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Prelaunch Notes

Lt Col Paul D. Berg, USAF, Chief, Professional Journals

ASPJ as a Dominant Cyberspace Operation and Introduction of the Latest *Chronicles Online Journal* Articles

THE MISSION OF the United States Air Force is to deliver sovereign options for the defense of the United States of America and its global interests—to fly and fight in Air, Space, and Cyberspace." This new mission statement retains the service's traditional emphasis on air and space operations, while the new reference to cyberspace reflects the growing importance of the informational domain.

Air and Space Power Journal (*ASPJ*), the professional journal of the United States Air Force, has deep cyberspace roots. Originally known as the *Air University Quarterly Review*, the journal has undergone several name changes over the years. Beginning publication in early 1947, months before the Air Force became a separate service, the journal existed only in printed form until the 1990s, when it established a cyberspace presence by posting new quarterly issues online. To expand their Internet outreach, the journal's staff members soon began scanning and posting back issues online. All of the English issues of *Air and Space Power Journal*, *Aerospace Power Journal*, and *Airpower Journal* dating back to 1987 are available at http://www.airpower.maxwell.af.mil/airchronicles/back.htm. *Air University Review* issues from the late 1960s to early 1987 are available at http://www.airpower.maxwell.af.mil/airchronicles/aureview/aureview.html. Many Spanish and Portuguese *ASPJ* issues published since 1949 are also available online, as are all issues of the Arabic and French *ASPJ*s, which appeared in 2005. Researchers now have instant access to thousands of articles in five languages. Eventually all back issues will be online.

E-mail now helps serve *ASPJ*'s global audience. Free e-mail subscriptions available at http://www.af.mil/subscribe instantly deliver new quarterly issues. The English *ASPJ* e-mail service, launched in 2003, has over 8,000 subscribers. Nearly 2,000 have joined the Spanish e-mail service, begun in 2004, and hundreds have joined the French one, begun in early 2006.

Today, *ASPJ* has an impressive cyberspace presence. The *ASPJ* Web site receives over 1,000,000 hits per month, dominating discourse about airpower and space power on the Internet. Try this simple demonstration: go to http://www.google.com, and search the term *air power*. The *ASPJ* Web site will be at the top of the list of several hundred million search results. A search for *space power* yields similar results. Clearly, *ASPJ* is a dominant cyberspace operation.

All *ASPJ* editions promote professional dialogue among Airmen worldwide so that we can harness the best ideas about airpower and space power. *Chronicles Online Journal* (*COJ*) complements the printed editions of *ASPJ* but appears only in electronic form. Not subject to any fixed publication schedule, *COJ* can publish timely articles anytime about a broad range of topics, including historical, political, or technical matters. It also includes articles too lengthy for inclusion in the printed journals.

Articles appearing in *COJ* are frequently republished elsewhere. The Spanish, Portuguese, Arabic, and French editions of *ASPJ*, for example, routinely translate and print them. Book editors from around the world select them as book chapters, and college professors use them in the classroom. We are pleased to present the following recent *COJ* articles (available at http://www.airpower.maxwell.af.mil/airchronicles/cc.html):

- Maj Clifford M. Gyves's "Getting inside the Enemy's Head: The Case for Counteranalysis in Iraqi Counterinsurgency Operations" (http://www.airpower.maxwell.af.mil/airchronicles/cc/gyves.html) and
- Col Stephen R. Schwalbe's "Organizational Institutionalization of BRAC" (http://www.airpower.maxwell.af.mil/airchronicles/cc/schwalbe4.html)

The *ASPJ* editorial staff always seeks insightful articles and book reviews from anywhere in the world. We offer both hard-copy and electronic-publication opportunities in five languages, as noted above. To submit an article in any of our languages, please refer to the submission guidelines at http://www.airpower.maxwell.af.mil/airchronicles/howto1.html. To write a book review, please see the guidelines at http://www.airpower.maxwell.af.mil/airchronicles/bookrev/bkrevguide.html. ❑

Ricochets and Replies

We encourage you to send your comments to us, preferably via e-mail, at aspj@maxwell.af.mil. You may also send letters to the Editor, Air and Space Power Journal*, 401 Chennault Circle, Maxwell AFB AL 36112-6428. We reserve the right to edit the material for overall length.*

ASPJ E-MAIL SUBSCRIPTION

I recently signed up for an e-mail subscription to *Air and Space Power Journal*, and the spring 2006 issue is my first. What an excellent magazine! There are few professional journals that I sit and read from cover to cover, but that is exactly what I have done this morning. I compliment you and your staff on your thoroughly professional publication. The journal contains some great articles, but the most important quality I've noticed is the wide variation of views on subjects, which is important because the more perspectives a person can get, the better decisions one can make. Making effective decisions is a large part of leadership. The topic of leadership is important to me because when I was an E-4 in the US Air Force, I was privileged to serve under some of the best leaders I have ever met. Imagine having a colonel tell you, "Mike, just tell me what you need, and we'll make it happen." You can't ask for more than that. Great job on the journal. Keep up the good work.

Michael P. Kopack
Raleigh, North Carolina

FIVE PROPOSITIONS REGARDING EFFECTS-BASED OPERATIONS

I read Col Steven Carey and Col Robyn Read's article "Five Propositions Regarding Effects-Based Operations" (spring 2006) with interest. I find proposition number two the least compelling of the five. True enough, coalition involvement is critically important to the legitimacy of any military operation, but its connection to effects-based operations (EBO) is less self-evident. Proposition number one stipulates that all military operations should be effects based. I would think that that would naturally include coalition operations as well.

The following points that Colonel Carey and Colonel Read make in their article seem most important and merit further emphasis:

- EBO is, first and foremost, a mind-set.
- EBO is not about inputs (bombs delivered or targets "serviced") but about desired outcomes.
- Attempts to overmechanize EBO will guarantee that its promise will never be fully realized.
- EBO is what ties tactical actions to strategic results.
- EBO is the means for ensuring that operations and goals are relevant.
- EBO is better thought of as an organizing construct than as an approach to targeting.
- EBO depends on good intelligence and understanding of the enemy.
- EBO is, as often as not, primarily about second-order rather than first-order effects.

Regarding the reference to the two bridges attacked during Operation Allied Force, the second bridge is a valid example of the point the authors are trying to make, but I'm not so sure if the first bridge is. The fact that the train appeared only after weapon release was a phenomenal stroke of bad luck for everyone involved and most definitely produced undesirable consequences. But it does not, in and of itself, mean that the bridge was not a legitimate target for the effect being sought.

Dr. Benjamin S. Lambeth
Santa Monica, California

EDUCATING FOR EXEMPLARY CONDUCT

I must admit that as I began reading Dr. James Toner's article "Educating for 'Exemplary Conduct' " (spring 2006), I thought I was being treated to a history lesson, but I was subsequently delighted to find myself immersed in historical continuity of the sort that needs periodic reinforcement. Wonderful article! Timely! Truly professional! The concept of an officer as a gentleman—the movie notwithstanding—is something I grew up with. My father graduated from the Virginia Military Institute in 1922, and I graduated from the US Military Academy (West Point) in 1963. I am now on the verge of reengaging with the officer-as-a-gentleman concept. Here at the US Army War College's Strategic Studies Institute, we are giving serious thought to establishing a Center for the Study of the Military Profession. We have been toying with the idea for about two years but have not had enough time or motivation to actually implement it. The time may now be upon us. To be perfectly frank, once our annual strategy conference is over, we'll be searching for an opportunity to begin discussing who (institutionally) would be willing to participate in such a venture and better define the essential question "To do what?" Dr. Toner offers us a serious starting point for those discussions.

Prof. Douglas V. Johnson II
US Army War College, Carlisle, Pennsylvania

DEFINING THE PRECISION WEAPON IN EFFECTS-BASED TERMS

In his article "Defining the 'Precision Weapon' in Effects-Based Terms" (spring 2006), Maj Jack Sine is squarely on the mark with his closing observations: "Operational and tactical planners should thoroughly understand the desired effects and undesired effects associated with each of the weapons available for use. Tactical planners do not require a separate term to distinguish between a weapon with three-meter [circular error probable] and one with 10-meter CEP. Operational and tactical planners, however, do require the ability to associate a level of effectiveness to a particular weapon in a particular scenario" (p. 87). Speaking on the basis of more than 35 years of experience as a retired USAF regular and Reserve component and civilian targeteer with the Department of Defense, I wholeheartedly second his appraisal of both the problem and the solution.

Semantic corruption, ignorance of the interplay of fundamental concepts, the desire for simplistic answers to complex questions, and failure to follow historically validated processes and methodologies for planning the application of capabilities have perennially deflected us from achieving the purposes embodied in Joint Publication 3-60, *Joint Doctrine for Targeting*, 17 January 2002. Further, they have hobbled efforts to improve the full range of tasks associated with formulating courses of action and assessing consequences of execution.

The "precision weapon" of choice is whatever weapon we employ in the tactical scenario that accomplishes our ultimate purposes at the strategic level of warfare. From that perspective, the requisite level of "precision" is defined not by whatever guidance technology happens to be built into any particular weapon but by the commander's objectives, guidance, and intent that energizes and directs the targeting process. Thus, a volley of artillery projectiles, a high-power radio-frequency weapon, a leaflet drop, or a diplomatic demarche is just as likely to be as "precise" a weapon of choice in any hypothetical scenario as a Joint Direct Attack Munition or cruise missile—both of which might turn out to be precisely the *wrong* weapon to use in that same scenario.

The truth of the preceding has long been known and accepted by a small community of individuals, primarily those from various service communities who migrated into the targeting profession. It is encouraging to see them become the substance of wider discourse. And it is time to stop the silly semantic gymnastics wherein the invalid definition and application of terminology serve only to confuse issues rather than solve problems.

Col Calvin W. Hickey, USAFR, Retired
Warrenton, Virginia

MAHAN ON SPACE EDUCATION

I was very impressed with 1st Lt Brent Ziarnick's article "Mahan on Space Education: A Historical Rebuke of a Modern Error" (winter 2005). Although an engineer by profession, I am also interested in politics and military history. I commend Lieutenant Ziarnick for reading and bringing to light lessons from past great strategists; I also commend *Air and Space Power Journal* for publishing interesting, potentially controversial articles. A free flow of ideas is critical for maintaining a healthy officer corps, service, and nation.

Jeffrey A. Jessen
Edwards AFB, California

OIL, AMERICA, AND THE AIR FORCE

I wanted to extend my compliments to Col Richard Fullerton for his article "The Future: Oil, America, and the Air Force" (winter 2005). I work for US Southern Command, so as you can imagine, Venezuela is often on our minds. When Venezuela comes up, the next word is usually *oil*. Unfortunately some people display a great deal of fuzzy thinking and convoluted logic regarding this topic. When I recently asked Daniel Yergin, author of *The Prize: The Epic Quest for Oil, Money, and Power* and the guy who literally wrote the book on oil, about Venezuela's intent to divert its oil to China at the expense of the United States, he replied, "That would beg economic logic." Few people seem to understand that oil is a world commodity with a world price and that no one country can "embargo" the United States with any impact. As for energy independence, as Colonel Fullerton makes clear, we use oil because it is cheaper than other sources of energy. When it isn't cheaper, we won't use it anymore. Colonel Fullerton's article clarifies the issue in language anyone can understand.

Lt Col Robert M. Levinson, USAF
Washington, DC

TECHNICAL EDUCATION FOR AIR FORCE SPACE PROFESSIONALS

Lt Col Raymond Staats and Maj Derek Abeyta's article "Technical Education for Air Force Space Professionals" (winter 2005) offers interesting recommendations for Air Force Space Command's (AFSPC) education initiatives for Air Force space professionals (official term: *credentialed space professionals* [CSP]). However, the article contains some inaccuracies regarding the Air Force Space Professional

Development Program, and the authors' recommendations to improve AFSPC's education efforts touch on several areas that AFSPC either considered during development of the Space Professional Development Program or had already implemented.

The authors' first recommendation cites the need for an AFSPC liaison with Air Education and Training Command and the Air Force Institute of Technology (AFIT) to address education concerns. They also note the need for AFSPC representation on the Space Professional Oversight Board and the Joint Space Academic Group. The Space Professional Oversight Board is a multiservice senior-officer forum, chaired by the undersecretary of the Air Force, that oversees space professional development across the Department of Defense. AFSPC's vice-commander is a standing member of the Space Professional Oversight Board, and other AFSPC general officers and members of the Space Professional Management Office routinely attend the Space Professional Oversight Board's biannual meetings. The Joint Space Academic Group is an academic body made up of AFIT, Naval Postgraduate School, and Army representatives. Although AFSPC members periodically attend Joint Space Academic Group meetings as observers, the command's primary input to the Joint Space Academic Group is through the Space Professional Oversight Board. Since AFSPC can address issues to the Joint Space Academic Group (and, therefore, AFIT) through the Space Professional Oversight Board, a liaison position seems unnecessary.

In their second recommendation, the authors call for a phased approach to establish a technical undergraduate degree requirement for CSPs by 2010. In 2005 AFSPC conducted an educational-needs assessment for CSP officers via interviews of senior space leaders and a follow-up survey of company-grade officers. This led to the conceptual framework for initial and advanced space-focused academic-certificate programs that will bolster the technical knowledge of the CSP community. Most senior space leaders felt that a change in accession requirements was unnecessary. The goal is to develop CSP technical credentials via individual courses and certificates as well as degrees. The results of this effort were forwarded to AFIT, the Naval Postgraduate School, and the Space Education Consortium to encourage certificate program development, which is under way. The Space Education Consortium, with the University of Colorado at Colorado Springs as the lead university, currently consists of 12 institutions dedicated to the advancement of CSP space education and research. The Space Education Consortium will develop a series of articulation agreements and a Web site that will enhance CSP planning for courses, certificates, and degrees. The Space Education Consortium is also considering preparatory courses to enhance CSP qualification for AFIT and Naval Postgraduate School programs. The formation of the Space Education Consortium also addresses the authors' third recommendation: development of curricula for advanced space degrees at military and civilian universities, since part of the Space Education Consortium's charter is to do just that.

In their fourth recommendation, the authors call on the Air Force to reaffirm AFIT and the Naval Postgraduate School as the primary providers of CSP graduate education. This is addressed by a memorandum of understanding signed in 2005 by AFIT, the Naval Postgraduate School, and the Space Education Consortium. In this memorandum, the signatories agree to ongoing communication to enhance their ability to provide space-related education to the national security space community. The memorandum further recognizes that AFIT and the Naval Postgraduate School will focus primarily on full-time education of military personnel, while the Space Education Consortium will focus primarily on part-time and off-duty education for military and civilian personnel. In this way, opportunities for space-related education for the CSP community are broadened and enhanced.

The fifth recommendation does not actually address space education but the composition of the CSP community, calling for addition of intelligence and logistics officers. Expansion of the CSP community is an appropriate next step, including the full spectrum of those performing the space mission. In addition to intelligence and logistics, communications and weather specialties are also candidates. AFSPC's approach is to complete full development of the current CSP community before exploring broader membership since that community currently includes Total Force officer, enlisted, and civilian scientists; engineers; acquisition managers; and operators. Integration of the Reserve and Guard programs and development of the civilian segment are still under way. We welcome inputs from the military and academic communities that help us develop the cadre of space professionals the nation needs to deliver effective space capabilities to the war fighter.

Lt Col Thomas Peppard, USAF
Peterson AFB, Colorado

LORENZ ON LEADERSHIP

I am particularly interested in the article "Lorenz on Leadership" by (then) Maj Gen Stephen Lorenz (summer 2005) because he describes with examples and personal experiences the qualities a leader needs to have. I think he is humble yet assertive. I like his description of how leaders have to assure the well-being of their people by knowing how they feel and how they are doing. I find it delightful that he sees the "ego" as both a facilitator and a detriment. I think he writes from his own perception, and there is nothing better than getting advice from someone who knows what he's saying.

I enjoyed this article very much. However, I would add that to be a leader, there must be a balance between one's professional and personal lives. I find that many of my students here at Georgia Military College face two battles: one at work (deployment to conflict areas) and the other at home. It is becoming more difficult to find a middle ground between these battles, and the solution many times is to leave the military life.

I am a civilian who grew up in Colombia before coming to the United States, but it is my experience as an instructor of young military students that they are struggling to succeed in a double-conflict life, in which staying focused at work is a challenge. I believe that leaders need to be focused at work to take care of their people, just as General Lorenz said.

Ana Maria Horst
Valdosta, Georgia

Editor's Note: Major General Lorenz was promoted to the rank of lieutenant general shortly after ASPJ *published his article. "Lorenz on Leadership" is also available in Spanish at http://www.airpower.maxwell.af.mil/apjinternational/apj-s/2005/3tri05/lorenz.html and in Portuguese at http://www.airpower.maxwell.af.mil/apjinternational/apj-p/2005/3tri05/lorenz.html. Arabic and French versions are planned.*

AIRPOWER, JOINTNESS, AND TRANSFORMATION

I enjoyed the article "Airpower, Jointness, and Transformation" by Dr. Stephen Fought and Col O. Scott Key (winter 2003). With all due respect to surface combatants, I think it properly elevates airpower to a superior position relative to other forces for two reasons. First, airpower transcends the defensive capabilities of even powerful navies and armies because of its sheer speed. Second, with the advent of airpower, neither a powerful navy nor an army can decide the outcome of a conflict without relying on airpower's capabilities. However, airpower—according to Giulio Douhet's theory—can by itself determine the outcome of a conflict.

Maj Jorge Napoleão, Angolan Air Force
Luanda, Angola

Editor's Note: Major Napoleão read the Portuguese version of Dr. Fought and Colonel Key's article, available at http://www.airpower.maxwell.af.mil/apjinternational/apj-p/2004/2tri04/fought.html.

INTRODUCING THE FRENCH *ASPJ*

Congratulations on welcoming an entirely new audience to the world's greatest—*Air and Space Power Journal*!

Brig Gen Randal D. Fullhart, USAF
Maxwell AFB, Alabama

Focus Area

Lt Col Paul D. Berg, USAF, Chief, Professional Journals

Space Power for War Fighters

THE SUMMER 2004 issue of *Air and Space Power Journal* (*ASPJ*), which focused on space power, was so well received that Air War College, Air Command and Staff College, and other organizations asked for extra copies. Because we still receive such requests, we decided to publish an encore issue to update the professional dialogue. Several interrelated questions involving the theory, organization, and force structure of the fast-evolving topic of space power seem prominent in today's Air Force.

Like their airpower cohorts, some advocates of space power still seek an overarching theory to explain the fundamental concepts that govern operations in their domain of choice. Whether such a theory is truly necessary remains an open question since pragmatically minded space operators have achieved quite remarkable things without any broadly accepted theory. Several fundamental questions raised by space professionals involve space power's proper role vis-à-vis other forces. Should space merely support air, land, sea, and cyberspace forces, or should it have a more independent role, perhaps including space combat? Can other forces support space forces? These unresolved conceptual questions lead directly to more inquiries about how best to organize military space forces.

Organizational possibilities run the gamut from those designed to improve liaison with other forces to those intended to establish an independent space service. Creation of the director of space forces (DIRSPACEFOR) position, a recent effort to integrate space operations more closely with those of other forces, marks a relatively small organizational change. Establishment of an independent space force does not appear imminent, but how should one organize space forces if space combat becomes a reality?

Constant realignments of space-related military agencies such as US Space Command (established in 1985, disbanded in 2002) and US Strategic Command (which absorbed US Space Command) reflect a turbulent organizational climate, but one can conceive of even more drastic space realignments. Just as the terrorist attacks of 11 September 2001 influenced creation of the Department of Homeland Security, so might a "space Pearl Harbor"—a possibility raised by the Rumsfeld Commission report of 2001—prompt a reorganization of military space. Nothing guarantees that the civilian space program under the National Aeronautics and Space Administration would remain distinct from military space activities. Recent events such as the response to Hurricane Katrina in 2005 are leading to reappraisals of traditional civil-military relationships within the government.

Theoretical and organizational questions cause one to wonder about which space force structure to build. The high cost of space operations means that we need to make judicious choices about the capabilities we develop. Exciting possibilities loom on the horizon, but experts disagree about how to prioritize alternative systems. Which launch systems should we develop? Should we field space weaponry? If space power's proper function is to support air, land, sea, and cyberspace operations, then the current force structure resembles what we need. Conversely, if space becomes a military operating medium on par with other environments, then we need major changes. However, such alterations might prove expensive at a time when all military services find themselves competing for scarce resources.

Determining how space power can best contribute to national defense will be a long-term process with very high stakes. Careful thought and analysis might make the difference between national success and failure in space. The Air Force plays the leading role in US military operations in space and boasts a world-class cadre of space professionals capable of engaging these matters intellectually. *ASPJ*, the professional journal of the Air Force, dedicates this issue to advancing the professional dialogue about space power. ❑

In air combat, "the merge" occurs when opposing aircraft meet and pass each other. Then they usually "mix it up." In a similar spirit, Air and Space Power Journal*'s "Merge" articles present contending ideas. Readers can draw their own conclusions or join the intellectual battlespace. Please send comments to aspj@maxwell.af.mil.*

Is Operationally Responsive Space the Future of Access to Space for the US Air Force?

Lt Col Kendall K. Brown, USAFR, PhD*

THE KEYSTONE OF the operationally responsive space (ORS) concept is a responsive launch capability. Without such space lift, improvements designed to establish suitable space assets and infrastructure will prove significantly less effective. Air Force Space Command (AFSPC), with support from the Air Force Research Laboratory (AFRL) and the Defense Advanced Research Projects Agency (DARPA), is currently conducting preliminary system-acquisition studies, technology development, and concept demonstrations to make responsive launch a reality. This article presents opposing ORS arguments.

Yes: Operationally Responsive Space Lift Is Essential to US Space Superiority.

The US Space Transportation Policy, issued on 6 January 2005, recognizes the United States' need to augment space capabilities in a timely manner by placing critical assets in space. The policy sets the following goals and objectives:

> 2) Demonstrate an initial capability for operationally responsive access to and use of space—providing capacity to respond to unexpected loss or degradation of selected capabilities, and/or to provide timely availability of tailored or new capabilities—to support national security requirements. . . .
>
> 4) Sustain a focused technology development program for next-generation space transportation capabilities that dramatically improves the reliability, responsiveness, and cost of access to, transport through, and return from space, and enables a decision to acquire these capabilities in the future.[1]

*Colonel Brown is a liquid-rocket-engine system engineer at the NASA Marshall Space Flight Center and a researcher at the College of Aerospace Doctrine, Research and Education, Maxwell AFB, Alabama.

Vice Adm Arthur Cebrowski, USN, deceased, director of force transformation in the Office of the Secretary of Defense, referred to ORS as a new defense business model, the key element of which is operationally responsive support to theater combatant commanders, as opposed to the current space model, which is based upon remnants of the Cold War.[2] As such, an ORS space-lift system must be timely (e.g., mission execution must fit within a joint force commander's timeline) and affordable (e.g., the cost/benefit ratio must be comparable to that of other mission capabilities or provide a unique capability at reasonable cost).

Responsive space systems delivered to space with responsive launch systems include replacement and augmentation satellites for communication; navigation; and intelligence, surveillance, and reconnaissance. Launch could support an evolving mission area of force application from or through space with the use of common aero vehicles to carry strike weapons. The US Marine Corps even envisions transporting a Marine reconnaissance platoon from the continental United States (CONUS) to anywhere in the world within hours to conduct missions with special operations forces. Such a system would provide the theater commander unprecedented flexibility and capability to produce desired effects.

An analysis of alternatives completed by AFSPC in 2004 concludes that "ORS can provide significant military utility at the campaign level" through the use of responsive space-asset delivery.[3] The greatest impact occurs when the enemy has offensive counterspace (OCS) capabilities and the United States uses responsive launch vehicles and satellite systems to maintain on-orbit capabilities. This ability to sustain and supplement on-orbit assets could become particularly critical if potential adversaries can destroy or disable our satellites—reportedly, China has this capability. Force application and OCS missions also provide significant military utility, with the former increasing as a function of theater access.[4] The United States has less access to some regions of the world as a result of the decreased forward presence of its forces and globalization of terrorism. Within that operational environment, the analysis of alternatives determined that a hybrid launch vehicle (HLV), a reusable first stage with expendable upper stages, was the most affordable solution to meet mission requirements. A subsequent study, by this author, developed a potential concept of operations for an HLV system which showed that no insurmountable technology challenges existed.[5]

ORS HLV wings located in the south central and southwestern United States will provide the combatant commander unprecedented strike capabilities without the burden of deployed assets or aerial-refueling resources required for long-range bombers. Inland CONUS basing offers an inherent degree of physical and operational security not available at deployed locations, as was the case with Atlas F intercontinental ballistic missiles (ICBM) at sites in southern and southwestern areas, including rural Oklahoma, Texas, and New Mexico.

One cannot overstate the strategic benefits of an ORS system. For example, in the days immediately following the attacks of 11 September 2001, suppose that intelligence assets had pinpointed the location of al-Qaeda leadership in a remote region of Afghanistan outside the range of Tomahawk cruise missiles. Without overflight permission already in place, launching air strikes would have proved politically impossible; however, with a responsive space-lift vehicle, we could have completed attacks within a few days—or hours if a vehicle had been on alert.[6] Despite the smaller payload of an HLV compared to that of a B-1, B-2, or B-52, the HLV's increased kinetic energy and tactical surprise offset that detriment. As the sortie rate increases, the cost-efficiency also increases, providing the Air Force an alternative to the recapitalization of its long-range attack aircraft.

The HLV's flexibility (the reusable first-stage booster is configured with different upper-stage vehicles, depending upon the mission) represents a key feature of the ORS system, enabling a single capital investment to support multiple mission areas. The ORS concept effectively operationalizes the space-support mission, increasing its ability to provide force application (strike from, through, or in space), force enhancement (satellites supporting air, land, sea, and space operations), and offensive as well as defensive counterspace (attaining and maintaining space superiority).

Prior to a formal decision to pursue an ORS program, as provided in the US Space Transportation Policy, a number of activities within the Air Force and the Department of Defense (DOD) have sustained the momentum and made progress in establishing the technology basis. DARPA's Responsive Access, Small Cargo, Affordable Launch (RASCAL) and Force Application and Launch from CONUS (FALCON) programs attempted to identify and develop low-cost, responsive launch concepts. The RASCAL program focused on concepts for launching small vehicles from high-speed, high-altitude aircraft, whereas FALCON concentrated on developing low-cost, expendable launch vehicles that could demonstrate ORS requirements. The DOD canceled RASCAL in February 2005 in order to focus on FALCON, which continues to investigate two distinctively different concepts: a conventional, multiple-stage, ground-launched rocket and a rocket deployed from the back of a C-17 cargo aircraft.[7] Under the FALCON program and with funding from the DOD's Office of Force Transformation, the Space Exploration Corporation (SpaceX) has demonstrated many low-cost and responsiveness attributes of ORS during preparation for the inaugural launch of its Falcon-1 small launch vehicle.[8] FALCON remains important to the future development of the HLV since the expendable rockets developed under the program could be used as upper stages on the reusable booster.

The Affordable Responsive Spacelift (ARES) program, the next step towards demonstrating the feasibility of an ORS system, set a goal of developing a subscale launch vehicle that demonstrates the characteristics of the HLV's reusable first stage. ARES has just begun system-concept studies, but its progress will shape the future of the ORS launch vehicle.

The operational responsiveness of an ORS system is not science fiction. Burt Rutan made history in October 2004 when his privately funded SpaceShipOne aerospace plane completed its second suborbital trip into space. Rutan and other start-up companies have demonstrated that it doesn't take a large, government-funded program to build a launch vehicle. Profit from commercial launch services, including space tourism, serves as their motivation; however, the systems required to enable such a business may use the same systems and technologies needed by the ORS launch vehicle. If these programs can launch operations responsively, development of an Air Force operational capability can proceed with substantially decreased risk.

Current trends in the air and space community show why this is possible. First, today's computer technology allows us to go from idea, to computer, to machine-shop floor, to final part in a fraction of the time it used to take. Second, the recent slump in the world space-launch market, coincident with a period in which the National Aeronautics and Space Administration (NASA) had no major hardware-development program, has permitted these new companies to hire technical experts who have experience in developing major space systems. This situation, coupled with the rapid increase in affordable computing capabilities and commercial engineering-analysis software, allows relatively few experienced engineers to produce designs that would have required much larger teams only a decade ago. Third, the economic potential of space tourism, combined with the wealth of a few dot-com company entrepreneurs, has opened up innovation and risk taking. DARPA projects encourage this type of innovation with significantly less government oversight than occurs in a typical DOD research and technology project. Building upon this philosophy, an ORS launch-vehicle program will prove successful.

A responsive HLV capability will serve as the foundation for ORS, which is critical to the future national security of the United States. A building-block approach now under development will ensure that full-scale operational system development does not proceed until we have mitigated all significant risks; therefore, success of the FALCON and ARES programs is a critical first step. Such a capability will allow the United States to reduce its reliance on forward-deployed forces and will either maintain or decrease response time. Obviously, much work lies ahead, not the least of which is the writing of doctrine to guide the building of organizational structures; strategy; and operational tactics, techniques, and procedures. However, ORS will become another paradigm-shaping event for the Air Force.

No: Expectations for an ORS Launch System Are Overly Ambitious and Put the Entire Concept at Risk.

The ORS mission-needs statement essentially began as a set of technology-push requirements meant to drive technology to determine the feasibility of such a concept. We have insufficient capability-pull from the war fighter to justify the cost of fielding such a system. Furthermore, unannounced responsive launches from the CONUS would produce a destabilizing effect due to possible confusion with strategic ICBM launches.

Admittedly, the United States needs many of the capabilities that an ORS system would purportedly provide, such as responsive replenishment of on-orbit space assets. However, attempting to do so with a single, partially reusable launch vehicle is a mistake. Several times in the past, we have attempted to create one aircraft platform to perform multiple mission roles (e.g., the F-4, F-111, A-12, etc.) with only limited success. Redeveloping an existing platform (e.g., the F-16) to conduct a different role has produced better results.

Many ideas concerning responsive launch within the ORS construct have their origins in Air University's *Spacecast 2020* study of 1994, which postulated a military space plane known as Black Horse that not only delivered satellites to orbit but also launched strike weapons.[9] When the National Space Policy of 1996 gave NASA responsibility for developing reusable launch vehicles, the Air Force could only participate in NASA's concept development; it also either monitored or became actively involved in that organization's DC-X, X-33, X-34, X-37, Integrated System Test of an Air-Breathing Rocket, and other technology and launch-vehicle demonstrator projects.[10]

Much of the passion for increasing US space-system capabilities originates with the paradigm-changing demonstration of space systems during Operation Desert Storm. The use of space capabilities continued to grow during the 1990s, with a significant increase in the use of precision-guided munitions aided by the global positioning system during Operation Allied Force. During this same time frame, many people within the space community advocated increased space-combat roles. One could almost hear their argument (one they never actually verbalized): "Just give us a strike system, and we'll win the war from our consoles in Colorado." Emphasizing their role in Desert Storm, they began to promote breaking away from the Air Force to create their own service—the US Space Force. With regard to competition for budget resources, space advocates became a "space mafia"—the modern equivalent of the legendary "bomber mafia"—arguing that space had yet to receive sufficient resources for its programs.

Also during this time—the late 1990s through about 2001—studies supporting AFSPC's long-term planning and research reports continued to develop the idea of a military space plane. The influence of space-sanctuary advocates, who oppose the militarization of space due to destabilization and proliferation worries, was waning, and the idea of using space for military purposes in a more aggressive manner gained greater acceptance. This period also saw a tremendous surge in commercial launch-vehicle development to support placement of commercial communication satellites in low Earth orbit.[11] The launch-vehicle and mission concepts that offered the potential to significantly reduce cost and increase responsiveness, as proposed by private companies, fit nicely within the military space-plane concepts, indicating to the plane's advocates that they were on the right path. Meanwhile, the Air Force began to become expeditionary, but AFSPC still tended to view its support as global and functionally based.[12] However, the nonspace Air Force busily flew missions in Allied Force and Operations Northern Watch, Southern Watch, Enduring Freedom, and Iraqi Freedom and did not have time to provide requirements for what we now call effects-based capabilities to support ORS development.

Built upon that history, the AFRL developed a set of requirements for its space operational vehicle (SOV) concept. These requirements sought to drive technology-development projects—that is, they were so aggressive that only advanced technologies or unproven system concepts could possibly satisfy them. The mission-needs statement, approved for ORS in 2001 by the Joint Requirements Oversight Council, has served as the basis for many subsequent launch-vehicle and propulsion-system technology projects. The analysis of alternatives study used requirements derived from this statement, specifying the reduction of launch-vehicle call-up times from months to days and of final preparation and launch from days to hours. The requirements also mention the ability to sustain multiple sorties per day during contingency operations, which might necessitate turnaround of the vehicle for a subsequent mission within hours of landing.

From this history of the responsive launch vehicle—whether it's called a military space plane, an SOV, or an ORS launch vehicle—one sees that the concept has emerged from the expansion of space capabilities through a technology-push program and that it has had inadequate capability-pull from the war-fighter community. Much of the support for a responsive launch concept depends upon obtaining access to space at lower costs. Claims of the low-cost-access-to-space companies in the 1990s, continuing with the more recent and better funded entrepreneurial companies, are accepted almost religiously.

These businesses are deceiving themselves and their supporters. Building the first test vehicle might prove relatively straightforward, but seeing such a system through production and operation will not. Such companies can operate inexpensively in the early phases of development because they have no past liability; no large, aging infrastructure to maintain and operate; no large pension and retiree health insurance funds to maintain; and no large bureaucracies to do the little things that have to be done. As a program matures, as such a system must, one will find no substantial cost difference between a system from one of the United States' traditional launch-vehicle companies and a system from one of the new companies.

The goals of low-cost responsive launch are not new. An essay on an online air-and-space-news Web site notes that the goals of the Pegasus and Taurus launch vehicles, developed by Orbital Sciences Corporation, differed little from those of ORS launch.[13] In fact, an Atlas F ICBM had more mass capability and better responsiveness than the small launch vehicles under development in DARPA's FALCON program today. Given the likenesses between the early Atlas vehicles and the SpaceX launch vehicles, one should not be surprised by their similar responsiveness.[14]

The AFRL has been using technology-push SOV requirements to perform research and technology studies of propulsion systems. Based upon the sortie rate and requirements for turnaround time, these studies have indicated a potential advantage of using liquid oxygen/liquid methane engines, leading many of the lab's current projects to focus on methane-fueled rocket-engine concepts. Methane has a slight performance advantage over rocket-engine-grade kerosene (RP-1); however, its density (almost 50 percent lower than kerosene) demands a larger vehicle. Moreover, the fact that it must be stored as a cryogenic liquid, at approximately -250° F, means that a methane-fueled vehicle would require more ground operations than one fueled by kerosene. Interestingly, the Soviet Union developed seven liquid oxygen/methane rocket engines for missiles and launch vehicles but never fielded any of them for operational use.[15] One can infer that the Soviets concluded that the increased size and operational complexity of the vehicle offset the performance advantage. Hence, one might expect the Air Force to come to the same conclusion, particularly when it develops the next iteration of responsiveness requirements for an ORS launch vehicle with effects-based operations in mind.

Perhaps we won't need an HLV to support the ORS construct—some other combination of systems may provide a better solution. A recent Air Force futures war game held at Air University included the capabilities of an ORS system and those of near-space balloons. Postgame analysis concluded that ultrahigh-altitude (often referred to as near-space) balloons, coupled with conventional attack aircraft, offer better support to the war fighter than does the responsive launch vehicle.[16] Thus, instead of spending a great deal of time and money developing and fielding a system that may not provide the capabilities expected of it, the use of near-space balloons, converted ICBMs, or other inexpensive, expendable launch vehicles might be a better solution.

Inclusion of a global strike capability might have a destabilizing effect on world affairs in times of heightened geopolitical tensions. Given an HLV that can deliver either a satellite payload to orbit or a common aero vehicle with a strike weapon to a terrestrial target, a third-party nation might detect the launch and fear a nuclear attack by the United States. Regardless of whether such fears have any foundation, the Cold War forged a paradigm that ICBMs deliver nuclear weapons, and a US adversary or a nation not friendly to the United States could have difficulty distinguishing the launch of an HLV from that of an ICBM with strategic weapons, despite the fact that the trajectories might differ. The world community would have to accept the uncertainty that a reentry vehicle could deliver a conventional precision-guided munition—in essence, we would be asking the world to trust us in a time of hostilities.

The political environment in a time of such uncertainty could restrict the operational usefulness of the ORS system's force-application capability. For example, if we determined that, in response to our planned delivery of a weapon by means of an HLV, a nation with theater or intercontinental nuclear capabilities might increase its readiness posture and thus amplify the risk of a launch on US forces or the United States itself, we would not execute the mission. Advocates of global strike dismiss such concerns, however, arguing that communications with the regional nations would prove sufficient to mitigate the risk. Nevertheless, would such communications affect the responsiveness and strategic surprise of the ORS system? Probably so.

In summary, these concerns indicate that the Air Force's operationalization of space is moving too fast. To date, primarily technologists—within the space community—have conducted ORS studies and planning. We may or may not need the capabilities derived from those studies to support the theater combatant commander. For example, we could make improvements in the responsiveness of existing expendable launch vehicles to sustain and supplement space assets without developing a new vehicle. Failure to meet low-cost goals and the detrimental effects of cost overruns and schedule delays will surely doom the ORS program, especially in light of strains on the Air Force budget caused by aircraft-recapitalization needs. ❑

Maxwell AFB, Alabama

Notes

1. "Fact Sheet: U.S. Space Transportation Policy, January 6, 2005," n.p., http://www.ostp.gov/html/SpaceTransFactSheetJan2005.pdf.

2. Arthur K. Cebrowski and John W. Raymond, "Operationally Responsive Space: A New Defense Business Model," *Parameters* 35, no. 2 (Summer 2005): 67–77, http://carlisle-www.army.mil/usawc/Parameters/05summer/cebrowsk.pdf.

3. Col Pamela Stewart, "AFSPC Operationally Responsive Space Lift (ORS) Analysis of Alternatives" (interim status brief, Core Technologies for Space Systems Conference, Colorado Springs, CO, 4 November 2003).

4. Ibid.

5. Maj Kendall K. Brown, "A Concept of Operations and Technology Implications for Operationally Responsive Space," *Chronicles Online Journal*, 1 June 2004, http://www.airpower.maxwell.af.mil/airchronicles/cc/brown2.html.

6. The day-to-day operations of an operationally responsive space-lift wing will have much in common with those of CONUS-based strategic aircraft during the Cold War.

7. "RASCAL—Responsive Access, Small Cargo, Affordable Launch/SLC-1," *GlobalSecurity.org*, http://www.globalsecurity.org/space/systems/rascal.htm; and Jeremy Singer, "Pentagon Cancels RASCAL Small Launcher Effort," *Space News*, 2 February 2005, http://dev.space.com/spacenews/militaryspace/newrascal_020205.html.

8. The inaugural flight of the SpaceX Falcon-1 vehicle failed on 25 March 2006, 29 seconds into the flight. The failure of this first flight does not diminish the progress made towards demonstrating the capability to launch a vehicle with a small support team and relatively little infrastructure.

9. "Spacelift: Suborbital, Earth to Orbit, and on Orbit," in *Spacecast 2020 Technical Report*, vol. 1 (Maxwell AFB, AL: Air University, 1994), http://www.fas.org/spp/military/docops/usaf/2020/app-h.htm.

10. "Fact Sheet: National Space Policy" (Washington, DC: The White House, National Science and Technology Council, 19 September 1996), http://www.ostp.gov/NSTC/html/fs/fs-5.html.

11. Development of commercial launch vehicles decreased significantly beginning in 1999 and 2000 when satellite-based telecommunications did not realize their market potential. Terrestrial fiber-optic networks and towers for local cellular phone systems provided a lower-cost solution.

12. The key exception within AFSPC was the increased development of deploying space capabilities, including the creation of space weapons officers by sending career space officers to the Air Force Weapons School to increase the integration of space capabilities at the theater-operations level.

13. Jeff Foust, "Operationally Responsive Spacelift: A Solution Seeking a Problem?" *Space Review*, 13 October 2003, http://www.thespacereview.com/article/52/2.

14. Atlas ICBM variants deployed around the United States in the early 1960s, which used liquid oxygen and kerosene propellants, relied upon the modest performance of a gas-generator-cycle rocket engine. The key enabling feature of the Atlas vehicle was the construction of its pressure-stabilized propellant tank, a new concept at the time, which minimized the booster vehicle's inert mass. The SpaceX Falcon-1 launch vehicle also uses the same propellants, same rocket-engine cycle, and a state-of-the-art design and fabrication approach—also designed to minimize the inert mass.

15. George C. Sutton (author of *A History of Liquid Propellant Rocket Engines* [Reston, VA: American Institute of Aeronautics and Astronautics, 2005]), interview by the author, December 2005.

16. Thomas R. Searle, "The Air Force of the Future: Thoughts from the Future Capabilities War Game of 2004," *Air and Space Power Journal* 18, no. 2 (Summer 2004): 19–26, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj04/sum04/vorsum04.html.

The Merge

In air combat, "the merge" occurs when opposing aircraft meet and pass each other. Then they usually "mix it up." In a similar spirit, Air and Space Power Journal*'s "Merge" articles present contending ideas. Readers can draw their own conclusions or join the intellectual battlespace. Please send comments to aspj@maxwell.af.mil.*

A Debate

Will the Larger Air Force Ever Accept the Space Cadre?

Col Richard Szafranski, USAF, Retired*
Col Donald Kidd, USAF, Retired

FULLY INTEGRATING THE space cadre into the US Air Force, perhaps even to the point that one day an Air and Space Combat Command exists within the US Air and Space Force, will require that proponents of space-based combat power overcome a wide range of obstacles, none of which are entirely new. The space cadre can solve these problems more easily if it learns the hard-won lessons of its many predecessors. Space-based combat power and its associated space cadre are just recent innovations struggling for acceptance by and integration into the existing warrior community.

Doctrine

Point

Significant doctrinal issues impede the integration of the space cadre into the Air Force. Space forces, the capabilities they now enable, and those they will one day generate organically are "inherently strategic." Absent a peer or near peer, no adversaries challenge US strategic prowess. America's foes are driving future engagements to the tactical level whenever possible and creating a need for more US expeditionary forces. In this tactically oriented warfare environment, how can space forces operating at the strategic level of warfare from behind computer terminals far from the battlefield ever hope to integrate with their expeditionary brethren?

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Counterpoint

Nothing is inherently strategic. Indeed, until the early air forces demonstrated their ability to contribute beyond the tactical level of warfare to the strategic level, they remained bound to the commanders of supported ground forces. Not until very long-range (read "strategic") bombing moved air forces beyond what the Army Air Corps could justify as a ground-support element, not until Airmen contributed unselfishly to success in all the theaters of World War II, and not until the United States developed this other innovation—the atomic bomb—did the Air Force emerge as a separate service, "unintegrating" itself from the Army.

Since 1947 the operations of the services have evolved, each in recognition of new and changing operating environments and their unique contributions to national security. A major portion of the Air Force has retained this "strategic" (read "very long-range") focus. But part of the Air Force has always tried to return to those tactical roots. It not only focuses on force-enabling missions such as transport, but also works diligently to remain directly relevant to tactical war-fighting forces; C-130 gunships and A-10 close-air-support missions represent just two examples. The space forces and space cadre are already moving down this road to tactical integration, having demonstrated the ability to wed capabilities derived from global systems such as precision positioning to weapons such as Joint Direct Attack Munitions for the purpose of taking out tactical-level targets. Space-based capabilities with strategic-level aspirations or pedigrees support ground forces at the company level. As the space cadre develops new combat-power capabilities organic to space forces, this will undoubtedly continue, thus bridging the doctrinal chasm between strategic and tactical operations.

Organization

Point

Three points. First, space is an organizational train wreck, inside and outside both the Air Force and the Department of Defense. The space cadre isn't organized to develop doctrine for space forces engaged in today's space missions—communications, navigation and timing, and surveillance—let alone tomorrow's. Launch, intercontinental ballistic missile (ICBM) forces, information operations (IO), and buckets like "offensive counterspace" and "force application," Fourteenth Air Force, Twentieth Air Force, and the global-strike "war-fighting headquarters" must be a confusing jumble to organizations like US Strategic Command. Second, the flying Air Force has become the check writer for the space part of the Air Force, and one would have to be a true spinmeister to convince joint forces or the Air Force that the future imagery architecture, or the space-based infrared system, or "transformational" communications, or any other space-system cost overrun (pick any system; they all have overruns) has increased core capabilities.

Third, many senior space officers in the Air Force may be passive-aggressive closet separatists who quietly and diligently work to get recognition as a space force, if not a "Space Force." The organizational train wrecks continue.

Counterpoint

Don't blame the victims of the train wreck for causing the wreck. Rather, focus on the fact that space-based capabilities support and inform national-level decision making, joint-force combat capabilities, weapon-system effectiveness, and US military prowess around the clock, regardless of whatever organizational idiosyncrasies may exist. The notion that senior space officers are separatists is silly and wrong.

Training

Point

Okay, but don't let facts get in the way of the power of perceptions. Perceptions are real too. If one asserts that any structure that works is a good structure, he or she must consider the challenge the space cadre has with training. The unique training requirements of new and different forces tend to work against the integration of their practitioners. In the history of arms, novel equipment that enabled new forms of engagement was often kept separate from the bulk of the forces, which decided the outcome of battles by maneuver for attrition. One uses the term *bulk* because in attrition warfare, numbers dominate the calculus of the operational art. Cavalry required different skills than infantry—horsemanship and swordsmanship—so the horse-mounted cavalry operated in conjunction with, but distinctly different than, the bulk of the infantry. Musketeers were dismounted, and artillery was kept separate even though it quickly proved integral to maneuver warfare. Artillerists required knowledge of chemistry and geometry, so the Army employed them with, but organized and trained them apart from, cavalry and infantry. Navies, having no choice, integrated them into warships. Air forces, once their utility exceeded signals and the Signal Corps, became the Air Corps—part of, but apart from, the bulk of the Army.

Counterpoint

Of course those elements started out as separate arms of what became their services. Until the service could wring out what these new forms of engagement meant and what new requirements they would dictate to the service, it made sense to train them separately until the full effect emerged and one determined how a form could, would, or should interact with existing forms of engagement. But eventually the novel equipment and its associated operating forces became unalterably linked to the originating force. Cavalry and infantry, although wielding different forms of fires and maneuvers as well as requiring different skill sets and training, are inseparable elements of today's ground force. And the Navy, in full recognition of the important role it plays in the fire-and-maneuver ability of ground forces (despite the fact there is nothing particularly naval about artillery), would never think of handing over its artillery to another service arm. So too will it be with the space cadre. In the beginning, it makes sense to train its members separately, but even now we are wringing out what this new space-based form of engagement means. Full integration is just the next—inevitable—step in the evolution of this new form of warfare.

Materiel

Point

New equipment that is foreign, even alien, to established forces will keep those who use it separate from the mainstream. When nuclear weapons arrived, only the Air Corps' 509th Bomb Group had them. Ballistic missiles and space followed——and then IO. Neither ballistic missiles, nor space, nor IO are missions that "naturally" belong to air forces built around air-breathing, winged platforms, no matter what anyone asserts about the Air Force's rightful turf. So unnatural is this new equipment to the offspring of the Air Corps that it likely has precious little chance of being integrated. Anything in which keyboards play a common role and keystroking represents combat or combat-support activity may pose intractable problems in organizing, training, and equipping for the Department of the Air Force.

Counterpoint

There was a time when missiles and space-based war-fighting capabilities were not obvious Air Force missions. Much to the chagrin of President Eisenhower, the late fifties saw huge Army, Navy, and Air Force programs develop intermediate-range missiles and ICBMs. But one could argue that the other services piled on not because missiles are not inherently Air Force missions, but because the brand-new US Air Force was not as established as its much older sister services and therefore could not defend its own turf, since that turf had yet to become fully defined. With the benefit of hindsight, ballistic missiles, space, and information warfare are not only "natural fits" for the Air Force but also natural extensions of previous missions; indeed, today they are essential contributions that the Air Force is best qualified to make to national security and joint war fighting. As foreign or even alien as space equipment may seem to air forces, it is all the more so to sea and, especially, ground forces. Practitioners of space-based warfare have a much better chance of joining the mainstream of the Air Force than similar elements within the Army or Navy have of joining the mainstream of those services.

Leadership

Point

The thread that runs through all the counterarguments is, "It could be worse." Rather than responding to this point by using an it-could-be-worse defense, one should accept the fact that as long as one chief of staff of the Air Force after another is a pilot (most probably a fighter pilot who grew up flying air-breathing, winged planes in the white-silk-scarf Air Force), the space cadre will remain a second-class citizen of the service and thus never become fully integrated. Full integration of a community will not happen if it does not have first-rate officers, and what bright, young, and ambitious Air Force officers are going to limit themselves by choosing a career field from which no chief of staff has ever been chosen?

Counterpoint

In the long run, the pedigree of the chief of staff will not be the deciding factor in the integration of the space cadre; rather, it will be the ability of the space cadre to deliver credible and reliable combat power to the president and combatant commanders. This will usher in the possibility of a member of the space cadre eventually becoming the Air Force chief of staff. Consider the Navy and the Office of the Chief of Naval Operations. Once upon a time, naval forces had only surface-warfare officers—captains of battleships, cruisers, and destroyers. But now they have submariners and naval aviators in their ranks, some of whom have gone on to become the chief of naval operations (e.g., Adm Frank Kelso, a submariner, and Adm Jay Johnson, an aviator). When submarines and aircraft carriers proved their mettle, no surface-warfare officer at the top would, or could, stop the full and complete integration of these new warfare communities into the Navy fold. But a difference in the manner of their integration may provide lessons for the space cadre. Specifically, submariners sprang on the scene almost as a full-fledged and equally capable combat arm of their navies, while aviators required a decades-long period of development to attain equal status, eventually overtaking the surface-warfare community as the prime instrument of tactical naval-power projection.

During the age of the dreadnought, the battleship ruled the seas. Some very early experiments occurred with submarine warfare—such as the Confederate States' CSS *Pioneer*, *Diver*, and *Hunley* in the 1860s—and 40 years later, torpedoes allowed subs to sink thin-skinned merchants and then the thicker-skinned battleships. Were submarines a weaker sister—relegated to a supporting role for the dominant force of the day—or did they enter fights by providing a full-fledged combat capability? They were an equal partner from birth, starting out organic, fully capable, and autonomous.

Now consider naval aviators. Like their land-based counterparts, they started out doing tactical support for established forces: early aviators promised battleship admirals that they would be better spotters for naval gunnery than any other spotters the fleet had. Progressing slowly through the development of better launch and arresting gear while developing tactics that allowed higher launch rates and thus bigger volumes of ordnance on target, they elevated themselves from weaker newcomers to full partners in naval power. The contributions of naval airpower to the victories in the Pacific in World War II almost made the battleship Navy look impotent. Eventually (well into the 1980s) the carrier replaced the battleship as the centerpiece of naval power, thus unintegrating the battleship admirals. When young Americans go to Annapolis, they can request their warfare specialty. The Navy has no problem filling its aviator ranks today. On the other hand, it can retain qualified surface-warfare officers only by enticing them with bonus pay.

Today's space cadre is probably following the naval-aviator model rather than the submariner model. Perhaps in the not-too-distant future, Air Force Academy graduates will clamor to become space warriors, relegating combat pilots to the same fate as the Navy's battleship admirals.

Ethos

Point

Fans of *Star Wars* and *The Last Starfighter* might think otherwise, but fans of *Star Trek* and *Aliens* saw naval forces (sailors and marines), not air forces, as stewards of the fluid medium of space. It could be that the astrophysicists and keystrokers will just never fit into the present or future Air Force.

Worse, there exists a psychology of comradeship among those who give and take direct fires together. The Air Force has drawn and will draw its leaders from those who go "downtown"—Berlin, Tokyo, Hanoi, Baghdad, and whatever is next—giving and taking direct fires. Marines who fought at Iwo Jima could meet each other for the very first time a half century later and feel an immediate, unbreakable bond. Members of the 506th Parachute Infantry Regiment of World War II are a band of brothers even today. One finds few more powerful examples of integration. How can members of the space cadre ever hope to achieve this level of integration as long as they never don a pair of muddy boots, scramble to their battle stations, or look an enemy in the eye at the kill-or-be-killed moment? We shouldn't fault anyone who makes it home in time to pick up the kids from soccer practice, but we shouldn't expect that ethos and the warrior ethos to be the same.

Counterpoint

This is a concern I think we share, but we should share it for the larger Air Force and not for the space cadre, which includes Airmen—nothing more or less. They (we) are part of a great enterprise engaged in a great endeavor. That technology has obviated the need for many of the direct fires of the past is a success story, not a tragedy. All of us in the Air Force—space, air, and cyberspace—need to be proud of this development, not demoralized by it. Others may make a virtue of the necessity of their circumstances, but committing ourselves to using technological wizardry to reduce risk is absolutely a virtue. The ethos we share is the comradeship of being in one Air Force—the only such service on the planet recognized as number one, with even number two far, far behind.

Conclusion

Point

So what have we concluded here?

Counterpoint

I've concluded that those who express certain points of view may be whining dinosaurs. The Air Force is creating its future as we sit here, having already accepted the space cadre. Pioneers will always have their critics, and innovators will always have naysayers. I'm confident we'll get this right, sooner rather than later.

Point

Cheerleading or analysis?

Counterpoint

Did you just hear a fossil, or am I imagining things? ❑

Isle of Palms, South Carolina

The Merge

In air combat, "the merge" occurs when opposing aircraft meet and pass each other. Then they usually "mix it up." In a similar spirit, Air and Space Power Journal*'s "Merge" articles present contending ideas. Readers can draw their own conclusions or join the intellectual battlespace. Please send comments to aspj@maxwell.af.mil.*

Stealing Zeus's Thunder

Physical Space-Control Advantages against Hostile Satellites

Capt Joseph T. Page II, USAF*

IN THE DEEP, dark depths of space, unmanned spacecraft go about their business collecting intelligence information on US military forces. This information, collected and analyzed, could tip the balance of power in a conflict. Imagine the chaos that would result if the satellite did not function as expected—remote-sensing satellites blinded to the changes happening on Earth and communication satellites without signals to relay back to the ground station. The civilian term for intentionally causing catastrophic failure of satellite resources is *space warfare*. In the realm of military science, the concept of space warfare is quite young, having come into existence only when the space age came about approximately five decades ago. Many different areas of space warfare exist, most of them developed as an extension of land-, air-, or sea-warfare techniques adapted to the space environment.

Since space warfare is pushing its way to the forefront of the US government's national strategic concerns, we should clearly define space warfare and strategy for the coming decades, without the overwhelming influences of land-, naval-, or air-warfare doctrine. The current situation resembles the one faced by airpower proponents in the early twentieth century. With weapons such as a parasitic attitude control system (PACS) with antisatellite (ASAT) capabilities and the tactics on how to use them, space warfare can begin to break the bonds of 50 years of earthbound politics and thought, thereby fulfilling its potential.

The United States has divided counterspace doctrine into two categories: defensive counterspace (DCS) and offensive counterspace (OCS). In official parlance, DCS operations "preserve US/friendly ability to exploit space to

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its advantage via active and passive actions to protect friendly space-related capabilities from enemy attack or interference."[1] Active defense seeks to increase US situational awareness in space while passive defense ensures the survivability of space assets and their information. Although DCS is an important part of a space strategy, the implicit understanding of defense means it will not increase the balance in our favor but only "hold the line" against enemy attacks.

The Five Ds

On the opposite end of the spectrum, OCS seeks to "preclude an adversary from exploiting space to his advantage" through deception, disruption, denial, degradation, and destruction (the five Ds).[2] There is no division into active or passive since in any particular situation, the methods may be one or the other (or both), depending on their usage. One uses physical damage as an overwhelming defining discriminator of OCS methods. The dichotomy of OCS breaks into methods that produce physical damage and those that do not:

- Deception—usually none
- Disruption—usually none
- Denial—usually none
- Degradation—usually some
- Destruction—usually much, possibly all

If the United States were able to develop a means of effective OCS that performed most or all of the five Ds, what impact would it have? How would the world react to it? More importantly, would US space forces use this technology to full advantage? Even though the answers to these questions seem to lie in the realm of policy and strategy, a commercial system currently in the research-and-development phase has the potential to turn ASAT warfare and the concept of space control on its head.

A New Way of Thinking

The five Ds of OCS exist as ways to hamper the enemy's ability to use space to his advantage—an effect easily attained through satellite control. US space forces' control of enemy satellites by means of an additional attitude control system (a PACS) would all but assure exercise of the five Ds. Supplementing or supplanting a satellite's integrated ACS allows control of the orientation of payload and bus (the structural shell that houses the mission-performing payload). Most work on the PACS has dealt with topics of extending the life of satellites on a particular mission, primarily communications. Previous research dealt with refueling satellites in orbit and using a satellite's own control system, but the PACS concept disregards the integrated ACS and provides control through an add-on system. Depleted fuel tanks no longer mean the end of a satellite's mission life—with the PACS, the mission extends until PACS fuel runs out or the payload fails.

The control result remains the same when one uses a PACS on a normally operating satellite for space-control purposes. The controller of the PACS has ultimate power in moving the satellite, not only by primary use of its thrusters to throw it out of control but also by making changes in the moment of inertia for spinning satellites or in the center of gravity for three-axis-stabilized satellites. Since payload-pointing accuracy depends heavily on stabilization of the satellite bus, additional thrusters that cause unwanted movement or stabilization changes will affect the target satellite's mission performance. Whatever the technique or intention, the PACS allows control over a satellite by using means other than its original attitude-and-orientation subsystems, an extraordinary capability in the realm of space control and space warfare.

Attitude Control Systems 101

Before delving into the aspects of surreptitious command and control (C2) of hostile satellites, one should acquire a basic understanding of the ACS. The design and operation of satellites include many unique but integrally coordinated subsystems that work in conjunction to carry out the required mission. Although subsystems may vary according to design and although some satellites may not require all subsystems, each satellite includes most of them:

- Structure and Mechanisms—physically support the entire satellite
- Thermal Control—monitors and controls internal and external temperatures
- Electrical Power—generates, stores, and distributes electrical power to other systems
- Command and Data Handling—processes commands and stores data
- Communications—maintains contact with ground controllers
- Propulsion—changes spacecraft's orbital position and orientation
- Attitude Control—determines spacecraft's position and orientation[3]

The last of these subsystems, sometimes known as the attitude determination and control subsystem or guidance, navigation, and control, is used in tandem with the propulsion subsystem, also known as the reaction control subsystem (RCS). ACS sensors measure the orientation of the satellite compared to other known quantities such as star brightness, magnetic fields, or infrared radiation against the cold background of space.

If the correct orientation does not exist, the ACS will adjust it or direct corrective action. Active ACS mechanisms operate *when commanded* to measure and adjust the orientation. Passive ACS systems do not adjust to stimuli; rather, they use physical characteristics such as gravitational attraction to maintain stability. With the ACS directing corrective actions, the propulsion system or RCS uses thrusters or actuators to move the spacecraft physically. The determination of identifying thrusters with propulsion or reaction control depends on their main purpose; if the satellite is already in a proper orbit, no propulsion subsystem is needed, and the thrusters (RCS) are identified with the ACS, whose functions are vital to spacecraft operation—both bus and payload. The ACS is usually doubly or triply redundant due to the importance of the mission. Impairment of these systems can cause degradation or complete failure of the mission; extension of their abilities can extend mission lifetimes.

Refueling Origins of the Parasitic Attitude Control System

The original idea for a PACS called for extending the life of geosynchronous satellites. Factored into the creation of every satellite from the different components and subsystem mean-time-between-failure (MTBF) rates, design life is the length of time the satellite will remain useful. In addition to MTBF rates, onboard ACS fuel-consumption rates from the available fuel supplies also help determine satellite life span. Once the onboard fuel runs out, the satellite is dead in space—its payload may still work, but its attitude will drift, degrading the pointing accuracy of its payload and C2 antennae.

Currently, there is no way to refuel a satellite's fuel tanks in space. However, astronauts Kathryn Sullivan and David Leestma conducted tests in refueling satellites aboard STS-41G, transferring fuel between two vessels inside the shuttle's cargo bay.[4] Although not the same as refueling satellites, this act did prove that manned shuttle missions could refuel low Earth orbit spacecraft such as reconnaissance satellites.[5] The fact that the target satellite must have docking couplers for fuel transfer creates an obstacle to refueling satellites. Future systems may incorporate this feature into the design process, but past and present systems do not have the ability to refuel. The solution created by engineers of the Orbital Recovery Group, a commercial venture, uses a "strap-on" thruster system to augment or supplant the original ACS, skipping the need to refuel the satellite's fuel tanks.[6]

A Parasitic Attitude Control System for Space Control

The idea of covertly supplanting a satellite's ACS is technologically feasible and may become a desired, mature capability when conflict arises in space. The Orbital Recovery Group is working on a life-extension package for high-interest geosynchronous satellites such as high-revenue-generating commercial communication satellites. Discussion of Orbital Recovery's technical plan concentrated on the topic of refueling communication satellites, but the key focus for space warfare remains on the intent of the system: *to help extend the life of aging geosynchronous satellites by adding an additional ACS*. For space control, the actions remain remarkably similar to refueling, but the intent of the user differs markedly. The space-control angle of the additional ACS (hereafter referred to as space-control PACS [SC PACS]) involves *controlling an enemy satellite by supplanting its original ACS and negating the satellite's mission with the PACS*. An SC PACS can control a satellite in numerous ways, incorporated within the five Ds of OCS:

- Depleting the satellite's primary ACS fuel until the satellite is drifting (denial/disruption). Once a satellite runs out of maneuvering fuel to counter drifting, it is considered dead.
- Stressing and straining the satellite bus until body-part separation occurs from changes in angular-momentum spin rates (destruction). Assuming the satellite is three-axis stabilized, enough rotational velocity would put tremendous stress on the solar panels/deployed antennae. Application of enough stress and strain will separate the appendages, depending upon the rate of spin applied to the satellite bus.
- Realigning C2/payload antennae for friendly-force intelligence collection by moving the directional antenna's "footprint" away from hostile ground-station coverage areas and towards space-based signals-intelligence satellites or simply aiming the antennae into deep space, away from Earth (deception/denial). Although such movement will not directly affect omnidirectional antennae due to their 360-degree orientation, their altered pickup patterns will result in less collected signal strength.
- Pushing the satellite into transfer orbit for atmospheric reentry or physical capture (destruction/denial/degradation/disruption). Deliberate movement of the satellite out of its expected orbital plane would allow the PACS controller full, positive control over the satellite's designated path. Physical capture by friendly spacecraft and crews becomes possible by bringing the satellite down to an acceptable orbital altitude. If the plan calls for its physical destruction, lowering the satellite's altitude and speed can allow atmospheric friction to heat up and structurally weaken or burn up the satellite bus and payload.

Concerns about Orbital Debris

The purpose of SC PACS is to create an ASAT capability with a low probability of destruction. Pieces may break off the satellite bus when torqued, but the system seeks to minimize orbital debris, unlike the kinetic-kill ASM-135 or nuclear-tipped Program 437 ASATs.[7] Designers planned for early ASATs to destroy hostile satellites with a kinetic kill (i.e., an explosion on or near the target spacecraft), but these produced too much dangerous orbital debris, affecting other friendly systems. Early satellite experiments such as West Ford, a communications program, dumped hundreds of thousands of small copper needles in near-Earth space, much to the chagrin of research scientists and military space planners.[8] Paint flecks impacting on the space shuttle's window have shown us how dangerous space debris can become.[9] SC PACS renders orbital debris negligible; however, secondary effects may occur with intentional physical damage to the satellite (bending and twisting around the center of gravity).

Military/Intelligence Functions of a Space-Control Parasitic Attitude Control System

The military functions of SC PACS offer a great leap in terms of legitimate space-control ability for any nation that possesses it. The advantage of physically removing a problem from the situation without destroying it lends a "kindler, gentler" approach to warfare operations and may earn the user some respect in the eyes of the world community. When dealing with hostile nations and their space operations, the United States must contend with eavesdropping intelligence satellites that monitor activities around the globe: high-resolution imagery satellites that photograph troop movements or buildup operations (similar to the buildup during Operation Iraqi Freedom in the Middle East in 2003). Following the Air Force's five Ds, SC PACS offers many avenues of approach to neutralize enemy satellites without necessarily obliterating them.

Satellite "Drifting"

SC PACS exerts space control primarily by depleting the satellite's ACS fuel until it drifts. Disturbance inputs such as gravity forces, solar-radiation pressure, Earth's magnetic field, and atmospheric drag all require corrective actions from onboard thrusters. Slight nudges provided by SC PACS exacerbate the expected problems of unwanted movement, and the combined attachment provides greater differences in gravitational force by magnifying the torque. Gravity forces cause spacecraft to act in mostly predictable ways. For example, physically long spacecraft tend to align themselves with the more massive end pointed towards Earth. Sometimes system designs include gravity effects, like the Navy's Transit navigation satellite. By introducing unexpected changes to the satellite bus, such as lengthening the satellite with an attachment of SC PACS, gravity will affect the vehicle in ways unexpected by the ground controllers.

Satellite "Breaking"

Changes in angular momentum also occur during attachment of SC PACS and rotation of the combined system around an axis. The resultant forces provide unaccounted stress and strain on the satellite bus until separation of appendages (i.e., solar panels, antennae, etc.) occurs. Since all spacecraft undergo a battery of tests to determine their response to stress and strain, SC PACS will push the vehicle to its limits and beyond. SC PACS will need a greater tolerance to these forces during its operation, but as long as it spins the satellite into damage or destruction, it may not need to remain connected. Minor changes in torque compel onboard systems to counter the action with momentum wheels and ACS thruster burns, using vital battery power and fuel supplies.

Antennae Realignment

If satellite destruction is not the goal, realignment of the command, control, and communications system as well as the payload antennae is possible. Moving the sensor from its prescribed limits negates the enemy's intelligence collection. The concept of shutter control requires organizations to refrain from imaging particular areas of interest for various political or financial reasons; complete camera control with SC PACS guarantees that no imagery collection will occur. Additionally, realigning enemy transmitters towards friendly intelligence-collection capabilities (ground- or space-based) by realigning their ground-coverage footprint gives US forces a better opportunity to collect, analyze, and understand foreign intelligence-collection methods in space.

Satellite Capture

US intelligence agencies have considerable knowledge of other countries' space programs, obtained mostly by distant-surveillance techniques such as radar or optical tracking. Other methods of intelligence collection include open-source information, such as *Jane's Space Directory* or fact sheets from satellite developers. Depending on the manufacturer or after-delivery modifications, some information remains hidden until after the satellite detaches from the launch vehicle's shroud. The US intelligence system would benefit immeasurably if technicians and engineers could closely examine hostile spacecraft and determine the technological advancement of another nation's manufacturing processes or intelligence-collection capabilities.

If an SC PACS spacecraft succeeds in attaching itself to a hostile spacecraft of interest, moving the satellite towards a friendly pickup vehicle will not present a problem. Coplanar rendezvous between two automated spacecraft has become more common in spaceflight—note for example the rendezvous between the International Space Station and Russian Progress resupply rockets. Remote rendezvous for satellite servicing is an important topic of interest for Air Force Space Command, whose stated purposes for satellite rendezvous are benign, aimed at retrieval or repair of damaged spacecraft.

Atmospheric Reentry

If destroying the spacecraft is a better option, an SC PACS burn can place the satellite into a terminal path through Earth's atmosphere. Commercial and civil entities use atmospheric reentry to destroy low-flying spacecraft, relieving them of the responsibility of actively dealing with on-orbit trash or worrying about liability issues if their derelict spacecraft collides with someone else's satellite.[10] In space warfare, atmospheric reentry prevents hostile nations from retrieving either information or physical specimens of the capabilities and limitations of friendly systems. Aiming through the thickest part of the atmosphere increases friction on the satellite or its payload, enhancing the probability of destruction through thermal means. This could occur as a result of orbital decay, whereby negative acceleration slows the spacecraft down, which in turn requires the spacecraft to spend more time in the atmosphere, which slows it even more in a constantly repeating cycle. The key to this destructive process of orbital decay is the interaction of atmospheric particles (air) against the spacecraft; that is, atmospheric interaction raises the external temperature, severely weakening the satellite's protective structure or burning up the spacecraft.

A Real-World Prototype of a Parasitic Attitude Control System?

Launched in early April 2005, the Air Force Research Laboratory's (AFRL) XSS-11 satellite (see fig.) is a test bed for emerging space technologies. The 11th satellite in the Experimental Satellite Series, XSS-11 has performed many amazing tasks during its time on orbit, including capturing images of the Minotaur launch vehicle that placed it into orbit.[11] Other mission areas covered by XSS-11 and mentioned by the AFRL's Space Vehicle Division fact sheet include proximity operations and autonomously conducted rendezvous—two activities key to a possible SC PACS. Additionally, according to the XSS-11 fact sheet, "the performed advancements will enhance Air Force Space Command's possible future missions [e.g., space servicing of military space systems, damage assessment of disabled space systems, space support, and efficient space operations]."[12]

If XSS-11 proves successful, its mission profile and new technologies may lay the foundation for an increase in space-control capabilities, even though it may not yet offer a direct translation to physical space-control techniques. The size of the XSS-11 satellite bus (less than 100 kilograms) places it directly in the microsat realm. Although the 100-kilogram satellite class may not offer a long-term or powerful PACS, its usefulness lies in prototyping for larger follow-on systems for future deployment.

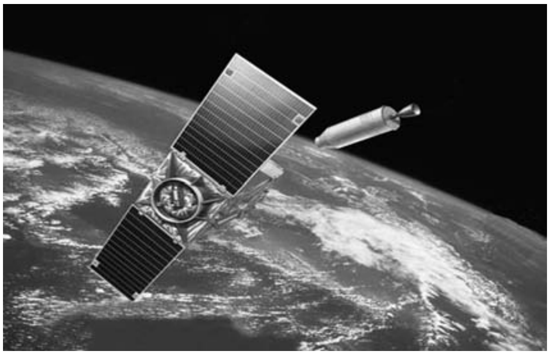

Figure. Artist's rendition of XSS-11's imaging of expended upper stage of launch vehicle. Courtesy of the AFRL Space Vehicle Directorate.

Will a Space-Control Parasitic Attitude Control System Change the Balance of Power?

Although the few SC PACS functions mentioned above are not all-inclusive, they suggest the immense utility of having such a system available for space warfare. How other countries will react to having such a system poised against their assets is another story. Most, if not all, spacefaring nations know the extraordinary advantages that satellites offer to their military, commercial, and civil sectors and recognize the same attributes in other countries' space programs. When one country develops technology to counteract another's advantages, a definite shift in the balance of power will occur.

The United States enjoyed an advantageous position during the so-called space race. Only two coequal nations in terms of technology—the United States and the Soviet Union—opposed each other. Since the fall of the Soviet Union, its technology has proliferated into second-world nations (China, France, etc.) and third-world nations (North Korea, Iran, etc.), shifting the strategic situation from one threatening nation to many. The proliferation of commercial remote-sensing assets has directly contributed to the increasing number of spacefaring nations. Imaging satellites such as Ikonos and Orbview as well as synthetic-aperture-radar satellites such as Canada's RADARSAT-1 give amazing views of nationally vital information, and now anyone with a credit card can purchase all of these products.[13]

If the United States decides to place an offensive space-control system in orbit, hostile nations will contemplate whether to use their space systems against the United States and its allies and risk losing them—or allow the United States to continue its space activities. Physical space control will become a reality for space systems. The question is whether the United States should drive the technological revolution for the safety and security of its space systems or allow another country to set the pace and force the United

States to catch up. If the United States truly intends to become *the* preeminent space power of the twenty-first century, the technological revolution of physical space control must begin here. ❑

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Notes

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3. Thomas P. Sarafin, ed., *Spacecraft Structures and Mechanisms: From Concept to Launch* (New York: McGraw-Hill Publishing, September 1995), 449–58, especially 451, table 14.1.
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Comprehensive space situation awareness (SSA) and defensive and offensive counterspace capabilities are the foundational elements of our Space Superiority efforts.

—The U.S. Air Force Posture Statement, 2006

In air combat, "the merge" occurs when opposing aircraft meet and pass each other. Then they usually "mix it up." In a similar spirit, Air and Space Power Journal*'s "Merge" articles present contending ideas. Readers can draw their own conclusions or join the intellectual battlespace. Please send comments to aspj@maxwell.af.mil.*

Editor's Note: As this issue of ASPJ *went to press, the secretary of the Air Force announced that "beginning with the calendar year 2008 central selection boards, information on all degrees earned by an officer will be available to the board."*

The Vanishing Education (Record) of an Officer

Col Chris J. Krisinger, USAF*

FOR YEARS, POSSESSING an advanced degree had a significant impact on an Air Force officer's promotion potential. In January 2005, however, the Air Force took steps to change that mind-set. New Air Force policy states that "advanced academic degrees will no longer be a factor in the promotion process."[1] First and foremost, the Air Force introduced a new, businesslike, "just-in-time" force-development approach that seeks to tailor education to current job needs. Key to that new policy is a changed educational paradigm: if officers need additional education or training for their jobs, the Air Force will arrange it—and they will get it.

Coincidentally, the Department of Defense (DOD) is gradually shifting to a new education policy of its own. The department realizes that if the United States is to prevail against jihadist extremists and other terrorists, then far greater understanding of different human behavioral patterns, cultures, politics, histories, languages, and religions becomes essential.[2] To fight the continuing global war on terrorism, the Pentagon has begun to transform its relatively broad education policy to focus more on these "soft" disciplines and push especially hard to develop linguists.[3] For the Air Force, these changes suggest that the expertise of a culturally savvy foreign-area specialist fluent in a particular language could one day influence the course and direction of an air campaign, which in turn could help save American, coalition, or civilian lives.

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Air Force Policy Not Optimal for the Broader DOD Approach

In the meantime, the new Air Force policy does not optimally complement the larger, broader DOD approach. Just-in-time thinking fits today's technology-driven Air Force, particularly for junior officers learning and maintaining skills in their early operational assignments. But the same approach does not lend itself to the kind of long-term commitment needed for officers to develop diplomatic acumen in politics, culture, history, and language. Such a commitment may even extend to recruitment based on a candidate's undergraduate studies. Air Force leaders may want to reconsider the service's new policy and thereby resynchronize with broader DOD objectives.

Right now, the Air Force intends to change the focus of its education and training to deliberate, targeted development with the goal of tailoring and providing education and training at an appropriate time, thus enhancing Airmen's job performance. For instance, if an officer needs a computer-science degree to become an information-warfare officer, then the Air Force will arrange for the appropriate schooling. Similarly, officers scheduled to work at a system program office may require a management degree. But tailor-made career development becomes more difficult when one tries to match appropriate education to an increasing number and variety of political-military jobs that demand long lead times to learn languages, cultures, and histories, as well as understand current events in the proper context. One can acquire such relevant, required skills only over the long run—likely beginning with undergraduate programs and recruitment.

Change Manifested at Promotion Boards

In January 2005, the Air Force removed all information regarding academic education, including bachelor's degrees, from promotion-board records of line officers through the rank of colonel. This information will not be visible at any level of the process, whether rater, senior rater, management, or promotion board. Such policy follows from the Air Force's newly declared emphasis on "job performance" as the overriding determinant of promotion potential.[4]

To explain the changes even further, Air Force policy and press guidance cite examples showing how perceptions of "filling squares" or "checking boxes" drive pressures supposedly associated with obtaining an advanced degree for promotion potential and career enhancement. Air Force leaders publicly expressed their concerns that merely obtaining the degree superseded learning itself or the effective use of that learning, whether during one's next assignment or over the course of a career.[5] Because this author had a different experience with selecting a degree program, he was surprised (but not shocked) that the Air Force decided to change policy in the midst of the current global war on terrorism, which places cultural, historical, and linguistic differences front and center.

Many officers purposefully choose undergraduate majors and graduate-degree programs such as international affairs, national security studies, and military history (many completed via "night school") to complement their vocational calling. Those degrees and programs offer excellent support and preparation for tours in political-military and public-policy-related assignments as well as provide a foundation of knowledge for careers in the military. Nevertheless, under the new Air Force policy, those degrees and academic achievements vanish from the promotion record and become invisible to board members.[6]

Frankly, it is reasonable for Air Force promotion boards to differentiate among competing officers based on the usefulness of their academic credentials to the military, no matter how they obtained the degrees. Boards could also judge officers' potential by reviewing both the rigor of their studies and their academic standing. Further, education plays an important role in preparation for greater responsibility—a factor worthy of consideration by a promotion board. Appropriate academic achievements reinforce whether or not officers' development meets Air Force needs and makes them candidates for future positions. Like traditional professions (e.g., law and medicine), the military should stress educational accomplishments and preparation when it considers a person for promotion and increased responsibility.

Given two officers with equally impressive job performance (which is the norm), ideally the next A5 (Plans, Programs, and Policy) for one of the regional major commands (e.g., US Air Forces in Europe or Pacific Air Forces) would have expertise in regional affairs. Similarly, the Air Force should select as its next defense attaché to a country of critical importance to US foreign policy someone who speaks the local language fluently and possesses an area-studies degree for the region (if not that country), rather than a generalist who majored in forestry, took the obligatory Spanish course in college, but excelled (for example) as an aviator, a maintainer, or a logistician in early operational jobs. If educational achievements vanish from promotion records, such important distinctions could be lost early in an officer's career progression when assignments (and evaluations) focus more on operations-related vocational skills.

Linguists and International Affairs Specialists

Promotion boards aside, two other factors will also exert influence on the Air Force: the DOD's efforts to increase the US military's foreign language skills and the Air Force's own new initiative to develop international-affairs specialists.[7] A recent Pentagon report notes that " 'language skill and regional expertise have not been regarded as warfighting skills and are not sufficiently incorporated into operational or contingency planning.' " It also points out that the ability of US troops to communicate in and understand foreign cultures has become " 'as important as critical weapons systems.' "[8] A measure still under consideration goes so far as to require that an officer understand a foreign language—possibly even test as bilingual. The DOD has mandated that the Air Force, along with the other services, conduct detailed planning for managing and monitoring the career progression of these individuals.

Moreover, the Air Force is expanding its own initiative to develop international-affairs specialists. Service guidance explains that for an "expeditionary Air Force" to "continue . . . success far from home," the service will have to "develop a cadre . . . with international insight, foreign language proficiency, and cultural understanding—Airmen who have the right skill sets to understand the specific regional context in which air and space power may be applied." These skills are deemed force multipliers for the effective application of air and space power.[9]

However, the proverbial "long pole in that tent" is that education in these soft subjects does not lend itself to quick fixes or the just-in-time delivery mode to develop officers competent in those areas. Only a long-term commitment, beginning in the undergraduate years and continuing through postgraduate education, can fully develop and nurture this type of officer. Admittedly, such a commitment will challenge the Air Force, particularly as it educates junior officers whose first priority is to learn and become proficient in a vocational-technical skill in their early assignments. Some officers will do this as a well-managed, career-broadening opportunity to gain experience in international political-military affairs. However, for a designated number of officers, the Air Force envisions an even more ambitious program to develop international-affairs specialists with multiple assignments designed to create a true regional expert with professional language skills—the regional-affairs strategist. Candidates for this program will have undergraduate degrees and a personal interest in these disciplines.

Another Approach

One finds a precedent among the great captains of the American military for a force-development approach that does not erase academic achievements from an officer's promotion-board record but in fact emphasizes their importance. For example, Gen George Patton owned a substantial personal library of hundreds of volumes (which he actually read) dedicated to military affairs and history. The last two evaluation (performance) reports of General Patton during his interwar assignment in Hawaii commended him as an individual "widely read in military history" and a "student of military affairs . . . intensely interested in his profession."[10]

Many Airmen would quickly carp that today's officers lack the time available to Patton's generation for personal study. Regardless of such differences, were Patton living today, he would persevere—he would make time for personal study just as he did over his military career of more than 40 years. His professional military development and maturation rested solidly on three pillars—self-study, the US Army's educational system, and on-the-job experience. Patton's superiors recognized him for achievements in all three areas. If Patton were in today's Air Force, however, a promotion board would dismiss his extensive self-study, emphasize job performance in his less-than-dynamic interwar environment, and marginally consider his formal education.

More Visibility on Education, Not Less

Particularly for a calling such as the profession of arms, education is a career-long, if not lifelong, commitment. The Air Force's decision to shift to a just-in-time delivery policy for education and training, along with the erasure of educational accomplishments from promotion records, myopically focuses on the officer's specific job at hand. Further, the new approach may not allow needed visibility over the long-term grooming of officers, for the service not only will place them in challenging, diplomatically sensitive coalition and allied positions, but also will expect them to convey confidence and savvy in politics, cultures, and languages. Understandably, the payoff of an education rich in such disciplines may not come until those officers become senior commanders. However, the rewards could prove disproportionately large in a critical international contingency.

If anything, perhaps the Air Force needs to place greater emphasis on educational development, given the political-military, nuance-driven international security environment in which it operates. The service would do well to restore—or conceivably increase—the visibility of an officer's academic achievements to his or her promotion record, even to the point of allowing supervisors and raters to formally make note of academic achievements, self-study, professional writing, language proficiency, and other related activities on annual performance reports and promotion recommendations.

Next Steps

Current Air Force policy guidance clearly indicates that officers—on their own—can still earn degrees. Assistance, such as benefits from the Veterans Administration, remains available, and education offices will continue to counsel prospective students on their options. However, the current sanctioned aversion to the recognition of advanced degrees is chilling for prospective students and junior officers who require long-term commitments for professional development in those soft disciplines now so critical to national security. Instead, the Air Force should provide promotion boards guidance that allows them to recognize academic achievements clearly beneficial to the military and to the development of a professional military officer.

In his *Chief's Sight Picture* of 2 February 2005, Gen John Jumper, former Air Force chief of staff, stated that "the goal is clear—develop professional Airmen who will collectively leverage their respective strengths to accomplish the Air Force mission. . . . We owe it to you to provide the skills and education you need to continue to excel!"[11] All Air Force members would agree with General Jumper's assertion; however, one must remember that military officers begin to obtain those skills and education before they receive their commissions and that their professional development extends over the course of an entire career. The military profession is no different from traditional professions in this regard. Therefore, once obtained, and without bias regarding venue or timing, the educational achievements of a professional military officer should appear in plain sight for all to see—and evaluate. In the current national security environment, which demands practical know-how and expertise in the soft disciplines of culture, history, language, politics, and religion, the Air Force should restore emphasis to educational accomplishments on individual performance reports and for consideration by line-officer promotion boards. ❑

Washington, DC

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2. "Tongue Tied," editorial, *Wall Street Journal*, 29 April 2005.
3. Bradley Graham, "Pentagon to Stress Foreign Languages," *Washington Post*, 8 April 2005, http://www.washingtonpost.com/wp-dyn/articles/A35263-2005Apr7.html (accessed 25 October 2005).
4. Jumper, "Force Development."
5. Harlan Ullman, "Educate the Military," *Washington Times*, 13 April 2005.
6. Headquarters Air Mobility Command, A1 (Personnel), PowerPoint slide for weekly "A-Staff" meeting, February 2005. Air Force–wide guidance to the major commands contained detailed instructions on prohibiting certain comments regarding the completion of or enrollment in professional military education or advanced academic education programs on both officer performance reports and promotion recommendation forms.
7. For an extensive discussion of the challenges the Air Force faces in developing greater foreign-language proficiency within the service, see Col John L. Conway III, USAF, retired, "The View from the Tower of Babel: Air Force Foreign Language Posture for Global Engagement," *Air and Space Power Journal* 19, no. 2 (Summer 2005): 57–69.
8. Quoted in Graham, "Pentagon to Stress Foreign Languages."
9. Gen John Jumper, "Officer Force Development: International Affairs Specialists," *Chief's Sight Picture*, 6 April 2005, http://www.af.mil/library/viewpoints/csaf.asp?id=129.
10. Steve E. Dietrich, "The Professional Reading of General George S. Patton, Jr.," *Journal of Military History* 53, no. 4 (October 1989): 406.
11. Jumper, "Force Development."

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.*

Operationally Responsive Space

A Vision for the Future of Military Space

Les Doggrell*

IN FUTURE CONFLICTS, military space forces will likely face challenges ranging from defending against opposing systems to dealing with rapidly changing technology and support needs. The Air Force describes its vision for responding to these challenges as operationally responsive space (ORS). Operations Desert Storm and Iraqi Freedom clearly demonstrated the force-multiplication effect of space systems on US military capabilities. Precision-guided munitions; global, high-speed communications; and enhanced situational awareness all contributed to the rapid destruction of the Iraqi military (fig. 1).[1] Unfortunately, future opponents observed the United States' dependence on space systems. To win the next war, this nation must prepare to respond to opposing space and counterspace systems. Gen Lance Lord, USAF, retired, former commander of Air Force Space Command, points to ORS as one way of shaping this response.[2] According to a draft study of ORS, it "will provide an affordable capability to promptly, accurately, and decisively position and operate national and military assets in and through space and near space. ORS will be fully integrated and interoperable with current and future architectures and provide space services and effects to war fighters and

Figure 1. The Joint Direct Attack Munition (JDAM). Widely used during Iraqi Freedom, the JDAM uses the global positioning system (GPS), combined with an inertial system for navigation. Once released, the bomb guides to its target regardless of weather. (From the Boeing Company.)

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other users. ORS is a vision for transforming future space and near space operations, integration, and acquisition, all at a lower cost."[3]

During Iraqi Freedom, described as the first counterspace war, both sides executed counterspace missions. Iraq, for example, attempted to jam GPS signals using Russian-made equipment, and US forces destroyed an enemy ground-transmitting facility, disabling Iraq's ability to communicate with its forces and the outside world by using commercial satellite television.[4] A more capable future opponent will find additional techniques for using space to counter the space capability of the United States.

We can anticipate some responses to our space systems. Specifically, Russia, North Korea, Iran, India, and China may be capable of building a nuclear-armed antisatellite weapon system.[5] Furthermore, "many countries are developing advanced satellites for remote sensing, communications, navigation, imagery, and missile warning," and Russia, China, and the European Union have developed or are developing satellite-navigation systems.[6] Improved antijam features can counter jamming defenses. However, the most effective countermeasures to our space capability will likely take the form of unanticipated actions by our adversaries. Secretary of Defense Donald Rumsfeld might call such actions the "unknown unknowns" or, in the worst case, a "space Pearl Harbor."[7] Fortunately, we have military techniques for responding to the unknown. Speed, maneuverability, and agility have allowed military forces throughout history to deal with unanticipated events. The ability to act and respond faster than the enemy is a well-known tenet of military operations.

Space systems do not adapt well to change. When it became obvious in September 1990, during the planning for Desert Storm, that existing satellite-communications capacity would not support the war effort, we made an urgent attempt to launch an additional Defense Satellite Communications System III spacecraft. That mission finally launched on 11 February 1992, missing the war by over a year. Luckily for the nation, we not only had access to a retired spacecraft but also were able to hire commercial communications capacity.[8] The ability of the United States to support Iraqi Freedom with additional space capability has not significantly improved since Desert Storm.

President Bush has noted the need for responsive space capability. US Space Transportation Policy Directive 40, issued 6 January 2005, directs our government to "demonstrate an initial capability for operationally responsive access to and use of space—providing capacity to respond to unexpected loss or degradation of selected capabilities, and/or to provide timely availability of tailored or new capabilities—to support national security requirements." The same document describes the purpose behind this direction: "Access to space through U.S. space transportation capabilities is essential to: (1) place critical United States Government assets and capabilities into space; (2) augment space-based capabilities in a timely manner in the event of increased operational needs or minimize disruptions due to on-orbit satellite failures, launch failures, or deliberate actions against U.S. space assets."[9] The challenge for the Air Force lies in responding to this direction within the constraints of austere budgets.

Responsiveness in space systems has proven difficult to attain. Characteristics of existing systems include development times exceeding a decade, high cost, and an emphasis on reliability and long mission life. These traits are driven, in part, by the considerable expense of getting to space. Nevertheless, we can achieve the space capability we desire through multiple approaches. The United States maintains a highly responsive fleet of launch vehicles in the ICBM force and has previously maintained communication spacecraft and counterspace systems on alert—an effective approach but costly and encumbered by nuclear politics.[10] Consequently, ORS is examining avenues other than brute force to secure responsiveness. To do so, we must change many aspects of the entire space architecture. The ground system, space vehicle, launch vehicle, and launch infrastructure all affect the responsiveness of space capabilities (fig. 2). Improving a launch vehicle's reaction time has little effect if we have not similarly improved the infrastructure and spacecraft.

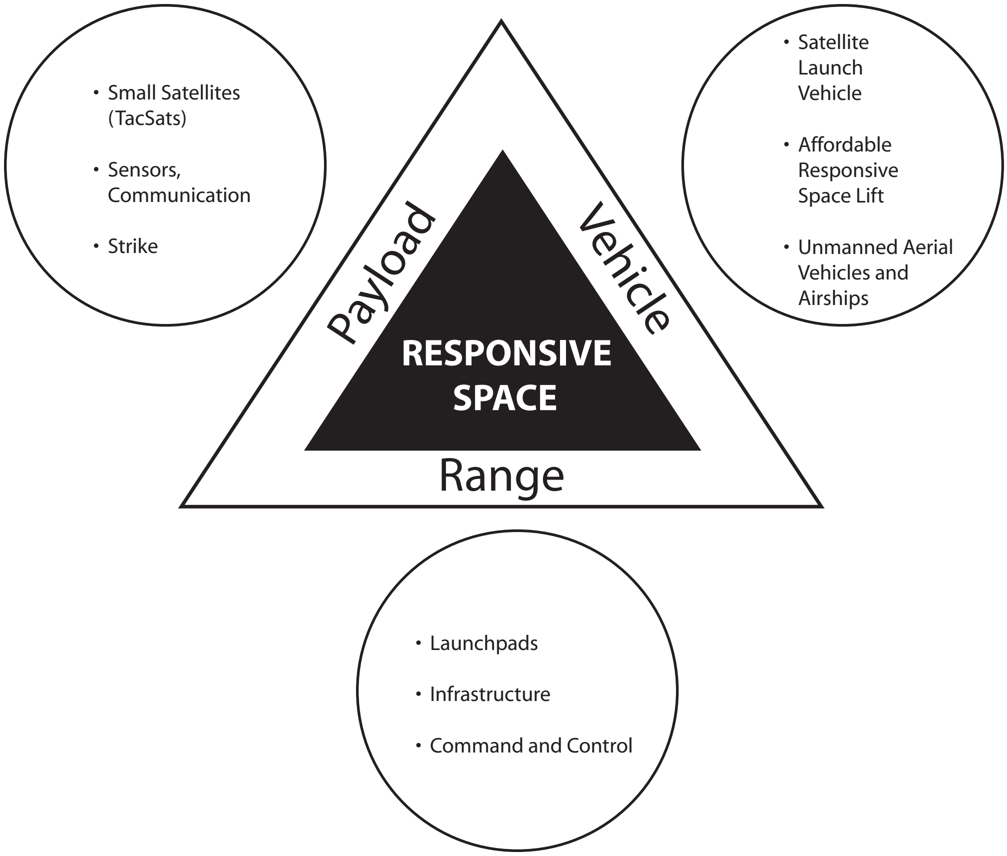


Figure 2. Responsiveness of space architecture. The ORS initiative divides improvements in responsiveness into categories that include the space vehicle, launch vehicle, and infrastructure. Improving each of these areas simultaneously presents a challenge. (From briefing, Lt Col Gus Hernandez, Headquarters Air Force Space Command [AFSPC], Directorate of Plans and Requirements, subject: ORS Overview, 7 March 2005.)

One approach entails not going to space at all since terrestrial systems or aircraft can meet many "space" needs. The Air Force identifies the domain above the typical operational altitudes for aircraft and below the orbital regime, roughly between 65,000 and 325,000 feet, as near space (fig. 3). This high altitude uniquely favors the deployment of intelligence, surveillance, and reconnaissance; battlespace situational awareness; and communications assets. Although we have not made extensive use of near space for military operations due to the technical challenges of operating in this environment, advances in materials, solar collection, and power-storage technology can give the United States an opportunity to exploit this regime for persistent applications.[11]

Spacecraft already on orbit can provide high levels of responsiveness to some types of requirements. Beginning with the end user, the process of tasking, posting, processing, and using data must be timely, flexible, and tightly integrated with the war fighter's processing infrastructure and communications.[12] Centralized national processes task many existing high-demand, high-value space capabilities.

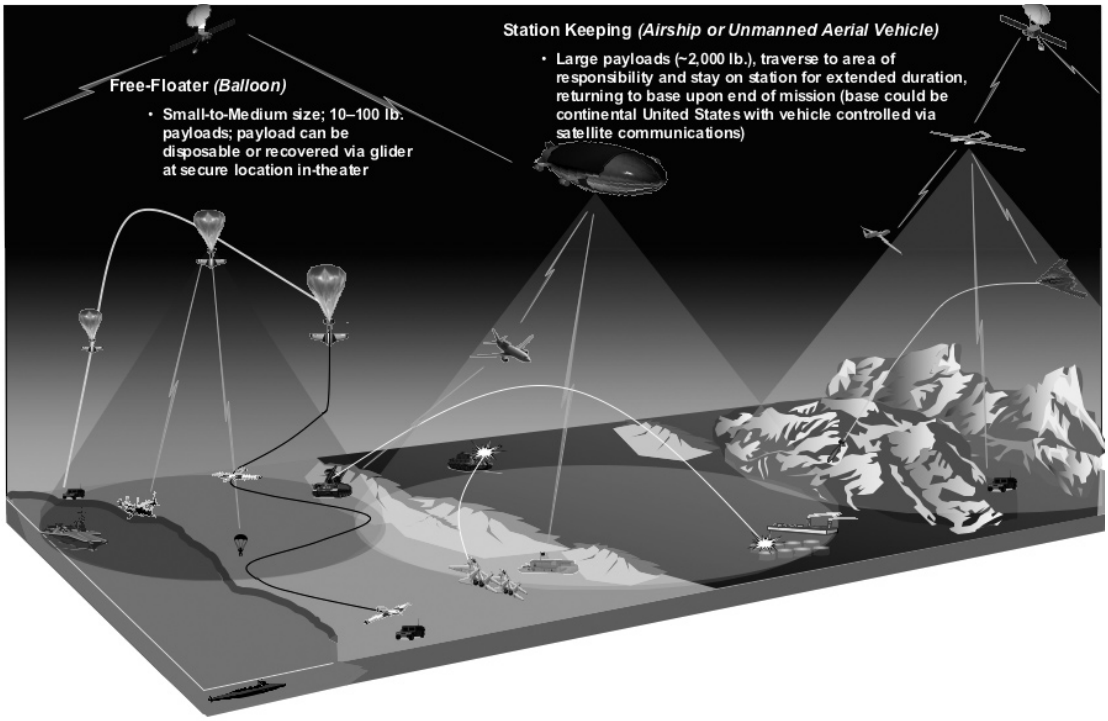


Figure 3. Operationally responsive space: view of near-space architecture. (From "Operationally Responsive Space/Near Space Initial Capabilities Document," draft [Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.], app. A.)

The process of retasking a spacecraft must become responsive to a larger user community. Responsiveness applies as well to such actions as reorienting or maneuvering a spacecraft, modifying onboard software, or changing the pointing of the vehicle's antenna.

We do not limit responsiveness to the space segment; launch can also improve the timeliness of meeting a new user need. Rapidly launching augmentation or replenishment spacecraft can prove essential to maintaining capability during a shooting counterspace war.[13] Efficiently bringing a spacecraft online requires a reduction in initialization and checkout time, which in turn necessitates deliberate engineering to automate processes or eliminate intermediate steps. Currently we build spacecraft according to a launch-on-schedule concept, but responsive vehicles must prepare for launch on demand. We can more effectively shift to the latter approach by maintaining an inventory of war-reserve materiel, spacecraft, and associated launch vehicles at the launch sites (fig. 4). Reaching farther back into the process, acceleration of the research, development, test, and acquisition phase can improve reaction to a new need or an evolving threat.

Because of the expense and risk of experimenting with major operational space systems, cost-reduction and risk-mitigation approaches need validation before commitment to a major acquisition program. The Air Force is exploring concepts for providing responsive capabilities using small spacecraft known as TacSats, relatively inexpensive vehicles weighing less than 1,000 pounds that hold promise as a proving ground for new concepts which enhance the responsiveness and survivability of

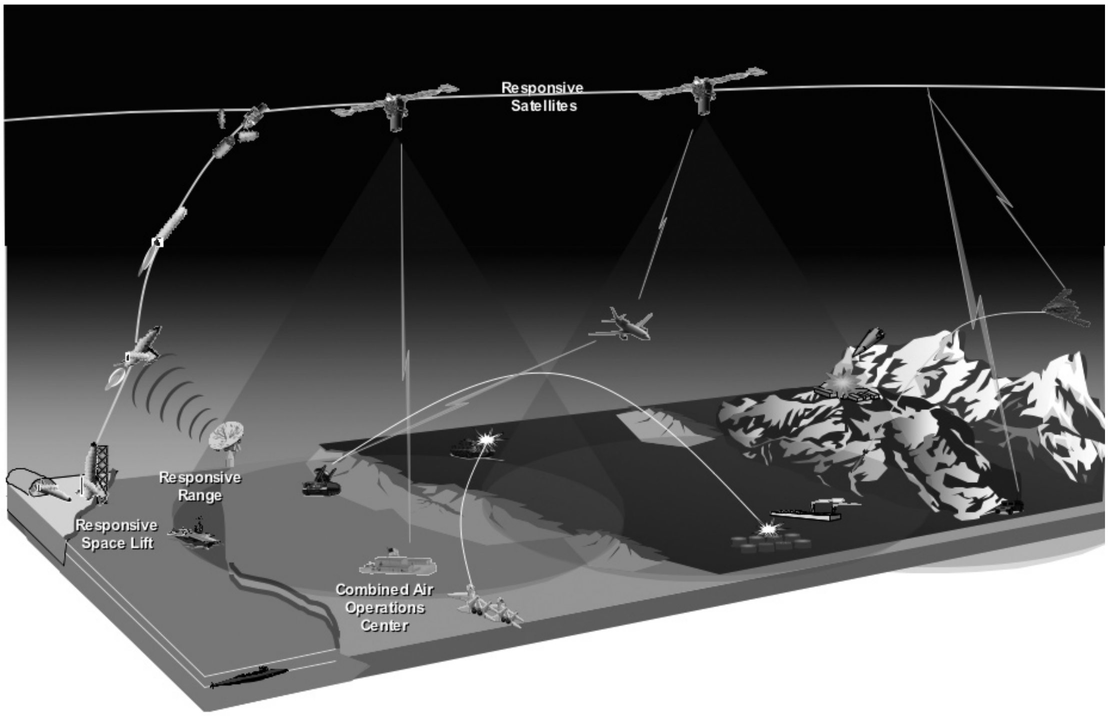


Figure 4. Operationally responsive space: view of satellite architecture. (From "Operationally Responsive Space/Satellite Initial Capabilities Document," draft [Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.], app. A.)

future systems. Additionally, small spacecraft allow the possibility of designing distributed architectures featuring more spacecraft. By providing more but individually less critical targets, such architectures offer the potential to degrade gracefully in response to countermeasures such as antisatellite or ground-based jamming systems. TacSat spacecraft allow the Air Force to experiment with these concepts.

Spacecraft are notionally divided into two system segments: the payload and nonpayload support portions, known as the bus. Responsive spacecraft concepts include improving both of these. Advances in such technological areas as microelectronics could provide "big space" capability in a smaller package. TacSat 3, for example, will feature a hyperspectral-imaging payload and onboard target-recognition software. Existing space systems with long acquisition cycles and on-orbit lifetimes have difficulty incorporating the latest technology, whereas shorter cycles and lifetimes encourage faster technology refreshment in the space segment.

More, smaller spacecraft launched on shorter mission timelines may have additional benefits. The small number of spacecraft and launch vehicles currently produced by the United States complicates the maintenance of an industrial base and increases the unit cost of each craft and vehicle. Convincing the military space industry, which drives the manufacture of high-reliability, radiation-tolerant parts, to continue this production at any price for only a few units per year poses a considerable challenge. Producing relatively few units means that the costs of each are dominated by the "standing army" or the fixed expense of maintaining a capability. For example, the price of owning infrastructure such as a launchpad or a vacuum test chamber remains largely independent of the frequency of use. The expense of maintaining specialized expertise becomes fixed as well when production rates stay low. Thus, larger numbers of spacecraft and launch vehicles, even smaller ones, might result in economic production quantities and cost-reduction benefits, which in turn would allow exploration of new missions or new approaches to existing missions.[14]

The TacSat series of spacecraft is also exploring alternative spacecraft bus-design concepts. By departing from typical spacecraft design (weight optimized and highly customized for the intended application) and instead designing common, modular, standard, or plug-and-play spacecraft buses, we could reduce the cost of the development and production schedule and, consequently, that of the fleet itself.[15] Production rate and operational concept highly influence the trade-off between efficiencies gained through commonality, standardization, and modularity and the place in production flow where we should make such trades. Spacecraft bus concepts offer the possibility of instantly customizing a spacecraft to meet a specific need on an accelerated timeline while keeping costs below existing equivalent-capability costs. For example, a plug-and-play concept may allow selection of the specific spacecraft payload at the launch site. However, preintegrated and tested spacecraft would expedite and simplify launch-site procedures.

Several launch-vehicle designs offer potential improvements to responsiveness. Small launch vehicles, designed as part of the Air Force's/Defense Advanced Research Projects Agency's Force Application Launch from the Continental United States program, offer the prospect of greatly reducing the time and cost of delivering a small spacecraft to orbit. The Space and Missile Systems Center at Los Angeles AFB is developing a new class of launch vehicles that can reduce cost and improve the responsiveness of space launch. The Affordable Responsive Spacelift (ARES) concept, a hybrid configuration, contains a reusable first stage with expendable upper stages (fig. 5). The reusable booster stage accelerates the expendable stages and payload to a separation point in near space. The separated expendable stages provide the remaining impulse to inject the payload into orbit. The reusable booster returns to the launch base to be prepared for the next flight. Cost analyses by the government and industry have shown repeatedly the advantage of fully reusable launch vehicles over expendable launch systems in terms of cost-effectiveness. However, fully reusable solutions require very high flight rates to offset development cost. Additionally, as demonstrated by several attempts, the design of a fully reusable launch vehicle has proven technically daunting. The hybrid ARES concept offers a means of exploring the usefulness of a partially reusable launch concept at low up-front cost and risk.

Both launch vehicles and spacecraft require ground infrastructure. In the case of the former, the Air Force operates extensive, fixed coastal facilities at Vandenberg AFB, California, and Cape Canaveral AFS, Florida, which need major upgrades and may be easy targets for opposing counterspace forces. Transportable launch infrastructure, however, which could operate from alternate locations, offers a means of avoiding the lengthy, expensive planning required to resolve safety issues and to use the existing infrastructure. On the spacecraft side, ground-control and data-processing costs can exceed those of the spacecraft. Responsive systems must exploit existing military and commercial infrastructure in order to keep the effect of costs and logistics manageable. Developing austere ground systems that can react rapidly will prove challenging.

Development of responsive space may in turn enable new concepts. We could use a highly responsive and inexpensive space-launch capability to precisely deliver conventional ordnance anywhere in the world (a Prompt Global Strike system). Low-cost spacecraft could enable space systems to provide direct support to the operational and tactical levels of warfare, as envisioned by the Air Force's concept document on joint war-fighting space.[16] Development of quick-response spacecraft capable of augmenting existing capabilities might allow transition to an expeditionary space forces

Figure 5. ARES vehicle. The ARES concept calls for a vehicle with a reusable first stage and expendable upper stages (also known as a hybrid launch vehicle). (Courtesy USAF.)

concept whereby we deploy the full system capability only when needed. Counterspace missions will benefit from improvements to small spacecraft and responsive-launch technologies associated with ORS. Ultimately, technologies that improve the responsiveness of new missions and small spacecraft will transform the way we perform traditional space missions.

Changing the way space professionals think about space systems may prove the most formidable obstacle to creating a more responsive space system. Some people perceive current systems as high-value assets that we must protect—not consume. Deciding whether or not to shorten the projected mission life of an existing spacecraft by using onboard fuel to move the spacecraft in support of a contingency will have national implications. In the future, operators of responsive space systems will need to react to the changing needs of US forces and to the actions of opposing forces in a dynamic, timely fashion. Initiatives such as the National Security Space Institute, which shapes future space leaders, may be more important than technology development in the long run (fig. 6).

Future adversaries will inevitably take steps to counter US space capabilities. At the same time, technology will continue to shape the evolution of military space systems. Improvements in the responsiveness of space systems give us the means of proactively engaging these future changes. ❑

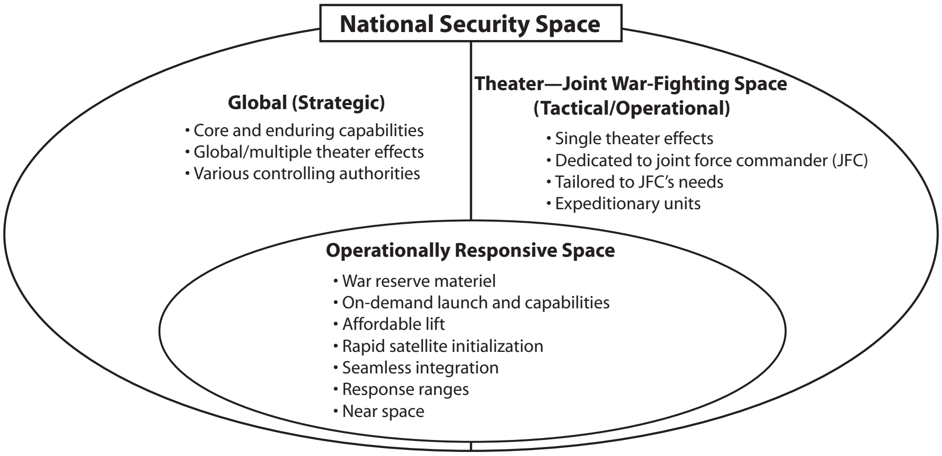


Figure 6. Relationship among ORS, strategic space, and tactical space. (From briefing, Lt Col Gus Hernandez, Headquarters AFSPC, Directorate of Plans and Requirements, subject: ORS Overview, 7 March 2005.)

Notes

1. During Iraqi Freedom, the global positioning system precision-guided more than 25 percent of the munitions expended. Lt Gen T. Michael Moseley, USAF, commander, USCENTAF, *Operation Iraqi Freedom—By the Numbers* (Shaw AFB, SC: USCENTAF/PSAB, 30 April 2003), http://www.globalsecurity.org/military/library/report/2003/uscentaf_oif_report_30apr2003.pdf.

2. Gen Lance Lord, commander, Air Force Space Command, White Paper (Peterson AFB, CO: Headquarters AFSPC, 23 August 2004), 1.

3. "Operationally Responsive Space/Launch Vehicle Initial Capabilities Document," draft (Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.), 3.

4. Jeremy Singer, "U.S.-Led Forces Destroy GPS Jamming Systems in Iraq," *Space News*, 25 March 2003.

5. Lt Col Clayton K. S. Chun, *Shooting Down a "Star": Program 437, the US Nuclear ASAT System and Present-Day Copycat Killers*, CADRE Paper no. 6 (Maxwell AFB, AL: Air University Press, April 2000), 32, http://aupress.au.af.mil/CADRE_Papers/PDF_Bin/chun.pdf.

6. *Challenges to US Space Superiority*, NASIC-1441-3894-05 (Wright-Patterson AFB, OH: National Air and Space Intelligence Center, March 2005), 2, http://www.armscontrolwonk.com/Challenges_to_Space_Superiority.pdf.

7. In 2001 the Rumsfeld Commission recognized the threat: "If the US is to avoid a 'space Pearl Harbor,' it needs to take seriously the possibility of an attack on US space systems." Jean-Michel Stoullig, "Rumsfeld Commission Warns against 'Space Pearl Harbor,'" *SpaceDaily*, 11 January 2001, http://www.spacedaily.com/news/bmdo-01b.html.

8. David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership*, rev. ed. (Peterson AFB, CO: Air Force Space Command in association with Air University Press, 1998), 247.

9. "Fact Sheet: U.S. Space Transportation Policy, January 6, 2005," n.p., http://www.ostp.gov/html/SpaceTransFactSheetJan2005.pdf.

10. See Chun, *Shooting Down a "Star,"* 32.

11. "Operationally Responsive Space/Near Space Initial Capabilities Document," draft (Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.), 3.

12. The network-centered approach of tasking, posting, processing, and using as opposed to the tasking, processing, exploiting, and disseminating process emphasizes making raw data available to a variety of users for analysis instead of fully analyzed products that are centrally distributed. Regardless of method, the emphasis of ORS remains on accelerating the response of the process.

13. "ORS Analysis of Alternatives" (Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.).

14. Dr. Pedro "Pete" Rustan, director of the National Reconnaissance Office's Advanced Systems and Technology Office, is well known for advocating this style of approach. He did so, for example, in his keynote address to the Third Responsive Space Conference in Los Angeles on 27 April 2005.

15. Douglas E. Lee, "Space Reform," *Air and Space Power Journal* 18, no. 2 (Summer 2004): 103–12, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj04/sum04/sum04.pdf.

16. "Joint Warfighting Space (JWS): The vision for JWS is a fully capable expeditionary space force, ready and responsive to theater warfighters' needs, bringing the full impact of space/near-space capabilities to the operational and tactical levels of war." "USAF Operating Concept for JWS" (Peterson AFB, CO: Headquarters AFSPC, Directorate of Air and Space Operations, January 2005).

Space Power Integration

Perspectives from Space Weapons Officers

Lt Col Kendall K. Brown, USAFR, PhD*

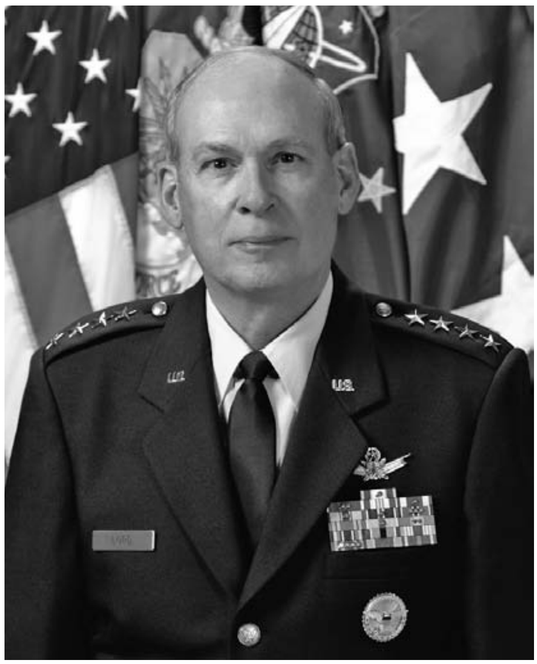
In March 2005 the first Space Weapons Officer Air and Space Integration Conference was held at Maxwell Air Force Base, Alabama, as a joint effort between Air Force Space Command (AFSPC) and Air Education and Training Command. As then-AFSPC commander Gen Lance Lord stated in the invitation to the cadre of space weapons officers (SWO), "We want to hear from the Space Weapons Officers on the best way to integrate space capabilities at the operational level of warfare. What do they think is the best way to do business? Differing views are okay. Articulate pros/cons and support with past experiences—what's worked, what hasn't."[1] General Lord envisioned a regular event where SWOs would gather in the spirit of the Air Corps Tactical School to discuss, argue, and generate new ideas that could then be tested in war games and exercises for incorporation into doctrine, organization, strategy, tactics, and procedures.

The papers presented at the conference have been published in a recent Air University Press book entitled *Space Power Integration—Perspectives from Space Weapons Officers*.[2] I had the honor of editing that book, compiling the conference papers into a handy reference for continued discussion. The following is a brief summary of the ideas presented in the book.

General Lord set the stage for the conference with his introductory remarks:

> We've got to get ready for what's going to happen next in the medium of space. When space starts in a big way, and it will, we have to have the conventional war fighters who have the capabilities, who know the rules of engagement, who are familiar with the laws of armed conflict, who know how to work in this medium and are able to shape and influence and make the right kind of decisions and direct the operational application of space capabilities.

The authors of each chapter presented their ideas directly to General Lord and over a dozen general officers from around the Air Force. The entire cadre of space-officer graduates of the Air Force Weapons School at Nellis AFB, Nevada, was invited, and more



Gen Lance Lord, USAF, Retired

*Colonel Brown, an Air Force Reserve individual mobilization augmentee, is a liquid-rocket-engine system engineer at NASA's Marshall Space Flight Center in Huntsville, Alabama.

than 60 attended. The SWOs presented their ideas not only to senior leadership, but also to their colleagues and peers. In the Air University tradition of nonattribution, most of the ideas presented generated lively debate. In particular, a recurring theme of "normalizing" the presentation of space forces to the theater commander was greeted with approval from most SWOs, although some of the senior officers in attendance were not quite as enthusiastic.

The papers in *Space Power Integration* address issues across a spectrum of air and space integration topics at the operational level of war. Several papers argue that current space doctrine regarding organization and

Ionospheric forecasts improve war-fighter communication efficiency. The Scintillation Network Decision Aid antenna, located on Kiritimati Island (Christmas Island), Republic of Kiribati, monitors geostationary satellite communication signals to determine the effects of ionospheric turbulence. (US Air Force photo) command relationships needs to be revised, with recommendations ranging from subtle modifications to paradigm-changing constructs. It is important to note that a major revision to Air Force Doctrine Document (AFDD) 2-2, *Space Operations*, 27 November 2001, was in progress at the time of the conference and during the preparation of this book. As such, many of the fundamental arguments about organizing space forces to best support the theater joint force commander may have been addressed within doctrine. Doctrine does not and cannot provide extensive implementation guidance and direction; therefore, *Space Power Integration* provides some perspectives from space operators who have had direct responsibilities for integrating air and space power at the operational level of war.

Space Power Integration begins with a paper providing a space-power framework and a recommendation for how the space-coordinating authority should enable unity of effort for diverse information services from space. The second paper builds upon that background by discussing the importance of counterspace operations and how they are needed to support counterterrorism. The background information in the early chapters helps the nonspace operator put the remaining chapters in better context. The following six papers discuss various perspectives on problems due to the current command and control (C2) of deployed space forces' organizational models. Some overlap of ideas is present, and no attempt was made to remove this overlap during the development of *Space Power Integration*; rather, this overlap serves to identify areas of consensus. Conversely, the areas of conflicting observations and recommendations highlight the difficulty of reaching a common

Combined air operations center at an air base on the Arabian Peninsula

SSgt Robert Cook watches a storm move south at Manas Air Base, Kyrgyzstan. The weather flight transmits updates every 15 minutes during weather events such as a thunderstorm, based on satellite images and physical observation of the skies overhead. (US Air Force photo by SSgt Lara Gale)

understanding on such a complicated subject. The next two papers highlight how the C2 structure of deployed space forces was not symmetric with other functions in the theater air operations centers for Operations Enduring Freedom and Iraqi Freedom, and recommend that space forces be organized within an expeditionary mind-set. The next four papers offer organizational-model alternatives envisioning an even greater role for deployed forces to support space-control missions, including offensive and defensive counterspace. The alternatives presented include an organizational model within the structure of the warfighting headquarters, a model based upon the structure of the Department of Defense's personnel-recovery organization, and two variations for models based upon air-mobility constructs. The final paper offers a very personal perspective on problems the author has experienced, what he believes are the fundamental causes, and his specific recommendations to address those issues.

The discussions that occurred during the conference could not have taken place in the past because space officers did not have the operational experience of integrating air and space at the operational level of war. Space officers have learned many lessons and are proposing that we use those lessons to improve future operations. These discussions also point out how the Air Force is moving more and more towards a seamless integration of air and space capabilities, versus the technically based centralization of space capabilities in the not-so-distant past.

As Gen Gregory Martin, then-commander of Air Force Materiel Command, commented during the conference,

> We do space, the United States Air Force does space, the others use it. We have the preponder-

Gen Gregory Martin, USAF

> ance of space warriors and space equipment. It is these advances in technology and personnel that have provided the Air Force the communication, navigation, and imaging capabilities that provide the United States a critical asymmetric advantage. Operation Iraqi Freedom was the first major engagement where these capabilities were so thoroughly integrated in support of the theater commander, through the combined force air and space commander and the air and space operations center. As future adversaries increase their space capabilities, the United States must meet the challenge by improving the efficiency of integrating our space capabilities across the entire spectrum of operations.

That is the challenge for the future, providing effective and efficient integration of air and space capabilities in support of the commanders' objectives. For this level of integration in the theater to be a reality, deployed space forces will be called upon to more actively participate in the commanders' planning and operations. Hopefully, the discussions in *Space Power Integration* will help spur the discussion and debate to arrive upon the doctrine and organizational models needed to provide that support. Planning for the second Space Weapons Officer Air and Space Integration Conference has begun, to be held in spring 2007; it will provide the forum for these discussions to continue. ❑

Notes

1. Space weapons officer (SWO) is an unofficial title for career space officers who have graduated from the US Air Force Weapons School. By having a common knowledge basis with their airpower brethren, SWOs have worked in theater operations centers during multiple recent operations to more fully integrate space capabilities into operational planning.

2. Kendall K. Brown, ed., *Space Power Integration—Perspectives from Space Weapons Officers* (Maxwell AFB, AL: Air University Press, 2006).

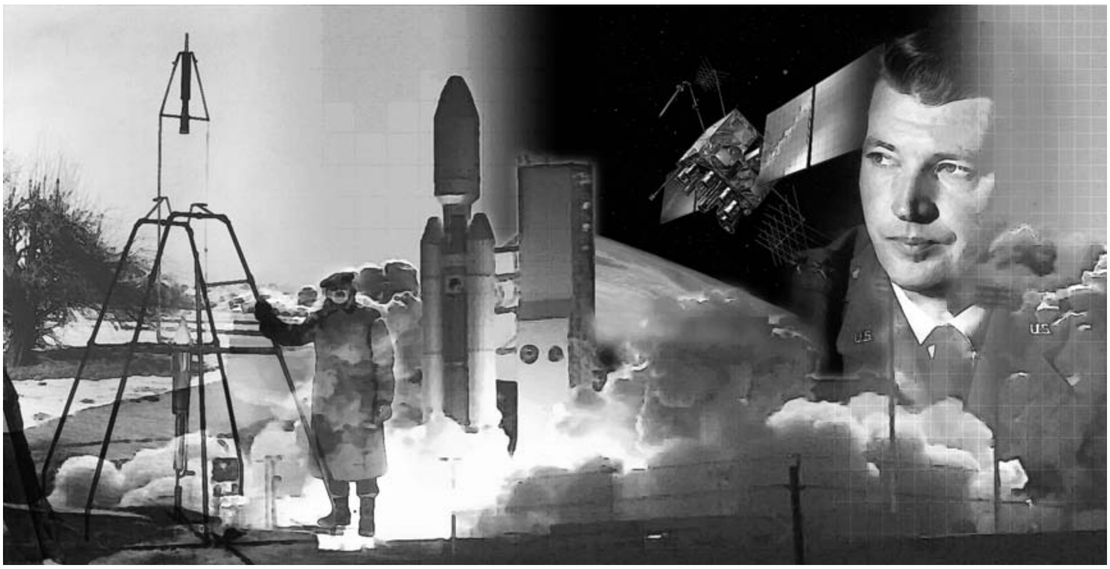
Features

Building Space Power for the Nation

Air Force Achievements, Challenges, and Opportunities

Lt Gen Michael Hamel, USAF

Editorial Abstract: Though an obvious and critical force multiplier for US combat power throughout its short history, US space power has been beset by numerous upheavals, stovepiped structures, military and civilian organizational rivalries, and an ever-expanding demand on its operational resources. General Hamel proposes new ways in which the United States can optimize its space assets for the future, with multiple steps toward fully mature space power fulfilling its role as a key element of our national military power.



ONGOING MILITARY OPERATIONS in Afghanistan, Iraq, and other regions of the world have graphically demonstrated the critical role that space capabilities play in planning and conducting joint military operations. Space forces provide unprecedented global presence, access, precision, speed, and agility, which give unique and asymmetric military advantages to the United States. Military space capabilities came into being less than 50 years ago; since that time, they have advanced from simply proving the feasibility of orbiting satellites to providing routine and reliable service to all military operations through a broad array of sophisticated space systems.

Although the Air Force and others have developed and fielded extraordinary space capabilities, one finds a prevailing sense that military space has not yet come of age—that it has not fully matured as a medium of military operations or a distinct warfare community. People disagree about the contribution of space in the spectrum of military capabilities, the best ways to employ it, and, more significantly, its role as an instrument of national power. Military space capabilities have grown for decades, but no unified and accepted theory of space power exists—certainly not as robust or mature as the body of theory and doctrine for land, sea, or air. One also finds no clear agreement on needed military space capabilities, their employment, and the Air Force's role in advancing our nation's military space power.

This article examines the evolution of military space within the Air Force, assesses where we are today, and discusses steps the service should take to advance military space capabilities. Its intended audience lies largely within the Air Force—both the space and air communities. Hopefully, the article will also prove helpful to other services and agencies as well as defense and congressional officials who have key responsibilities and interests relative to the military uses of space. In order to better indicate where we should be going and how best to get there, it examines issues by tracing from whence our military space capabilities evolved and how they did so.

How Did We Get Here?

Several factors have hampered researching and writing about the history of military space. Although we have operated in space for over four decades, from a historical perspective this is a relatively short period of time. Additionally, numerous changes in military space organization over the years have clouded institutional memory and the historical record. Further, much of the history of military space remains classified, by virtue of the secretive role space played throughout the Cold War. Rather than providing a comprehensive history, this article discusses key events, decisions, and formative forces that have led us to our current status; most importantly, it offers lessons and implications for the future.

We recognized the potential military benefits of space as the "ultimate high ground" long before we proved the means of getting into or operating in space. Scientists and experimenters dreamed of spaceflight and worked diligently in the early twentieth century to develop rocket technologies. World War II accelerated rocket development, and Cold War competition between the United States and Soviet Union made long-range nuclear missiles the centerpiece of the nation's defense. Rapid advances in nuclear weaponry and rockets were essential to containing Soviet ambitions; the launch of *Sputnik I* in 1957 and the shootdown of the U-2 piloted by Francis Gary Powers in 1960 galvanized military space as a top defense priority. Space rapidly became a vital element of our national security strategy and international stability.

Fresh from post–World War II debates over the roles of airpower and the establishment of the Air Force as a separate service, the Air Force quickly asserted its vision and claims regarding military space. Through the 1950s and into the early 1960s, the service argued that space was a logical extension of the medium of air, coining the concept of aerospace and asserting that it should be the lead service for space within the Department of Defense (DOD). Other services and agencies had significant space capabilities and aspirations, but through visionary leadership, astute organizational moves, and key program successes, the Air Force established itself in the early 1960s as the primary space service. A parallel and covert National Reconnaissance Office (NRO) emerged to develop and operate space reconnaissance systems designed to collect critical intelligence over denied areas, primarily the Soviet Union. After solidifying space leadership in the 1960s, the Air Force led rapid growth in military space technologies, programs, and infrastructure. A broad array of space capabilities was developed and fielded in this decade, including communications, weather, navigation, missile warning, nuclear detection, imagery, and signals-intelligence satellites, as well as launch systems, satellite control, and test ranges. These systems rapidly matured, becoming routine and reliable operations by the late 1960s and early 1970s.

The Air Force conducted most of its early space efforts in Air Force Systems Command (AFSC)—its research and development community. Some space capabilities, such as space surveillance, missile warning, and nuclear command and control (C2) operations, were the responsibilities of Aerospace Defense Command and Strategic Air Command. A unique culture developed in the space community during the first decades, characterized by innovative program management; cutting-edge technical and engineering expertise; rapid, spiral development of mission-unique systems; and close partnership between government and industry. Although strategic and operational needs of the Cold War clearly drove the overall space business, the capabilities produced were more often driven by "technology push" rather than "operational pull."

By the early 1980s, the Air Force concluded it needed an operational space command to bring military space to full maturity, so it established Air Force Space Command (AFSPC) in 1982. Creation of United States Space Command followed in 1985. As interest and dependence on space grew, other services and agencies created space commands and organizations to develop and exploit space capabilities. This action inevitably fueled interservice and interagency rivalries and competitions; it also led to fragmentation of military space programs, operational capabilities, and authorities.

Simultaneously other major tectonic shifts in military space occurred. A national decision mandated establishment of the National Aeronautics and Space Administration's (NASA) space shuttle as the nation's sole means of accessing space, forcing redesign of virtually all military and intelligence satellites, major Air Force investments in military-unique shuttle capabilities, and significant organizational and cultural accommodations among the very different Air Force and NASA communities. Loss of the *Challenger* space shuttle in 1986 reversed directions, and numerous program, organization, and personnel changes ensued. In addition, the president's decision in 1983 to pursue space-based missile-defense capabilities—the "Star Wars" program—brought about major realignments of space programs and responsibilities within the DOD.

Operational commands for space continued to mature through the 1980s and early 1990s. The Air Force realigned space roles, responsibilities, and forces from AFSC to AFSPC and made a priority of "operationalizing" and "normalizing" Air Force space, including creating space wings, formalizing operational training, developing space-career tracks, and advocating operational space systems and programs. Shifts in responsibilities, organization, and culture created significant rifts and frictions among the space communities within the service—AFSPC, AFSC, and the Air Force NRO element—leading to internal conflicts and dilution of space expertise across the Air Force community.

The fall of the Berlin Wall and collapse of the Soviet Union brought into question the fundamental roles, capabilities, and purposes of military space. Operation Desert Storm, referred to as the "first space war," quickly answered many of these questions. Space had been integral to strategic nuclear deterrence for decades but did not see its first large-scale operational and tactical use in a conventional war until the first Gulf War. Desert Storm provided a glimpse into a future in which space would serve as a key enabler of joint war fighting. The end of the Cold War also brought about many significant organizational, program, and budget changes. The Air Force disestablished Strategic Air Command and transferred its air assets to the newly created Air Combat Command and its intercontinental ballistic missile forces to AFSPC in 1993. AFSC merged into the new Air Force Materiel Command, and a new service acquisition-management structure was created, with the program executive officer and the assistant secretary of the Air Force for acquisition placed directly in charge of program-management execution. Finally, the NRO underwent realignment from its separate program structure—Program A

(Air Force), Program B (Central Intelligence Agency), and Program C (Navy)—to an integrated structure organized by major mission areas (imagery, signals intelligence, and communications).

The enormous organizational, program, and cultural change in military space that occurred from the early 1980s to early 1990s produced divergent communities, fractious relations, and competing visions and directions throughout the Air Force as well as the broader military space community. Systems and operations became both more interdependent and "stovepiped." As the Air Force evolved into new post–Cold War organizations and forces, space played a more prominent role, and the service placed great emphasis on integrating space capabilities into war-fighting operations. The mission of the Air Force evolved to "controlling and exploiting air and space" with a vision of an "air and space force" evolving into a "space and air force." To further emphasize the synergies of the air and space mediums, the Air Force focused for several years on "aerospace integration" as its guiding vision. Efforts to unite the Air Force institutionally to a common air and space vision produced much progress but also blurred the different capabilities, effects, nature, and contributions of both air and space.

In addition, much of the history of military space has seen continuing domestic and international debate over the uses of space for military purposes. Few people question such use to enhance or enable terrestrial military operations. However, heated debate persists regarding the use of space for delivering combat force against terrestrial or space targets. From the earliest days of the space age, the United States purposely advocated the principle of peaceful and unimpeded use of space by all nations, as well as the legitimate right to use that medium for military purposes and for defense of its vital interests. Since the 1970s, US national policy regarding space has proved remarkably steady—it has recognized space as vital to the nation's well-being and competitiveness. Further, consistent with treaties and accepted international agreements and norms, the United States as a matter of policy will maintain the right—and ability—to take any actions necessary to defend its space capabilities and interests, as well as deny adversarial uses of space that threaten American interests. Despite the constancy of policy, debates continue, and no clear national intent exists to field military capabilities for actual combat operations in or from space.

Where Are We Today?

Today space is integrated and employed in virtually every aspect of military planning and operations, from peace through crisis to major theater war. It critically enables warfare at all levels—strategic, operational, and tactical—and has become integrated into virtually all air, land, sea, and special operations. Although we use and depend upon space to an ever-increasing extent, we do not have a clear and consistent theory or intellectual framework for its use. For decades people have debated whether space is an area of operation, a medium, a mission, or a collection of functional capabilities. Each of these perspectives has proponents, but the absence of a unifying, broadly accepted intellectual framework for space impedes the development and employment of space power. The Air Force has long held the view that space is analogous to and a logical extension of the medium of air, but has wrestled for some time over the concepts of aerospace versus air and space. Most people generally agree that differences exist between the two mediums with regard to the physics of flight, vehicles, international law, attributes, and effects, all of which require different expertise and thinking. At the same time, one can also make a strong case that the vertical dimension of warfare requires unique, integrated perspectives best brought to bear by the Air Force.

Today military space includes numerous stovepiped systems operated by different communities, services, and agencies that use different concepts and approaches for operating and employing these capabilities in peace, crisis, and war. Some individuals view space-based communications as simply communication systems, while others see them as space operations. Similarly, some often look at reconnaissance, warning, and other missions performed in the medium of space as national intelligence functions—not as joint war-fighting operations.

The Air Force is responsible for the majority of the space programs, people, resources, and infrastructure across the DOD—roughly 85–90 percent of the total. However, other services and agencies have important needs for space in execution of their assigned missions and often bring service-unique space capabilities. In fact, even though the Air Force provides most military space capabilities, it is not the major user of them and their effects. This fact creates a number of tensions. The Air Force does not fully understand or appreciate the use of space by other services or agencies. Other services criticize the Air Force for not providing all the desired joint space capabilities. Inside the Air Force, one encounters concerns that growing demands for space capabilities will inevitably affect other needs and priorities of the service.

Most of today's space capabilities were originally conceived and fielded in the 1960s and 1970s, with the global positioning system (GPS) representing the most recent "new" one, reaching initial operational capability in the early 1990s. Significant enhancements in individual systems and technology have occurred, but development delays and cost overruns have become the norm while technological innovation has slowed and risk has become increasingly unacceptable. Some would argue that the culture of innovation, together with operational, technical, and management skills developed in the first decades of military space, has atrophied.

The many changes in organizations, programs, culture, and priorities over the past two decades have seriously fragmented the military space capabilities and community. Despite the fact that the Air Force provides the bulk of space expertise and capabilities, one finds serious fragmentation and dilution of authorities and responsibilities among the services, defense agencies, combatant commands, and DOD staffs. Operational responsibility, service expertise, mission advocacy, operational requirements, system acquisitions, and budgets are not aligned as they are in other service-warfare communities.

Where Should We Go, and How Do We Get There?

The DOD is organized around mediums of operation—land, sea, and air—and depends upon military services to provide institutional capabilities and competencies to organize, train, and equip forces for combatant commands to plan and execute joint military operations. Air Force space should have the fundamental goal of leading and bringing operational capabilities in the medium of space to full maturity by building institutional capabilities—people, forces, and processes—necessary to employ space capabilities as an integrated element of joint war fighting. We have identified and studied many of the problems and issues associated with military space and have begun a variety of efforts and initiatives to enhance our capabilities in national security space. In 2001 the Space Commission provided a comprehensive assessment and recommendations concerning management and organization of national security space. Although many of these (discussed below) are important, other steps are also essential to the maturation of space power and its role as a key element of our national military power—developing a coherent and accepted intellectual framework for military space; focusing on space superiority as the overarching and unifying imperative for military space; building a critical mass of space professionals with common culture, expertise, and vision; getting space development and acquisition on track; and bringing a space-leadership mind-set to all we do within the Air Force space community.

Establishing an Intellectual Framework for Space Power

An intellectual framework for space needs to be founded on several important realities. First, space is inherently global and joint. Satellites operate by rules of orbital mechanics, function according to separate international rules, and afford unique global perspective and access. Space is joint in the sense that all services, agencies, and commands need it to fulfill their respective missions and to enable or enhance their distinct war-fighting capabilities. For the most part, joint and service doctrine on space describes roles, responsibilities, relations, and systems. It focuses neither on inherent attributes, capabilities, and effects, nor on the best means to employ or exploit space power. The intellectual framework needs to consider the inherent physical characteristics and operational capabilities of space and apply proven principles of war: unity of command and effort, centralized control and decentralized execution, speed, mass, surprise, and initiative. Information-centric warfare is becoming a critical center of gravity, and space has become the medium through which we enable information superiority for expeditionary operations. Space capabilities connect forces, sensors, and decision makers across the battlespace; they collect data on operationally relevant conditions; they reconnoiter, surveil, and target hostile forces and activities; and they enable precision, synchronization, and C2 of forces in the field. Combat advantages derived from space increase the imperative and incentives for adversaries to deny and disrupt our use of space and to gain their own space capabilities.

One of the key steps in developing and refining the intellectual foundation for space power is to define and describe space capabilities and effects in operationally relevant terms. We need concepts of operations that describe what we do, how we do it, and to what effect. AFSPC's current effort to develop a comprehensive set of space concepts of operation and employment constitutes an important step in moving from stovepiped, system-centric thinking to true operational capabilities and effects-based thinking.

The intellectual framework needs grounding in real operational employment and experience. Today space operates all day, every day, but we have not fully integrated it from the start in deliberate and crisis-action planning. We do not routinely and realistically use it in training or exercises to refine tactics, techniques, and procedures for the joint use of space in the same way we do with air, land, and sea operations. Employed in crisis and war fighting, space has made major contributions to every conflict in which we have participated over the past decade. However, because we often use it in an ad hoc fashion, we have not institutionalized its lessons and capabilities—a situation that reduces the familiarity and confidence of users and commanders. The intellectual foundation for space must capture and codify real operational lessons and experience.

Gaining and Maintaining Space Superiority

The growing military advantage derived from space increases dependency upon those space capabilities, making space forces an attractive and lucrative target for adversaries as well as a serious potential risk to friendly operations. One way to mitigate this risk would be to reduce the use of and dependence on space, but the unique asymmetric advantage derived from space makes this impractical. Alternatively, we could take effective steps to protect friendly capabilities and deny adversaries access to space. Just as air superiority is a first priority in any joint operation, so should gaining and maintaining space superiority become a top priority in peace, crisis, or conflict. Such superiority includes knowing what is in space, natural conditions in the environment, status of friendly and nonfriendly forces, and hostile or threatening actions or events. That is, we need space situational awareness, comprised of a robust set of sensors, analyses, and C2 capabilities, to maintain awareness, formulate responses, and respond to situations/events; defensive counterspace capabilities to detect, characterize, assess, and react to hostile and nonhostile events; and offensive counterspace capabilities to deny an adversary's use of space that could threaten American lives or limit military freedom of action.

During the Cold War, we treated space superiority very seriously, spending billions of dollars on hardening satellites against attacks, building backup ground stations and links, and continuously monitoring adversary actions. Many of those capabilities and much of that expertise passed with the end of the Cold War but have not been replaced with anything suited to current space threats and needs. Further, we have an overarching imperative for cooperation among all space services and agencies to assure space superiority. Despite disagreements over organization, roles, and responsibilities, all players within the space community can and must agree to work in a joint and collaborative way to ensure space superiority for joint operations. Given the growing dependence on space, we cannot assume space superiority; we must guarantee it—and if need be, fight for it.

Developing a Critical Mass and Common Space Culture

The Space Commission noted the need for a robust space-professional culture and community to develop, operate, and employ future space capabilities. This cadre must become truly expert in the space medium, platforms, and operations in order to plan, execute, and employ the full range of capabilities and effects. The commission made many recommendations about developing a space cadre, and the Air Force has taken important steps to invigorate its recruiting, education, training, and career development of space professionals. It is important for the space community to have a broad array of skills and develop a common culture and vision. Its members must identify with and consider themselves part of the space team, derive professional pride from being part of it, and support the larger air and joint war-fighting teams. Members of the space community must be experts in the development and operation of the full spectrum of space capabilities; moreover, they must understand and take responsibility for producing and delivering the combat effects they provide, whether communications; intelligence, surveillance, and reconnaissance; counterspace; or launch. The community must understand in joint war-fighting terms what kind of space capabilities we need and how best to deliver them, when and where we need them. This broad range of capabilities means that the space cadre must include a diversity of specialties beyond simply satellite operators; it must include intelligence, acquisition, communications, and C2 experts. It must include other services and must leverage the full range of people—active military, Reserve component, civilians, and contractors. Space professionals not only must value the things that made military space programs and operations so successful in the early years—technical expertise, innovation, personal initiative, and mission focus—but also must have operational war-fighting focus and ethos. AFSPC's Space Professional Development Strategy and the Air Force's force-development initiatives are excellent frameworks that provide many of the needed tools and skills. However, development of a real space culture and a critical mass of space professionals remains up to the space community itself, which must set high standards of space knowledge, expertise, performance, and leadership. Furthermore, it must be inclusive and accountable for producing and delivering operational capabilities and effects.

Getting Space Development and Acquisition on Track

The end of the Cold War led to significant reductions in people and budgets across the DOD in the 1990s. At the same time, maintaining capabilities on orbit and meeting growing needs for space capabilities meant that demands exceeded available resources. Anticipated growth in commercial space products and services in the 1990s brought about significant private investment in a number of commercial space ventures, the Iridium satellite communications systems prominent among them. This led to a strategy within the DOD and the Air Force of leveraging the commercial investment and industrial base. A series of acquisition-reform initiatives put the Air Force into the role of a buyer rather than an active developer with industry. Wholesale reductions occurred in government people and roles in design, development, manufacturing, integration, and testing of space systems. Processes, practices, and skills that had developed over decades were discarded. Further exacerbating the erosion of capabilities, the air and space industry went through significant consolidation and downsizing in the 1990s. The effects of these eroding capabilities first came to light with a series of launch failures in 1998 and 1999, leading to a loss of critical capabilities and billions of dollars. Similarly, numerous development problems in military space programs became clear: serious overruns, schedule delays, and program breaches on the space-based infrared system, future imagery architecture, evolved expendable launch vehicle, GPS, and national polar-orbiting operational environmental satellite system. These failures have served as a wake-up call for the space community. Nothing threatens US military superiority in space more than the loss of ability to develop, field, and sustain our space systems.

The Air Force's Space and Missile Systems Center at Los Angeles AFB, the leader in space and missile development for over 50 years, has roots in the Western Development Division begun by Brig Gen Bernard Schriever in 1954. The "birthplace of military space," it has conceived, developed, and fielded the vast majority of military space capabilities for over a half century. Recognizing the erosion of space-acquisition capabilities in the 1990s, we have started an aggressive campaign to get "back to basics," elements of which include restoring processes in the development and acquisition business—specifically, systems engineering, mission assurance, integrating and testing, cost estimating, and program control. Another key element calls for rebuilding the space-acquisition workforce—both military and civilian—together with federally funded research-and-development centers and industry through active recruitment and retention as well as education, training, and career incentives. Strong partnership remains the bedrock of success in space for all sectors: government, industry, developers, operators, users, military, intelligence, civil, and commercial. Finally, an emerging business model for space includes tiered, evolutionary development from basic technology to production of operational systems and the use of "lean principles" to reduce cycle time, cut waste, and focus on customer needs. The Air Force and the Space and Missile Systems Center have an aggressive program for change under way to improve space development and acquisition—a key to ensuring continued space superiority.

Exerting Leadership of Military Space

The Space Commission recommended and the secretary of defense concurred with formally establishing the Air Force as the lead service and executive agent for space within the DOD. Realignment of organizational roles and responsibilities has included establishing the undersecretary of the Air Force as the senior space official within the DOD; creating a single budgeting mechanism for space programs (the so-called Space Major Force Program); consolidating oversight of space acquisition; and enhancing the development of space professionals. Realignment of space responsibilities to the new Strategic Command (STRATCOM), another major step in integrating space power with joint war fighting, makes STRATCOM the combatant command for space with responsibility and authority for global military space capabilities. At the same time, because of the enormous breadth of its assigned missions and responsibilities, the command must increasingly look to its service components and defense agencies to provide operational expertise, mission capabilities, resources, and knowledge to deliver joint space war-fighting capabilities and effects to other supported regional combatant commands around the globe.

Military space must focus on the operational capabilities and effects it provides—not simply the systems it builds, the satellites it flies, or the teams it deploys. The space community must become more than the provider of systems: it must serve as the thought leader, it must take responsibility and stand accountable for the combat effects it produces, and it must include all members of the joint team in producing and delivering those effects. These capabilities and effects must operate on a global basis, but theater commanders and forces must have access to them at the needed times and places. The Air Force has made good progress in building space's operational integration capabilities in theaters by assigning space officers to staffs and establishing the theater's joint force air component commander as the space coordinating authority, with a senior director of space forces assigned to help execute those responsibilities. Making the space coordinating authority's responsibilities and authorities work requires having a well-integrated global space operational force and commander able to execute STRATCOM's space mission and the commander's intent.

The Air Force should act as STRATCOM's outspoken advocate for the space medium and operational missions and should serve as its principal provider of space-combat capabilities and effects. Given the breadth of STRATCOM's mission responsibilities, there exists a clear opportunity and need to establish a joint, operational-level space command and responsible commander to provide global space operational capabilities all day, every day. Doing so would bring much needed focus on operational space and offer the opportunity and responsibility for the Air Force to lead joint space operations, much as it does with airpower in regional combatant commands. Just as its role as executive agent conveys authority, responsibility, and accountability for developing and fielding space capabilities, so are integration and leadership of joint, global space operations under combatant command authority of STRATCOM essential to achieving the full potential of space power. This role will require the Air Force to fully develop the vision, concepts, and capabilities for joint space power; commit to its development; and earn the trust and confidence of STRATCOM, as well as the trust and confidence of the other combatant commands, services, and defense agencies.

Conclusion

In the nearly 50 years since the beginning of the military space and missile program, we have made remarkable progress in developing, fielding, and employing space capabilities. Today we find ourselves at a point where military space power has gained recognition as a critical element of our national military power. Having positioned itself at the forefront of leading space development since the earliest days, the Air Force should take great pride in its many achievements. Our service provides the vast majority of people, programs, budget, and expertise for military space but does not have a primary role in operationally delivering those space capabilities and effects. Numerous reorganizations, program restructures, career-field realignments, and mission changes have disrupted the maturation of the Air Force's space community and culture. Further, these events have led to fragmentation of space capabilities and responsibilities across the DOD. Growing dependence on space for success in joint operations demands firm steps to improve war-fighting capabilities within the space community. This in turn means that the Air Force, as the clear leader in DOD space, must assert its leadership—vision, commitment, and excellence. Our service's history in space provides key insights into the culture and expertise that produced incredible capabilities and successes over the past 50 years and can help refocus our people, expertise, operational capabilities, and organizational excellence. The Air Force must provide the essential intellectual, human, and institutional leadership if space power is to realize its full potential as an instrument of vital importance to our national security and defense of the nation. ❑

Ten Propositions Regarding Space Power

The Dawn of a Space Force

Lt Col Mark E. Harter, USAF

Editorial Abstract: Through an exhaustive historical review of space, multiple interviews with field professionals, and thorough examination of pertinent sources, Colonel Harter develops a list of fundamental propositions and keys to space power. From this discussion, he advocates that the logical consequence of these propositions for realizing the full potential of military space power is a separate and distinct space force, replete with its own doctrine, leadership, organization, and resources.

No one can predict with certainty what the ultimate meaning will be of mastery of space.

—Pres. John F. Kennedy, 1961

ON 4 OCTOBER 1957, the Soviet Union stunned the world by successfully launching the first artificial satellite, *Sputnik I,* into low Earth orbit (LEO). By repeating this feat within a month (*Sputnik II*), the Soviets made a bold statement of profound technological, political, and military significance that ushered in mankind's race for space—"the final frontier." As the Cold War escalated, the United States quickly realized the global implications and military potential of space assets in the "high ground" and responded by developing its own space capability, culminating a decade later in the achievement of President Kennedy's vision and national goal of the National Aeronautics and Space Administration's (NASA) Apollo moon missions. Since then, space development has proliferated, as dozens of nations now pursue economic and military benefits from using space systems.

Based on the current demand for both military and commercial space operations, it is prudent to contemplate (and act upon) the essential elements that define the nature and potential of robust space power. What are the fundamental characteristics of a nation's potential strategic

military space power? Are there propositions regarding space that can provide guidance on the questions and issues that shape a nation's military space-power capability? The answer is yes.

What fundamental strengths best characterize the potential of military space power?

What are space power's key limitations, and how can they be overcome?

What are the keys to executing successful space power?

What resources and command and control (C2) structure are required?

How does a nation achieve space-power status?

This article provides a concise, fresh perspective on the nature and potential of national space power.[1] Through a historical examination of military and commercial space activity, personal interviews with nearly 100 space professionals, and a review of space-power literature from more than 50 sources, this research assesses the strategic *potential* of robust space power and the fundamental propositions that define it.[2] The results point to a "top 10" list of individual propositions and keys to space power, ultimately concluding that a nation's true strategic space power cannot reach its full potential without a separate, independent space force. In effect, this work parallels (in a limited respect, based on time and resources) the thought-provoking research of Col Phillip S. Meilinger, USAF, who published *10 Propositions Regarding Air Power* at the School of Advanced Airpower Studies (SAAS) in 1995, as well as several corollaries produced by other space professionals since then.[3]

Space Power: Historical Background

Space Power will be as decisive in future combat as airpower is today.

—Hon. E. C. Aldridge Jr.
USAF Space Policy, 1988

There is a familiar correlation between early twenty-first-century space power and airpower's infancy in the post–World War I era. The parallels in the development of airpower and space power are interesting if not predictable—the space community is currently wrestling with many of the same issues that plagued early airpower. Similar to post–World War I airpower, there is no question that today's space forces provide a wealth of force enhancement to joint war fighters. Additionally, from a national perspective, space systems provide essential economic, commercial, and scientific capabilities resulting in potential centers of gravity (COG).[4] Just as nations protect their land, sea, and air assets for economic, commercial, and military purposes, the protection of space capabilities is becoming increasingly important (space control). Like the early airpower advocates wrestling with how to achieve effective airpower, today's space community wrestles with very similar doctrinal, organizational, and operational issues:

Airpower: After World War I	*Space Power: Early Twenty-first Century*
Proven force enhancement (intelligence, surveillance, and reconnaissance [ISR]) from World War I.	Proven force enhancement (ISR, navigation, weather, communications) from Operations Desert Storm, Allied Force, Iraqi Freedom/Enduring Freedom.
Demonstrated support to ground/naval forces.	Demonstrated support to ground, naval, and air forces.
Can airpower be both offensive and defensive?	Can space power be both offensive and defensive?
How to develop strategic/tactical airpower?	How to develop strategic/tactical space power?
Best way to integrate airpower into joint operations?	Best way to integrate space power into joint operations?
Acquire adequate budget for airpower systems?	Acquire adequate budget for space-power systems?
Optimized airpower C2?	What is the most effective space-power C2 construct?
Develop airpower doctrine, policy, and training.	Develop space-power doctrine, policy, and training.
Does airpower warrant its own separate service?	Does space power warrant its own separate service?

Lessons learned from the history of airpower development allow national space power to avoid similar mistakes and pain. Recall that airpower emerged during the post–World War I era as a legitimate military capability, bringing with it the great airpower theorists William "Billy" Mitchell, Giulio Douhet, and Hugh Trenchard (to name a few), and leading to an eventual independent US Air Force. This author suggests that, based on the parallels with the birth of airpower, the space community is on the brink of undisputable space power, with the emergence of spacepower theorists and the birth of an independent space force in the next decade.

Definitions

Proposition—something offered for consideration or acceptance.[5]

Space—begins where satellites can maintain orbit (81 miles) and extends to infinity.[6]

Power—control or authority to influence; the ability to produce an act or event.[7]

Space power—a nation's ability to exploit and control the space medium to support and achieve national goals.[8]

This article offers relevant guidance on the questions and issues that shape a nation's space-power capability. Military space operators, strategists, planners, policy developers, and acquisition professionals will benefit from contemplating these propositions as they develop their understanding of space power and employ space forces into the next century:

1. Space is the ultimate high ground.
2. Space is a distinct medium; space forces require space-focused theory, doctrine, and policy.
3. Space power is a force multiplier for every combatant commander and military service.
4. Space forces can support all levels of war simultaneously.
5. Space power leverages a nation's economic and military centers of gravity.
6. Space superiority starts with assured access to space.
7. Controlling space requires eyes, ears, shields, and swords.
8. Space forces require centralized command and control led by space professionals.
9. Space power is a function of a nation's total space capability (space unity of effort).
10. National space power reaches its full potential when a nation commits to a separate, independent space force.

Ten Propositions Regarding Space Power

These 10 space-power propositions are grouped in two categories: space characteristics and space challenges. Propositions one through five characterize the space medium, revealing the significance, advantages, and value of space power. Propositions six through 10 frame the challenges in achieving robust national space power. Arguments are provided for the security, control, and dominance of the space medium through space superiority (space lift, counterspace operations, and space-forces C2) and national unity of effort. The 10th proposition summarizes the key to achieving national space power—an eventual and necessarily separate, independent space force.

1. Space is the ultimate high ground.

Take the high ground, and hold it!

—Sun Tzu, circa 500 BC

Great military leaders realize the strategic, operational, and tactical advantages of controlling the high ground. From Sun Tzu's ancient Chinese warriors securing a hill, to US Civil War manned balloons, World War I aeroplane pioneers, World War II aviation heroes, and Cold War high-flying SR-71s and U-2s, the high ground provides the strategic advantages of security, situational awareness, reconnaissance, targeting, and offensive force to dominate the battlespace. The space medium is the ultimate high ground, with unparalleled speed, range, altitude, and stealth.

High-ground space systems provide a conduit to channel instruments of national power (diplomatic, informational, military, and economic) to coerce an enemy to capitulate. The twenty-first-century information age, the global information grid, information technology, and network-centric warfare all depend on real-time global collection and dissemination of information, often only possible from space systems. The informational and military instruments of national power are closely linked. Information operations, information warfare, and information-in-war likewise depend on robust space platforms and illustrate that "bullets win battles; information wins wars." Space systems are one of the main pipelines for network-centricity, powering digital networks to distribute information instantly without borders. Satellite communications (SATCOM) provides real-time, secure, jam-resistant C2 to enable diplomatic actions among nations. Space systems support or disrupt a nation's economy by moving large data streams at the speed of light around the world, reshaping national economies with global connectivity (SATCOM, weather, navigation, environmental, scientific, etc.). The White House's national security strategy of 1998 benchmarked the importance of space.[9]

> *Space has emerged as a new global information utility with extensive political, diplomatic, military, and economic implications for the United States. Unimpeded access to and use of space is essential for protecting U.S. national security and promoting our prosperity.*
>
> *A National Security Strategy for a New Century*, October 1998

As the ultimate high ground, the space medium is potentially the most geopolitical, perhaps more so than any other medium in which the military operates. Space is global by nature. The space medium holds no geographic or nation-state boundaries. Satellites traverse in their orbits above every nation in the world, usually unnoticed and eluding traditional terrestrial choke points. In space, territorial sovereignty is nonexistent (with the exception of equatorial geosynchronous Earth orbit [GEO] slots directly above each country) but still highly geopolitical with numerous complicated space treaties, international policy, and the laws of armed conflict.[10]

2. Space is a distinct medium; space forces require space-focused theory, doctrine, and policy.

> *When you think about protecting this nation's global interests, you have to remember it starts with space. It is the fourth medium of warfare.*
>
> —Gen Ronald R. Fogleman, USAF
> Air Force Doctrine Document 2-2,
> *Space Operations*, 1998

> *At the very heart of war lies doctrine. It represents the central beliefs for waging war in order to achieve victory. It is fundamental to sound judgment.*
>
> —Gen Curtis E. LeMay, USAF, 1968

Just as ground, naval, and air forces operate in their own distinct environments (mediums), space forces operate in their own distinct medium—the vacuum of space. Air Force Doctrine Document (AFDD) 2-2, *Space Operations*, clearly states, "Space is a medium of warfare like air, land, and sea."[11] Physical laws constrain, empower, and distinguish each medium. Land forces are bound by gravity in two dimensions; sea and air forces are three-dimensional and fully dependent upon Bernoulli's laws of fluid dynamics; and space forces function via Kepler's laws of planetary motion. Accordingly, if ground, naval, and air forces are governed and optimized by their own medium-unique theory, doctrine, and policy, it makes sense that space forces would benefit from their own space-unique theory, doctrine, and policy. Because of each distinct operating environment, sea-power theory clearly does not translate to airpower theory; nor would it seem logical for airpower theory to transfer to space-power theory.[12]

The problem for current space forces is that, since the inception of the US Air Force in 1947 until the 1990s, airpower has overshadowed space-power development, as both were governed under the umbrella of Air Force theory, doctrine, and policy. The USAF claimed in 1958 that the air and space vertical domain (aerospace) was "indivisible."[13] This unfortunately resulted in both airpower and space power being developed simultaneously in an airpower-centric service. Limited resources (budget and manpower) existed during the Cold War to develop both airpower and space power equally; airpower took priority, and space power—viewed as a subset of airpower—suffered.[14] Two major events in the 1990s reversed this 40-year trend and significantly improved space-power development: (1) the end of the Cold War freed up resources for space-power development, and (2) the Persian Gulf War proved to be a "watershed event in military space applications," quickly driving space investments throughout the Department of Defense (DOD).[15] Since then, space-power doctrine at both the service and joint levels has made significant progress, but there is still a long way to go.[16]

3. Space power is a force multiplier for every combatant commander and military service.

> *As proved during Desert Storm, and again during the Balkans air campaign, space is an integral part of everything we do to accomplish our [military] mission.*
>
> —Gen Lester P. Lyles, USAF, 2001

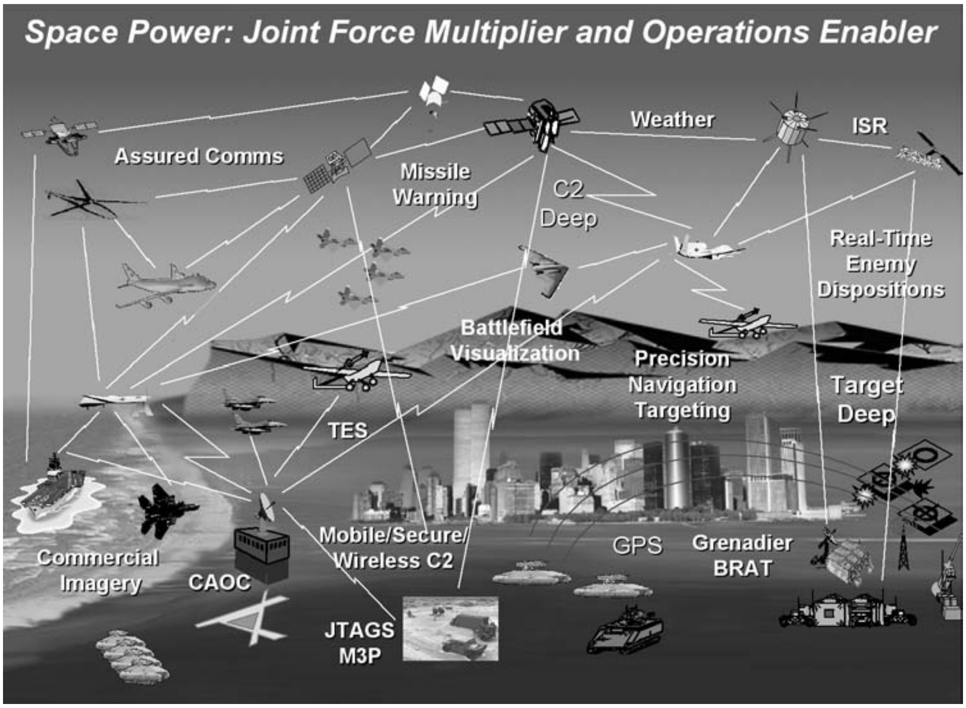
> *Any discussion of Desert Storm cannot ignore the immense contribution made by our space forces. Even less will we be able to ignore space contributions in the future.*
>
> —Gen Charles A. "Chuck" Horner, USAF, 1999

Space power provides military leaders, operators, and planners with enormous force-enhancement effects that multiply joint combat effectiveness in prosecuting theater campaigns. Space systems significantly improve friendly forces' ability to strike at the enemy's heart or COGs, paralyzing an adversary to allow land, sea, and air forces to achieve rapid dominance of the battlespace. Space assets reduce the Clausewitzian "fog of war" by providing synergistic, effects-based operations to terrestrial forces, producing effects that achieve campaign objectives in ways that air, land, and sea forces alone cannot (fig. 1). The emergence of military space following the Vietnam War produced monumental combat advances using 24 hours a day/seven days a week (24/7) space assets such as global precision navigation/targeting; global-reach SATCOM; strategic and theater missile warning; global weather data; phenomenal intelligence, surveillance, and reconnaissance (ISR); and highly integrated combat search and rescue. In addition to being a huge force multiplier, space power is joint by nature; its effects to earthbound land, sea, and air combat operations can be direct or indirect, immediate or delayed. Integration of space into the joint force commander's (JFC) theater campaign plan, as well as deliberate and crisis-action planning, has come a long way since Operation Desert Storm, providing even more lethal and rapid dominance of the battlespace.[17] Simply put, terrestrial forces combined with effects-based space operations produce unparalled synergistic combat capability: 1 + 1 = 3!

4. Space forces can support all levels of war simultaneously.

> *Space is already inextricably linked to military operations on land, at sea, and in the air.*
>
> —Joint Strategy Review, January 1997

Space systems produce global and theater effects *simultaneously* due to their speed, range, precision, and global presence. Satellites, because of their high-ground advantage, have the ability to simultaneously cover multiple theaters. GEO constellations provide 24/7 SATCOM and missile warning due to their stationary position; LEO ISR satellites in populated constellations provide rapid revisits within hours; and global positioning system satellites provide 24/7 global navigation, tailored for specific theater operations. These capabilities allow space forces to directly impact combat operations at the global, theater, and local levels simultaneously.



Legend: BRAT Beyond Line of Sight Reporting and Targeting
CAOC Combined Air Operations Center
JTAGS Joint Tactical Ground Station
M3P Multimission Mobile Processor
TES Technology Experiment Satellite

Figure 1. Effects-based operations

Likewise, because of its unique high-ground medium, space power delivers information critical to planning and execution of military operations in *all levels of war*—strategic, operational, and tactical (fig. 2). While terrestrial forces generally fight sequential tactical battles before they can move on to operational or strategic objectives, space forces (and to a limited extent, air forces) have the ability to engage in separate, parallel campaigns at all levels of war.[18] For example, the Defense Support Program constellation detects, identifies, tracks, and warns of *strategic* missile launches (intercontinental ballistic missiles), while also providing *tactical* theater missile warning from short-range enemy missiles.

Figure 2. Space-power umbrella

Finally, space systems provide information across the *spectrum of conflict*, including conventional warfare, unconventional warfare (nuclear), asymmetric warfare (global war on terrorism), and military operations other than war, which include humanitarian assistance and disaster relief, peacekeeping operations, noncombatant evacuation operations, and so forth. As the US military's operations tempo continues to increase in quantity and duration (fig. 3), often at austere global locations that have limited or no existing infrastructure, military forces increasingly depend upon immediate space-based capabilities.[19] Space systems are usually first in-theater by virtue of their high-ground, ubiquitous orbits, ready to provide 24/7 navigation, weather, SATCOM, and ISR from the start of a conflict.

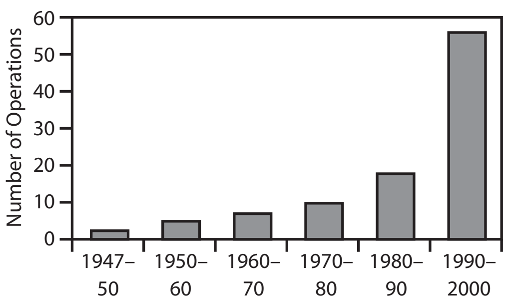


Figure 3. USAF operations tempo, 1947–2000

The key for space power to support all levels of war simultaneously and across the spectrum of conflict is to ensure that space systems have global access to the entire depth and breadth of an adversary or a regional conflict. However, if space assets are limited in number, capability, or constellation size, they quickly become very scarce, high-demand, low-density (HD/LD) assets that military leaders compete for in priority and support, ultimately reducing their ability to support all levels of war simultaneously.

5. Space power leverages a nation's economic and military centers of gravity.

Space will undoubtedly be a center of gravity in any future war.

—Jeffrey R. Barnett
Future War: An Assessment of Aerospace Campaigns in 2010

Conducted properly, space power leverages military and economic COGs, providing an avenue for all instruments of national power to more effectively respond to global situations. Space is emerging as a military and economic COG for nations that conduct information-dependent military and economic operations.[20] The global increase of government, military, and commercial space activity is significant despite a brief economic hiccup in the late 1990s. For example, US space-industry expenditures (military, civil, and industry) are valued in excess of $80 billion per year; the space industry involves over 500,000 jobs in the United States alone; and since 1959 the total US government national space investment is nearly $1.3 trillion.[21] The late 1990s marked the first time commercial space-investment activities actually exceeded government activity in areas such as number of launches, satellite-manufacturing revenue, and launch revenue.[22] Most recently, during Operation Iraqi Freedom, commercial satellites provided 80 percent of all SATCOM used by the US military.[23] From a global perspective, space contributions will account for an estimated $209 billion in the 2006 global economy.[24]

A COG is a source of power from which a nation-state derives its freedom of action, physical strength, or will to fight.[25] The United States is more space dependent than any other nation, yielding an asymmetric advantage (and potential vulnerability).[26] Collectively, US space assets are already a COG, and dominance of the space medium is key to sustained national health, security, and prosperity. In the current information age, economies are built and wars waged increasingly with information (electrons); space is rapidly becoming the primary medium for information transfer. Like any other military or national COG, a nation's space COG must be secure. Consider the strategic implications and vulnerability of both military and economic COGs should space systems become unavailable. Space-based communication, navigation, imagery, and weather are now essential for global situational awareness, the transportation industry, and financial markets.

Space is a lucrative COG for other nations as well; it is no longer a "sanctuary" for the United States alone to enjoy. Other nations are rapidly getting into the space race. Currently, 58 nations have satellites on orbit for military or economic purposes; 15 nations have their own indigenous space-lift capability; and there are five international-consortium space-launch providers to launch satellites for those who cannot do so themselves.[27] While space growth occurs predominantly among technologically advanced nations, sales of commercial space products to all nations are on a dramatic rise. Dozens of international space-consortium SATCOM and imagery providers offer their services in open global markets.[28] The existence of these commercial and international space organizations means that a nation does not have to be a technologically advanced superpower to acquire space power—space imagery, weather, and SATCOM are available and can be purchased over the Internet with a credit card. Space commercialism makes all nation-states potential space players, blurring the line between hostile (red), friendly (blue), and neutral (gray) space forces.

6. Space superiority starts with assured access to space.

> *Whoever has the capability to control space will likewise possess the capability to control the surface of the earth.*
>
> —Gen Thomas D. White
> USAF Chief of Staff, 1958

> *The first principle that should guide our air and space professionals is the imperative to control the high ground.*
>
> —Hon. Peter B. Teets
> Undersecretary of the
> Air Force, 2002

The purpose of a nation-state's space power is to support and achieve national objectives. To accomplish this, a nation needs to be able to secure its space assets, control the space medium, and deter potential space adversaries. Space superiority—ensuring freedom of action in space by protecting space assets and, if necessary, denying an adversary's space capabilities—is fundamental to national space power and is currently Air Force Space Command's top priority.[29] The author suggests that space superiority is best represented as a pyramid consisting of three critical components: responsive space lift (getting to space), counterspace operations (space control), and a space-focused C2 structure (fig. 4).[30] Eliminate any of these three elements, and a nation's space power quickly deteriorates.

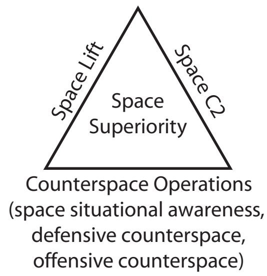


Figure 4. Space-superiority pyramid

Position is strategic. Position is vital. Position is the key to success in most aspects of life, whether sports, business, or politics—and *especially* military combat operations. To get the ultimate position in space, a nation needs assured access to space—it is the foundation on which space superiority operates. Space lift provides access to strategic, vital positions for on-orbit assets to achieve national objectives integrated with military campaigns. To ensure security and dominance of the space medium (space superiority), a space-power nation needs responsive, affordable space lift to deploy, sustain, augment, and operate space systems on orbit when required. Reliable, responsive, affordable space lift is the door to true national space power.

This research indicates that *space lift* (assured access to space) is without question the leading limitation to effective, sustained, robust space power. National space lift must be integrated among the military, civil, commercial, and international space-lift communities—sharing synergistic technology, common-core launch vehicles, and ground/range infrastructure is essential to national space-lift capability (see proposition no. 9). Replacing expendable launch vehicles with reusable launch vehicles (RLV), single-stage-to-orbit systems, and air-breathing hypersonic propulsion systems (ramjets, scramjets) is overdue.[31] A spacefaring nation requires indigenous space-launch capability for national defense operations but should also take advantage of international space-lift opportunities for non-DOD missions such as commercial, scientific, and civil space activities. National space power requires multiple spaceports from which to achieve orbit to eliminate ground choke points in time of crisis or increased launch activity.[32] Without these elements of space lift, a nation cannot execute efficient space power.

7. Controlling space requires eyes, ears, shields, and swords.

> *U.S. space policy is to promote development of the full range of space-based capabilities in a manner that protects our vital security interests. We will deter threats to our interests, and if deterrence fails, defeat hostile efforts against U.S. access to and use of space.*
>
> —National Security Strategy, 1998

> *The goal is not to bring war to space, but rather to defend against those who would.*
>
> —Donald H. Rumsfeld
> US Secretary of Defense, 2004

For a nation to achieve decisive space power in support of national objectives and goals, it must have the means to control the space medium. Space control, or *counterspace operations*, is the second element of the space-superiority triad. Ensuring and denying the use of the space medium require a robust counterspace architecture: space situational awareness (SSA) with corresponding defensive/offensive counterspace (DCS/OCS) means to protect space interests (fig. 5).[33]

SSA forms the basis for national space control, mapping the battlespace by providing the "eyes and ears" of friendly, neutral, and potentially hostile global space activity. Without SSA, a nation is blind and deaf to space activity, rendering DCS/OCS capabilities useless and jeopardizing national security. Robust SSA allows a nation to understand adverse environmental conditions (e.g., space weather), know where space adversaries are, predict nefarious foreign space operations, and determine courses of action. SSA includes finding and tracking space objects, identifying links and nodes, and characterizing the signals of red, blue, and gray forces. The goal is rapid, accurate, and meaningful space intelligence preparation of the battlespace with a single integrated space picture.

DCS operations are the "shields" for a nation's space power, deterring and defending space systems from enemy attack with active or passive means. As advanced nations depend on their space capabilities and develop military/economic COGs, this space dependence also represents a potential vulnerability for an adversary to exploit. A nation's robust DCS operations reduce this threat with hardened satellite systems, antijam components, kinetic attacks against ground jammers, frequency-hopping and spread-spectrum signals, on-

SSA: Eyes and Ears **DCS: Shields** **OCS: Swords**

Figure 5. Counterspace operations

orbit maneuvers to evade hostility, and rapid reconstitution of on-orbit systems.[34]

OCS operations provide the "swords" for national space power by negating an adversary's space capability (ground segment, satellite, or signal). Just as land, sea, and air forces all eventually employed offensive weapons, so will space forces; it is only a matter of time.[35] While the weaponization of space is highly controversial, it is not explicitly prohibited by international law and treaty.[36] OCS forces should be suited for effects-based operations; AFDD 2-2.1, *Counterspace Operations*, identifies five levels of desired OCS effects: deception, disruption, denial, degradation, and destruction. These effects are achieved through a variety of OCS resources, including aircraft, missiles, special operations forces, antisatellite weapons, directed-energy weapons, network-warfare operations, jamming systems, and surface forces.[37] Flexible, effects-based OCS is key to decisive, dominant national space power; together with SSA and DCS, they form the foundational architecture for operational space superiority.

8. Space forces require centralized command and control led by space professionals.

> *Future warfare depends on the rapidity of collecting information and making decisions.*
>
> —Gen Chuck Horner, USAF, 1998

The final piece of the space-superiority puzzle is effective *command and control of space forces* (C2 of both people and systems) (fig. 6). Unlike air, land, and sea power, space power is unique in that space systems have simultaneous impacts on and contributions to multiple theaters (proposition no. 4); this makes space-power C2 especially challenging. Just as experienced soldiers, sailors, and airmen control land, sea, and air forces, so are experienced military space professionals the best choice to centrally control space forces. Perhaps Douhet stated it best when he advocated that "only *airmen* can fully appreciate airpower's intricacies: therefore, only airmen should command air forces" (emphasis in original).[38] So is it with control of space forces—it needs to be done by space experts. The most straightforward and effective solution for space-force C2 employment (both global and theater) is to fuse today's service- and agency-fragmented US space forces into an independent space force led by space professionals.

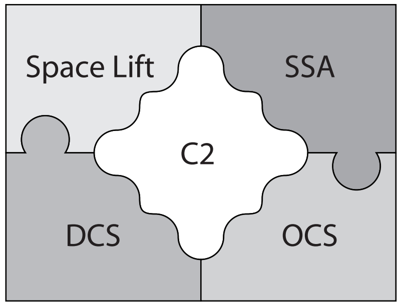


Figure 6. Space superiority: C2 brings it together

The current devolution of C2 of joint operational US military space forces is complicated and different for global and theater operations (described in AFDDs 2-2 and 2-2.1). To plan and execute global operations, US Strategic Command operates joint military space forces through its space and global-strike functional component (Eighth Air Force) via the joint space operations center (JSpOC) at Vandenberg AFB, California.[39] C2 of theater space forces gets more complicated. There is no question that space forces need to be integrated into the JFC's theater-campaign battle rhythm. The issue becomes how and by whom space forces are best controlled in-theater.

Currently, the joint force air component commander (JFACC) is normally responsible for air and space operations to accomplish the JFC's objectives; the JFACC is assisted by a newly created director of space forces.[40] As space forces become more "taskable" and lethal in theater operations, the author suggests taking C2 of space forces one step further by transitioning C2 of theater space forces from an already multitasked JFACC to the dedicated space leadership of a joint force space component commander (JFSCC) (fig. 7). The result would be a space professional leading and integrating theater space operations at a level equivalent with the other services (mediums), focusing on space power (not air *and* space power, as current JFACCs do).

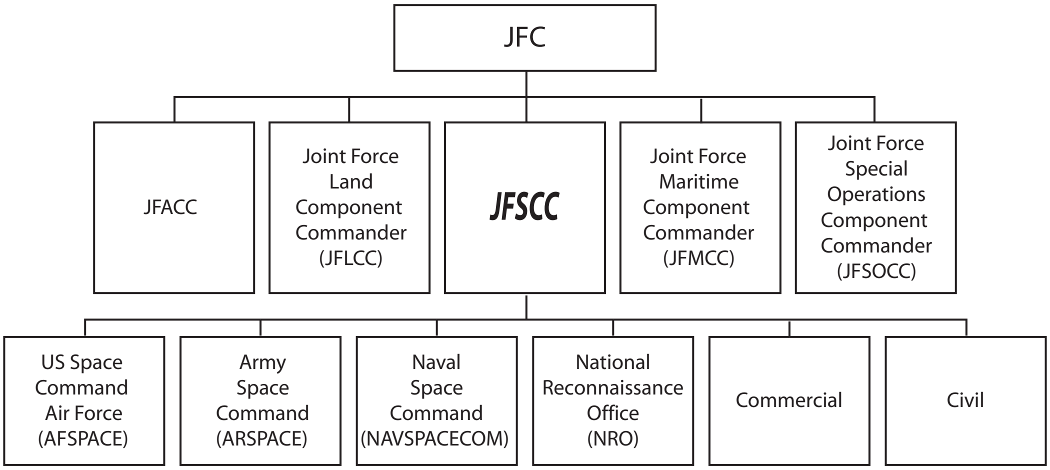


Figure 7. Proposed theater command and control of the joint force space component commander

9. Space power is a function of a nation's total space capability (space unity of effort).

> *Space power is the total strength of a nation's capability to conduct and influence activities to, in, through, and from space to achieve its objectives.*
>
> —Joint Publication (JP) 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 12 April 2001 (as amended through 31 August 2005); and JP 3-14, *Joint Doctrine for Space Operations*, 9 August 2002

Current joint doctrine reflects the significance of a *national* space-power effort by its very definition. Space power is a nationwide endeavor. However, the 2001 report of the Space Commission identified a main problem with current US space capability: the US space community is fragmented and lacks unity of effort. This is primarily due to decades of stovepiped, agency-focused projects and security barriers between military and non-DOD space sectors.

The solution is cooperative efforts among military, government, civil, scientific, commercial, and, to a certain extent, even allied international space organizations (fig. 8). Clearly, because of the incredible technology and limited available resources to pursue space systems, space power must be a cooperative, synergistic endeavor. Even more so than airpower, space power and technology are integrally and synergistically related.[41] One way to overcome technological complexities and tremendous space-related costs is to encourage (and reward) the leveraging of technology and shared resources (infrastructure, ranges, etc.) among industry, the DOD, the National Reconnaissance Office (NRO), the National Geospatial-Intelligence Agency, NASA, the Defense Advanced Research Projects Agency, and academia. The Pentagon's newly created [May 2004] National Security Space Office

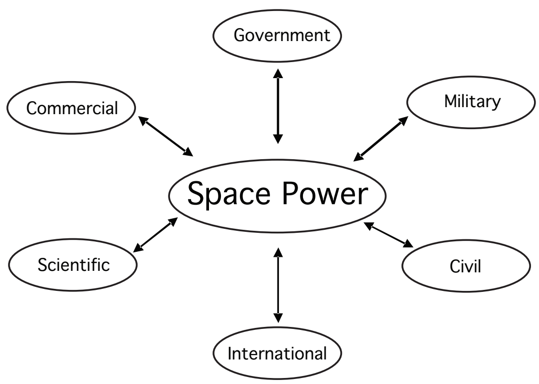


Figure 8. Space power: a function of national teamwork

(NSSO) is a good first step to building a cooperative space culture.[42] The NSSO charter is to identify both military and national-intelligence space activities, develop architectures and implement programs that bridge both communities, and improve the integration of space capabilities into joint war-fighting and intelligence operations. Synchronizing and integrating the NRO and the DOD space communities increase efficiency by reducing redundancy and space-system costs.

A cooperative space culture would most benefit the number-one space limitation today—space lift—due to its limited infrastructure, complex technology, and high operations cost. The co-use of HD/LD space-lift infrastructure assets and codevelopment of RLVs, advanced materials, and propulsion technologies would pay huge dividends to the national space effort by improving assured access to space. Government incentives and rewards for private industry to develop new space-lift capabilities, technologies, and approaches result in a win-win situation for a nation's total space capability.[43]

10. National space power reaches its full potential when a nation commits to a separate, independent space force.

> *So long as the budget for the development of aircraft is prepared by the Army, Navy, or other agency of the Government, aviation will be considered as an auxiliary and the requisite amount of money, as compared with the other services, will be subject to the final decision of personnel whose main duty is not aviation.*
>
> *The greatest deterrent to development which air forces combat in every country is the fact that they have had to be tied up to armies and navies where senior officers, unused to air work, were placed in the superior positions.*
>
> —Gen William "Billy" Mitchell
> US Army Air Service, 1925

True national space power cannot reach its full potential until a nation commits itself to a separate, independent space force. War fighters would do well to recall the prophetic words of arguably the most ardent forefather of a separate, independent US Air Force, Gen Billy Mitchell.[44] Plug in the word "space" for "air," and it is a close fit to the current twenty-first-century status of space-power development. It was right for the Army to nurture and shelter airpower in the Army construct until airpower demonstrated decisively that it warranted its own separate military service. Once the Air Force became an independent service, airpower rapidly grew into a global, strategic instrument of national power. Likewise, it was right for the USAF to shelter and nurture the vertical dimension of space—it has been the best place to foster space power since its inception 50 years ago. However, as airpower was constrained during the post–World War I era, US space power was constrained during the Cold War and morphed to airpower doctrine, policy, and theory. In spite of this restraint, military space power has grown to be a pervasive influence on nearly every facet of military operations. The United States holds a decisive asymmetric space-power advantage—clearly it is too critical to be considered a subset of airpower. An independent space-force organization would fully unleash the true potential of space power, allowing freedom to explore, develop, and refine space theory, doctrine, and policy without undue influence from other service cultures.

US Space Force: No Longer a Question of "If" but "When"

This may be an unpopular statement, but it is irrefutable, based on the historical precedent of the creation of separate and distinct land, sea, and air services. Nearly half of the surveys conducted in this research indicated that a separate space force was the eventual and *necessary* path of US space power. This does not mean that space power cannot positively influence joint military operations while under the umbrella of the USAF—it can and has proven so, as discussed throughout this article. The issue becomes availability of resources (e.g., budget, manpower, and equipment), for which both airpower and space power compete in the USAF. In today's realistic environment of finite resources, space systems have historically received lower priority than terrestrial weapon systems. Today US space power has grown to the point where either a bigger USAF umbrella is needed (more resources to pursue space power) or an entirely separate umbrella is created (an independent space force).

> *Our space force may need to become a military entity in its own right, equal and apart from our air, land, and maritime forces.*
>
> —Gen Chuck Horner, USAF, 1999

From a joint perspective, there is also cause for a separate space force. Land and sea services are heavily dependent on USAF-controlled space assets. As the designated executive agent for space, the USAF controls approximately 86 percent of the DOD's $11 billion space budget.[45] With space assets competing within the USAF against airpower programs (e.g., the F-22A), the other DOD services are concerned that the USAF may not be pursuing adequate space capability (in a timely manner) to support joint land and sea combat needs. A separate, independent space force would provide more equitable representation among the services for space-power budget and combat-support capability as well as reduce or eliminate confusion and redundancy among the three services' own space efforts (AFSPACE, ARSPACE, and NAVSPACECOM).

While such a reorganization of space forces into a separate, independent space force is understandably delayed due to the current global war on terrorism, it no doubt needs to be addressed sooner rather than later. Some say that a separate space force is not justified until there is a serious space peer competitor that challenges US space superiority. The response to that argument is that although the United States holds a healthy asymmetric space-power advantage today, it would be foolish to wait for national space forces to be threatened or allow a potential "space Pearl Harbor" to occur when the opportunity exists now to organize space forces to prevent that very threat.[46] An independent space force will foster a space-force culture, reduce competition for resources, and allow space-power theory and resulting combat capability to develop more effectively to counter future space threats.

> *If the Air Force cannot or will not step up to its responsibilities as the executive agent for military space, then Congress must create a separate space force to become that strong advocate.*
>
> —Senator Bob Smith, 2002

Summary and Conclusions

These 10 propositions illustrate the necessity and challenges of national space power:

Characteristics	*Challenges*
• High Ground	• Responsive Space Lift
• Distinct Medium/Doctrine	• Counterspace Operations
• Joint Force Multiplier	• Space-Forces C2
• Simultaneity and Versatility	• Space Unity of Effort
• Center of Gravity	• Independent Space Force

The strength of space contributions in strategic military, commercial, and economic operations is undeniable. Space power is not just a continuation of airpower; space is a unique, distinct, war-fighting medium. Continuing to restrain US space power from developing its own identity, culture, theory, and doctrine is to confine a powerful dimension of war fighting available only through the fourth medium of space. Undisputed combat space power is drawing near, and the United States may be on the brink of unleashing decisive military space operations, ushering in the era of a separate space force. The reality is that, as in the evolution of airpower, the true potential of a nation's military space power will come to fruition only when a separate space force is created, complete with its own space-competent leadership, organization, doctrine, theory, policy, and resources. ❑

Notes

1. All research was conducted at the unclassified, public-release level.

2. Perhaps the most revealing aspect of this research was the prolific response received from a survey of nearly 100 space professionals across the nation, including military space operators, acquirers, industry, and academia. The demographics and combined space experience alone of these survey participants are staggering, totaling more than 1,500 years of collective space background from the backbone of today's space cadre. Survey participants include Army, Navy, Air Force, and Marine personnel, along with participants from key national space organizations including NASA, the NRO, Air Force Space Command, and the US Strategic Command. To ignore such a pool of knowledge would be foolish, and in fact their jewels of wisdom are woven into the fabric of this research. Additionally, the author visited more than a dozen key components of the space community to collect information and build the basis of this research.

3. Col Phillip S. Meilinger, USAF, *10 Propositions Regarding Airpower* (Maxwell AFB, AL: Air University Press, 1995). The author acknowledges the thought-provoking works of Maj M. V. Smith, "Ten Propositions Regarding Spacepower" (thesis, School of Advanced Airpower Studies, Maxwell AFB, AL, 2001); Maj Kevin M. Rhoades, USAF, "Bernoulians versus Keplerians: Is Airpower Doctrine Good Enough for Employment of Space Forces?" (thesis, School of Advanced Air and Space Studies, Maxwell AFB, AL, June 2004); and Maj Samuel McNeil, "Proposed Tenets of Spacepower: Six Enduring Truths," research report (Maxwell AFB, AL, Air Command and Staff College, 2003). The author also appreciates the sponsorship of the Institute for National Strategic Studies, in Washington, DC, for this research.

4. Already, many commercial and economic ventures are entirely dependent on space assets for modern commercial and economic growth and operations. For example, the global positioning system is critical for transportation-systems navigation (air, sea, rail, and highway) and also provides precise timing for international stock-market trades affecting national economies; weather satellites provide key environmental information and forecasts to predict potential weather disasters, facilitate agricultural planning, and monitor forest fires and solar (sun) phenomena; and information technologies depend exclusively on satellite communications for global communications, direct satellite TV/radio broadcasts, and emergency services.

5. *Merriam-Webster's Collegiate Dictionary*, 11th ed. (Springfield, MA: Merriam-Webster, 2003), 997. The "proposition" definition is consistent with Meilinger and Smith in their research.

6. Jerry Jon Sellers, *Understanding Space* (New York: McGraw-Hill, 1994), 60–61; and AU-18, *Space Handbook, An Analyst's Guide* (Maxwell AFB, AL: Air University Press, 1993), 4–5.

7. *Merriam-Webster's Collegiate Dictionary*, 973.

8. Definition is consistent with current joint-operations definitions of *space power* as defined in Joint Publications (JP) 1-02 and 3-14, and similar to Lt Col David Lupton's definition of the term in his book *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, AL: Air University Press, 1988).

9. The White House, *A National Security Strategy for a New Century* (Washington, DC: The White House, October 1998), 25–26.

10. The GEO belt slots (22,300 miles above a country's equatorial longitude) are governed by the International Telecommunications Union and are becoming a highly sought after commodity since the GEO belt is getting crowded. Demand for geosynchronous slots and frequency allocations is intensifying to a geopolitical battlespace, resulting in recent political and international disputes.

11. Air Force Doctrine Document (AFDD) 2-2, *Space Operations*, 27 November 2001, 4; and AFDD 2-2, draft, 15 May 2005, 3. Headquarters AFDC/DR, Maxwell AFB, AL.

12. Lt Col Peter B. Hays, USAF, *United States Military Space into the Twenty-first Century*, Institute for National Strategic Studies Occasional Paper 42 (Maxwell AFB, AL: Air University Press, 2002), 25–26.

13. Chief of Staff of the Air Force (CSAF) Gen Charles A. Gabriel stated, "From battlefield to highest orbit, airpower provides deterrence," implying that space was a subset of airpower. Air Force Manual (AFM) 1-6, *Military Space Doctrine*, 15 October 1982. An earlier CSAF, Gen Thomas D. White, set the "aerospace" tone in 1958 by declaring, "There is no division . . . between air and space. Air and space are an indivisible field of operations." *Air Force*, March 1958, 40–41.

14. Rhoades, "Bernoulians versus Keplerians," 67–72. The paper provides a thorough historical review of Air Force doctrine and analogy to space-doctrine development.

15. Gen Thomas S. Moorman, USAF, former vice CSAF and commander, Air Force Space Command, stated, "Desert Storm . . . was a watershed event in military space applications because for the first time, space systems were both integral to the conflict and critical to the outcome of the war." AFDD 4, *Space Operations Doctrine*, 10 July 1996, http://www.fas.org/spp/military/docops/usaf/afdd4.htm. "During the 1991 Persian Gulf War . . . over 60 military satellites and others from the commercial and civil sectors were employed." George W. Bradley III, "A Brief History of the Air Force in Space," *High Frontier: The Journal for Space and Missile Professionals* 2, no. 2 (Fall 2004): 7.

16. Between 1995 and 2005, over 75 Air University research papers, articles, and books were produced dealing with space issues, and significant DOD service doctrine has been approved, including AFDD 2-2, *Space Operations*; AFDD 2-2.1, *Counterspace Operations*; AFDD 4, *Space Operations Doctrine*; JP 3-14, *Space Operations*; Army Field Manual (FM) 100-18, *Space Support to Army Operations*; and *National Security Space (NSS) Acquisition Policy* 03-01.

17. This is clearly evidenced in Operations Allied Force, Enduring Freedom, and Iraqi Freedom, and military operations other than war, including humanitarian assistance/disaster relief (HA/DR) activities.

18. Meilinger, *10 Propositions Regarding Airpower*, 35. "Parallel Operations occur when different campaigns, against different targets, and at different levels of war, are conducted simultaneously."

19. The trend indicates that the DOD operations tempo is growing and increasingly involved in small-scale contingencies and military operations other than war,

such as humanitarian relief, noncombatant evacuation operations, and peacekeeping/peace-enforcement operations. Data collected from the Air Force Historical Research Agency, Maxwell AFB, AL.

20. *United States Space Command Long-Range Plan: Implementing USSPACECOM Vision for 2020* (Peterson AFB, CO: US Space Command, Director of Plans, April 1998), 4–5.

21. Hays, *United States Military Space*, 21; Gen Lance Lord, commander, Air Force Space Command, quoted in Louis Arane-Barradas, "Civilian Sector the Biggest Space Customer," *Academy Spirit*, 24 February 2006; and $1.3 trillion in constant FY05 dollars. Data from Tamar A. Mehuron, "2004 Space Almanac," *Air Force Magazine*, August 2004, 26–53.

22. Hays, *United States Military Space*, 21.

23. AFDD 2-2.1, *Counterspace Operations*, 23.

24. Lord, quoted in Arane-Barradas,"Civilian Sector," 4.

25. Ibid., 50. The great Prussian military strategist Carl von Clausewitz defined a COG as "the hub of all power and movement, on which everything depends." Carl von Clausewitz, *On War,* ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 595–96.

26. *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington, DC: Space Commission, 2001), 18, http://www.defenselink.mil/pubs/space20010111.pdf.

27. "Rest of World Space Launch," *Air University Space Primer*, chap. 20 (Maxwell AFB, AL: Air War College, July 2003), http://space.au.af.mil/primer/rest_of_world_launch.pdf.

28. Intelsat, Inmarsat, Arabsat, Eutelsat, LandSat, Spot Image, Indian Remote Sensing, Ikonos, Quickbird, etc.

29. Col James E. Haywood, USAF, "Making Vision a Reality: Delivering Counterspace Capability to the High Frontier," *High Frontier: The Journal for Space and Missile Professionals* 2, no. 2 (Fall 2004): 54.

30. Reference definitions in JP 3-14, *Joint Doctrine for Space Operations*; AFDD 2-2, *Space Operations*; AFDD 2-2.1, *Counterspace Operations*; and Department of Defense Directive (DODD) 3100.10, *Space Policy*. Space superiority encompasses space situational awareness (SSA), defensive counterspace (DCS), and offensive counterspace (OCS). Space-control missions include surveillance, prevention, protection, and negation. Space superiority is a *condition* of dominance, while space control is actually one of several contributing activities that result in national space superiority.

31. The United States needs to develop and employ RLVs, which will provide significant improvements in military responsiveness and life-cycle costs. Recent attempts (e.g., evolved expendable launch vehicles [EELV]) have made progress in standardizing the "family of systems," but US space lift remains largely unresponsive (months to launch), expensive (on the order of 50–200 million dollars per launch), and unpredictable (significant integration and launch infrastructure delays). Foreign launch services are becoming highly competitive and challenge US space-lift capability.

32. The two main US spaceports (30th Space Wing, Vandenberg AFB, CA, and 45th Space Wing, Patrick AFB, FL) represent two choke points for polar and GEO space launches. Elimination of either range would cripple US access to space due to lack of alternate sites and facilities. Range infrastructure needs an overhaul to improve cost and responsiveness (payload/booster processing, launch-facility maintenance, etc.).

33. SSA, DCS, and OCS are the three components of counterspace operations as defined by AFDD 2-2, *Space Operations*, and AFDD 2-2.1, *Counterspace Operations*.

34. AFDD 2-2.1, *Counterspace Operations*, 25–29.

35. "We know from history that every medium—air, land and sea has seen conflict. Reality indicates that space will be no different." *Report of the Commission*.

36. Maj Elizabeth Waldrop, USAF, "Weaponization of Outer Space: US National Policy," *High Frontier: The Journal for Space and Missile Professionals* 1, no. 3 (Winter 2005): 35–46. International space law *does not* prohibit conventional force-application weapons in space, antisatellite weapons, or protection of space assets, but there are some limitations. The 1963 United Nations (UN) Limited Test Ban Treaty bans nuclear-weapon tests in outer space. The 1967 UN Outer Space Treaty declares that outer space and all celestial bodies are free for exploration by all states and are to remain free of military bases; it bans Earth-orbiting weapons of mass destruction. The 1972 US-USSR Antiballistic Missile (ABM) Treaty prohibits the development, testing, or deployment of space-based ABM systems (the United States withdrew from the ABM Treaty in 2002).

37. AFDD 2-2.1, *Counterspace Operations*, 31–34.

38. Rhoades, "Bernoulians versus Keplerians," 9.

39. The Unified Command Plan assigns US Strategic Command as the functional unified command with overall responsibility and combatant command for space operations. The JSpOC provides day-to-day operational command of joint space forces by issuing daily and weekly space tasking orders to space units, which mirror the air tasking orders produced by an air operations center. The JSpOC fuses and analyzes space information into a single integrated space picture, determines courses of action, and serves as the reach-back interface for theater space support.

40. The JFACC is also usually assigned the role of space coordinating authority, the single authority in-theater to coordinate joint theater space operations and integrate space capabilities and effects. A newly created director of space forces assists the JFACC in planning, executing, and assessing space operations for the JFC's campaign plan.

41. Meilinger, *10 Propositions Regarding Airpower*. This is a space-power corollary to Meilinger's proposition regarding the synergism between airpower and technology. Similarly, and in parallel with airpower technology and development, Gen Billy Mitchell also recognized early on the symbiotic relationship between civil and military airpower. Rhoades, "Bernoulians versus Keplerians," 13.

42. The capstone directive for this effort is NSS 03-01, the result of a recommendation from the Space Commission report.

43. Similar to the recent $10 million space prize won by Burt Rutan's Scaled Composites Spaceship One endeavor.

44. Gen William "Billy" Mitchell, USA, *Winged Defense: The Development and Possibilities of Modern Air Power—Economic and Military* (1925: repr., New York: Dover Publications, 1988), 160, 248–49.

45. Mehuron, "2004 Space Almanac," 26–53.

46. *Report of the Commission*, 22, 25.

Air Force Space Command

A Transformation Case Study

Dr. Michael F. Stumborg

Editorial Abstract: Many organizations claim to have undergone "transformation." However, Dr. Stumborg asserts that a gradual, seamless shift in an organization's operational environment does not constitute transformation but merely reflects change. Working now to achieve transformational elements through a strategic action plan of seven thrust areas, Air Force Space Command has undertaken a true transformational process in order to guarantee future US space superiority.

CONSISTENTLY SUCCESSFUL organizations maintain their core purpose and values even as their strategies and practices adapt to changing operational environments. When changes in the operational environment occur gradually, the organization can likewise undergo a gradual, seemingly naturally occurring, and apparently effortless shift to cope with the new reality. This is change but not transformation. If instead the change in the operating environment is so abrupt or severe that it threatens the effectiveness, relevance, or even survival of the organization, then the organization must undertake a concerted effort to adapt to the new reality.

We define *transformation* as *any purposefully directed change necessary to ensure an organization's future success in a drastically different operational environment.* Using this definition, Air Force Space Command (AFSPC) is fundamentally changing the American use of space for military purposes, and recent initiatives position the command to capitalize on its initial successes, regardless of its final organizational form.

But is that so? Is AFSPC transforming or not? The American use of space for military purposes has experienced evolutionary changes and revolutionary transformations during its roughly 50-year history. Sometimes it has been difficult to distinguish one from the other. This observation raises a question: to what degree is the American use of space for military purposes today in the throes of a transformation, requiring reasoned and focused action by the space community's leadership, or to what degree is it instead experiencing a period of rapid but manageable change that can be accommodated by a less dramatic or urgent approach?

To answer this question, we look to the history of military space, to case studies from other military organizations that have achieved successful transformations, and to the information-age corporate community, which, because of the rapid and accelerating pace of change in business's operating environment, provides a diverse array of transformation case studies for comparison. Robust data within these case studies, both military and civilian, illuminate the elements of successful transformation. Because these elements appear widely in business literature, one need not develop them here. John P. Kotter's best-selling book *Leading Change* identifies eight elements common to most successfully executed transformations:

- *Establish a Sense of Urgency.* Some internal or external stimuli, either recently introduced or predicted to occur soon, create a threatening change in the operational environment.

- *Create a Guiding Coalition.* The leadership must identify, convert, and align those individuals who can marshal the resources necessary to effect the transformation.

- *Develop a Vision and Strategy.* A unifying and easily understood vision has the power to direct, align, and inspire the actions of every member of the organization.

- *Communicate the Change Vision.* An immediate, unified, and relentlessly repeated communication of the leadership's vision to all members of the organization and its external stakeholders demonstrates the magnitude of the importance placed on the proposed transformation.

- *Empower People for Broad-Based Action.* Empowering people to overcome obstacles to change plays an important role in maintaining morale.

- *Generate Short-Term Wins.* A few "first downs" engineered along the way to the ultimate goal line play an important part in maintaining momentum.

- *Consolidate Gains and Produce More Change.* Leadership must recognize intermediate victories, remind the organization of its ultimate goal, and press forward.

- *Anchor New Approaches in the Culture.* One must inculcate the new behaviors necessary for success in the new operating environment into the social norms and shared values of the transformed organization's members.[1]

These eight elements draw from extensive experience with transformation in both public- and private-sector organizations. A set of elements drawn from successful military innovations, particularly those that drove peacetime transformation, would prove equally germane.

Some have argued that the current AFSPC finds itself in a period analogous to the beginning of the interwar period from 1918 to 1939.[2] World War I saw the introduction of technologies and tactics in aerial, submarine, and mobile armored warfare that did hint at their great potential but did not begin to predict the extent or manner of their employment during World War II. The great potential alluded to on the battlefields of World War I put military planners on notice that they would have to contend with (and ideally employ) aerial, submarine, and mobile armored warfare in the next Great War.

Operation Desert Storm serves as the analog to World War I for space warfare. Gen Merrill McPeak, former Air Force chief of staff, labeled the conflict in the Persian Gulf as the "first space war," and Lt Gen Michael Hamel called Operations Enduring Freedom and Iraqi Freedom "graduation exercises."[3] The great promise of space demonstrated in the deserts of Iraq put military planners from all spacefaring nations (as well as nonspacefaring nations or groups who might oppose them) on notice that the next Great War will very likely have a space theater of operations.[4]

A collection of transformation case studies from the interwar period that identifies the elements of successful transformation would thus have great relevance to this case study. Because the understanding of transformation is just as critical to military leaders as it is to corporate leaders, an analog to Kotter's study exists in the military realm. Williamson Murray and Allan R. Millett's *Military Innovation in the Interwar Period*, which examines the elements of successful military innovation/transformation during peacetime, offers today's military planners the following six elements for successful peacetime military transformation:[5]

- *A Concrete Military Problem.* A specific problem whose solution is critical to carrying out the national security strategy and a military institution with a vital interest in solving it are common to the interwar period.[6] This explains the interest in amphibious warfare by the Japanese and American navies who sat astride the Pacific theater of operations, the interest in strategic bombing by America and Britain, and the development of blitzkrieg by the Germans, recent losers of a two-front continental war.

- *An Empowered Officer Corps.* Military transformation cannot depend (entirely) on the maverick charisma of a Billy Mitchell or a Heinz Guderian. Institutionalizing new warfare methods requires attracting a cadre of the best and brightest officers at all levels. The education and training of officers who gamble their military careers on new forms of warfare are of critical importance, as is the existence of viable promotion paths.[7] Officers who support transformation must not be "firewalled" from those pursuing more traditional—sometimes competing—methods of warfare. Instead, members of the new cadre must be in the mainstream of their profession with some prospect of attaining high rank.[8]

- *Bureaucratic Acceptance.* For transformation to have real staying power, it must evolve from an endeavor undertaken "outside the system" to one thoroughly entrenched in bureaucratic processes. It can then compete for funding and personnel on a level playing field with the more established warfare communities. Congress's creation of the Navy Bureau of Aeronautics in 1921 offers a good example. Headed by Adm William Moffett, it created well-informed and accredited officers to make the case for naval aviation to Congress.[9]

- *Consistency of Message and Purpose.* One can attain such consistency by a succession of like-minded champions in key leadership positions or by the reappointment of the original champion. They must consistently and continually beat the drum, making it clear that the transformational capability is here to stay. Admiral Moffett again provides the historical example: he was able to obtain two four-year extensions at the Bureau of Aeronautics, a feat that required presidential intervention over the objection of the chief of naval operations.[10]

- *A Cadre of Warriors at All Ranks.* Military transformation often takes a generation, with newly minted officers requiring "top cover" until they can become senior leaders and perpetuate the "officer pipeline" in the new warfare area. "Peacetime innovation has been possible when senior military officers with traditional credentials . . . have acted to create a new promotion pathway for junior officers practicing a new way of war."[11] Sir Hugh Trenchard actively identified and pushed the careers of airmen who provided leadership for the Royal Air Force in World War II.[12] Early proponents of Army air mobility sent senior officers from other combat arms to flight school, modeling their approach after Moffett's.[13]

- *A Military Culture of Honest Study, Reflection, and Projection.* Taking the nascent capabilities demonstrated on the World War I battlefields and turning them into the revolutionary capabilities of World War II required a military culture open not only to critical examination of the les-

> sons from the battlefield, but also a desire for further development that transcended earlier doctrine and tactics. War games designed to justify current doctrine are a recipe for future defeat.[14] Transformation requires that one use "mistakes" in the use of new methods as an opportunity to learn—not as a reason to punish or end a career. Feedback mechanisms must be created so that combat units can train and exercise to fix identified weaknesses.[15]

It should come as no great surprise that significant overlap exists between Kotter's eight elements of successful business transformation and Murray and Millett's six elements of successful peacetime military transformation; therefore, adding the last (and only unique) element of the military case studies to Kotter's list yields a consolidated list of just nine elements. By using these nine elements of successful transformation as a yardstick to determine the state and probable success of transformation in AFSPC, one can pose a new question for this transformation case study: to what degree have the actions of AFSPC addressed these elements as the command has sought to further operationalize space-based war-fighting capabilities since the release of the "Space Commission's" recommendations?[16]

In April 2002, Gen Lance W. Lord took command of a newly reorganized AFSPC after a tour as the assistant vice-chief of staff of the Air Force, during which he worked with James Roche, secretary of the Air Force at that time, to craft the Air Force's response to recommendations made by the Space Commission.[17] By early 2003, several AFSPC strategic planning off-sites for general officers resulted in a *Strategic Master Plan* with seven thrust areas as part of a "Commanding the Future" initiative: (1) Command the Future, (2) Enterprise, (3) Partner, (4) Unleash Human Talent, (5) War Fighters, (6) Wizards, and (7) Rapidly Move Technology to War Fighting.[18] These thrust areas defined the processes for transforming the command from a force-enhancement organization into a full-spectrum Space Combat Command. The actions undertaken in these areas address each of the nine identified elements for successful transformation.

Establish a Sense of Urgency/ A Concrete Military Problem

Taking a page from past space-related transformations, AFSPC loses few opportunities to identify and articulate the urgent problem that drives today's transformation. In 1945 it was the need to secure air superiority through the development of supersonic flight.[19] In 1958 it was the need to counter the Soviets' "demonstrated capability to launch long-range missiles and space vehicles."[20] As early as 1980, people recognized the emergence of technologies to support tactical operations from space. After the Persian Gulf War, it became abundantly clear that "today's operations are significantly enhanced by US space superiority—tomorrow's will be nearly impossible without it."[21] Thus, the Air Force should articulate the growing space threat and reassert its commitment to the space-control mission. Essentially, that is the urgent message and specific military mission articulated by General Lord in an article titled "Commanding the Future": "These lessons from the past, when coupled with the uncertain threats looming in the dynamic and changing security environment of the twenty-first century, necessitate a change in focus for military space operations: 'Defending the United States of America through the control and exploitation of space.' "[22] Military space professionals reinforce this message as often as possible in every available venue: congressional testimony, professional journals, and speeches to space stakeholders and advocacy groups.[23]

Create a Guiding Coalition/A Cadre of Warriors at All Ranks

If one initiative can be considered the centerpiece of AFSPC's transformation effort, it would have to be the Space Professional Strategy, part of the Unleash Human Talent thrust area. Although the initial "guiding coalition" responsible for space transformation consisted of general officers who, at the direction of the commander, championed transformation initiatives under the seven thrust areas, the ultimate guiding coalition will be the space cadre itself. The Space Professional Strategy calls for identifying all members of the Air Force's space cadre, tracking their unique space experiences, developing new and improved space education and training courses, and instituting a robust certification program to monitor the progress and status of each individual.[24] Like the advocates of many military transformations before them, members of the space cadre must draw their first champions from the ranks of other warfare communities—the more senior the better.

General officers as well as company- and field-grade officers from all the services attend space-operations and space-familiarization classes at the National Security Space Institute. US Air Force Academy cadets also receive space instruction. Granted, the space cadre will comprise the core of the guiding coalition, but many external coalition partners are also important. AFSPC is working under its Partner thrust area to expand and maintain effective partnerships throughout the defense and national security space arenas to help in the pursuit of innovative solutions and transformational capabilities.[25] These outreach efforts include industry, research labs, academia, and other parts of the government.[26] The National Security Space Institute has signed memoranda of agreement with the National Reconnaissance Office, Army, and Defense Acquisition University. Classes at the institute are purposefully designed to maximize the organizations and career fields represented so that members of the space cadre can expand and solidify relationships initiated by their senior leaders with other communities. Finally, General Lord arranged the first gathering of weapons-school graduates (the "Whiskeys") at the Air War College.

Develop a Vision and Strategy/ Consistency of Purpose

An organization's vision and strategy define its core purpose and values.[27] These in turn drive the creation of actionable plans with objectives, milestones, and metrics for progress. Although the strategic action plan may require adjustments to meet emergent contingencies, the vision, core purpose, and core values remain unchanged. AFSPC developed and published its strategic vision in "Commanding the Future."[28] Over the last 12 years, operationalizing space has served as a central tenet of the command's agenda. Transformation is part and parcel to this vision. In the past, AFSPC focused largely on the force-enhancement role of space systems and the deterrence role of nuclear forces. Space and missile operations of tomorrow will focus on developing and projecting combat power. The core purpose of AFSPC is to generate, maintain, and ensure space superiority. The vision of "Commanding the Future" serves as the guidepost from which yearly planning strategies derive and by which all other actions are judged. Similar to past examples of military transformation, the extension of General Lord's tenure as commander of AFSPC greatly enhanced consistency of purpose.

Communicate the Change Vision/ Consistency of Message

AFSPC exploits multiple venues to get the transformation message out. Publishing the future vision in "Commanding the Future" is just one of these. Every issue of *High Frontier*, the quarterly professional journal of the space community, opens with a message from the commander describing the theme of the current issue and the way it ties into the larger vision for transformation, consistent with General Lord's belief that staying on message is a critical component of transformation.[29] *Air and Space Power Journal*, the official professional publication of the US Air Force, now dedicates entire issues to space.[30] As General Lord passes the mantle of responsibility to his successor (General Lord retired on 3 March 2006), consistency of message will be aided greatly by the contents of the report to the secretary of defense on the impact of the Space Commission's report.

Beyond the written word, AFSPC's commander and vice-commander miss few opportunities to give speeches or provide testimony to drive home the message of space transformation. One speech presented by General Lord to the Royal United Services Institute in London (later published in *Vital Speeches of the Day*) outlined for an international and allied audience the heritage of AFSPC, ways in which space has transformed war fighting, and the importance of defending space capabilities.[31] The command's public affairs Web site lists no fewer than 47 public presentations by General Lord in 2004 and 2005.[32] These are supplemented by numerous private presentations by senior leaders, who speak with one voice, to influential individuals and groups both inside and outside the national security establishment. Of particular interest is General Lord's ability to sum up and simplify the transformation message for his audience with his preferred closing: "If you're not in space, you're not in the race."

Empower People for Broad-Based Action/An Empowered Officer Corps

It is not enough to simply create a space cadre. Military officers who will lead that cadre must have the opportunities and tools to advance the cause of transformation. Many of those tools come from in-depth technical education and training via multiple initiatives under the Unleash Human Talent thrust area. Just as at the dawn of the space age, so too will space transformation today require "a broad training program for officers in scientific and engineering fields," and "officers with engineering training and duty should not be handicapped with regard to promotion."[33] One can best ensure the promotability of these technically savvy officers by expanding the set of staff and command opportunities so they can apply their space competencies in direct support of war-fighting operations.

Establishing space cadre billets in the numbered air forces, war-fighting headquarters, and air and space expeditionary force (AEF) offers one example. Participation in AEF rotations has resulted in many more space cadre personnel with experience in combat operations—one of the critical ingredients of promotability. Stand-up of the Joint Space Operations Center by Fourteenth Air Force has made space planning and execution routine, placing space cadre officers precisely where they need to be: in the mainstream of combat arms. Having a director of space forces (DIRSPACEFOR) on the staff of the combatant commanders provides additional opportunities. Much of this activity falls under the Enterprise thrust area's objective of creating an operationally responsive AFSPC.

Generate Short-Term Wins

A key aspect of the seven thrust areas in the "Commanding the Future" initiative of AFSPC's *Strategic Master Plan* is the identification of a general-officer champion for each area and General Lord's insistence that the generals develop three-month action plans which would generate quick wins in each thrust area. Despite the critical nature of these quick wins in developing programs, people, and processes that will transform space, the more important (and motivational) wins come from battlefield examples of outcomes that would have been decidedly different—and not for the better—in the absence of capabilities fielded by the transformed use of space. US Army soldiers in Iraq surrounded by 20 tanks and more than 10 other armored vehicles lived to fight another day because of their confidence in requesting the dropping of Joint Direct Attack Munitions (from B-1 bombers) enabled by the global positioning system (GPS) in close proximity to their position.[34] On at least one occasion, GPS-enabled pinpoint bombing of enemy armor convinced enemy soldiers to flee rather than engage the 1st Marine Expeditionary Force in

Iraq.[35] Space provided over 60 percent of communications at the height of Iraqi Freedom and 100 percent of secure satellite communications.[36]

During Exercise Resultant Fury in November 2004, Navy F-18 and Air Force B-52 aircraft conducted unprecedented precision strikes on moving targets under significant cloud cover at sea.[37] Although Navy F-14 crew members had to bail out over hostile territory in Iraq at the height of combat operations due to an aircraft malfunction, a search-and-rescue operation quickly recovered them. As Gen John Jumper, former USAF chief of staff, liked to say, "Space takes the 'search' out of search and rescue."[38] AFSPC has apprised the space cadre and key stakeholders of these wins to help maintain a high level of morale, dedication, and support.

Consolidate Gains and Produce More Change

One can best consolidate gains by clearly and explicitly demonstrating the value of space to the war fighter in an operational setting. This in turn will produce more beneficial change as combatant commanders begin to instantiate—even fight for—the continued presence of value-added space capabilities. The presence of DIRSPACEFORs in-theater illustrates this effect. Currently in US Central Command, Korea, and Pacific Air Forces, they are becoming a highly desirable part of warfighting commands. Originally established simply to demonstrate space expertise, they now see extensive use because they also put a face on joint space, speak for all services, and facilitate communications between the joint space operations center and the theater. Combatant commanders from all services who have come to depend on DIRSPACEFORs would now be hard pressed to give them up.[39] Realizing the value of space support, senior military planners are now beginning to include them in their campaign plans.

Anchor New Approaches in the Culture/ Bureaucratic Acceptance

Bureaucracy and transformation are seemingly antithetical to each other, with bureaucratic resistance often cited as the single greatest impediment to successful transformation.[40] Bureaucracy is not an enabler of transformation, but its presence in new forms indicates successfully *completed* transformation. If bureaucracy defends the status quo, new bureaucratic forms provide an indication of a new, firmly anchored status quo. Transformational capabilities must grow deep cultural and bureaucratic roots.

Both concrete and symbolic actions introduce new cultures. Culture creates a powerful sense of community. Substantial symbolic acts, such as creation of the new Space Badge now worn by space and missile warriors and presentation of the first one to military-space pioneer Gen Bernard A. Schriever by General Lord, help cultivate these cultural roots.[41] Additionally, each year AFSPC recognizes and honors individuals who played a significant role in the history of the Air Force's space and missile programs.

In 1980 the Air Force Scientific Advisory Board noted that "Air Force commanders do not generally believe that the space program is an Air Force program in which all can take pride."[42] That attitude can only change with the elevation of the space cadre's cultural institutions, recognition of AFSPC as a full-spectrum Space Combat Command, and establishment of a warrior ethos—the focus of the War Fighters thrust area. Bureaucratic acceptance may prove a much tougher task, often requiring as a first step consolidation and control. New forms of warfare frequently require the integration of capabilities (and resources) that exist across multiple organizations within the subject military service. As far back as 1945, taking a page from German successes in World War II, the US Army Air Forces recognized that "leadership in the development of these new weapons of the future can be assured only by uniting experts in aero-dynamics, structural design, electronics, servomechanisms, gyros and control devices, propulsion, and warheads under one leadership, and providing them with facilities . . . adequately funded by the highest ranking military and civilian leaders."[43] In 1993 the Air Force was advised to seek designation as the single Department of Defense manager for space acquisition *and* operation, establish a Space Warfare Center, and integrate air-and-space employment in all training and education programs.[44]

Clearly, AFSPC has applied these lessons from the past under the Rapidly Move Technology to War Fighting thrust area, which aims to integrate space-modernization planning, research, and development with acquisition organizations and processes, with the end focus on war-fighting capabilities. Additionally, the Space and Missile Systems Center has been folded into AFSPC to provide better linkage between space-acquiring and space-operating commands.

A Military Culture of Honest Study, Reflection, *and* Projection

AFSPC is taking significant steps on many levels to ensure that the US military not only learns the lessons of past space operations, but also grows beyond them to employ space systems for projecting combat power in future conflicts. This will require a robust physical and organizational infrastructure dedicated to intellectual debate, experimentation, war gaming, and development of concepts of operations. The journal *High Frontier* was designed from the onset to generate vigorous intellectual debate.[45] Space experimentation is alive and well at the US Air Force Academy, where cadets design and construct satellite systems in the laboratory.

Although the Air Force Doctrine Center serves as the single voice of all doctrinal matters in the Air Force, the National Security Space Institute will arm space professionals from all services with the knowledge of space systems they will need to participate in space-doctrine debates. In this way, the institute will aid and accelerate the development of space power doctrine and push for space technologies, just as the Air Corps Tactical School did for airpower, beginning in 1926.[46] AFSPC's Wizards thrust area aims to encourage and challenge space professionals to develop new space power theories as well as operational, readiness, and war-fighting concepts.[47] The war gaming of space-based capabilities, limited in the past to scenarios in which they were either present or not, is evolving to a state that allows gaming participants to understand and learn how to counter enemy attempts to degrade or deny space assets. War-gaming venues exist, but new training equipment must be developed to inject these scenarios into joint exercises at the tactical level.

Conclusion

Comparing the organizational environs of today's AFSPC to the historical analogs of multiple services from multiple nations makes clear that a transformation is required and is indeed under way. One sees the degree of the command's revolutionary transformation (as opposed to evolutionary change) in the extent to which AFSPC's current strategic actions mirror those of the transformation efforts that have gone before. That these actions mirror those of *successful* past transformations bodes well for the eventual success of AFSPC's current transformation strategy. Furthermore, the nine-point transformation-evaluation criteria developed here can serve as a useful guidepost to commanders attempting military organizational transformation in the future. Under the seven thrusts of "Commanding the Future," AFSPC's leadership has taken—and continues to take—actions to ensure the success of a transformation vital to space superiority, American military dominance, and the American way of life. ❑

Notes

1. John P. Kotter, *Leading Change* (Boston: Harvard Business School Press, 1996), 33–158.

2. Gen Lance W. Lord, "Space Superiority," *High Frontier* 1, no. 3 (Winter 2005): 5, http://www.peterson.af.mil/hqafspc/news/images/JournalWinter05.pdf.

3. Rick W. Sturdevant, "The Satellite—From Definite Possibility to Absolute Necessity: Five Decades of Technological Change," in *Golden Legacy, Boundless Future: Essays on the United States Air Force and the Rise of Aerospace Power*, ed. Rebecca H. Cameron and Barbara Wittig (Washington, DC: Air Force History and Museums Program, 2000), 323; and Lt Gen Michael A. Hamel, commander, Space and Missile Systems Center, Air Force Space Command, interview by the author, 13 September 2005.

4. This same promise manifested itself later, during Enduring Freedom and Iraqi Freedom in the mountains of Afghanistan and the urban centers of Iraq, respectively. Jacob Kipp, senior analyst, Foreign Military Studies Office, US Army Training and Doctrine Command, made the point that the Soviets viewed space as a part of a theater of military operations (TVD). As such, their objective of space superiority was integral to an overall objective of air superiority in the TVD. Col Lawrence E. Stellmon, *A Comparison of the U.S. and Soviet Space Programs: The Forgotten Dimension*, National Defense University Library Special Collections Report 87-2 C.1 (Washington, DC: National Defense University, 1987), 23.

5. Williamson Murray and Allan R. Millett, eds., *Military Innovation in the Interwar Period* (Cambridge: Cambridge University Press, 1996). The six elements are not listed explicitly, as are the eight elements of Kotter's study. Instead, they reappear repeatedly in similar forms throughout the 10 essays of this collection. Barry Watts and Williamson Murray ask a question similar to that of this case study when they propose the hypothesis that "we are now in the early stages of a period in which advances in precision weaponry, sensing and surveillance, computational and information-processing capabilities, and related systems will trigger substantial changes in future wars." "Military Innovation in Peacetime," in *Military Innovation*, 405. The similarity lies in the fact that each of these transformational capabilities is heavily dependent on space.

6. Williamson Murray, "Innovation: Past and Future," in *Military Innovation*, 311.

7. Ibid., 325.

8. Ibid., 326.

9. Geoffrey Till, "Adopting the Aircraft Carrier: The British, American, and Japanese Case Studies," in *Military Innovation*, 211.

10. Ibid., 210.

11. Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military*, reprint ed. (Ithaca, NY: Cornell University Press, 1994), 251.

12. Williamson Murray, "Strategic Bombing: The British, American, and German Experiences," in *Military Innovation*, 104.

13. Rosen, *Winning the Next War*, 87–90.

14. Murray, "Innovation: Past and Future," 317.

15. Ibid., 314.

16. See *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington, DC: The Commission, 11 January 2001), http://www.defenselink.mil/pubs/space20010111.pdf.

17. In response to a recommendation by the Space Commission, the commander of AFSPC was no longer triple-hatted; neither were the commanders of North American Aerospace Defense Command and US Space Command.

18. *Air Force Space Command Strategic Master Plan FY06 and Beyond* (Peterson AFB, CO: Headquarters AFSPC/XPXP, 1 October 2003), 3, http://www.peterson.af.mil/hqafspc/library/AFSPCPAOffice/Final%2006%20SMP–Signed!v1.pdf.

19. Theodor von Kármán, "Where We Stand: First Report to General of the Army H. H. Arnold on Long Range Research Problems of the Air Forces with a Review of German Plans and Developments" (Wright-Patterson AFB, OH: Air Force Materiel Command History Office, 22 August 1945), 12.

20. Sturdevant, "Satellite," 315.

21. John L. McLucas to Ray Bisplinghoff, chairman, Scientific Advisory Board, United States Air Force, letter, 13 August 1980; and Lt Gen Thomas S. Moorman Jr., *Blue Ribbon Panel of the Air Force in Space in the 21st Century* (Washington, DC: Office of the Chief of Staff of the Air Force, February 1993), 9–27.

22. Gen Lance W. Lord, "Commanding the Future: The Transformation of Air Force Space Command," *Air and Space Power Journal* 18, no. 2 (Summer 2004): 13, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj04/sum04/sum04.pdf.

23. House, *Congressional Testimony of General Lance W. Lord, Commander, Air Force Space Command, before the House Armed Services Strategic Forces Subcommittee*, 109th Cong., 1st sess., 12 July 2005; and Col Jeffrey Yuen, "Warfighting Needs and Uses for Responsive Space in the USPACOM Theater," *High Frontier* 1, no. 4 (n.d.): 22.

24. Gen Lance W. Lord, "Developing Space Professionals," *High Frontier* 1, no. 1 (Summer 2004): 7.

25. Senate, *Congressional Testimony of General Lance W. Lord, Commander, Air Force Space Command, before the Senate Armed Services Strategic Forces Subcommittee*, 109th Cong., 1st sess., 16 March 2005.

26. Gen Lance W. Lord (speech, National Defense Industrial Association, Space Policy and Architecture Symposium, 20 July 2004).

27. James C. Collins and Jerry I. Porras, "Building Your Company's Vision," *Harvard Business Review*, September–October 1996, 65.

28. Lord, "Commanding the Future," 9–15; and Hon. Peter B. Teets, "National Security Space in the Twenty-first Century," *Air and Space Power Journal* 18, no. 2 (Summer 2004): 4–8.

29. Gen Lance W. Lord, interview by the author, 21 November 2005.

30. See, for example, *Air and Space Power Journal* 18, no. 2 (Summer 2004); and Hon. Peter B. Teets, "Develop-

ing Space Power: Building on the Airpower Legacy," *Air and Space Power Journal* 17, no. 1 (Spring 2003): 11–15.

31. Gen Lance W. Lord, "The Impact of Space on Security: Stability in International Affairs," *Vital Speeches of the Day*, 15 March 2004, 325–30.

32. Air Force Space Command, http://www.peterson.af.mil/hqafspc/library/speeches/speeches.asp?.

33. Von Kármán, "Where We Stand," 88.

34. Gen Lance W. Lord, "The Face of Space" (speech, Air Power Council, Fort Worth, TX, 27 July 2005).

35. House, *Congressional Testimony*.

36. Senate, *Congressional Testimony*.

37. Ibid.

38. Gen Lance W. Lord, "Space: The Lynchpin to Joint Operations" (speech, Air Force Defense Strategy and Transformation Breakfast Seminar, Capitol Hill Club, Washington, DC, 9 March 2005).

39. Maj Gen Douglas Fraser, director of air and space operations, AFSPC, interview by the author, 28 August 2005.

40. Combining these two elements may seem an oversimplification, but the contention is that bureaucratic acceptance is a direct reflection of the new method's acceptance within the organizational culture.

41. Gen Lance W. Lord, "We Walked with a Legend: General Bernard A. Schriever, 1910–2005," *High Frontier* 1, no. 4 (n.d.): 54.

42. McLucas to Bisplinghoff, letter.

43. Von Kármán, "Where We Stand," 26.

44. Moorman, *Blue Ribbon Panel*, recommendations 1, 5, 12, and 15a.

45. Gen Lance W. Lord, "Welcome to High Frontier!" *High Frontier* 1, no. 1 (Summer 2004): 3–4.

46. Lt Col Joseph E. Brouillard, "SOPSC Educates Space Warriors," *High Frontier* 1, no. 1 (Summer 2004): 22–23.

47. Taking a leaf from Fred Kaplan's *The Wizards of Armageddon* (Stanford: Stanford University Press, 1991), an examination of the process and people who created the US vision of warfare using nuclear weapons, one sees that the Wizards thrust area intended to apply equal energy to war fighting in space.

Operational space systems are critical for our nation. Our satellites provide war fighters in the field with situational awareness, aid operational mission planning, and are crucial for precision navigation, communications, and missile defense operations.

—Dr. Ronald M. Sega
Undersecretary of the Air Force and Executive Agent for Space

The Myth of the Tactical Satellite

Lt Col Edward B. Tomme, USAF, retired

Editor's Note: This article is derived from a much more detailed, fully documented paper entitled "The Strategic Nature of Tactical Satellites" *available at the Web site of Maxwell Air Force Base's Airpower Research Institute: https://research.maxwell.af.mil/papers/ay2006/CADRE/tomme.pdf. While this article discusses the case of a single optimized low Earth orbit, the longer paper demonstrates that the results discussed here are quite general. It details the optimization technique and its underlying assumptions, discusses sensor limitations in depth, and debunks common arguments against the study methodology.*

Editorial Abstract: Many current proponents insist that "tactical" satellites are a must-have asset since they give the tactical war fighter a significant, palpable advantage in the battlespace. Colonel Tomme, however, argues that developing, funding, and producing these satellites constitute misdirected attempts to convince field commanders that satellite capabilities exist for battlefield exploitation. The author suggests that these proponents need to shift their focus toward the strategic realm, where measurable satellite effects can be meaningfully realized.

The wise are not wise because they make no mistakes. They are wise because they correct their mistakes as soon as they recognize them.

—Orson Scott Card
Xenocide, 1991

THE CONCEPT OF operationally responsive launch to get tactically useful payloads into orbit quickly and cheaply has been around for many years.[1] Operationally responsive launch has yet to be realized but is much closer to reality. There is a definite need for a capability to place inexpensive payloads into space on a very short time schedule.

Developing *tactically* useful payloads that can take advantage of responsive launch, however, is a different matter. A combination of *physical constraints* placed on satellites by orbital mechanics and *operational requirements* placed on their payloads by the missions that can be performed from space prevents all but the most rudimentary tactical missions from being attainable for the foreseeable future. Even if these missions can be performed from space, they will end up costing hundreds of thousands to several million dollars per hour overhead, a cost that would seem to place them beyond the reach of tactical or even theater commanders. Continued funding of the tactical satellite program under the misguided notion that such satellites can provide tactical effects on the ground only serves to drain scarce budgetary resources from other programs that *can* provide the desired effects.

The myth of tactical satellites is that they are tactical. As currently envisioned, there is no mission where a tactical satellite can provide primarily tactical effects.[2] To use computer programming language, "tactical" is a reserved word. When one uses that word to sell a program to a warrior, the warrior has a very specific understanding of what that technical term means—applying to small-scale, short-lived events, usually involving troops in contact.

The ability to launch small payloads into orbit on an operationally responsive timescale, however, does have its utility. The tactical satellite program needs a change of name and a change of focus, as the effects it can provide lie much closer to the strategic end of the spectrum of conflict. Such a change of focus would allow operationally responsive launch to compete in the *strategic* arena where it actually has a great deal of utility. In this case, however, tactical satellites appear to be a round peg in a square hole—a solution being forced into a mission where there are much better answers.

Background

The following table summarizes the optimized number of satellite passes, pass durations, and gap times for one reasonable circular

Table. Contact time and cost data for a 500 km circular orbit over Baghdad

Mission	*500 km Circular Orbit*				
	Average Number of Passes per Day	Average Pass Duration	Average Gap between Passes	Average Percent Useful Time Overhead (Duty Cycle)	Cost per Hour Overhead
	SINGLE SATELLITE				
Signals Intelligence (SIGINT)	9.7	7 min. 47 sec.	2 hr. 20 min.	5.6	$ 43K
Communications/ Blue Force Tracking (Comm/BFT)	8.7	6 min. 12 sec.	2 hr. 39 min.	3.9	61K
Imagery	4.6	1 min. 40 sec.	5 hr. 10 min.	0.5	429K
	FIVE-BALL CONSTELLATION				
SIGINT	48.6	7 min. 47 sec.	28 min.	27.8	43K
Comm/BFT	43.5	6 min. 12 sec.	32 min.	19.4	61K
Imagery	23.0	1 min. 40 sec.	1 hr. 02 min.	2.7	429K

Note: The hourly cost for a single satellite and a constellation of satellites is the same in this table due to the fact that adding a second satellite doubles both the coverage time and cost.

orbit altitude, chosen because it is about as high as any funded tactical satellite Advanced Concept Technology Demonstration (ACTD) is designed to orbit.[3] The parameters used to generate these results define the *tactical satellite program* as that term is used in this article.[4] The goal acquisition price per satellite and booster is no more than $20 million each.[5] They are designed to last between six months and one year to reduce the construction costs.[6] Again, I have not assumed numbers that will lead to a predetermined solution that will not support tactical satellites; these numbers are those espoused by tactical satellite proponents.

As can be seen from the table, signals intelligence (SIGINT) and communications/blue force tracking (comm/BFT) missions get significantly better performance than imagery missions. This difference is due to the severely constrained field of regard (FOR) available to imagery missions. Figure 1 shows the relative FORs, the area on the ground that its sensors

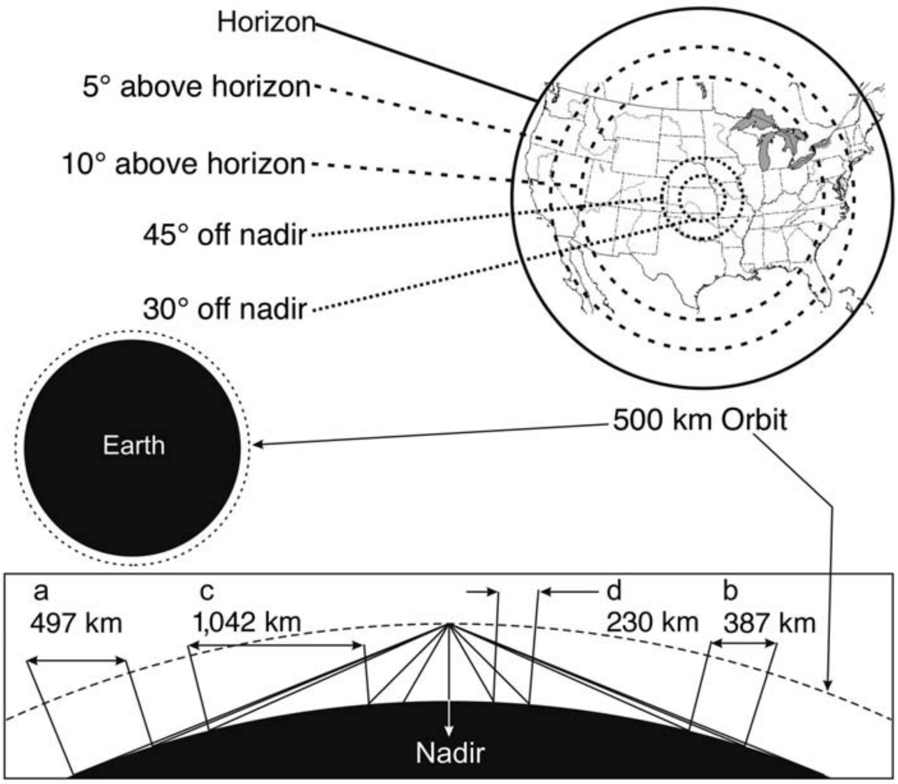


Figure 1. Fields of regard from 500 km. While it may appear at first glance that there are two points of view expressed in this figure (the ground-based point of view, above the horizon, and the satellite-based point of view, off nadir), the terms actually describe the same information. For any given altitude, any satellite-based FOR can be converted into a ground-based angle and vice versa. The conversion is a complicated function that depends upon satellite altitude. The two terms used are the ones commonly used operationally for the different mission types.

Note: In the upper portion of the figure, the dotted lines represent imagery-related FORs, the dashed lines represent comm/BFT-related FORs, and the solid line represents the SIGINT-related FORs. The middle-left portion shows the earth and a 500 km orbit to scale. The lower portion shows an enlarged side view of the FORs for the 500 km orbit. The distance labeled “a” is the difference between the radius of the horizon FOR and the five degrees above horizon FOR; b: between five and 10 degrees above the horizon FORs; c: between 10 degrees above horizon and 45 degrees off-nadir FORs; d: between 45 and 30 degrees off-nadir FORs.

can use, available to a satellite in a 500-kilometer (km) circular orbit—higher orbits would have similarly proportioned but larger FORs.[7] It should be obvious to any tactical war fighter that the levels of coverage shown in the table are inadequate for tactical needs. A tactical war fighter needs persistent imagery. Getting a snapshot every hour or so is not very useful at the tactical level, where the timescale of the action is measured in minutes or seconds.

SIGINT and comm/BFT missions are similarly ineffective from low Earth orbit (LEO) circular orbits. It is almost inconceivable to contemplate sending commanders into combat after telling them that they would only be able to communicate five minutes out of every half hour. A larger network similar to the 66 satellites in the Iridium constellation can provide good coverage, but even at a relatively inexpensive $20 million per satellite per year, the expense of such a network exceeds the reach of the tactical commander.[8]

In this article I will present the tactical satellite program in the best light possible. *I will assume that the satellites will work perfectly; they can be placed at will in the desired, optimized orbits; they will meet cost and lifetime goals; and the assumptions made about FORs will be as generous as possible. I will also assume perfect environmental conditions so the onboard sensors will always be able to perform their SIGINT, imagery, communications, and BFT missions. The goal is to show that even when all systems work better than advertised, the tactical satellite program still fails to provide tactical effects on the ground.* These generous programmatic assumptions will demonstrate that the failure to provide effects is not due to engineering shortfalls, where more money might solve the problem, but is due to physical limitations that cannot be overcome until the satellites become inexpensive enough to field constellations of hundreds simultaneously. By postulating the existence of a perfectly working technological product, we can then concentrate on evaluating the operational-utility part of the problem.

What is meant by a "perfectly working technological product" is a point worthy of discussion. From various briefings and published articles attributed to tactical satellite proponents, the goals of the generalized tactical satellite program appear to be to launch the energy equivalent of a 1,000-pound payload into a 100-nautical-mile (185 km) circular orbit.[9] Furthermore, the program seeks to keep it there for six months to a year at an acquisition cost of about $20 million per satellite and booster combined.[10] The results in the table assumed the use of an optimized orbit designed to give the maximum time for the satellite overhead, or *contact time.*[11] By optimizing the contact time, we also maximize the average number of satellite passes per day, maximize pass duration, minimize the amount of time the satellite is *not* overhead or *gap time,* and minimize the cost per hour overhead. These orbits are not necessarily the ones that are used operationally, as those orbits may be optimized for different constraints such as a constant-solar-illumination angle. However, these orbits give the absolute best cases for time and cost; all other orbits will necessarily give less time and will cost more per hour overhead.

Physical Constraints on Orbiting Objects

There are a number of "truisms" associated with orbits. They are presented here without proof. First, to optimize contact time, the inclination of the orbit should be very close to the latitude of the target. Second, increasing the orbital altitude increases the contact time.[12] This result is due to two causes. One can see farther when one gets higher.[13] Increasing altitude physically increases the size of the FOR, which in turn has a positive effect on contact time. Additionally, moving to a higher orbit slows the satellite down a bit, more closely matching its speed with that of the earth's rotation. The FOR thus moves more slowly across a target, also tending to increase the contact time. Finally, it is a truism that targets near the equator and the poles receive better optimized coverage than midlatitude targets.

As discussed above, a tactical satellite's orbital parameters will be limited by the energy that can be supplied by the booster. A booster that can put a 1,000-pound payload into a 185 km circular orbit could also put a 500-pound payload into a highly elliptical orbit with a perigee of 500 km and an apogee of 8,000 km.[14] If properly oriented, such a "magic orbit" will overfly the same point on the earth once per day and can provide a huge, slowly moving FOR during parts of its orbit, resulting in hours per day of coverage instead of mere minutes.[15]

We now have a good idea of how to optimize a satellite's circular orbit to obtain the maximum contact time over a specified target—put it as high as possible and match its inclination to the desired target's latitude. To optimize a magic orbit, we only need to make sure it is oriented properly in space using a specific set of orbital parameters. For the remainder of this article, I will assume the use of orbits optimized to maximize contact time. *This assumption will further ensure that we examine the operational utility of the tactical satellite concept in the best possible light: a platform that perfectly meets program goals and has been launched into an orbit that gives it the best chance for tactical success.*

Sensor Constraints on Optimized Orbits

As shown in figure 1, there are a number of FORs that can be applied to a satellite in any orbit. These FORs are based on the designed mission of the satellite. It would be nice to be able to use the huge horizon FOR all the time, but it is actually valid only for a few SIGINT missions. For other SIGINT missions as well as for the communications, BFT, and imagery missions, it is not. The reason the horizon FOR is not generally valid is due to sensor requirements. For SIGINT, communications, and BFT missions, the emitter of the signal being detected must have an unobstructed line of sight (LOS) to the sensor on the satellite.

SIGINT sensors can take in and analyze any signal they can detect. Thus, there is generally no requirement for them to be a certain angle above the horizon. If the terrain is flat and they can see all the way to the horizon, great. If there are mountains in the way, the sensor simply waits until it establishes LOS to the emitter and then begins collecting. For these reasons, I assume the horizon FOR is valid for most SIGINT missions.

Communications, BFT, and imagery missions are different. They cannot use the horizon FOR. Tactical comm/BFT capability has to be there all the time. Comm/BFT providers typically require their platforms to be at least five degrees above the horizon, with 10 degrees being more commonplace. While this requirement does not guarantee coverage in the bottom of a deep canyon, it does ensure that the odd tree, house, or hill will not normally interfere with direct LOS to the platform. As seen in figure 1, restricting the FOR to five degrees above the horizon has a significant effect on the performance delivered by an optimized orbit.

Imagery sensors are even more tightly constrained. Not only must they have LOS like the other missions, but they cannot look too far away from the vertical (nadir) without introducing a host of problems. These problems include foreshortening, excessive atmospheric degradation, and decreased resolution that can make analysis exceedingly difficult, if not impossible. Additionally, many imagery sensors operate in the visible-light region. It is extremely difficult for these sensors to function at night. Even night-capable infrared sensors have a hard time penetrating significant cloud cover.

Figure 2 shows the end result of the combination of orbital and sensor constraints for all latitudes on tactical satellites in 500 km orbits optimized to maximize contact time. Choosing any other orbit to achieve required mission goals will necessarily decrease coverage and increase cost.

The results in the table and figure 2 ignore the nontrivial limitations of weather and darkness and present optimized numbers that reflect an ability for imagery sensors to operate at full capability 24 hours a day/seven days a week (24/7); this assumption significantly overstates the actual capability.

The Operational Utility of Optimized Tactical Satellites

It is now time to examine space missions and compare the requirements placed on sat-

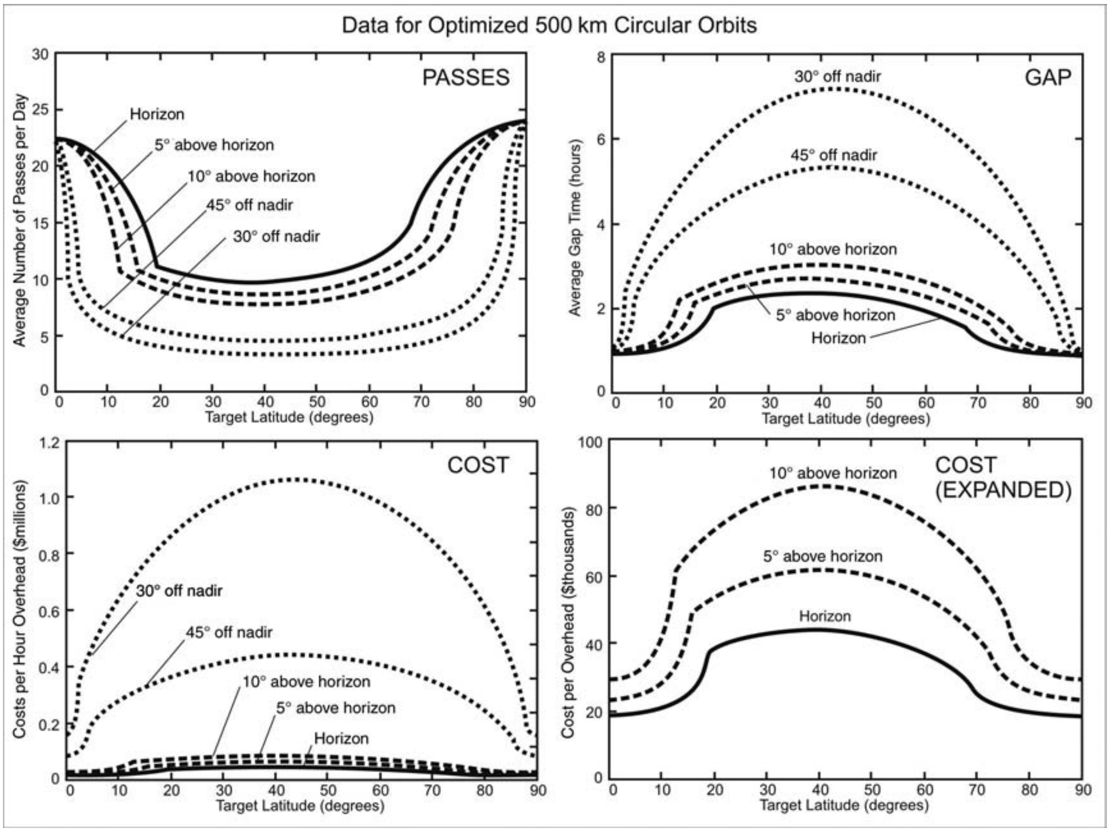


Figure 2. Number of passes, average gap time, and cost data for a tactical satellite in a 500 km orbit.

Note: The curves represent data for three mission types: SIGINT (solid), comm/BFT (dashed), and imagery (dotted). Cost data are shown in two panes as the scales between imagery and the other missions are quite disparate.

ellites with the constraints we have studied to this point. US joint space doctrine spells out four primary space mission areas: space force application, space support, space control, and space force enhancement.[16] Space force application consists of attacks against terrestrial targets by systems operating from or through space. Space support is the mission area that involves cradle-to-grave support of on-orbit assets. Space control ensures friendly use of space while denying it to adversaries and includes both offensive and defensive measures. Space force enhancement multiplies joint force effectiveness through heightened battlespace awareness. It includes the functions of intelligence, surveillance, and reconnaissance (ISR); tactical warning and attack assessment; environmental monitoring; communications; and precision navigation and timing. In this section of the study I will attempt to find niches in these mission areas for which tactical satellites are suited.

Space force application is not affected by the preceding discussion of orbital optimization, as no orbiting weapons are currently foreseen for the tactical satellite program. The *mass* of weapons such as lasers that could have an effect on the planet's surface would be much greater than the 1,000-pound tactical satellite reference mass. Conventional intercontinental ballistic missiles could possibly provide force-application effects within the weight range of the tactical satellite booster, but they are not satellites and will not be discussed in this article.

Likewise, space support is not a mission that has been discussed in the literature as a mission for tactical satellites. Space support from such things as launch facilities, operations centers, and the space communications and control network will be required for constellations of tactical satellites, but it will not provide a tactical effect to warriors on the ground. Tactical satellites will require space support but will not provide it. Note that I do not include the cost of any of this required space support in my cost calculations, as it is at present a relative unknown compared to the postulated $20 million per booster and satellite quoted by tactical satellite proponents.

Space control certainly seems to be within the purview of the reference energy (orbit/mass combination) of the tactical satellite program. Being able to responsively launch a satellite with the capability to maneuver in close proximity to other satellites would be a boon to those tasked with exercising both lethal and nonlethal shutter control on the space capabilities of hostile nations. However, such control is unquestionably a strategic mission with immense political ramifications and global effects. Employing it may provide advantage to tactical war fighters on the ground—many strategic actions do—but the advantage will be indirect. Thus, space control from a responsive launch platform will not be discussed further, since we are concerned with providing tactical effects on the ground.

After examining and eliminating the first three space missions from consideration, one sees that the only remaining space mission for which tactical satellites appear most useful is space force enhancement, the traditional role of most satellites. In fact, this mission appears to be the only one discussed to any degree in the literature dealing with tactical satellites. We will examine each of the five subelements of space force enhancement individually below, using the circular LEO and magic orbits discussed previously as baseline points of reference.

The tactical warning and attack assessment mission deals with providing timely notification of enemy use of ballistic missiles and nuclear detonations to the president and secretary of defense. This mission is currently performed from geosynchronous Earth orbit (GEO) by platforms such as the handful of Defense Support Program (DSP) satellites.[17] Such a mission would certainly be impossible from LEO without a constellation of hundreds of satellites, as it would require continual monitoring of the entire globe. While tactical satellites in magic orbits could conceivably perform the mission, it would still take between 12 and 20 of them to provide continual global coverage, at an acquisition cost of at least $240–400 million per year—a cost comparable to a single DSP bird, which is designed to last much longer. The mission is also undeniably strategic.

The environmental-monitoring mission provides data on space and terrestrial weather that could affect military operations. The Defense Meteorological Satellite Program (DMSP) platforms are one part of the current implementation of this mission element.[18] Tactical war fighters rely heavily on DMSP information to help plan their actions. Likewise, execution of the precision navigation and timing space mission element through the global positioning system (GPS) gives war fighters an enormous edge on the battlefield. GPS birds orbit much higher at about 11,000 km, making an orbit about every 12 hours.[19] Both systems are unarguably strategic, though, and replacement would not be the job of a small number of tactical assets. Additionally, were the DMSP or GPS constellations knocked out of service by some hostile act, it is difficult to imagine a situation where constellations replenished by responsively launched assets would be any less vulnerable to whatever brought the original systems down.

In contrast to the three subelements just discussed, the ISR and communications mission subelements do appear to have a need for tactical enhancement. Unfortunately, the cost-performance constraints of any responsive-launch boosters envisioned in the foreseeable future make tactical satellites poorly suited to be the source of that enhancement. I will discuss these constraints first in relation to circular LEO and then magic orbits.

The primary limitation to all tactical satellite applications from LEO is the very rapid passes of a relatively small FOR. LEO satellites do not and cannot provide persistence, an effect of paramount importance to warriors on the ground. This limitation is a severe constraint even for the best-case horizon FOR. From the truisms discussed above, it is obvious that to mitigate the rapid FOR pass, one should move to a higher altitude. However, there are drawbacks to this solution in addition to the reduction of payload mass in the energy trade for extra altitude.

While increasing the contact time and reducing the cost per hour overhead, raising the altitude has a negative impact on signal strength. Using the basic $1/r^2$ law for the attenuation of an electromagnetic signal, one sees that increasing altitude enough to significantly affect the FOR pass rate even more significantly decreases the signal strength received by the satellite.[20]

Large antennae for reception of radio signals can be manufactured relatively easily, and they are a relatively low-mass portion of the payload. To double the signal-collecting ability of an antenna, it is only necessary to double the antenna *area*, so compensating for the decreased signal strengths in most LEO orbits does not require an insurmountable increase in mass. The actual antenna sizes depend upon the required received signal strength, which is highly variable. Thus, it appears technically doable to put optics and antennae in LEO on tactical satellites.

That said, it remains for us to determine whether the effects provided by satellites in these LEO orbits are valuable to a tactical war fighter. The primary factors involved are, in decreasing order of importance to tactical warriors, coverage opportunities, coverage time, and cost. *To be truly useful to a tactical war fighter, effects have to be felt inside of the decision cycle of the enemy.* Information must be provided rapidly enough that it can influence the next friendly move before the enemy has time to readjust.[21] The table clearly shows that even at the 500 km altitude over Baghdad, the gap times are much longer than the timescale of a tactical engagement.

To get 24/7 persistence from even a SIGINT mission at 500 km would take a constellation of about 80 satellites.[22] It is quite evident that even at the relatively inexpensive projected cost of tactical satellites and their projected lifetimes that these numbers make persistent tactical satellite presence unaffordable. The acquisition cost of such a system would be at least *$1.6 billion each year.* It is for just such reasons that tactical satellite proponents instead propose very limited constellations, usually of five or fewer satellites, to provide what they call "tailored persistence."[23] Such persistence is obviously stroboscopic at best, providing a flash of utility periodically with large gaps of blindness in between.

On the other hand, even the relatively sparse constellation of five satellites discussed above would make such enemy communications and movement blackouts extremely difficult to employ for their *strategic* operations—operations where the timescale is long compared to the revisit rate. In most foreseeable situations, it would appear to be counterproductive to stop operations this frequently. On the other hand, for tactical engagements where the timescale is measured in minutes or seconds, much shorter than the satellite revisit rate, the overhead information will likely be too late and too sporadic to be of much use to friendly forces. "Tactical" satellites thus employed in LEO for SIGINT and imagery applications appear to be much more useful for strategic missions.

The budgetary numbers associated with tactical satellites greatly exceed the costs of putting existing manned and unmanned aircraft or proposed lighter-than-air, near-space assets over the battlefield. The persistence that these nonorbital platforms provide could be truly tailored to the pace of the battle instead of giving pseudorandomly-timed stroboscopic flashes of insight.[24]

The above discussions deal with the SIGINT and imagery missions, where even the sparse information provided by a small constellation could be of some use. On the other hand, sparse constellations of satellites in LEO have no chance of providing a useful communications capability. During an engagement, communications are needed when the warrior needs them, not when they are available. The tail can't wag the dog. Sporadic, pseudorandomly-timed communications capabilities will not support a tactical mission. Tactical commanders need the information available to them when *they* need it, not when the sensor is available to give it to them.

Apparently, tactical satellite proponents devised the magic orbit to counter the LEO coverage problem I have just discussed. The relatively long hang times over the target mean that five or six satellites could conceivably provide the 24/7 persistence that is unaffordable from LEO. This solution attacks only one of the two constraints on getting tactical effects from space—orbital mechanics. By moving much further away from the earth in an attempt to slow down the satellite passes, this solution compounds the other constraint—the payload's ability to perform the mission.

Using the 500 km orbit as the baseline, one finds that the average magic orbit distance from the target is 17 times further than the LEO. As an example of a specific effect on payload performance that such an increase in range will have, to get a one-meter optical image of Baghdad from the average magic distance of 8,500 km would take at least a 5.1 meter optical aperture (the size of the large telescope mirror at Mount Palomar Observatory in California) instead of the 0.36 meters required from 500 km.[25] For this reason, it would seem impractical to use the magic orbit for conventional imagery applications.

Similarly, a communications or SIGINT antenna in a magic orbit would have to increase in size to be as sensitive to signals as its LEO counterpart. Satellite communications on the move is a highly desired capability in the field.[26] Many people are familiar with satellite phones with their simple, easy-to-use whip antennae. These phones are generally run through the 66-satellite Iridium system orbiting in LEO at about 780 km. Iridium satellites use a set of three 1.6 square-meter (m^2) antennae for reception.[27] Having the satellites so close to the earth in LEO is the reason that the phones can employ antennae that don't require precise pointing at and tracking of the rapidly moving satellites. At their average distance above the horizon, magic orbits are 11 times further than even the Iridium constellation. The signal reaching them from the ground would thus be at least 120 times weaker. Since weight is a huge factor in getting to these higher orbits, increasing the size of the antennae to about the required 200 m^2 does not seem feasible. Without significantly larger antennae on the satellite, the ability to use whip antennae on the ground becomes problematic and would most likely require the use of the familiar small dishes to increase signal strength.

However, the use of a high-gain dish antenna is even more difficult for communicating with satellites in magic orbits. As discussed previously, it is currently difficult and therefore operationally prohibitive for troops on the move to stop, set up a dish antenna, and point it toward the *stationary* communications satellites that currently exist. This difficulty is significantly compounded when a *moving* satellite in a magic orbit has to be found and tracked in the middle of a tactical engagement. In contrast to the soldier on the ground who needs to manually point his antenna, many unmanned aerial vehicles (UAV) are already controlled through satellite links. It seems feasible for these links to be through satellites in magic orbits. However, the severe environment inherent in this orbital regime will likely be the ultimate arbiter of success for any magic orbit solution.

The requirement for satellites in magic orbits to regularly traverse the inner Van Allen belt will call for some mitigating engineering design to ensure that the one-year goal lifetime can be met. This mitigation can come in one of two ways: by using radiation-hardened, space-qualified components or by adding additional shielding to protect the cheaper commercial off-the-shelf electronics. The first method will almost certainly cause the budgetary goals of the program to be exceeded. The second method will add significant weight to the system. Neither solution seems palatable.

It is a physical fact that the constraints imposed by orbital mechanics and those imposed by sensor limitations work contrary to each other. Choosing a higher orbit that slows down the satellite pass to improve persistence ends up requiring huge increases in payload physical size, mass, and cost in order to maintain the standard of performance. It is an interesting "Catch-22": put the satellite low enough that it's affordable, and it's only marginally useful due to limited pass times, but put it high enough to be useful, and it's no longer affordable except at the strategic level.

Even with the favorable assumptions I have used in this analysis, it is clear that the ability of tactical satellites to deliver tactical effects is severely limited. Less optimistic (and more realistic) assumptions would further tip the balance against the utility and suitability of tactical satellites for tactical applications. As I have shown, there are severe physical constraints on satellites in circular LEO and elliptical magic orbits that conflict with tactical mission requirements. It seems highly impractical, if not impossible, to perform tactically useful imagery, communications, SIGINT, and BFT missions within these constraints, especially if cost remains a consideration.

Conclusion

Tactical satellites as currently defined by proponents aren't tactical. Just having a tactically responsive launch rate, if achievable, doesn't make an asset tactical. Just being much cheaper than other orbital platforms does not make an asset tactical. To meet the program goals briefed by tactical satellite proponents to senior military leaders, a tactical asset must also provide tactically relevant effects on the ground on a timescale that is less than that of a tactical engagement.

All is not gloom and doom for the tactical satellite program. Many of its goals are extremely worthwhile and will definitely benefit the nation and its defense. Standardizing busses and developing plug-and-play payloads will do a great deal to bring the cost of space effects down to earth. Being able to launch responsively will have a huge impact on space control options available to the national leadership. Being able to provide very cheap augmentation to expensive, hard-to-reconfigure national assets would be a boon to strategic planners. Being able to cross-correlate information from GEO and LEO birds for short time periods will make many strategic analysts extremely happy. It's not the program that is bad; it's simply misdirected. By using the word "tactical," proponents lead warriors to make unsupportable assumptions about the program's actual capabilities. Their focus needs to shift toward the strategic where the effects they advertise are possible to achieve and are useful.

In the end, it is much more appropriate for mythical *tactical* satellites to compete for funding against other strategically oriented programs. When they compete with and win funding against programs that actually have the potential to serve warriors on the ground, they detract from Congress's intended budgetary goals. Continuing to fund tactical satellites out of budget lines intended directly to serve the tactical war fighter does a disservice to both the taxpayer and the warrior on the ground. ❑

Notes

1. For example, see Maj Richard A. Hand, Maj Bonnie Houchen, and Maj Lou Larson, eds., *Space Handbook: A War Fighter's Guide to Space,* vol. 1 (Maxwell AFB, AL: Air University Press, 1993).

2. Air Force Tactical Exploitation of National Capabilities has a mission of finding tactically relevant uses for national assets, including satellites. While many tactical uses for satellites are possible, the global nature of an orbit makes the primary mission of these satellites strategic. "Air power *can* be global in its reach and ability to impose effects on an opponent, whereas space power, by its very nature, can *only* be global." Benjamin S. Lambeth, *Mastering the Ultimate High Ground: Next Steps in the Military Uses of Space*, RAND report MR-1649 (Santa Monica, CA: RAND, 2003), 45.

3. "TacSat-2/RoadRunner Micro Satellite Fact Sheet," February 2006, http://www.vs.afrl.af.mil/FactSheets/RoadRunner.pdf (accessed 4 April 2006); and "SpaceX Selected for Responsive Space Launch Demonstration under DARPA FALCON Program," SpaceX Web Site, 20 September 2004, http://www.spacex.com/index.html?section=media&content=http%3A//www.spacex.com/press11.php (accessed 6 November 2005).

4. There is no all-encompassing "tactical satellite program"; instead, there are a number of research efforts being conducted by Air Force Space Command's Space and Missile Systems Center (AFSPC/SMC), the Air Force Research Laboratory (AFRL), the Defense Advanced Research Projects Agency (DARPA), and others. The goals and parameters quoted throughout this article are generalized numbers based on numerous sources cited below.

5. In 2004 the advertised baseline cost for a tactical satellite and launch was $15 million. DOD, *Operationally Responsive Space Experiment: TacSat-1*, US Government White Paper (Washington, DC: DOD Office of Force Transformation, 17 October 2003), 2. By early 2005, the price was being quoted as $20 million to $30 million. Andy Pasztor, "Pentagon Envisions Operations with Small Satellites," *Wall Street Journal*, 26 August 2005. The current TacSat 2 will cost at least $50 million, barring further problems. Col Pamela Stewart, AFSPC Directorate of Plans and Requirements, "Responsive Space Near-Term Plan" (briefing, Air Force Scientific Advisory Board, Colorado Springs, CO, 27 April 2004). See also Col Rex Kiziah, AFRL, "Joint Warfighting Space" (briefing, Schriever III War Game, Nellis AFB, NV, 8 February 2005); and "Joint Warfighting Space: Not (Just) an Idea, Not Yet a Program," *Inside the Pentagon*, 6 May 2004, 1.

6. Kiziah, "Joint Warfighting Space." See also T. Ryan Space et al., "Transforming National Security Space Payloads," Paper no. RS2-2004-2001 (Los Angeles: Proceedings of the Second Responsive Space Conference, American Institute of Aeronautics and Astronautics, 19–22 April 2004); and Maj Scott Cook, AFSPC Directorate of Plans and Requirements, "Tactical Satellite (TacSat)/Joint Warfighting Space (JWS) Demonstration Program" (briefing, Headquarters AFSPC, Peterson AFB, CO, 6 January 2005).

7. The results presented in the table are based on quite optimistic fields of regard for the different mission types: horizon for SIGINT, five degrees above the horizon for comm/BFT, and 45 degrees off nadir for imagery. The numbers become much less favorable when more realistic fields of regard are used (10 degrees above the horizon for communications and 30 degrees off nadir for imagery). Cost data are based on the full year of service and the $20 million acquisition cost only, without factoring in infrastructure, daily operations, or personnel costs. Information on how the numbers were derived and much more detailed orbital-optimization calculations are provided in the longer version of this article.

8. Iridium Satellite Web Site, 12 November 2005, http://www.iridium.com/.

9. A booster can supply a certain amount of energy to a satellite. That energy is a somewhat complicated combination of the satellite's altitude and mass. The boosters currently envisioned for the tactical satellite program, DARPA's FALCON and SpaceX's Falcon 1, both have the approximate capability to put 1,000 pounds in a 100-nautical-mile orbit. They can put lighter payloads into higher orbits as long as the combination of payload mass and orbital altitude is less than the energy available from the booster.

10. Kiziah, "Joint Warfighting Space"; and Capt Beth Stargardt, AFRL Space Vehicle Directorate, "Tactical Space Employment for Joint Warfare" (briefing, Joint Forces Command Joint Space Concept Development and Experimentation Workshop, Norfolk, VA, 31 March 2004).

11. Data for circular orbits computed by the author using equations derived in M. W. Lo, "The Long-Term Forecast of Station View Periods," *The Telecommunications and Data Acquisition Progress Report 42-118, April–June 1994* (Pasadena, CA: Jet Propulsion Laboratory, 15 August 1994), 1–13, http://tmo.jpl.nasa.gov/progress_report/42-118/118J.pdf (accessed September 2005); and M. W. Lo, *Applications of Ergodic Theory to Coverage Analysis*, Paper no. AAS 03-638 (Big Sky, MT: Proceedings of the AAS Astrodynamics Specialist Conference, August 2003).

12. This truism is actually only true to certain altitudes. At a height at which one can almost see an entire hemisphere, raising the altitude further only marginally increases contact time. Additionally, the absolute maximum contact time would occur when a geostationary satellite is in view; that contact time would be 24/7. Moving higher than geosynchronous Earth orbit actually decreases the contact time. Since we are dealing with tactical satellites in LEO for this study, though, these limitations on the truism don't come into play.

13. T. S. Kelso, "Basics of the Geostationary Orbit," *Satellite Times*, May 1998, http://celestrak.com/columns/v04n07/ (accessed July 2005). In fact, it is possible to *actually* see an entire hemisphere only from a point an infinite distance away. A satellite in geostationary orbit can see only about 42 percent of the globe and cannot see locations with latitudes higher than 81 degrees.

14. James R. Wertz, "Coverage, Responsiveness, and Accessibility for Various 'Responsive Orbits,'" Paper no. RS3-2005-2002 (Los Angeles: Proceedings of the Third Responsive Space Conference, American Institute of Aeronautics and Astronautics, 25–28 April 2005), http://www.responsivespace.com/Papers/RS3%5CSESSION%20PAPERS%5CSESSION%202%5C2001-WERTZ%5C2001P.pdf (accessed 8 November 2005).

15. Rich Tuttle, "Air Force Studies Unique Orbit for Projected Family of Small Sats," *NetDefense*, 11 March 2004.

16. Joint Publication (JP) 3-14, *Joint Doctrine for Space Operations*, 9 August 2002, ix–x, IV-5–IV-10, and A-1–E-4.

17. "Defense Support Program Satellite Fact Sheet," 26 October 2005, http://space.au.af.mil/factsheets/dsp.htm.

18. "Defense Meteorological Satellite Program Fact Sheet," 26 October 2005, http://space.au.af.mil/factsheets/dmsp.htm.

19. "Navstar Global Positioning System Fact Sheet," 26 October 2005, http://space.au.af.mil/factsheets/gps.htm.

20. Ideal electromagnetic waves propagate as spheres or angular sections of spheres. The π area of a sphere is $4\pi r^2/3$. As the energy contained at any particular wave front must remain constant over time, the intensity of the wave at any point on that wave front must decrease to counter the spherical increase in the wave-front area. Thus, as the wave-front area increases as r^2, the intensity must decrease as $1/r^2$.

21. John R. Boyd, "A Discourse on Winning and Losing," Air University Library document no. MU 43947, August 1987. Unpublished briefing notes and essays.

22. Byron Hays, *Responsive Space/Tactical Satellite Utility Analysis* (briefing, Brig Gen William Shelton, director of Plans and Policy, US Strategic Command, April 2004).

23. Kiziah, "Joint Warfighting Space."

24. Orbital passes are not actually randomly distributed; they are, in fact, quite well determined, especially when highly variable perturbations such as atmospheric drag are neglected. However, for most orbits, the pattern of repetition for the satellite passes is not easily discerned by the warrior on the ground. Unless the orbit has been specifically tailored to do so (and in which case the satellite will not be providing the optimized maximum coverage time), the warrior cannot say, for example, "I will get two passes a day—one at noon and one at midnight—for the next two weeks." The pattern of repetition is vastly more complicated than that. For this reason, I will use the term *pseudorandom* to describe the pattern of satellite passes over a spot on the earth.

25. The wavelength used for this calculation was 400 nanometers (middle of the visible region). Distances were based on the slant range from the satellite to the edge of the FOR. The actual optics required to achieve the stated resolutions would be larger, as the diffraction limit is based on theoretically perfect seeing conditions.

26. David Hardy, "TacSat Demo Status: Senior Leader Vector Check" (briefing, AFRL, Kirtland AFB, NM, 22 September 2004).

27. Visual Satellite Observer's Web Site, "Catch a *Flaring/Glinting Iridium" (updated 6 March 2002), http://satobs.org/iridium.html (accessed 26 October 2005).

The Evolved Expendable Launch Vehicle

Tough Decisions to Assure Access to Space

MAJ GREGORY E. WOOD, USAF

Editorial Abstract: With the recent phaseouts of multiple medium/heavy space-launch vehicles, the evolved expendable launch vehicle (EELV) will soon become the nation's only vehicle able to insert capabilities into space and replenish them. However, the future EELV faces serious challenges. Major Wood contends that only a determined effort to maintain multiple providers, foster indigenous propulsion sources, and share civil-military technology will prevent potentially critical program delays and reduced effectiveness of space missions.

SINCE OPERATION DESERT STORM, the joint operational arena has recognized space as having vital strategic and tactical military significance. Assuring our access to space and having a responsive space-launch capability are key to success in all aspects of spaceborne operational capabilities, including communications, weather, navigation, positioning/timing, and intelligence, surveillance, and reconnaissance. With the recent phaseout of Atlas II/III, Titan II, and Titan IV, the evolved expendable launch vehicle (EELV) has already taken over for previous medium-through-heavy space lifters. The Air Force will fully transition from the last remaining "heritage" launch vehicle, the Delta II, following launch of the final global positioning system IIR satellite in 2008. The EELV will then become the nation's only space enabler, assuring accurate placement of our critical space assets so they can provide new or augmented capabilities—or replenishment of current capabilities.

The US Space Transportation Policy of 6 January 2005 states that the United States "must maintain robust, responsive, and resilient U.S. space transportation capabilities to assure access to space [and that] for the foreseeable future, the capabilities developed under the Evolved Expendable Launch Vehicle program shall be the foundation for access to space for intermediate and larger payloads for national security, homeland security, and civil purposes to the maximum extent possible."[1] The EELV is part of a space-lift modernization program of the Department of Defense (DOD) whereby the government contracts for launch services from two providers: Boeing, which builds the Delta IV family of boosters, and Lockheed Martin, which builds the Atlas V family. This article summarizes the EELV program's history and current status, introduces some program challenges to maintaining launch success and assured access, and provides recommendations to better support our war fighters.

Background and Program History

Based upon recommendations from the *Space Launch Modernization Study* (otherwise known as the Moorman Study), the National Space Transportation Policy of August 1994 directed the development and implementation of a plan for evolving current expendable launch systems.[2] Plan development took place in October of the same year, and Congress appropriated $40 million for space-launch modernization. Following release of a "request for proposal" in May 1995, Lockheed Martin and McDonnell Douglas (now the Boeing Company) were selected in December 1996 to continue with the preengineering and manufacturing-development-studies phase, each receiving $60 million to refine its concepts. The intent called for selecting one provider that better met the goal of reducing launch costs by at least 25 percent while meeting requirements for war-fighter operability.

In November 1997, the Air Force foresaw what it considered a dramatic increase in the commercial-launch market. The service believed that both the commercial-launch industry and the government would benefit from developing a partnership whereby the government would spend less money to purchase launch services, while launch contractors would have permission to sell their services in the commercial marketplace to make up for—and perhaps exceed—the difference in revenue. Contractors would invest their own resources for design, manufacturing, and launch infrastructure and would lease launchpads as well as facilities from the government. Therefore, instead of awarding a $1.6 billion contract to one EELV contractor, the government awarded two separate contracts, each for an initial investment of $500 million, to Lockheed Martin and Boeing in June 1998. Boeing would conduct 19 launches for $1.38 billion, and Lockheed Martin nine launches for $650 million.

Under this new partnership, the Air Force began purchasing launch services instead of actually taking possession of launch vehicles. The government now pays a contractor to place the payload in a specified orbit rather than actually buying flight hardware. Additionally, instead of operating launchpads and supporting facilities, it leases them to launch-service providers responsible for day-to-day operations even though the facilities reside on Air Force bases.

This arrangement, which represents a dramatic shift in the conduct of the launch business, produced effects felt throughout Air Force Space Command (AFSPC). The Air Force moved from the traditional role of contractor oversight to a new concept of insight into contractors' processes. The act of taking a step back from the launch process and leaving details of daily operations to the launch providers has considerably restricted—in some areas removed—the government's control over this process. Mandatory inspection points during booster production disappeared since the Air Force no longer bought the hardware, and AFSPC saw its role at the launch sites diminished. Oversight of hardware and protection of launchpad resources no longer resided with the launch squadrons.

Vehicle Families

The Atlas V and Delta IV each comprise a family of standardized, modularly designed launch vehicles configured to carry medium-to-heavy payloads to a variety of low Earth, polar, medium Earth, geostationary/geosynchronous, and geosynchronous transfer orbits (GTO). We have chosen these vehicles to optimize the positioning and availability of each of our critical defense payloads (fig.).

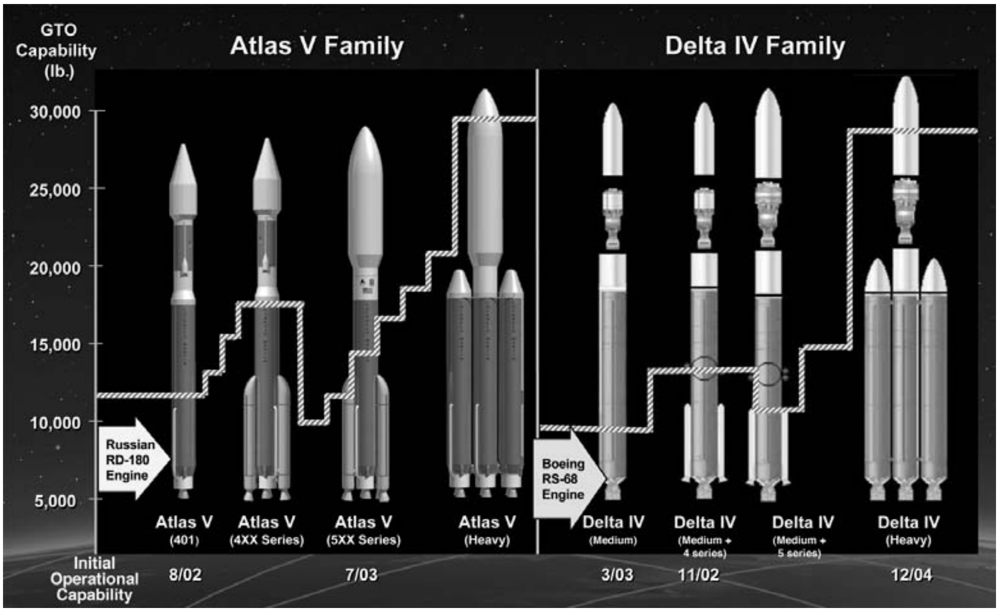


Figure. Atlas V and Delta IV families. (Courtesy AFSPC/PA.)

Note: The "stair-step" represents capabilities of different vehicle configurations using varied numbers of strap-on, solid-fuel rocket motors.

Atlas V

The Atlas V family, built by Lockheed Martin and operated by International Launch Services, evolved from the company's experience with both the Atlas II/III and Titan II/IV programs into a commercial and government launch system for the twenty-first century. The Atlas III served as a technology test bed for the future Atlas V technologies, primarily the Centaur upper stage and the Russian-built RD-180 first-stage engine. The medium- through intermediate-class vehicles in the family use a single-stage Atlas main engine—the RD-180—and the newly developed common booster core (CBC) with up to five strap-on, solid-fuel rocket boosters. The booster uses liquid oxygen and RP-1 (rocket-grade kerosene) propellants. The Atlas V has a 4.57-meter-diameter composite payload fairing; it can also use the heritage Atlas II/III payload fairings. The Atlas V 500 series will use three configurations. A stretched configuration will support larger payloads if Lockheed Martin develops an Atlas V heavy-vehicle configuration to carry the largest payloads to orbit.

The Atlas V Centaur upper stage uses a pressure-stabilized propellant-tank design using cryogenic propellants. Usually powered by one Pratt and Whitney RL 10A-4-2 engine with 22,300 pounds of thrust, the Centaur can accommodate two engines mounted on the second stage if required. The engines are capable of multiple in-space starts, which permit insertion into low-Earth parking orbit followed by a coast period and then insertion into GTO.

The Russian AN-124-100 aircraft transports the Atlas V boosters (manufactured in Waterton, Colorado, as is the Centaur upper stage) to the launch base. Atlas V currently launches from Space Launch Complex (SLC) 41 at Cape Canaveral Air Force Station, Florida, with a planned first flight from SLC 3E at Vandenberg AFB, California, in 2006. All variants of the Atlas V medium and intermediate launch vehicles can launch from the same pad. Although Lockheed Martin has designs for the Atlas V heavy, it has received no orders for it to date and has produced no flight hardware.

Delta IV

The Delta IV family, built by Boeing and sold by Boeing Launch Services, is designed for optimum performance in a wide range of flight profiles and can carry payloads up to 29,500 pounds to GTO. The Delta IV partly evolved from the Delta III launch system that flew three times in the late 1990s and demonstrated the second stage now flown on Delta IV. Each Delta IV configuration maximizes the use of common hardware; combines highly reliable, flight-proven systems; incorporates the latest technology; and uses a single CBC—except the heavy, which utilizes three. Furthermore, all but the heavy can be augmented by two or four 1.5-meter-diameter strap-on, solid-fuel, graphite-epoxy motors. The booster main engine, a Rocketdyne RS-68 liquid-hydrogen/liquid-oxygen engine producing 663,000 pounds of liftoff thrust, mounts to the CBC first-stage structure. The fact that it has significantly fewer parts than older engine designs simplifies manufacturing and increases reliability.

The cryogenic second stage incorporates the Delta II's guidance system and the Pratt and Whitney RL-10B-2 engine. All Delta IV vehicles use the same RL-10B engines and fly using a second stage either four or five meters in diameter. Similarly, the vehicle can fly with either a four- or five-meter payload fairing to accommodate a wide variety of payloads. Ships transport the Delta IV, manufactured in Decatur, Alabama, to SLC 37 at Cape Canaveral and SLC 6 at Vandenberg. All Delta IV vehicle variants for the medium, medium-plus, and heavy vehicles can launch from the same pad.

Current and Future Challenges

As the EELV becomes the sole space-launch vehicle for the Air Force, the program faces a number of operational, technical, and programmatic challenges. The original EELV vision called for a government-commercial partnership to develop and operate an efficient, reliable, and cost-effective expendable launch vehicle to meet our nation's needs. This partnership would produce a robust US commercial launch capability that would handle government payloads safely and effectively; it would also develop a family of vehicles that would reduce launch costs by 25–50 percent yet support a robust commercial launch capability for both providers. The commercial space-launch market collapsed shortly after the Air Force's decision to retain two providers, however, making it very difficult for both to remain financially solvent. The cut-rate prices that the Air Force enjoyed in the 1998 competition are not available for future purchases of launch services. At nearly the same time, the policy of assured access to space through two families of launch vehicles emerged. The United States learned an important lesson about putting all of its eggs in one basket in the late 1980s with the two-and-one-half-year grounding of all DOD space launches following the loss of the *Challenger* space shuttle. Failures of three heavy-lift missions in 1998–99 and recognition of critical capabilities enabled from space further amplified the need for space access. As a result, the Air Force finds that its EELV program has become an "anchor tenant" for the Lockheed Martin and Boeing launch systems. The president's budget for fiscal year 2006 as well as the National Security Space Policy demonstrated the Air Force's support of assured access to space through two families of launch vehicles through 2010. Although the service requested significant EELV budget increases, undoubtedly at the expense of other capabilities, the continued expense of maintaining two providers leads many people to argue in favor of downselecting to just one.

These incredibly complex vehicles and their supporting infrastructure depend upon a very specific engineering, operations, and maintenance skill set, making space lift quite expensive in comparison to many other DOD activities. Nevertheless, this country simply cannot afford to sacrifice space support of frontline war fighters. We must maintain this baseline workforce and the experience it brings or risk losing key strategic and tactical advantages over our adversaries.

This leads us to continue to try to eliminate any single points of failure in our launch programs. First among these is our requirement to maintain two providers. Several other issues also contribute to concerns over maintaining assured access to space. For example, the Atlas V family currently uses a Russian-built main engine, which brings with it obvious concerns over supply-line issues for DOD payloads. Additionally, both the Atlas V and Delta IV families rely upon variants of the same RL-10 second-stage engine, which represents yet another potential single point of failure for the DOD's entire space-launch program.

Two Providers

The Air Force must accept the cost of maintaining two launch providers; otherwise, we will face another scenario like the one we experienced after the *Challenger* accident in 1986. This comes at a cost of nearly $1 billion annually, but it is a burden we must bear. Within the next five to seven years, current plans call for the phaseout of both the Delta II family and the space shuttle. Although the National Aeronautics and Space Administration (NASA) plans to bring a new shuttle-derived capability online in that time frame, this remains in the conceptual phase; we cannot leverage our nation's ability to reach space on a new, undeveloped program and its anticipated schedule. The EELV will be the DOD's only means of accessing space. Additionally, NASA is designing its vehicle to a very specific set of requirements focused on exploration rather than EELV-like payload-delivery needs. The new NASA vehicle will not serve as a viable alternative for most, if not all, DOD requirements. Thus, dropping to a single provider would unquestionably result in putting all of our eggs in one basket again. We do everything possible to guarantee mission success, but the harsh reality of space launch is that accidents have occurred in the past and will happen again, leading to at least a temporary grounding of an entire vehicle family. Under a single-provider approach, this will result in a complete, likely extended, grounding of all launch capability throughout the DOD. Both the Air Force and the DOD have made financial decisions by asking how they could save money today and in the near term. We need to base funding decisions for this program not upon a traditional approach but upon a mature, longer-reaching one that takes into account the unacceptable ramifications of this country's losing military access to space.

Both Lockheed Martin and Boeing have proposed a merger to form a joint operation called United Launch Alliance (ULA), which has not received approval at the time of this writing. Contractor-provided estimates show a potential savings to the government of over $100 million annually through efficiencies gained. The basic construct of the ULA would move both Atlas V and Delta IV production under the same roof in Boeing's Delta facility in Decatur and would locate engineering and management at Lockheed Martin's Atlas facility in Denver. The ULA construct does not represent a drawdown to a single vehicle family; rather, it provides for synergies between the two. As proposed under this alliance, both the Atlas V and Delta IV families would continue production. Assuming the contractor savings estimates—not yet validated by the Air Force—are accurate, this proposal could significantly decrease the cost of maintaining two separate providers and avoid the post-*Challenger* scenario mentioned above. Even with two providers, we must still address a variety of issues in order to guarantee our access to space: the need for a purely American industrial base, new upper-stage technologies, more responsive launch capability, and the possibility of partnering and sharing technology and costs with NASA.

RD-180 Coproduction

An agreement between NPO Energomash and Pratt and Whitney Rocketdyne, two leading Russian and American rocket-engine manufacturers, will eventually allow production of the Atlas V's Russian-made RD-180 main engine in the United States, assuming the availability of funding to support the effort. Operation of a US coproduction facility will not begin until 2008, and the first launch using a coproduced engine may not occur until 2012. Any delays in coproduction will prolong US dependence upon Russian-built engines to launch vital DOD payloads. Under current restrictions of the International Traffic on Arms Regulations, it is difficult for the Air Force to gain the same in-depth understanding of engine design and test questions as it has with American-built engines used on other launch vehicles.

However, one might reasonably ask whether having the first-stage engine made in the United States is worth the start-up cost and risk of switching to this "new" one. Moreover, is it worth having an industry partner build a multi-hundred-million-dollar factory to produce engines that will see use only on Air Force/National Reconnaissance Office launches for the last seven years of the program (from 2013 to 2020)? The answer is a resounding yes. Again, this requires us to step back and make a longer-term funding commitment. In all likelihood, the EELV will continue to fly long beyond its originally projected phaseout in 2020. At some point, NASA's new launch vehicle will have matured and may be able to provide a viable backup to certain DOD launch requirements. Although likely capable of lifting large payloads into low Earth orbit, it would remain impractical for launches to GTO—a capability probably at least 10 years down the road. Once this happens, reliance upon a single provider may make sense if the Air Force is willing to accept a certain level of risk for its missions to geosynchronous Earth orbit.

Imagine a downselect occurring today, leaving us with only the Atlas V family and no capability to launch our payloads from the United States without relying upon a foreign-built engine. Having no inherent ability to build its own engines or troubleshoot production problems, the DOD would become solely reliant upon a Russian manufacturer to guarantee our access to space. Any issues with supply, production, or reliability would ground the fleet. In addition, reliance upon foreign-built engines greatly decreases the United States' baseline workforce in this highly specialized field. During the 1960s through 1980s, our workforce gained an immense amount of knowledge and experience from the Apollo, shuttle, and expendable-launch-vehicle programs. That aging workforce is now retiring; nevertheless, launch requires a highly specialized skill set. After losing an experienced workforce to retirement, potentially exacerbated by reliance on foreign manufacturers, America will find itself devoid of the required infrastructure to support its own access to space. Thus, we must fund coproduction of the RD-180 in the near term not only to protect our access to space, but also to protect our nation's baseline technological and production infrastructure in order to build the experience we need for future programs.

RL-10 Upper Stage

Propulsion remains the principal cause of launch failures. Unsurprisingly, most efforts to ensure access to space focus on the engines used on the EELV. Unlike the first-stage engines found on the Delta IV (RS-68) and Atlas V (RD-180), the engine used on both EELV second stages is based upon a single design.

The Pratt and Whitney RL-10 liquid-fueled rocket engine has served the United States as the hydrogen-fueled upper-stage propulsion system for over 40 years. Providing access to space for the Air Force by powering both EELV vehicles, the engine has seen its thrust level upgraded significantly in the last 15 years from 16,500 pounds to 24,750 pounds. The increase in power has resulted in a reduction in the structural and thermal margins of the engine's components, leaving it susceptible to manufacturing variations. We can attribute flight failure of a Delta III's RL-10 in 1999 to a poor brazing process in fabrication of the combustion chamber. Clearly, we could gain considerable benefits by investing in improvements to upper-stage propulsion.

Currently, AFSPC makes a yearly investment in improving the manufacturing, engineering, and reliability of the RL-10 engine. Such investment and the use of modern technology can yield engine reliability and marginal improvements in the near term. Specific areas identified by the RL-10 community to enhance robustness include product, process, and inspection improvements. Even as work progresses on the existing engine design, there are concerns that we may have squeezed all the performance out of this system—that we are flying the engine at the edge of the envelope.

Alternatively, a clean-sheet approach would yield a new engine with modern manufacturing techniques and ample margin for the future. In preparation, we need to identify technology investment that can increase reliability and reduce risk to future programs. The Air Force's space program should invest in the future of upper-stage propulsion, both short and long term. Maintaining the status quo will not achieve and maintain reliable access to space.

Obviously, coproduction of the RD-180 and enhancements to or replacement of the RL-10 program reflect fixes to specific concerns. Several options exist for less specific but broader solutions, including a "rolling booster" and a potential partnership with NASA to explore emerging technologies as that agency pursues its own next-generation technologies.

Rolling Booster

Currently the DOD must purchase an EELV booster two years prior to an anticipated launch date to allow for production and launch-site processing. The rolling-booster concept, however, would posture the Air Force to launch a given payload on demand, enabling a more responsive capability since the government would place an advanced order for a generic vehicle from each launch provider. Rather than order this vehicle and set it aside, we would use the first one off the production line but retain a "spare" in the event we had need of a rapid launch, such as an expedited launch in time of crisis. Assuming we have built a payload and integrated it with the launch vehicle, the rolling-booster concept could possibly cut call-up times from two years to something on the order of days or weeks.

AFSPC attempted to fund this rolling-booster effort in the budget for fiscal year 2006, but at present, maintaining a spare booster in the contractor's inventory appears cost-prohibitive. As payloads become more responsive and war-fighter needs for real-time augmentation of space assets emerge, the rolling booster will become a key enabler of America's assured access to space. Additionally, we have designed and integrated many of our critical payloads, such as the global positioning system, for launch on both the Atlas and Delta families. The rolling-booster concept provides significant flexibility for launch on demand, but many people view it as an unnecessary expense since a spare booster would likely cost in excess of $50 million for each family. They should consider the fact that the DOD spends over $1 billion annually to maintain our launch infrastructure and that this one-time purchase of "insurance" would represent only a small variation in that baseline. Furthermore, it would provide unprecedented operational flexibility for on-demand space support and guard against any potential grounding of a particular payload family. (A launch catastrophe or serious production issue by either provider grounds that vehicle family.) Rapidly moving a launch from one provider to the other would minimize or even negate the impact to war fighters in the field who rely upon precision navigation, intelligence, and communication capabilities from space.

DOD/NASA Partnership

In August 2005, the DOD and NASA committed to working together to assess and explore mutually beneficial technologies. They determined that "separating human-rated space exploration from unmanned payload launch will best achieve reliable and affordable assured access to space while maintaining our industrial base in both liquid and solid propulsion systems."[3] Regarding the use and development of launch systems, the EELV is the vehicle of choice for missions of 11,000–44,000 pounds, which include intermediate and heavy payloads "for national security, civil, science, and International Space Station cargo re-supply missions."[4] For missions of 25–30 metric tons, NASA will develop a crew-launch vehicle derived from the space shuttle's solid-fuel boosters and develop a new upper stage for human spaceflight. For future moon missions, NASA plans call for development of a new launch vehicle in the 100-metric-ton class built from the shuttle's external tanks and solid rockets.

The Air Force and NASA will share a requirement for the EELV and face many of the same challenges posed by potential single points of failure. Current fiscal constraints prevent either agency from pursuing the types of technological advances that will likely be required in the future. This recent policy opens a variety of avenues for both to share the cost burdens associated with the needed technological advances, making continued assured access to space more affordable for them; however, time is of the essence.

The foremost of these opportunities concerns the second-stage engine described above. NASA must develop a new second stage for its proposed exploration efforts to the moon and Mars since the RL-10 is inadequate for its mission profiles. The flight regime for the DOD's Earth-orbiting payloads and that for a translunar injection make it impossible for both agencies to use identical second stages because the thrust level required for NASA's missions far exceeds that required by the DOD. As recently as late 2005, NASA was considering pursuing new upper-stage technologies for this effort, creating potential cost sharing with the Air Force. But NASA changed paths in early 2006, deciding to use a new single upper-stage engine derived from the Saturn V J-2. Leveraging this existing technology will greatly reduce the timeline for NASA to return to the moon but leaves the Air Force with no easy way out of its reliance on the RL-10.

Clearly, the Air Force has already missed an outstanding opportunity to partner with NASA. Solely reliant upon the RL-10, the service will have to bear the full cost of eliminating this single point of failure. The merger of Rocketdyne and Pratt and Whitney in 2005 to form Pratt and Whitney Rocketdyne essentially eliminates competition in the private sector that might improve upon the RL-10 or decrease costs. Assuming that the ULA becomes a reality or that the Air Force is eventually forced to rely on a single launch provider, we will quickly find ourselves in a position in which a sole-source commercial launch agency procures upper stages from a single manufacturer. Such a situation will remove any commercial incentive to improve engine technologies or decrease costs because the Air Force will have to meet the prices dictated. Obviously the Air Force and NASA must continue to look for synergies—but more in the realm of technology sharing than in common hardware. Research agencies within both organizations must poise themselves for cross talk. We have already missed a prime opportunity for partnering, and we must not let it happen again.

Conclusion and Recommendations

An ever-growing dependency on space requires us to provide a responsive means of assuring access to that medium. As our capabilities have evolved, we have experienced success with the two EELV families of launch services and expect much more in the future, with solid partnerships and a streamlining of our capabilities guaranteeing entry to space and ensuring that we meet our joint-service needs. Although both families, still in their infancy, reflect a natural evolution from our heritage system, they carry many risks. The DOD's current funding environment offers nothing extra for this or any other program. As the Air Force works hard to minimize costs while maximizing capability, the DOD must consider making a financial decision that is good for the short term; at the same time, it must avoid unacceptable risk to this nation's space-launch capability in the long term.

First and foremost, we must maintain two families of launch providers in the near term. Currently, the DOD has no payloads designed for or manifested on the space shuttle—we rely completely upon the EELV. Delta II will fly its last mission in 2008. At the time of this writing, the two providers have a total of only 11 EELV launches between them—not enough to instill the confidence required to justify a single launch provider in the near future. The rolling booster, a cheap insurance policy that allows flexibility in the near term as we continue to use new launch technologies, will provide responsiveness in the future as demand for real-time payload support continues to evolve, in sharp contrast to our current two-year call-up time.

Reliance upon a Russian-built engine is unacceptable. Instead, we should encourage the planned coproduction of the RD-180, which would allow us to use American technology to support DOD activities and minimize reliance upon foreign governments, all the while helping maintain a critical industrial baseline in the United States. Moreover, we must eventually replace the RL-10. Partnering with NASA on its emerging manned-exploration initiatives opens many doors for cost sharing and cooperative technological gains. We cannot stand by and watch any longer. The Air Force has already missed a prime opportunity and must now lean forward to share requirements, funding, and technology for the benefit of both agencies.

None of this can happen without stepping back and taking a big-picture approach to our funding methodologies. Even though maintaining guaranteed access to space will require significant short-term costs, the longer-term expense of not maintaining this ability will prove far greater. Troops in the field will lose their current advantage over potential and current adversaries if we do not approach the EELV with a mature, life-cycle-oriented approach. We must maintain two providers, gain responsiveness through a rolling booster, establish an American baseline infrastructure, and aggressively engage with NASA to share technologies and approaches to develop commonality and synergies. Doing so will make both programs more cost-effective for the long haul. ❑

Notes

1. "Fact Sheet: U.S. Space Transportation Policy, January 6, 2005," n.p., http://www.ostp.gov/html/SpaceTransFactSheetJan2005.pdf.
2. *Space Launch Modernization Study* (Washington, DC: Department of Defense, 18 April 1994); and "Fact Sheet: National Space Transportation Policy" (Washington, DC: The White House, Office of Science and Technology Policy, 5 August 1994), http://www.ostp.gov/NSTC/html/pdd4.html.
3. Ronald M. Sega and Michael D. Griffin to the Honorable John H. Marburger III, director, Office of Science and Technology Policy, letter, 5 August 2005.
4. Ibid.

The mission of the United States Air Force is to deliver sovereign options for the defense of the United States of America and its global interests—to fly and fight in air, space, and cyberspace.

—US Air Force Mission Statement

Near Space 2015

A Conceptual Vision of Near-Space Operations

Maj Mark Steves, USAF

Editorial Abstract: Major Steves presents a fictional account of an Air Force unit in 2015. In this scenario, from a perch too high for most aircraft to reach but too low for most space objects to orbit, airships provide reconnaissance and communication services for military operations ranging from combat missions to humanitarian assistance.

THE FOLLOWING STORY is fiction. It depicts a "week in the life" of a hypothetical Air Force organization conducting near-space operations in the year 2015. The systems described are based on current concepts, both real and proposed. Projected timelines for developing such systems make the following scenario plausible. Although the story rests on these factors, the vehicles, payloads, organizational structure, and missions remain the fabrication of the author and have no direct relationship to any specific contractor proposals.

The near-space realm has no official or legal definition. Loosely, the concept refers to very high altitudes above which most aircraft cannot fly, but below altitudes at which satellites and other space objects reach orbit. Current proposals focus on technologies that would operate between 65,000 feet (20 kilometers) and 325,000 feet (100 kilometers). We have long known of the benefits of a platform able to function in the near-space realm. Both manned and unmanned aerial vehicles (UAV) have flown at near-space altitudes for decades, albeit for short durations. In 2006 advances in technology allow us to envision long-duration operations in near space. The US military, other government agencies, and commercial providers have all recognized the immense potential of this realm. Aggressive programs now under way seek to create a family of near-space systems to provide true persistence to a variety of users.

Our story begins in the year 2015. Collaborative efforts of the Department of Defense (DOD) and industry have resulted in three distinct near-space systems. Small, hand-launched balloons incorporate a glider system to return payloads after transiting a region. Joining these semiexpendable systems are large, fully reusable airships and high-altitude lightweight UAVs (HALU). All of these systems are operational and controlled by Air Force Space Command's 1st Near Space Group (NSG). We begin this week on a typical Monday morning as day-shift operations begin. . . .

Monday

Maj Hilary Newman, USAF, arrives at the 1st NSG operations building early in the morning. A unique organization, the group is responsible for the near-space systems in use by the US government. Based at Edwards AFB, California, it has units based worldwide to provide near-space capabilities as needed—anyplace and anytime. Major Newman begins her week as commander of the day-shift operations crew. Manned round-the-clock, the operations center is the hub of all near-space operations for the DOD. The ops-crew commander serves as the conductor, overseeing a team of officer, enlisted, and contractor personnel who monitor and control the active near-space systems. As Major Newman receives her changeover briefing from the night-shift commander, the rest of her team members arrive and assume control over their individual stations.

Of primary concern to the ops crew this morning is the health and status of the on-station airships. Over 600 feet long, the stratospheric airships are the "Big Daddies" of the near-space fleet. Capable of lifting 2,000 pounds of payload, these remarkable craft have more

in common with the great dirigibles of the 1930s than with the smaller blimps that most people recognize from sporting events. In addition to giving the aircraft its torpedo shape and rigid structure, the combination composite-and-metal skeleton acts as a frame upon which the propulsion, power, and payload systems rest. Hydrogen gas fills internal ballonets, providing the lift necessary to keep the massive craft airborne. Propelled by four ducted fan engines, the airship can reach a top speed of 45 knots. Flying with prevailing winds allows the airship to reach almost any point in the world from its base in 10 days. Once on station, the craft drives itself to an operational altitude where it sets up a station-keeping pattern based on wind speed and direction. Remaining there for the standard six-month time frame requires a renewable power source. Thus, thousands of square feet of ultraefficient photovoltaic cells cover the top half of the airship, converting radiant sun energy into stored power. Because they fly above the clouds, the airships have uninterrupted sunlight throughout the day. At night, the batteries release their power to the airship's systems and payload. This energy-efficient system allows round-the-clock operation for a full six months.

Major Newman and her team have as their first priority checking the status of the five airships currently in the air. Because the airships remain on station autonomously, no one has to "fly" them manually from the ground. After technicians enter coordinates from the global positioning system (GPS) into the redundant onboard computers, the craft will maintain itself within a predetermined footprint. Satellite-communication links to the ops center provide real-time telemetry of the airship's position and health. Any deviation of position or anomaly in the platform or payload triggers an immediate alert at the corresponding monitor station. If necessary, a trained operator can assume control of the airship, but switching to redundant components usually solves such problems. A quick check by the incoming crew confirms that all five airships are in the proper location, performing their missions.

Three airships are currently assigned to the Department of Homeland Security and the North American Aerospace Defense Command (NORAD). The new fleet of lighter-than-air craft drew their names from the first US military balloons used during the Civil War: the *Intrepid* and the *Washington* fly a slow pattern up and down the east and west coasts of the US mainland, with the *Excelsior* monitoring the southern border. As new airships come online, they will add to the coastal monitoring duty, filling in gaps that exist with only the two current assets. The data from their onboard sensor suites goes directly to NORAD, which shares it with the Office of Homeland Security. This data provides a lookout capability of hundreds of miles, monitoring the air, ground, and maritime traffic approaching our borders. Before the airships assumed this mission, border coverage was spotty. Now, however, it has increased to nearly 100 percent all the time.

The two remaining airships flying today provide support to the US military. Tensions between the allied Iraqi nation and Iran have caused concerns for our troops stationed at bases there. US Central Command requested that the *Constitution* monitor the border for any signs of hostile activity. The *Eagle* provides support to the Navy, maintaining station over a carrier battle group on maneuvers in the Pacific. Because of the situation in that area, it has become standard practice to assign an airship to the Navy to provide unparalleled over-the-horizon monitoring in all directions around the fleet. With all five airships on station and in running order, Major Newman and her team settle down to what they hope will be an uneventful day.

On the other side of the world, the unit responsible for another near-space system also hopes for a quiet week. Located at a Royal Air Force base in the United Kingdom (UK) and responsible for HALUs based in the European theater, the HALU-Europe squadron is one of two planned regional HALU units. Next year the HALU-Pacific squadron will station its fleet of aircraft at an airfield in Japan. Until then, the UK-based team bears any HALU taskers that come down. The newest arrow in the near-space quiver, the HALUs have been operational for only a year. These vehicles—evolutionary upgrades from the UAVs used for the past decade—differ from the older systems in two crucial ways: autonomy and persistence. Designed to fly without human input, they typically require manual control only during takeoff and landing, when the aircraft's 220-foot wingspan can create problems. Once at altitude, the onboard flight-control system flies the aircraft to the proper coordinates to begin its racetrack pattern. Additionally, whereas other UAVs can loiter for perhaps two days, HALUs can remain on station for up to two weeks; such persistence makes them true near-space assets.

Because of the time difference, Lt Col Toby "TR" Masino, the HALU-Europe squadron commander, began his day hours before Major Newman went on duty. Colonel Masino ensures that the five HALUs in his care remain at a constant state of readiness. Although the big airships provide the most lift and endurance, they still take more than a week to arrive at their destination. But conditions in today's world sometimes demand a more rapid response. Unlike the airships, HALUs can reach nearly any location in their hemisphere in just one to two days. True, their payloads of 1,000 pounds amount to only half that of the airships, but that's still enough to meet the needs of vital communications and/or reconnaissance missions. Not powered by solar energy, they usually stay on the ground until needed. A modular "plug-and-play" design unites the airframe and payloads, allowing the squadron to have a variety of payloads on hand for quick integration. Colonel Masino's team has just finished two weeks of exercises over Africa, so he's looking forward to a quiet week of rest and refurbishment.

Another 1st NSG team, however, is just beginning its mission. In a friendly Central American country, MSgt Ed Grant oversees the arrival of his balloon team—one of two teams in the 1st NSG responsible for deployed operations of the Tactical High Overhead Resource (THOR) balloon system. One of the first near-space systems to become operational back in 2006, THOR began as a demonstration program but exceeded everyone's expectations and quickly entered into service. After proving its worth in combat operations, it became a standard feature for US military operations worldwide. Today, the team is deploying to support a special operations mission to extract American hostages held by narco-terrorists.

The THOR system employs a rather simple concept: suspending a glider with an internal payload from a balloon. After reaching a preset altitude, the balloon drifts with the wind over a region of interest. At the conclusion of the mission or before the balloon drifts into unfriendly territory, the glider detaches from the balloon. Using onboard GPS, it autonomously flies back to a secure landing zone, where crews can hook up the glider and payload to another balloon and relaunch them. Using multiple launches from an upwind location, the team can provide continuous coverage over a region indefinitely. For the upcoming extraction, enough balloons and gliders have shipped with Sergeant Grant's team for five days of continuous coverage—although everyone hopes that only one day will suffice.

As Monday draws to a close, Major Newman and Colonel Masino have caught up on some paperwork. Sergeant Grant gets his team into quarters and then works on the ops plan for the upcoming mission. As the midshift begins its duty on the ops floor, the near-space airships keep watch high above their assigned areas.

THOR balloon system

Tuesday

Tuesday morning dawns bright and clear over the California desert. Major Newman performs her shift-changeover duties and attends to her checklist items. After establishing the state of the on-station airships, she contacts the various parts of the 1st NSG that are conducting their own operations.

First she calls Colonel Masino, who reports a ready status for his HALUs. The second call goes out to Sergeant Grant and his deployed THOR team, who have arrived at their operating base along the Central American coast. Veterans at this sort of task, the teams deploy about eight to 10 times per year to provide short-duration near-space support. Regular Army, Navy, and Marine Corps units have integrated balloon operations into their own forces. Each month the 1st NSG training squadron runs sessions for selected troops to learn the ins and outs of balloon operations. This training gives ground-force commanders an internal near-space balloon capability without having to call on the 1st NSG to deploy to every theater, leaving the THOR-deployable teams free to support smaller units such as the special ops on today's hostage-rescue mission.

Equipment checkout for the team includes assembling the gliders, integrating the payloads (in this case, communication-relay repeaters), and inspecting the balloons. As with every deployment, the team has brought more supplies than it should need. Because of the critical, time-sensitive nature of the operations, the team can't wait for replacements or additional equipment to arrive. Besides, even with advances in weather-prediction tools, forecast accuracy remains limited. Strong winds can push a balloon across the designated area in a matter of hours, requiring the launching of more balloons. Or a single balloon can effectively hover over the area for a day or more, with the mission ending only when the onboard batteries are depleted.

Sergeant Grant checks with his weather expert for the optimum launch location. Accurate weather forecasts are vital to the success of the mission since the team needs to know where and when to release, based upon wind speed and direction at altitude. Because the extraction operation has a small window, they will launch multiple balloons to provide redundancy in case equipment malfunctions or the operation runs longer than planned. All seems set for balloon releases at 0130 local time. Sergeant Grant informs Major Newman of his team's status and schedule; he then signs off to give his troops some rest before they commence operations.

For her last call of the morning, Major Newman checks with the maintenance squadron, whose job this week entails final preparations for launching the airship *Union*—the oldest in the fleet—named after the first US military balloon. Since returning to base three weeks ago, the *Union* has undergone routine refurbishment, which includes inspection of the 50,000 square feet of solar arrays for damage and replacement as necessary. The fabric skin and internal structure of the airship undergo inspection as well. Previously deployed for border-monitoring duty over the United States, the airship received a new payload last week for its upcoming mission. All the airships have proven themselves tough, requiring little maintenance after a routine deployment, so the *Union* will launch tomorrow and begin its transit to replace the *Constitution* over Iraq—weather permitting, of course. The airships can remain at altitude for months, but they are difficult to maneuver close to the ground. Because of the wind limit of 15 knots for launch, the craft typically depart in the calm desert air of early morning. For the rest of this day, Major Newman will prepare her team for tomorrow's launch.

Tuesday draws to a close just as it began—quietly. But tomorrow will be an entirely different story.

Wednesday

The *Union* rolls out of its immense hangar in the predawn hours. The crew encounters no problems during rollout, and the weather is picture perfect for launch. Major Newman's team at the ops center performs its prelaunch checkout and ensures that the airspace has been cleared. At the hangar, the visitors assemble. Even today, an airship launch draws a crowd. The 600-foot-long craft dwarfs everything except its hangar. It doesn't linger on the ground very long. Any wind gusts could make the airship hard to handle and dangerous to the ground crew, who checks the *Union*'s systems—especially the command and control system, which will guide this giant on its journey. Back in the ops center, Major Newman watches her team closely, and all systems check out green. With a final go/no-go check, the order comes down to release the airship from its mooring mast, and the vehicle takes to the misting morning sky. Slowly at first, the airship begins to rise. The large, ducted engines point the vessel into a nose-up attitude. The airship doesn't need the engines to reach altitude; they provide direction to make the ascent as efficient as possible. Weather-squadron personnel, who have already mapped out the upper-air wind speeds and directions, are in contact with other weather forecasters around the world. Thirty minutes later, the airship has be-

Union *airship*

come a mere dot in the sky. After just over an hour, it has reached cruising altitude.

Utilizing jet-stream winds, the *Union* rides the currents in a west-to-east pattern on a preprogrammed flight route. Avoiding any country's overflight restrictions, the airship follows a path to the Mideast that should have it arriving in eight days. Once in motion, the airship assumes control of its flight. The autonomous guidance system constantly updates its position via GPS satellites and monitors speed and direction. The ops-control team can manually input commands but only rarely needs to. For the next week, the team will monitor the airship's progress as it makes its way across the world. Once it arrives over Iraq, control authority for both platform and payload will transfer to the local commander.

The relative quiet that Major Newman and her team have enjoyed this past week comes to an end early in the afternoon. They hear reports of a major earthquake on the Indian coast, first on the news and then through the 1st NSG's Tasking Office—the conduit for any potential users of the group's near-space assets. Normally they support DOD users but sometimes receive requests from other government agencies, allies, and even foreign countries. Today, as the scope of the earthquake becomes clearer, Major Newman and the team realize that a major humanitarian crisis may soon unfold. The Indian government quickly calls for assistance from any nation, and the United States responds. In addition to the typical disaster relief that our country always rapidly provides, these days the world looks to US near-space assets for critical help. Although the 1st NSG can't deliver blankets or food, a single near-space asset over a disaster zone can establish communications to the entire region. The first use of these craft over the mud-slide disasters in Panama three years earlier clearly demonstrated this fact, and the Tasking Office knows that the Indian earthquake may lead to a formal tasking from the Department of State.

On the ops floor, Major Newman—expecting a call-up—begins to examine her options. There are two airships on station in that part of the world, but the Navy craft isn't carrying the correct type of payload. The *Constitution*, on the Iraqi border, could carry out the task, but it's unlikely to receive an order to abandon its current mission. The *Union*, launched this morning, could revector to assist in the short term, provided the *Constitution* can remain on station a little longer. But it will take the *Union* a week to arrive at the disaster site. Since she needs something more immediate, Major Newman decides to give the HALU-Europe squadron a heads-up.

In the United Kingdom, Colonel Masino isn't surprised by Major Newman's call since he's been watching the news as well. After receiving an update from her, he decides to start recalling his team. Confident of an imminent tasking order to use his HALUs in the relief effort, Colonel Masino wants to be ready to roll when he gets the word. The five aircraft stay in a normal state of readiness, but he raises them to an even higher level of alert and has his team start prepping one of the aircraft with a standard communications payload. In addition to providing relay for ground-to-ground radios, the payload also serves as a satellite-communications booster, allowing ground personnel to use low-power radios to talk through satellites to any location in the world. In only three hours, a HALU stands loaded with the payload and positioned for fueling. Because of the hazards associated with fueling, Colonel Masino holds off on that last act until formal notification arrives. In the meantime, his controllers have already plotted the best possible route from the UK base to the disaster zone. The HALU can arrive within 24 hours after launch and should be able to loiter for 10–12 days. If necessary, his people can launch a second HALU or perhaps redirect an airship. During the process of examining all these possibilities, Colonel Masino gets the tasking order: launch the HALU!

Members of the fueling crew move around the aircraft in their protective clothing, loading the liquid hydrogen. The specialized hangars at the base allow inside fueling, out of the weather. In the event of strong winds or winds blowing from the wrong direction, the HALUs stay grounded. Luckily, today's conditions are favorable, so the HALU shortly begins its taxi to the end of the runway. At this stage, a certified pilot from the squadron's ops center manually controls the vehicle. A similar setup back at the 1st NSG at Edwards AFB could control the HALU as well, but today those personnel only shadow the takeoff. After final checks of the craft's systems and an all-clear from the tower, the aircraft begins to roll slowly down the runway, and after using a good two-thirds of it, the HALU begins to rise. The great wings, drooped while the vehicle rested on the ground, now rise up, lifting it into the sky. The HALU performs no radical maneuvers or barrel rolls upon takeoff—just a gentle turn to line up on the predetermined heading. Like an airship, the HALU takes advantage of prevailing winds at lower altitudes to reach its destination as quickly as possible. As it approaches India, it will climb to 65,000 feet and begin to orbit the disaster area. But that won't occur until tomorrow. For now, Colonel Masino turns over control of his HALU to the team back at Edwards and starts prepping another vehicle in case it is needed.

Thursday

By 0130 local time on the Central American coast, Sergeant Grant's THOR team members stand ready for their first balloon release. They use hydrogen bottles, filled the day before, to release three balloons tonight. Based on the wind speed and direction, they can launch inside their deployed base. At the proper time, the inflated balloon attaches to the small, lightweight glider, which contains the relay payload that will provide communications connectivity to ground and airborne forces conducting today's operation. An hour after release, the balloon reaches an optimum altitude of 70,000 feet. The THOR's command and control system, operated via laptop by the launch team, monitors the ascent and commands venting and ballasting to hit the target altitude. Because of the good weather and relatively short distances involved, the gliders for tonight's operations will fly back to their launch location after separation from the balloons. The THOR teams can deploy a separate recovery crew if necessary, but Sergeant Grant is glad that he doesn't have to split his team today.

Three hours later, the team releases the second balloon, and the extraction mission is a go. As this balloon drifts over the target area, controllers switch on its payload systems and switch off the first balloon's payload. At this point, they command the first glider to release from the balloon. After plummeting for several thousand feet, the glider begins an automatic pullout and orients itself back to the launch location, over 200 miles away. Forty-five minutes after release, the glider performs a soft landing in the predesignated clearing. Sergeant Grant remains unaware of the operation's progress, but deep in the jungle the special forces troops consider his balloon a lifeline. As they strike out to the terrorist camp, their small tactical radios maintain contact with the recon unit monitoring the site and with the air-support helicopters in a holding pattern several miles away. Before the use of near space, such communication was impossible because terrain reduced a radio's effective range to about five miles. Now troops can talk to forces over 350 miles away. After rendezvousing with the recon team, they call in air support and begin their attack. Catching the terrorists completely off guard, the special forces quickly infiltrate the compound and rescue the American hostages. Within 10 minutes, all of them exit the camp, and helicopters come blazing in to pick them up.

Back at the launch location, recovery-team members retrieve the first glider and load it into their vehicles after notification of mission success. They then command the second glider to release and return to base. Knowing that their systems saved lives today, they are justifiably proud.

By the time Major Newman arrives for the start of her day, the THOR team has recovered all its equipment and has packed up. She finds it pleasing to report up the chain not only the team's success, but also the HALU's good progress and likelihood of arriving over the disaster area later today. Having coordinated with the various military and civilian relief agencies descending on the area, the 1st NSG's Integration Office needs to ensure the most effective use of the communications services provided by the HALU.

Like the day before, Thursday holds some surprises. On the ops floor, Major Newman notices an alarm at the station monitoring the airship *Eagle*, which supports the Navy carrier fleet. Apparently, the craft has blown off station. The upper-level winds have started gusting, blowing too hard for the airship's engines to fight. The ops floor swings into action, first gathering accurate weather data for all altitudes around the airship's position. Perhaps it's possible to rise above or go below the gusting winds to regain station. The weather-squadron personnel on shift discover a layer 5,000 feet lower than the current cruising altitude that would allow the airship to recover over the fleet. Even better, they do not foresee the higher winds at operating altitude lasting very long—good news because operating at lower altitudes requires more engine performance (therefore more power). Although they have not yet reached a critical threshold, if the engines cannot handle the power requirements, the payload might need to shut down. In the worst case, the airship would have to drift, sometimes hundreds of miles, until the batteries recharge sufficiently to allow the airship to fly back to its station—something that happens periodically to almost all of the airships.

Fortunately, the gigantic footprint from near-space altitude often means that the data flow remains uninterrupted, and users on the ground have no idea that their airship is no longer directly overhead. In only rare circumstances are the airships unable to recover within a day or two. The loss of a near-space asset, even for a day, sounds the alarm bells. Already informed of the temporary loss of his big eye-in-the-sky, the fleet commander on the Navy ship launches conventional aircraft to take up the slack. Formerly the norm for providing fleet defense, these aircraft now launch only rarely. Major Newman considers this scenario a prime example of the vital importance of near-space assets in today's world. It seems hard to believe how we conducted operations without them.

For the *Eagle*, a new flight plan will take it to a lower altitude. By the time the day shift ends, the airship is heading back to the fleet. The midshift team will take it the rest of the way.

Friday

Friday typically signals the end of a work week. But for the men and women of the 1st NSG, the work week never ends. The HALU begins to circle over the Indian disaster area, its payload providing communications coverage to a devastated region. Relief forces in the most remote and hardest-hit areas can now communicate with the aid center, arranging for medical airlift and supply delivery. Six airships are in the air; the *Eagle* has come back on station, shadowing its Navy user; the *Union* rides the jet stream east to Iraq; and the THOR team prepares to head home.

Back on base, Major Newman takes her lunch break to watch the dedication of their newest airship hangar. Although it contains upgrades such as a new fueling system and mobile scaffolding, this structure's retractable roof sets it apart. Operating much like a sports stadium, the roof will allow airship launches in all but the most severe weather, thus improving the team's ability to meet users' needs for near-space platforms.

Major Newman is proud to be a member of an organization that has become so significant to military operations in such a short time. The vision of Air Force leadership in the past several years—aggressively pursuing near-space systems to operational status—has paid off. Near-space assets fly every day in all corners of the world, providing support to military, diplomatic, security, and humanitarian causes. People now take their presence for granted, and Major Newman can only imagine what future fleets will ply the near-space realm. ❑

Strategy for Effects-Based Doctrine

Douglas E. Lee
Maj Timothy Albrecht, USAF

THE DEPARTMENT OF DEFENSE (DOD) has defined the term *effects* to varying degrees; however, a cogent strategy for effects does not exist among the military services and agencies. Although one can understand the term in the abstract, responses at a more tangible level elicit myriad definitions. One needs an effects-based road map consisting of common terminology when disparate and geographically separated organizations (e.g., US Central Command, Multi-National Force-Iraq, US Central Command Air Forces, and Multi-National Coalition-Iraq) work towards the same goal. A common language offers such benefits as

- translating objectives into a collective set of measurable goals applicable to all parties,
- providing a medium to bridge the "apples-to-oranges" paradox (e.g., measuring contributions from a concurrent-presence mission and a neighborhood patrol),
- standardizing the "sight picture" at all levels of command, and
- changing platform-based needs (one Predator and two A-10s) into effects-based requests (support a platoon hunting high-value target X in area Y).

At the strategic level, any road map should include US forces, the indigenous population, and the enemy (identified as terrorist forces for the war-termination phase in Iraq). Strategic-level effects might include (1) ensuring that US forces prevail, (2) making a successful transition to democracy, or (3) defeating terrorist insurgents. The next level of effects would deconstruct the insurgency into key attributes (see fig.).

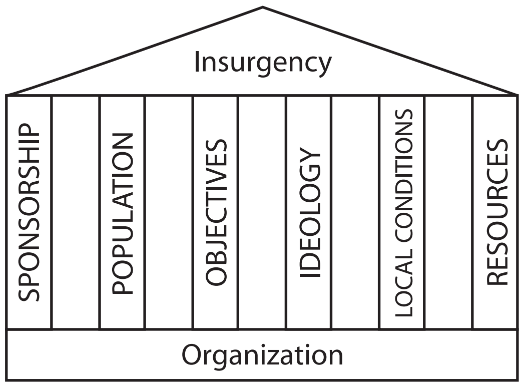


Figure. Key attributes of an insurgency

A subsequent iteration would define effects for these key components: (1) deny access to sponsors, (2) make objectives unattainable, (3) shut down the resource pipeline, or (4) disrupt the organization. The next step would further define key attributes—for example, expanding resources into funding, technology, and manpower. The process would continue until an effect corresponds to a concrete action (e.g., confiscate funds at bank Y in account 123). After developing the road map, one could use it to establish the effects foundation for any operation.

Possible courses of action include the following:

- Increase the effects-based operations (EBO) segments in professional military education, professional continuing education, and the curriculum for general officers, with a goal of generating discussion that would move towards a comprehensive, effects-based doctrine for the Air Force.

- Establish a joint tiger team to develop a common framework for the services to build upon. This team would use the services' models as a baseline for a DOD standard.
- Integrate standardized, effects-based metrics into the requirements-generation process as the basis for identifying service shortfalls.
- Link effects derived from service capabilities to potential measurements in order to focus assessment activities.

After one develops a common EBO language, an employment framework can follow, thus avoiding delays due to confused meaning. ❑

Book Reviews

Vital Guide: Air Aces of WWII by Robert Jackson. Crowood Press (http://www.crowoodpress.co.uk), The Stable Block, Crowood Lane, Ramsbury, Wiltshire, SN8 2HR, England, 2003, 112 pages, $12.95 (softcover).

Crowood Press has added another volume to its Vital Guide series of historical books. *Air Aces of WW II* looks at 104 airmen, presenting a one-page narrative of each man's exploits during the war. Robert Jackson, author of over 60 books on military subjects, has done a good job preparing this work. As with most books of this type, one rarely finds any earth-shattering information that makes the work historically indispensable. That said, *Air Aces of WWII* is not a book that readers *need* in their collection but is one they may want to add.

In addition to the 104 profiles, *Air Aces of WWII* boasts more than 100 photographs. My only complaint about them is that although the book focuses on aviators, many of the biographies have photos of planes rather than the men—as is the case for German superace Hans-Joachim Marseille, which features a picture of an Me-109 instead of Marseille. Also, anytime an author compiles a "greatest hits" type of list, people will second-guess the selections. For the most part, I was extremely pleased with Jackson's choice of biographies although I did question the omission of Guenther Rall, World War II's third-highest-scoring ace with 275 victories.

I did like the fact that although the book's title suggests the inclusion of fighter pilots only, Jackson generously includes bomber, attack, antisubmarine, and torpedo pilots. Too often, studies overlook the contributions of these aviators in favor of single-engined fighter pilots or their twin-engined, night-fighting brothers. What many of these other pilots accomplished against daunting odds, day after day, is nothing short of amazing. Kudos to Jackson for including them.

Overall, *Air Aces of WWII* is a short, easy, and informative read. This book is not on the same level as some of the author's previous works, but then again, that is not its purpose. Given the quality of the author's research and the book's modest price, readers will probably wish to add it to their collection.

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Decisions for War, 1914–1917 by Richard F. Hamilton and Holger H. Herwig. Cambridge University Press (http://us.cambridge.org), 40 West 20th Street, New York, New York 10011-4221, 2004, 282 pages, $60.00 (hardcover), $17.99 (softcover).

Soon after World War I ended, historians began writing about its causes. The outpouring of books and articles on this controversial issue has focused either on underlying (long-term) causes—nationalism, economic and colonial rivalries, Social Darwinism, militarism, and/or the prewar alliance systems—or immediate causes, including the assassination of Archduke Franz Ferdinand of Austria, the Austrian ultimatum to Serbia, the flurry of diplomatic notes among European capitals, and the troop mobilizations of late July 1914. Regardless of the approach and despite the outpouring on this subject, *Decisions for War* proves that there are still fresh and compelling interpretations of the causes of the Great War.

A pared-down version of a more extensive work published in 2003, this book falls into the "immediate causes" genre but with a significant difference. Instead of rehashing or reinterpreting the events between 28 June and 1 August 1914, Hamilton and Herwig, both well-known historians of modern Europe and modern military history, look at *how* the leaders of the belligerents, including those who joined the fighting after August 1914, arrived at their declarations of war. The authors thoroughly, concisely, and authoritatively analyze the actual decision-making process of the leaders and conclude that, generally, in each state, a small group of men at the center of their governments made the decision to go to war.

The book begins by rejecting the traditional underlying causes of the war. Instead, the authors argue that it is impossible to determine the weight, extent, and intensity of these factors, prevalent in many other works, because of the lack of real data on how these factors influenced the leaders. Additionally, they maintain that those leaders remained unaffected by the mass media and economic, religious, and any other "outside" pressure. They also spend little space discussing the various military plans developed by 1914 in case of war. Hamilton and Herwig conclude that the decision makers of 1914–17 considered only their country's strategic interests and prestige in their deliberations on whether or not to go to war.

The remaining chapters examine prewar deliberations of the leaders of each of the belligerents. The authors place primary "blame" on Austrian leaders who wanted a limited third Balkan war to "definitively eliminate a troublesome Serbia" (p. 68) but were willing to risk a continental war. German leaders felt they had to support their Austrian ally, turning the conflict into a European war, but were beset with internal confusion and bickering. Although neither French nor Russian leaders wanted war, the former wished to make their ties lasting and credible, and the latter were not sure what their mobilization meant. In other words, according to Hamilton and Herwig, the leaders of each country arrived at a decision to declare war based on their calculated view of their states' interests in going to war.

Most people generally view foreign-policy decisions as the products of states acting as unitary actors, not as the result of a process involving "real people." In that respect, *Decisions for War* provides a rarely seen view—how a small group of governmental leaders, including monarchs, ministers, military officers, party leaders, ambassadors, and others, decided on war rather than peace in the period 1914–17. Their decisions ultimately left nearly 16 million dead and 22 million wounded, destroyed four empires, led to another even more destructive war, and irrevocably changed the course of history.

This volume is a welcome addition to an already extensive literature on this controversial subject. Although it provides an invaluable look into the process that led the major belligerents in World War I to declare war, one cannot completely dismiss the influences of the war's underlying causes. For example, in October 1915, the Central Powers offered Macedonia to Bulgaria in exchange for Bulgaria's joining them. Bulgarian prime minister Vasil Radoslavov declared that "Bulgaria 'cannot and will not be denied its historical and ethnographic rights. It cannot be without Macedonia, for which it has shed so much blood' " (p. 174). Was he not appealing to Bulgarian nationalism to justify Bulgaria's entry into the war? If these traditional factors did not lead directly to war in the late summer of 1914 and later, they certainly framed the minds of leaders who made the decisions for war and cannot be dismissed as having no influence on those individuals, as the authors of *Decisions for War* have done.

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Desde el Dogfight hasta los UCAVs: Evolución del Poder Aéreo by Revista de la Escuela Superior de Guerra Aérea (RESGA). Editoria Gráfica Independencia Argentina S. R. L, Maipú 231, Buenos Aires, Argentina, 2002, 158 pages. (Not sold commercially.)

Written as a class project by officers of the Fuerza Aérea Argentina's (Argentinean air force) Escuela Superior de Guerra Aérea (Air Command and Staff College) and designed for academic use at that school, *Desde el Dogfight hasta los UCAVs* analyzes air operations from World War I through Operation Allied Force.* Campaigns covered in the book's 13 chapters, all written in Spanish, include the customary ones—those that took place in World War II, Korea, Vietnam, and the Gulf War of 1991—but the authors also examine the operations of less frequently studied campaigns: the Six-Day War of 1967, the Yom Kippur War of 1973, the Falklands/Malvinas War of 1982, the Bekaa Valley operation of 1982, and the Peru-Ecuador conflict of 1995. Because combat action dominates the discussion, readers will not find a chapter devoted to the Berlin airlift, arguably one of the most successful air operations on record. Not a history per se, the book critically analyzes each campaign, primarily from doctrinal and operational perspectives. Individuals

*The following faculty and students of Escuela Superior de Guerra Aérea's classes of 2000 and 2001 contributed to the book: Brig Gen Ricardo José Ciaschini, retired; Brig Gen Alberto Catalá, retired; Col Luis Augusto Demierre; Col José Cándido D'Odorico, retired; Col Jorge Alberto López, retired; Lt Col Percy Ryberg; Maj Walter Daniel Amaral; Maj Eduardo Mingorance; Maj Mario Collaizo; Maj Pedro Girardi; Maj Xavier Isaac; Maj Pablo Andrés Farías; Maj Ángel Rojo; Maj César Cunietti; and Maj Claudio Daniel Salaberry.

unfamiliar with this particular selection of air operations may want to consult a basic history text prior to reading this study.

Generally sympathetic to the value of airpower, *Desde el Dogfight hasta los UCAVs* heavily emphasizes doctrine, especially basic concepts such as centralized control of airpower and the importance of air superiority. Readers will note sympathy for the basic ideas of airpower pioneers like Giulio Douhet; however, the book criticizes the overly optimistic post–Allied Force assessments of analysts regarding airpower's ability to operate independently of surface forces. Throughout, the authors exhort their audience to think broadly and flexibly about airpower's ever-evolving nature and relation to surface forces.

For the most part, one finds the factual information highly accurate, although a few scattered errors intrude themselves. For example, the chapter on World War II lists the wrong dates for the Battle of Midway and discusses that battle before examining the Battle of the Coral Sea, which actually preceded Midway (pp. 47–48). Furthermore, the chapter devoted to the Vietnam War refers to Ho Chi Minh during the Linebacker II operation against North Vietnam in 1972 although Ho had actually died three years earlier (p. 88). These flaws, however, amount to little more than minor detractions.

In any critical analysis of this sort, some readers will take issue with the views and perspectives presented. For example, American readers may wince at comments such as "the Vietcong guerrilla was happy to get a daily ration of rice he carried in his pack, but the American soldier wasn't happy unless he had a cold Budweiser in his hands every day" (p. 92). Similarly, the treatment of the Falklands/Malvinas War reveals that Argentineans still have strong feelings regarding that unfortunate conflict. Although the chapter extols the bravery of Argentinean aircrews, it still manages to conduct a clear-eyed assessment of a painful episode in the history of Argentina's armed forces.

Several aspects of the book's layout could stand refinement. Printed in an extremely small font, the text will challenge some readers' eyesight. Fortunately, a number of black-and-white photos provide some relief. Although a separate bibliography is available from RESGA, readers who wish to delve more deeply into the campaigns will regret the absence of endnotes. Lastly, in some chapters, the lengthy listings of different aircraft types flown by opposing sides become tedious to read.

Despite its title, the book says little about unmanned aerial vehicles (UAV) and unmanned combat aerial vehicles (UCAV) until the last chapter, which describes recent developments in unmanned flight and speculates about future trends. Although UAVs have a long history, they began to enjoy particular prominence in 2002, just as the book appeared following the early months of Operation Enduring Freedom.

Overall, this study offers a good examination of twentieth-century air operations. Despite its fairly recent publication, the inexorable march of events threatens to render it outdated. One hopes that a more recent edition will address air operations in Afghanistan and Iraq, perhaps incorporating more background information about UAVs in past wars to set the stage for discussion of today's unmanned aircraft. In any event, students in Spanish-speaking military academies or staff colleges may find *Desde el Dogfight hasta los UCAVs* especially useful. Although readers cannot obtain it commercially, they might consider requesting a few copies from the Argentinean air force.

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Power to the Edge: Command . . . Control . . . in the Information Age by David S. Alberts and Richard E. Hayes. Command and Control Research Program Publications (http://www.dodccrp.org), c/o EBR, Inc., 1595 Spring Hill Road, Suite 250, Vienna, Virginia 22182-2216, 2003, 259 pages, free. http://www.dodccrp.org/publications/pdf/Alberts_Power.pdf.

Power to the Edge is one of the latest attempts by David Alberts and Richard Hayes to provide a vision for defense transformation. Like other books published by the Department of Defense's Command and Control Research Program (CCRP), it is available free of charge, both in softcover and electronically—perhaps one of the reasons it has been so widely read and, as such, so influential. Its influence on policy makers at the Pentagon provides motivation enough for readers with an interest in military strategy to become familiar with it, but one needs to read it critically. The premise of the book is that the availability of information afforded by the imminent network "infostructure" will allow the pushing of decisions previously made high up in the chain of command to the "edge" of the organization, closer to the "pointy end of the spear"—hence *power to the edge.* Only then will the "self-synchronization" promised by the prophets of network-centric warfare (Alberts and Hayes among them) be realized.

The authors never completely address several problems with this vision—the issue of novelty, for one. Although they raise the example of Trafalgar, at which individual captains imbued with Horatio Nelson's battle plan exercised tactical control over their own ships without real-time control by the admiral, they fail to indicate that this is only one instance of what would later be called *Auftragstaktik*. Perfected by Helmuth von Moltke in his wars against Denmark, Austria, and France, the idea of providing only mission (*Auftrag*) orders to subordinates—who then rely on their training, situational awareness, and understanding of command intent to make tactical decisions at the front—has now become the norm in most Western armies.

Alberts and Hayes do not emphasize that the model of distributed decision making used by Nelson and Moltke was based not on the *availability* of information, but on the lack thereof. Precisely *because* both officers knew that the fog of war would prevent them from visualizing the tactical situation on the battlefield, they adopted such a method of command. It is counterintuitive that both a dearth and a plethora of information should engender the same approach. Indeed, an abundance of information seems more likely to lead to micromanagement than to decentralized command, a fact to which the authors do not lend credence.

Nor do they discuss in detail the far-reaching implications of their vision. Although they call for a revolution in military acquisition, they fail to delve into the implications of *power to the edge* for force structure. If one pushes authority and responsibility out to the edge of an organization, what do the people nearer the center do? If lieutenants make major tactical and operational decisions, why do we need lieutenant colonels?

Analysis in the book is largely based on a comparison between future information-age command and control (C2) with older industrial-age methods. The authors spend a great deal of time enumerating the "characteristics" of industrial-age C2 but fail to comment on either their derivation or their orthogonality. Although the reader might assume that members of the specified set are relatively independent, they are linked together narratively as though one characteristic is a response to a combination of previous ones, which suggests that one might have profitably subjected them to further decomposition. This aside, Alberts and Hayes also fail to indicate whether viable alternatives exist for each of the attributes introduced. For example, what is the alternative to specialization?

At times the authors endeavor to frame their arguments in terms of psychological theory but never demonstrate a deep understanding of the vast literatures on either decision making or situational awareness, both of which are relevant. For example, they note in a discussion of Operation Iraqi Freedom that "the prompt suboptimization that created the desired effects was clearly preferable to the slow, ponderous processes that sought to optimize the use of weapons systems and platforms" (p. 68). This is in accord with Gary Klein's model of naturalistic decision making, which suggests that expert decision makers under time-stress do not make optimal decisions; instead, they make fast decisions that are "good enough." Unfortunately, Alberts and Hayes criticize this "method" of decision making in the very next chapter.

In addition to problems with the analysis, one notes issues with the presentation of the material. For one thing, it relies too much on other work by Alberts and his colleagues. If the authors are really talking about a revolution in military affairs, then the book itself should convince readers, without their having to read all of the other books in the series. Moreover, the citation of previous work gives the impression that the work has conclusively demonstrated a point—in the same way that scientific papers cite earlier scientific papers—to avoid having to re-prove the same assertion each time it is addressed. In this case, however, Alberts and Hayes often simply point to earlier incarnations of their opinion or vision as evidence, which can be misleading to the naïve reader—especially one not willing to follow the footnote trail.

The figures constitute the other major problem with the portrayal of information. For the most part, they are information-free—not wrong but trivial, usually because they illustrate a point that does not require illustration. As an example, the figures on page 61 occupy an entire page in an attempt to visually connote the concept of optimization. In general the authors need to consider their readership's level of education. Not all of the people at the Pentagon are mathematical geniuses, but they are certainly intelligent enough to understand the concepts presented in *Power to the Edge* without recourse to elementary-school figures.

Despite these criticisms, not everything in the book is bad. The fact that someone wrote it at all is a good thing if only because it means that smart people are thinking and writing about such vital themes. Further, much of what Alberts and Hayes have to say makes good sense. Their discussion of interoperability is useful, as is the fact that failures in interoperability are an inherent problem of platform-based acquisition. Their call for disruptive change instead of mere modernization should strike a chord in everyone who has experienced frustration with lags in the acquisition process and consequent difficulties in the development of tactics and doctrine. Moreover, the authors stress the importance of agility, the requirement for good collaborative tools, and the need for a change in culture.

In essence, the problem with *Power to the Edge* lies not so much in what it says but in what it does not say. Although the book focuses on the human decision maker, it issues a final appeal for a revolution in the command chain and acquisition process. Alberts and Hayes miss the boat because they fail to call first for an unbiased evaluation of the concepts underlying network-centric warfare and *power to the edge* in terms of their impact on the human operator. Unless the requirements for network-centric infostructure and the edge organization are firmly grounded in sound models of human decision making, the entire enterprise is doomed to failure.

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Launch the Intruders: A Naval Attack Squadron in the Vietnam War, 1972 by Carol Reardon. University Press of Kansas (http://www.kansaspress.ku.edu), 2502 Westbrooke Circle, Lawrence, Kansas 66045-4444, 2005, 440 pages, $34.95 (hardcover).

Carol Reardon, an accomplished military historian of nineteenth-century America, has served as an editor of the *Papers of Henry Clay* and has written two attention-getting books on the legacy of the Civil War. The first book looks at the impact of the conflict on the system of professional military education during the Gilded Age and Progressive Era; the second explores the history and memory of Pickett's Charge. She now turns her attention towards another war and a totally different topic—naval aviation—in an effort to avoid becoming a "one-war wonder" among military historians.

As the subtitle implies, this book is a unit history of one naval-aviation squadron during the last stages of the Vietnam War. Medium Attack Squadron 75 (VA-75) (the "Sunday Punchers"), which flew off the USS *Saratoga* (CVA-60), lacks the notoriety of squadrons such as Freiherr Manfred von Richthofen's Flying Circus, the Eagle Squadrons of the Royal Air Force, or Greg Boyington's Black Sheep. The Sunday Punchers, though, were the best in the Navy at the time, receiving in 1972 the Admiral C. Wade McClusky Award presented by the chief of naval operations to the best attack squadron. This lack of attention is one of the reasons Reardon decided to study this squadron. VA-75 flew A-6 Intruders and participated in the two Linebacker operations of 1972. Other than the novel and film *Flight of the Intruder*, naval aviation in general and the tactical-attack community in particular have received little attention from those who write about airpower in Vietnam. "This is an effort to explore, through one squadron's experiences, the contribution of the A-6 to LINEBACKER I and II" (p. xv).

The account that follows is the product of a good deal of varied historical research. Appearing at a history conference while she was working on this book, Reardon remarked that she considered the greatest strength of the project the fact that many of the veterans were still alive and consented to interviews. At the same time, their willingness to talk posed the greatest problem she had in writing this book. We all know that memory is a tricky thing and that war stories get better and better with each telling. Judging from the text, though, having living sources proved an important asset for Reardon. Many of the squadron members shared their personal papers, diaries, and photos with her, thus giving the account more immediacy and detail than it would have had otherwise. These types of documents often end up long forgotten in attics, and surviving family members rarely know what to do with them.

Although Reardon gives ample attention to combat operations, she is not one to focus just on bombs and bullets. Rather, she examines the debate over A-6 doctrine and spends time looking at the enlisted personnel in the squadron and the maintenance problems they faced in keeping planes in the air. Furthermore, covering the lives of family members who stayed at home adds rich detail and explains the concerns of many squadron members.

No book is perfect. The use of military acronyms seems excessive at times but will probably not bother readers of this journal. The study also lacks a conclusion that firmly assesses the impact of the A-6 on the Linebacker operations. These blemishes aside, this book is authoritative, and any officer taking command of a squadron should read it carefully.

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Mission Debrief

Air and Space Power Journal, the US Air Force's professional journal, is published in English, Spanish, Portuguese, Arabic, and French. Each version has its own personality as well as an editor—a native speaker of the particular language and an expert in the region of coverage—who selects the *Journal*'s content. We're always looking for good, thought-provoking articles up to 5,000 words in length, written in any of our published languages. All submissions will be edited in accordance with the standards set forth in the *Air University Style and Author Guide* (available online at http://aupress.maxwell.af.mil/Resources/style/austyle_guide.pdf). For details, please see our guidelines for submitting articles at http://www.airpower.maxwell.af.mil/airchronicles/howto1.html. You can contact us by e-mail at aspj@maxwell.af.mil; regular mail at *Air and Space Power Journal*, 401 Chennault Circle, Maxwell AFB AL 36112-6428; phone at DSN 493-5322 (commercial [334] 953-5322); or fax at DSN 493-5811.

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The Editor

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Maj Mark Steves (BS, University of Delaware; MS, Air Force Institute of Technology; MBA, Embry-Riddle Aeronautical University) works on the Commander's Action Group, Headquarters Air Force Space Command (AFSPC), Peterson AFB, Colorado. He formerly served as the Near Space Command lead at AFSPC, working within the Directorate of Plans and Requirements. He performed launch-operation tasks for 22 Delta II missions at Cape Canaveral AFS, Florida, as well as satellite command and control duties at Onizuka AFS in Sunnyvale, California. At the National Reconnaissance Office, he conducted satellite-operations tasks and served as a mission manager for launch integration of national space systems. Major Steves was competitively selected to attend the first Intermediate Developmental Education class at the Air Force Institute of Technology, Dayton, Ohio.

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Mr. Rémy M. Mauduit, editor of the new *Air and Space Power Journal* in French, presents a copy of the inaugural issue to Lt Gen Stephen R. Lorenz, commander of Air University (January 2006, Maxwell AFB, Alabama).

***Left to right*: Col Steven D. Carey, vice-commandant of the College of Aerospace Doctrine, Research and Education, Maxwell AFB, presents a gift to Gen Manuel José Taveira Martins, chief of staff, *Força Aérea Portuguesa* (Portuguese air force); and Lt Gen Helder Bernardo Rocha Martins, vice-chief of staff, *Força Aérea Portuguesa*, receives a gift from Mr. Almerisio B. Lopes, editor of *Air and Space Power Journal* in Portuguese (March 2006, Lisbon, Portugal).**