stake in the future—a stake in our success or failure to properly equip and employ space capabilities for our nation.

That goes for me, too! I intend to exert every effort in my duties to fulfill the Air Force's responsibility as the Department of Defense's executive agent for space—to do whatever it takes to ensure that our nation's space capabilities can perform every conceivable mission needed to conduct effective war fighting.

The challenge—is now. The time to act—is now. The United States has a proud history of successfully wielding land, sea, and airpower in the protection of our nation and its freedoms. It must be our goal that the United States will carry this legacy of success into the medium of space. With your help, it will. □

Note

1. John Keegan, "Please, Mr. Blair, Never Take Such a Risk Again," *London Daily Telegraph*, 6 June 1999, on-line, Internet, 15 January 2003, available from http://www.portal.telegraph.co.uk/htmlContent.jhtml?html=%2Farchive%2F1999%2F06%2F06%2Fwkee06.html.

Gen Benjamin O. Davis Jr.

ASPJ STAFF

"During World War II, a group of blacks went to Tuskegee Institute in Alabama to train as pilots. The famous Tuskegee airmen went on to serve with distinction in the European theater and in the nation's military for years thereafter. The most notable of these men was Benjamin O. Davis Jr."[1]

Davis was the son of Brig Gen Benjamin O. Davis Sr., the first black flag officer in the US military. Davis Jr. was West Point's fourth black graduate and its first in the twentieth century; "Davis did not have a pleasant four years there. Because of his race, he was officially 'silenced' by all cadets—no one spoke to him during his entire stay except on official business; he roomed alone; and he had no friends. That so many cadets, faculty members, and senior officers could allow such behavior is astonishing and surely stands as one of the most shameful chapters in West Point history" (71). He graduated 35th out of 276 in the Class of 1936 and became one of only two black line officers in the US Army at the time—the other was his father. He was "promptly turned down for pilot training—no black officers were allowed in the Air Corps. While he served in the infantry in 1940, however, the service reconsidered this policy, and Davis went to Tuskegee for pilot training. Because of the war and his ability, promotion followed rapidly, and he soon found himself a lieutenant colonel commanding the 99th Fighter Squadron in combat. After one year with this all-black unit in Italy, Davis was promoted to colonel and tasked to form the 322d Group, a black fighter unit that served admirably for the remainder of the war" (71–72).

In the summer of 1947, the Army Air Forces integrated aviation training at Randolph Field, Texas; and in April 1948, Gen Carl Spaatz, the first Air Force chief of staff, publicly announced that the Air Force would desegregate to improve its combat effectiveness. That announcement was followed by President Truman's 26 July 1948 Executive Order 9981 to integrate the entire US military. Davis then attended the Air War College in the class of 1949–50. Afterwards he "served in the Pentagon, and went to Korea in 1953 to command a fighter wing.

The following year, he received his first star and moved to the Philippines as vice commander of Thirteenth Air Force at Clark Air Base (AB). After tours in Taiwan, Germany, the Pentagon, and a return to Korea—gaining two more stars in the process—Davis became commander of the Thirteenth. Obviously relishing this command at the height of the Vietnam War, he was reluctant to leave in July 1968 to become deputy commander of US Strike Command. He retired from that assignment in 1970" (72) as a lieutenant general and then held several government posts. In 1998 President Clinton awarded him an honorary promotion to general. General Davis died on the Fourth of July, 2002.

Note

1. Col Phillip S. Meilinger, *Airmen and Air Theory: A Review of the Sources* (Maxwell AFB, Ala.: Air University Press, 2001), 71. Subsequent references to this book are indicated parenthetically in the text.

To Learn More . . .

Davis, Benjamin O., Jr. *Benjamin O. Davis, Jr., American: An Autobiography.* Washington, D.C.: Smithsonian Institution Press, 1991.

Gropman, Col Alan L. "Benjamin Davis, American." *Air Force Magazine* 80, no. 8 (August 1997). On-line. Internet, 30 January 2003. Available from http://www.afa.org/magazine/Aug1997/0897benja.html.

Prelaunch Notes

LT COL ANTHONY C. CAIN, EDITOR

THE *AIR AND SPACE POWER JOURNAL (ASPJ)* staff regrets to announce—and many of our authors will regret to hear—that Dr. Doris Sartor has moved on to exciting opportunities at Air University's Ira C. Eaker College for Professional Development (CPD). Dr. Sartor provided wise counsel and a keen eye for quality writing for many years. Indeed, several former editors of *ASPJ* have described her as the person who gracefully and tactfully taught them their job. We know that she will bring the same grace, tact, and professionalism to her new duties at the CPD. Thanks and Godspeed, Dr. Sartor!

As always, the *ASPJ* editorial staff looks forward to reading and publishing *the best in air and space power thought.* Refer to our publication guidelines in the "Mission Debrief" section, or check the submission instructions on our Web site at http://www.airpower.au.af.mil/airchronicles/howto.html. We seek quality articles that explore emerging air and space power technologies; the relationship between regional security and air and space power; and the history, doctrine, and strategy of air and space power. □

America must maintain a state of readiness for defense and counterattack. This is not just for the sake of being prepared. Of equal or greater importance is the fact that the visibility of our preparedness will deter attacks against us.

—Gen Curtis E. LeMay

Air and Space Power

Asymmetric Advantage for the United States

THE TERM *asymmetric attack* has received much attention in the last decade, but those who use it usually refer to the exploitation of some undetected vulnerability by devious adversaries who seek to harm US forces, property, or interests. To be sure, the attacks against our homeland on 11 September 2001 exploited weaknesses in diabolically creative ways. We tend to forget, however, that our asymmetric air and space power advantages place virtually every country in an almost insoluble quandary with respect to US power and the exercise of national sovereignty. As we begin the year that marks the anniversary of the Wright brothers' historic flight at Kitty Hawk, North Carolina, reflection on the extraordinary freedom provided by US air and space dominance seems in order.

Our manned-aircraft capabilities enable us to launch strikes from deep within the United States and recover those same aircraft at their home bases. To be sure, such missions place great strain on the airmen who execute them. Yet, even after 100 years of global air and space power development, the list of countries with similar abilities to penetrate sovereign airspace—without the normal preparations associated with deploying infrastructure and logistical networks—remains remarkably short. The global-strike potential that resides in the mix of US air and space capabilities represents a unique competence that appears set to keep adversaries permanently off balance. In asymmetric terms, countries that choose to threaten the United States, while trusting in the time-honored protections afforded by geography and distance, do so at their peril—and their remaining options for defense offer no better shield.

Even with the myriad combat-oriented operations that occurred over the past decade, US air and space power extends our nation's reach in more subtle ways. From Mozambique to the Philippines to Europe to South America, air and space power supports diplomatic and humanitarian efforts to ease suffering and improve human dignity for thousands each year. This stance sends a dramatic, asymmetric double message to both people and governments: (1) "Air and space power can deliver justice to your borders as easily as it delivers food, medicine, and other supplies," and (2) "America prefers to help rather than to destroy." The campaign in Afghanistan offered a striking example of this asymmetric use of airpower as US forces delivered tons of food and relief supplies to villagers and refugees while simultaneously working to restore freedom and justice to that conflict-ridden society. As one journalist noted, the United States could have used all of its might to strike out blindly to avenge the terrorist attacks. Instead, air and space power allowed our leaders to focus and balance the constructive and destructive characteristics of our response with an unprecedented level of precision.

Our asymmetric advantage extends into space, where US satellites provide other countries free navigation, communication, and weather support—capabilities once consigned to the realm of the mystical and mysterious. Air and space power thus permeates the economies of even the most backward countries through such technologies and capabilities. Those nations experience the asymmetric effects that accompany technological revolu-

tions. Rather than enduring firsthand each painful step of technological enlightenment, from agriculture to industry to space exploration, developing countries find themselves catapulted from the "dark ages" to the space age in a matter of only decades or even years. Therefore, air and space contributions provide an asymmetric catalyst for economic, thus human, advancement.

Ironically, the expanding asymmetry between us and our competitors may not necessarily enhance either our security or regional and global stability, because demagogues who endeavor to exploit their people and promulgate injustice will seek ways to neutralize our asymmetric advantage. We appear caught in a new type of security dilemma of our own making. For most countries, conventional military conflict with the United States is not an option because of our asymmetric air and space power advantage. Instead, our competitors pursue strategies designed to negate the overwhelming technological and organizational competency that US air and space power represents. As we transform our service from a threat-based force into a capability-based force, our technology, doctrine, and operating concepts will widen the gap between us and our potential adversaries. As we pursue transformation, US airmen should rightfully focus on the asymmetric threat; to do otherwise would be foolhardy and irresponsible. However, we should also understand the awesome capability we wield and its effect on friends and adversaries alike. □

Ricochets and Replies

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

THANK YOU!

I want to thank your staff and Garner Johnson for the nice review of my book on Gerald Johnson (winter 2002, pages 107–8). *Jungle Ace* was a labor of love that started as a paper in graduate school and grew into a career as an aviation historian. I appreciate the kind words that Mr. Johnson had to say about it, and he was right on in his criticisms of the book.

John Bruning
Independence, Oregon

RESPONSE TO "THE BEST IN PROFESSIONAL AIR AND SPACE POWER THOUGHT"

I seldom write letters to editors, but your editorial comments in the winter 2002 issue were so on-target that I felt compelled to send a few words. For most of my working life, I was a reporter or editor at newspapers—the *Kansas City Star, Chicago Daily News, Chicago Tribune,* and *Milwaukee Journal.* From 1985 to 1991, I was editor of *The Quill,* published by the Society of Professional Journalists, an old-line organization dedicated to the hopeless task of improving the quality of journalism in general and of encouraging higher ethical standards in the practice of journalism. (The latter was also a hopeless task, I fear.)

The value of *The Quill* depended on men and women on the front lines sharing their experiences, solutions, and opinions with us. All of the comments you noted in "Flight Lines"—"almost nobody reads it," "we just don't have time," and so forth—ring true insofar as my experience at *The Quill* was concerned.

It is a constant battle, this business of getting people who really know something to contribute. But from my vantage point as a regular lay reader of the on-line version of your journal, you do it well.

Mike Moore

The function of the Army and Navy in any future war will be to support the dominant air arm.

—Gen James Doolittle

The Air and Space Nation Is in Peril

PHILLIP S. MEILINGER*

THIS IS A GOOD news, bad news story. The United States is the world's first and only air and space nation. That fact is evidenced in our dominance of air and space technology and infrastructure, as well as in the future visions shared by our political, economic, military, and cultural leaders. This domination has important implications for our national security. Unfortunately, many Americans have come to view air and space dominance as their birthright. It is not, and troubles are brewing, so we must take steps now to ensure our dominance in the future.

Americans have always looked to technology to ease their problems, so they took naturally and quickly to air and space power—the epitome of advanced technology. America was the birthplace of aviation, and it is now difficult to imagine life without our television satellites, cell phones, Internet, and air travel. Indeed, US airline-passenger traffic has tripled over the past 25 years (fig. 1).

Speed is the engine of commerce and economic growth. Rapid means of transportation have been essential for nations seeking economic dominance. The rise of Britain in the eighteenth century was based on global trade carried by its large merchant fleet, which in turn was protected by the Royal Navy, the world's largest and most powerful. By the beginning of the twentieth century, the United States was also a maritime power, possessing a sizeable merchant fleet and navy.

As the twentieth century progressed, however, speed became synonymous with aircraft, and expanding American aviation began to push out the ship. Over the past 40 years, the growth of the US airline industry has been dramatic, in contrast to the decline of our shipping industry.

*The author is a retired Air Force colonel and command pilot with a PhD in military history. He has written extensively on airpower theory and operations, and is currently the deputy director of the Air and Space Center at Science Applications International Corporation (SAIC). The views in this article are his and do not reflect those of SAIC.

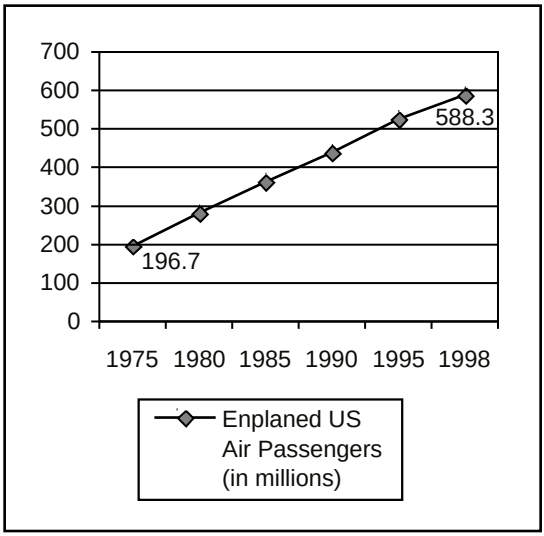


Figure 1. US Air-Passenger Growth (From *National Transportation Statistics 2001,* "US Air Carrier Aircraft Departures, Enplaned Revenue Passengers, and Enplaned Revenue Tons" [table 1-35], on-line, Internet, 17 January 2003, available from http://www.bts.gov/publications/nts/index.html)

Since 1960 the number of airliners has quadrupled (and aircraft have more than doubled in size), while the size of the US merchant fleet has dropped 84 percent, a mere 2 percent of the world's total (fig. 2).

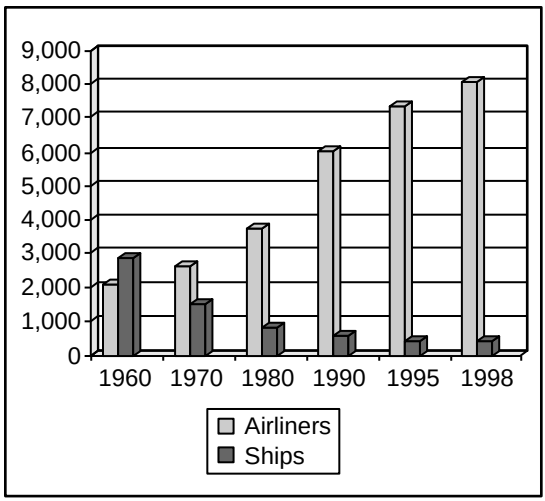


Figure 2. Airlines versus Merchant Ships (From *National Transportation Statistics 2001,* "Number and Size of the US Flag Merchant Fleet and Its Share of the World Fleet" [table 1-20], on-line, Internet, 17 January 2003, available from http://www.bts.gov/publications/nts/index.html)

In addition, airport expansion is under way at many airports because airline-passenger travel is expected to double over the next decade. As for cargo, 95 percent of the world's air-cargo capacity resides in Boeing airframes, and the value of goods shipped is telling. In 1997 the average pound of cargo traveling by boat was worth seven cents; by rail it was 10 cents, but by air it was $25.59. When Americans have something important and valuable to ship and it needs to get there quickly, they send it by air.

Air and space trade has significantly increased over the past several decades. In 1999 America's air and space industry contributed $259 billion to the nation's economy. The black ink in the air and space balance of trade rose to over $32 billion in 2000, making it the largest net exporter in the US economy (fig. 3). At the same time, the *overall* US trade balance has been negative for 27 of the past 30 years, and the deficit now exceeds $250 billion annually. Given these statistics, it is apparent that the United States has now become an air and space nation—indeed, *the* air and space nation.

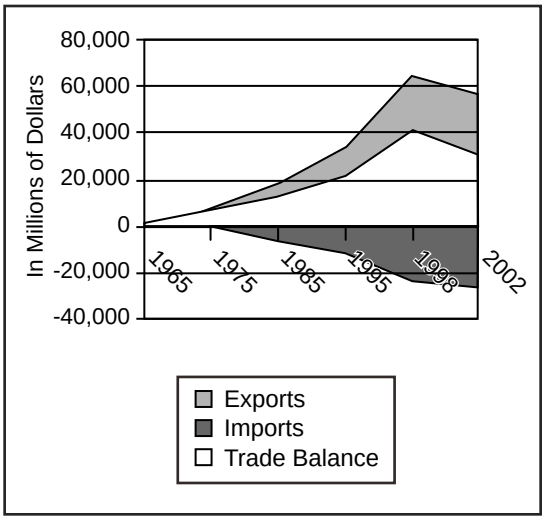


Figure 3. Air and Space Imports/Exports and Balance of Trade (From Aerospace Industries Association, *Year-End Review and Forecast,* "Aerospace Balance of Trade" [table 6], on-line, Internet, 17 January 2003, available from http://www.aia-aerospace.org/stats/yr_ender/tables/2002/tble67_2002.pdf)

One must remember, however, that America once led the world in other transportation technologies, but over the past two centuries, it has relinquished leads in railroads, shipbuilding, and automaking. The US share of the world auto market, for example, has fallen from 48 percent to 15 percent over the past 40 years. We cannot allow our lead in air and space to evaporate similarly.

National Security and Air and Space

Just as the Royal Navy defended British economic strength over a century ago, so do our air forces protect our economic security. This is especially true because military strategy has evolved so dramatically over the past decade. The basic factors that shaped our geopolitical environment during the Cold War era have changed. The Soviet threat is gone, but other threats and other commitments remain. In fact, US military deployments have increased fourfold while the size of our military has shrunk by 40 percent. The character of these engagements has also altered. It is ever more essential that the United States maintain strong public support for its actions. This in turn means we must be extremely careful about both inflicting and sustaining casualties. Our military campaigns from the Persian Gulf War to Afghanistan have been marked by remarkably low losses, and the increasing use of precision weapons has limited civilian casualties and collateral damage, essential to maintaining worldwide public support.

It is obvious, however, that if such sterilized warfare is our goal, then certain types of strategies, tactics, and weapons are more desirable than others. Precision or nonlethal weapons delivered by air platforms—ideally either unmanned, unseen, or flying beyond the range of enemy fire—are the instruments of choice. To be sure, the process of identifying, tracking, and destroying mobile targets—tanks, trucks, and terrorists—remains one of our most difficult challenges, but this problem is being addressed through the use of a combination of space-, air-, and land-based sensors tied to strike aircraft by satellite.

It would be foolish for our leaders to think that air and space power could be effective in any crisis, but it has now become their weapon of first resort. The American people intuitively realize this: recent Gallup Polls reveal that 42 percent of those surveyed believe the Air Force is the most crucial arm of our national defense, and a like number believe it should be built up to a greater extent than the other services.

Just as our commercial air fleet is the largest and most modern in the world, so too is our military airpower. Our superiority is even greater than a comparison of the number of US military aircraft to the totals of other leading countries would indicate (fig. 4). Although China has a large supply of aircraft, most are obsolescent, including over 4,500 Vietnam-era MiG-17s, -19s, and -21s. Certainly, quantity has its own quality, but most of the Chinese air force would stand little chance against a frontline adversary. Similarly, Russia's air force has atrophied dramatically over the past decade. Once the pride of the Soviet state, much of this vaunted air force now sits unused.

Examining the *types* of military aircraft comprising the world's air forces is also revealing. The majority of combat aircraft worldwide consists of short-range fighter-bombers, such as the F-16, Mirage 2000, and MiG-21. The United States has nearly 4,000 such aircraft but has far more capability than that. Our airlift and aerial-tanker fleets allow us to project power anywhere in the world on short notice. The United States possesses the

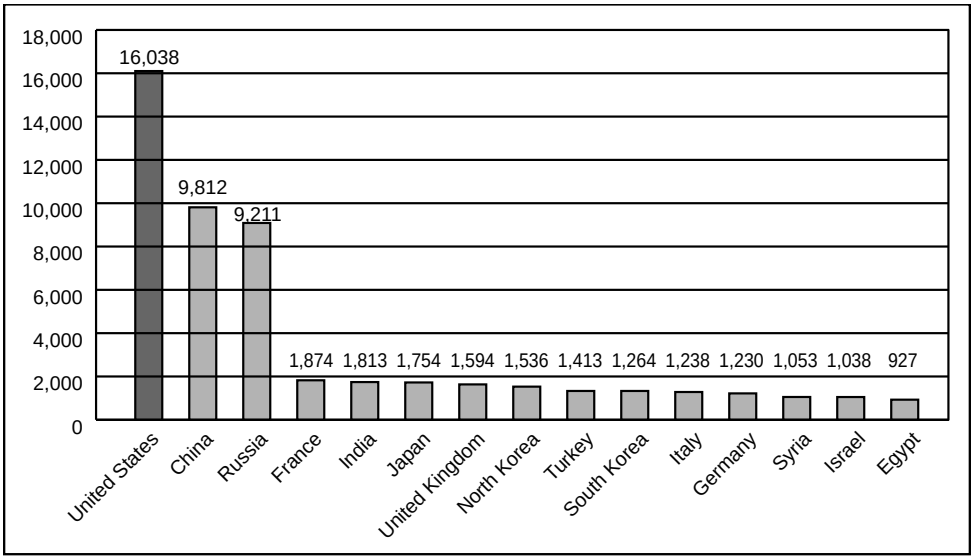


Figure 4. Leading Nations in Total Airpower (From "World Military Aircraft Inventory," *Aviation Week and Space Technology,* 13 January 2003, 257–76)

vast majority of the world's large military cargo aircraft, such as the C-17 and C-5, while also having four times more tankers than the rest of the world combined. Tankers turn our tactical fighters into strategic bombers. No other nation has such an impressive capability to project power and influence. China, for example, has fewer than 50 modern cargo aircraft and virtually no aerial-refueling capability.

Our dominance in space is equally compelling. At present, approximately 550 operational satellites are in orbit. Nearly half of those were launched by the United States, and approximately 100 of them have military missions. In addition, the Global Positioning System's constellation of 28 satellites provides precise geographical data to users all over the world. In contrast, Russia now has only 90 operational spacecraft, and much of its space infrastructure—its missile-launch detection system, for example—is moribund. Although China can be expected to become a space competitor—it is currently working on an antisatellite system—it has launched an average of fewer than four satellites per year over the past decade.

Within the US military services, one finds an increasing reliance and emphasis on air and space power. According to an old saying, if you want to know what's important, follow the money. In the American military, that trail is clear. The backbone of the Navy is the aircraft carrier, which costs over $5 billion each (without its aircraft and support ships), and the Navy spends nearly as much on aircraft each year as does the Air Force. The top funding priority of the Marine Corps is the tilt-rotor V-22 cargo plane, which will cost $85 million apiece. The Army has major production and

modernization programs for Comanche, Apache, and Black Hawk helicopters that will total $70 billion. Indeed, over the past decade, the Army has spent more on aircraft and missiles than it has on tracked combat vehicles. In sum, over 60 percent of the US defense budget is devoted to air and space forces. In fact, a comparison of our four air arms with those of the rest of the world shows that each *individually* is greater than the military air assets of most major countries (fig. 5). The qualitative superiority of American aircraft makes our air and space dominance even more profound.

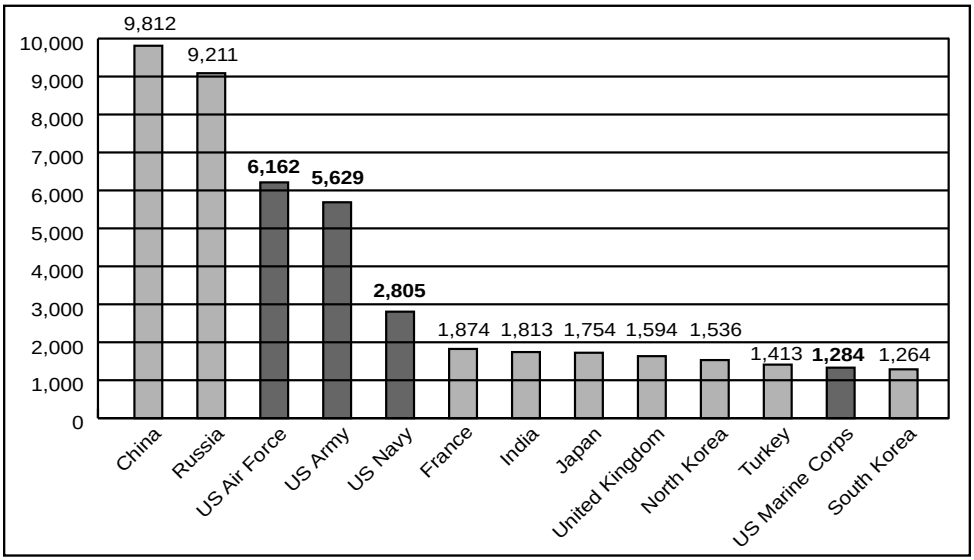


Figure 5. US Airpower versus the World (From "World Military Aircraft Inventory," *Aviation Week and Space Technology,* 13 January 2003, 257–76)

The reason for this emphasis on air and space power among our soldiers, sailors, and marines is their realization that military operations have little likelihood of success without it. It has become the American way of war. Indeed, the major disagreements that occur among the services today generally concern the control and purpose of air and space assets. All of them covet those assets, but their differing views on the nature of war shape how they should be employed. Thus, we have debates regarding the authority of the joint force air component commander, the role of the corps commander in the deep battle, the question of which service should command space, and the question of whether the air or ground commander should control attack helicopters. All the services trumpet the importance of joint operations, and air and space power increasingly has become our primary joint weapon.

Air and space dominance also provides our civilian leadership with flexibility. Although intelligence is never perfect, our leaders now have unprecedented information regarding what military actions can or cannot accomplish and how much risk is involved in a given action. For example, our leaders understood far better than ever before how many aircraft and weapons would be needed over Serbia and Afghanistan to produce a specified military effect, weapon accuracy, collateral damage that might occur, and risk to our aircrews. This allowed our leaders to fine-tune the air campaign, providing more rapid and effective control than previously.

Other factors affect the way we'll fight. One hears much talk today of "transforming the military" to meet new threats. The Persian Gulf War, Bosnia, Kosovo, and Afghanistan—and, for that matter, Somalia and Haiti—indicate that traditional methods, weapons, forces, and strategy will often be inadvisable. Warfare has changed. Stealth, precision weapons, and space-based communication and intelligence-gathering systems are examples of this new form of war. Certainly, the human element in war can never be ignored. People make war, and all their strengths and weaknesses must be considered. Yet, it would be foolish not to exploit new technologies that remove part of the risk and human burden in war. It is not always necessary for people to suffer. Air and space power permits new types of strategies that make war on things rather than on people and that employ things rather than people. It capitalizes on the explosion in computer, electronic, and materials technologies that so characterize the modern era. This is America's strength—one that we must ensure.

Dangers Ahead

The terrorist attacks of 11 September 2001 (9/11) served as a wake-up call. Problems simmering at or below the surface for several years have now burst forth. The shutdown of air traffic after 9/11 stranded thousands of travelers and disrupted business. Things are still far from normal. Perhaps the greatest challenge facing the air and space nation today is conceptual. Although Americans have become dependent upon air and space and although our uniformed leaders realize the dominance of air and space power in military operations, they have yet to think through its implications or ways of maintaining its momentum.

Air and space power is not merely a collection of airplanes or spacecraft—although those assets are certainly essential. It is not even the combination of those machines with an effective command and control network and intelligence-gathering capabilities. Rather, air and space power is the totality of our military air and space assets from all the services; plus our commercial airline industry and the pilots and mechanics who comprise it; plus our commercial air and space industry, with its thousands of engineers and designers; plus the massive airport and airways structure stretching across the nation and, indeed, the world; plus our codified doctrine on how all this

power should be employed. All of these facets are essential for the United States to remain *the* air and space nation.

One problem is a tendency to focus on individual services and weapons or specific airport and air-traffic-control problems, thus failing to see air and space power in the broadest sense. Attempts to look at parts of the problem—"tactical" aircraft, airlift requirements, or air-traffic-control sequencing issues—are limited by their myopia. The tactical-air debate, for example, never discusses attack helicopters—their cost, vulnerability, or role in conjunction with fixed-wing air assets. Similarly, airlift requirements are tied to Army deployments that may or may not be relevant in the future. Questions remain to be asked. How does one measure the relative value of land-based versus sea-based airpower—or rotary versus fixed wing? What are the trade-offs between the use of air and space power versus ground troops or maritime forces? In an even broader sense, how do we articulate a vision for all of our air and space assets, military and civilian? How do we ensure the viability and superiority of our industrial base and the competitiveness of our commercial airline companies?

Over the past few years, we have heard references to a "crisis" in the American air and space industry. Despite America's dominant position, concerns need to be addressed. Funding cuts during the 1990s have left the Federal Aviation Administration (FAA) facing a backlog in modernizing equipment and software. Although its budget has recently been increased, most of the funding is going into security—not new air-traffic-control equipment. Our scientific and engineering force is graying—the average age of the US air and space worker is nearly 50, and over half of that force will be eligible to retire during the next six years. The profitability of airlines is down—they sustained huge losses in 2001 due largely to 9/11 and the subsequent requirement for expensive new security procedures. After the attack, passenger travel dropped 60 percent, and over 60,000 people have lost their jobs in the industry. Passenger loads are not expected to return to normal levels in the near term.

Less travel means fewer flights and aircraft—aircraft sales are down, and nearly 300 civil cargo aircraft now sit in storage in the desert. Total cargo traffic worldwide fell an unprecedented 9.7 percent last year, billed the worst in the history of air transport. In space only 60 launches took place worldwide in 2001—the lowest number since 1962—and US commercial space exports were 75 percent below 1998 levels. Also, international competitors—Airbus, for example—are garnering a greater market share of a field traditionally dominated by American legends such as Boeing, Lockheed Martin, and McDonnell-Douglas. Although Boeing is still the top air and space company in the world, its lead is shrinking, and the European Aeronautics Defence and Space Company has pushed Lockheed Martin out of the number-two slot. Industry analysts continue to maintain that the long-term future of air and space is bright, but for the short term, major problems need to be addressed.

Spending on air and space research and development is down nearly 20 percent in the past decade, and the Bush administration has proposed cuts in research of $58 million at the National Aeronautics and Space Administration and $20 million at FAA for 2003. In addition, airline stocks are down; defense spending as a percentage of gross domestic product is 3 percent—a post–World War II low (fig. 6); employment in the US air

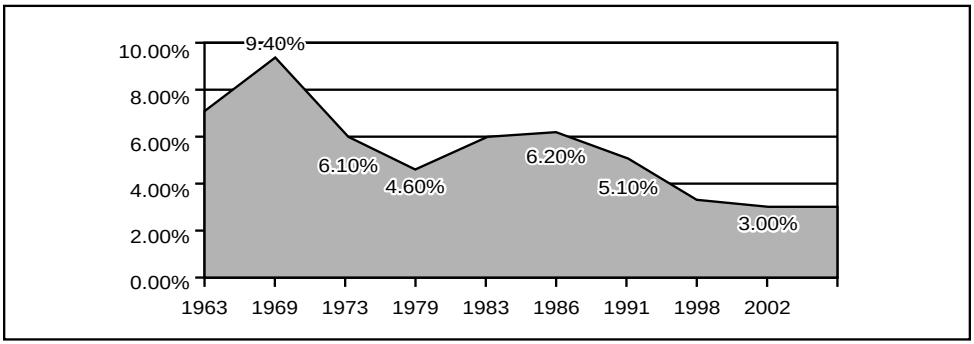


Figure 6. Defense Outlays as a Percent of Gross Domestic Product (From Tamar A. Mehuron, "The Defense Budget at a Glance," *Air Force Magazine,* September 2001, 78)

and space industry has dropped by 600,000 people over the past decade (fig. 7); the US share of the world air and space market is down 20 percent over the past 15 years; the number of technology graduates seeking a career in air and space has fallen by 57 percent since 1990; and

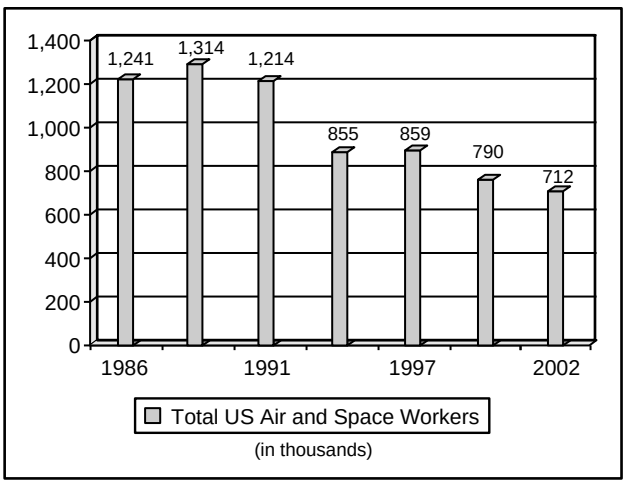


Figure 7. Employment in the US Air and Space Industry (From Aerospace Industries Association, *Year-End Review and Forecast,* "Aerospace Related Employment" [table 9], on-line, Internet, 17 January 2003, available from http://www.aia-aerospace.org/stats/yr_ender/tables/2002/tble09_2002.pdf)

the air and space industry's net debt is up. US Airways recently declared bankruptcy, and United Airlines has announced that it might have to file for Chapter 11 as well. How can we reverse these trends?

First and foremost, we must conduct a broad-based examination of all aspects of the air and space nation. Congress took the first step by establishing the Commission on the Future of the United States Air and Space Industry. This blue-ribbon panel of industry and financial experts and former government officials was chartered to study the health of the air and space industry and infrastructure in the United States—both military and civilian—identify problems, and propose solutions. Their final report was published in November 2002 and reidentified several problems and highlighted others. They noted, for example, that the World Trade Organization has come down hard on the US air and space industry for "illegal export subsidies" that, if uncorrected, will cost the United States over $4 billion in fines per year. At the same time, American corporations complain that European value-added taxes are a form of government subsidies that are unfair to the United States. These are the types of economic issues that need to be addressed at the cabinet/congressional level. Partly as a result of the commission's findings, Sen. George Allen (R-Va.) and Sen. Chris Dodd (D-Conn.) have introduced legislation—the Aeronautics Research and Development Revitalization Act of 2002—to help rectify some of the industry's problems.

Overcrowded airports and late departures are becoming endemic. Herb Kelleher, the retired head of Southwest Airlines, argues that a mere "fifty miles of paved highway"—essentially 30 new runways nationwide—will solve the airport overcrowding problem.[1] Even if his claim is true, it too easily ignores the task of building the ramps, terminals, parking garages, and so forth that must accompany the new runways. So the solution is not easy, given environmental concerns and debates over the use of valuable real estate. Nonetheless, it is important to realize that Kelleher's proposal would require someone with both vision and persistence to implement it. The American Institute of Aeronautics and Astronautics has called for presidential action—a commitment similar to that made by Dwight Eisenhower in the 1950s to build our national interstate highway system.

As for military air and space power, the problems are also daunting. Since taking office, Defense Secretary Donald Rumsfeld has labored to transform his department. The results so far are mixed. It appears that the Army's Crusader artillery system is dead, but there is little else to show in the way of "transformation" over the past 18 months. Part of this is due to the war on terrorism, which has generated a large boost in defense spending. These funds, plus the necessary focus on the war itself, have tended to defer and blur action on needed changes. Indeed, debate continues as to the best way to fight this war and with what weapons and organizations. Unfortunately, serious systemic problems must be addressed, and they can't wait for things to quiet down.

For example, the F/A-22, the Air Force's new air-superiority fighter, only recently received congressional approval for production. The F/A-22 was designed 20 years ago. The weapons-acquisitions process is broken. Over the past decade, virtually all of the numerous studies on the organization of the Department of Defense cite the need for acquisition reform. It has not yet happened. Thus, Congress commonly delays, stretches out, and reduces the number of weapons to be purchased—ostensibly in an effort to reduce costs. In reality, this practice creates havoc with the manufacturers, while also driving costs through the roof. For example, Congress originally authorized the purchase of 750 F-22s. Over the past several years, it has cut the planned buy to 295, and further cuts are being discussed. Testimony before Congress reveals that these cuts have raised the unit price of the F-22 by over $21 million. That's real money. Similarly, recent congressional action restructured the Army's Comanche program, cutting the number of helicopters to be purchased. Although this move "saved" $10 billion, it raised the chopper's unit cost to a whopping $60 million. We cannot afford to have the air and space star hitched to a Model T acquisition system.

The other danger lies in the realm of grand strategy. It became clear during the Persian Gulf War and operations against Serbia that our air and space strength not only exceeded that of our adversaries, but also exceeded that of our allies. The vast majority of some key air and space assets—stealth, precision munitions, electronic jammers, intelligence satellites, tankers, and strategic airlifters—was provided by the United States. This made it very difficult to devise an effective and balanced air plan. Interoperability has been a goal of the North Atlantic Treaty Organization (NATO) for decades, but it is now of even greater concern. If our strategy calls for increased reliance on air and space power and the continual quest for technological advances, this interoperability problem can only get worse.

At the same time, it is apparent that US foreign policy requires close relations with our allies. If we are to maintain the moral high ground, we cannot be seen as the lone ranger. This was apparent in the aftermath of the 9/11 terrorist strikes. We must have the political top cover provided by either a formal alliance such as NATO or an ad hoc coalition, as existed during the Persian Gulf War. Clearly, the imperative to operate in an alliance/coalition will clash with our technical disparity relative to those allies. We must find a way to bridge this gap.

Conclusion

The United States is the world's first and only air and space nation. This is true for many reasons, but the most basic one is that we wished to be. We developed the technology, infrastructure, and mentality—at great cost and effort—to achieve our dominant status. The fact of this preeminent position is reflected in our political, economic, military, and cultural lives.

We must not take this dominance for granted. If we intend to maintain our position and make full use of the benefits that air and space power provides, then we must do certain things.

The United States must have a comprehensive plan to develop, improve, and coordinate the commercial and military aspects of our policy. We must stem the decline in our research and development efforts while rebuilding and expanding our air and space infrastructure and educational base. We must change the way we develop and buy our air and space technologies to take full advantage of new ideas and advances, ensuring that our equipment is not out of date before it is even fielded. At the same time, we must remember that we are part of a world community that looks to us for leadership. That means we need to cooperate—not dictate—and we must become true partners with our allies.

We must look closely at the fundamental principles and assumptions underpinning our military strategy and force structure. Too much of what our military does today is based on tradition. Old ideas and old ways may not work in the twenty-first century. Air and space power offers a cost-effective, rapid, and discriminate weapon for our political leaders. Let us sharpen that weapon. □

McLean, Virginia

Note

1. Herbert D. Kelleher, "The Next Century of Flight," *Aviation Week and Space Technology*, 4 June 2001, 86.

Nowadays, thanks to space, in the first few days of a conflict, we can shut their eyes, ears, and their ability to talk. Then you can apply your forces with much less risk. Just look at what happened in the Persian Gulf and in the Balkans . . . entirely different from Korea and Vietnam. Space had everything to do with that.

—Gen Bernard A. Schriever

Needles in the Haystack

Hunting Mobile Electronic Targets

MAJ MICHAEL PIETRUCHA, USAF*

0300 Zulu, 26 June 2006, the Persian Gulf. Four F-15E Strike Eagles fly through the Zagros mountain range in southern Iran, their terrain-following radars guiding the aircraft safely at 300 feet in pitch-black conditions. In addition to their normal self-defense AMRAAM/Sidewinder loadout, the aircraft carry a variety of munitions intended for use against a specific SAM array—the S-400 Triumf and SA-20 Gargoyle batteries guarding the naval base at Bandar Abbas—and incidentally covering much of Oman, the UAE, and all of the Straits of Hormuz.

RADAR DEFENSES ARE very difficult targets. The addition of mobility to their arsenal has greatly complicated the problem of finding and killing the radars that serve as the backbone of both the surveillance and "shooter" portions of an integrated air defense system (IADS). The United States is highly reliant on its standoff sensors to find radar targets. Unfortunately, the picture provided by these sensors is incomplete and lags the radar transmission event by a significant time.[1] It is long past time to take advantage of our other, underutilized sensor array—the gear on board the strike aircraft. If we want to detect and target the threat in single-digit minutes, the shooters must also be the sensors.

The introduction of the S-75 Volkhov (NATO code name SA-2 Guideline) surface-to-air missile (SAM) into Vietnam came as an unpleasant surprise to American airpower, which initially had few defenses against the system. Eight years later, the ZRK-SD Kub (NATO code name SA-6 Gainful) wreaked havoc with the Israeli Defense Force's fighters over the Sinai.[2] Both the United States and Israel began crash programs to defend themselves against these threats, resulting in successful operations in the Bekaa Valley and the Gulf War years later. But as US capabilities evolved, so did the threat. While NATO losses in Operation Allied Force were low, the Serbs demonstrated to NATO (and anybody else watching) the advantage that mobility provides the defender. We can no longer assume that defense systems will be easy to find or easy to hit.

To establish air superiority we must have the ability to find and suppress or destroy air defense systems. With increasing mobility, modern SAM threats are extremely fleeting targets—targets that cannot be allowed to roam the battlefield unhampered. However, the ability to destroy these targets is predicated upon the ability to find them—a capability that must be greatly enhanced.

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*Maj Mike Pietrucha is a former F-4G/F-15E IEWO and currently assigned to HQ USAF/XOXS.

Off-Board Sensors

The Strike Eagles are running under emissions control (EMCON) with only low-power modes of the terrain-following radar and the radar altimeter to betray them. Given the terrain, detection by active or passive means is extremely unlikely. But the crews are not blind. A high-bandwidth receive-only data link, relayed by satellite, provides them with a partial picture from off-board sensors far from the area. An onboard precision radar-warning receiver (RWR) is silently listening for nearby threats.

The use of off-board sensors and data links to pass high-fidelity data to strike aircraft is an established concept. It is valuable when considered as an adjunct to the striker's own sensor array but dangerous if considered as a substitute. An analogy can be drawn with the F-15C in its air-to-air role. That aircraft is capable of independent detection, identification (ID), and weapons employment. Data link from off-board sensors merely enhances those abilities. Any suggestion that an F-15 pilot could rely on data-linked information from airborne warning and control systems (AWACS) aircraft, to the exclusion of its own radar, would be inaccurate and unwelcome.

Similar limitations exist with other sensors. Electronic surveillance (ES) sensors removed from the immediate battlefield have serious physical limitations; they are not generally in the radar's main beam and are often unable to see weak signals. Air-breathing sensors may be blocked by terrain and the curvature of Earth. All of these factors combine to make a distant sensor's picture incomplete.

Low-power signals are particularly difficult for our intelligence, surveillance, and reconnaissance (ISR) sensors to pick out at long range. The distant collector often has to detect the low-signal-strength sidelobes or backlobes, rather than the main beam. Additionally, the strength of a signal is further attenuated by distance[3] and atmospheric[4] and weather effects.[5] Thus, a distant sensor has much more difficulty picking up any signal. For example, a radar signal detected at a tactical range of 20 nautical miles (nm) is 100 times stronger than it is at 200 nm. This becomes a critical detection issue for ingressing aircraft because low-power signals, such as missile guidance, are less likely to be detected by sensors at standoff ranges (i.e., Global Hawk, RC-135, or space-based systems).

In addition, radar signals travel in straight lines, and both terrain and the curvature of Earth may block a signal's line of sight (LOS). For example, a collector must be at 25,000 feet to be able to detect a signal source at 195 nm, even with no obstructing terrain, due to the effect that simple Earth curvature has on the radar horizon.[6] The higher the collector, the greater the advantage; at 65,000 feet a collector can "see" a sea-level emitter at 315 nm. Unfortunately, this relationship is true only for very flat terrain or over the ocean, since high terrain can also block signals. Obrva airfield is located in the Kragujevac river valley in the center

of Serbia with high ridgelines to the east, north, and west. It was very well defended, and its position made it difficult for off-board collectors to search and detect signals. Therefore, no air-breathing standoff collector outside the target area could reliably detect signals in the valley because their LOS to the source of those signals was blocked by the high ridgelines. In our scenario, if the strike aircraft were reliant solely on off-board sensors, they might arrive at the target without any threat warning.

Data Link

During the ingress of the F-15Es, the lead and the number three aircraft execute a preplanned pop to an altitude just above the ridgeline in a 20-second target-acquisition maneuver (fig. 1). *The ES sensors on board their aircraft detect the SA-20's Clam Shell radar, but their location in the high terrain is outside the Clam Shell's ability to detect them. While their individual RWRs locate the threat, the two aircraft communicate via a low-power interflight link to improve their individual passive solution. Within seconds, all four aircraft have shared the new location for the Clam Shell—not good enough for weapons employment, but good enough to confirm that the previous coordinates were out of date and to provide a cue for other sensors* (fig. 2).

Figure 1. An F-15E, equipped with a Precision ES Array and armed with four JDAMs, is busy locating nearby threat radars.

The assumption that all the participants will have a functional data link is implicit in the idea of networked sensors in general and off-board sensors in particular. One cannot disregard the possible loss of data link due to equipment failure or operator error, and the considerable adverse effects that loss would create. We should, therefore, not design an architecture that is totally dependent on having a data link. Any such architecture would be an invitation to an enemy to make a considerable effort to deny us the use of our own data links—a single point of failure.

Figure 2. A pair of F-15Es locating radars. Each sees a portion of the threat array (solid lines) and, using data link (dotted line), performs cooperative ranging against the threats that are seen by both aircraft (dashed lines).

For example, a scheme that requires a number of sensors on various aircraft to coordinate their actions over long distances can be neutralized if only the data link is denied.[7] A more robust architecture would allow an individual aircraft to get its own solution and cooperate through data link to enhance and refine its single-ship solution. This approach would allow networks to degrade gracefully with the loss of data link, and individual aircraft could still locate threats—just less precisely.

Data links need not reach across the battlefield. A flight of four aircraft could exchange information between nearby strike aircraft via a low-power data link that need not even use a radio frequency. A link can be designed for jam resistance and low probability of intercept.

Strike Aircraft Sensors

The Strike Eagles were 90 seconds from the initial point (IP) when the trailing element launched a salvo of miniature air-launched decoys (MALD). The decoys flew up to an altitude where they could be detected by the enemy IADS and proceeded toward the target area. The MALDs provided a rather rude awakening to the Tin Shield acquisition-radar crew, who had been presented with a convincing imitation of a large strike package headed toward the naval base. The automatic features of the SAMs came into play against the decoys, and the first Triumf missiles cleared the canisters before the MALDs were a third of the way toward the target. Within seconds, all target engagement radars in both batteries were radiating.

Putting aside the fact that current RWRs on US strike aircraft were not designed with the modern threat in mind, a hypothetical ES sensor suite (think advanced RWR) in the target area has a much greater chance of detecting a radar signal in its vicinity than would an off-board sensor. After all, the strike aircraft is nearby; and if it is being targeted, it can be assumed that the sensor is in the main beam and has a direct line of sight to the radar. Thus, the onboard sensor detects concentrated energy from a radar beam pointed directly at it rather than a much weaker sidelobe or backlobe that is scattered in other directions.

The ability of an RWR to accurately locate a modern SAM system is critical to the survival of the aircraft. A pulse-Doppler (PD) radar operator detects an aircraft by noting a difference in the frequency of the transmitted and reflected energy. That frequency (Doppler) shift is caused by the component of the aircraft's velocity that is directed toward or away from the radar. Pilots in a detected aircraft may try to break the enemy radar's tracking by turning and placing the radar at 90 degrees to their own vector. That change in direction reduces the velocity component toward or away from the radar site to near zero which results in a near-zero-Doppler shift. A reduced Doppler shift also enhances the effectiveness of chaff and decoys, which should allow the aircraft to break lock and hide in ground clutter. Most Doppler radar systems use a filter to reduce clutter by eliminating all returns below a certain velocity. To make the aircraft appear to have a velocity less than the filter velocity, or stay "in the notch," the pilot of a strike aircraft flying at 540 knots must hold a heading (plus or minus three degrees) that is perpendicular to the direction from the aircraft to the radar (fig. 3).[8] To do that, pilots must know the location of the threat radar precisely if they are to survive and attack the target.

If the strike aircraft can locate the emitter to within a 2,000-foot-radius circle, it can cue other sensors. The F-15E, F-18, B-1, and B-2 can use high-resolution synthetic aperture radar (SAR) maps to precisely locate the

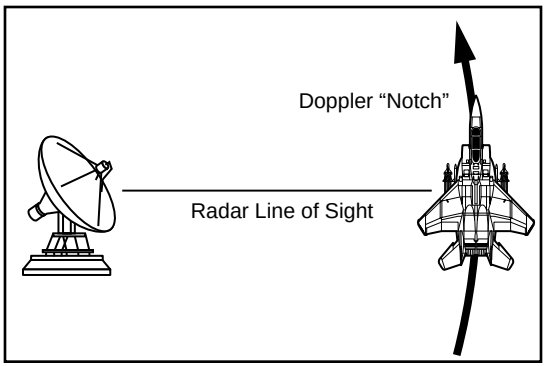

Figure 3. Doppler-Notch Diagram. The target aircraft must fly a curved line to maintain a constant distance from the radar and remain in the zero-Doppler region.

target cues by onboard ES, thus bridging the gap from the circle provided by ES to Global Positioning System (GPS) quality coordinates provided by the SAR. Most importantly, this precise location is done rapidly, entirely within the cockpit of a strike aircraft capable of conducting an immediate attack.

Sensor/Shooter

Four miles from the IP, the F-15Es enter a valley and achieve a direct LOS to the very-active radar array that is engaging the MALDs. The F-15Es are immediately detected, but it is too late for the defenders. The F-15E radars are fully active now, mapping the target array that had been located by their onboard ES sensors. They pass target location data via data link for use by other assets in-theater. Within 10 seconds of unmasking, the trailing element launches a pair of antiradiation missiles at the enemy radars. The crews identify target coordinates from the SAR maps and the jets drop behind a ridgeline and resume terrain masking. Total exposure time: 20 seconds.

Rather than simply being a user of the ISR data collected by larger, standoff systems, the strike aircraft also become *providers* of critical sensor data to other assets. Their positioning in the battlespace makes them an ideal collector. They stimulate the air defenses, becoming the reason that the radars turn on in the first place. They are the closest to an air threat. An array of onboard sensors, infrared (IR), radar, and electro-optics can be used to gather information, record it, and download it after the mission. Only the most time-critical data is transmitted using data-link bandwidth (fig. 4).[9]

Figure 4. The Final Link. Data from the two strike aircraft, working in cooperation, is burst data-linked to a "traditional" ISR platform, the RQ-4 Global Hawk, providing an extension to the UAV's own sensor array.

Electronic intelligence (ELINT) information, for example, can be used to update threat databases, characterize enemy radars, and analyze enemy tactics. The ability to bring back recorded data and conduct a postflight download will provide additional and essential intelligence, remembering that not everything of value is needed in real or near-real time.

An immediate benefit of using strike aircraft sensors is shortening the time required to engage mobile SAMs and other fleeting targets. Rather than have the targeting data pass from a sensor through a targeting cell to the Air Operations Center controllers, the information starts and ends where it can do the most good—in the cockpit. This is an important improvement because strike aircraft have a very small time window in which to engage between the time a threat emits radar energy and reveals its position and before it packs up and drives away in less than 10 minutes.

Our sensors and architecture should also take advantage of the human-in-the-loop benefits of manned combat aircraft. We can make much better use of the crew than we currently do. These individuals are well trained in target recognition, threat knowledge, tactics, and weapons employment. The combat aircrew is accustomed to making rapid decisions on complex problems for high stakes. Given a set of well-written rules of engagement to operate under, the shooter is in an excellent position to make the decision to employ weapons.

Unattended Sensors

Shortly after ducking back into the mountains, the Strike Eagles make the most of the information gathered by the radar and onboard ES. The lead pair fires their first shots of the day, launching a total of four stealthy Joint Air-to-Surface Standoff Missiles (JASSM) at the enemy radars. The trailing element drops the last of their ordnance—another, smaller group of MALDs with jamming packages and a handful of AGM-154A Joint Standoff Weapons (JSOW). The overworked SAM crews continue to engage the new threat, but the saturated computers allow three JASSMs through, and the target-engagement radars go down for good—victims of 1,000-pound unitary warheads. The JSOWs arrive later, scattering the target array with small submunitions, and destroying launcher vehicles and support equipment. Hidden among the submunitions scattered over the ground are small, covert sensors that will continue to pass data long after the fighters have gone.

Any sensor net can have its collection capabilities improved by the inclusion of remote, unattended sensors. In Vietnam, Igloo White sensors were dropped by aircraft along the Ho Chi Minh Trail to provide target-detection data to listening aircraft. While there are serious technical limitations on the sensing and communications capability of small sensors, even limited sensors can provide important information. Strike aircraft will

often be the delivery platforms, although cruise missiles and rocket artillery can also be used to seed an area with sensors.

Unattended sensors can be seeded into preplanned areas to pick up specified types of data. But they may also be deployed on an ad hoc basis by strike aircraft. For example, a strike aircraft that had detected a radar threat, but not its precise location, could deploy sensors in the area and wait for the target to move. A beer-can-sized submunition similar to the BLU-97/B could be loaded in CBU-87 canisters or AGM-154A JSOW bodies for easy, predictable dispensing.[10]

There are other uses for cheap, expendable remote sensors. Small and micro unmanned aerial vehicles (UAV) are often considered as part of an airborne net, but their usefulness need not be as limited as their airborne endurance. If the sensors aboard these tiny aircraft survive the inevitable crash (as they could be designed to do) after the UAV ran out of fuel, they could provide an additional enhancement to a distributed sensor net. If one of the MALDs used in the illustrated scenario had a data link and an ELINT sensor, it could have popped up above the mountains and sampled the electronic environment for the F-15Es. A cheap, expendable MALD will not have the ability to locate the threat, but it could see which signals are "on the air." Then, the Strike Eagles could have unmasked their ES sensors, knowing which threats to look for.

Conclusion

The scenario above is entirely notional. The F-15E does not currently have the RWR to make this vision a reality. In fact, no US combat aircraft has the sensor array described above; the MALD is not fielded; and the small, unattended sensors described do not exist. Having said that, they are not beyond our technical or financial reach—especially given the high stakes.

While this article concentrates on air defenses, there is a requirement to engage varying classes of time-sensitive targets (TST). Putting sensors and shooters as far forward as possible applies the air-to-air model to attacking certain surface targets. F-15s today are capable of individually detecting, identifying, and engaging hostile aircraft and cruise missiles—very fleeting targets.

There is a demonstrated need to be able to counter enemy air defenses rapidly in any air campaign. The core capability to detect and locate the threat must be based on the strike aircraft, with additional enhancements built upon that solid core capability. The increased proliferation of advanced, highly mobile, and lethal SAM and radar systems makes targeting these systems extremely problematic. SAMs are a very special subset of TST because they shoot back; they must be detected in a timely fashion, rapidly and precisely located, and targeted in the shortest possible time. Off-board sensors suffer from the disadvantages associated with their distance from the battlefield. The use of a distributed network of ES

sensors that not only includes, but relies on, strike aircraft could extend the reach of a typical ISR constellation to the heart of the battlefield, where it is most needed and useful. The ability to detect, locate, and subsequently suppress and destroy enemy air defenses is vital to the US armed forces' ability to conduct air operations in defended airspace, and we must make good use of all of our available assets. □

Herndon, Virginia

Notes

1. Any radar transmission.
2. The SA-6 Gainful missile was guided by a continuous-wave illumination beam that the Israeli and US RWRs of the time period did not detect. Egyptian Gainfuls capable of engaging targets at very low altitudes wreaked havoc among the Israeli strike fighters, who up to then had little respect for Arab defenses.
3. Signal strength is an inverse square function—the strength attenuates with the square of the distance. Thus, at 10 miles, a 10 gigahertz (GHz) signal would suffer 137 dB of attenuation; 157 dB at 100 nm. In plain English, a signal detected at 100 miles is one hundredth the strength of the same signal detected at 10 miles.
4. Most radar signals suffer from little atmospheric attenuation. Radar signals weaken rapidly at a frequency of 21–29 GHz, which is a water vapor absorption band, and around 60–72 GHz, which is an oxygen absorption band.
5. Medium rainfall (one-half inch per hour) adds about 0.1 dBm of attenuation per kilometer in the I band (8–10 GHz). Thus, at a distance of a mere 90 kilometers (54 nm), the signal strength is one-eighth of what it would be in clear air.
6. Since most radar signals travel in a straight line, this means that a receiver beyond the radar horizon cannot detect a transmitter. Ducting is a phenomenon that "traps" a radar signal below an inversion and allows it to travel over the horizon, but sensors above the inversion will have great difficulty collecting signals.
7. At least one proposed architecture requires that two systems, 45 degrees apart, use data link to work in concert to locate a threat with GPS-quality precision. Aside from the tactical difficulty of arranging an adequate geometry against a mobile threat, this system is functionally disabled if the data link is interrupted.
8. If one pictures a string connecting the aircraft to the radar, the aircraft must put the string at 90 degrees to the nose (directly off the left or right wing), which results in a curved flight path with the radar at the center. This means that the aircraft is not changing its distance from the radar, has no apparent velocity to the radar, and so is much harder to break out of clutter.
9. As an added benefit, this arrangement conserves data-link assets. Information gathered by the strike aircraft is transmitted to an ISR platform on a simple, line-of-sight link. The UAV (in the above example) then transmits the data beyond line of sight, using its own dedicated data links and removing the need to have a complex (and expensive) communications array aboard the strike aircraft.
10. If the sensors also look exactly like undetonated BLU-97/B submunitions, enemy soldiers will have an understandable reluctance to disturb them.

Science is in the saddle. Science is the dictator, whether we like it or not. Science runs ahead of both politics and military affairs. Science evolves new conditions to which institutions must be adapted. Let us keep our science dry.

—Gen Carl M. Spaatz

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 air and space power items of interest.*

F-35

The "F" Stands for "Future"

JOHN KENT*

IN LATE 2005, the F-35 Joint Strike Fighter (JSF) will rocket down the runway near Lockheed Martin's Fort Worth, Texas, plant and lift into the air for the first time. The event will signal the beginning of an ambitious flight-test program designed to validate the effectiveness of the world's most advanced multirole fighter. Between now and then, engineers and program managers will continue to work tirelessly to ensure that schedules are met, costs are minimized, and a mature weapon system is delivered that meets or exceeds customer expectations.

For much of the free world's military forces, the F-35 represents the future—a new family of affordable, stealthy combat aircraft designed to meet the twenty-first-century requirements of the US Air Force, Navy, and Marine Corps, as well as the United Kingdom's Royal Air Force and Royal Navy. The program is truly

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international in its scope and participation: Italy, the Netherlands, Turkey, Canada, Denmark, Australia, and Norway recently joined the F-35's system development and demonstration (SDD) phase. All SDD partners will be active in the F-35's development process and stand to gain economically from the program.

The goals for the F-35 are lofty: to be a single-pilot, survivable, first-day-of-the-war combat fighter with a precision, all-weather strike capability that uses a wide variety of air-to-surface and air-to-air weapons—and that defends itself in a dogfight. The F-35 program emphasizes low unit-flyaway cost and radically reduced life-cycle costs, while meeting a wide range of operational requirements.

The F-35 family tree branches into three distinct variants. The conventional takeoff and landing (CTOL) F-35A will replace F-16s and A-10s in the US Air Force. It will complement the F/A-22 Raptor air-dominance fighter as a nine-G-rated aircraft with an internal 25 mm gun mounted on the left intake shoulder and a combat radius of more than 600 nautical miles (NM). This model—and all F-35 variants—will have two internal weapons bays, each capable of carrying a 2,000-pound precision-guided munition and a radar-guided AIM-120 air-to-air missile. Current requirements calling for 1,763 aircraft will make the F-35A the most-produced variant.

The short takeoff/vertical landing (STOVL) F-35B will replace the aging AV-8B Harrier STOVL attack jets (which have also proven increasingly difficult to support) of the US Marine Corps, as well as its F/A-18s. The F-35B will have a stealthy, belly-mounted 25 mm missionized gun pod and a combat radius of more than 450 NM—nearly two times that of legacy STOVL strike fighters. A shaft-driven lift fan, in combination with a vectoring rear exhaust nozzle, gives this fighter the ability to take off in short distances, accelerate to supersonic speeds in level flight, and land vertically. Thanks to the lift-fan system, the F-35B's total vertical lifting thrust is about 39,700 pounds (the aircraft weighs about 30,000 pounds)—more than 14,000 pounds greater than the engine alone would produce without the lift fan. The F-35B will be the world's first operational supersonic STOVL aircraft. The Marine Corps currently plans to deploy 609 F-35Bs.

The F-35C carrier-based (CV) variant will complement the US Navy's F/A-18E/Fs and replace F-14s and earlier model F/A-18s. The wings (with folding tips) of the F-35C will span nine feet more than the wings of the F-35A and F-35B models. Like the F-35B, it also will have a stealthy, missionized 25 mm belly gun. The combat radius on internal fuel will be greater than 700 NM—again, more than twice the range of the aircraft it is designed to replace. The Navy's current plans call for 480 aircraft. The United Kingdom's Ministry of Defence has chosen the F-35B to replace its Harrier GR.7s and Sea Harriers for the Royal Air Force and Royal Navy. The United Kingdom's current plans call for 150 aircraft.

Led by prime contractor Lockheed Martin, along with principal partners Northrop Grumman and BAE SYSTEMS, the F-35 team is crafting an exceptionally lethal, survivable, and supportable next-generation strike aircraft. Compared with the aircraft it will replace, the F-35 will provide significant improvements in range, payload, lethality, survivability, and mission effectiveness. Uniting stealth with advanced mission systems and high maneuverability, the F-35 will bring revolutionary twenty-first-century capabilities to the battle space.

Conflicts in recent years have clearly demonstrated the desirability of longer combat radius (or longer time on station). The F-35 will dramatically increase its user's ability to support combat operations at longer ranges due to its tremendous internal fuel capacity and single-engine design. For example, the CTOL F-35A carries more than 18,000 pounds of internal fuel—more than two-and-one-half times the internal fuel capacity of the legacy multirole fighters it will replace. Likewise, the advantage in range more than doubles. The F-35 is not limited to internal fuel only; it can carry 600-gallon external drop tanks for ferry flights or for missions that do not require a stealthy signature. This further stretch in combat radius means that the pilot can op-

erate with reduced dependence on air refueling and can have significantly greater time on station for close air support or combat air patrol missions.

Survivability, a cornerstone of F-35 design, is enhanced foremost by the aircraft's radar-evading properties. Stealth capability, available for the first time in a multirole fighter, will minimize the threat to the pilot during operations in heavily defended areas. The aircraft also is configured with advanced countermeasures to reduce the effectiveness of enemy defenses.

Integral to the aircraft's low-observable equation is the large internal-weapons bay. When stealth is not required, the F-35 also can carry wingtip air-to-air missiles and up to 15,000 pounds of external ordnance mounted on underwing pylons. A pneumatically powered ordnance-release system replaces the traditional cartridge-powered equipment. This new design greatly reduces maintenance requirements. The internal 25 mm cannon will enable pilots to engage targets from higher altitudes and longer range.

The F-35's mission systems are designed to return the pilot to the role of tactician and to increase combat effectiveness dramatically. Next-generation sensors will provide the pilot coherent and fused information from a variety of onboard and off-board systems. Sophisticated data links will connect the aircraft to both ground-combat elements and airborne platforms. In addition to fighter-to-fighter data links, the F-35 will be equipped with satellite-communications capability for both transmitting and receiving.

The aircraft's onboard sensor suite is optimized to locate, identify, and destroy movable or moving ground targets under adverse weather conditions. This all-weather capability is achieved with the aircraft's advanced electronically scanned array (AESA) radar built by Northrop Grumman. The AESA enables simultaneous air-to-ground and air-to-air operations. It can track moving ground targets and display them on a radar-generated terrain image, enabling precise target location relative to terrain features. These instruments, coupled with off-board sensors, will make the F-35 capable of all-weather close air support under the most demanding conditions.

An internally mounted electro-optical targeting system (EOTS) is installed in the nose of the F-35, enhancing both air-to-ground and air-to-air capabilities. The EOTS will provide long-range, high-resolution targeting-infrared imagery; laser-target designation; and battle-damage-assessment capability. This system will provide pinpoint weapons-delivery accuracy for close air support and deep-strike missions.

A distributed-aperture-infrared sensor system will provide full spherical infrared coverage around the aircraft. In addition to providing warnings of missile launches, information from the system can be displayed on the pilot's helmet visor, permitting the pilot to see "through" the airplane's structure in all directions, and eliminating the need for night-vision goggles. This system will dramatically increase the ability of the F-35 to conduct any type of mission at night.

The cockpit features a large eight-inch by 20-inch color display, providing tactical information as well as aircraft system data. A next-generation voice-command system allows the pilot to manage systems without manual input. Tasks such as changing radio channels are accomplished simply by speaking a command. The pilot also has the option to manipulate the displays by touching the screen or by using a yoke-mounted cursor. Unlike the cockpit design of current-generation fighter aircraft, the F-35's does not include a head-up display. Rather, the information normally visible on such a display is instead projected on the pilot's helmet visor.

Most of the cutting-edge technologies scheduled for incorporation into the F-35 were independently demonstrated during the previous concept demonstration phase (CDP) and will now be integrated into a single platform. During the most visible part of the CDP, the JSF team validated the aircraft's superb aerodynamic performance. From October 2000 through August 2001, the JSF X-35 demonstrator aircraft established a number of flight-test standards during 139 flights and 107 flight hours:

- X-35A CTOL—most flights (27), most flight hours (27.4), most pilots checked out (six), fewest canceled flights (two), and highest flight rate (six-and-one-third flights/week) in the first 30 days of new-aircraft testing
- X-35B STOVL—first and only aircraft in history to achieve a short-takeoff, level supersonic dash and vertical landing in a single flight; first aircraft to integrate and fly a shaft-driven lift-fan propulsion system; logged 17 vertical takeoffs, 14 short takeoffs, 27 vertical landings, and five supersonic flights
- X-35C CV—demonstrated a high level of carrier suitability with 252 field carrier landing practice (FCLP) tests, extremely precise handling qualities, and prodigious power availability; first X-plane in history to complete a coast-to-coast flight (Edwards Air Force Base, California, to Naval Air Station Patuxent River, Maryland)

Despite the promise of awe-inspiring performance and capability, affordability has long been the F-35 program's foundation, and it is a subject of intense focus. According to Jim Engelland, the F-35 JSF systems-integration director, "Every decision we make across the program has to address cost. We've always worked under a performance mantra—that is, get as much performance out of an aircraft as we can. Before JSF, nobody ever said, 'If I can add five pounds here, this part will be easier to manufacture and will cost less.' We have asked all of our integrated product teams to design and develop as though they were spending their own money."*

The F-35 is designed to reduce operational and support costs significantly by increasing reliability and reducing required maintenance. Such high reliability will enable rapid deployment with minimum support equipment. The cost to operate and maintain the F-35 is expected to be 50 percent less than that for the aircraft it is designed to replace. For decades, the concept of repairing new aircraft came only after the aircraft was built. Then, it had to conform to an existing logistics structure. But the F-35's logistics system has to be up and running before the first aircraft is flown. Don Searles, deputy director of JSF autonomic logistics, notes that "the government directed [that] the logistics system be built concurrently with the air vehicle and that it perform with a level of information accuracy, best value, and total life cycle cost from the beginning."

The autonomic logistics system, as the F-35 system is called, will monitor the health of the aircraft systems in flight; downlink that information to the ground; and trigger personnel, equipment, and parts to be pre-positioned for quick turnaround of the aircraft. Ultimately, this automated approach will result in higher sortie-generation rates. Autonomic logistics is also something of a mind reader. Through a system called prognostics and health management, computers use accumulated data to keep track of when a part is predicted to fail. With this aid, maintainers can fix or replace a part *before* it fails and keep the aircraft ready to fly. Like the rest of the program, the autonomic logistics system is on a fast track. It has to be available to support the air vehicle during operational test and evaluation.

The F-35 assembly line will be notable for its automation, reduced tooling, and virtual elimination of hammered rivets. The subassemblies will be loaded into simplified tooling capable of building any of the F-35 variants. The machine will do its work, and the entire assembly—tool and all—will move to the next position. Previous manufacturing technologies would require different tooling for each variant as well as require the subassembly to be unbolted from one tool and reinstalled in another before the next process could proceed—a time-consuming exercise. Because the three variants have more than 80 percent of their parts in common, all of which are located in the assembly tooling in a common manner, major components such as bulkheads can be manufactured from the same blanks, milled and drilled on the same fixture, and assembled

*All quotations in this article are sourced internally at Lockheed Martin.

using common tools. Again, using the bulkheads as an example, the only difference among the variants is their thickness.

Larry Mestad, leader of the F-35 JSF Airframe System Engineering Integration Team, comments that "the main task is to build the aircraft affordably. We want to eliminate as much tooling as possible, improve production flow, and reduce disruption and delays. By using precise fabrication and robust assembly methods, we can eliminate hand fitting and rework as the assemblies come together. We are not using technology for technology's sake; we are using technology to reduce cost."

The first 22 airframes—14 flyable aircraft and eight nonflying ground-test articles—will be built on that assembly line during the current phase of the program. The test fleet will include five flyable CTOLs, four STOVLs, and five CVs. Static- and fatigue-test F-35s will be built for each variant, along with a CTOL radar-signature test article. A CV drop-test article will be used for live-fire testing later on. "The SDD aircraft will look a lot like the X-35," says Paul Park, director for the JSF air vehicle. "Your grandma won't be able to tell the difference, but the production models will be different from the X-35 demonstrators."

Although the automotive industry was not a direct source of expertise for the F-35, it was a source of inspiration to the people who will build the aircraft. According to Mestad, "Automotive plants don't keep inventory on an auto assembly line. They only have about two hours worth of inventory on the floor at any given time. Even the seats come off the delivery truck in sequence of installation. Our assembly line will resemble that line. It is called mixed-model production. We won't have three assembly lines; we'll have one line. We might build a CTOL version today, a STOVL version tomorrow."

The F-35 team combines the manufacturing expertise of the program's three principal partners—Lockheed Martin, Northrop Grumman, and BAE SYSTEMS—and builds on the lean-manufacturing legacy of the highly successful single-seat, single-engine F-16, as well as the F/A-18, B-2, and Eurofighter. Comparing the F-35 to current-generation fighters, engineers project that Lockheed Martin F-35 assembly will

- reduce tooling by 90 percent,
- reduce manufacturing time by 66 percent,
- reduce manufacturing costs by more than 50 percent,

- require up to 50 percent fewer parts, and
- require up to 50 percent fewer fasteners.

The F-35 is designed to accommodate growth in both mission and technology. Possible future versions of the aircraft include an electronic-attack variant, an uninhabited version, and an F-35 that incorporates a laser weapon.

Because of designed-in flexibility, the F-35 will be able to accommodate a wide range of next-generation weapons, including the small-diameter bomb currently under development. This weapon's smaller size will enable the F-35 to carry a far greater number of bombs internally, thus increasing the number of targets that can be specified per mission.

The Air Force is tentatively scheduled to receive its first F-35 in 2008, but initial operational capability (IOC) for the service is set for 2011. The US Navy, along with the Royal Navy and Royal Air Force, is scheduled for a 2012 IOC. The Marine Corps, with an IOC planned for 2010, will be the first of the military services to operate a fleet of F-35s.

On 27 June 2002, the F-35 program achieved its first major technical milestone, on schedule and under budget, when engineers finalized the external lines of the aircraft. The resulting "lines freeze" configuration is nearly indistinguishable from that of the X-35 JSF demonstrators that underwent flight testing in 2000 and 2001. Design changes, though small, will bring overall performance gains to the stealthy fighter. The design has been evolving incrementally since the configuration that flew as the X-35 demonstrator.

Finalized changes include the following:

- Extending the forward fuselage by five inches to better accommodate avionics and sensors, and moving the horizontal tail rearward by two inches to maintain stability-and-control with the newly extended forward fuselage.
- Raising by about one inch the top surface of the aircraft along the centerline, thus increasing fuel capacity by 300 pounds and extending range.
- Adding slightly more twist to the wing camber on the CV variant to improve both handling qualities and transonic performance.
- Slightly adjusting the positioning of the vertical tails to improve aerodynamic performance.

Earlier in the design phase, engineers also reduced the length of the engine's inlet ducts, thereby saving weight and improving performance.

"During the concept demonstration phase of this program, we believed the only way to validate the aerodynamic performance of our concept was to test-fly an aircraft that was representative of the one we intended to produce," points out Tom Burbage, executive vice president of Lockheed Martin and general manager of the JSF program. "When you look at this final design and compare it to the one we flew during CDP, it's clear that the two aircraft are essentially identical, save for some fine-tuning. That means the outstanding performance of our X-35 JSF concept demonstration aircraft can also be expected of our production model, the F-35."

The F-35, designed to survive in a high-threat environment and provisioned for growth, will feature levels of supportability and maintainability that have never before been achieved. Jim Engelland effectively captures the excitement and anticipation surrounding the JSF: "We are really on our way. I told some new hires that we will have a first flight in less than 40 months. We will see some tears and a lot of goose bumps that day. If you don't get either one, you are in the wrong business." □

High Ground over the Homeland

Issues in the Use of Space Assets for Homeland Security

LT COL (SEL) S. DIDI KUO, PHD, USAF

Editorial Abstract: Lt Col (sel) S. Didi Kuo outlines the challenges that space professionals face as they support traditional power-projection missions and new homeland-security tasks. Many navigation, communication, and weather-support missions translate easily from military roles to domestic-security support. But legal constraints, security classification, and complicated relationships among many agencies may make space-based intelligence, surveillance, and reconnaissance capabilities difficult to integrate with local, state, and federal response agencies. Colonel Kuo also states that partial solutions to such challenges can come from innovative and creative uses of space assets.

How the U.S. develops the potential of space for civil, commercial, defense and intelligence purposes will affect the nation's security for decades to come.

—Commission to Assess United States National Security: Space Management and Organization January 2001

THE ATTACK ON 11 September 2001 (9/11) has forever altered how Americans view their security at home. Homeland security is now a top priority for our country in the new war on terrorism. That attack has also transformed our government's approach to defending the homeland. Space assets are being used in the overseas battle against terrorism in intelligence gathering and support of military operations. Space-based surveillance also provides early warning for national missile defense.[1] However, there are several challenges to overcome before we can fully integrate space assets into the homeland-security framework for operations within our US borders.

Space Capabilities for Homeland Security

Space already plays an important role in the area of navigation and communication, and it provides the information infrastructure necessary for homeland security. Use of communication satellites, especially commercial ones, provides the backbone for many of the current homeland-security communication needs. The reliance on these satellites becomes even more critical in a crisis where terrestrial communications (both landlines and cellular) are unavailable.[2] Satellite communications provided a message of "assurance and resolve" at a time when the public-accessible communications infrastructure was in disarray.[3]

The Global Positioning System's (GPS) constellation of over 24 satellites has revolutionized the navigational field.[4] After 9/11, GPS attracted attention for its potential uses in homeland security as well as a terrorist target.[5] The integration of GPS into search and rescue and other emergency services is already widespread. After 9/11 major city leaders envisioned how GPS could be used to track certain vehicles and their contents.[6] Surveillance of vehicles belonging to suspected terrorists could also be done through GPS tagging devices. During a crisis response, all emergency vehicles, and even individual personnel, could be tracked by GPS by the Federal Bureau of Investigation's (FBI) Joint Operations Center. The discontinuation of "selective availability" increased the positional accuracy for civil users. The military, however, still receives greater positional accuracy because their encrypted receivers can better compensate for ionospheric error.[7] A study should be conducted to determine if homeland-security applications would benefit from that greater positional accuracy.

Weather information from satellites aids in preparedness and consequence management efforts. Real-time environmental data supports vulnerability and risk analyses while forecasts support the decisions that will guide preparation, protection, response, and recovery operations.[8] After the 9/11 attack, the National Weather Service provided this information using special forecasts to assist decision makers in their recovery efforts.[9] Forecasting and real-time data were also provided in support of Operation Noble Eagle.[10]

Overhead signals intelligence (SIGINT) collection can aid in the detection and prevention of terrorist attacks. SIGINT's greatest potential lies in communications intelligence (COMINT)—the interception, monitoring, and location of communications systems and their voice content.[11] In light of the extensive planning done for 9/11, it is clear that domestic surveillance was not as aggressive as it should have been.[12] COMINT derived from space sensors is an additional tool to be added to the terrestrial COMINT systems for the collection of needed intelligence on terrorists in the United States.[13]

Remote sensing is perhaps one of the biggest contributions space can make to homeland security. It has long been used for intelligence and environmental purposes and has seen tremendous growth in the last decade through commercial and civil systems. National systems provide overhead imagery intelligence (IMINT) in the form of high-resolution images. Commercial and civil satellites can collect additional lower-resolution imagery.[14]

Remote sensing from space will play a role in homeland-security preparedness that very much resembles its counterpart mission in the military—intelligence preparation of the battlefield (IPB).[15] The National Spatial Data Infrastructure program is attempting to provide geographical information systems (GIS) for major cities to assist with preparedness for terrorist attacks.[16] Imagery with GIS data could be used to map political and governmental facilities, lines of communication (LOC), choke points such as bridges and tunnels, food and water distribution points, and nuclear facilities. This information can be used both during threat assessments of potential terrorist targets and to aid first responders immediately after an attack.

In the area of response and recovery, remote sensing can be used in assessing thermal activity, the damage to infrastructure, the accessibility to damaged areas, and displace-

ment of debris.[17] Satellite imagery was used a day after the 9/11 attack to aid in the recovery efforts (fig. 1).

Satellites may provide the quickest means to gain situational awareness, especially when wide-area coverage is needed. More importantly, they can provide a single integrated picture of an incident area. Remote sensing data can be used to aid responders in formulating a proper response, such as evacuation routes for a weapon-of-mass-destruction attack.[18]

Homeland-Security Customers

Table 1 shows the actual and potential uses of space-asset capabilities by homeland-security organizations. Some agencies have already integrated space components into their operations. Many agencies consider GPS and satellite communications to be inherently part of their information infrastructure. Other systems, most notably intelligence, surveillance, and reconnaissance (ISR) satellites, are still relatively unused. The next section discusses reasons for this underutilization.

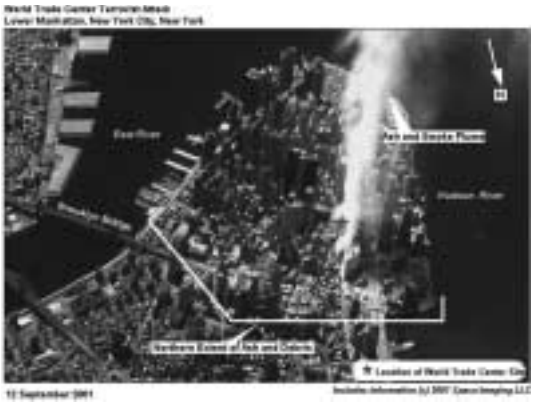

Figure 1. Panchromatic Image of the World Trade Center from IKONOS (From Federal Emergency Management Agency, on-line, Internet, available from http://www.gismaps.fema.gov/2001graphics/dr1391/nyc_pan_12sep.jpg)

Table 1

The Use of Space Assets by Homeland-Security Agencies

Homeland-Security Agency	*Major Areas of Space Support*
US Northern Command	ISR, Communication, Navigation, Weather, and Remote Sensing
Federal Bureau of Investigation	ISR, Communication, and Navigation
Federal Emergency Management Agency	Remote Sensing, Mapping, Communication, Weather, and Navigation
National Infrastructure Protection Center	Remote Sensing, Mapping, and Navigation
Office of Domestic Preparedness	Remote Sensing, Mapping, and Navigation
US Border Patrol	ISR, Remote Sensing, and Navigation
US Coast Guard	Navigation, Communication, and Weather
Environmental Protection Agency	Remote Sensing
Department of Energy	Remote Sensing
US Customs	Navigation
State and Local Law Enforcement Agencies	ISR and Navigation
State and Local Emergency Services	Communications, Navigation, Weather, and Remote Sensing
National Guard	Communication, Navigation, Weather, and Remote Sensing

Issues on the Use of Space for Homeland Security

Space communication, navigation and weather systems are designed for use within the United States and are well integrated into the federal, civil, and commercial sectors. As a result, there are no major limitations on their use in the homeland-security mission. However, with the exception of commercial imagery, the focus of ISR systems has been on overseas areas. The national ISR space architecture, ranging from satellite orbits to the infrastructure on the ground, is geared towards supporting military operations and intelligence gathering on foreign soil. Prior to 9/11, the defense and intelligence communities did not perceive a need for the use of ISR space assets in homeland security. Now, however, several organizations are examining the contributions ISR space can make to this new mission.[19]

The Space Community: Black or White?

Multiple organizations build and operate satellites for the US government because of the many national security space missions performed. The national security space community is still largely divided between unclassified Department of Defense (DOD) systems (the white world) and classified intelligence systems (the black world). On the DOD side, Strategic Command is responsible for coordinating all military and civilian space assets while Air Force Space Command acquires and operates the majority of military satellites. The National Reconnaissance Office (NRO) is responsible for the acquisition and operation of the nation's intelligence satellites, often known as national technical means (NTM).

Recent Space Commission recommendations generated several organizational changes in the national security space community.[20] The undersecretary of the Air Force (USecAF) became responsible for DOD space as well as serving as the director of the NRO. While implementing the Space Commission recommendations should improve interagency coordination, some organizational issues will remain.[21] The NRO commission stated that the NRO is caught between the competing requirements of its DOD and intelligence community customers.[22] An independent Commission on the National Imagery and Mapping Agency (NIMA) called this the "national versus tactical" problem and found it to be a highly polarizing issue.[23] Until the recent implementation of the Space Commission recommendations, only the president had the authority to provide the leadership, direction, and oversight for a coherent national security space policy.[24] Even with the USecAF's new responsibilities and authority, it remains to be seen if these old barriers can be dismantled.

There are three important issues to consider when defining homeland-security roles and missions for space: competition between space missions, customer requirements, and funding. The first issue is how much the homeland-security mission will compete with other space missions for the same resources. Homeland-security requirements will not significantly affect GPS because of its inherent design for civil applications. US Northern Command (NORTHCOM) will dominate DOD's requirements, and the ability of military communication satellites to support NORTHCOM and other federal agencies will be stressed if there is a major theater war (MTW) and a large-scale terrorist attack in the United States. Under those conditions, there may not be enough secure bandwidth to support NORTHCOM, and additional bandwidth would have to come through commercial communication satellites.

National systems may experience a similar problem during an MTW. These systems not only have to support military operations overseas, but also maintain regular intelligence collections of other nations. The NRO Commission pointed out that customer demands, both strategic and tactical, already exceed the NRO's capabilities.[25] Supporting the homeland-security mission will put an additional burden on the NTM systems. Again, commercial satellites may be able to supplement the collection needs over the United States, especially due to the lack of restrictions on their operations.

The second issue is identifying homeland-security customers and determining their space

capability requirements. The organizational landscape for homeland security is vast and often confusing. DOD and other federal agencies are involved at the national level, while state and local organizations play a critical role as first responders. A proper provider-customer relationship between the space and homeland-security organizations is currently lacking and must be developed. Many of these homeland-security-organization customers are not yet aware of the capabilities that space assets offer. For that reason, they have not yet determined their requirements, which further complicates the identification of space resources needed for the homeland-security mission.

The third issue is funding. If space assets are to play a role in homeland security, they must be properly funded. This is especially critical for dual-hatted organizations like the NRO, NIMA, and National Security Agency (NSA) that must not only be concerned about the amount of funding but also the funding's source and the legal constraints on its use. Using DOD money on homeland security may violate the Posse Comitatus Act, while the intelligence community dollars are reserved for foreign intelligence collection. In the long-term, the homeland-security mission may even require new capabilities on satellites (i.e., enhanced GPS civil capabilities or new NTM sensors). The new Department of Homeland Security may eventually become the appropriate funding source for the amount of funding that includes proper legal authorization on its use. Until then, programming funds for this capability may be difficult.

The Homeland-Security Landscape

The war on terrorism will truly be an interagency process involving some 40 federal agencies. They will be joined by a host of state and local offices that will be involved in some form of homeland-security activities.[26]

The Department of Homeland Security is responsible for preventing, to the degree possible, terrorist attacks in the United States and aiding in the recovery from such attacks.[27] Three of the assigned functions for this new office may involve advocating the need for space support. The first is to ensure that there are sufficient technological capabilities and resources to collect intelligence and data on terrorist activities within the United States. The second function is to make certain that proper resources are allocated to improve and sustain national preparedness against terrorist threats. The third function is to coordinate the response and recovery efforts to a terrorist attack. Space capabilities can help the Department of Homeland Security carry out these functions.

Currently the DOD role in homeland security is limited. America's long-standing fear of military involvement in domestic affairs has resulted in a myriad of statutes and directives that govern the use of the armed forces within the United States.[28] Key tasks are air and missile defense as well as assisting civilian authorities in responding to natural disasters and terrorist attacks.[29] The National Guard is exempt from many of the restrictions.[30] Until federalized, they belong to their respective states and thus may provide domestic support.[31] Like other homeland-security organizations, the close integration of National Guard units with space assets is limited.

Both *Joint Vision 2020* and the *2001 Quadrennial Defense Review* discuss the importance of homeland security.[32] The creation of NORTHCOM will help focus the DOD's homeland-security mission.[33] NORTHCOM has both North American Aerospace Defense Command's (NORAD) mission of air and space defense as well as US Joint Forces Command's mission of providing military assistance to civil authorities.[34] The need to integrate space operations within the United States, especially ISR systems, means NORTHCOM has unique space issues not encountered with the other geographical commands.

Past experience demonstrates that nonfederal local authorities are normally the first to respond to emergencies and threats.[35] Several studies and reports recommended strengthening the state and local agencies responsible for homeland security.[36] There is a lack of understanding at the state and local levels of what space can do. This is especially true of national

systems because of the necessary security clearances. Unless there is an education process among these organizations, new applications of space to homeland security will be limited.

The number of organizations involved in homeland security may be an impediment to the effective use of space for homeland security. Bureaucratic infighting and the lack of clear lines of responsibility make the integration of space into various homeland-security missions difficult. Not only are civil and military agencies involved at the national level, but state and local agencies will also play a crucial role. To compound this problem, the space community itself is made of multiple organizations that are currently in a state of transition. There is no place for the Department of Homeland Security to go for "one-stop shopping" on space issues. To get all of these moving parts from both communities to work together will be a monumental challenge. While it is out of the scope of this article to solve these homeland-security organizational problems, a solution must be found if space is to be effectively used.

Legal and Policy Limitations: Blindfolding the Eye in the Sky

Obstacles to using ISR satellites for homeland security include the legal and policy issues surrounding the intelligence collection on US persons. While surveillance systems such as the Defense Support Program satellites do not have an issue because of their low resolution, NRO's IMINT and SIGINT satellites have the capability to aid homeland security in this area.[37] In addition, possible new surveillance methods such as GPS tagging will also face legal issues. There has always been a delicate balance between the need for national security and the protection of individual privacy rights under the US Constitution.[38]

Domestic intelligence collection from space is subject to a complex legal and policy landscape with multiple directives that are often open to interpretation. Table 2 illustrates some of these laws and policies.

Executive Order (EO) 12333 establishes the overall framework for all intelligence gathering within the United States. It is the primary guidance for IMINT collections on US soil and provides additional instruction to the Foreign Intelligence Surveillance Act (FISA) for domestic SIGINT collections. Even though NRO satellites collect both SIGINT and IMINT, NSA and NIMA have additional and different guidance for this process.[39]

FISA regulates the collection of SIGINT on US persons.[40] This classified document requires a special court order to collect SIGINT within the United States. The Bremer Commission found that under ordinary circumstances, the FISA process can be slow and burdensome.[41] The reviewing agency often used stricter interpretations requiring more information than mandated by FISA.[42] Additional guidance for SIGINT comes from the United States Signals Intelligence Directive 18.[43] This NSA directive ensures that these types of collections are conducted in a manner that safeguards the constitutional rights of US persons.

Because the NRO, NSA, and NIMA are also affiliated with the DOD, Title 10 issues such as the Posse Comitatus Act may apply to them. A review of the literature quickly shows there is no universal agreement on what the Posse Comitatus Act allows and forbids the military to do in homeland security.[44] While most DOD space operations within the United States are considered passive and thus permitted under this act, intelligence satellites play a more active role. As a result, the NSA and NIMA may be prohibited from distributing NTM products under the Posse Comitatus Act because they are DOD support agencies.

As table 2 illustrates, there are many legal and policy constraints on NTM activities and what it collects in the United States. Much of this direction overlaps itself, and almost all of it is subject to interpretation. One example is that both DOD and the intelligence community regulations apply to NIMA. Must NIMA use the most restrictive guidance to limit its operations, or can it use the most advantageous policy to provide imagery? Unless such issues are resolved in advance, timely distribution of NTM products is unlikely in a critical situation. Now is the appropriate time to

Table 2

Major Regulations Affecting the Use of Space for Homeland Security

Regulation	*Type*
Executive Order 12333, United States Intelligence Activities	Executive Directive
Executive Order 12958, Classified National Security Information	Executive Directive
Presidential Decision Directive 35, Intelligence Requirements	Executive Directive
Presidential Decision Directive 39, US Policy on Counterterrorism	Executive Directive
Presidential Decision Directive 49, National Space Policy	Executive Directive
Foreign Intelligence Surveillance Act (50 *USC*)	Statute
USA PATRIOT Act	Statute
Posse Comitatus (10 *USC* 1385)	Statute
National Security Act of 1947 (50 *USC*)	Statute
Classified Information Protection Act (18 *USC*)	Statute
Freedom of Information Act (5 *USC* 552)	Statute
DOD Directive 5525.5, *DOD Cooperation with Civilian Law Enforcement Official*	Department Policy
DOD Directive 3025.1, *Military Support to Civil Authorities*	Department Policy
DOD Directive 5240.-R, *DOD Activities That May Affect US Persons*	Department Policy
CIA Headquarters Regulation 7-1, *Law and Policy Governing the Conduct of Intelligence Activities*	Department Policy
US Signals Intelligence Directive 18	Department Policy
United States v. Kyllo (2001)	Judicial Ruling
United States v. Katz (1966)	Judicial Ruling
United States v. Dow (1983)	Judicial Ruling

revise these regulations in order to provide greater latitude for intelligence collection from space within the United States.

The TPED Issue Hits Home

Tasking, processing, exploitation, and dissemination (TPED) of national space products is currently a major hindrance to fully utilizing these assets. The problem of having sufficient resources to get the product to the military user in the field has been widely identified.[45] The same challenge will be faced when getting the product out to homeland-security agencies, especially in a timely manner. NIMA is responsible for national IMINT space products, while NSA is responsible for SIGINT space products. Both of these organizations have come under scrutiny for their performance of that role.[46] The addition of the homeland-security mission will only increase the strain on their already overburdened TPED resources.

On the tasking side, the homeland-security agencies need to understand what they can task and how to frame the request for collection so that it can be done legally. While NIMA is in the process of streamlining the approval process for domestic imaging, requests still must come through other federal agencies.[47] During time-critical events, this bureaucratic delay can result in missed opportunities by satellites with limited observation windows. For processing and exploitation of space products, the homeland-security agencies have neither the same expertise nor tools as the space and TPED organizations. An inadequate distribution infrastructure also hampers the dissemination of NTM products. One option is to provide special equipment to homeland-

security agencies that can receive and exploit NTM imagery, similar to what is being done for military units.[48] Classification of the products is another issue. A way is needed to rapidly declassify the information so that local responders can use it in a timely manner. For IMINT, the image can be degraded or used as a source for a derived product. For SIGINT, information needs to be disseminated without attribution to the NSA.

Because state and local agencies play a vital role in homeland security, the national TPED capabilities must reach down to the local levels.[49] Currently the availability of NTM products to these agencies is almost nonexistent. The increasing availability of commercial imagery may improve this situation. Because state and local authorities are typically the first responders, it is imperative to extend the TPED process down to this level.

Commercial Imagery: The New Satellite on the Block

A discussion on the use of space for homeland security would not be complete without mentioning the growing role of commercial space imagery. A commercial satellite owned by Space Imaging took some of the most widely recognized pictures of the 9/11 attack.[50] The New York governor's office contacted Space Imaging directly to request information on the use of satellite imagery for disaster assessment and emergency management.[51] It was an unusual situation where a state went directly to a private company rather than a federal agency for help on using space assets. As second-generation satellites with improved resolution are launched (fig. 2), the importance of commercial imagery for homeland security will become even more pronounced.

The two main advantages of commercial imagery are the lack of legal restrictions on their use over the United States and the unclassified nature of their product. Because they are privately owned, commercial systems do not face the same restrictions as national systems. Their unclassified products can easily be distributed to anyone, provided the proper licenses are bought. This is important because many homeland-security agencies, especially at the state and local levels, do not have the necessary security clearances for national imagery. Also, the dissemination of these products can be done through the Internet, thus providing quick and easy access. Because of these advantages, commercial imagery, as it becomes more available, will be a major source of data from space for homeland security.

Figure 2. Second-Generation Commercial Imagery (0.6-meter resolution image from Quickbird, courtesy of Digitalglobe, on-line, Internet, 28 February 2002, available from www.digitalglobe.com)

The High Ground for Homeland Security

Space assets can play a significant role in enhancing homeland security. These systems provide communication and navigation support that is vital to homeland-security functions. Satellites also provide unique information from their vantage point in space. Whether it is providing intelligence against a terrorist threat or preparing and responding to a WMD attack, space provides unfettered access to quickly collect information over wide areas at any location in the United States. Despite these capabilities, significant legal, policy, organizational, and procedural limitations exist. These limitations must be examined and

addressed if space is to be fully utilized for homeland security.

The same situation for the use of space in homeland security today existed with the military in Desert Storm. Many space assets were an unknown quantity when planning for operations at that time. Only after 10 years of effort is space now an integral part of military operations, as demonstrated in Operation Enduring Freedom. The challenge now is using space for this new national security threat. The Department of Defense and the Department of Homeland Security must now work together to bring the high ground home to America. □

Notes

1. The Defense Support Program (DSP) satellites, a key part of North America's early warning system, detect missile launches, space launches, and nuclear detonations. The Space-Based Infrared System (SBIRS) is scheduled to replace it.

2. Immediately after the 9/11 attacks, cell phone use was unavailable both in Manhattan and Washington, D.C., due to overwhelming usage.

3. This was the comment made by Richard DalBello, executive director of the Satellite Industry Association, at the 18th National Space Symposium.

4. For an excellent review of how GPS is used worldwide, see National Aeronautics and Space Administration's GPS homepage at http://gpshome.ssc.nasa.gov/. For a tutorial on how GPS works, see Jeff Hurn, *GPS: A Guide to the Next Utility* (Sunnyvale, Calif.: Trimble Navigation, 1989). Additional information can also be found on-line, GPS Joint Program Office Web site available from http://gps.losangeles.af.mil.

5. "Terrorism Attacks Accelerate Interest in GPS Applications," SpaceDaily.com, 1 December 2001, on-line, Internet, 28 February 2002, available from http://www.spacedaily.com/news/gps-01s.html.

6. Although a contract was awarded by an unnamed city to do this, no specific details were given. I have speculated on what some of the applications might be.

7. The Standard Positioning Service provides civil users a minimum of 36-meter accuracy (based on a worst-site positioning-domain accuracy at 95 percent all-in-view horizontal error).

8. Donald Wernly, "NOAA's (National Oceanic and Atmospheric Administration) Capabilities to Support Homeland Security," presentation to the Committee for Operational Processing Centers (COPC) and Shared Processing Operations Steering Committee (SPOSC) Meeting, Camp Springs, Md., 28 November 2001, on-line, Internet, 28 February 2002, available from http://www.ofcm.gov/copc/copc_meeting-01-2.htm.

9. "NOAA's Role in the Nation's Recovery Efforts and the War on Terrorism," *NOAA Magazine*, 1 November 2001, on-line, Internet, 15 January 2003, available from http://www.noaanews.noaa.gov/magazine/stories/mag2.htm.

10. Col Bob Allen, "Air Force Weather Agency Director's Update," presentation at the COPC/SPOSC Meeting, 28 November 2001, on-line, Internet, 28 February 2002, available from http://www.ofcm.gov/copc/copc_meeting-01-2.htm.

11. SIGINT can be broken into electronic intelligence (ELINT), foreign instrumentation signals intelligence (FISINT), and communications intelligence (COMINT). ELINT and FISINT are used to collect information on radars, weapon systems, and telemetry, and probably would not be of much utility since terrorists are unlikely to use weapons of that sophistication. Definitions of these three types of SIGINT can be found in Air Force Doctrine Document 2-5.2, *Intelligence, Surveillance, and Reconnaissance Operations*, 21 April 1999, 27, on-line, Internet, 28 February 2002, available from https://www.doctrine.af.mil/Main.asp.

12. Kurt Campbell and Michele Flournoy, *To Prevail: An American Strategy for the Campaign against Terrorism* (Washington, D.C.: Center for Strategic and International Studies Press, December 2001), 79.

13. This collection is already done overseas, although there have been questions raised on the ability to track terrorists who may limit their electronic conversations.

14. The Department of Energy's Multi-Thermal Imager provides both mid-wave and long-wave infrared imagery. LANDSAT, SPOT, IKONOS, and Quickbird have four to seven multispectral bands. Canada's RADARSAT provides synthetic aperture radar (SAR) imagery.

15. IPB is defined as the continuous process used to develop a detailed knowledge of the adversary's forces and capabilities.

16. The NSDI falls under the auspices of the Federal Geographic Data Committee chartered by the Office of Management and Budget. For more information, visit their Web site on-line at http://www.fgdc.gov/nsdi/nsdi.html.

17. These were the type of questions asked to the remote sensing community after the 9/11 attacks. Senate Governmental Affairs Subcommittee on International Security, Proliferation, and Federal Services, "Assessment of Remote Sensing Data Use by Civilian Federal Agencies," 10 December 2001, 10.

18. A Domestic Emergency Support Team (DEST) would provide on-scene expertise for nuclear, biological, and chemical attack.

19. Some conferences held to address these issues were the Chamber of Commerce Space Enterprise Council's forum on the use of space for homeland security held on 8 November 2001, the NRO's Federal Reconnaissance Conference held on 4 February 2002, and the National Defense Industrial Association's Changing Face of Military Space Conference on 26 February 2002.

20. Hon. Donald Rumsfeld, secretary of defense (SECDEF), memorandum to secretaries of the military departments et al., subject: National Security Space Management and Organization, 18 October 2001.

21. Even a year after the release of the Space Commission, one panel member stated that many of the same problems still exist.

22. Report of the National Commission for the Review of the National Reconnaissance Office: The NRO at the Crossroads (NRO Commission), 1 November 2000, on-line, Internet, 16 January 2003, available from http://www.fas.org/irp/nro/commission/nro.pdf. The NRO Commission called on the SECDEF and director of Central Intelligence (DCI) to work closely together to balance these needs.

23. Independent Commission on the National Imagery and Mapping Agency, *The Information Edge: Imagery Intelligence and Geospatial Information (NIMA Commission)*, December 2000, on-line, Internet, 16 January 2003, available from http://www.fas.org/irp/agency/nima/commission/report.pdf. See section 8.2 and 10.1 where it notes that several capabilities desired by the JCS in the NRO's future imaging architecture were unable to be met because of cost constraints.

24. Commission to Assess United States National Security: Space Management and Organization (Washington, D.C., 11 January 2001), on-line, Internet, 16 January 2003, available from http://www.defenselink.mil/pubs/spaceintro.pdf. See "Executive Summary," 19.

25. NRO Commission, "Executive Summary."

26. Center for Defense Information Terrorism Project, "Organizations for Homeland Security: Issues and Options," 21 December 2001, on-line, Internet, 28 February 2002, available from http://www.cdi.org/terrorism/homelandsecurity.cfm.

27. The Department of Homeland Security, June 2002, on-line, Internet, 10 July 2002, available from http://www.whitehouse.gov/deptofhomeland/book.pdf.

28. John R. Brinkerhoff, "The Posse Comitatus Act and Homeland Security," *ANSER Institute Homeland Defense Journal*, February 2002, on-line, Internet, 28 February 2002, available from www.homelandsecurity.org/journal/articles/displayarticle.asp/article=30.

29. Dale Eisman, "Command of Homeland Defense Combines Parts of 2 Agencies," *The Virginian-Pilot*, 6 February 2002, A-6.

30. The National Guard and Reserve operate under Title 32, not Title 10, and thus are exempt from the Posse Comitatus Act.

31. Gen Russell C. Davis, "The National Guard: Americans at Their Best," lecture, Air Command and Staff College, Maxwell AFB, Ala., 6 February 2002.

32. *Joint Vision 2020* highlights the need for interagency cooperation when dealing with HLS. In the *QDR*, released weeks after 9/11, HLS was cited as a top priority for the military.

33. Secretary of Defense Donald Rumsfeld, "21st Century Transformation of the U.S. Armed Forces," speech, National Defense University, Washington, D.C., 31 January 2002.

34. Chairman of the Joint Chiefs of Staff, Joint Publication 1, *Joint Warfare of the Armed Forces of the United States*, 14 November 2000.

35. Jeffery Brake, "Terrorism and the Military's Role in Domestic Crisis Management: Background and Issues for Congress," CRC Report for Congress, 19 April 2001.

36. *Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction*, pt. 3, Third Annual Gilmore Report (Washington D.C., 15 December 2001), on-line, Internet, 28 February, 2002, available from http://www.rand.org/nsrd/terrpanel/terror3-screen.pdf., iv.

37. Since the National Security Act of 1947 stated the CIA "shall have no . . . internal security functions," there have been strict guidelines on NTM collections over the United States.

38. For an excellent discussion of this topic, see Stewart Baker, "Shall Spies Be Cops?" *Foreign Policy*, no. 97 (winter 1994/95): 36.

39. For SIGINT, NSA follows DOD Directive 5240.1-R and US Signals Intelligence Directive 18. For IMINT, NIMA follows DOD Directive 5525.5.

40. A US person is defined as a citizen of the United States or an alien lawfully admitted for permanent residence. In the FY 2000 Intelligence Authorization Act, the FISA standards were reemphasized on SIGINT collections. FY 2000 Intelligence Authorization Act, Legal Standards for the Intelligence Community in Conducting Electronic Surveillance (Washington, D.C.: February, 2000).

41. *Countering the Changing Threat of International Terrorism: Report of the National Commission on Terrorism*, The Bremer Commission (Washington, D.C.: 7 June 2000), on-line, Internet, 28 February 2002, available from http://www.terrorism.com/documents/bremercommission/index.shtml, chap. 2.

42. The Department of Justice's Office of Intelligence Policy and Review (OIPR) must first approve FISA orders. In practice the OIPR required additional evidence of wrongdoing or specific knowledge of the group's terrorist intentions in addition to the person's membership. The Bremer Commission recommended that the attorney general order the OIPR not to require information in excess of FISA standards. The Bremer Commission, chap. 2.

43. US Signals Intelligence Directive (USSID) 18 is classified; however, a declassified version can be found on-line.

44. John R. Brinkerhoff, "The Posse Comitatus Act and Homeland Security," *ANSER Institute Homeland Defense Journal*, February 2002, on-line, Internet, 28 February 2002, available from http://www.homelandsecurity.org/journal/articles/displayarticle.asp/article=30.

45. The NIMA Commission, "Executive Summary."

46. Ibid.; and Bill Gertz, "Spy Data Analysis Criticized as Slow," *Washington Times*, 25 October 2001, 14.

47. Catherine MacRae, "NIMA Eyes Simpler Process to Share Intel with Domestic Authorities," *Inside the Pentagon*, 11 July 2002, on-line, Internet, 11 July 2002, available from ebird.dtic.mil/Jul2002/s20020711nima.htm.

48. Some examples of these exploitation tools that can be deployed to the field include the NIMA In-a-Box for Leveraged Exploitation (NIMBLE), Broadcast-Request Imagery Technology Experiment (BRITE), and Eagle Vision.

49. This was highlighted by the director of NIMA at a recent symposium. "Clapper: NIMA Transforming to Respond to Homeland Defense Role," *Aerospace Daily*, 11 April 2002.

50. Pictures shown in this article are available on the Space Imaging Web site, www.spaceimaging.com.

51. David Leonard, "Private Satellites Primed for National Security Role," *Space News*, 14 September 2001, on-line, Internet, 28 February 2002, available from http://space.com/news/remote_surveillance_010914-1.html.

The air ocean and its endless outer space extension are one and indivisible, and should be controlled by a single homogeneous force.

—Alexander P. de Seversky

The Looming Biological Warfare Storm

Misconceptions and• Probable Scenarios•

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Editorial Abstract: The several anthrax incidents that occurred in Florida, New York, and Washington, D.C., during the fall of 2001 did not provide convincing evidence that a mass-casualty biological warfare attack is likely. Colonel Davis systematically unravels six prevailing myths that, in his view, blind US decision makers to the possibility of bioattacks against agriculture, troops, and population centers. In Davis's opinion, our persistent denial of the realities that characterize our adversaries' biological warfare capabilities could result in catastrophic consequences.

Yet, this is still a dangerous world, a less certain, a less predictable one. . . . Many have chemical and biological weapons. Most troubling of all, the list of these countries includes some of the world's least-responsible states.

—President George W. Bush
National Defense University, 1 May 2001

THE LIKELIHOOD THAT biological weapons will be used against our nation continues to rise. Many in the recent past have considered the talk of such horrific weapons as only hype to justify funding for certain programs for DOD, other governmental agencies, or government contractors. The stark reality of 11 September 2001—when hijacked airliners were used as missiles, and anthrax attacks followed—has changed that perception for many. However, since we have not yet suffered a mass-casualty biological warfare (BW) event, there are others that still dismiss the scenario as highly unlikely.

If this view is persuasive to US decision makers, it will impede the nation's ability to

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prepare for or prevent such an event. Until very recently, the lack of focus on this subject had resulted in a lack of appropriate funding and accountability. There are six important myths that have caused some senior civilian and military government leaders to develop an inappropriate view of this threat.

It would be valuable to those who recognize the nation's vulnerability to BW to know the most likely scenarios we should expect to encounter. Such informed speculations and visualization allow us to prepare before the event or possibly even to prevent it. This article describes six common myths about BW and three of the most likely future BW scenarios we may face.

Why Postulate?

Thomas C. Schelling observes that "the tendency in our planning is to confuse the unfamiliar with the improbable. The contingency we have not considered seriously looks strange; what looks strange is thought improbable; what is improbable need not be considered seriously."[1]

The United States has limited funds to spend on social and military programs. The military budget is currently 3 percent of the US gross national product (GNP) as compared to 6 percent of the GNP during the late 1980s.[2] The most devastating terrorist attack ever perpetrated against the United States occurred on 11 September 2001 and not only cost many lives, but the associated economic impact exceeded hundreds of billions of dollars in direct replacement costs, lost revenues, and costly response efforts. Yet, the human impact and economic impact of 11 September 2001 will be dwarfed if adversaries are able to effectively deploy mass-casualty biological weapons against the United States. Unless we focus appropriate dollars and develop a coherent national plan to prepare for and prevent such actions, the United States will likely suffer an enormous economic loss that could even lead to our demise as a superpower.

Will There Really Be an Attack?

A belief in one or more of at least six false assumptions or myths helps explain why individuals, including senior civilian and military leaders, do not believe that a mass-casualty BW attack will occur.

Myth One: There Never Really Has Been a Significant BW Attack

This contention is counter to historical fact. Even before the fall 2001 anthrax terrorism in the United States, incidents of BW and bioterrorism have occurred on multiple occasions. Today, more countries have active BW programs than at any other time in history, which increases the likelihood that BW will be used again in the future.

Military organizations have used biological weapons many times. One BW event occurred in 1346 when the Mongols used plague (*Yersinia pestis*) at the Battle of Kaffa. More recently, during the French and Indian War, the British used smallpox (*Variola*) against the Delaware Indians and also are alleged to have used smallpox against Gen George Washington's forces during the Revolutionary War.[3] The Germans used anthrax (*Bacillus anthracis*) and glanders (*Pseudomonas mallei*) against the horses and mules of the US Army and its Allies in World War I. The Japanese used typhoid (*Salmonella typhi*) in World War II in direct attacks on approaching Russian forces.[4] They also used over 16 different BW agents (plague, anthrax, etc.) on Chinese forces and citizens, US prisoners of war, British detainees, and others. Ken Alibek, former head of the civilian branch of the Soviet offensive biological program, has unearthed information that leads him to believe that the Soviet army may have used tularemia (*Francisella tularensis*) to halt the oncoming German army in World War II.[5] The *Textbook for Military Medicine*, published in 1997, states that an estimated 10,923 deaths resulted from the Soviet use of chemical and biological warfare (CBW) agents in Afghanistan, Laos, and Kampuchea (Cambodia).[6] In 2001, the US Senate and other US government offices were attacked through the mail system by letters

filled with lethal anthrax spores milled to the 1–5 micron size, which can inflict death from inhalation. BW, it must be concluded, has been an accepted practice for a number of states for a long time.

Myth Two: The United States Has Never Been Attacked by a BW Agent

Counting the 2001 anthrax attacks, there are at least six known instances where BW has been used against US citizens or resources. The British were alleged to have used smallpox in the Revolutionary War. The Germans used glanders against US horses and mules during World War I. The Japanese used multiple biological agents against their foes during World War II. The Aum Shinrikyo cult failed in 1990 in its botulinum toxin attack on the two US naval bases located at Yokosuka and Yokohama.[7] In 1984, the Bhagwan Shree Rajneesh cult contaminated 10 restaurant salad bars in Oregon with salmonella and infected at least 750 local citizens.[8] This BW attack, like the naval base attacks, was not discovered until several years after the event. Proliferation experts, such as the National Defense University's Seth Carus, agree that these examples lend credence to the possibility that the United States may have unknowingly fallen victim to still other BW attacks in the past.[9]

Myth Three: You Have to Be Extremely Intelligent, Highly Educated, and Well Funded to Grow, Weaponize, and Deploy a BW Agent

Financial status or brilliance is no longer a major roadblock for an individual or group to acquire a significant BW capability. Dr. Tara O'Toole, deputy director for the Center for Civilian Biodefense Studies at Johns Hopkins University, believes we have probably crossed over the threshold from "too difficult" to accomplish to "doable by a determined individual or group."[10] It is true that there are certain technical hurdles, but there are many thousands of highly educated microbiologists or other health science professionals worldwide that are capable of growing, weaponizing, and employing a BW agent. Much of the technical information is readily available on the Internet, in libraries, and through mail-order channels that provide "how-to" manuals. For example, Steve Priesler, who has a degree in chemistry, wrote such a manual and made it available on the Internet for only $18.[11] This manual, titled *Silent Death* by "Uncle Fester," tells the reader where to find, grow, and weaponize agents such as *Bacillus anthracis* and *Clostridium botulinum;* it also instructs the reader on how to employ the agents to kill small or large numbers of people.

Myth Four: Biological Warfare Must Be Too Difficult Because It Has Failed When It Has Been Tried

Most of the BW attempts mentioned in this article resulted in deaths or casualties. However, not all attempts in the past have been successful. For example, it was not known until 1995 (when several of its incarcerated leaders confessed) that in 1990 the Aum Shinrikyo cult had sprayed two US naval bases in Japan. It is not known why their attack failed, but there were thousands of US sailors and dependants who were one breath away from dying had the Aum Shinrikyo cult been a bit more skilled. While this cult may have failed to master the technological hurdles, several nations had learned a great deal about how to make and effectively use these weapons over half a century earlier. The Japanese began their BW program in the early 1930s and used it against their opponents in World War II. The United States, Great Britain, and the Soviet Union also started BW programs during the 1930s and 1940s. Basic BW technology has been around for 60 years, and all of these countries were to develop large and potent BW programs. This was long before the era of genetic engineering and the mapping of genomes. Although some of the BW program secrets were probably not available to the Aum Shinrikyo cult, the 1990s brought a proliferation of information and biotechnological advances.[12] In light of all the previously successful attacks, it is a weak argument to say that BW "has not been successful," based only on the Aum Shinrikyo's inability to kill Americans with botulinum toxin or its failed attempts to kill Japanese with anthrax.[13] In the

twenty-first century, technological barriers are no longer as formidable as they once were, and some experts believe that a determined individual or group can independently develop BW mass-casualty weapons.[14]

Myth Five: There Are Moral Restraints That Have Kept and Will Keep BW Agents from Being Used

Most states in the twentieth century have generally avoided the use of BW agents. For example, the United States had an offensive BW program from 1942 to 1969, but it never used BW agents. The Soviets had enough BW agents weaponized to kill the world several times over and yet exhibited restraint. It may be that the various political, military, and moral constraints against BW use have thus far prevented BW on a mass scale, but it appears that we are now entering a new era. Jessica Stern, in *The Ultimate Terrorists,* outlines four techniques of "moral disengagement" that individuals and groups have used to justify their use of mass-casualty weapons.[15]

The following examples illustrate the lack of moral inhibition by various types of terrorism. On 26 February 1993, terrorist Ramzi Yousef and several other Muslim terrorists exploded a bomb intended to topple the World Trade Center twin towers and kill at least 250,000 people.[16] The blast, although not completely successful, killed six, injured more than 1,000, and inflicted costs in excess of $600,000,000.[17] On 19 April 1995, Timothy McVeigh committed the worst act of domestic terrorism by an American citizen when he bombed the Alfred P. Murrah Federal Building in Oklahoma City.[18] More than 550 people were targeted, and the resulting tragedy left 168 dead and hundreds of others wounded.[19] On 11 September 2001, international terrorists destroyed the twin towers of the World Trade Center, ruined over 20 adjacent buildings, and significantly damaged the Pentagon by hijacking and crashing US commercial airliners into these icons of American society. In less than two short hours, these brutal acts of terror killed approximately 3,000 innocent civilians and military personnel while injuring many thousands more and bringing US air travel to a temporary and very costly halt.[20]

We can look to the emergence of organizations such as al Qaida, Osama bin Laden's group, and see that any previous moral constraints to inflicting massive civilian deaths are no longer applicable. They have launched a "holy war" against the United States and are not reticent to inflict heavy casualties on US citizens—even if it entails the loss of their own lives. In fact, according to the holy war paradigm propagated by Bin Laden, great honor is supposed to accrue to those who die killing many "infidels." Thus, "morality" can be marshaled as a reason both to limit BW use and to advocate mass killings—depending on the decision maker's values and perspectives.

Myth Six: The Long Incubation Period Required for BW Agents before Onset of Symptoms Makes BW Useless to Users

There have already been multiple BW attacks, and to a savvy biological weaponeer, the incubation period can be used as an advantage rather than a disadvantage. The two following scenarios illustrate that advantage. In the first scenario, an anthrax attack is made on an adversary's military installation. That attack could render the installation nonfunctional within 72 hours. The first clinical cases of anthrax would probably manifest themselves in around 24 hours, with the number of subsequent cases increasing rapidly. A follow-on conventional military attack that was timed to occur three to four days after the BW attack would likely find the installation defenders laid low by the disease and therefore would be more likely to succeed. Moreover, because of the nature of the *Bacillus anthracis* organism, the attackers would not have to be overly concerned about significant secondary infections from their infected adversaries or by large amounts of residual spores in the environment.

The second scenario involves an attack on an adversary's population or military installation with Q fever (*Coxiella burnetii*). With Q fever's two- to 10-day incubation period, the attacker and his followers would have days to escape before their adversary would recognize

that there had been an attack. Between the fifth and 10th day after the attack, the attackers could announce that a nonlethal weapon had been used as a "show of force and resolve" and demand whatever concessions they were after. The attackers would have little concern of being exposed to secondary infection because Q fever is not communicable. Likewise, the low fatality rate would take away the adversary's justification for a massive retaliation but at the same time leave the adversary's population with a heightened sense of fear because of their proven vulnerability.

What Would Motivate a BW Attack on the United States?

There are two primary motivations that might drive an adversary to attack the United States with a BW agent. Either one is enough to cause a nation, organization, or individual to act against the United States, but concerns should be particularly heightened when both of these motivations intersect.

The first motivation is to gradually "erode US influence" as a world superpower. Adversaries such as Iraq, Iran, or the al Qaida organization desire more influence in their region. They are infuriated that American infidels have increased their presence in the Middle East from three ships in 1949 to over 200,000 US military personnel in 2001.[21]

Likewise, there are other emerging economic powers in the world that see the United States in a love/hate relationship. They realize the United States is helping them to become economically sound, but they would ultimately like to take a piece of the economic action from the United States. These nations might also want to inflict damage to the US economy, and in their mind, level the playing field in a way that would minimize damage to their own economy. The far-right wing of groups with this motivation include religious terrorist groups such Osama bin Laden's al Qaida who declare that they have a religious obligation to destroy the "evil race" in the name of "Allah."

The second motivation is categorized as "revenge or hate." At a time when the United States is an integral part of stimulating the global economy and thereby improving the standard of living for millions in the world, the so-called transparency of the United States inflames envy, which often leads to hatred, in millions around the world. The United States has 5 percent of the world's population yet uses 24 percent of the global energy.[22] The extravagance of the United States is seen by some as the reason for a worldwide moral decay. Often these same individuals may want to inflict revenge because of what they perceive the United States or its "puppet nations" have done to them individually, their family, or their group. Many of these individuals have been taught from childhood to hate the United States. This prejudice often grows as they see images on television that portray the United States as a drunken, immoral, gluttonous, and violent society.

There is synergism when a nation, group, or individual desires to erode US influence as a world superpower and is also full of revenge and hate. This effect would amplify their desire and ability to enlist support financially and deliver an effective BW attack. They then have a cause where emotion reinforces or even overrides the logic or illogic of such an attack.

Possible Future BW Scenarios

This author believes that there are three most likely BW scenarios the United States and its allies might face in the future:

- An agroterrorist event against the United States,
- A BW attack on United States and allied troops in the Middle East, and/or
- A bioterrorist attack against a large population center in the United States or an allied state.

Scenario One: An Agroterrorist Event

Anne Kohnen states that "agricultural targets are 'soft targets,' or ones that maintain such a low level of security that a terrorist could carry

out an attack unobserved. Biological agents are small, inexpensive, and nearly impossible to detect. A terrorist may choose to use BW against agriculture simply because it is the easiest and cheapest way to cause large-scale damage."[23]

As was articulated by Mark Wheelis, a senior microbiologist at the University of California, Davis, many of the moral constraints that might inhibit an adversary can be overcome by using agroterrorism.[24] The US economy could be made chaotic by inflicting damage to the US agricultural industry with three to five BW agents over a few years. For example, the United Kingdom suffered a severe disruption in day-to-day life in 2001 when foot-and-mouth disease broke out, forcing the slaughter of hundreds of thousands of livestock. Estimated cleanup and economic loss is assumed to have reached $30 to $60 billion.[25] Belgium suffered an apparent agroterrorist event when dioxin was discovered in chicken feed.[26] This resulted in boycotts across Europe and Asia of Belgian meat products that cost their economy nearly $1 billion.[27] Such an incident in the United States could potentially jeopardize $140 billion in yearly pork, beef, and poultry exports.[28] Table 1 was developed to show the status of some of the offensive agricultural BW capabilities developed or maintained by certain nations.

This type of attack has an added benefit for the adversary: unless he desires otherwise, he may never be identified. Since the goal is not to achieve attention, but to promote the demise of and inflict pain on the United States, the perpetrators could maintain a safe distance and enjoy the daily news of turmoil in the United States. They could watch the successful completion of their plan as the contagious nature of their weapon operated on its own—the gift that keeps on giving. Perpetrators willing to use this style of BW attack(s) would have to recognize that it might take years to achieve their objective. Some world terrorists may be willing to wait and see their strategic plans carried out over this longer period of time.

Scenario Two: A BW Attack on Forces in the Middle East

This attack's goal is to have the United States withdraw its military forces from the region and possibly reduce its aid to allies like Israel. The Middle East contains more states with biological weapons than any other region of the world. According to the Center for Nonproliferation Studies at the Monterey Institute of International Studies, there are 11 states with suspected or confirmed offensive biological programs. Of these, six reside in the Middle East.[29] Additionally, more weapons of mass destruction (WMD) attacks have occurred in the Middle East than in any other region. Although most of the examples in table 2 are chemical warfare (CW) and not CBW, use clearly indicates that this region of the world has an entirely different view about the use of weapons considered taboo by much of the rest of the world. Table 2 shows some regional highlights.

So how would a BW attack be carried out in the Middle East? There are multiple options an adversary might choose to pressure the United States to withdraw from the region. The three options discussed below are illustrative of the variety of problems those attacks could create.

An adversary might choose to use a nonlethal BW agent, perhaps VEE (Venezuelan Equine Encephalitis), on a US installation. Such an attack would make personnel sick and incapacitated, but would not kill them. It could be used to demonstrate an adversary's capability, resolve, and even compassion. The adversary could allow time to ensure that the attack was effective, that deaths were minimal, that people were recovering, and then announce why and what he had done. If the BW attack failed, then the adversary would not make an announcement or lose credibility. Likewise, if the attack caused many unexpected deaths, he could merely remain quiet and potentially avoid US retaliation.

With a successful attack, the adversary's announcement of responsibility could include a stated abhorrence to killing. He could announce that while he has lethal BW agents, he had elected not to kill the sons and daugh-

Table 1

States with Past and Present Agricultural BW Capabilities

STATE	*STATUS*	*DATES*	*DISEASE*	*COMMENTS*
Canada	Former	1941–60s	Anthrax, Rinderpest	Exact date of project termination unclear.
Egypt	Probable	1972–present	Anthrax, Brucellosis, Glanders, Psittacosis, Eastern Equine Encephalitis	(none)
France	Former	1939–72	Potato Beetle, Rinderpest	Exact date of project termination unclear.
Germany	Former	1915–17, 1942–45	Anthrax, Foot-and-Mouth Disease, Glanders, Potato Beetle, Wheat Fungus	In World War II experimented with Turnip Weevils, Antler Moths, Potato Stalk Rot/Tuber Decay, and misc. anticrop weeds.
Iraq	Known	1980s–present	Aflatoxin, Anthrax, Camelpox, Foot-and-Mouth Disease, Wheat Stem Rust (Camelpox may have been surrogate for Smallpox)	Believed to retain program elements despite UN disarmament efforts.
Japan	Former	1937–45	Anthrax, Glanders	During World War II experimented with misc. anticrop fungi, bacteria, nematodes.
North Korea	Probable	? – present	Anthrax	(none)
Rhodesia (Zimbabwe)	Uncertain/ Former	1978–80	Anthrax	Suspicious epidemic of cattle anthrax resulted in 182 human deaths. Some scientists believe government forces infected livestock to impoverish rural blacks during last phase of civil war.
South Africa	Former	1980s–93	Anthrax	(none)
United Kingdom	Former	1937–60s	Anthrax	Exact date of project termination unclear.
United States	Former	1943–69	Anthrax, Brucellosis, Eastern and Western Equine Encephalitis, Foot-and-Mouth Disease, Fowl Plague, Glanders, Late Blight of Potato, Newcastle Disease, Psittacosis, Rice Blast, Rice Brown Spot Disease, Rinderpest, Venezuelan Equine Encephalitis, Wheat Blast Fungus, Wheat Stem Rust	(none)
USSR (Russia, Kazakhstan, Uzbekistan)	Formerly active; current status unclear	1935–92	African Swine Fever, Anthrax, Avian Influenza, Brown Grass Mosaic, Brucellosis, Contagious Bovine Pleuropneumonia, Contagious Ecthyma (sheep), Foot-and-Mouth Disease, Glanders, Maize Rust, Newcastle Disease, Potato Virus, Psittacosis, Rice Blast, Rinderpest, Rye Blast, Tobacco Mosaic, Venezuelan Equine Encephalitis, Vesicular Stomatitis, Wheat and Barley Mosaic Streak, Wheat Stem Rust, parasitic insects, and insect attractants	(none)

Source: Monterey Institute of International Studies, Center for Nonproliferation Studies, *Agro-terrorism: Agriculture Biowarfare: State Programs to Develop Offensive Capabilities,* created October 2000, on-line, Internet, 25 January 2003, available from http://cns.miis.edu/research/cbw/agprogs.htm. (Chart edited for space considerations; see complete chart and extensive footnotes on Web page.)

Table 2

Examples of CBW Uses in the Middle East

Date	*Country*	*Specific CB Agent*	*Description*
1917	Iraq	glanders	In 1917, German agents infected over 4,500 British pack animals in Mesopotamia.
1920–30	Morocco	mustard	Spain employed mustard shells and bombs against the Riff tribes.
1930	Libya	mustard	Italy dropped 24 mustard gas bombs on an oasis fighting Libyan rebels.
1935–36	Ethiopia	mustard, tear gas, various other agents	Benito Mussolini authorized the use of chemical weapons on 16 Dec 1935, with the first attack on 23 Dec, when Italian air force planes sprayed mustard gas and dropped bombs filled with mustard agent on Ethiopian soldiers and civilians. Italian forces repeatedly attacked Ethiopian soldiers and civilians with mustard gas and used tear gas, sneezing gas, and various asphyxiating agents. A letter from the Ethiopian delegate to the League of Nations, dated 13 Apr 1936, alleges Italy made 20 "poison gas attacks," with mustard gas being used frequently.
1930s	Kurdistan	lung irritants	Soviet Union was accused of using lung irritants against Kurdistan tribesmen.
1944	Israel/ Palestine	unknown	Plot by the grand mufti of Jerusalem and Germans to poison wells in Tel Aviv. Ten containers were discovered with enough poison to kill 10,000 people.
1957	Oman	BW	Britain was accused of using biological warfare agents in Oman.
1963–67	Yemen	mustard, phosgene, tear gas, possibly nerve gas	Egypt employed chemical weapons against royalist forces in the Yemen civil war. Egypt used Soviet-built aerial bombs to deliver phosgene and aerial bombs as well as artillery shells abandoned by British forces after World War I to deliver mustard gas. According to chemical weapons expert Milton Leitenberg, some of the nerve agent reportedly used by Egyptian forces may actually have consisted of hand grenades fitted with containers of organophosphate pesticides. This incident is sometimes referred to as the first use of nerve gases, but according to some reports, this is unsubstantiated.
1965	Iraq	unknown	In May 1965 at a press conference in London, a spokesman for the Kurdish Democratic Party stated that on at least two occasions during the previous six weeks the Iraqi army had used gas against Kurdish forces.
1984–88	Iran /Iraq	sarin, tabun, sulfur, mustard	During the 1980s Iran-Iraq War, Iraq repeatedly attacked Iranian troops with chemical warfare agents. The first allegation of Iraqi CW attacks was in Nov 1980. In Nov 1983, Iran made its first official complaint to the UN regarding Iraqi CW attacks. Iraq was confirmed to have used mustard/nerve agents against Iranian forces from 1983 to 1988. Iran is believed to have conducted initial CW attacks by firing captured Iraqi CW munitions at Iraqi forces in 1984 or 1985. By the end of the war, Iran reportedly employed domestically produced CW munitions against Iraqi soldiers. First-ever use of tabun (nerve agent) on the battlefield was by Iraq in 1984.
1987	Chad	unknown	Libya reportedly used Iranian-supplied chemical weapons against Chad troops.

Table 2 (Continued)

1988	Iraq	hydrogen cyanide, mustard, sarin, tabun	Iraqi warplanes attacked the Kurdish city of Halabja, Iraq, with mustard and nerve agents, killing up to 5,000 people, mostly civilians. (Following Iraqi mustard gas attacks on Halabja, fleeing Kurds may have been mistaken for Iraqi troops and bombarded with hydrogen cyanide [AC] artillery shells by Iranian forces.)
1990	Sudan	mustard	President Omar al-Bashir's Sudanese government had been accused of producing CW with Iranian and/or Iraqi assistance. The government was accused of initiating several mustard gas attacks on civilians and Sudanese People's Liberation Army forces in the Nuba mountain region. The allegations were not independently confirmed.
1997	Jordan	toxic gas	Israeli agents used toxic gas in assassination attempt on a Hamas official in Amman.

Source: Unclassified research at the USAF Counterproliferation Center, Maxwell AFB, Ala., 2001.

ters of the United States, because he only wants the US forces out of the region—killing would only be used as a last resort.

This approach would likely trigger great debates in Washington, D.C., and Middle Eastern countries, and might even cause the US Congress to pressure the president to withdraw US forces. If the United States then elected to stay in the region and a lethal attack did occur, local populations around US bases would die along with the targeted Americans. Thereafter, local governments would be under enormous pressure and might choose to ask the United States to withdraw rather than suffer additional BW attacks on their populations.

Another option an adversary might choose would be to release a lethal agent just outside a US base so that the wind would carry it away from the base. A desirable effect could be achieved by even a small attack aimed at killing as few as 20 to 50 of the local population. The downwind casualties would be blamed on the Americans, creating a local mistrust of the American government. The responsible group would never claim credit but would inform the media and others that the deaths were caused by US BW agents (even though the United States does not have any offensive BW agents). It's likely that the regional media would have a "heyday," which would lead to a groundswell of anger against the United States. Another similar attack could be launched after several months if the United States had not elected to significantly downsize its presence in the region. Again, the United States would be blamed, and locals might evacuate areas close to US installations. A continued US presence in the region could become politically impossible to maintain. Such small-scale attacks could be repeated over and over with lethal or nonlethal BW agents.

An adversary could also use a lethal agent directly against a US installation in the region. The adversary would never claim credit for this attack option, but might release a small dose of BW agent like anthrax or tularemia to try to kill two to 10 Americans. These deaths could raise fear of future lethal attacks and cause US officials and members of Congress to debate the merit of a continued US presence in the Middle East. In a response similar to the last option, the host government might become uncomfortable with a US presence if a few of its local citizens also died. A single attack might not cause the United States to "tuck tail and run," but if repeated often enough, the United States might reconsider and remove its forces from harm's way.

Scenario Three: A Bioterrorist Attack on a Large US or Allied Population Center

The American public learned to fear anthrax after letters containing the substance had been sent via the US Postal Service to senators and various news agencies shortly after the 11 September 2001 terrorist attacks. The resultant

deaths and the discovery that some al Qaida terrorists had explored renting crop dusters caused the US government to temporarily ground these important agricultural aircraft. The news media, in turn, informed the public that biological attacks were possible.

Similar to the 11 September attacks, a BW attack might be a coordinated attack and take place in several major US cities. Anthrax would probably be the agent of choice in a mass-casualty attempt since it is not contagious and the perpetrators would not have to worry about the disease getting back to their country. Five 100-pound bags of anthrax could easily be smuggled into the United States using one of the many shipments of grain that arrive at US ports every day. These bags could be made to blend in with the shipment and lined with plastic so that no powder would be prematurely released. Three to five major cities, on the order of Houston or Los Angeles, could be targeted and would require only a 100-pound bag each. An appropriate aerosolizing device, easily procured in the United States, could be mounted on an automobile, airplane, or boat. The terrorists that perpetrate this attack would not have to die because they could be vaccinated and treated with antibiotics prior to delivering the agents, which would protect them even if they were exposed. They could also easily depart the country before the first symptoms appeared and defeat the ability of federal authorities to respond and arrest them.

Hundreds of thousands of American citizens could potentially become infected and die if the agent were correctly manufactured and employed and if optimal climatic conditions were present during the attack. Such a mass-casualty attack would overwhelm the US medical system and a human, economic, and political catastrophe would result.

Summary

Many of our national leaders still do not believe that a mass-casualty BW event will happen in the next 10 years—in spite of our experience with the anthrax attacks that followed the 11 September 2001 attacks. This view is based on their belief in one of the several myths discussed in this article. Such myths continue to inhibit the adequate funding of US and allied biodefense.

US national security leaders must appreciate the urgency to refocus programs and develop appropriate budgets to support a concerted biodefense effort to counter BW possibilities. The counteragroterrorism effort is woefully underfunded. This program is of extreme importance, and it needs billions of additional dollars to upgrade the protection of our agricultural industry.

United States military forces in the Middle East must be well prepared for a BW attack, but all countries in the region have a long way to go before their biodefense equipment and tactics are adequate for the threat. US Central Command and the Office of the Secretary of Defense have an aggressive cooperative defense initiative (CDI) with allies and friends in the region designed to overcome the threat of WMD. Huge steps forward have already been made in preparation for a BW attack, but there is still much work ahead. While detection capabilities in the region have improved, lab results still require several hours, and these are limited to just a few of the possible BW agents. Only US installations have detection capabilities in place, and there are none in the local areas. Although there is a correct emphasis on ballistic missiles within the CDI, the biocruise missiles threat, described by Kiziah in his *Assessment of the Emerging Biocruise Threat*, may be an even more likely threat and should be addressed with an equal effort.[30]

One of the most horrifying possibilities would be a coordinated and simultaneous BW attack against several major cities in the United States and in allied countries. Those attacks could occur today, and we might not become aware of them for days. A series of major exercises have documented the likely and frightening results; many hundreds of thousands could die, and US and allied societies could be thrown into chaos and panic.

Myths to the contrary, the biological warfare and bioterrorist threats are real and require the full commitment of the United States and its allies to have a well-funded biodefense effort to produce an effective defense. The United States must take up the yoke of preventing such attacks and prepare for consequence management—managing the aftermath of such attacks—with the same vigor our nation used during the cold war. Otherwise, our national security stands in jeopardy. □

Notes

1. Roberta Wohlstetter, *Pearl Harbor: Warning and Decision* (Stanford, Calif.: Stanford University Press, 1962), vii.

2. Anthony H. Cordesman, *Trends in US Military Forces and Defense Spending: Peace Dividend or Underfunding?* (Washington, D.C.: Center for Strategic and International Studies, 26 July 1999), 4, on-line, Internet, 11 September 2001, available from http://www.csis.org.

3. James E. Gibson, *Dr. Bodo Otto and the Medical Background of the American Revolution* (Baltimore, Md.: George Banta Publishing Company, 1937), 88–89; and Jonathan B. Tucker, *Scourge: The Once and Future Threat of Smallpox* (New York: Atlantic Monthly Press, 2001), 18–22.

4. Sheldon H. Harris, *Factories of Death: Japanese Biological Warfare, 1932–45, and the American Cover-up* (New York: Routledge, 1994), 74–76.

5. Ken Alibek with Stephen Handelman, *Biohazard* (New York: Random House, 1999), 29–31.

6. Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz, eds., *Textbook of Military Medicine: Medical Aspects of Chemical and Biological Warfare* (Washington, D.C.: Office of the Surgeon General, US Army, 1997), 656.

7. W. Seth Carus, *Bioterrorism and Biocrimes: The Illicit Use of Biological Agents in the 20th Century*, rev. ed. (Washington, D.C.: National Defense University, Center for Counterproliferation Research, 1998), 58; Jessica Stern, *The Ultimate Terrorists* (Cambridge, Mass.: Harvard University Press, 1999), 63; and Dean A. Wilkening, "BCW in Attack Scenarios," in *The New Terror: Facing the Threat of Biological and Chemical Weapons* (Stanford, Calif.: Hoover Institution Press, 1999), 91–93.

8. W. Seth Carus, "The Rajneeshees (1984)," in *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*, ed. Jonathan B. Tucker (Cambridge, Mass.: MIT Press, 2000), 115–37.

9. David E. Kaplan, "Terrorism's Next Wave, Nerve Gas and Germs Are the New Weapons of Choice," *U.S. News and World Report*, 17 November 1997, on-line, Internet, 17 November 1997, available from http://www.infowar.com/CLASS_3/class3_112897b.html-ssi.

10. Dr. Tara O'Toole, "Medical and Public Health Aspects of Bioterrorism," presentation, Johns Hopkins University, Baltimore, Md., 25 June 2001.

11. Uncle Fester, *Silent Death*, 2d ed. (Unknown, Uncle Fester, 1997), available for sale on Internet only, on-line, Internet, 25 January 2003, available from http://www.crbbooks.com/catalog_2_item_n1/uncle-silent.htm.

12. O'Toole; Michael T. Osterholm and John Schwartz, *Living Terrors: What America Needs to Know to Survive the Coming Bioterrorist Catastrophe* (New York: Random House, Inc., 2000), 37–39; and Judith Miller, Stephen Engelberg, and William Broad, *Germs: Biological Weapons and America's Secret War* (New York: Simon and Schuster, 2001), 316.

13. Wilkening, 91–93; and David E. Kaplan and Andrew Marshall, *The Cult at the End of the World* (New York: Crown Publishers, 1996), 1–283.

14. O'Toole; Osterholm, 37–39; and Miller, 316.

15. Stern, 81–83.

16. Simon Reeve, *The New Jackals; Ramzi Yousef, Osama bin Laden and the Future of Terrorism* (Boston, Mass.: Northeastern University Press, 1999), 24.

17. James Phillips, "After World Trade Center Bombing, U.S. Needs Stronger Anti-Terrorism Policy," *The Heritage Foundation Backgrounder*, 22 February 1995, 240, on-line, Internet, 12 September 2001, available from http://www.heritage.org/library/categories/natsec/bgu240.html.

18. "Sentenced To Die," *Online NewsHour with Jim Lehrer*, 13 June 1997, n.p., on-line, Internet, 12 September 2001, available from http://www.pbs.org/newshour/bb/law.

19. "Deadly Explosion," *Online NewsHour with Jim Lehrer*, 19 April 1995, n.p., on-line, Internet, 12 September 2001, available from http://www.pbs.org/newshour/bb/law.

20. "September 11, 2001 Victims," *American Liberty Partnership*, 2 February 2002, on-line, Internet, 5 February 2002, available from http://www.september11victims.com.

21. John Pike, "Administrative Support Unit Southwest Asia (ASU SWA) Manama, Bahrain," *FAS Military Analysis Network*, on-line, Internet, 12 September 2001, available from http://www.fas.org/man/dod-101/fac/port/manama.htm.

22. "World Population," *PBS*, 12 September 2001, n.p., on-line, Internet, 12 September 2001, available from http://www.pbs.org/kqed/population_bomb/hope/worldp.html.

23. "Responding to the Threat of Agroterrorism: Specific Recommendation for the United States Department of Agriculture," Belfer Center for Science and International Affairs (BCSIA) Discussion Paper 2000-29, Executive Session on Domestic Preparedness (ESDP) Discussion Paper 2000-04 (Cambridge, Mass.: John F. Kennedy School of Government, Harvard University, October 2000), 12.

24. Mark Wheelis, *Agricultural Biowarfare & Bioterrorism: An Analytical Framework & Recommendations for the Fifth BTWC Review Conference*, September 1999, n.p., on-line, Internet, 2 February 2002, available from http://www.fas.org/bwc/agr/agwhole.htm.

25. "The 'Hidden' Epidemic of Foot-and-Mouth Disease," *News and Highlights—Food and Agriculture Organization of the United Nations*, 29 May 2001, n.p., on-line, Internet, 12 September 2001, available from http://www.fao.org/News/2001/010508-e.htm.

26. Steve Goldstein, "U.S. Officials Awakening to Threat of Agroterror," *Dallas Morning News*, 27 June 1999, n.p., on-line, Internet, 12 September 2001, available from http://www.dallasnews.com/national/0627nat4agroterror.htm.

27. Ibid.

28. Ibid.

29. "Chemical and Biological Weapons: Possession and Programs Past and Present," *Center for Nonproliferation Studies* (Chemical and Biological Weapons Resource Page), 4 September 2002, n.p., on-line, Internet, 25 January 2003, available from http://cns.miis.edu/research/cbw/possess.htm.

30. Rex R. Kiziah, *Assessment of the Emerging Biocruise Threat*, Future Warfare Series no. 6 (Maxwell AFB, Ala.: USAF Counterproliferation Center, August 2000), n.p., on-line, Internet, 25 January 2003, available from http://www.au.af.mil/au/awc.

Atlas: The Grandfather of ICBMs and Space-Launch Vehicles

ASPJ STAFF

Atlas, the first-generation intercontinental ballistic missile (ICBM), had a fitful start. Originally part of a classified Army Air Forces effort (Project MX-774), it fell prey to budget cuts in 1947. With the onset of the Korean War and Cold War, it was revitalized in 1951 under Air Force research and development. Original plans called for a missile over 120 feet long with five engines, but by 1954 the "stage-and-a-half" Atlas had emerged, utilizing two booster engines and one sustainment engine. Even then, the final dimensions of 75 feet and 260,000 pounds represented an innovation in missile design.

Atlas incorporated a number of new technical concepts and utilized an innovative procurement paradigm. One of the former featured dual-purpose, pressurized, stainless-steel tanks that not only held the propellant, but also provided structural rigidity to support the weight of the missile and warhead. This revolutionary design yielded vast weight savings by reducing requirements for stiffening the missile's structure. Less weight made propulsion more manageable, thus permitting the thrust-to-weight ratio necessary to meet and surpass the intercontinental-distance requirement of 5,000 miles. Engineers met the 10-mile accuracy goal by using gimbaled motors under gyroscopic-guidance control. Furthermore, Gen Bernard A. Schriever's visionary management concept of "concurrency" reduced the time from initial concept development to full-scale weapon-system deployment as authorized by the Air Force.

Strategic Air Command assumed responsibility for the missile in January 1959, and the first full Atlas D squadron became operational in 1960. Initially stored horizontally in above-ground buildings with removable roofs, the missiles later moved to underground horizontal facilities and finally to underground vertical silos. Launch from a silo required that the missile first be raised through

the removable storage roof or doors. Thirteen squadrons saw active service as part of the ICBM deterrent force.

Atlas led a dual life. Although it was retired from the strategic missile fleet in 1965, the National Aeronautics and Space Administration had begun using Atlas as a space-launch vehicle as early as December 1958, when it lifted SCORE—the world's first communications satellite—into orbit. President Eisenhower took advantage of this opportunity to broadcast a prerecorded Christmas message to the world. Additionally, Atlas vehicles launched space probes and Project Mercury's first orbital flights, including John Glenn's historic journey on 20 February 1962.

To Learn More . . .

F. E. Warren AFB Intercontinental Ballistic Missile and Heritage Museum. "Atlas (SM-65)." On-line. Internet, 31 January 2003. Available from http://www.pawnee.com/fewmuseum/atlas.htm.

Launius, Roger D., and Dennis R. Jenkins, eds. *To Reach the High Frontier: A History of U.S. Launch Vehicles.* Lexington: University Press of Kentucky, 2002.

Neufeld, Jacob. *The Development of Ballistic Missiles in the United States Air Force, 1945–1960.* Washington, D.C.: Office of Air Force History, 1990.

Strategic-Air-Command.com. "Atlas Missile History." On-line. Internet, 31 January 2003. Available from http://www.strategic-air-command.com/missiles/Atlas/Atlas-Missile_History.htm.

US Army Corps of Engineers. "Did You Know? The Corps Built the Launch Sites for *Atlas,* the United States [*sic*] First ICBM?" Vignette no. 32. Washington, D.C.: US Army Corps of Engineers, 15 January 2003. On-line. Internet, 31 January 2003. Available from http://www.hq.usace.army.mil/history/vignettes/vignette_32.htm.

Not with Impunity

Assessing US Policy for Retaliating to a Chemical or Biological Attack

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Editorial Abstract: Devastation, annihilation, obliteration—*these words convey how US leaders would deal with enemies who use chemical/biological weapons against either the homeland or US troops and personnel abroad. The author argues that such words provide diplomatic flexibility but insufficient structure for developing a credible strategy for retaliation should the unthinkable occur. Rather than imply that the US reaction would include nuclear weapons, Colonel Conley offers four variables (context, adversary class, number/types of casualties, and identification of perpetrators) that serve as a decision matrix to determine the type of response to what some analysts see as an inevitable chemical/biological attack on the United States.*

Sen. Jesse Helms: Suppose somebody used chemical weapons or poison gas on people in the United States. . . . Would they damn well regret it?

Secretary of Defense William Perry: Yes.

Helms: I want to know what the response will be if one of these rogue nations uses poison gas or chemical weaponry against either us or our allies. . . . What is the response of this country going to be?

Perry: Our response would be devastating.

Helms: Devastating—to them?

Perry: To them, yes. . . . And I believe they would know that it would be devastating to them.

Helms: Let the message go out.

—Testimony of Secretary of Defense William Perry
Senate Foreign Relations Committee
28 March 1996

HOW SHOULD THE United States determine its response to a chemical or biological attack against American personnel or interests? The current US retaliation policy, known as *calculated ambiguity,* warns potential adversaries that they can expect an "overwhelming and devastating" response if they use chemical or biological weapons (CBW) against the United States or its allies.[1] Implied in this policy is a threat of nuclear retaliation, but the specifics of the US response are left to the imagination. By not identifying a specific response to an attack, this intentionally vague policy is designed to maximize flexibility by giving the United States a virtually unlimited range of response options.[2] Ambiguity gives flexibility to policy makers and enhances deterrence by keeping adversaries guessing. But there is a downside to flexibility and ambiguity. Because it is easier to prepare to execute a specific strategy than it is to prepare for a broad range of possibilities, military preparedness suffers—at least at the strategic level—under a policy of ambiguity. It is not surprising that the policy of calculated ambiguity, intended to place doubt in the minds of potential adversaries, has engendered uncertainty among those who would implement the policy. This uncertainty could manifest itself in strategic unpreparedness. The United States needs a clearer reprisal policy, one that strikes a better balance between flexibility and preparedness.

In general, national policy should facilitate strategy development. If a policy fails to provide enough substance for making strategy, the policy should be revised. Adjectives such as *overwhelming* and *devastating* are the only guidelines that the calculated-ambiguity policy provides to strategy makers. Because current policy aims to achieve unlimited flexibility through ambiguity, the policy simply lacks enough substance to support strategy development. Without a strategy, military means may not be able to support policy ends. In making the case that the current reprisal policy hampers strategic preparedness, this article examines existing policy and assesses its strengths and weaknesses; it then suggests a means for clarifying the policy with a view toward achieving a better balance between flexibility and preparedness. Having proposed a policy that better supports strategy development, the article then presents an analytic framework consisting of four critical variables that must be considered in formulating strategies for responding to a chemical or biological attack.

Current Reprisal Policy

President William Clinton's national security strategy (NSS) called weapons of mass destruction (WMD) "the greatest potential threat to global stability and security."[3] It further stated that "proliferation of advanced weapons and technologies threatens to provide rogue states, terrorists, and international crime organizations with the means to inflict terrible damage on the United States, our allies, and U.S. citizens and troops abroad."[4] At his confirmation hearing in 1997, Secretary of Defense William Cohen asserted, "I believe the proliferation of weapons of mass destruction presents the greatest threat that the world has ever known."[5] Barry Schneider, director of the US Air Force Counterproliferation Center, claims that "there are perhaps one hundred states that have the technical capability to manufacture and deploy biological weapons."[6] That Americans will be subject to a CBW attack is not a matter of *if* but *when*.

In 1969 President Richard Nixon stopped all biological weapons programs in America. More recently, the United States has begun to destroy its chemical weapons stockpile in accordance with the Chemical Weapons Convention.[7] The United States no longer has the option of responding in kind to a chemical or biological attack. This situation has made a conundrum of US retaliation policy: How best to respond to a WMD attack when the only WMDs in the arsenal are nuclear? In *America's Struggle with Chemical-Biological Warfare,* Albert Mauroni writes, "Our national policy of responding to enemy use of CB [chemical and/or biological] weapons has shifted over the years from one extreme to the other; from retaliation using similar CB weapons to massive

conventional retaliation to (most recently) nuclear retaliation."[8]

Prior to the Gulf War, President George H. W. Bush and other officials let it be known that nuclear weapons might be employed against Iraq if it used WMDs against coalition forces.[9] However, in private Bush reportedly ruled out the use of nuclear weapons.[10] During Operation Desert Shield, Secretary of State James Baker coined the term *calculated ambiguity* to describe this policy of secretly planning not to use nuclear weapons yet publicly threatening just the opposite.[11] Defense Secretary William Perry's testimony at hearings in 1996 on the Chemical Weapons Convention made it clear that ambiguity was still the policy of the Clinton administration. When asked what the US response to a chemical attack would be, Perry replied, "We would not specify in advance what our response to a chemical attack is, except to say that it would be devastating."[12] When asked if the response could include nuclear weapons, he responded, "The whole range [of weapons] would be considered."[13] Cohen, Perry's successor, reiterated the policy in 1998: "We think the ambiguity involved in the issue of nuclear weapons contributes to our own security, keeping any potential adversary who might use either chemical or biological [weapons] unsure of what our response would be."[14] It appears that the current Bush administration will advocate the same policy of ambiguity as did its predecessors. For example, National Security Advisor Condoleezza Rice threatens "national obliteration" to those who would use such weapons.[15] Robert Joseph, the Bush administration's senior advisor on counterproliferation issues, argues that nuclear weapons should be an "essential component of the U.S. deterrent posture against [proliferation of WMDs]."[16]

Nuclear weapons have always been a lightning rod for controversy, so it should come as no surprise that an intense debate has been raging over the possible use of nuclear weapons in a US reprisal against a CBW attack. At issue is the decades-long clash between so-called deterrence hawks, who advocate a prime role for nuclear weapons in the calculus of deterrence, and the counterproliferation doves, who maintain that there are safer ways to deter the use of CB attacks and that the United States should reject the first use of nuclear weapons. Deterrence theory, long relegated to the proverbial back burner, is witnessing a resurgence, driven in no small part by this reprisal policy, which, when taken at face value, allows the United States to use nuclear weapons in response to something other than a nuclear attack. On the one hand, according to deterrence hawks, the potential threat to American interests from these other attacks is so large that only by threatening absolute devastation with nuclear weapons can the United States deter such attacks.[17] The deterrence doves, on the other hand, give primacy to countering nuclear proliferation. The dove position is that the goal of nuclear nonproliferation will be irreparably damaged if America continues to maintain a policy that allows the first use of nuclear weapons. The United States should renounce nuclear retaliation, they argue, and instead threaten a massive conventional response.[18]

Evaluating Current Policy

Is the current policy of calculated ambiguity viable? In assessing that policy, one must answer two questions: What are the general criteria for evaluating a reprisal policy? To what degree does the current US policy satisfy these criteria?

To answer the first question, one must measure retaliatory policy against two key criteria. First, does the policy meet its stated objective? Second, does it support the development of strategy? The objective of stated US reprisal policy is clear: to deter the use of CBWs against US interests. Colin Gray defines *deterrence* as "a condition wherein a deteree—the object of deterrent menaces—chooses not to behave in ways in which he would otherwise have chosen to behave, because he believes that the consequences would be intolerable."[19] Thus, there is no purpose in having a publicly stated reprisal policy if the United States does not believe that it will cause the deteree to avoid undesirable behavior. Moreover, it is

important that a reprisal policy deter not only state actors, but also nonstate actors as well. To be effective against state and nonstate actors, the "deterrent menaces" of the policy must be applicable against each. Finally, the target audiences of the policy must perceive the threat as *credible*.

Deterrence has two essential objectives in a reprisal policy. Perhaps the most important one is deterrence of the first use of CBWs. Deterring first use sometimes fails, however, which leads to the second objective: preventing recurrences or escalation of CBW attacks. One can prevent recurrences with threats or direct military action. A primary mechanism for deterring or preventing escalation is punishment, the threat and execution of which is intended to serve as a deterrent against further CBW attacks on the part of the adversary or other parties. For example, the swift trial and conviction of Timothy McVeigh likely deterred other terrorists who might have been considering actions against the United States. Thus, in evaluating a reprisal policy, one must determine its applicability to state and nonstate actors, its credibility, and the degree to which the stated policy addresses the two objectives of deterrence.

The second criterion in evaluating reprisal policy is the degree to which it supports strategy development. If a policy requires military action that cannot be well executed, then the policy is flawed. Military forces may not be able to accomplish a proposed action because they do not have the necessary means, such as equipment. Conversely, if no viable strategy exists, military forces may not be able to carry out an action even if they have the proper equipment. In this case, the forces are strategically unprepared.[20] Policy must enable the development of *strategy*, which Gray defines as "the bridge that relates military power to political purpose."[21] *Military strategy*, according to Dennis Drew and Donald Snow, is "the art and science of coordinating the development, deployment, and employment of military forces to achieve national security objectives."[22] Thus, if a policy (political purpose) is not clearly defined, the development of strategy is problematic. A viable policy must embody clear national-security objectives for the development of strategy.

The 1998 cruise missile strikes against terrorist facilities in Afghanistan and Sudan provide an illustration of what the thinking of the Clinton administration was, relative to reprisal policy, and how this US action was intended as punishment and prevention of further attacks. In his address to the nation, announcing the strikes, Clinton stated that a key reason for the US response was "the imminent threat [the facilities] presented to our national security."[23] These strikes served several purposes: they sent a strong signal of US willingness to retaliate; they served as a form of punishment against terrorist behavior; and they decreased the likelihood that those facilities could be used again.

Weaknesses

Does the current policy of calculated ambiguity meet the stated objective of deterrence, and does it support the development of strategy? When measured against these two key criteria, existing policy has some significant shortcomings. One of the weaknesses of the policy is its credibility. Would an American president really use nuclear weapons in retaliation for a CBW attack? It would seem that the threshold of damage would have to be high for a president to do so, yet the stated policy does not address thresholds of damage. The main reason for the policy's lack of credibility is that it fails to address proportionality. Adjectives such as *overwhelming* and *devastating* in the policy bring to mind a massive response. Yet, one of the widely held tenets of the international law of armed conflict—the rule of proportionality—holds that armed action "must be measured and not excessive in the sense of being out of proportion to the original wrong nor disproportionate in achieving its redress."[24]

Suppose an adversary killed several dozen American soldiers with a biological attack. Taken at face value, the current policy would seem to stipulate a response out of proportion to the original attack. A disproportionate response would surely trigger an international furor over US actions. Moreover, it is

not clear that threatening massive retaliation is the best deterrent against CBW use. In his book *The Continuing Storm*, Avigdor Haselkorn writes, "Frequently, the bigger and more indiscriminate the threat, the less believable it is in the eyes of the target audience."[25] Unfortunately, current policy wording may commit the United States to a massive response when the situation does not actually call for it.[26] In their statements, policy makers seem to imply that all potential CBW events are equal, each demanding the same massive response. In reality, of course, future CBW events will vary widely, and US policy should be worded carefully to allow for a tailored response appropriate to the situation.

Another shortcoming of the current policy is its implicit focus on state actors, when in fact the threat of the use of CBWs from nonstate entities may be greater than that from states. More than likely, Rice's phrase "national obliteration" would not have much deterrent effect on terrorist groups. The current policy raises two questions: Does the threat of a nuclear response deter terrorists, and would the United States ever launch a nuclear weapon into a sovereign state in response to a terrorist attack? The answer to both questions is, "very unlikely." Although terrorists are a highly likely source of CBW attacks, the current policy all but ignores these nonstate threats.

Strengths

The policy of calculated ambiguity does have one strong feature. The more uncertain an adversary is about US response, the less likely he is to use CBWs. As Paul Bernstein and Lewis Dunn write, "Deliberate ambiguity creates significant uncertainty for an adversary regarding the nature of our response to CBW use."[27] Indeed, ambiguity deters as long as the adversary perceives US willingness and ability to respond forcefully. Since the ambiguity in the current policy incorporates the possibility of nuclear retaliation, one must ask whether or not today's CB-capable adversaries are deterred by the US threat to retaliate with nuclear weapons. Even Scott Sagan, an articulate advocate of abandoning the role of nuclear weapons in US reprisal policy, concedes that nuclear weapons contribute "the extra margin of deterrence" against CBW use.[28] The inherent deterrent value of nuclear weapons is a strength of the current policy, but policy makers must clarify the conditions under which they might consider using nuclear weapons.

Failure to Support Strategy Development

We have seen that the current US reprisal policy has weaknesses that should be redressed, the most important of which is a lack of clarity. The policy is so ambiguous that it hampers the development of strategies necessary for its implementation. Ample evidence indicates that the policy fails to support strategy development.

The first piece of evidence is the waffling of the Bush administration during the Gulf War, when the United States faced a foe known to have used chemical weapons in the recent past and suspected of possessing biological weapons.[29] Bush and his top advisors struggled to answer the question, What should the United States do if Iraq uses these weapons?[30] In his book *Crusade*, Rick Atkinson describes the alternatives under consideration: a recommendation by Gen Norman Schwarzkopf to threaten the use of nuclear weapons; air strikes against the presidential palace; a proposal to strike dams on the Tigris and Euphrates Rivers above Baghdad; Brent Scowcroft's suggestion to attack the oil fields; and a hint by Secretary of Defense Dick Cheney that Israel would retaliate with nuclear weapons if Iraq attacked it with CBWs.[31] There was no consensus on how to respond.[32] In the end, writes Haselkorn, "The ambiguity of the U.S. position on the proper response to Iraq's use of weapons of mass destruction was as much a result of the conflicting stands within the Bush administration as it was part of a calculated policy."[33] The widely varying views taken by these influential individuals should be of great concern. If we had needed to retaliate, uncertainty and lack of consensus among our political and

military leaders would have created difficulties in planning and executing a response.

The second piece of evidence that suggests the current policy's lack of pragmatism is the persistent stumbling over the issue by the Clinton administration. In *An Elusive Consensus*, Janne Nolan concludes that confusion over US reprisal policy persisted throughout the Clinton administration.[34] The most visible issue with which the administration grappled was the African Nuclear Weapons Free Zone (ANWFZ) Treaty, in which the United States promised not to use nuclear weapons in Africa. To assuage Pentagon concerns, the administration issued a declaration reserving the US right to use such weapons against states that employ WMDs against US interests. In another incident, a senior Pentagon official publicly argued for development of a new, earth-penetrating nuclear weapon that could be targeted against a Libyan chemical weapons plant. Pentagon spokesman Kenneth Bacon later had to issue a clarification to "correct the impression . . . that the U.S. had accepted a policy of nuclear preemption against Libya," which would violate the ANWFZ Treaty.[35] This waffling and stumbling by the last two administrations raise the question of whether it is possible to develop sound military strategy when policy is unclear. The answer appears to be "no."

The third piece of evidence that the flawed reprisal policy has hampered strategy development is the disconnection between statements of grand strategy (including the NSS) and the national military strategy (NMS) of the chairman of the Joint Chiefs of Staff. Recent grand-strategy documents have trumpeted the national security threat posed by CBWs, whereas NMS barely gives it a nod. A perusal of these two documents highlights the disparity in focus between grand strategy and military strategy. President Clinton's NSS of 1999 makes numerous references to a counter-WMD strategy, including the previously cited statement that WMDs present "the greatest potential threat to global stability and security,"[36] as well as the following: "Because terrorist organizations may not be deterred by traditional means, we must ensure a robust capability to accurately attribute the source of attacks against the United States or its citizens, and to respond effectively and decisively to protect our national interests."[37] The NSS also specifically addresses the issue of reprisal: "The United States will act to deter or prevent such [WMD] attacks and, if attacks occur despite those efforts, will be prepared to defend against them, limit the damage they cause, and respond effectively against the perpetrators."[38] The predominant focus of the NMS, on the other hand, is the nation's strategy for two major theater wars, with relatively minor emphasis on WMDs. The NMS concedes that the use of WMDs by an adversary is "increasingly likely" and states that the armed forces must be able to detect and destroy WMDs, deter their use, protect forces from the effects of such weapons, and restore affected areas.[39] But the NMS barely addresses the challenges of WMD use by nonstate actors—and it does not discuss retaliation.

The evidence is clear: because of an ambiguous policy of CBW reprisal, no strategy links military capabilities with political objectives. Given the increasing likelihood that CBWs will be used against the United States, it is time to begin redressing the broken link. The time frame immediately following the first large-scale use of CBWs against Americans is certain to be filled with extreme emotions. During a CB crisis, leaders will be inclined to make emotional judgments. Terry Hawkins, director of nonproliferation and international security at Los Alamos National Laboratory in New Mexico, warns, "If you don't have the preplanning, it will be almost impossible to deal with in the panic of the moment."[40] To rectify this situation, we must implement two changes: the policy must be clarified, and the strategy bridge linking ends and means must be developed.

Clarifying the Policy: Balancing Flexibility and Preparedness

To clarify US reprisal policy, we must make regime survival and accountability the hallmark of the policy and then determine under what

conditions nuclear weapons would be used. Rather than making vague threats such as "national obliteration," we should see to it that the primary feature of US reprisal policy is a guarantee to bring to justice those responsible for a CB attack, such as the leaders who directed the action, as well as their lieutenants who executed it. Making regime survival and accountability the hallmark of the reprisal policy has many benefits. First, it applies equally well to state and nonstate actors, a distinct advantage over the current policy. Second, a promised retribution against the responsible parties does not have to be implemented immediately. Recent US experiences with terrorism—including the joint Yemeni/Federal Bureau of Investigation inquiry into the bombing of the USS *Cole* (which netted six suspects and prompted others to flee to Afghanistan), the embassy bombings in Africa, and the downing of Pan Am Flight 103—demonstrate the effectiveness of American and international justice systems when patience and diligence are applied to challenging scenarios. Third, focusing the reprisal actions on those responsible for a CBW attack averts the potential criticism of a disproportionate US response, which would be likely under the current policy. Certainly, solid precedent exists for threatening regime destruction. At his meeting with Iraqi foreign minister Tariq Aziz two weeks before Operation Desert Storm, Secretary Baker told him, "If there is any use of weapons [of mass destruction], our objective won't just be the liberation of Kuwait, but the elimination of the current Iraqi regime, and anyone responsible for using those weapons would be held accountable."[41] Finally, issuing direct threats against the decision makers responsible for the attacks—instead of promising "national obliteration"—would enhance policy credibility as a deterrent.[42]

The second major change to current US reprisal policy should be to clarify when nuclear weapons would be used. Existing policy leaves this as an open issue. Some people argue that this ambiguity enhances deterrence. The mushroom cloud is indeed one of the enduring images of the twentieth century, and only the most ardent of the nonproliferators would argue that the threat of nuclear weapons has no deterrent effect. Nuclear weapons may simply be too good a deterrent to take off the table. Yet, because current policy provides no guidance on the conditions under which nuclear weapons would be considered, planning and strategy regarding both conventional and nuclear responses have been severely hampered. Bernstein and Dunn capture the controversial issue of when and whether to use nuclear weapons: "There is no way to resolve fully these competing considerations related to what punishment to threaten. It would be dangerous to rule out the possibility of a nuclear response to CBW use, particularly in the face of egregious and highly damaging attacks. But it would be equally imprudent to rely exclusively on nuclear threats for deterrence of CBW use."[43]

Nuclear weapons should be considered *only* in the most horrifying and damaging attacks. Policy should reflect the reality that nuclear weapons will be used only in the most extreme circumstances. This will enable planners and strategists to get on with the business of planning and developing strategies for conventional response—the most likely kind to be directed by the president.

Joseph asserts that "for deterrence to work, the adversary must be convinced of our will and capability to respond decisively. On this score, ambiguity and uncertainty play very much against us."[44] But emphasizing regime survival/accountability and clarifying the role of nuclear weapons would result in a less ambiguous policy. Given the current situation in which an unclear policy has paralyzed US planning and strategy, it is time to make these clarifying changes to policy. The benefit—a clear policy that supports strategy development—outweighs the drawbacks.

Analytic Framework: Four Critical Variables

How should the United States determine its response to a CBW attack? Guided by political objectives inherent in a clearly articulated reprisal policy, one can proceed with crisis-

response analysis by examining four key variables: context (wartime or peacetime), adversary class, number and type of casualties, and identification of perpetrators. These variables form the genesis of an analytic framework that can enable policy makers and planners to begin developing reprisal strategies.

Context

Our response to a "bolt-from-the-blue" CBW attack is likely to be far different than if US armed forces were attacked during a conflict or period of hostilities. During hostilities, the mind-set of American leaders and the public is at a higher state of alert. If casualties in a conflict have already occurred from conventional means prior to a CBW attack, the leadership and the public may be somewhat hardened and may not react as strongly as they would in a peacetime scenario. Moreover, during hostilities, US forces are likely to use CBW defense equipment, such as masks and detection devices, which could serve to minimize the adverse effects of a CBW attack. In fact, depending upon the nature and scope of the attack, US forces could "take it in stride," with little if any change in operational plans. In this case, a specific reprisal action may not be necessary.

The international legal standards for retaliation during peacetime are much higher. Richard Erickson makes the point that reprisal has a "very low level of acceptability" in international law. "The general view is that articles 2(3) and 2(4) of the UN Charter have outlawed peacetime reprisals. . . . When states have relied upon it, the UN Security Council has condemned their action soundly."[45] Thus, reprisals in peacetime will have to pass a stricter set of criteria.

Adversary Class

One must also determine whether the perpetrator is a state or nonstate actor. International law gives clear guidance as to how states may legally respond to attacks from other states, but the law is murky when it deals with nonstate actors; hence, any proposed US retaliatory action must take this difference into account. For example, despite the evidence and strong justification for its actions against terrorist facilities in Afghanistan and Sudan, the United States endured much condemnation from the international community—not to mention internal criticism. US reprisal attacks against nonstate actors are likely to require much more evidence and justification, compared to similar actions against state actors. Many kinds of military actions can be taken against a state actor, whereas those against nonstate actors may be limited. The type of actor involved, therefore, will heavily influence the nature of the reprisal.

Number and Types of Casualties

The number of American casualties suffered due to a WMD attack may well be the most important variable in determining the nature of the US reprisal. A key question here is how many Americans would have to be killed to prompt a massive response by the United States. The bombing of marines in Lebanon, the Oklahoma City bombing, and the downing of Pan Am Flight 103 each resulted in a casualty count of roughly the same magnitude (150–300 deaths). Although these events caused anger and a desire for retaliation among the American public, they prompted no serious call for massive or nuclear retaliation. The body count from a single biological attack could easily be one or two orders of magnitude higher than the casualties caused by these events. Using the rule of proportionality as a guide, one could justifiably debate whether the United States should use massive force in responding to an event that resulted in only a few thousand deaths. However, what if the casualty count was around 300,000? Such an unthinkable result from a single CBW incident is not beyond the realm of possibility: "According to the U.S. Congress Office of Technology Assessment, 100 kg of anthrax spores delivered by an efficient aerosol generator on a large urban target would be between two and six times as lethal as a one megaton thermo-nuclear bomb."[46] Would the deaths of 300,000 Americans be enough to trigger a nuclear response? In this

case, proportionality does not rule out the use of nuclear weapons.

Besides simply the total number of casualties, the types of casualties—predominantly military versus civilian—will also affect the nature and scope of the US reprisal action. Military combat entails known risks, and the emotions resulting from a significant number of military casualties are not likely to be as forceful as they would be if the attack were against civilians.

World War II provides perhaps the best examples for the kind of event or circumstance that would have to take place to trigger a nuclear response. A CBW event that produced a shock and death toll roughly equivalent to those arising from the attack on Pearl Harbor might be sufficient to prompt a nuclear retaliation. President Harry Truman's decision to drop atomic bombs on Hiroshima and Nagasaki—based upon a calculation that up to one million casualties might be incurred in an invasion of the Japanese homeland[47]—is an example of the kind of thought process that would have to occur prior to a nuclear response to a CBW event. Victor Utgoff suggests that "if nuclear retaliation is seen at the time to offer the best prospects for suppressing further CB attacks and speeding the defeat of the aggressor, and if the original attacks had caused severe damage that had outraged American or allied publics, nuclear retaliation would be more than just a possibility, whatever promises had been made."[48]

Even the "overwhelming and devastating" conventional response threatened by Secretary Perry would seem unlikely unless a large number of Americans or allies died.[49] In any event, it is imperative that policy makers and planners consider that the number and types of casualties, as well as the attendant public opinion resulting from those casualties, will play a significant role in determining the nature of US reprisal actions.

Identification of the Perpetrator

Before taking action against the parties responsible for a CBW attack, the United States is compelled to demonstrate that it has strong evidence linking the perpetrators to the act itself. How compelling does the evidence have to be? According to Erickson, "the threshold for what constitutes sufficient evidence varies. Factors that must be considered are the threat, the response contemplated, and the audience to be persuaded."[50] Stronger evidence may allow the United States to conduct a stronger response. As a final consideration on the issue of evidence, policy makers must consider the possibility of a large-scale attack with heavy US or allied casualties that yielded insufficient evidence to allow for a reprisal.

In the final analysis, the US response must be determined by a thorough cost-benefit calculation. Decision makers must determine the potential results of a reprisal, both internationally and domestically. Are there any unanticipated consequences? Are there any vulnerabilities in the strategy? Tough questions such as these must be answered prior to determining a reprisal action. Current policy, with its reliance on an "overwhelming response," is not useful in many potential situations. Indeed, Bernstein and Dunn call it "a false justification for inaction—for avoiding tough resource allocation decisions needed to improve our ability to defend against hostile CBW acts."[51]

Implications and Conclusion

The suggested policy clarifications and strategic framework proposed above could serve to bound and focus policy debates and, if implemented, would enable strategists to better link military capabilities with political objectives. Adapting these policy changes has implications for at least two elements of US military power: intelligence and special operations. If regime survival becomes the hallmark of US reprisal policy, then the intelligence community must improve its collection activities against organizations suspected to be involved with CBWs. Successful collection of this needed intelligence requires new ways of thinking about intelligence, improved cooperation among domestic and allied intelligence

agencies, and increased budgets to reflect the national priority and concern for WMDs.

Readiness to retaliate following a CBW attack against the United States also implies an increased emphasis on special operations forces. In such situations, "[these forces], because of their unique skills, regional expertise, cultural sensitivity and operational experience, may be the force of choice for meeting the strategic requirements of the [president and secretary of defense]."[52] Finally, the United States must continue its investment in CB defense. If defense equipment can mitigate the effects of a CBW attack, the adversary may see no advantage in using WMDs.

Ultimately, the aim of CBW retaliation policy is deterrence. Although an element of ambiguity certainly can serve to enhance deterrence by keeping adversaries guessing about the response to an attack, it seems more likely that the United States is stuck with the current approach because we have dedicated scant critical thinking to devising a more robust policy. In other words, the current policy of calculated ambiguity—with its overreliance on the nuclear "big stick"—is a cop-out. America is paying full price for this half-policy, the result of which is that the armed forces may find themselves strategically unprepared to respond when the time comes.

In the days following the cruise missile strikes against Sudan and Afghanistan, National Security Advisor Sandy Berger said that those strikes "have made it clear that those who attack or target the United States cannot do so with impunity."[53] To back up this statement with a credible deterrent threat requires the United States to have a robust, well-considered retaliation policy. Without such a policy, America is fated to fall victim to the panic of the moment. □

Notes

1. Senate, *Prepared Statement of William J. Perry; Hearing before the Committee on Foreign Relations,* 104th Cong., 2d sess., 28 March 1996. See also Scott D. Sagan, "The Commitment Trap," *International Security* 24, no. 4 (spring 2000): 85.

2. Because the *calculated ambiguity* policy seeks to maximize the options available to policy makers, it could also be called *absolute flexibility*.

3. William J. Clinton, *A National Security Strategy for a New Century* (Washington, D.C.: The White House, December 1999), 6.

4. Ibid.

5. Testimony of Secretary William S. Cohen, quoted in Department of Defense, *Proliferation: Threat and Response,* 1997, on-line, Internet, 15 January 2001, available from http://www.defenselink.mil/pubs/prolif97/index.html.

6. Barry R. Schneider, *Future War and Counterproliferation: U.S. Military Responses to NBC Proliferation Threats* (Westport, Conn.: Praeger, 1999), 199.

7. Albert J. Mauroni, *Chemical-Biological Defense* (Westport, Conn.: Praeger, 1999), 171. Effective 1997, the Chemical Weapons Convention "outlines a verifiable ban on all production, storage, and use of chemical weapons" (171).

8. Albert J. Mauroni, *America's Struggle with Chemical-Biological Warfare* (Westport, Conn.: Praeger, 2000), 4.

9. Stephen I. Schwartz, "Miscalculated Ambiguity: U.S. Policy on the Use and Threat of Use of Nuclear Weapons," *Global Beat,* February 1998, on-line, Internet, 15 January 2001, available from http://www.nyu.edu/globalbeat/nuclear/schwartz0298.html.

10. Ibid.

11. Ibid.

12. Senate, *Prepared Statement of William J. Perry*.

13. Ibid.

14. Secretary of Defense William S. Cohen, quoted in Sagan, 85.

15. Condoleezza Rice, "Promoting the National Interest," *Foreign Affairs* 79, no. 1 (January/February 2000): 61.

16. Robert G. Joseph and Barry M. Blechman, "Deterring Chemical and Biological Weapons," *Transforming Nuclear Deterrence,* Institute for National Strategic Studies, on-line, Internet, 25 January 2001, available from http://www.ndu.edu/ndu/inss/books/tnd/tnd2. html.

17. See three recent publications that provide excellent discussions of the two sides of this heated debate: Victor A. Utgoff, *Nuclear Weapons and the Deterrence of Biological and Chemical Warfare,* Occasional Paper no. 36 (Washington, D.C.: Henry L. Stimson Center, October 1997); Sagan; and Chemical and Biological Arms Control Institute, *Responding to the Biological Weapons Challenge: Developing an Integrated Strategy* (Alexandria, Va.: Chemical and Biological Arms Control Institute, 2000).

18. Utgoff; Sagan; and Chemical and Biological Arms Control Institute, *Responding to the Biological Weapons Challenge.*

19. Colin S. Gray, "Deterrence in the 21st Century," *Comparative Strategy* 19, no. 3 (July/September 2000): 256.

20. The failed attempt in 1980 to rescue the hostages held in Iran is a good example of this second case. US military forces had clear political objectives (rescue the hostages), and they had the equipment; however, they lacked a viable strategy, joint doctrine, training, and interoperability. In other words, the United States was not "strategically prepared" for the Desert One operation.

21. Colin S. Gray, *Modern Strategy* (New York: Oxford University Press, 1999), 17.

22. Dennis M. Drew and Donald M. Snow, *Making Strategy* (Maxwell AFB, Ala.: Air University Press, 1988), 18.

23. William J. Clinton, "The Fight against Terrorism," *Vital Speeches of the Day* 64, no. 23 (15 September 1998): 706–7.

24. Richard J. Erickson, *Legitimate Use of Military Force against State-Sponsored International Terrorism* (Maxwell AFB, Ala.: Air University Press, 1989), 180.

25. Avigdor Haselkorn, *The Continuing Storm: Iraq, Poisonous Weapons and Deterrence* (New Haven, Conn.: Yale University Press, 1999), 49.

26. Sagan advocates removing nuclear weapons from the US reprisal calculus because American leadership may feel committed to responding to a CBW attack with nuclear weapons based on strong policy declarations and promises to allies. Sagan calls this conundrum the *commitment trap*.

27. Paul I. Bernstein and Lewis A. Dunn, "Adapting Deterrence to the WMD Threat," in *Countering the Proliferation and Use of Weapons of Mass Destruction*, ed. Peter L. Hays, Vincent J. Jodoin, and Alan R. Van Tassel (New York: McGraw-Hill, 1998), 159.

28. Sagan, 114.

29. Mauroni, *Chemical-Biological Defense*, 26–27.

30. Ibid., 28.

31. Rick Atkinson, *Crusade: The Untold Story of the Persian Gulf War* (Boston: Houghton Mifflin, 1993), 86–87.

32. McGeorge Bundy reported that some of these differing opinions became public: "The President's associates . . . sometimes disagreed with each other. The most notable of these disagreements was that between some Pentagon officials and John Sununu, the White House chief of staff, who at one point found it prudent to give assurance that there was no likelihood of resort to tactical nuclear weapons. Nameless Pentagon sources then rebuked him for the military error of telling the enemy what we were not going to do." Bundy, "Nuclear Weapons and the Gulf," *Foreign Affairs* 70, no. 4 (fall 1991): 86.

33. Haselkorn, 60.

34. Janne E. Nolan, *An Elusive Consensus* (Washington, D.C.: Brookings Institution Press, 1999), 81.

35. Ibid.

36. Clinton, *A National Security Strategy for a New Century*, 6.

37. Ibid., 15.

38. Ibid., 20.

39. John M. Shalikashvili, *Shape, Respond, Prepare Now: A National Military Strategy for a New Era* (Washington, D.C.: Office of the Chairman of the Joint Chiefs of Staff, 1997), on-line, Internet, 15 January 2003, available from http://www.dtic.mil/jcs/core/nms.html.

40. Terry L. Hawkins, "The Role and Limits of Science and Technology" (presentation to Air War College NBC Seminar, Los Alamos National Laboratory, Los Alamos, N. Mex., 12 September 2000).

41. James A. Baker III, *The Politics of Diplomacy* (New York: G.P. Putnam's Sons, 1995), 359.

42. Making regime accountability the linchpin of US reprisal policy would imply some modest changes to today's military force structure. According to Bernstein and Dunn, a significant challenge for the United States lies in "operationalizing and projecting a credible threat [of regime elimination]" (159). To meet this challenge—of making credible the threat of regime elimination—the United States should place more emphasis on human intelligence and special operations.

43. Ibid.

44. Joseph and Blechman.

45. Erickson, 180.

46. Congressional report cited in Randall J. Larsen and Robert P. Kadlec, *Biological Warfare: A Post Cold War Threat to America's Strategic Mobility Forces* (Pittsburgh, Pa.: Matthew B. Ridgway Center for International Security Studies, University of Pittsburgh, 1995), 7.

47. Richard B. Frank, *Downfall* (New York: Random House, 1999), 338. Frank discusses the current debate over the number of casualties that Truman expected and the methodology for determining those estimates. Whether he believed 25,000 or 250,000 US servicemen would be killed in an invasion of the Japanese homeland, Truman made the decision. His calculus in World War II is not dissimilar to what might face a future US president if extremely large numbers of Americans are killed by a CB attack.

48. Utgoff, 3.

49. Perry, quoted in Sagan, 85.

50. Erickson, 105.

51. Bernstein and Dunn, 152.

52. *United States Special Operations Forces Posture Statement* (Washington, D.C.: US Special Operations Command, 1998), 38.

53. Dian MacDonald, "Berger: Those Who Attack U.S. 'Cannot Do So with Impunity,' " USIS Washington File, 23 August 1998, on-line, Internet, available from http://www.fas.org/man/dod-101/ops/docs/98082303_tpo.html.

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Gen Bernard A. Schriever
Father of the Ballistic Missile Program

ASPJ STAFF

Born in Bremen, Germany, on 14 September 1910, Bernard A. Schriever and his family immigrated to the United States in 1917, settling in New Braunfels, Texas. He entered the Army Air Corps Flying School at Kelly Field, Texas, in 1932 after graduating from Texas A&M University with a BS degree in architectural engineering. In 1939 he was assigned as a test pilot at Wright Field, Ohio. After earning an MA degree in aeronautical engineering from Stanford University in 1942, he flew 63 combat missions in B-17s with the 19th Bombardment Group in the Pacific theater during World War II.

From 1946 to 1954, he served in several headquarters positions with responsibilities related to material and development planning. In March 1953, Schriever learned of the successful testing of a hydrogen bomb, brainchild of the physicist Dr. Edward Teller, which had occurred in November 1952. Dr. John von Neumann, head of the Institute for Advanced Study at Princeton University, corroborated the successful test and predicted that hydrogen warheads would be extremely light and possess tremendous explosive power. Formerly, delivering an atomic warhead 5,000 miles to Europe would have required a missile weighing 500 tons.

In 1954, after becoming commander of the Air Force Western Development Division, Schriever sought to win the race for missile supremacy by capitalizing on the technological breakthrough achieved by joining the lighter hydrogen warheads to long-range missiles. Pioneering the concept of "concurrency," his organization integrated each element of the total weapon system into a single plan, program, and budget, while executing each program element in parallel rather than sequentially. Under his direction, the Thor intermediate-range ballistic missile moved from program approval to initial operational capability in only three and one-half years; the Atlas missile program moved

through its research, development, and deployment phases in slightly more than five years; the Titan system took fewer than six years to reach operational status; and the Minuteman system activated in only four years and eight months. The first 10 Minuteman missiles were on combat alert in their underground silos by October 1962.

Schriever assumed command of Air Force Systems Command in 1961 and became a full general in July of that year. In addition to fulfilling his duties to develop all Air Force weapons, he partnered with the National Aeronautics and Space Administration to begin transforming missile technology into reliable launch systems for the manned space program. General Schriever retired on 1 August 1966.

To Learn More . . .

Air Force Space and Missile Pioneers. "General Bernard A. Schriever." On-line. Internet, 30 January 2003. Available from http://www.spacecom.af.mil/hqafspc/history/schriever.htm.

Encyclopedia Astronautica. "Bernard A. Schriever." On-line. Internet, 30 January 2003. Available from http://www.astronautix.com/astros/schriever.htm.

Frisbee, John L., ed. *Makers of the United States Air Force.* Washington, D.C.: Office of Air Force History, 1987.

Johnson, Stephen B. "Bernard Schriever and the Scientific Vision." *Air Power History* 49, no. 1 (spring 2002): 30–45.

Thomas, Shirley. *Men of Space: Profiles of the Leaders in Space Research, Development, and Exploration.* Vol. 1. Philadelphia: Chilton Co., Book Division, 1960.

United States Air Force Biography. "General Bernard A. Schriever." On-line. Internet, 30 January 2003. Available from http://www.af.mil/news/biographies/schriever_ba.html.

The Emerging Biocruise Threat

COL REX R. KIZIAH, USAF*

Editorial Abstract: The advantages in stealth, precision, and cost afforded by cruise missile technologies make this weapon increasingly attractive to both state and nonstate actors as a substitute for manned air forces. Colonel Kiziah provides a chillingly convincing argument for the next logical leap in this threat—the marriage of cruise missiles with chemical or biological weapons. As the Air Force moves from a threat-based to a capability-based force, planners should consider what is required to counter an adversary's biocruise capabilities to attack both deployed expeditionary forces and the homeland.

The simultaneous proliferation of cruise missile delivery systems and BTW [biological and toxin warfare] production capabilities may pose a serious strategic threat in the future.

—Jonathan B. Tucker
"The Future of Biological Warfare"

THE UNITED STATES clearly demonstrated the strategic and operational effectiveness of cruise missiles to the world between 16 January and 2 February 1991, when US Navy surface ships and submarines in the Persian Gulf, Red Sea, and Eastern Mediterranean launched 288 Tomahawk land-attack missiles (TLAM) and the US Air Force expended 39 conventional air-launched cruise missiles (CALCM) against "strategic" targets in Iraq. These attacks targeted command and control headquarters, power-generation complexes, weapons of mass destruction (WMD) facilities, and oil-production and refining factories.[1] Although Department of Defense (DOD) sources and outside analysts disagree regarding the degree of success of these land-attack cruise missile (LACM) strikes, the consensus is that LACMs proved to be very effective weapon systems. As

*This article is based upon the author's essay "Assessment of the Emerging Biocruise Threat," in *The Gathering Biological Warfare Storm*, 2d ed., ed. Col (Dr.) Jim A. Davis and Dr. Barry Schneider (Maxwell AFB, Ala.: USAF Counterproliferation Center, April 2002), 193–251, on-line, Internet, 21 January 2003, available from http://www.au.af.mil/au/awc/awcgate/cpc-pubs/biostorm/kiziah.doc.

stated in DOD's *Conduct of the Persian Gulf Conflict: Final Report to Congress*, "The cruise missile concept—incorporating an unmanned, low-observable platform able to strike accurately at long distances—was validated as a significant new instrument for future conflicts."[2]

Since Operation Desert Storm, LACMs have become a centerpiece of US military strike operations. Our leaders value LACMs for their ability to penetrate enemy air defenses, strike at long ranges (over 1,000 miles from the launch platform for the TLAM), and, most importantly, to do so without endangering the lives of US personnel. Increasingly, operational war fighters view LACMs as the ultimate "smart weapons." The rest of the world has also observed and learned. Given nearly a decade of prominent, successful, and escalating use of these weapon systems—along with the proliferation of enabling technologies such as precision navigation and guidance, compact and efficient turbojet and turbofan engines, and composite and low-observable materials—it should come as no surprise that countries around the world desire and actively pursue cruise missile technologies, especially land-attack versions.[3]

Nations value LACMs not only for their long-range, precision-strike capabilities and their conventional, high-explosive warheads, but also for their potential to deliver payloads of chemical and biological warfare (CBW) agents. Advances in dual-use technologies such as satellite navigation (the US Global Positioning System [GPS] and the Russian Global Navigation Satellite System [GLONASS]) and highly efficient, small turbofan engines used in aircraft allow Western nations to improve their long-range, precision-strike weaponry. However, they also allow lesser-developed countries to close the technology gap and begin inserting comparable weaponry into their arsenals relatively "on the cheap" by historical standards, compared to other weapon systems such as modern aircraft and ballistic missiles. Additionally, with years of determined efforts that have recently intensified, the United States has pursued theater missile and air defense systems to counter potential adversaries' aircraft and increasingly sophisticated ballistic missiles. Consequently, competitors seek to acquire and develop hard-to-detect-and-engage LACMs to maintain, and possibly to enhance, their capabilities to deter and confront the United States and its allies.

These developments have clearly captured the attention of government officials, defense planners, and intelligence analysts. Dr. Ramesh Thakur, vice rector of United Nations University in Tokyo and author of numerous proliferation and arms-control articles, argues that "for developing and rogue countries, the balance in cost, accessibility, lethality, complexity, and operational requirements is shifting from ballistic to cruise missiles."[4] More specifically, in an address to the National Defense University Foundation in April 1999, Donald Rumsfeld, now the secretary of defense, stated that "the United States must expect such states as Iran, Iraq, and North Korea to acquire or develop cruise missiles over the next few years."[5] The National Intelligence Council's unclassified report *Foreign Missile Developments and the Ballistic Missile Threat to the United States through 2015* (September 1999) echoes this assessment: "We expect to see acquisition of LACMs by many countries to meet regional military requirements."[6] Thus, trends indicate that cruise missiles may represent a greater long-term threat to US interests and global stability than do ballistic missiles.

Land-Attack Cruise Missiles: The Basics

A comprehensive description of a cruise missile includes the following characteristics: an unmanned aircraft configured as an anti-surface weapon intended to impact upon or detonate over a preselected surface (land or sea) target; an integral means of sustained self-propulsion and a precision-guidance system (usually autonomous but possibly requiring limited external input from a human operator); aerodynamic surfaces that generate lift to sustain the missile's flight; and autonomous achievement of a sustained cruise phase of flight at a predetermined level, relative to over-

flown terrain or water.[7] Thus, cruise missiles represent a subset of armed, unmanned aerial vehicles (UAV) or standoff weapons.

Typically, cruise missiles are categorized according to the intended mission and launch mode instead of their maximum range, which is the classification scheme for ballistic missiles. The two broadest categories are antiship cruise missiles (ASCM) and LACMs.[8] On the one hand, ASCMs—currently in the military arsenals of 73 countries—are the most widely deployed cruise missiles[9] and represent the most important naval weapons possessed by many of these countries: "The punch provided by ASCMs has made it possible for Third World countries to maintain relatively powerful naval forces that rely on comparatively inexpensive missile-armed patrol boats or small corvettes."[10] ASCMs are designed to strike small targets such as ships at sea at relatively long ranges (up to approximately 500 kilometers [km]) and thus are terminally guided to ships with high accuracy. The terminal-guidance systems include active or semiactive radar, radar homing, infrared (IR), television, or home-on-jam.[11]

On the other hand, LACMs are designed to attack ground-based targets, either mobile or fixed. Basic components include the airframe, propulsion system, navigation and guidance system, and warhead. Basically, the LACM airframe is an elongated, cylindrical missile/aircraft structure constructed from metals and composite materials, with short wings and rudders. The propulsion system (rocket or air-breathing engine) is located in the rear; the navigation and guidance system is located in the front; and the fuel and warhead are typically located in the midbody.[12] LACM guidance occurs in three phases: launch, midcourse, and terminal. During launch, the missile receives initial guidance information from its onboard inertial navigation system (INS). In the midcourse phase, a radar-based terrain contour matching (TERCOM) system and/or satellite navigation system such as GPS or GLONASS correct for the inherent inaccuracies of the INS.[13] Upon entering the target area, the terminal-guidance system (one or a combination of the following: GPS/GLONASS, TERCOM with more accurate terrain-contour digital maps, Digital Scene Matching Correlator [DSMAC] or a terminal seeker [optical- or radar-based sensor]) controls the missile to the desired impact point.[14] The mission ranges of LACMs currently in military arsenals around the world vary from 50 to more than 3,000 km, and most of the missiles fly at high subsonic speeds.

Proliferating Cruise Missile Technologies

The elimination of substantial technological barriers that prevented Third World countries from producing accurate LACMs coincided with the "eye-opening" performance of US TLAMs during the Persian Gulf War of 1991. Until the late 1980s, accurate LACMs required sophisticated guidance and navigation technologies—stand-alone, accurate, and complex INS, TERCOM, and DSMAC—controlled through Missile Technology Control Regime auspices and thus available to only a few countries such as the United States, United Kingdom, Soviet Union, and France.[15] In the 1990s, critical enabling technologies became commercially available, thus allowing states to begin pursuing viable LACM procurement programs. Such technologies included precision navigation and guidance technologies; high-resolution satellite imagery and sophisticated Geographical Information Systems (GIS); high-efficiency, reduced-volume, air-breathing engines; more efficient fuels; and composite and low-observable materials.

The commercial availability of accurate satellite navigation information has allowed Third World countries to bypass approximately 15 years of research and development for long-range, fairly accurate LACMs. Low-cost GPS receivers can augment relatively inaccurate and widely available INS systems to achieve the navigational accuracies of stand-alone, fairly accurate, expensive INS systems formerly produced only for Western commercial aircraft.[16] GPS, Differential GPS (DGPS), and GLONASS receivers can be incorporated into all guidance

phases of LACM flight. Used in combination, these technologies allow nations seeking to compete militarily in the international arena to develop relatively inexpensive LACMs that can deliver payloads to within a few meters of the intended target. Commercial DGPS systems are available worldwide that can improve the accuracy of GPS coarse/acquisition (the GPS signal available to all users and providing accuracies around 30 meters [m]) guidance by an order of magnitude.[17] Additionally, GLONASS, used in conjunction with GPS, improves the robustness and accuracy of guidance systems.

GPS, DGPS, and GLONASS guidance technologies provide sufficient LACM accuracies for delivery of both conventional and nuclear, biological, and chemical (NBC) payloads without the need for TERCOM- or DSMAC-like systems that require extensive digital maps. However, developing countries may want to develop a LACM that flies at very low altitudes while maximizing terrain masking in order to increase survivability and penetration of air defenses. Such low-altitude flight profiles require accurate digital-mapping capabilities that, until recently, were too expensive for most developing nations. Now such capabilities are commercially available within affordable ranges. Potential adversaries can purchase one-meter-resolution satellite imagery, add accurate GPS/DGPS position information with GIS, and produce very accurate three-dimensional digital maps.[18]

Increasingly efficient fuels as well as turbojet and turbofan engines available on the international market provide poorer countries the ability to field cruise missiles with ranges of at least 1,000 km.[19] Additionally, commercially available radar-absorbing structures, materials, and coatings, along with IR-suppression techniques, can greatly reduce the signatures of cruise missiles. Potential competitors who combine these technologies with LACMs significantly complicate regional air defense scenarios for the United States and its allies.

Besides accessibility to the technologies described above, many advantageous characteristics of LACMs as weapon systems motivate lesser-developed countries with limited fiscal resources to acquire or develop them as part of a balanced military strike force that includes combat aircraft, ballistic missiles, and cruise missiles. One particularly desirable feature is their small size compared to aircraft and ballistic missiles. LACMs are easily deployable on a wide variety of platforms—ships, submarines, and aircraft, as well as small, fixed, or mobile land-based launchers. This flexibility translates into increased survivability before launch. Unlike combat aircraft, LACMs are not restricted to operating from vulnerable airfields susceptible to preemptive attacks. Also, the fact that, on land, LACMs are much easier to hide from opposing forces and are more mobile than ballistic missiles further enhances an enemy state's ability to conduct "shoot and scoot" launches, such as those the Iraqis executed with great success during the Persian Gulf War in spite of intensive "Scud hunt" operations by coalition forces.

By 2005–10, modestly equipped states could produce LACMs with a range of 500 to 700 km (8.5 m in length, an .8 m body diameter, and a 2.4 m wingspan) that could fit into a standard 12 m shipping container along with a small erector constructed for launching the LACM directly from the container.[20] A range of 500 to 700 km allows an adversary deploying such ship-based LACMs to strike most key population and industrial centers in Europe and North America yet remain outside the 200-mile territorial-waters limit. Such a threat poses difficult monitoring challenges for both the intelligence and defense communities. Dennis Gormley writes that "the non-governmental 'Gates Panel,' in reviewing NIE [National Intelligence Estimate] 95-19 . . . concluded that not nearly enough attention was being devoted to the possibility that land-attack cruise missiles could be launched from ships within several hundred kilometres of U.S. territory."[21] Perhaps in response to this criticism, the intelligence community's unclassified national intelligence estimate of September 1999 on the ballistic missile threat to the United States through the year 2015 stated that "a commercial surface vessel, covertly equipped to launch cruise missiles, would be a plausible alternative

for a forward-based launch platform. This method would provide a large and potentially inconspicuous platform to launch a cruise missile while providing at least some cover for launch deniability."[22]

Because of its small size, a LACM has inherently low visual, IR, and radar signatures—characteristics that translate into increased survivability. The reduced radar observability, referred to as a reduced radar cross section (RCS), makes the missile difficult for air defense radars to detect, identify, track, and engage, especially compared to the conventional combat aircraft in a rogue state's arsenal. Complicating the air defense problem, the application of low-observable materials can make a LACM even more difficult to detect. The simplest approach would be to apply radar-absorbing coatings to the airframe surface and to incorporate an IR reduction cone around the engine. The airframe could also be constructed with radar-absorbing polymers and nonmetallic composites that would only minimally reflect radar energy. Finally, engineers could design the LACM's shape, structure, composition, and integration of subcomponents to be inherently stealthy. Clearly, this option would require the most technical skill.

The impact of lowered observability can be dramatic because it reduces the maximum detection range from missile defenses, resulting in minimal time for intercept. For example, a conventional fighter aircraft such as an F-4 has an RCS of about six square meters (m^2), and the much larger but low-observable B-2 bomber, which incorporates advanced stealth technologies into its design, has an RCS of only approximately 0.75 m^2.[23] A typical cruise missile with UAV-like characteristics has an RCS in the range of 1 m^2; the Tomahawk ALCM, designed in the 1970s and utilizing the fairly simple low-observable technologies then available, has an RCS of less than 0.05 m^2. The US airborne warning and control system (AWACS) radar system was designed to detect aircraft with an RCS of 7 m^2 at a range of at least 370 km and typical nonstealthy cruise missiles at a range of at least 227 km; stealthy cruise missiles, however, could approach air defenses to within 108 km before being detected. If such missiles traveled at a speed of 805 km per hour (500 miles per hour), air defenses would have only eight minutes to engage and destroy the stealthy missile and 17 minutes for the nonstealthy missile. Furthermore, a low-observable LACM can be difficult to engage and destroy, even if detected. According to Seth Carus, a Soviet analyst, cruise missiles with an RCS of 0.1 m^2 or smaller are difficult for surface-to-air missile (SAM) fire-control radars to track.[24] Consequently, even if a SAM battery detects the missile, it may not acquire a sufficient lock on the target to complete the intercept. Even IR tracking devices may not detect low-observable LACMs, and IR-seeking SAMs may not home in on the missile. To further thwart engagement, a LACM could employ relatively simple countermeasures such as chaff and decoys.

A LACM can also avoid detection by following programmed flight paths on which the missile approaches the target at extremely low altitudes, blending with the ground clutter while simultaneously taking advantage of terrain masking. Technologies that enable "terrain hugging" flight—such as radar altimetry, precision guidance and satellite navigation, computerized flight control, high-resolution satellite imagery, and digitized terrain mapping via sophisticated GIS—are becoming increasingly available from commercial sources at affordable costs. These technologies allow longer-range LACMs to fly lengthy and circuitous routes to the target, thus minimizing or eliminating their exposure to air defense systems.

Another approach to defeat air defenses afforded by the operational flexibility of the LACM entails launching multiple missiles against a target simultaneously from various directions, thereby overwhelming air defenses at their weakest points. Adversaries could also launch both theater ballistic and cruise missiles to arrive simultaneously at the designated target. The different characteristics of these two approaching missiles—the high-altitude, supersonic ballistic trajectory of the ballistic missiles and the low-altitude, subsonic flight of the

cruise missiles—could overwhelm the capabilities of even the most sophisticated air defense systems. A Joint Chiefs of Staff official interviewed by an *Aviation Week and Space Technology* reporter commented that "a sophisticated foe might be able to fire 20 or 30 [Scud-type] battlefield ballistic missiles, followed by aircraft that pop up to launch waves of cruise missiles. The resulting problem for U.S. defenders would be staggering in complexity."[25] Similarly, a former senior planner for Desert Storm noted that "during Desert Storm, if the Iraqis could have fired even one cruise missile a day—with a two-city block [accuracy]—into the headquarters complex in Riyadh [Saudi Arabia], we would have been out of commission about half the time."[26] To further complicate the defender's situation, the attacker could time LACM strikes to coincide with the return of the defender's aircraft. As stated by a senior official at the Pentagon's Joint Theater Air and Missile Defense Office, "The challenge with ballistic missiles is hitting them. . . . With cruise missiles, it's figuring out whether it's friendly or not."[27]

Enabled by the increasing commercial availability of advances in key technologies for all components of a LACM—airframe, propulsion, guidance and navigation, and warhead—the combined accuracy and range attributes of LACMs now exceed those of ballistic missile systems at far less cost per weapon system. For example, LACMs can be developed with warheads and ranges similar to those of substantially more complex ballistic missiles but at less than half the cost and with at least 10 times the warhead-delivery accuracy (10–100 m circular error probable [CEP] compared to 1,000–2,000 m CEP).[28] By carrying different warheads, a LACM provides competitor states more cost-effective options for a deep strike of heavily defended targets such as airfields; ports; staging areas; troop concentrations; amphibious landing areas; logistics centers; and command, control, communications, and intelligence nodes. Because the accuracy of the LACM is significantly better than that of a similar-ranged ballistic missile, the probability of destroying or damaging the target is much higher. Furthermore, the range of a LACM is extended by the range of its launch platform, thus giving it the potential to attack targets well beyond the range of comparable ballistic missile systems.

The characteristics discussed above make LACMs ideally suited for disseminating biological warfare (BW) agents. As would be the case for aircraft dissemination, a subsonic LACM, using an aerosol sprayer embedded in its wings and built-in meteorological sensors coupled to the guidance-and-control computer, could alter its flight profile and release a line source of BW agent tailored to the local topography, micrometeorological conditions, and shape of the target, thus maximizing the resultant lethal area of the BW payload. The advantage of employing a LACM for the delivery of BW agents as opposed to an aircraft is that it involves no risk to the pilot; the disadvantage is forfeiture of pilot improvisation.

Gormley argues that "the lethal areas for a given quantity of CBW, and this is a very, very conservative calculation, are at least ten times that of a ballistic missile delivery program. This judgment reflects the results of extensive modeling and simulation."[29] In Gormley's simulation, an optimal pattern of distribution of CBW agents using submunitions was assumed for ballistic missile delivery. For LACM delivery, both worst-case and best-case distributions were averaged for the comparison. The increased lethality area for a LACM-delivered CBW payload is primarily attributable to the aerodynamic stability of the LACM and the capability of distributing the CBW agent payload as a line source. It is interesting to note that the United States investigated using the Snark cruise missile for delivery of BW and chemical warfare (CW) agent payloads as early as 1952 and funded projects for developing dissemination systems for cruise missiles and drones through the early 1960s.[30]

In addition to achieving significantly more effective dissemination of BW agents, subsonic LACM delivery is less challenging technically than supersonic ballistic missile delivery. There are considerable technical difficulties with packaging BW agents within a ballistic missile

warhead and ensuring that the agent survives and is disseminated as an aerosol at the correct height above the ground.[31] The reentry speed is so high during the descent phase of the ballistic missile's trajectory that it is difficult to distribute the agent in a diffuse cloud or with the precision to ensure dissemination within the inversion layer of the atmosphere. Also, the high thermal and mechanical stresses generated during launch, reentry, and agent release may degrade the quality of the BW agent. US tests have shown that, without appropriate agent packaging, less than 5 percent of a BW agent payload is viable after flight and dissemination from a ballistic missile.

A few other operational features may make LACMs economically and militarily appealing to developing nations intent on building strike capabilities with very limited defense resources. Compared to aircraft and ballistic missiles, LACMs require less support infrastructure and have lower costs for operations and maintenance. The fact that they can reside in canisters makes them significantly easier to maintain and operate in harsh environments. Furthermore, the fact that they are unmanned eliminates the need for expensive pilot and crew training.

Potential adversaries have numerous reasons for pursuing WMDs and their means of delivery. The most compelling motivation may be that WMDs are the only viable levers of strategic power in the post–Cold War world for many nations. They are often the most realistic means for carrying out the three actions adversaries desire to accomplish—deter, constrain, and harm the United States—but cannot with the conventional military forces at their disposal. During the Persian Gulf War, the United States demonstrated to the world that it had developed overwhelming superiority in conventional military force against any other nation. Although since that war, the US defense budget has decreased significantly, so have the budgets of most other countries, and no country appears to be narrowing the US superiority gap. Currently, the US defense budget is more than triple that of any potentially hostile nation and more than the combined military spending of Russia, China, Iran, Iraq, North Korea, and Cuba.[32] As Richard Betts, director of national security studies at the Council on Foreign Relations, further notes, "There is no evidence that those countries' level of military professionalism is rising at a rate that would make them competitive even if they were to spend far more on their forces."[33] Hostile states and potential competitors simply cannot currently—or for the foreseeable future—confront the United States successfully on conventional military terms. Many countries are fully aware of this situation and see WMDs and their delivery vehicles as an effective means of asymmetrically challenging the overwhelming conventional military power of the United States. In essence, WMDs can be a weaker country's equalizer to the larger and more advanced conventional forces of the United States and its allies.

WMDs, combined with standoff delivery systems, provide lesser-developed countries far less expensive yet qualitatively superior military and political options for deterring, constraining, and harming the United States, compared to strategies that rely on advanced conventional forces, whose price tag is prohibitive. In other words, WMDs and long-range delivery systems allow countries to achieve regional and strategic objectives "on the cheap." Rogue nations see WMDs as an inexpensive means of coercing neighbors, deterring outside intervention, deterring other WMD threats and aggression against their interests, and—if necessary—directly attacking the United States and its allies.

The widespread proliferation of enabling technologies and the weapon systems themselves, along with ineffective post–Cold War barriers to such proliferation, is allowing rogue nations to acquire cost-effective WMDs and associated delivery systems. In the nuclear arena, India and Pakistan are prime examples of how determined states will pursue and obtain WMDs regardless of the international treaties, agreements, and sanctions imposed to prevent their acquisition. Similarly, Iraq surprised the international community with the expansiveness of its programs in all areas of WMDs—

NBC weapons and delivery systems such as ballistic missiles, aircraft, and UAVs. These programs continued in spite of pre–Persian Gulf War proliferation barriers, concentrated attacks during that war, comprehensive international sanctions, and unprecedented intrusiveness of the UN Special Commission (UNSCOM) on Iraq, all directed at destroying Iraq's WMD capabilities. The abundance of countries willing to provide assistance—by offering WMDs and delivery systems for direct purchase and providing components and technologies for in-country production—further exacerbates the proliferation problem. The most notorious are China, North Korea, and Russia, all of whom actively assist the proliferator nations in their efforts to develop WMD arsenals.

Eroding inhibitions on WMD use further encourage developing states to acquire WMDs and various delivery systems. Iraq, in particular, has clearly demonstrated its willingness to use WMDs on the battlefield. Throughout the Iraq-Iran War of 1980–83, Iraq employed CW agents against Iranian troops. In 1983 Iraq fired at least 33 Scud missiles at Iranian targets and is believed to have employed mustard gas on some of the missile launches against Iranian forces. During the last year of the war, in March–April 1988, Iraq attacked Tehran with 200 Scud missiles, causing approximately one-quarter to one-half of the city's residents to flee, fearing that some of the Scuds were armed with poison-gas warheads.[34] These Iraqi WMD attacks and others left a lasting impression on Iranian leaders and on their views of the effectiveness and international acceptability of WMDs.

WMDs also figured prominently in the Persian Gulf War when Iraq deployed modified Scuds armed with CW and BW payloads, along with other large quantities of CW agents. Some 25 Scuds were armed with BW agents, including 10 with anthrax.[35] The Iraqi regime also kept a dedicated aircraft in a hardened shelter equipped with spray tanks for dispersing BW agents. Had the Iraqis employed this weapon on the first day of the ground war, analysts at the Office of the Secretary of Defense estimate that over 76,000 of the 320,000 coalition troops southeast of Kuwait City would have died if they had not been vaccinated against anthrax. Apparently, US and Israeli threats of nuclear retaliation deterred the Iraqis from launching WMD attacks against coalition forces.

But the credibility of the United States's historically successful, punitive deterrence of WMDs by threatening nuclear retaliation may be declining. Betts offers a brief answer to a very relevant and interesting question: "Would the United States follow through and use nuclear weapons against a country or group that had killed several thousand Americans with deadly chemicals? It is hard to imagine breaking the post-Nagasaki taboo in that situation."[36] What if Iraq had used BW agents to kill 76,000 troops at the beginning of the Persian Gulf War? Further addressing the credibility of the US nuclear deterrent, Gormley and Scott McMahon, experts in the area of the proliferation of WMDs and delivery systems, note that

> this seems to have convinced Saddam Hussein not to use his chemical or biological weapons in 1991. But there are reasons to believe that future threats of nuclear retaliation will neither deter NBC strikes nor reassure regional allies enough that they would permit Western use of their bases while under the threat of NBC attack. Senior U.S. military officers, for example, have declared that they would not condone nuclear retaliation under any circumstances, even if NBC weapons were used against the United States. Although such comments are unofficial, when they are combined with a termination of nuclear testing and the virtual elimination of nuclear planning, it becomes apparent that nuclear deterrence is fast becoming an existential rather than practical option.[37]

Another issue with exercising deterrence to prevent the use of WMDs is that deterrence relies on retaliation, and retaliation requires knowledge of who has launched the attack. Combining a WMD such as a BW agent, which inherently creates difficulties in identifying the source of the resulting disease, with a delivery system such as a long-range LACM, which can be programmed to fly circuitous routes to the target, may provide an adversary with a

nonattributable method of attack, thus eliminating any attempt at retaliation.

National prestige also influences a country to acquire WMDs and associated delivery systems. Robert Gates, former director of Central Intelligence, observes that "these weapons represent symbols of technical sophistication and military prowess—and acquiring powerful weapons has become the hallmark of acceptance as a world power."[38] Similarly, referring specifically to the WMD means of delivery, Willis Stanley and Keith Payne comment that "some regimes in the developing world see a missile force as a talisman which imparts international respect and ushers them into the company of the great powers."[39] For this symbolic effect, countries like China, India, Pakistan, and others have concentrated on acquiring ballistic missiles. The demonstrated effectiveness of US TLAMs during the Persian Gulf War has perhaps elevated the prestige of LACMs to that of ballistic missiles. As Richard Speier, a consultant for the Carnegie Non-Proliferation Project, notes, "In the Gulf War the U.S. used three times as many cruise missiles as the Iraqis used ballistic missiles, and our cruise missiles had a very telling military effect."[40]

A growing community of experts has come to view the proliferation of biological weapons with increasing concern. One of the main reasons for this trend can be expressed with a slight modification to a popular phrase: biological weapons provide "more bang for the buck and effort." As Betts observes, biological weapons combine maximum lethality with ease of availability. Nuclear weapons wreak massive destruction but are extremely difficult and costly to acquire; chemical weapons are fairly easy to acquire but possess limited killing capacity; and biological weapons possess the "best" qualities of both (table 1).[41] (One should note that biological weapons most closely resemble a special category of nuclear weapons called "neutron bombs." They harm people, not property, with lethal effects against living organisms.)

A number of pathogens (bacteria and viruses) and toxins are generally considered to be effective BW agents (table 2). Edward Eitzen, a researcher at the US Army Medical Research Institute of Infectious Diseases, notes that under suitable weather conditions, cruise missiles equipped to deliver anthrax could cover an area comparable to that of the lethal fallout from a ground-burst nuclear weapon.[42] More rigorously, the Congressional Office of Technology Assessment conducted a study in 1993 that investigated the airplane dissemination of 100 kilograms (kg) of anthrax as an aerosol cloud over Washington, D.C., on a clear and calm night. The study showed that between one and three million deaths could

Table 1

Comparison of NBC Weapons

				Effectiveness			
				Protected Personnel		Unprotected Personnel	
Type	*Technology*	*Cost*	*Signature*	*Tactical*	*Strategic*	*Tactical*	*Strategic*
Biological	+	–	–	–	–	+	++
Chemical	+	+	+	–	–	++	+
Nuclear	++	++	++	++	++	++	++

++ Very High + High – Lower

Source: Lester C. Caudle, "The Biological Warfare Threat," in *Medical Aspects of Chemical and Biological Warfare,* ed. Frederick R. Sidell, Ernest T. Takafuj, and David R. Franz (Washington, D.C.: Office of the Surgeon General at TMM Publications, 1997), 459.

Table 2

Candidate BW Agents for Weaponization

Disease	*Causative Agent*	*Incubation Time* (Days)	*Fatalities* (Percent)
Anthrax	*Bacillus anthracis*	one to five	80
Plague	*Yersinia pestis*	one to five	90
Tularemia	*Francisella tularensis*	10 to 14	five to 20
Cholera	*Vibrio cholerae*	two to five	25 to 50
Venezuelan equine encephalitis	*VEE virus*	two to five	< one
Q fever	*Coxiella burnetti*	12 to 21	< one
Botulism	*Clostridium botulinum toxin*	three	30
Staphylococcal enterotoxemia	*Staphylococcus enterotoxin type B*	one to six	< one
Multiple organ toxicity	*Trichothecene mycotoxin*	Dose Dependent	

Source: The Biological and Chemical Warfare Threat (Washington, D.C.: US Government Printing Office, 1999), 2.

result—300 times the number of fatalities that could occur from a similar release of 10 times the amount of sarin gas.[43] A study by the World Health Organization in 1970 concluded that a BW attack on a large city (five million people) in an economically developed country such as the United States, using 50 kg of anthrax disseminated from a single airplane under favorable conditions, could travel downwind in excess of 20 km with the potential to kill upwards of 100,000 people while incapacitating an additional 250,000.[44] Additionally, US military scientists verified the order-of-magnitude effects of the release of BW agents against urban populations estimated by these studies by conducting combat-effects investigations at Dugway Proving Ground, Utah.[45] Thus, after comparing the killing power of WMDs on a weight-for-weight basis, one finds that BW agents are inherently more lethal than CW nerve agents and that biological weapon systems can potentially provide broader coverage per pound of payload than can CW weapons.[46]

In addition to being extremely lethal and offering feasible alternatives to nuclear weapons as a strategic arsenal, biological weapons are economically and technically attractive, or, as Betts describes, easily available compared to nuclear and chemical weapons. The costs to launch a BW program are much lower than those for comparable nuclear- and chemical-weapons programs: estimates are $2 to $10 billion for a nuclear-weapons program, 10s of millions for a chemical program, and less than $10 million for a BW program.[47] Adding to the appeal of biological weapons, almost all the materials, technology, and equipment required for a modest BW-agent program are dual use, obtainable off the shelf from a variety of legitimate enterprises, and widely available. Moreover, the technical skills required to initiate and conduct an offensive BW-agent production program are commensurate with those of graduate-level microbiologists, thousands of whom received advanced training in some of the best Western universities and who are now available worldwide.[48]

The most significant technical hurdle to overcome in obtaining biological weapons involves weaponizing the BW agents. Primary weaponization concerns include (1) effectively disseminating the BW agent for maximum

effect (area coverage and lethality or incapacitation); (2) maintaining the viability and virulence of the agent; and (3) selecting the appropriate delivery system and conditions.[49] BW agents should be disseminated as an aerosol cloud for maximum infectivity via inhalation through the lungs and for maximum geographic dispersal over the target population. Obtaining the right aerosol particle size is extremely important. Carus, a world-renowned expert and prolific writer on proliferation issues, notes that aerosolized BW agents of the wrong size can render a BW attack completely ineffective.[50] The ideal particle size ranges from one to five microns in diameter. An aerosol formed from particles in this size range is stable and can be carried downwind over long distances without significant fallout of the BW-agent particles. Also, one to five microns is the ideal range of particle sizes for retention in the lungs—particles less than one micron are readily exhaled, and those greater than five microns are filtered out by the upper respiratory passages, unable to reach the lowest level of the lungs.

BW agents can be produced and aerosolized in either liquid or dry-powder form. The liquid form is easier to produce but has a relatively short shelf life (most liquid BW agents can be stored for only three to six months under refrigeration) and can be difficult to aerosolize. Commercial sprayers can be modified for disseminating liquid BW agents, but one encounters nontrivial issues associated with the clogging of the sprayer nozzles and with destroying the agent during the spraying process.[51] Both the shelf life and spraying limitations can be overcome by producing BW agents in dry form through using lyophilization (rapid freezing and subsequent dehydration under high vacuum) and milling the appropriate particle sizes into a powder. Anthrax spores produced in this fashion can be stored for several years.[52] However, producing dry BW agents is extremely hazardous and requires more specialized equipment and greater technical capabilities.

Whether the BW agents are in liquid or dry form, individuals who seek to weaponize them must overcome environmental conditions that kill or reduce the virulence of the agents. The rate of biological decay depends upon several factors, including ultraviolet radiation, temperature, humidity, and air pollution.[53] The optimal atmospheric conditions for a BW attack would occur on a cold, clear night with relative humidity greater than 70 percent. The inversion layer (the stable blanket of cool air above the cool ground) would prevent vertical mixing of the aerosol cloud, thus keeping the BW agent near the ground for inhalation. Weaponization of BW agents presents many challenges. Nonetheless, from a proliferation viewpoint, it is important to note that more than 40 years ago the US Army Chemical Corps overcame these challenges and successfully demonstrated and conducted tests of large areas and effective dissemination of biological agents.[54]

Because of the low costs associated with initiating and conducting biological-weapons programs and the dual-use nature of BW research and equipment, a BW program can flourish clandestinely under the guise of legitimate research. This unique feature of biological-weapons programs may make them particularly attractive to rogue nations. No unambiguous signatures readily discriminate a program focused on conducting legitimate biomedical research on highly contagious diseases from one that researches and produces BW agents for offensive military purposes. The absence of verification provisions in the Biological and Toxin Weapons Convention adds to the difficulty of detecting and countering clandestine BW programs. As the Iraqi situation illustrates, detecting and understanding the extent of a clandestine BW program is extremely difficult. In January 1999, UNSCOM officials provided a report to the UN Security Council summarizing eight years of extensive investigations and destruction of Iraq's chemical and biological weapons programs. Even with these intensive and powerful inspections, UNSCOM officials now believe that Iraq, through well-coordinated concealment and deception efforts, may have produced another, as yet unidentified, BW agent in an unreported and unlocated production facility.[55]

From an aggressor's perspective, another advantage of biological weapons over chemical or nuclear weapons is that, currently, no reliable detection devices exist to provide advanced warning of a BW attack, thus allowing a greater probability of large numbers of casualties per weapon. Additionally, coupled with the delayed onset of symptoms from a BW attack and the fact that these symptoms could easily be attributed to a natural outbreak of disease, biological weapons potentially provide the country employing them plausible deniability. Thus, an aggressor may use biological weapons as a precursor to a conventional military attack to wreak havoc and weaken the target forces of a conventionally superior foe with a reduced risk of retaliation and condemnation from the attacked country and international community. It would be possible to identify a large outbreak of anthrax, for example, as an almost certain BW attack since such episodes occur rarely, if at all, in nature. However, the outbreak of a common disease regularly found in a given region of the world would possibly be seen at first as a natural occurrence.

Conclusion

From the perspective of a competitor facing the formidable conventional military power of the United States and its allies, a LACM equipped with a BW-agent payload could represent a politically attractive, cost-effective, and militarily useful weapon system. Politically, the mere threat of using a system with a payload of 120 kg of anthrax against a major US or allied city could deter the United States from becoming involved in an adversary's aggression against a neighbor or bid for regional hegemony. Militarily, such a delivery system, especially if it is equipped with low-observable technologies and simple endgame countermeasures such as chaff and decoys, would have a high probability of penetrating air defenses and accurately delivering its payload, thus causing large numbers of casualties. Such weapon systems are cost-effective, especially compared to similarly ranged ballistic missiles and conventional combat aircraft. As such, lesser-developed states with limited defense resources could purchase relatively large numbers of LACMs and use them to complicate the air defense problem for the United States and its allies.

With the emergence of commercially available enabling technologies for precise navigation and guidance; sophisticated mission planning; low-weight, high-efficiency propulsion; and air defense penetration, the development of biocruise weapon systems is now within the reach of many potential adversaries. States such as Iran, Iraq, and North Korea have persistently demonstrated the will to acquire weapon systems that will provide them with strategic leverage against the United States and its allies. Such nations pursue multiple-acquisition strategies that have the potential to provide them with highly capable LACMs. These strategies include direct purchase of advanced LACMs from various countries, including France, Russia, and China; indigenous development, with or without outside assistance; and development of a highly capable LACM via the relatively low-cost and technically straightforward conversion of an ASCM such as the Chinese HY-4 Sadsack. Given these proliferation conditions, which clearly favor adversary states, the probability is quite high that by 2005 one or more such competitors will possess a biocruise weapon system with a range of 500 to 1,000 km, capable of effective BW-agent delivery against US and allied military operations in regional conflicts around the world or against military and civilian targets within the United States and allied countries.

Just as disturbing, these capabilities will likely emerge with little if any warning. The National Intelligence Council's 1999 report *Foreign Missile Developments and the Ballistic Missile Threat to the United States through 2015* states that

> a concept similar to a sea-based ballistic missile launch system would be to launch cruise missiles from forward-based platforms. This method would enable a country to use cruise missiles acquired for regional purposes to attack targets in the United States. . . . We also judge that we may not be able to provide much, if any, warning of a forward-based ballistic missile or . . . LACM threat to the United States. Moreover, LACM development can draw upon dual-use technologies.[56]

Assessing, predicting, and tracking the proliferation of strategically significant LACMs is difficult for the intelligence community. George Tenet, director of the Central Intelligence Agency, testified before the Senate Select Committee on Intelligence that the US intelligence services might be incapable of monitoring the proliferation of NBC expertise and technologies. He also stated that, now more than ever, "we risk substantial surprise."[57] By adding to these sobering assessments the disturbing knowledge that some states have clearly demonstrated that they will use WMDs and that the United States and its allies are not likely to deter such use, one can appreciate the need to develop strategic, operational, and tactical structures to counter the emerging biocruise threat. □

Notes

1. Humphry Crum Ewing et al., *Cruise Missiles: Precision and Countermeasures,* Bailrigg Memorandum no. 10 (Lancaster, United Kingdom: Centre for Defence and International Security Studies, 1995), 60.

2. Department of Defense, *Conduct of the Persian Gulf Conflict: Final Report to Congress,* vol. 1 (Washington, D.C.: US Government Printing Office, April 1992), 244.

3. Kori Schake, "Rogue States and Proliferation: How Serious Is the Threat?" in *Strategic Assessment 1999: Priorities for a Turbulent World,* ed. Hans Binnendijk et al. (Washington, D.C.: US Government Printing Office, June 1999), 220. The United States has identified Iran, Iraq, Libya, North Korea, and Syria as rogue nations capable of BW proliferation and believes them to be sponsors of terrorism. No single, universally accepted definition of a rogue nation exists. The Clinton administration defined such states as "recalcitrant and outlaw states that not only choose to remain outside the family [of democracies] but also assault its basic values." See Anthony Lake, "Confronting Backlash States," *Foreign Affairs* 73, no. 2 (March/April 1994): 45–46. Some of the characteristics of rogue nations are that they aggressively pursue unconventional means to threaten US and international interests, do not conform to the norms of international behavior (and are not easily persuaded to do so), and tend to be sponsors of terrorism.

4. Ramesh Thakur, "Arms Control, Disarmament and Non-Proliferation: A Political Perspective," in *Arms Control in the Asia-Pacific Region,* ed. Jeffrey A. Larsen and Thomas D. Miller (Washington, D.C.: US Government Printing Office, August 1999), 43.

5. "Iran, Other Rogue Regimes Developing Cruise Missiles," May 1999, on-line, Internet, 1 February 2000, available from http://www.ourjerusalem.com/documents/febmay99/0412docs.htm.

6. National Intelligence Council, *Foreign Missile Developments and the Ballistic Missile Threat to the United States through 2015,* September 1999, on-line, Internet, 21 January 2000, available from http://www.usconsulate.org.hk/uscn/others/1999/0909.htm.

7. In Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms,* 12 April 2001 (as amended through 25 September 2002), on-line, Internet, 22 January 2003, available from http://www.dtic.mil/doctrine/jel/new_pubs/jp1_02.pdf, a *cruise missile* is defined as a "guided missile, the major portion of whose flight path to its target is conducted at approximately constant velocity; depends on the dynamic reaction of air for lift and upon propulsion forces to balance drag." A *guided missile* is "an unmanned vehicle moving above the surface of the Earth whose trajectory or flight path is capable of being altered by an external or internal mechanism."

8. National Air Intelligence Center, *Ballistic and Cruise Missile Threat,* NAIC-1031-0985-99 (Dayton, Ohio: Wright-Patterson Air Force Base, April 1999), 6.

9. Centre for Defence and International Security Studies, "Cruise Missile Capabilities: An Assessment," on-line, Internet, 1 February 2000, available from http://www.cdiss.com/tabanaly.htm.

10. W. Seth Carus, *Cruise Missile Proliferation in the 1990s* (Westport, Conn.: Praeger, 1992), 15.

11. Ibid.

12. Marshall Brain, "How Cruise Missiles Work," on-line, Internet, 21 September 1999, available from http://www.howstuffworks.com/cruise-missile.htm.

13. Ewing et al., 49 and 51. INS uses gyroscopes and accelerometers to detect changes in speed and direction of the LACM, which can then be used to compute changes in relative positions. Although an INS guidance system has the advantage of being jamproof, the gyroscopes have inherent inaccuracies that result in increasing positional errors (called drift) with increasing LACM flight time. For example, the US TLAM INS drifts by 900 meters per hour. At the TLAM's cruising speed of 800 km per hour, an uncorrected INS would result in a 1.8 km positional error for striking a target at a range of 1,600 km. Thus, to strike targets at long range, the LACM's INS must be supplemented with other guidance systems such as GPS or TERCOM. TERCOM corrects any INS by taking periodic fixes on the terrain features (which must be areas of distinctive topography) over which the LACM is flying. To accomplish this, the TERCOM system uses an onboard computer, in which maps of the relevant terrain, obtained from high-resolution satellite images, are stored, along with a radar altimeter. The computer correlates data received from altimeter readings with elevation data from the stored maps. The system then calculates the corrections needed to put the LACM back on course and provides this information to the missile's autopilot.

14. DSMAC is a two-dimensional map-matching technique that employs an onboard sensor to obtain a sequence of images of the ground directly below the missile. The images are compared to reference data stored in the missile's navigational computer, and position changes are made as needed prior to final target acquisition. DSMAC is a complex technology that significantly improves the terminal accuracy of the cruise missile.

15. This regime was created in 1987 by the G-7 governments of Canada, France, Italy, Japan, United Kingdom, United States, and West Germany. It is an informal, voluntary export-control arrangement with guidelines prohibiting the sale or transfer of certain categories of ballistic and cruise missiles and their related technologies. The regime grew out of the mutual fears of the G-7 nations that rogue states would acquire offensive missiles for use as WMD-delivery platforms. The current membership includes 32 countries.

16. K. Scott McMahon and Dennis M. Gormley, *Controlling the Spread of Land-Attack Cruise Missiles,* AISC Papers, no. 7 (Marina del Rey, Calif.: American Institute for Strategic Cooperation [AISC], January 1995), 22.

17. DGPS is a method of correcting GPS that allows a weapon system to obtain extremely high positional accuracies. The concept of DGPS is as follows: A receiver is placed at a presurveyed location whose position has been determined very accurately. Both the GPS receiver at the known location and the DGPS receiver on the weapon system acquire the same set of GPS signals from the same set of satellites. The errors in the GPS signals are determined by comparing the surveyed site's known position to the position determined using the GPS signals. Correction terms are then calculated

and transmitted to the weapon-system DGPS receiver, allowing elimination of most of the errors of the GPS signals. The DGPS technique can yield weapon-system positional accuracies of 1 to 5 m.

18. "IKONOS Satellite Launches into Space," on-line, Internet, 1 October 1999, available from http://www.spaceimage.com/newsroom/releases/1999/inorbit.htm. Space Imaging, a US firm, successfully launched its IKONOS satellite on 24 September 1999. This is the first commercial imaging satellite of its kind, simultaneously collecting panchromatic images of 1 m resolution and multispectral images of 4 m resolution. Space Imaging is now selling and distributing imagery. Many other commercial imaging satellites, both US and foreign, that provide imagery of 1 m resolution were scheduled for launch in 2000, 2001, 2002, and so forth. See also McMahon and Gormley, 24.

19. McMahon and Gormley, 25.

20. Dennis Gormley and Richard Speier, "Cruise Missile Proliferation: Threat, Policy, and Defenses" (presentation to the Carnegie Endowment for International Peace Proliferation Roundtable, 9 October 1998), on-line, Internet, 21 September 1999, available from http://www.ceip.org/programs/npp/cruise4.htm.

21. Dennis M. Gormley, "Hedging against the Cruise-Missile Threat," *Survival*, spring 1998, 92–111, on-line, Internet, 21 September 1999, available from http://www.ceip.org/programs/npp/gormley%20survival.htm.

22. National Intelligence Council, *Foreign Missile Developments.*

23. Ewing et al., 50.

24. Carus, 22.

25. David A. Fulghum, "Stealth, Cheap Technology Complicate Defense Schemes," *Aviation Week and Space Technology* 147, no. 2 (14 July 1997): 47.

26. Ibid.

27. Bryan Bender, "Cruise Control," *Jane's Defence Weekly* 30, no. 3 (22 July 1998): 21.

28. Dennis M. Gormley, "Remarks from a Panel on the Missile Proliferation Threat at the Conference on Nuclear Non-Proliferation: Enhancing the Tools of the Trade," 9–10 June 1997, Washington, D.C., on-line, Internet, 29 September 1999, available from http://www.ceip.org/programs/npp/np9715gohtm. See also McMahon and Gormley, 14–18; Amy Truesdell, "Cruise Missiles: The Discriminating Weapon of Choice?" *Jane's Intelligence Review*, February 1997, 87–90; and Carus, 69 and 83.

29. Gormley and Speier.

30. Carus, 25.

31. *Militarily Critical Technologies List (MCTL) Part II: Weapons of Mass Destruction Technologies, Section I—Means of Delivery Technology*, September 1998, II-1-2, on-line, Internet, 10 September 1999, available from http://www.fas.org/irp/threat/mctl98-2/p2sec01.pdf.

32. Richard K. Betts, "The New Threat of Mass Destruction," *Foreign Affairs* 77, no. 1 (January/February 1998): 28. See also Eugene Gholz, Daryl G. Press, and Harvey M. Sapolsky, "Come Home America: The Strategy of Restraint in the Face of Temptation," *International Security* 21, no. 4 (spring 1997): 7.

33. Betts, 27.

34. Efraim Karsh, "Rational Ruthlessness: Non-Conventional and Missile Warfare in the Iran-Iraq War," in *Non-Conventional-Weapons Proliferation in the Middle East*, ed. Efraim Karsh, Martin S. Navias, and Philip Sabin (New York: Oxford University Press, 1993), 36–42.

35. Robin Ranger and David Wiencek, *The Devil's Brews II: Weapons of Mass Destruction and International Security*, Bailrigg Memorandum no. 17 (Lancaster, United Kingdom: Centre for Defence and International Security Studies, 1997), 16.

36. Betts, 31.

37. Dennis M. Gormley and K. Scott McMahon, "Counterforce: The Neglected Pillar of Theater Missile Defense," on-line, Internet, 29 September 1999, available from http://www.cdiss.org/colsep1.htm.

38. House Committee on Armed Services, *Countering the Chemical and Biological Weapons Threat in the Post-Soviet World*, Special Inquiry into the Chemical and Biological Threat, Report to the Congress (Washington, D.C.: US Government Printing Office, 23 February 1993), 4.

39. Willis Stanley and Keith Payne, "Chapter II. Missile Proliferation: Threat and U.S. Response," *Comparative Strategy* 16, no. 2 (1997): 135.

40. Gormley and Speier.

41. Betts, 32.

42. Edward M. Eitzen, "Use of Biological Weapons," in *Medical Aspects of Chemical and Biological Warfare*, ed. Frederick R. Sidell, Ernest T. Takafuj, and David R. Franz (Washington, D.C.: Office of the Surgeon General at TMM Publications, 1997), 446.

43. US Congress, Office of Technology Assessment, *Proliferation of Weapons of Mass Destruction: Assessing the Risks*, OTA-ISC-559 (Washington, D.C.: US Government Printing Office, August 1993), 54.

44. World Health Organization Group of Consultants, *Health Aspects of Chemical and Biological Weapons* (Geneva, Switzerland: World Health Organization, 1970), 98–99.

45. Lester C. Caudle, "The Biological Warfare Threat," in *Medical Aspects of Chemical and Biological Warfare*, 437–50.

46. Biological agents are either replicating agents (bacteria or viruses) or nonreplicating materials (toxins or physiologically active proteins or peptides) that can be produced by living organisms. The replicating nature and extreme infectivity at low doses of pathogens such as *Bacillus anthracis* (the organism that causes anthrax) and *Yersinia pestis* (the organism that causes plague) make them, weight-for-weight, more deadly than CW nerve agents. Additionally, toxins such as the staphylococcal enterotoxins and botulinum toxins are extraordinarily toxic—1,000- to 10,000-fold more toxic than classic nerve agents. For further information, see *The Biological and Chemical Warfare Threat* (Washington, D.C.: US Government Printing Office, 1999), 1–23; Frederick R. Sidell and David R. Franz, "Overview: Defense against the Effects of Chemical and Biological Warfare Agents," in *Medical Aspects of Chemical and Biological Warfare*, 1–7; and Eitzen, 437–50.

47. Caudle, 458. See also Lord Lyell, "Chemical and Biological Weapons: The Poor Man's Bomb," 4 October 1996, on-line, Internet, 11 May 2000, available from http://www.pgs.ca/pages/cw/cw980327.htm. Lyell states that "a more specific assessment suggests that the development of biological weapons would cost less than $100,000, require five biologists, and take just a few weeks using equipment that is readily available."

48. *The Biological and Chemical Warfare Threat*, 1.

49. Jonathan B. Tucker, "The Future of Biological Warfare," in *The Proliferation of Advanced Weaponry: Technology, Motivations, and Responses*, ed. W. Thomas Wander and Eric H. Arnett (Washington, D.C.: American Association for the Advancement of Science, 1992), 67.

50. W. Seth Carus, *Bioterrorism and Biocrimes: The Illicit Use of Biological Agents in the 20th Century* (Washington, D.C.: Center for Counterproliferation Research, National Defense University, August 1998 [March 1999 revision]), 25.

51. Carus, *Bioterrorism and Biocrimes*, 24.

52. Tucker, 67.

53. Carus, *Bioterrorism and Biocrimes*, 25.

54. Ibid., 26.

55. Milton Leitenberg, "Deadly Unknowns about Iraq's Biological Weapons Program," 9 February 2000, on-line, Internet, 14 February 2000, available from http://www.isis-online.org/publications/iraq/leitenberg.html.

56. National Intelligence Council, *Foreign Missile Developments.*

57. Judith Miller, "U.S. Intelligence: Flying Blind in a Dangerous World," *New York Times*, 6 February 2000, D5.

Complexity-Based Targeting

New Sciences Provide Effects

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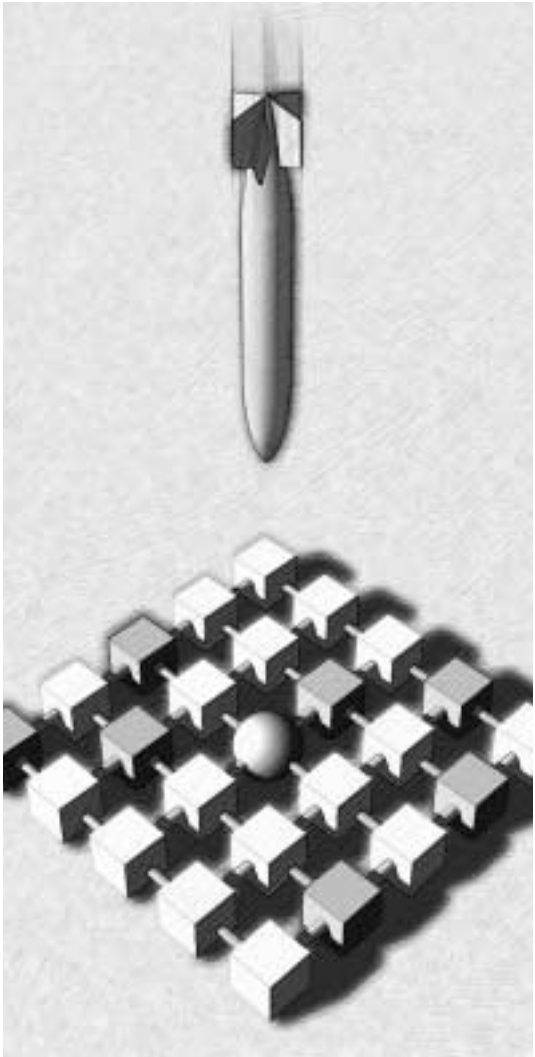
Editorial Abstract: Air campaign planners historically focus on levels of destruction to determine success. The authors argue that by focusing on system complexity (the degree to which the system contains interacting entities with coherent behavior) and system entropy (the amount of work lost within the system when destructive forces are introduced), planners can take advantage of both kinetic and nonkinetic approaches to degrade system function and performance. By focusing on complex system characteristics, planners can induce cascading, chaotic behavior that achieves campaign objectives more dramatically and effectively.



THROUGHOUT THE MODERN history of bombardment, targeting philosophies have remained deeply rooted in industrial-age mind-sets and mechanistic, linear analyses of systems as engineered entities. As a result, in most significant bombing campaigns, targets have been classified by their physical attributes alone. For example, in the "serial bombing" philosophy of World War II, aircraft attacked large sets of physical targets sequentially.[1] Contemporary targeting philosophy—the "parallel warfare" employed during the Gulf War—advocates attacking targets with more simultaneity yet still focuses almost exclusively on their physical attributes and their engineered physical interactions.[2] In general, these targeting constructs are exceedingly inefficient, requiring inordinate amounts of "inputs" (tonnage of bullets and bombs, amounts of information warfare [IW], etc.) often not justified by or traceable to observed "outputs" (effects). Since the end of Operation Desert Storm, bombing campaigns have evolved in concept toward an objective of

having specific effects on the enemy and his systems; in practice, planners still choose targets based upon engineering analyses of physical systems and physical interactions inside those systems. Little has changed.

Recent research asserts that the American military has historically misunderstood the systemic nature of targets.[3] Targeting has remained inefficient and unpredictable because most targets of military value are elements in complex adaptive systems, which behave according to a radically different operating dynamic than do mechanistic systems. An evolving body of scientific work, based on understanding the emergent behaviors of large collections of interacting entities, describes the behavior of these systems. Although this body of work is collectively referred to as the "new sciences," this article uses the terms *complexity theory* or *complex adaptive systems theory*. Whereas industrial-age Newtonian analysis focuses on classifying targets according to their physical nature, complexity theory allows targeteers to focus on how targets interrelate, particularly in nonphysical ways. Complexity-based targeting emphasizes and exploits the characteristics of complex adaptive systems.

Theory of Complexity-Based Targeting

Two concepts from complexity theory underpin complexity-based targeting: *complexity* and *entropy*. *Complexity* is a measure of the degree to which a system contains large numbers of interacting entities with coherent behavior. Notionally, one can measure complexity from a value of zero to some maximum number. Zero complexity indicates a completely simple system; few entities have either minimal or no interactions. Generally, one can account for the behavior of such a system with a simple set of equations or a short description—for example, contemporary military combat models, replete with attrition equations.[4] *Entropy*, on the other hand, is a measure of the amount of work lost in a system due to destructive forces such as friction or interference. One can measure entropy on a scale from zero to one—zero indicating a completely linear system that loses no work and behaves predictably. Maximum entropy designates a completely chaotic system that loses all work and behaves randomly.

As the number of possible interactions in a system increases, entropy increases—as does the number of coherent behaviors. When the system becomes more complex, predicting specific events becomes more difficult, describing what is occurring in the system takes longer, and making mathematical calculations becomes more involved. Complexity increases to a point that the interacting entities and groups of entities become too numerous and interfere with each other, and the aggregate behavior of the system becomes more random. As interference increases, so does entropy, causing complexity to fall to zero because the system's aggregate behavior becomes simple (i.e., all behaviors can cancel each other out, and one can usefully describe the system at some higher scale in much the same way one can describe the temperature of a gas without listing the temperature of each molecule).

Between the extremes of complete linear simplicity and complete chaotic simplicity lies a wide range of complex systems, including those containing most targets of military significance. Examples include electrical distribution grids, transportation networks, communications architectures, command and control organizations, naval missile exchanges, and ground combat. We call such examples complex adaptive systems because they meet our criterion of having a large number of interacting entities that can adapt to their environment as it changes (fig. 1).[5]

Complex adaptive systems are difficult to defeat because they have many groups of entities with coherent behavior. In a military context, as some entities are attacked, others change their behavior or alter their interactions, allowing the larger system to adapt. For example, if bridges in a road network are destroyed, maneuver forces will find other means—such as alternate routes, temporary bridges, or river fords—to accomplish their mission. Complexity-based targeting seeks to

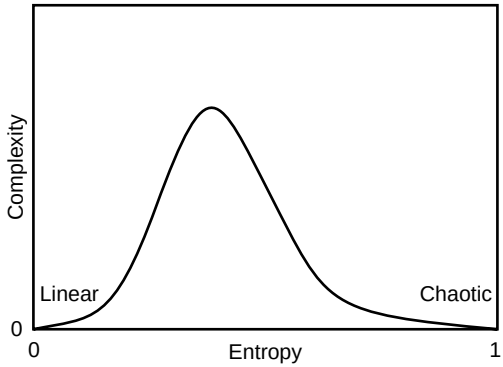


Figure 1. Most Complex Adaptive Systems

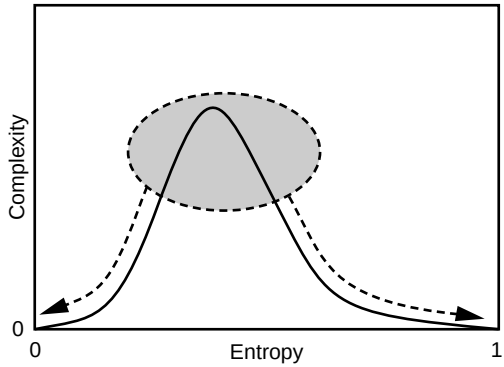


Figure 2. Driving a System into Lockout or Chaos

prevent a complex adaptive system from using its attributes and mechanisms in response to an attack.

One can prevent a system from adapting by taking away options or by removing its internal structure and coherence. The former drives the system toward linearity, where it becomes predictable, allowing one to identify the viable options and "lock them out." The latter drives the system toward chaos (another form of lockout), where systems experience cascades of functional failure (fig. 2). Importantly, one may achieve both of these effects without using lethal kinetic force.

Comparison of Contemporary and Complexity-Based Targeting

Contemporary targeting philosophies do not exploit the complex adaptive nature of systems. Targets in, say, a transportation network tend to be physical (table 1). Because military forces do not target the adaptive properties and mechanisms inherent in the system, they must employ brute force to drive this system into lockout or chaos. Without such an effort, the system will continue to adapt and survive. Complexity-based targeting, however, focuses

Table 1

Contemporary Transportation Targets

Rail	*Sea*	*Road*	*Air*
Tracks	Ports	Bridges	Runways
Switching Stations	Handling Systems	Intersections	Hangars and Equipment
Freight Yards	Fueling Equipment	Primary Roads	Fueling Capacity
Trains	Ships	Secondary Roads	Airplanes
Trestles	Docks	Vehicles	Revetments

not only on the physical elements, but also on the adaptive mechanisms and properties of complex adaptive systems (table 2). Thus, one may envision a transportation network as a complexity-based target set (table 3).

Historically, success in attacking physical targets (table 1) has generally depended on tremendous destructive effort, usually entailing a vast tonnage of munitions or costly precision ordnance. Even if one destroys half the targets in such a system, it likely will remain functional if the adaptive properties and mechanisms survive:

- A rail system can reroute traffic around destroyed tracks, repair sections of damaged rail, or even transfer freight from boxcars to trucks.
- If a shipping system loses piers and container-handling gear, ships can use alternate ports, or crews can use bulk methods of transferring cargo. If ships are sunk, traffic can shift to safer sea lines of communications.
- If a road network loses bridges or major roadways, materiel and troops can still take alternate routes or dismount. In the event of wholesale destruction of vehicles, surface traffic can move at night or intersperse with civilian traffic.
- If an air system is completely destroyed, commodities can travel via surface, rail, or road. If main runways are damaged, airplanes can land on freeway segments or dirt fields.

Even though one may hit each system simultaneously, clever people can find new ways of working around the damage until the destruction is nearly total. However, absolute destruction of a country's infrastructure, particularly in a conflict of less scope than a major theater war, can cause even greater problems postbellum. Destroying the ability of the system to adapt without pummeling an enemy requires different information about system behavior than that produced by most existing methods of target analysis.

Table 2

Classification of Complexity-Based Targets

Property	*Mechanism*
Grouping	Similar elements of the system join together for a specific function.
Membership and Identification	Groups stay together and function because they have affinities and because they can distinguish themselves from other groups.
Nonlinearity	Levers and feedback govern the system's dynamics; manipulating them causes cascading effects.
Rule Sets	Such sets determine the behavior of groups.
Networks and Flows	Groups move throughout the system and are subject to feedback and interaction.
Competition	Groups compete with each other as they interact. Competition can be either constructive or destructive.
Building Blocks	Each group can become part of a larger group, creating significant interlocking structures in the system.

Source: John H. Holland, *Hidden Order: How Adaptation Builds Complexity* (New York: Perseus Printers, 1996).

Table 3

Complexity-Based Transportation Targets

Grouping	*Membership and Identification*	*Nonlinearity*	*Rule Sets*	*Networks and Flows*	*Competition*	*Building Blocks*
Vehicles	Mile Markers	Intermodal Interruption	Rail Schedules	Rail Network	Container v. Bulk	Radio, Radar
Containers	Boxcar ID	Power-Grid Blackout	Approach Patterns	Port Operations	Bridges v. Ferries	People
Companies	Call Signs	Weather	Rules of the Road	Interstate Road System	Trucks v. Trains	Wheels, Tracks
Shipping Lines	Vessel Flags	Traffic Jams	Traffic Lights	Bridges	Commodity v. Retrograde	Vehicle Types
Yards, Ports	Road Signs	Commodity Flow	Commodity Requisitions	Off-Ramps		Transportation Subnets
Channels	Runway Markers			Fuel Stations		Engines
Routes	Tactical Air Navigation/ Identification, Friend or Foe					Fuel
Warehouses						

Complexity-based targeting offers a different perspective on the target system or systems by focusing on the interrelationship of elements with the larger system. One devotes particular attention to those properties and mechanisms that account for coherent behavior in the system. This type of targeting provides a longer list of targets than contemporary targeting methods (compare tables 1 and 3) but does not necessarily mandate more effort. In fact, complexity-based targeting provides more information about the behavior of the entire target system, allowing one to more reliably identify and more logically derive the desired effects. In addition, one can coordinate kinetic, nonkinetic, and IW methods across the target set—a more economical approach than the current "stovepiped" application of these means. To produce a complexity-based target set (such as the one in table 3), one must

- identify different coherent groups in the system, including their contributions to the proper functioning of the entire network;
- discover methods by which elements can identify, and therefore interact with, the various parts of the system (these are particularly rich targets for IW);
- determine nonlinearities such as choke points, failure thresholds, and cascading effects;
- define and analyze basic rules by which the system functions (these too are rich targets for IW attack);
- examine the direction, rate, and alternate paths of system flows (in addition to physical network components, information flows, knowledge flows, people flows, etc.);

- determine methods for creating interference between groups (rich targets for IW attack); and
- identify basic building blocks, including the extent to which they create interlocking structures and nested loops of activity.

Because one targets the adaptation properties and mechanisms, simultaneous attack across each of the seven categories (table 3) will prove more effective in preventing system recovery than a high-volume, rapid attack on just the physical components of a system. Moreover, the fact that an enemy must defend in seven dimensions, rather than in only the physical dimension, significantly complicates his task. Once again, complexity-based targeting focuses on and exploits the complexity of an enemy's system to drive it into either lockout or chaos.

Conclusions

Historically, targeting philosophies have reflected a mechanistic, industrial-age mindset, but complexity-based targeting utilizes a more holistic, systems-oriented approach. In particular, it identifies the information that each element needs to function in a system with other elements. As a result, complexity-based targeting unifies kinetic and nonkinetic methods of attack, proves significantly more effective because of its close coupling of targets to desired effects, and successfully disables a system without destroying every physical target. Such a method provides more useful, systemic knowledge of a target set and uses that knowledge to lock out most of an enemy's courses of action or rout that enemy by transforming coherent behavior into chaos and confusion. □

Notes

1. For a critique of industrial-web targeting concepts, see Maj Steven M. Rinaldi, "Beyond the Industrial Web: Economic Synergies and Targeting Methodologies" (thesis, School of Advanced Airpower Studies, Maxwell AFB, Ala., June 1994).

2. David A. Deptula, *Firing for Effect: Change in the Nature of Warfare* (Arlington, Va.: Aerospace Education Foundation, 24 August 1995), 2. The term *parallel warfare* was coined by the Air Force Directorate of Warfighting Concepts Development (AF/XOXW). The concepts themselves were based on the ideas of Col John A. Warden III, USAF, retired. See his article "The Enemy as a System," *Airpower Journal* 9, no. 1 (spring 1995): 41–55.

3. John F. Schmitt, "Command and (out of) Control: The Military Implications of Complexity Theory," *Marine Corps Gazette* 82, no. 9 (September 1998): 55–58; Tom Czerwinski, *Coping with the Bounds: Speculations on Nonlinearity in Military Affairs* (Washington, D.C.: National Defense University, 1998); Alan Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," *International Security* 17, no. 3 (winter 1992–1993): 59–90; and Rinaldi.

4. Indeed, historically, combat models have been poor descriptors of combat because the latter is often much more complex than the simple equations suggest. Still, these simple models abound.

5. James P. Crutchfield and Karl Young, "Computation at the Onset of Chaos," in *Complexity, Entropy and the Physics of Information*, ed. Wojciech H. Zurek (New York: Addison-Wesley Publishing Company, 1990), 8: 224–27.

More than 3 million square miles of territory to protect; 10,000 miles of border to guard; and a fence to build 10, 11, or 12 miles high. . . . It is better to have less thunder in the mouth and more lightning in the hand.

—Gen Ben Chidlaw, Commander
US Continental Air Defense Command, 1954

Attack Operations

First Layer of an Integrated Missile Defense

LT COL MERRICK E. KRAUSE, USAF*

Editorial Abstract: US forces have a long history of conducting attack operations. The proliferation of theater and long-range ballistic missiles suggests that the concept should be adapted to support missile-defense operations. To do so, we must include missile-defense capabilities in air and space expeditionary force packages, mature technology and doctrine to accommodate such capabilities, and connect Air Force capabilities to joint doctrine and employment concepts. Colonel Krause argues that, although current structures contain pieces of the puzzle, we must fully integrate those pieces within an overall theater missile-defense architecture that includes offensive capabilities.

The gravest danger to freedom lies at the crossroads of radicalism and technology. When the spread of chemical and biological and nuclear weapons, along with ballistic missile technology—when that occurs, even weak states and small groups could attain a catastrophic power to strike great nations. Our enemies have declared this very intention, and have been caught seeking these terrible weapons. They want the capability to blackmail the U.S., or to harm the U.S., or to harm our friends—and we will oppose them with all our power.

—President George W. Bush
West Point, New York
1 June 2002

TO MANY AIRMEN, "Attack!" is the nature of the business. Air Force operations and perhaps even Air Force culture are historically geared toward the offensive application of air and space power to execute combat operations in war. However, the joint community—particularly those members engaged in high-priority missile-defense programs—perceives "attack operations" differently. This article introduces the concept of attack operations in the context of missile defense and similar time-sensitive targets,

*The views in this article are the author's and do not reflect those of either the Joint Staff or the Office of the Chairman of the Joint Chiefs of Staff.

asserting that such operations provide the critical first layer of an integrated missile defense. It also presents key themes, issues, and proposals to increase the capabilities of integrated missile defense.

Attack Operations: A Critical Capability

In a joint environment, attack operations are essentially offensive actions that seek to destroy or disrupt enemy missile systems and support structures, preferably before missiles are fired.[1] Aircraft, special operations forces (SOF), information operations, or uninhabited aerial vehicles can perform attack operations *today*. Although they represent both a joint capability and a multiservice "organize, train, and equip" issue, attack operations are one mission with which the Air Force has considerable practical experience, particularly in the realm of time-sensitive targeting and threats intended to limit US access to a region.

The United States has a long history of conducting attack operations. In World War II, Operation Crossbow attempted to destroy German V-1 and V-2 missile sites, which were terrorizing the British through disruptive and deadly attacks on cities. Between August 1943 and March 1945, the US Army Air Forces and Royal Air Force flew 68,913 sorties and expended 122,133 tons of ordnance in the campaign to destroy German missiles.[2] Indeed, Crossbow was a large-scale counterair and strategic-attack operation that expended substantial effort to delay V-weapon attacks and then limit their effectiveness once Germany began to employ the missiles.[3]

Although the Cold War produced intercontinental ballistic missiles (ICBM) and a variety of specialized missile-defense systems, theater ballistic missiles (TBM) captured the imagination of third world nations as a relatively cheap supplement to bolster both their status and their anemic air forces. Deterrence by a robust American nuclear capability was the counter to the Soviet ICBM threat.[4] Because of the Cold War legacy, however, US missile-defense systems were divided between theater and intercontinental systems, with testing and deployment of the latter severely restricted by provisions in the Antiballistic Missile (ABM) Treaty with the Soviet Union.

The 1991 Persian Gulf War radically increased the priority of TBMs in US national security policy. Once regarded by many military leaders as a tactical nuisance, especially when armed with conventional high explosives, TBMs suddenly became weapons of terror that could cause significant political and diplomatic problems. Although Iraq did not use weapons of mass destruction (WMD) in the 1991 war, when Iraq fired conventionally equipped Scud missiles against Israel, it created a political crisis for the coalition.[5] Moreover, a single conventionally armed Scud produced the greatest number of US fatalities of any single event during Operation Desert Storm when it struck a barracks in Dhahran, Saudi Arabia.

During the Persian Gulf War, hundreds of sorties and thousands of man-hours were devoted to countering the Scud threat. Some people suggest that the resources used against Scuds could have been employed to attack other targets, perhaps ending the war more rapidly. Undoubtedly, "Scud hunts" diverted some of the coalition's military resources; however, the utility of the Scud hunts may be better measured more in political than purely military terms. The experience of Desert Storm helped shape how the United States is now actively investing to better defend against missile threats in the future. These threats include ICBMs and cruise missiles, as well as other theater air and missile systems.

The *Quadrennial Defense Review (QDR)* of September 2001, published in the shadow of the al Qaeda terrorist attacks of 11 September 2001, recognized a changing international strategic environment affected by missile and WMD proliferation. The *QDR* articulated the need for transformational change in the US military.[6] One important directive stated that the Department of Defense (DOD) would examine options for establishing standing joint task forces to address the capability to "continuously locate and track mobile targets at any range and rapidly attack them with preci-

sion."[7] The *QDR* also noted that the continued proliferation of ballistic and cruise missiles is a threat to "U.S. forces abroad, at sea, and in space, and to U.S. allies and friends."[8] Therefore, the *QDR* refocused US missile defense toward research and deployment of a layered system of systems to defend forward-deployed troops and allies threatened by theater missiles and to provide a "limited defense" against long-range missiles for the US homeland.[9]

DOD has spent billions of dollars developing systems to defeat ballistic missiles.[10] Although programs of the individual services frequently overlap, several DOD organizations, including the Missile Defense Agency (MDA) and Joint Air and Missile Defense Organization (JTAMDO), use the concept of an integrated "family of systems" to defeat ballistic missiles.[11] Significantly, on 13 June 2002, the United States officially withdrew from the ABM Treaty, thus enabling expanded testing and deployment of a missile-defense system for the US homeland. That same year, Secretary of Defense Donald H. Rumsfeld directed MDA to develop a single, integrated ballistic-missile-defense system—one that would no longer differentiate between theater and national missile defense.[12]

Integrated capabilities are important because some individuals contend that soon every southern European capital will be within range of ballistic missiles based in North Africa or the Levant (including Syria, Iraq, and Iran).[13] In a military sense, the threat in the Mediterranean region has shifted dramatically as the focus in Europe changed "from the Fulda Gap to the South."[14] Many allies, including the particularly vulnerable southern European countries such as Portugal, Spain, Italy, Turkey, and Greece, lack the ability to defend successfully against missile strikes or to deter WMDs. The United States will face a radically different European security problem if Madrid, Rome, or Athens are at risk to missile attack and if some allies are deterred from joining it in a coalition.[15]

This problem of susceptibility to missile and WMD attacks is not confined to Europe. North Korean threats to Japan and Guam, as well as the persistent and increasing threat of cruise missiles or missiles operated from ships near US coasts, are also near-term concerns. The *National Security Strategy* of 2002 enunciates these threats and presents a US strategy for countering them:

> We must be prepared to stop rogue states and their terrorist clients before they are able to threaten or use weapons of mass destruction against the United States and our allies and friends. Our response must take full advantage of strengthened alliances, the establishment of new partnerships with former adversaries, innovation in the use of military forces, modern technologies, including the development of an effective missile defense system, and increased emphasis on intelligence collection and analysis.[16]

Doctrine

The historical legacy of attacks conducted by the Army Air Forces during Operation Crossbow is evident in Joint Publication (JP) 3-01.5, *Doctrine for Joint Theater Missile Defense*, which defines four operational elements of theater missile defense: passive defense; active defense; attack operations; and command, control, communications, computers, and intelligence (C^4I). Passive defense involves efforts to minimize the effects of theater missile attacks, while active defense includes operations that destroy enemy missile "airborne launch platforms" or missiles in flight. Attack operations seek to "destroy, disrupt, or neutralize theater missile launch platforms and their supporting structures and systems." Finally, the purpose of C^4I is to coordinate and integrate these efforts.[17] Based on DOD's new, multilayered approach and the removal of theater and national divisions from both missile-defense systems and philosophy, this joint publication needs substantial revision.

Although the multilayered, integrated missile-defense concept presents a more holistic view of the missile threat, historically different philosophies toward missile defenses provide a source of conflict. For example, the Air Force argues (as do some air arms of other services and nations) that airpower is best employed offensively. But today, active missile defenses and

investments tend to focus on surface-based systems, which are reactive weapons by nature. Interestingly, JP 3-01, *Joint Doctrine for Countering Air and Missile Threats*, states that "air superiority is achieved through the counterair mission, which integrates both offensive and defensive operations from all components to counter the air and missile threat."[18] Similarly, Army Field Manual (FM) 3-0, *Operations*, recognizes that in large campaigns, offensive and defensive actions occur simultaneously and that defense should be aggressive.[19] Yet, the weight of effort for missile defense typically is geared toward the reactive phase of the engagement.

Offensive counterair (OCA), an obvious amalgam of attack-operations missions, represents the freedom *from* attack and the freedom *to* attack. This concept is based on the Air Force proposition that "air and space forces are inherently offensive and yield the best effect when so employed."[20] When the Airborne Laser (ABL) destroys ascending enemy missiles, it provides defensive counterair and is thus a second layer of defense. Midcourse, terminal, and passive defenses are much deeper layers. This contrasts with using SOF or fighter-bombers first to destroy ballistic missile launchers (OCA) or missile-supply depots (interdiction/strategic attack).[21] The joint term *attack operations* overlaps several US Air Force and other joint doctrinal mission areas. JP 3.01 agrees, stating that, with regard to missiles and support infrastructure, "OCA operations are most effective when conducted against theater missiles before launch. The preemptive destruction of missiles, launch facilities, storage facilities, and other support infrastructure greatly limits subsequent [theater missile] attacks. OCA assets may also be rapidly retasked to destroy time-sensitive targets such as mobile launchers."[22]

An unresolved conundrum derived from this doctrinal ambiguity is that joint doctrine considers attack operations offensive and proactive, but also defensive and reactive. This situation could become more complicated when the new Strategic Command takes functional control of an integrated missile defense; but, contemporaneously, a joint force air component commander (JFACC) and regional commander have different antiaccess, preemption, contingency, or daily air tasking order priorities for limited or multirole assets.

The problems of allocation, command relationships, and use of resources—not yet resolved—are exacerbated when an adversary possesses a variety of long- and medium-range missiles. JTAMDO is moving forward with an integrated missile-defense concept of operations, now in the coordination stage, to attempt to address some of these concerns. However, the entire missile-defense layered system and command relationships to control all of the affected subsystems are evolving and will continue to develop as the new Strategic Command and Northern Command emerge.

Integrated Missile Defense

MDA's system of integrated missile defense consists of terminal, midcourse, and boost segments (fig. 1). The agency does not currently advertise a segment geared to attacking missiles and missile-support assets *before* the boost phase.

Terminal Segment

The terminal segment consists of several weapon systems.[23] These include the Patriot, Medium Extended Air Defense System (MEADS), Arrow, Theater High Altitude Area Defense (THAAD), and a sea-based system.

Patriot. The Patriot Advanced Capability (PAC-3) is an upgraded version of the weapon used during the Persian Gulf War. It is a point-defense weapon that has some ability to defend against cruise missiles, aircraft, and TBMs in their terminal phase of flight. Although the PAC-3 can be airlifted, it is cumbersome and thus a relatively stationary system. It is the most mature of MDA's theater missile-defense systems and is considered America's current premier lower-tier TBM defense system.

An essential feature of the PAC-3 is its "hit-to-kill" capability, which is consistent with MDA's emphasis on using hit-to-kill systems against WMDs.[24] Yet, a concern with the PAC-3, as with

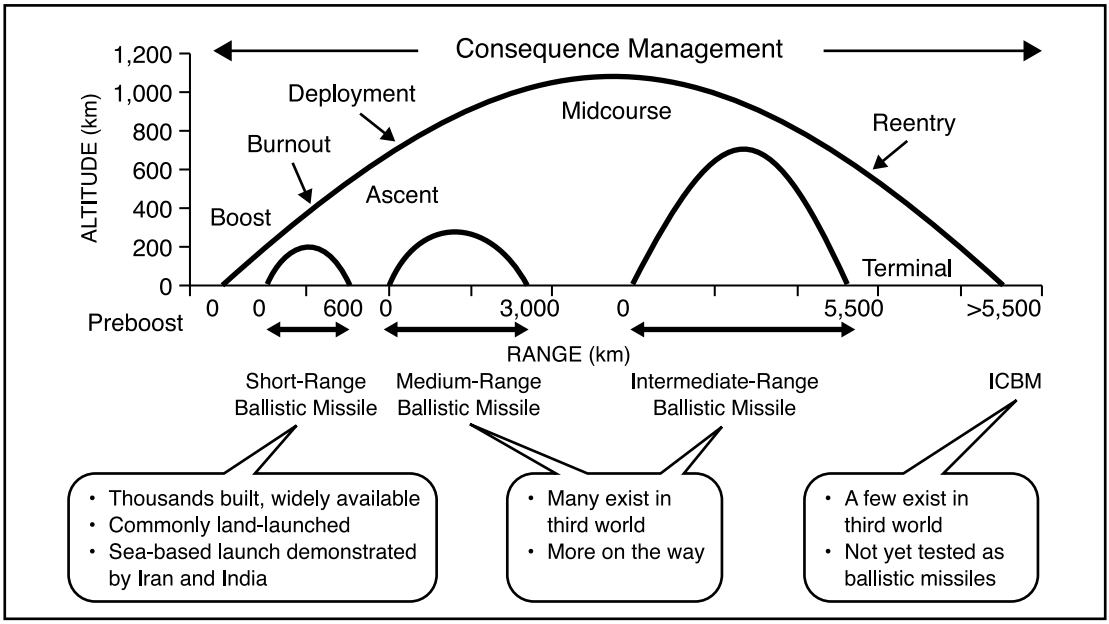


Figure 1. An Integrated, Layered Defense against Missiles of All Ranges (Unclassified) (Adapted from briefing, Defense Science Board, subject: Integrated Missile Defense, 13 October 2002)

all terminal systems, is the risk of debris falling on friendlies following a successful terminal-stage missile interception.

MEADS. The United States has pursued this mobile, lower-tier program on a cooperative basis with Germany and Italy.[25] Planned to reduce the risks to Army and Marine Corps operations, "MEADS will improve tactical mobility and strategic deployability over comparable missile systems and provide robust, 360-degree protection for maneuvering forces and other critical forward-deployed assets against short- and medium-range missiles."[26] It is intended to bridge the gap between handheld man-portable systems, such as the Stinger, and less mobile systems, such as the PAC-3. MEADS will be a multicanister vertical-launch system mounted on a wheeled vehicle.[27] In fiscal year 2003, MEADS will continue design-development activities for system components, including the addition of the capability to integrate the PAC-3 missile with the MEADS system.[28]

Arrow. This joint US-Israeli missile-defense system will be able to operate with US theater missile-defense systems in order "to assist in the protection of forward deployed U.S. and Coalition forces."[29] The Arrow engages enemy missiles at a higher altitude than does the PAC-3, thus providing a better safety margin, particularly for missiles with WMD warheads.[30] The Israeli Ministry of Defense received its first Arrow missile in November 1998.[31] Continuing this partnering effort, operational since October 2000, will support Israeli acquisition of a third Arrow battery and promote interoperability with US missile-defense systems and battle-management command and control (C^2).[32]

THAAD. MDA has categorized THAAD as an upper-tier terminal-defense-segment system because the intercept is planned to occur in the terminal phase of the missile's trajectory, yet on the edge of the atmosphere. As a ground-based, high-altitude weapon system, THAAD will use exoatmospheric and endoatmospheric hit-to-kill interceptors to destroy missiles. The goal of the THAAD system is to destroy incoming medium- and short-range ballistic

missiles far enough from friendly troops or population centers so that the debris is no danger to the intended target.[33] MDA expects fielding in 2007 or 2008.[34] Essentially, THAAD is the most mature upper-tier system, but it is also a terminal-segment system.

Sea-Based Terminal System. In the wake of the cancellation of the Navy Area terminal-defense missile in December 2001, DOD directed MDA to initiate a soon-to-be-completed sea-based terminal study.[35] The Navy continues to have a requirement for a sea-based system and argues that seaborne missile defenses are less expensive because they use current platforms and thereby reduce the demand for airlift and sea lift.[36] The first unit equipped was targeted for fiscal year 2007; however, the results of the 2002 sea-based terminal study will determine new programmatics.[37]

Midcourse Segment

The midcourse segment consists of both ground-based and sea-based systems.

Ground-Based Midcourse System. A successor to the National Missile Defense System, the Ground-Based Midcourse System has as its objectives "1) to develop and demonstrate an integrated system capable of countering known and expected threats; 2) to provide an integrated test bed . . . [and] 3) to create a development path allowing for an early capability based on success in testing."[38] Not intended to be mobile, it will begin with a test bed in Alaska, followed by selective deployments for homeland defense as the system matures.

Sea-Based Midcourse System. The successor to Navy Theater Wide is the Sea-Based Midcourse System, which will intercept enemy ballistic missiles in the ascent phase of midcourse flight. Its emphasis is on the exoatmospheric ascent phase for intercept.[39] Designed to intercept medium-range and long-range ballistic missiles, this system is expected to have a contingency capability in 2004 or 2005, with initial operational capability in the 2008–10 time frame.[40]

Boost Segment

The boost segment includes the ABL, Space-Based Laser (SBL), and kinetic-energy concepts.[41]

Airborne Laser. The primary boost-phase program for theater missile defense is the Air Force's ABL program, which had its maiden flight on 18 July 2002.[42] If the testing schedule is executed, the initial operational capability of the ABL will occur in 2009, with seven aircraft available for combat operations in 2011.[43] Since future generations of TBMs could release multiple warheads and launch large volleys of theater missiles, the laser's boost-phase destruction is designed to provide ascent-phase defenses against ballistic missiles and to deter adversaries because their warheads could fall back on their own territory.

Space-Based Laser. The SBL may provide both missile-defense and space-superiority capabilities although MDA sees it principally as contributing to defense in the boost phase, as well as serving as a potential deterrent. MDA is focusing on design validation and hopes to fly an on-orbit experiment to exhibit a lethal demonstration of SBL technologies by 2012.[44]

Kinetic-Energy Concepts. MDA plans to produce experiments in the 2003–6 time frame, using kinetic-kill concepts for destroying enemy missiles shortly after launch.[45] The goal is a kinetic-boost-phase defense capability in the 2006–10 period, using either a sea-based or space-based platform. Possibly, testing may lead to an operational, sea-based, kinetic-energy interceptor by 2006.[46]

Attack Operations

The main objective of missile-defense attack operations is to prevent the missiles from being used "against U.S. forces, U.S. allies, and other important countries, including areas of vital interest."[47] Attack operations can also contribute to preventing future attacks by destroying launchers after firing but before reuse. Attack operations are a joint capability but one in which the US Air Force has considerable experience, particularly through the C^2 functions resident in the joint air operations center

(JAOC), as well as platforms, sensors, navigation (Global Positioning System), and weapons.

Attack operations are executed through the sensor-to-shooter loop, which finds, fixes, tracks, targets, engages, and assesses mobile and fixed missile systems and equipment, and through "strategic targets," such as factories. In addition, interdiction targets, storage sites for enemy missile and WMD storage/maintenance sites, fixed and mobile C^2 nodes, and supply lines would be subject to attack, as would prelaunch and postlaunch theater-missile sites.[48] Mobile and fleeting opportunities for attack make time-sensitive target strikes integral to attack operations.

Inherent in the concept of attack operations is effects-based operations theory, which involves selecting targets whose destruction would have specific effects that result in second- or third-order levels of disruption, resulting in "control" of an adversary leader's decision-making process, as opposed to traditional goals of attrition or annihilation.[49] Attack operations may not eliminate the missile threat, but they will reduce the threat posed by missiles and WMDs, as well as reduce the options an adversary may employ.

SOFs are also quite relevant to attack operations.[50] Such forces rely on the ability to insert personnel covertly, but they also typically integrate with the C^2 system. With miniaturization and advances in communications technology, SOF attack operations will be improved by using more capable battle-management systems, while faster or stealthier insertion methods would improve SOF capabilities. Furthermore, special-operations activities, when well coordinated with air and space power, create a synergy that makes attack operations more effective.

C^2 and Sensors

MDA considers sensor suites and battlefield-management C^2 the "backbone" of the ballistic missile-defense system and plans to develop these capabilities in parallel with other missile-defense systems to better integrate systems and equipment—including sensors, interceptors, and tactical-control centers—into a joint, layered missile-defense architecture.

Linking sensors to C^2 is critical to the effective execution of attack operations or time-sensitive targeting. Integrating experiments build upon lessons learned in regional air operations centers, including Operations Desert Storm, Northern and Southern Watch, Allied Force, and Enduring Freedom. Among other important tasks, Joint Expeditionary Force Experiment 2002 tested new management and retasking of intelligence, surveillance, and reconnaissance (ISR) sensors, the new Boeing 707 Paul Revere test bed, and the integrated JAOC at Nellis Air Force Base, Nevada.[51] The JAOC gathers information from many sources, condenses the data into "a constantly updated picture that is fine-grained enough to find small, important moving targets in minutes and rationally assign the resources at hand to monitor and strike them."[52] This is an example of a joint effort that builds upon Air Force experience and directly affects attack operations and time-sensitive target capabilities.[53]

The sensor segment includes a variety of research-and-development projects to enhance ballistic-missile detection, midcourse tracking, and discrimination through two primary projects: space sensors and international cooperation.[54] However, multiuse sensors will have the capability for early warning, intelligence, and C^2 for the spectrum of operations from attack operations to terminal-phase missile defense. Technological advances are effectively reducing the time between when a sensor detects a missile and the time that a weapon can destroy that missile by increasing C^2 and sensor capabilities.

Near-Term Missile-Defense Gap

The integrated missile-defense system will lack several key components over the next few years. As a result, the United States faces a near-term *gap* in its capabilities, particularly in theater missile defense during the boost and midcourse phases and in ICBM defense throughout the flight envelope.[55] This gap translates to increased risk and increased vulnerability of US forces, allies, and interests. Such a reality makes preemptive and persistent attack

operations proportionally more critical to bolstering overall near-term US missile-defense and antiaccess capabilities.[56]

The antiaccess threat is noteworthy, given the deployment and operational limitations and risk of debris impacts associated with current point-defense systems, such as the Patriot. The emerging Air Force concept of a global strike task force and other spearhead force conceptions address this threat. At the same time, significant ISR capability is essential for locating missile launchers, C^2 nodes, and support equipment.[57] Indeed, significant equities may be realized through joint participation, and JAOC time-sensitive target experience provides a proven model for attack-operations execution.

Many commanders and senior military officers recognize the value of attack operations, particularly with regard to improved C^2 and the destruction of time-sensitive targets. Attack operations, however, represent an under-advertised capability, which implies that future funding will be limited in comparison with the core activities of MDA. That agency currently does not emphasize attack operations in a prelaunch segment, and no significant breadth of joint or Air Force doctrine specifically emphasizes integrated attack operations.

As with other incarnations of defense against air threats, the metaphor that hitting the eggs in the nest is better than throwing stones at flying birds remains relevant. Furthermore, improving C^2, as well as sensors, makes attack operations more effective than in World War II or Desert Storm. Given growing concern over ballistic-missile attacks, WMDs, and the limited ability of point defensive systems to protect targets, attack operations have become increasingly important. Thus, it is imperative to improve the ability of attack operations with additional training and funding to respond to operational demands.

Proposals

This article proposes three options for improving missile defenses, thus addressing some potential near-term antiaccess threats. First, the Air Force should establish a standing capability within its air and space expeditionary force (AEF) for conducting attack operations and time-sensitive targeting. This capability would serve multiple purposes, including operations against ballistic missiles, cruise missiles, mobile targets, and WMDs, as well as time-sensitive missions and other strike efforts. This approach builds on assets that are capable of conducting multiple missions but requires additional training, equipment, or further specialization to provide effective, reliable options.[58]

An antiaccess task force or a standing capability within existing AEF units would provide a model or perhaps an operational experiment with this concept. For example, tasking specific Air Force Guard and Reserve units for attack-operations missions would give those units a primary or secondary responsibility for conducting attack operations during training and combat. Furthermore, training as part of an AEF, a multirole force (perhaps in coordination with the emerging global strike task force concept), tailored and trained for attack operations/time-sensitive targets, would give commanders a significant standing operational capability. This might be accomplished by emphasizing training and systems required to conduct time-sensitive targeting for certain squadrons. Before becoming an operational capability, these units could exercise their capabilities through a training program and incorporate as a small part of a Red Flag or other exercise venue. Such a tailored AEF concept would not conflict with either current Air Force doctrine or joint publications. Finally, training and maintaining units within the AEF structure would be possible by assigning squadrons a time-sensitive-targeting/attack-operations secondary mission in their wing's mission statements, similar to combat search and rescue or AGM-130 operations.[59]

An additional benefit to an organic attack-operations/time-sensitive-target capability is that expeditionary units trained specifically for these missions may have sufficient offensive credibility to deter states from exposing or employing missiles. However, the capability would have to be communicated to adversaries in order to have a deterrent or dissuasive effect.

Its operational value would rest upon its rapid-response capability, flexible deterrent capability, and ability to destroy missiles and WMDs on the enemy's side of the border. Moreover, effectively and precisely destroying missiles armed with WMD warheads could limit collateral damage.

As F/A-22s become operational, US spearhead force capabilities will improve, but a threat to forward-based (land or sea) forces from enemy missiles will still exist. The global strike task force concept will provide a capability to mitigate the initial antiaccess missile threat by using long-range and stealthy precision attack to suppress initial missile threats. The F/A-22 will be extremely valuable in an attack-operations role as part of a spearhead force performing counterair missions, including attack operations. It will permit daylight, precision, stealthy strikes in conjunction with significant ISR assets throughout a time-phased deployment.

Second, the Air Force can improve how it conducts attack operations in the near term by advancing attack operations, time-sensitive targeting, C^2, ISR capabilities, and Air Force doctrine. A principal reason that Air Force philosophy exceeds joint doctrine is that attack operations overlap numerous missions imbedded in Air Force doctrine. In addition, the Air Force has considerable experience with attack operations, time-sensitive targeting, and the fusion of surveillance and reconnaissance data through an air operations center, as well as using C^2 and disparate platforms and weapons in offensive action. Unfortunately, numerous offices on several staffs contribute to the attack-operations/time-sensitive-targeting picture, which may create difficulties in coordinating a unified message to present to JTAMDO and MDA in programming and doctrine deliberations.

In view of DOD's determination to create effective, multilayered missile defenses to counter WMDs, a logical step for the Air Force is to focus on improving attack operations, including time-sensitive-targeting equipment, procedures, and training. More investment in C^2, time-sensitive targeting, and the development of air operations centers will further the effectiveness of attack operations and thus provide a better first layer of missile defense. Attack operations should also be integrated and defined, just as its doctrinal theory should be more definitively stated in core Air Force doctrine documents. This effort may provide weight to arguments that MDA should provide additional funding for Air Force–sponsored efforts in joint-attack operations.

Finally, joint doctrine should consistently reflect the fact that attack operations are offensive missions, although they may be executed in the context of a proactive defense. The central concept should be that missile defense—or antimissile/counter-WMD missions—include offensive, defensive, and C^2 activities, all of which have implications for interdiction and strategic attack. Clearly, attack operations are not strictly a "defensive" activity. In fact, the decision to attack enemy assets in enemy territory is an inherently offensive operation, and in the case of WMDs, attack operations leverage both deterrence and destruction.[60]

Attack operations require joint-doctrinal consistency. Joint doctrine states that the joint force commander (JFC) will typically select the JFACC to direct attack operations, as well as support other component commanders in their attack-operations efforts.[61] Resource allocation and target-selection priority must be negotiated in a joint environment, weighing long-range threats to the US homeland and allies with threats to friendly fielded forces or population centers. Phasing is also a consideration, particularly the determination of what weight of effort attack operations will take in each phase and how that is coordinated with point missile-defense systems, such as the Patriot; it also includes the balancing of limited allocations of area defenses, such as the ABL or ground-based midcourse. These factors, the command relationships that occur when a missile threat spans regional commanders' areas of responsibility, defense of the United States, and WMDs indicate that changes to joint doctrine are merited.

Conclusion

The proliferation of ballistic missiles, antiaccess threats, and WMDs creates new operational and technological challenges for the United States. In the multilayered missile-defense paradigm, attack operations provide an essential first layer of missile defense. A joint attack-operations capability, backed by a long history of airpower experience with the mission, provides an effective means to reduce an enemy's capabilities through a measured, offensive campaign to remove ballistic and cruise missiles, long-range threats to the US homeland, and other antiaccess and time-sensitive targets. In this strategic and technological environment, efforts made today will enhance the ability of US forces to conduct increasingly more effective attack operations. Furthermore, contemporary, joint organizational changes open a window of opportunity to revisit doctrinal issues worth discussing. If properly fostered, attack operations and time-sensitive-targeting capabilities will yield an improved ability to project joint military power while simultaneously protecting US troops, allies, and the American homeland—thus denying future enemies sanctuary or the leverage provided by WMDs and missile-delivery systems. □

Notes

1. Joint Publication (JP) 3-01.5, *Doctrine for Joint Theater Missile Defense,* 22 February 1996. According to this publication,

> attack operations are characterized by **offensive actions intended to destroy and disrupt enemy TM** [theater missile] **capabilities before, during, and after launch.** The objective of attack operations is to **prevent the launch of TMs by attacking each element of the overall system,** including such actions as destroying launch platforms, RSTA [reconnaissance, surveillance, and target acquisition] platforms, C^2 [command and control] nodes, and missile stocks and infrastructure. Attack operations also strive to deny or disrupt employment of additional TMs that may be available to the enemy. **The preferred method of countering enemy TM operations is to attack and destroy or disrupt TMs prior to their launch** (emphasis in original) (III-10).

2. *United States Strategic Bombing Survey,* vol. 60 (Washington, D.C.: Military Analysis Division, 1945), 26–27.

3. Ibid., 4.

4. In particular, the "second strike" capability was an effective deterrent to the Soviet Union.

5. The Scud is a TBM, initially of Soviet origin, that has proliferated to third world nations as a relatively inexpensive terror weapon. The Scud is capable of delivering WMDs.

6. *Quadrennial Defense Review Report* (Washington, D.C.: Department of Defense, 30 September 2001), 18.

7. Ibid., 34.

8. Ibid., 42.

9. Ibid.

10. Ballistic Missile Defense Organization, "Ballistic Missile Defense Organization Funding," 2001 Submit, on-line, Internet, 14 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/html. Although there are multiple sources for the specific funds spent on missile-defense systems, studies, and research programs, this source summarizes specific Ballistic Missile Defense Organization projects in terms of procurement, research and development, and military construction.

11. The term *family of systems* is used by the Ballistic Missile Defense Organization, forerunner of MDA, to describe the multilayered architecture of planned missile-defense systems. *Multilayered* implies more than a single defense system—perhaps defense systems that are effective in different phases of the missile's flight. Before 2002, JTAMDO was known as the Joint Theater Air and Missile Defense Organization.

12. Missile Defense Agency, MDA*link,* "The Ballistic Missile Defense System," on-line, Internet, 13 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/html/system.html.

13. Ian O. Lesser and Ashley J. Tellis, *Strategic Exposure: Proliferation around the Mediterranean* (Santa Monica, Calif.: RAND Corporation, June 1996), x.

14. Lt Gen Richard C. Bethurem, interviewed by author, 23 February 1998.

15. Lesser and Tellis, x, 27, 32.

16. President George W. Bush, *The National Security Strategy of the United States of America,* on-line, Internet, 20 September 2002, available from http://www.whitehouse.gov/nsc.

17. JP 3-01.5, viii, I-3.

18. JP 3-01, *Joint Doctrine for Countering Air and Missile Threats,* 19 October 1999, I-2.

19. FM 3-0, *Operations,* 14 June 2001. "The purpose of defensive operations is to defeat enemy attacks. Defending forces await the attacker's blow and defeat the attack by successfully deflecting it" (par. 8-2). "Successful defenses are aggressive; they use direct, indirect, and air-delivered fires; information operations (IO); and ground maneuver to strike the enemy. They maximize firepower, protection, and maneuver to defeat enemy forces. Static and mobile elements combine to deprive the enemy of the initiative. The defender resists and contains the enemy. Defending commanders seek every opportunity to transition to the offensive" (par. 8-5).

20. Air Force Doctrine Document (AFDD) 1, *Air Force Basic Doctrine,* September 1997, 46.

21. Ibid., 46–51.

22. JP 3-01, IV-2.

23. MDA refers to the systems it manages that would provide defense against missiles during the terminal phase as the "Terminal Defense Segment." The Ballistic Missile Defense Organization (BMDO) previously discussed most of these systems as lower-tier systems (the Theater High Altitude Area Defense System is considered an upper-tier terminal-segment system).

24. US Senate, Lt Gen Lester L. Lyles, director, BMDO, "Opening Remarks," *Congressional Testimony before the Subcommittee on Strategic Forces Committee on Armed Services,* 24 March 1998.

25. William S. Cohen, *Annual Report to the President and Congress* (Washington, D.C.: Government Printing Office, 1998), 64.

26. Missile Defense Agency, MDA*link*, "Terminal Defense Segment," on-line, Internet, 27 January 2003, available from http://www.acq.osd.mil/bmdo/bmdolink/html/terminal.html.

27. Missile Defense Agency, fact sheet, "Medium Extended Air Defense System," January 2002, on-line, Internet, 14 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/pdf/meads.pdf.

28. Lt Gen Ronald T. Kadish, "The Missile Defense Program," FY 03 Budget Hearings, 16, on-line, Internet, 14 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/pdf/budget03.pdf.

29. Cohen, 65.

30. Michael R. Gordon, "Israel Set to Use New Missile Shield to Counter Scuds," *New York Times*, on-line, Internet, 6 October 2002, available from http://www.nytimes.com/2002/10/06/international/middleeast/06MISS.html.

31. For statements compiled from multiple news services, see "For the Record," *Washington Post*, 30 November 1998, A20.

32. Missile Defense Agency, MDA*link*, "Terminal Defense Segment."

33. Missile Defense Agency, fact sheet, "Theater High Altitude Area Defense (THAAD)," January 2002, on-line, Internet, 14 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/pdf/thaad.pdf.

34. Ballistic Missile Defense Organization, fact sheet 204-00-01, November 2000, on-line, Internet, 13 December 2001, available from http://www.acq.osd.mil/bmdo/bmdolink/html. See also Missile Defense Agency, fact sheet, "Theater High Altitude Area Defense (THAAD)."

35. Kadish, 15–16. See also Hunter Keeter, "Service Officials: Navy Terminal-Phase Missile Defense Remains a Requirement," *Defense Daily International*, Potomac, 25 January 2002. The US Navy canceled the point-defense Navy Area Program on 14 December 2001 but retained the Navy Theater Wide Program under the direction of the newly reorganized MDA. The Navy Theater Wide Program is evolving into the "sea-based midcourse" system, which will be part of the new layered-defense concept currently promoted by MDA. See also Philip Sen and Richard Scott, "Pentagon Cancels Navy Area TBMD," *Signals*, Jane's Navy International, 1 March 2002, on-line, Internet, 12 February 2002, available from http://www.janes.com.

36. BMDO, fact sheet 97-18, *Navy Area Ballistic Missile Defense Program*, July 1997.

37. Robert Snyder, "Ballistic Missile Defense Organization Press Release: FY01 President's Budget," 4 February 2000, on-line, Internet, 12 December 2001, available from http://www.acq.osd.mil/bmdo/bmdolink/pdf/bmdopress.pdf.

38. Missile Defense Agency, MDA*link*, "Midcourse Defense Segment," on-line, Internet, 13 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/html/midcrse.html.

39. Missile Defense Agency, fact sheet, "Sea-Based Midcourse," January 2002, on-line, Internet, 13 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/pdf/seabased.pdf. "The Sea-based Midcourse Defense (SMD) element . . . will provide the capability for U.S. Navy Aegis surface combatants to utilize hit to kill technology to destroy or negate Medium Range to Inter-Continental Ballistic Missiles (ICBM) in the midcourse phase of the exoatmospheric battlespace."

40. Timing for operational capability was initially taken from the National Institute of Public Policy "frequently asked questions" Web site, on-line, Internet, 13 December 2001, available from http://www.nipp.org/Adobe/laymans%20guide%20adobe/No.%2013.pdf. These times were further revised as of January 2002. See MDA fact sheet, "Sea-Based Midcourse."

41. MDA refers to the systems it manages that would provide defense against missiles during the boost phase as the "Boost Defense Segment" (BDS). MDA lists four objectives for the BDS: (1) demonstrate and deploy the Airborne Laser, (2) define and evolve space-based and sea-based kinetic-energy Boost Phase Intercept (BPI) concepts with a development decision in 2003–5, (3) execute a "proof-of-concept Space-Based Interceptor Experiment," and (4) continue Space-Based Laser for a proof-of-concept in 2012. See Missile Defense Agency, MDA*link*, "Boost Defense Segment," on-line, Internet, 14 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/html/boost.html.

42. Kenneth Englade, "Airborne Laser Completes First Flight," DE Release no. 2002-27, 18 July 2002, on-line, Internet, available from http://www.acq.osd.mil/bmdo/bmdolink/html/abl.html.

43. Missile Defense Agency, fact sheet, "Airborne Laser," January 2002. It should be noted, however, that the ABL program office estimates initial operational capability two years earlier, in 2007, with full operational capability in 2009. Further, after the demonstrations in 2004, residual operational capability will be left behind, enabling the deployment of the test bed for operational purposes, if required. See the ABL program home page, on-line, Internet, 21 March 2002, available from http://www.airborne laser.com.

44. Missile Defense Agency, fact sheet, "Space Based Laser (SBL)," January 2002, on-line, Internet, 13 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/pdf/sbl.pdf.

45. Missile Defense Agency, MDA*link*, "Boost Defense Segment."

46. Missile Defense Agency, fact sheet, "Kinetic Energy," January 2002, on-line, Internet, 13 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/pdf/kinetic.pdf.

47. Archived briefing, XORFS, "USAF Roadmap for Theater Missile Defense Attack Operations," presented 27 July 1997 (unclassified extract dated 5 February 1998). For further information, please consult the Counterair (Theater Missile Defense) Mission Area Plan, FY 1996, 15 November 1995. Obviously, attack operations would be important for suppression and destruction of intercontinental ballistic and other missiles. This sentiment is aligned with the current national security strategy.

48. Briefing, Maj Brad Butz, AF XORFX and SAF AQPT, "USAF Attack Operations," for Lt Gen Lester L. Lyles, 9 February 1998.

49. Maj Gen David A. Deptula, *Firing for Effect: Change in the Nature of Warfare* (Arlington, Va.: Aerospace Education Foundation, 24 August 1995), 11–18.

50. Special operations forces are not discussed in depth in this article. Nevertheless, they definitely provide attack-operations capabilities, both in conjunction with direct conventional air and space power attacks and as an additional intelligence-gathering source.

51. David A. Fulghum, "Paul Revere Designers Critique New Configuration," *Aviation Week and Space Technology*, 23 September 2002, 52–53. See also idem, "USAF Streamlines Air Operations Center," *Aviation Week and Space Technology*, 23 September 2002, 53–55.

52. Fulghum, "USAF Streamlines Air Operations Center," 53.

53. Fulghum, "Paul Revere Designers," 53. Lt Gen William T. Hobbins, commander, Twelfth Air Force, was quoted as saying that the Paul Revere Multisensor Command and Control Aircraft was "meant to replicate the execution piece of the Joint Air Operations Center."

54. Missile Defense Agency, fact sheet, "Sensors," January 2002, on-line, Internet, 14 March 2002, available from http://www.acq.osd.mil/bmdo/bmdolink/pdf/sensors.pdf.

55. Pat Towell, "Bush's Missile Defense Plan Harks Back to Father's 'Layered' Approach," *Congressional Quarterly Weekly*, 16 March 2002, 718. "Nearly $2 billion of the fiscal 2003 request is for systems designed to protect relatively small areas by striking enemy warheads in the 'terminal' phase of flight—as they near their targets. . . . All the systems currently funded are designed to deal with shorter range—and slower—missiles, such as the Scuds."

56. Preemption, in this case, refers to the time before missiles have been employed but could also mean the time before a second salvo. This article does not enter the debate over preemptive use of military force or proactive defensive measures through attacks—although attack operations certainly can accomplish preemptive strikes against missiles and WMDs.

57. C^2 (and sensors) also provide warning for passive defense measures and point defense through the PAC-2 or -3.

58. The AEF Battlelab at Mountain Home AFB, Idaho, could address the organizational issues and configuration decisions facing attack-operations missions in order to refine this concept.

59. The AGM-130 is a guided bomb, steered in flight through a data link by a weapon-systems officer. Experienced F-15E crews are usually asked to perform AGM-130 missions due to their complexity.

60. According to AFDD 1, antimissile attack operations may be more like suppression of enemy air defenses (SEAD) than defensive counterair. As noted in the XORFS attack-operations road map, "Because air and space forces are inherently offensive and yield the best effect when so employed, **OCA is often the most effective and efficient method for achieving the appropriate degree of air superiority.** *This function consists of operations to destroy, neutralize, disrupt, or limit enemy air and missile power as close to its source as possible and at a time and place of our choosing* [emphasis in original]. . . . The aircraft and missile threat may include fixed- and rotary-wing attack aircraft, reconnaissance aircraft, unmanned aerial vehicles, air-, land-, and sea-launched *cruise missiles, ballistic missiles* [emphasis added], and air-to-surface missiles" (46–47). Gen Ronald R. Fogleman noted that attack operations are offensive because

> pre-emptive precision strikes against point targets and application of denial weapons will greatly hinder near-term enemy TBM activity. Meanwhile, lethal precision attacks against the TBM support tail will undercut the enemy's ability to sustain long-term ballistic missile operations. . . . If the enemy succeeds in launching a mobile TBM, detection of the launch event will key our attack operations. We will capitalize on the inputs from overhead and surface sensors, special operations forces, JSTARS, AWACS, Rivet Joint aircraft, U-2s and unmanned aerial vehicles—uninhabited aerial vehicles. Those inputs will identify the launch point and cue Air Force and other service assets for time-critical strikes on the enemy TEL.

See Fogleman, "The Air Force Role in Theater Ballistic Missile Defense," remarks delivered to the American Defense Preparedness Association / National University Foundation Breakfast Seminar Series on Missile Defense, Counter Proliferation, and Arms Control, Washington, D.C., 16 June 1995.

61. According to JP 3-01.5,

> the joint force air component commander (JFACC) plans for the theater / joint operations area-wide attack operations effort. The JFACC is also responsible for executing attack operations outside other components' areas of operations (AOs). Component commanders are normally designated as supported commanders for attack operations inside their AOs [sidebar]. **The JFC will normally assign responsibility for the planning and execution of JTMD attack operations outside the other component commanders' AOs to the JFACC.** Since the location of these AOs may change with the maneuver of forces or with changes in JFC guidance, **the JFACC should also plan for and maintain visibility on the theater / joint operations area (JOA)-wide attack operations effort.** This will ensure the JFACC is prepared to support the other component commanders when, for example, they request JFACC support in conducting JTMD attack operations within their AOs. **Inside their AOs, component commanders are normally designated as supported commanders for attack operations** (emphasis in original) (xi).

See also JP 3-01, II-1: Joint publications affirm that the JFACC is "normally the supported commander for counterair."

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Command and Control Doctrine for Combat Support

Strategic- and Operational-Level Concepts for Supporting the Air and Space Expeditionary Force

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Editorial Abstract: Air and space power planning processes have improved over the past decade to provide a more efficient joint capability to joint force commanders. These improvements have caused service and joint doctrine to evolve and communicate how best to employ air and space power. The authors argue that combat support (CS) doctrine has not achieved that same clarity. Instead, better integration of CS and operations planning and command and control (C2) represents a doctrinal growth area that should receive our focus as we transform the Air Force into an expeditionary, capability-based force. Approaching CS doctrine from the same campaign-based planning mind-set as force employment offers the key to eliminating the ad hoc and inefficient nature of sustaining and supporting Air Force combat power.

NEW COMMAND AND control (C2) concepts have played a key role in helping to guide the evolution and development of recent Air Force (AF) expeditionary concepts and capabilities. Doctrine has kept pace with these changes and helped shape some of the new policies, technologies, and approaches to planning. Some concepts have stood the test of time, such as acting decisively within the enemy observe, orient, decide, and act (OODA) loop, and are found in doctrine that is routinely used to guide air campaign planning activities.[1] Other concepts that have found their way into C2

doctrine include strategic campaign planning and the operational strategies-to-task framework.[2] Even more recently, the concept of effects-based operations has taken hold in campaign planning and execution.[3] While doctrine continues to evolve and enable air-and-space-expeditionary-force (AEF) projection, more work is needed, specifically in the area of combat support (CS), where improved integration of CS capabilities and C2 of critical resources can better enable campaign planning and proactive decision making.

Joint and AF doctrine defines C2 as the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. Specifically, C2 includes the battlespace-management process of planning, directing, coordinating, and controlling forces and operations (OPS). Enabling a commander to exercise C2 across the range of military operations involves the integration of systems, procedures, organizational structures, personnel, equipment, information, and communications.[4]

Unfortunately, C2 doctrine for CS is not fully developed. For instance, C2 of CS is minimally addressed in Air Force Doctrine Document (AFDD) 2, *Organization and Employment of Aerospace Power,* and AFDD 2-4, *Combat Support.* As a result, procedures for integrating CS considerations into operations-planning processes are not understood by large segments of operations and CS personnel. During recent conflicts, combatant commanders have employed ad hoc approaches to cobble together CS operational and administrative chains of command, processes, and procedures during contingency operations. This ad hoc approach delays the establishment of CS C2 organizations like the Air Force Forces (AFFOR) Logistics Directorate (A-4) and confuses the alignment of roles and responsibilities between other CS organizations such as the Air Force Combat Support Center (CSC) and the CS functional staffs of the commands providing forces. This delay and confusion results in campaign plans being developed with minimal CS inputs. The time it takes to follow the ad hoc approach to establish and accomplish CS functions and the differing approaches that result in each contingency operation are not consistent with AEF goals. This article offers suggestions for the development of CS C2 doctrine and discusses how it can improve AF campaign planning and execution.

Important additions to CS doctrinal concepts include relating CS process performance, resource levels, and constraints to operationally meaningful measures and capabilities; establishing CS control parameters and closed-loop reporting on CS process performance with indicators of potential system failures that could impact mission goals; and identifying what CS organizations will conduct specific C2 functions. Changes such as these will strengthen the capability of the AF C2 system in terms of the underlying C2 principles and tenets described in AFDD 2-8, *Command and Control.*[5] For example, relating CS process performance and inventory levels to operational capability will enable commanders to understand the impact CS decisions might have on war-fighting capability, thereby providing an environment for more informed decision making.

Defining Doctrine

The evolution of CS doctrine has been slowed by a lack of understanding about doctrine and its purpose. In 1995, during the early development stages of AFDD 2-4, working groups contended with defining CS doctrine and struggled over the balance between simplicity and completeness, determining the target audience, and ownership of content.[6] The environment for codifying CS principles into doctrine has not significantly changed. Oftentimes, the relationship between doctrine, concept of operations (CONOPS), instructions, policies, procedures, and techniques is not clearly defined or understood. To address this, we begin with a definition of doctrine and a short discussion on the relationship between doctrine and other formal AF publications.

AFDD 1, *Air Force Basic Doctrine,* provides the following definition of doctrine:

> Air and space doctrine is a statement of officially sanctioned beliefs and war-fighting principles that describe and guide the proper use of air and space forces in military operations. Doctrine prepares us for future uncertainties and, combined with our basic shared core values, provides a common set of understanding on which airmen base their decisions. Doctrine consists of the fundamental principles by which military forces guide their actions in support of the nation's objectives.[7]

AFDD 1 goes on to describe the various levels of doctrine.

> **Basic doctrine** states the most fundamental and enduring beliefs that describe and guide the proper use of air and space forces in military actions. . . . Because of its fundamental and enduring character, basic doctrine provides broad and continuing guidance on how Air Force forces are organized and employed.
>
> **Operational doctrine,** contained in AFDD 2 series publications, describes more detailed organization of air and space forces and applies the principles of basic doctrine to military actions. Operational doctrine guides the proper employment of air and space forces in the context of distinct objectives, force capabilities, broad functional areas and operational environments.
>
> **Tactical doctrine** describes the proper employment of specific weapons systems individually or in concert with other weapons systems to accomplish detailed objectives. . . . Tactical doctrine is codified in Air Force Tactics, Techniques, and Procedures (AFTTP) 3-series manuals.[8]

Doctrine is designed to provide a set of principles to guide the further development of policy, instructions, procedures, and techniques. Each level of doctrine should guide thoughts, actions, and decisions of those charged with execution. For example, many CS decisions are concerned with the allocation of resources. Oftentimes, allocation decisions must be made when competition for limited critical resources exists. In this example, operational-level CS doctrine should provide guidelines for how those decisions should be made. For example, allocation of critical resources will be made based on an operations impact analysis that considers campaign objectives and Joint Staff–directed priorities. Associated tactical-level doctrine should delineate the process by which operations-impact analysis is accomplished. Following our example, a unit's demand for resources will be submitted to the AFFOR A-4 and include statements of operations impact. AFFOR A-4 staff(s) will review the request, validate impact statements, and make allocation decisions when competing demands are between two or more organizations over which they have operational control. Otherwise, the request and associated impact statements will be forwarded to the Air Staff Combat Support Center.

Doctrine for CS is contained in AFDD 2-4, which "outlines the Air Force perspective on how best to rapidly deploy and support operational aerospace capabilities."[9] While it addresses the need for a capability to command and control CS resources, it fails to address how the core principles of C2 (e.g., unity of command, centralized control—decentralized execution, and informed decision making) apply in the context of CS. Best practices, such as the creation of an AFFOR A-4 rear-echelon function to execute CS reach-back responsibilities, were proven effective in Operation Desert Storm, Operation Noble Anvil, and Operation Enduring Freedom, but have not been codified in doctrine.

AFDD 2-4 fails to give CS personnel a framework in which to think about the art and science of providing CS. In this absence, AFDD 2-4 does not point us in the direction of ensuring CS planning is accomplished as an integral part of the air campaign plan, master air attack plan (MAAP), airspace control plan (ACP), and air tasking order (ATO) development—rather, current doctrine continues our current "reactive" method vice an integrated, proactive method.

Developing Doctrine for Command and Control of Combat Support

The concepts for C2 of CS relate directly to the mission needs associated with being an expeditionary force. Those needs and their

correlating CS C2 requirements are identified in table 1.

Based upon the CS C2 requirements listed below and previous analyses of best practices, we developed concepts that could serve as a basis for modifying Air Force doctrine. The C2 capability envisioned should

- enable the CS community to quickly estimate CS requirements for force-package options and assess the feasibility of operational and support plans,
- quickly determine beddown capabilities, facilitate rapid force planning and flow development, and configure a distribution network to meet employment timelines and resupply needs,
- facilitate execution resupply planning and monitor performance,
- determine impacts of allocating scarce resources to various combatant commanders, and
- indicate when CS performance deviates from desired state and implement get-well plans.[10]

Concepts for Future Doctrine—Principles of C2 for CS

At the strategic and operational levels, doctrine for C2 relates core principles to guide CS actions and decisions. The principles identified here represent a fundamental shift in the way CS is viewed, employed, and controlled, both to the CS community internally and to the consumers of CS resources externally.

C2 of CS is accomplished through a fundamental process that integrates operations and CS planning in a closed-loop environment, providing feedback on performance and resources. Figure 1 illustrates the elements of this process, which can be applied through all phases of an operation from readiness, through deployment, employment, and sustainment, as well as redeployment and reconstitution. It centers on integrated operations and CS planning and incorporates activities for continually monitoring performance and dynamically making adjustments.[11]

Some elements of the process, in the large box in figure 1, are accomplished in planning for operations. It is in this box that operations and CS personnel must share a common vocabulary. The measures of effectiveness by which the plan can be assessed must be developed and understood by both operations and CS planners. Certainly, the integrated

Table 1

CS C2 Functionality Required to Meet Expeditionary Operational Goals

Expeditionary Mission Need	*CS C2 Requirements*
Rapidly tailor force packages to achieve desired operational effects	• Estimate CS requirements for suitable force-package options; assess feasibility of alternative operational and support plans
Deploy rapidly	• Determine forward operating location beddown capabilities for force packages and facilitate rapid force planning and flow development
Employ quickly	• Configure distribution network rapidly to meet employment timelines and resupply needs
Shift to sustainment smoothly	• Execute resupply plans and monitor performance
Allocate scarce resources to where they are needed most	• Determine impacts of resource shortage on users with competing requirements; prioritize and allocate scarce resources to users
Adapt to changes quickly	• Indicate when CS performance deviates from desired state and implement get-well plans

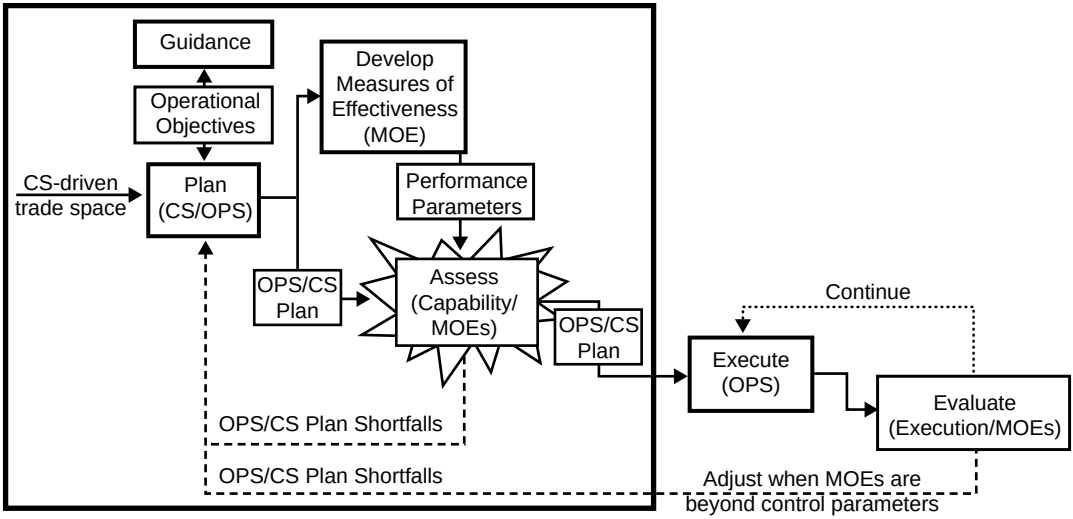

Figure 1. CS C2 Concept Process

plan they develop should be feasible from the CS standpoint. However, CS inputs should not only make it supportable, but they should seek the most efficient and effective approach for accomplishing the campaign plan. When a plan is executed, all elements of the process above are accomplished. A key element of the process template during planning and execution is the feedback loop that monitors how well the system is expected to perform (during planning) or is performing (during execution). That performance is compared to the predetermined measures of effectiveness and provides warning of potential system failures.[12] It is this feedback loop that enables the CS plan and infrastructure to be reconfigured as necessary to meet dynamic operational requirements during both planning and execution.

Planning for employment of CS must be effects-based and operationally relevant. For the CS system to provide timely feedback to the operators, it must be tightly coupled with operations planning and execution processes. Feedback to operations planners should be in the form of options that will provide the same or better operational effect yet cost less in CS terms.

The transition to effects-based operations reflects a desire to be more effective in the employment of air and space power and a need to be more efficient in the use of resources. According to Maj Gen David A. Deptula, effects-based operations are replacing annihilation and attrition as determinants of success. In previous conflicts where annihilation and attrition determined success, CS resources were critical.[13] With effects-based operations, where airpower is employed deliberately and orchestrated to achieve specific and precise target kills, CS must be tailored and strategically employed to enable the desired operational effects. Rather than stockpiling available munitions at forward operating locations and distributing aircraft parts based on a replacement-in-kind basis, munitions and parts must be allocated with the objectives of ensuring that specific weapons systems are mission capable and certain high-demand, low-density munitions are available when needed for a critical mission.

To enable effects-based operations, CS must be applied using effects-based principles. In the past, CS planning was reactive, taking an operations plan and deriving CS tasks to execute the plan. This approach often resulted in an unnecessary agglomeration of CS resources to assure success or a delayed determination

that logistics constraints rendered the operation plan unfeasible. In the current environment of constrained resources and frequent quick-response operations, neither of these planning results is acceptable. It is no longer sufficient to let CS inputs to operational planning be limited to statements of available inventories (e.g., numbers of bombs, gallons of fuel, available transportation, etc.). Rather than simply list available resources, CS planning must describe how resources will be configured, allocated, and used to accomplish mission objectives. Using the closed-loop process defined in figure 1, CS capabilities must be integrated with operations and translated to operational output throughout the entire planning process. Figure 2 examines this concept in relation to the operations planning cycle for employment of air and space forces.[14]

The planning activities reflected in figure 2 occur across the spectrum of operations. During day-to-day operations, planning supports

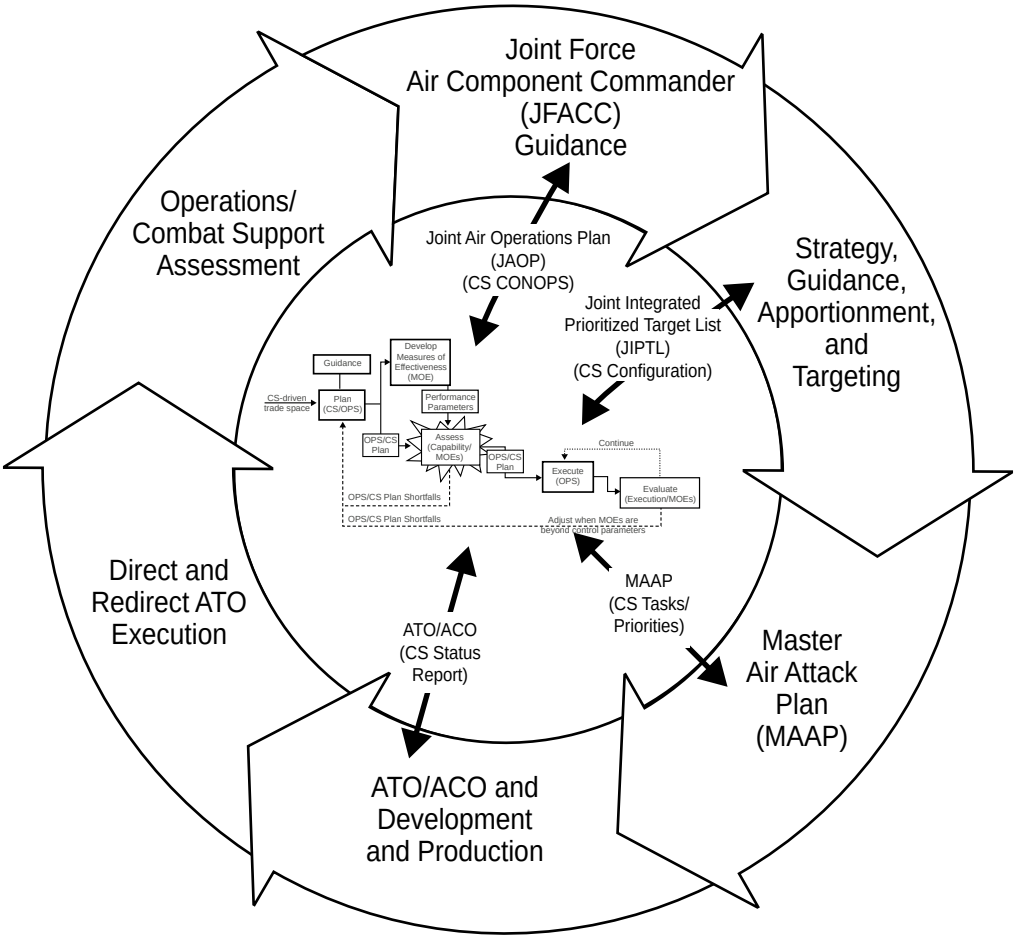

Figure 2. Operations/CS Integrated Planning (From James A. Leftwich et al., *Supporting Expeditionary Aerospace Forces: An Operational Architecture for Combat Support Execution Planning and Control,* RAND Report MR-1536-AF [Santa Monica, Calif.: RAND, 2002])

programmed flying hours to achieve training objectives and prepare for combat. Planning products are flying schedules and air campaign plans for the operators, and for CS, depot maintenance repair plans, spares allocation plans, and war reserve materiel distribution to support the flying program and air campaign plans. On the installation support side, planning products center on infrastructure operation and maintenance, utility operations, and personnel service activities like billeting and dining. During wartime or contingency operations, combat execution is prepared in the crisis action planning process, with similar products and plans produced in a time-compressed environment. For both peacetime and wartime planning, the focus of CS should be production of installation support and sorties.

From readiness through redeployment and reconstitution, the core process remains the same, but individual information flows vary, and plans and assessments become more refined through each phase. For example, theater- and unit-capability assessments are first accomplished in peacetime and then continue to be constantly performed. The assessment results feed the budgeting and planning processes to allocate funds to programs and redistribute other resources as required for the AF to fulfill its *Defense Planning Guidance* responsibilities. In this example, the assessment results are at a global level and will be used to make strategic resource-allocation decisions. As a world situation develops, the relationship between CS and OPS capabilities feeds into the crisis action planning process and contributes to the development of a suitable course of action (COA). Based on new information (e.g., refined operations requirements, known threats, better-known theater capabilities), assessments are reaccomplished, the CS plan is refined, and infrastructure configured as necessary to support a new COA. As a result of the COA and these CS configuration actions, the relationship of CS capabilities to operations capabilities is again refined to feed into the development of the joint air operations plan (JAOP), MAAP, and eventually the ATO. The assessment capabilities and feedback loop enable iterative planning with operations.

Control of the CS battle space will be accomplished proactively to enable robust and efficient support for operations alternatives. As with the operations community, CS personnel must be able to quickly recognize, shape, and control their battle space. The CS battle space is multidimensional. As seen in figure 3, it exists within the air operations center; at beddown locations, continental United States (CONUS) support locations (CSL), forward support locations (FSL), and depots; and within the distribution network. Once combat operations commence, the CS battle space must be regulated to ensure continued support for dynamic operations. The C2 system controlling the CS battle space must monitor actual CS performance against planned performance. The performance parameters and measures of effectiveness established during execution planning should provide advance warning of potential system failure. When CS performance diverges from the desired level (because of changes in CS performance or operational objectives), the system must be able to detect the change, modify the original plan, develop a get-well plan, and reassess the modified plan's feasibility. As discussed earlier, plan feasibility is assessed continuously and iteratively until it is determined that the modified plan will be able to support the operation. Operations-focused metrics of CS capabilities can provide warning of a pending inability to meet operational requirements. Key decision measures, such as the mission cost of CS performance shortfalls and CS cost of accomplishing mission objectives, should provide analysis to support operations/CS trade-off decisions. The analytical ability to look ahead must address the long-range impact of near-term decisions from both an operations and a CS perspective. As the system monitors the performance of key CS demand indicators, it must recognize and notify decision makers when those indicators and CS measures are beyond planned thresholds and then facilitate the necessary planning to get well. When early warning of an impending failure to support operational requirements

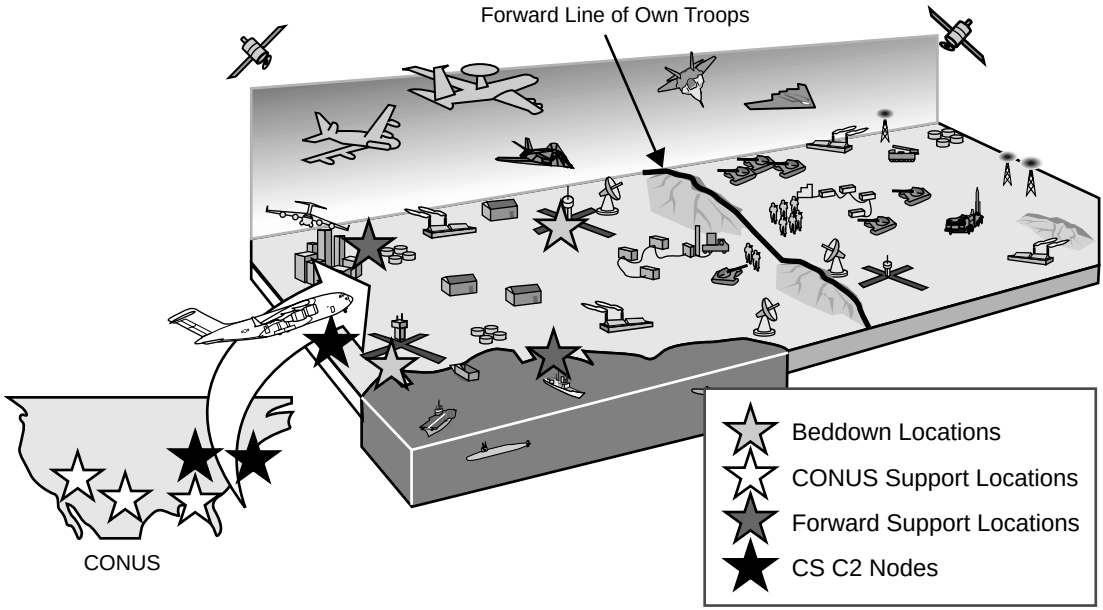

Figure 3. The Combat Support Battle Space

is received, the system should be able to drill down to the element or infrastructure component that is contributing to the general failure. While the CS battle space is being monitored at the higher level against key operational measures, the lower levels are monitoring the performance of component processes against the planning parameters and thresholds established during execution planning.

Concepts for Future Doctrine—Organizing to Command and Control Combat Support

To improve the performance of the existing process and make the necessary changes to implement the fundamental concepts and principles described above, modifications must be made to organizational responsibilities. Just as the principles for C2 of CS must be codified in doctrine, so too must the policy, training, and organizational architecture that will enable and execute CS C2. Gen John P. Jumper, Air Force chief of staff, put it simply:

> Just as important to the expeditionary culture is the fundamental understanding that we organize, deploy, and employ using organizational principles based on doctrine, not ad hoc command arrangements. . . . In most cases we don't even notice doctrinal negligence because our airmen are such superb operators—we'll get the job done even in a lousy organization. We need to fix this for them. . . . Write it down and publish it.[15]

The following concepts can guide future doctrine development on C2 organizational responsibilities for CS.

The alignment of C2 responsibilities must be clearly defined and assigned to standard CS nodes. Table 2 reflects the roles and responsibilities of the organizational nodes in an organizational template for CS.[16]

This node template is a key element of the C2 operational architecture for CS. Specific organizations will be designated to fulfill the

Table 2

Combat Support's Command and Control Nodes and Responsibilities

CS C2 Node	*Roles and Responsibilities*
Air Force	
Air Force Combat Support Center	• Monitor operations • Represent Air Force CS interest to Joint Staff
Global Integration Center (GIC)	• Perform integrated weapon-system assessments • Assess or provide critical resource supply/demand arbitration across AFFORs
AFFOR	
Air Operations Center (AOC) CS Element	• Provide JAOP/MAAP/ATO production support
AFFOR A-4 Staff	• Perform site surveys and beddown planning • Act as liaison with AOC CS Element
Operations Support Center (OSC) (Theater or Regional)	• Perform mission/sortie capability assessments • Provide beddown/infrastructure assessment • Provide or assess Air and Space Expeditionary Task Force (AETF) force-structure support requirements • Provide supply/demand arbitration within AETF among AEFs/bases • Monitor theater distribution requirements planning • Perform force-closure analysis • Liaison with air mobility division in AOC • Act as liaison with theater US Transportation Command (USTRANSCOM) node
Deployed Units	
Wing Operations Center (WOC)	• Disseminate unit tasking • Report unit status
CSC	• Monitor and report performance and inventory status
Supporting Commands (Force and Sustainment Providers)	
Logistics Readiness Center/CSC	• Monitor unit deployments • Allocate resources to resolve deploying unit shortfalls
Deploying Units	
WOC	• Report unit status • Disseminate unit tasking
Deployment Control Center (DCC)	• Plan and execute wing deployment • Report status of deployment
Commodity Inventory Control Points (ICP)	
Munitions; Spares; Petroleum, Oils, and Lubricants; Bare-Base Equipment; Rations; Medical Materiel; etc.	• Monitor resource levels • Perform depot/contractor capability assessments • Work with the GIC to allocate resources according to theater and global priorities
Sources of Supply (Depots, Commercial Suppliers, etc.)	
Command Centers	• Monitor production, performance, and report capacity

responsibilities of each of the nodes. The template allows for variations in organization assignments by theater, while retaining standard "grouped" responsibilities. It may serve as a guide to configure the C2 infrastructure that is based on the current requirements. Along with the template, having standing CS C2 nodes that operate in both peacetime and wartime can also ease the transition from daily to higher-intensity operations and allow us to train the way we intend to fight.

Standing organizations will execute CS C2. In the past, organization structures were established and responsibilities assigned at the start of a conflict. Responding globally to continuing threats places new demands on CS C2. First, continuing operations tempo is such that organizations seldom completely finish providing support after a contingency operation winds down, but instead, they transfer their focus from one conflict to another. Second, CS resources are continually consumed and reconstituted during and between contingencies. Many times, demands outpace supply, driving reallocation of resources from one theater to another in order to meet the most urgent demand. This requires a streamlined ability to arbitrate, allocate, and relocate these resources across and amongst the competing areas of responsibility (AOR). To accomplish the arbitration function, CS resource assessments and allocation management tasks need to be assigned to permanent organizational nodes dedicated to resource monitoring, prioritization, and reconfiguration. An integration function for all CS resource management will facilitate the incorporation of relevant resource data into capability assessments and raise the visibility and importance of these assessments in the eyes of the operational community.

To coordinate resource-level management, the operations support center (OSC) will act as a regional hub for monitoring, prioritizing, and allocating theater-level CS resources and be responsible for mission support, base infrastructure support, and establishing movement requirements within the theater.[17] The OSC will be the theater integrator for commodities managed by inventory control points (ICP) discussed below. To be effective, the OSC must have complete visibility of theater resources and the authority to reconfigure these resources. It should receive commodity-specific information from commodity inventory managers, perform integrated capability assessments of the base and sortie production, and report those capabilities to the CS personnel supporting air campaign plan/MAAP/ATO production in the AOC. In this role, it will be able to make informed resource-allocation decisions when there are competing demands for resources within the theater. Finally, it must work closely with the joint forces community to assure that resources are allocated in accordance with global priorities. To do this, it must be capable of providing impact analysis to justify demands for critical resources in competition with other theaters. Just as prescribed in AFDD 2-8, the OSC could perform a reach-back function.[18] It could incorporate mission, base infrastructure, and movement capability assessments into operational plans and support the deployed AFFOR A-4 staff during a contingency, which would minimize the number of personnel required to deploy forward. It would also alleviate problems associated with an undermanned numbered air force staff currently trying to perform the functions listed above, in addition to their roles under the unified command structure.

Commodity inventory managers called ICPs should be responsible for the management of supplying needed resources to the major commands (MAJCOM) and deployed forces. This is essential for the management and distribution of critical resources. For example, spares management should be accomplished, along weapon-system lines, by an ICP run by AF Materiel Command (AFMC). This existing AFMC C2 node would operate spares management along the continuum of operations, having immediate access to both the data and analytical tools needed to exercise capability assessments and manage distribution of resources to the MAJCOMs and theaters. The ICP would normally take direction from the OSCs; however, when demand exceeds supply, a neutral integrator at the Air

Force level, called the global integration center (GIC), will provide the necessary direction. The GIC could be a virtual organization with cells at ACC, AMC, and SPACECOM. The spares ICP will be responsible for monitoring resource inventory levels, locations, and movement information, and use these data to assess contractor and depot capabilities to meet throughput requirements. The GIC would conduct weapon-system operational capability assessments and coordinate with the joint community and theater OSCs to prioritize and allocate resources in accordance with theater and global priorities. The integrated assessments can support allocation decisions when multiple theaters are competing for the same resources and can serve as the AF voice to the Joint Staff when arbitration across services is required. In light of the global nature of AEFs and US commitments, other commodities should be considered for management in the same manner.

At both the OSCs and the GIC, individual resource prioritization will be guided by a common set of rules: given a required operational capability, the OSC will calculate the CS resources needed to meet it. When there are multiple ways to achieve the same goals, this will be considered in resource prioritization. Resources will then be assessed and allocated to meet the operational capability requirements set at higher levels (e.g., the JCS, *The National Security Strategy of the United States*, *Defense Planning Guidance*). The allocation of these resources will be based on operational capability, rather than on an individual commodity basis.

Based on these assessments and allocations, the ICPs will direct purchases, repair operations, and the distribution of components and spares; the ICPs will then interface with combatant commanders and the joint community to direct the distribution of resources among theaters and coordinate intertheater airlift. Theater OSCs will provide advice about infrastructure capabilities, needed resources to implement plans, and the consequences of not improving capabilities. Then the theater joint command can prioritize needs and advise the Joint Staff and others of theater capabilities and issues. Ongoing capability assessments generated by the GIC and OSCs will be incorporated into a theater's operational planning processes that are executed by combat support liaisons in the AOC.

This organizational structure and companion processes outlined above offer three important strengths. First, they enable planners to use theater and global priorities and capability estimates (based on operational capability assessments) to allocate resources. This enables a more informed distribution of CS capabilities, allows the movement of resources in a predictive way before requests are made, and reduces the distress of filling emergency requests. Second, this structure considers the complete spectrum of CS resources. Each resource influences operational capability in some way, and hence must be prioritized and allocated in conjunction with the others. By codifying CS capability assessments, capability becomes a commodity, which can be managed like any other, with a single set of decision makers. While this management is ultimately broken down into the movement of individual resources, these resources are not managed individually, but rather in an integrated manner. Third, by establishing nodes to perform designated tasks, this structure is a consistent framework for decision making throughout all phases of operations. Because the standing nodes are devoted to the monitoring, prioritization, and reconfiguration of all CS resources, they are equally capable of addressing long-term weapon-system development considerations, peacetime training, or crisis-action planning and execution.

Although these responsibilities can be performed by different organizations in different theaters, the grouping of the tasks, the information required to complete them, and the products resulting from each task should not change from one theater to the next. Predefining the organizations to perform each task will ensure ownership of tasks, clear lines of communication, and a smoother transition as the level of operations expands and contracts.

Summary

With AEFs the Air Force has fundamentally changed the way it presents forces. However, that creates significant new challenges to the current CS structure. To meet the AEF's stated objectives, the CS community has undertaken the challenge to completely reexamine its current support system. Since the AEF is the "way" the Air Force has structured itself to conduct operations and since doctrine represents the "how," then appropriate CS doctrine must be developed that reflects the expeditionary mind-set and provides the appropriate guidelines. Evolving Air Force doctrine that incorporates the guiding C2 of CS principles highlighted in this article can be the necessary catalyst to enhance CS training, education, information systems, and decision-support tools. That doctrine should emphasize the importance of the C2 for CS, describe the basic objectives, functions, and activities of a CS C2 system, and define organizations to perform these functions and activities.

Once Air Force doctrine has guiding principles in place that describe C2 of CS, current processes can be revised to integrate Air Force CS and operations planning. Resources can then be allocated according to required capabilities and, with the creation of closed-loop planning and execution functions, better and more informed plans can be created. This revised process will enhance combatant command and Joint Staff–level planning.

Existing C2 organizations, each with their well-defined responsibilities, information flows, and clear chains of communication, are best positioned to facilitate CS planning and execution processes. The combination of these guiding principles and organizational structure will ultimately provide the means for effects-based CS. □

Notes

1. John R. Boyd, "A Discourse on Winning and Losing" (unpublished collection of briefing slides, Air University Library Document No. M-U43947, Maxwell AFB, Ala., August 1987).

2. John A. Warden III, *The Air Campaign: Planning for Combat* (Washington, D.C.: National Defense University Press, 1988); and David E. Thaler, *Strategies to Tasks*, RAND Report MR-300-AF (Santa Monica, Calif.: RAND, 1993).

3. Brig Gen David A. Deptula, *Effects-Based Operations: Change in the Nature of Warfare* (Arlington, Va.: Aerospace Education Foundation, 2001), on-line, Internet, 30 January 2003, available from http://www.aef.org/pub/psbook.pdf.

4. Joint Publication 1-02, *DOD Dictionary of Military and Associated Terms*, 12 April 2001, on-line, Internet, 30 January 2003, available from http://www.dtic.mil/doctrine/jel/new_pubs/jp1_02.pdf.

5. AFDD 2-8, *Command and Control*, 2001. This document defines the principles and tenets of C2 as unity of command, centralized control/decentralized execution, and informed decision-making.

6. Lt Col William T. McDaniel Jr., "The Doctrinal Challenge: A Rebirth of Logistics Thought," *Air Force Journal of Logistics*, winter 1986.

7. AFDD 1, *Air Force Basic Doctrine*, 1 September 1997.

8. Ibid.

9. AFDD 2-4, *Combat Support*, 22 November 1999.

10. James A. Leftwich et al., *Supporting Expeditionary Aerospace Forces: An Operational Architecture for Combat Support Execution Planning and Control*, RAND Report MR-1536-AF (Santa Monica, Calif.: RAND, 2002).

11. Elements of these concepts are described in the Air Force C2 CONOPS, vol. 3, and the AFMC C2 CONOPS; Raymond Pyles and Robert S. Tripp, *Measuring and Managing Readiness: The Concept and Design of the Combat Support Capability Management System*, RAND Report N-1840-AF (Santa Monica, Calif.: RAND, 1982); and Leftwich et al.

12. Leftwich et al.

13. Deptula.

14. Air Force Instruction (AFI) 13-1AOC, "Operational Procedures—Air Operations Center," vol. 3, July 2002.

15. Gen John P. Jumper, chief of staff, US Air Force, Chief's Sight Picture, subject: The Culture of Our Air and Space Expeditionary Force and the Value of Air Force Doctrine, 5 August 2002, on-line, Internet, 31 January 2003, available from http://www.af.mil/lib/sight.

16. Leftwich et al.

17. With today's communications and computer technology, it can be argued that analysis cells of the virtual GIC at Air Combat Command, Air Mobility Command, and SPACECOM could assess and provide worldwide support for weapons systems that are combat, strategic lift and tanker, and space related, respectively. This would reduce the responsibilities of the OSCs to providing bed-down support and transportation priorities among sites within the theater. Doctrine currently calls for the combatant commander to take support responsibilities for forces that are chopped to them for operational control. This was not followed during Operation Enduring Freedom, when AMC retained support responsibilities for some KC-10 and KC-135 units. Mission-capable rates for units that were engaged in-theater, but remained under AFMC's support control, were higher than those that were supported by the combatant commander. This doctrine needs to be revisited. We have, however, assigned the assessment and control function to the theater OSC in this article.

18. AFDD 2-8, 31.

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