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50 YEARS OF AIR FORCE SPACE & MISSILES

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COVER: Air Force space and missile leadership over five decades was critical to winning the Cold War, enabled global and theater military operations and is vital to assuring United States security and well being in the 21st century.

HIGH FRONTIER

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Introduction

50 Years of Air Force Space & Missiles

General Lance W. Lord
Commander, Air Force Space Command

Warfare is evolving and space is transforming the way we fight ... We have made great progress over the decades in expanding the range of those exploiting these space capabilities from a small set of strategic users to multiple government agencies and virtually the entire warfighting force.

... our space community enables us to defend our interests and preserve our time-honored values of freedom and equality, wherever and whenever they are challenged around the globe.

- Secretary of the Air Force James G. Roche

Speech to the 19th National Space Symposium, Colorado Springs, Colorado, 9 April 2003

Introduction

Just as 2003 marked the 100th anniversary of powered flight, this year marks the 50-year anniversary of Air Force Space and Missiles. Of all the military services, the Air Force has been preeminently involved for the past fifty years in initiating, developing, and applying the technology of space-based systems in support of our Nation's national security.

This year's "50 Years of Air Force Space and Missiles" celebration takes center-stage for the second issue of *High Frontier*. This milestone presented us with a singular opportunity to commemorate General Bernard A. Schriever and his Western Development Division team of scientists, engineers, contractors, government officials and airmen who developed missile and satellite systems that led the nation into outer space, made possible arms control agreements with the Soviet Union and helped win the Cold War. The innovative and prescient leadership of General Schriever and his early team of experts have enabled the transformational military space and missile capabilities the Air Force operates today.

Our brilliant group featured in this issue of *High Frontier* commemorate and celebrate "50 Years of Air Force Space and Missiles." Distinguished Air Force historians Skip Bradley, Rick Sturdevant, Jack Neufeld and Harry Waldron have painstakingly captured and documented the heritage and legacy of this Command. They recognize Air Force contributions and leadership in securing America's national security. One of our Nation's great space champions, General Don Kutyna, educates and inspires readers as he explains the Command's contributions during the first Gulf War. Colonel Carol Hattrup and Major Elizabeth Waldrop treat us to a world-class legal treatise, which clarifies many important issues and events during the 50 years of Air Force space and missiles. Lieutenant Colonel George Farfour crafts an exemplary essay that connects the legacy of yesterday's space and missile pioneers with today's Space Professional Development efforts.

Origins and Development of Air Force Space & Missile Power

In late 1953, Assistant Secretary of the Air Force for Research and Development, Trevor Gardner, convened a group of experts in the field of long-range missiles that became known as the Teapot Committee. Their report urged acceleration of the Intercontinental Ballistic Missile (ICBM) program and the implementation of a new agency to develop it. As a result, Air Research and Development Command established the Western Development Division (WDD) in the summer of 1954, under the command of then Brigadier General Bernard "Bennie" Schriever. WDD's work on the Atlas and Titan ICBMs and the Thor Intermediate Range Ballistic Missile (IRBM) became the cornerstone of deterrence during the Cold War and the foundation for America's access to space for the next four decades.

While the Atlas ICBM was being conceived, engineered, produced and developed, General Schriever simultaneously supervised creation of the Thor IRBM, which went from contract award in December 1955 to Initial Operational Capability (IOC) in June 1959 – less than four years. The far more sophisticated Titan ICBM reached IOC in April 1962. Most amazing of all, an entirely new concept in ICBMs, the solid-fuel Minuteman, achieved IOC in December 1962, rendering obsolete all but Titan II missiles for nuclear deterrence. Mr. Jack Neufeld, senior Air Force historian, enlightens *High Frontier* readers that in just eight years, General Schriever and his brilliant organization created a missile industry capable of providing the US Air Force with four complete missile systems of almost unimaginable complexity and capability. Today, over 40 years since the Minuteman was first deployed, advanced models of the missile still safeguard our nation.

These early ICBM systems also became instrumental to all our achievements in space, resulting in very safe, effective and reliable launch vehicles. The first Atlas missile launch was in 1958, and its booster was used for all Mercury manned orbital launches. We continue to launch the successful Atlas II today while transitioning to the Atlas V Evolved Expendable Launch Vehicle (EELV), a true testament to the design and scientific marvels of our early space pioneers. Military and commercial versions of Atlas have launched interplanetary exploration missions to the moon (Surveyor), Mars (Mariner)

and beyond (Pioneer). Atlas has also lofted critical communication satellites, including the Defense Satellite Communications System (DSCS), Navy Fleet Satellite Communication (FLEETSATCOM), International Telecommunications Satellites (Intelsat), NASA Tracking and Data Relay Satellite System (TDRSS) and continual use broadcast systems like DirecTV.

Dr. Rick Sturdevant covers the important Titan story for *High Frontier* readers. A second generation of Titan ICBM, the Titan II, was used for all of NASA's Gemini missions. Last October, the final refurbished Titan II booster launched a Defense Meteorological Satellite on a perfect mission. This 25th launch for the Titan II booster capped an amazing overall record of 100% success. Titan III and IV, big brothers to the Titan II, carried our most capable national security satellites to orbit – including the Military Strategic Tactical Relay (MILSTAR) communications satellites and the Defense Support Program (DSP) missile warning satellites. Titan III also lofted the Voyager interplanetary probes (Voyager 1 is now over 8.4 billion miles from earth and still operating) and Viking 1 and 2, the first Mars Landers.

The Thor IRBM had its first successful flight in 1957. Just two years later, Thor launched Discoverer 1, the world's first polar orbiting satellite. From the Thor program, we built the Delta launch vehicle that took our GPS constellation to orbit and launched prized NASA missions – most notably the two Mars rovers, Spirit and Opportunity. Delta IV now forms a key part of our future access to space.

WDD's development of Air Force spacecraft began with Weapon System 117L (Corona), a reconnaissance satellite program. It took twelve unimaginable failures before the first CORONA satellite made it to orbit and worked correctly. Because of the dedication of WDD and its industry partners, our Nation was able to take 30-foot resolution pictures of Soviet missile fields in 1960. Not many Americans know the true leadership behind the trail-blazing paths that led to our high technology missile and space capabilities – in missile early warning, satellite communication, global navigation, weather forecasting and imaging. Our *High Frontier* contributors bring those amazing accomplishments to light during this issue.

It's important to remember our history – our roots – and the space and missile pioneers who gathered around the chalkboard, the design table, the factories and the launch pads that set our Nation on a historic path to the stars. Every summer at Air Force Space Command, we honor a select number of past space and missile leaders as winners of the "Air Force Space and Missile Pioneer Award." They crafted the innovative systems that evolved into the full-spectrum capabilities we have today – improving the life of our citizens and transforming our military in the process. Air Force Space Command began presenting this official Air Force Award in 1997 on the 50th anniversary of the Air Force. Each year since then, we have selected additional Space and Missile Pioneers to highlight our heritage and to honor those visionary leaders of yesteryear. They continue to inspire us today; to always push forward in developing the innovative solutions needed to safeguard our most pressing National Security Space concerns.

There is no better example of this transformation than recent actions from Operations ENDURING FREEDOM (OEF) and IRAQI FREEDOM (OIF). Simultaneously, our forces limited collateral damage, delivered humanitarian aid and saved the lives of combatants and civilians alike while conducting highly successful combat operations. I am proud of the Airmen, Soldiers, Sailors and Marines, who along with our industry partners, made it all possible. We know that you can't go to war and win without space.

General Tommy Franks, Former Commander of US Central Command, really hit the nail on the head when he told Congress:

> The pieces of this operation which have been successful would not have been so without space-based assets… it's just very simply a fact.

Space power continues to improve our battlefield speed, precision, lethality, reach and flexibility. During OEF and OIF, it took only minutes, not weeks, hours or days as in past wars, for commanders to identify and engage targets and to receive timely battle damage assessment. Our Coalition partners, and our adversary, got the message loud and clear: space power is now in the fight like never before.

Conclusion

Our Nation's space power is a true tribute to the legacy and heritage of the WDD. Our space capabilities have evolved overtime and served us well, but there is now a different threat that demands increasing requirements. Our capabilities have grown exponentially over the last 50 years beyond even the wildest dreams of our early space and missile pioneers. We must ensure these capabilities are deliberately and fully integrated into our war plans and operationally responsive to the Joint Force Commander. Our new vision is to provide full spectrum combat effects, from strategic to tactical effects using non-kinetic through kinetic systems in full combat synergy with all Joint Forces.

We owe it to our Nation to ensure that near-term space priorities succeed. We need to demonstrate that success before we can confidently move to larger and more ambitious endeavors. Hope alone is an inadequate strategy for more capability, our loftiest hopes must be reinforced with deliveries on current commitments. The leadership, technical and operational excellence, and the outstanding example of our early Space and Missile Pioneers will continue to serve as the guiding light for all of us who follow in their footsteps.

Air Force Space Command stands ready for whatever the future brings by continuing to innovate, develop, design, launch and operate leading-edge space and missile systems. This issue of *High Frontier* looks back on our space and mis-

sile heritage with pride and anxiously anticipates the bright future that awaits us all.

This edition also presents a perfect opportunity to comment on the success of our 50-year celebration. This effort relied heavily on the ability to implement and integrate our 50-year message across the Air Force and AFSPC. Our units developed and executed strong implementation plans, while our History Office and Public Affairs team engaged the rest of the Air Force. You have taken this 50-year celebration back to your office, your unit, your wing and told our amazing story. Our partnership with industry and community groups helped facilitate and execute successful 50-year space and missile anniversary events all across this country. Thanks for all your great work and what you do for our Air Force – congratulations on being a part of this important celebration. *High Frontier* welcomes article submissions, and values reader critiques, comments and letters to the editor. Now let's take all the lessons learned from our early space and missile pioneers and make a lasting impact beyond 2004.

General Lance W. Lord (BS, Otterbein College; MS, University of North Dakota) is the Commander of Air Force Space Command, Peterson Air Force Base, Colo. General Lord is responsible for the development, acquisition and operation of the Air Force space and missile systems. The general overseas a global network of satellite command and control, communications, missile warning and launch facilities, and ensures the combat readiness of America's intercontinental ballistic missile force (ICBM). The general has commanded two ICBM wings and a space wing as well as served as the Commandant of Squadron Officer School. Prior to his current position, General Lord was the Assistant Vice Chief of Staff for Headquarters US Air Force. The general is also a graduate of Squadron Officer School, Air War College and a distinguished graduate from Air Command and Staff College.

MILESTONES IN SPACE HISTORY

28 Feb 1958

HQ USAF authorizes Air Force Ballistic Missile Division to proceed with research and development of Minuteman solid-propellant ICBM

24 May 1960

US Air Force orbits its first MIDAS Early Warning satellite and recovers capsules ejected from Discoverer XIII (11 Aug) and XIV (19 Aug)

18 Jun 1965

First Titan IIIC research and development vehicle is launched successfully from Complex 40 at Cape Canaveral

1 Sep 1982

US Air Force activates Space Command to consolidate operational space activities

19 Apr 2002

AFSPC becomes a separate, four-star command and is assigned lead for all United States military space programs

A Brief History of the Air Force in Space

George W. Bradley III
Command Historian,
Headquarters Air Force Space Command

In the later years of World War II, the Army Air Forces began looking at the possibility of expanding its mission into space. Since those early days, the role of space has continued to grow within the Air Force. Indeed, the space medium had become so important to the service that in 1992, General Merrill "Tony" McPeak, Chief of Staff of the Air Force, stated that the mission of the Air Force was "to defend the United States through control and exploitation of air and space," -- for the first time formally placing air and space as equals in the Air Force mission statement.[1]

Towards the end of World War II Army Air Force leaders such as General Henry "Hap" Arnold, initiated studies of the possible ramifications of the technological changes that had taken place during the war. For example, Arnold asked longtime friend and scientist, Theodore von Karman, to study advances in aeronautical technology. Von Karman's report, "Toward New Horizons", issued in November 1945, flatly stated that "the satellite is a definite possibility." In 1946, the RAND Corporation report, "Preliminary Design of an Experimental World-Circling Spaceship", not only suggested that satellites were possible but predicted that the United States could put a 500 pound satellite into orbit by 1951. The Air Force continued to study the value of space and long-range missiles over the next decade. In late 1953, Assistant Secretary of the Air Force for Research and Development, Trevor Gardner, convened a group of experts in the field of long-range missiles known as the Teapot Committee, which issued its report on 10 February 1954. Among its recommendations, the committee urged acceleration of an ICBM program and the establishment of a new agency that would be free of excessive oversight. Following this recommendation, the Air Research and Development Command established the Western Development Division (WDD) on 1 July 1954 in Inglewood, California. On 2 August 1954, Brigadier General Bernard Schriever assumed command of the new organization whose mission was to develop an ICBM. Concurrent with the efforts to develop long-range missiles, the nation also pursued a space-based platform that could provide accurate information on Soviet intentions. Assigned the responsibility for studying this possibility, the RAND Corporation issued the "Project Feed Back Report" on 1 March 1954. Summarizing conclusions from numerous earlier studies, the report recommended that the Air Force develop a program to produce an electro-optical reconnaissance satellite. Following RAND's recommendation, the Air Force issued Weapon System Requirement No. 5 (WS 117L) on 27 November 1954, which directed the development of a reconnaissance satellite. While WS 117L's initial purpose was the development of a reconnaissance satellite, the program's scope later broadened to include other space-based missions such as meteorology, missile warning and multispectral imaging. These two missions, the development of missiles and the production of satellites were brought together on 15 October 1954 when the ICBM Scientific Advisory Group recommended the integration of Air Force satellite and missile programs and that the mission be assigned to the Western Development Division.

Over the next two decades, the Air Force would play a critical role in the development of an infrastructure to support the nation's space programs and would pursue more advanced and sophisticated satellite constellations in areas such as meteorology, navigation, communications, and warning. However, several key organizational and policy changes at the end of the 1950s and in the early 1960s led to fundamental changes in the Air Force's space responsibilities. In 1958, the National Aeronautics and Space Administration (NASA) was established and given responsibility for civil and manned space ventures. Two years later the National Reconnaissance Office (NRO) was formed to take charge of highly classified reconnaissance satellites.

The Air Force continued to develop satellite capabilities that would, in time, lead to operational space systems. For example, the Missile Defense Alarm System (MIDAS) represented the Air Force's first attempt at providing space-based detection and warning of long-range missile attacks. Essentially, MIDAS used an infrared scanner and telescope mounted in a rotating nose turret to detect launches. MIDAS 7, launched in May 1963, proved the concept of infrared (IR) sensing from a nearly circular 2,000-mile orbit. The development of a dedicated military weather satellite system was known initially as the Defense Satellite Applications Program (DSAP). The initial DSAP military weather satellites were relatively unsophisticated, weighing about 430 pounds. One of the earliest Air Force satellite communication systems was the Initial Defense Satellite Communications Program (IDSCP). The basic design principle of IDSCP involved strategic communications from fixed bases using satellites in random, subsynchronous orbits. The first IDSCP satellite was launched on 16 June 1966. Another capability provided by early satellites was navigation. Although the Navy, rather than the Air Force, produced the first working satellite navigation system (Transit), an early Air Force navigation satellite program was proposed by Ivan Getting and designated as Project 621B in 1963. Project 621B was designed to provide precise time and navigation information in three dimensions. Later, a joint Air Force and Navy program would result in what became known as the NAVSTAR Global

Positioning System. The need for accurate information on Soviet nuclear testing led to the development of a space-based system that could detect nuclear explosions. On 2 September 1959, the Department of Defense directed the Advanced Research Projects Agency (ARPA) to undertake the development of the Vela Hotel nuclear detection program, which was a low-cost, automated nuclear detection satellite constellation. The first pair of Vela satellites was launched from Cape Canaveral, Florida, on 16 October 1963 and detected a nuclear blast the very next day. More mature programs, all of which are still in service, eventually replaced the early satellite constellations developed in the 1960s and 1970s. These included the Defense Support Program (early warning), the Defense Meteorological Satellite Program (weather), the Defense Satellite Communications System (communications), and the Global Positioning System (navigation).

Concurrent with fielding these various satellite constellations, the Air Force also had to develop the ground-based infrastructure to support, augment and complement the space-based portions of the satellite systems. Among the ground-based systems were: ballistic missile warning (the Ballistic Missile Early Warning System, or BMEWS); surveillance of orbiting space objects (provided initially by systems such as the Baker-Nunn cameras and later by more sophisticated optical and electro-optical systems (Space Surveillance Network, or SSN); and satellite command and control (Air Force Satellite Control Network, or AFSCN). In addition, the Air Force developed the launch support bases necessary to get the satellites into space – one at Cape Canaveral Air Station in Florida and the other at Vandenberg AFB in California. They provided support not only for DoD sponsored systems but also for programs developed by other agencies such as the NRO and NASA, as well as for commercial launch requirements.

While the possibility of a command focused solely on space had been discussed in the Air Force for decades, it was not until the late 1970s and early 1980s that Air Force leaders sensed the time had come to substantially reorganize the way the Service managed its space systems. In February 1982 at Corona South, Air Force Chief of Staff, General Lew Allen, directed the leaders of Air Force Systems Command and Air Defense Command to develop proposals for an Air Force organization dedicated to space. The two commands formed a working group, which presented its findings to a meeting of senior Air Force officers, including General Allen, in April 1982. After some deliberation, General Allen decided that further planning would be directed towards establishing a Major Command. On 21 June 1982, General Allen appeared with Under Secretary of the Air Force Pete Aldridge to announce the formation of Space Command, which would be activated on 1 September 1982. Air Force Space Command's responsibilities grew quickly over the ensuing decade as it absorbed programs from Aerospace Defense Command, Air Force Systems Command, and Strategic Air Command. Eventually the command's missions included missile warning, space surveillance, satellite control, space defense, space support to operational forces, and launch operations.

The organizational changes that led to the establishment of Air Force Space Command reflected a growth in the use of space systems in support of operations worldwide. The first, extensive and broad-based employment of space support capabilities occurred during the 1991 Persian Gulf War. Over 60 military satellites and others from the commercial and civil sectors were employed during this conflict. DMSP provided dedicated support to forces in theater, which helped provide safe, highly effective planning and application of combat power in a harsh environment characterized by sandstorms and oil fires. It also aided in quick targeting shifts by mission planners. Satellite-based systems delivered over 90% of all communications to and from theater due to the sheer volume and the lack of ground-based infrastructure in that part of the world. At the height of the conflict, about 700,000 phone calls and 152,000 messages per day flowed in and out of theater over satellite links. DSP gave timely warning of Iraqi Scud missile launches to US forces in theater and allowed Patriot batteries in Israel, Saudi Arabia, and Kuwait sufficient time to engage the incoming Iraqi IRBMs. GPS satellites were employed in a variety of ways: precision weapons delivery, artillery spotting, and maneuvering of large troop formations.

One outcome from the Gulf War was an increased awareness throughout the Air Force and the other services of the importance of space in modern warfare. This led to a number of significant initiatives following the conflict. One important change was that AFSPC activated a new organization, the Space Warfare Center (SWC), on 1 November 1993. The mission of the new unit was to foster better support to warfighters through education and the development of new ideas. Also during that year the command organized Air Force Space Support Teams to provide in-theater space expertise to unified warfighting commanders. On 1 July 1993, the command significantly increased its size and responsibilities when the Air Force transferred the ICBM mission from Air Combat Command to AFPSC. In April 1997, a laboratory was created which integrated space with overall battle management.

As a result of those organizational changes and other factors, by the time the Air War over Serbia (AWOS) commenced in 1999, the Air Force had achieved an unprecedented level of integration between air and space capabilities. During AWOS, AFSPC deployed nearly 150 space professionals to nine different locations in theater. During the conflict, multi-source Tactical System/Combat Track I modifications to five B-52s and two B-1s allowed near real-time information to be flowed to the cockpits. The space-enabled information included such things as threats, target updates, imagery, and secure communications with the wing operations center. Other systems supplied on-demand battlespace characterization feedback on 620 events to the Combined Aerospace Operations Center (CAOC). GPS satellites provided terminal guidance for 656 Joint Direct Attack Munitions (JDAMs), 78 Conventional Air Launched Cruise Missiles and selected Tomahawk Land Attack Missile deliveries. Significantly, this was the first combat employment of JDAM, which allowed delivery of weapons against multiple aim points on a single pass with unprecedented precision re-

gardless of weather conditions.

In October 2001, the United States launched Operation ENDURING FREEDOM in Afghanistan. The operation was directed against the Taliban regime in Afghanistan, which harbored Osama Bin Laden and his Al Qaeda terrorist organization. Air Force space systems played an even more significant role in ENDURING FREEDOM than they had during Operations DESERT STORM and ALLIED FORCE. Combat operations in Afghanistan began with small groups of elite American military forces deployed to support anti-Taliban Afghani fighters. A number of the deployed troops carried 2.75-pound Precision Lightweight GPS Receivers (PLGRs) and satellite-based communications devices. GPS-guided munitions were employed with great accuracy, enabling air planners to reduce the number of air sorties required to destroy a particular objective. Space-based communications satellite constellations such as DSCS III, upgraded Milstar, and the Global Broadcast System (GBS), provided Allied forces with an array of reliable, improved, high-speed, secure and non-secure, long-range communications options. The amount of intelligence and other data relayed through space was unprecedented. DMSP satellites provided timely meteorological information in support of the air campaign; the space-based weather information was also invaluable to ground forces that often had to endure a harsh climate.

"I think we have truly integrated air and space operations better than ever before to achieve the battlefield effects we wanted—shorten the kill chain and be able to respond dynamically to what was going on out there."

- William B. Scott and Craig Covault

Less than two years later, American and Allied forces were once again on the offensive in southwest Asia. On 19 March 2003, a coalition of American and Allied forces entered Iraq to end the reign of dictator Saddam Hussein and the Ba'ath Party. The Allied forces leveraged space-based assets to an unprecedented combat advantage. As in previous operations, US commanders wanted to optimize the advantage provided by space systems. This was underscored during Operation IRAQI FREEDOM since it was in this conflict that, for the first time, the Combined Forces Air Component Commander (CFACC) was also designated as the Space Coordinator. Throughout the war space experts issued a Space Tasking Order (STO) that ensured space resources were in place and integrated into combat operations. Space assets were refined to provide maximum capabilities to forces. For example, the GPS satellite constellation was configured to ensure an average 3.08-meter (10ft) accuracy throughout active combat operations; this enhanced the accuracy of GPS directed Joint Direct Attack Munitions (JDAMs), which were employed at an unprecedented rate during the conflict. Four DSCS III communications satellites were optimized to support operations in the AOR and DSCS III satellites carried 80% of all Defense Department satellite communications and 45% of all wideband communications in theater. Because of the availability of medium-data-rate capability on the newest Milstar satellites, the US Navy was able to make more than 750 updates of Tomahawk cruise missile data packages. DSP satellites provided data on large explosions which, when combined with other information, helped the on-site commanders to assess battle damage. In an apt summary of space support during the conflict, Brigadier General Larry D. James, the senior space officer assigned to the Combined Air Operations Center (CAOC) during the war, commented that "I think we have truly integrated air and space operations better than ever before to achieve the battlefield effects we wanted—shorten the kill chain and be able to respond dynamically to what was going on out there."[2]

As space has become a more integral part of the military tool kit in both peace and war, the demand for more and better space capabilities has increased. For example, the need for improved launch capabilities led the Air Force to develop a new family of expendable launch systems, the Evolved Expendable Launch Vehicles or EELV. In addition, NASA and the Air Force have undertaken joint efforts to explore improved Reusable Launch Vehicle technology. All across the spectrum of space capabilities, new technology and innovative applications are leading to significantly advanced systems. The Air Force has proceeded with the development of a replacement for its DSP program, the Space Based Infrared System (SIBRS), which will provide unprecedented missile detection and tracking capability.

The growing importance of military space over the last few decades has resulted in a number of reviews. A study initiated by Congress in FY 2000 "The Commission to Assess United States National Security Space Management and Organization," better known as the Space Commission, had a significant impact on the Air Force space mission. The Space Commission issued its report in January 2001. Among its findings, the Commission observed the need for even closer ties between the Air Force and the NRO. Specifically, the study group recommended that the Air Force and NRO return to the relationship they had when the NRO was formed in the early 1960s; that is, that the Under Secretary of the Air Force would also serve as the Director of the National Reconnaissance Office and be designated the Acquisition Executive for Space. A key provision for AFSPC in the report was that the AFSPC Commander would no longer be triple-hatted as the Commander-in-Chief (CINC) of USSPACECOM and NORAD. Rather, the command would be led by an Air Force four-star general officer whose only responsibility would be to AFSPC. In addition, the Commission recommended that AFSPC's role in research and acquisition would be enhanced by the transfer of the Space and

Missile Systems Center (SMC) from Air Force Materiel Command (AFMC) to AFSPC. The capstone to the Commission's recommendations was that the Air Force be designated as the Executive Agent for Space for the Department of Defense. In addition to those organizational changes, the Commission also sought a change in the culture of the Air Force with respect to space. Towards that end the commissioners recommended that a high emphasis be placed on developing space professionals. By the end of CY 2002, the DoD and the Air Force had implemented most of the Commission's recommendations. The key remaining recommendation of the Commission, the establishment of the Air Force as the Executive Agent for Space for the Department of Defense, finally became effective on 7 July 2003.

From the establishment of the fledging Western Development Division in 1954, the Air Force has played a major role in advancing the nation's military space program. Satellite systems that played a relatively minor role during military operations have now become essential parts of the nation's warfighting arsenal. Significantly, many of the space systems developed by the military have found major applications in the civil and commercial space sectors. During the 1960s and 1970s the space mission in the Air Force evolved from being a relatively subordinate task assigned to various commands to becoming a major part of the Air Force's mission concentrated in one major command. Since its activation in 1982, Air Force Space Command has seen significant growth and is playing an ever more significant role in military space. In the end, the very nature of how the Air Force pursues its mission has indeed been changed. As noted by former Chief of Staff of the Air Force Michael E. Ryan in January 2000, "Never again can airman apply airpower without the seamless integration of space assets into their operational art, mind-set and culture."[3]

Notes:

[1] Lt Col Suzanne B. Gehri, "The Air Force Mission (Singular)," *Airpower Journal*, Winter 1992.

[2] William B. Scott and Craig Covault, "High Ground Over Iraq: Although relatively transparent to combat forces in the field, space assets and personnel were tightly linked to the fight," *Aviation Week and Space Technology*, 9 June 2003.

[3] HQ AFSPC/HO briefing, "How Did We Get Here? Where Did We Come From? – A History of the Air Force in Space," January 2001.

Note on Sources:

This essay is largely taken from a briefing prepared by George W. Bradley III, Dr. Rick Sturdevant, and Dr. Rick Eckert, of the HQ AFSPC Office of History, entitled "*How Did We Get Here? Where Did We Come From? A History of the Air Force in Space,*" January 2001.

The other key source for this article is David N. Spires' study on the history of the Air Force in space, *Beyond Horizons: A Half Century of Air Force Space Leadership* (Government Printing Office: Washington, D.C., 1997).

Another useful survey of Air Force space history is Curtis Peebles' *High Frontier: The United States Air Force and the Military Space Program* (Air Force History and Museums Program: Washington D.C., 1997). This short pamphlet is a handy reference for various Air Force space topics, especially specific space-related programs.

Jacob Neufeld's *Ballistic Missiles in the United States Air Force, 1945-1960* (Office of Air Force History: Washington, D.C., 1990) was useful in the section dealing with the early history of ICBMs. The author also used information on space support to recent contingencies found in the Space and Missile Systems Center (SMC) Office of History website on SMC history. The website's *Chapter VII : Increasing Reliance on Space Systems in Combat*, though brief, includes extremely useful summaries of Air Force support to Operations DESERT STORM, ALLIED FORCE, ENDURING FREEDOM, and IRAQI FREEDOM. More detailed information on space support to Operation IRAQI FREEDOM was found in William B. Scott and Craig Covault, "High Ground Over Iraq," *Aviation Week and Space Technology*, 9 June 2003.

The author also borrowed liberally from his own special study, "AFSPC and the Space Commission," HQ AFSPC Office of History Archives, for the section in the essay on the Space Commission.

The author relied on Lt Col Suzanne Gehri's, "The Air Force Mission," *Airpower Journal*, Winter 1992, for information on the changing Air Force mission statement.

An extremely detailed facts and statistics study, *Operation Iraqi Freedom – By the Numbers*, prepared by the Assessment and Analysis Division, HQ USCENTAF (CENTAF-PSAB: 30 April 2003) was used to verify specific statistical information on the war.

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The Air Force Ballistic Missile Division and the Pioneer Lunar Probes of 1958

Dr. Harry N. Waldron
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Space beckoned strongly in 1957, and the moon was its most compelling face. Reaching it represented leadership among nations, justification of cultures and institutions, a frontier for the daring to explore, a source of knowledge for hungry sciences, and—in the opinion of some space planners—a very real military advantage for states whose strategists possessed the technical competence and resources to use it.

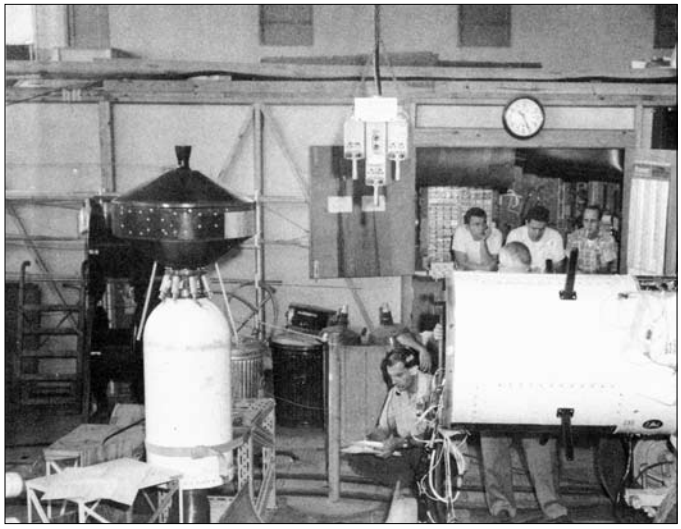
The Pioneer lunar probes were rooted in all of those aspirations. However, they also drew momentum from the national response to Soviet space achievements, as did all possible demonstrations of American space technology during the next 11 years, particularly those aimed at the moon.

The Pioneer lunar launches were also significant because they took some of the earliest steps in the conquest and management of space. Although the Air Force had been working on the development of a reconnaissance satellite called Weapon System 117L since 1955, that program had yet to launch any hardware. The Pioneer missions were the Air Force's first operational ventures into space. They involved:

- First space launches of any kind attempted by the Air Force;
- First deep space or lunar probes attempted by anyone, as well as the world's first practical attempts (although unsuccessful in their ultimate objective) to place payloads in the vicinity of the moon;
- World's first attempts to gather data about a celestial body other than Earth by means of spacecraft, as well as the world's first attempts to photograph a celestial body other than Earth from a spacecraft;
- First scientific measurements of the interplanetary environment, including the first observations from space of Earth's magnetic field, the first measurements of the density of micro-meteorites in outer space, and the first measurement of the dimensions of Earth's radiation belt;[1]
- First space mission (Pioneer 0) carried out under the direction of the newly formed Advanced Research Projects Agency (ARPA);[2]
- First missions (Pioneer 1 and Pioneer 2) under the direction of the even newer National Aeronautics and Space Administration (NASA);
- First program to be transferred from the Department of De-

Northrop Grumman Photo Services

This photograph shows the exterior of the spacecraft and retrorocket for Pioneer 0. The nozzle of the retrorocket is at the top of the structure. The circular port in the side of the spacecraft is the infrared "television" scanner, and the rectangular plate near the scanner port is the strike diaphragm for the micrometeorite detector. One of the two telemetry antennas is visible underneath the spacecraft.



AFBMD

This photograph shows the interior of STL's testing lab in its hangar at LAX. Testing of the second, third, and fourth stages, probably for Pioneer 1, is under way. The top part of the Able second stage is visible at right on the wheeled vehicle. The spacecraft and fourth stage are mounted on the third stage at left. (Illustration from AFBMD, "Space Probes Program Status Report," 10 December 1958, figure 5)

fense to NASA;

- First use of the Thor missile as a space booster and the first step in the development of the Delta launch vehicle derived from it; and
- First activation of ground sites in what would become the Air Force Satellite Control Network, as well as the first significant communication with a spacecraft from ground stations and the first use of a telemetry, tracking, and control network to control a spacecraft.

Even before the Soviet Union launched Sputnik 1 on 4 October 1957, but especially after it launched Sputnik 2 on 3 November 1957, space proponents within the Department of Defense were looking hard for any available upper stages to use on their available missiles to turn them into satellite launchers. In January 1958, the Air Force Ballistic Missile Division (AFBMD) recommended that the second stage of the Vanguard launch vehicle—which was being prepared to launch the second American satellite, the Naval Research Lab's Vanguard I, on 17 March 1958—be used with the Thor missile for early space launches.[3] Later that month, the division's technical advisory contractor, Space Technology Laboratories (STL), published two influential reports that proposed using the Vanguard stage with the Thor in lunar probes.[4] Secretary of the Air Force James H. Douglas recommended this proposal to Secretary of Defense Neil H. McElroy on 14 February 1958, noting that "the United States could make a major international psychological gain by beating the Russians to the moon."[5]

On 7 February 1958, Secretary McElroy activated the Advanced Research Projects Agency (ARPA) to provide unified direction to the more promising development programs within the Department of Defense. The new agency issued its first three directives on 27 March 1958, and all three dealt with lunar probes. The Army had prepared its own plans for space launches, including lunar launches, based on the Jupiter Intermediate Range Ballistic Missile developed by the Army Ballistic Missile Agency (ABMA) at Redstone Arsenal, Alabama.

ARPA's first directive went to ABMA, instructing it to launch one or two lunar probes in late 1958 or early 1959.[6] ARPA's second directive went to the AFBMD, instructing it to launch three lunar probes using the Thor with a Vanguard second stage. These were to be launched "as soon as possible, consistent with the requirement that a minimal amount of useful data concerning the moon be obtained."[7] The third directive went to the Naval Ordnance Test Station (NOTS) at China Lake, California, instructing it to develop a "mechanical ground scanning system"—a small, rudimentary, infrared scanner with a transmitter—to be carried on the lunar probes.[8]

STL designed and assembled the three spacecraft at its R&D Facility, now Area A of Los Angeles AFB. Each spacecraft consisted of a roughly doughnut-shaped fiberglass shell containing telemetry and experiments to measure the Earth's and moon's magnetic fields, the intensity of radiation fields in space, and the number and intensity of micrometeorites. Each also contained an imaging scanner to return an image of the moon at closer range. A small solid rocket motor filled the hole in the center of the doughnut, with its exhaust nozzle pointed against the forward movement of the spacecraft. This retrorocket was to fire on command when the spacecraft reached the vicinity of the moon to reduce its velocity enough to allow the moon's gravity to pull it into a lunar orbit. Sixteen batteries of three chemical varieties provided separate power supplies for each component.[9]

STL also modified the upper stages for AFBMD's three lunar probes. It established an assembly and checkout facility for the second stage in its corporate hangar at Los Angeles International Airport, and it assembled and tested the upper stages and

US Air Force

Thor 130 stands on the pad on 11 October 1958, holding the Pioneer 1 payload. Although the fourth stage traveled about 70,717 statute miles into space, its trajectory was slightly off, and it did not quite achieve escape velocity despite firing all eight of the fourth stage solid rockets.

US Air Force

Key managers of the Air Force lunar probe program talk to the press at AFBMD after the launch and reentry of Pioneer 1 on 11 October 1958. Left to right in the first row are Col Richard D. Curtin (AFBMD), Dr. George E. Mueller (STL), Maj Gen Bernard A. Schriever (AFBMD), Dr. Ruben F. Mettler (STL), Col Charles H. Terhune (AFBMD), Dr. R.C. Booton (STL), Maj John Richards (AFBMD).

spacecraft there. The lunar probes added two additional stages to Aerojet General Corporation's Able second stage (as the Vanguard second stage came to be called), which was being tested in a series of re-entry launches. The third stage consisted of a solid rocket motor developed by Allegheny Ballistics Laboratory as an advanced third stage for the Vanguard vehicle but never flown. The fourth stage consisted of eight small solid rockets mounted in a ring around the base of the spacecraft. The ring would be jettisoned after imparting the final increments of velocity.[10]

All three Air Force lunar launches took place at the Thor launch site, Launch Complex 17A at Cape Canaveral. The first launch, using Thor 127, was on 17 August 1958. Unfortunately, the first stage engine exploded 77 seconds after liftoff because of a turbo-pump failure, and the flight returned no useful data. Because it failed so soon after liftoff, the mission was subsequently referred to as Pioneer 0.

The second launch—that of Pioneer 1 using Thor 130—was on 11 October 1958. It reached an altitude of 71,700 miles, completed fourth stage burn, and returned much useful scientific information from the payload, especially about the extent of the Van Allen Radiation Belts. However, its trajectory and velocity were slightly off, and it did not achieve escape velocity. After realizing that the lunar mission had failed, the launch team attempted to insert the spacecraft into an Earth orbit by firing the retro-rocket, but the spacecraft's batteries were too cold to ignite the rocket, and it reentered 43 hours after liftoff.

The third launch—that of Pioneer 2 using Thor 129—was on 8 November 1958. All went well until the solid-fuel, third-stage motor failed to ignite, and the remaining stages reentered after 42 minutes of flight.[11]

Although none of the three missions reached the vicinity of the moon, Pioneer 1 was nevertheless the world's first successful space probe.[12] Overall direction of the Pioneer program officially passed from ARPA to NASA on 1 October 1958.[13]

The Army Ballistic Missile Agency (ABMA) used its own Juno II launch vehicles, also launched from Cape Canaveral, for the following two lunar missions. The payloads for both were designed and built by the Jet Propulsion Laboratory and were much lighter than STL's spacecraft, considering their only active experiments were radiation monitors. Pioneer 3 lifted off on 6 December 1958. Like Pioneer 1, it failed to reach escape velocity but did reach an altitude of almost 70,000 miles. The payload returned additional scientific information about the distribution of the Van Allen Radiation Belts.

ABMA's Pioneer 4 mission, launched from Cape Canaveral on 3 March 1959, was much more successful as a lunar probe. It was the first United States mission to escape from the Earth's gravitational field, passing the moon at a distance of about 36,650 miles and gathering radiation data as it went into permanent orbit around the sun.

By then, however, the Soviet Union had already performed the first successful lunar fly-by. Its Luna 1 spacecraft had passed within 3,725 miles of the moon on 4 January 1959 before entering solar orbit. The Soviets soon achieved the first lunar impact as well with Luna 2 on 13 September 1959. On 7 October 1959, the Soviets' Luna 3 successfully attained the early Pioneer missions' ultimate goal of photographing the far side of the moon.[14]

Although Pioneer had successfully put the United States in the race for the moon, it also left the national space program with a great deal of catching up to do.

Notes:

[1] The Army's Explorer I satellite had carried a radiation experiment by James van Allen that detected the presence of the radiation belts, but Pioneer 1 and Pioneer 2 mapped their upper and lower altitudes.

[2] Renamed the Defense Advanced Research Projects Agency (DARPA) in 1972; renamed ARPA again in 1993; renamed DARPA again in 1996. See the chronology of DARPA, 24 July 2004, available from http://www.darpa.mil/body/arpa_darpa.html.

[3] See Historical Division, Space Systems Division, "Chronology of Early Air Force Man-in-Space Activity, 1955-1960," 1965, entry for 3 January 1958. Richard E. Horner, Air Force Assistant Secretary for Research and Development, tried to obtain OSD's approval for the Air Force proposal in using the Thor with Vanguard upper stages to accomplish lunar flights. See Memo, Horner to William M. Holaday (OSD Director of Guided Missiles), "Astronautics Development Program," 24 January 1958. In early February 1958, Lt Gen Putt, the Air Staff's Deputy Chief of Staff for Development, informed ARDC that it should plan to conduct the lunar launches but wait for OSD's approval before beginning work on them. See Memo, Brig Gen Homer A. Boushey (Deputy Director of R&D under Lt Gen Putt) to the commander of ARDC, "Astronautics Program," 3 February 1958.

[4] The two reports were STL (R.A. Cornog, P. Dergarabedian, J.B. Kendrick, Richard C. Booton, Jr.), "Lunar Missions with Thor-Vanguard Stages," 21 January 1958; and STL, "Project Baker: Hard Impact Lunar Flight Experiment," 27 January 1958.

[5] James H. Douglas (Secretary of the Air Force) to Secretary of Defense (Neil H. McElroy), "Thor and WS-117L Program," 14 February 1958.

[6] Roy W. Johnson (ARPA Director), memorandum to Commanding General, Army Ballistic Missile Agency, "ARPA Order #1-58," 27 March 1958.

[7] Roy W. Johnson (ARPA Director), memorandum to Commanding General, Ballistic Missiles Division, ARDC, "ARPA Order #2-58," 27 March 1958. ARPA had a much clearer idea about what configuration it wanted for AFBMD's launch vehicle than it did about what it wanted the lunar probes to accomplish. This probably tells us something about ARPA's highest priority for the mission—namely, to demonstrate the capability of the launcher—and about the relative stage of evolution of spacecraft and launch vehicles. Spacecraft were much more primitive.

[8] Roy W. Johnson (ARPA Director), memorandum to Commander, Naval Ordnance Test Station, "ARPA Order #3-58," 27 March 1958.

[9] For descriptions of the spacecraft and experiments, see STL, "1958 NASA/USAF Space Probes (ABLE-1) Final Report," vol. 2, (18 February 1959). The NOTS and STL imaging systems are discussed on pp. 88-122. The shell was 29 inches in diameter and 30 inches high at the center. When filled with experiments, telemetry, batteries, retrorocket and other components, the spacecraft weighed (in order of launch) 83.8 pounds, 84.39 pounds, and 87.3 pounds. The retrorocket and its mounting accounted for 43.7 pounds in the first two launches and 44.3 pounds in the third. The rest of the spacecraft therefore weighed about 40 pounds. ARPA's direction had required a payload of at least 30 pounds.

[10] STL, "1958 NASA/USAF Space Probes (ABLE-1) Final Report," vol. 3, (18 February 1959), 27-28, 40. In order to spin the spacecraft about an axis stable enough to allow the imaging system to build up a picture of the moon during many revolutions of the spacecraft, any extraneous nutation (wobbling) of the fourth stage would be controlled by a mercury-filled damper ring developed by NOTS.

[11] For the results of the three Air Force lunar probes, see STL, "1958 NASA/USAF Space Probes Final Report," vol. 3, (18 February 1959), 121-158. See also two articles in *Proceedings of Lunar and Planetary Exploration Colloquium*, 12 January 1959: C.P. Sonett, "Results of Pioneer I Flight," 42-47; A.R. Hibbs and C.W. Snyder, "Results of Pioneer III Flight," 48-53.

[12] For a chronology and accomplishments of American and Soviet space probes, see Asif A. Sidiqi, *Deep Space Chronicle: A Chronology of Deep Space and Planetary Probes, 1958-2000* (NASA, 2002).

[13] President Dwight D. Eisenhower, Executive Order 10783, Transferring Certain Functions from the Department of Defense to the National Aeronautics and Space Administration, 1 October 1958; Press Release, The White House, 1 October 1958; Advanced Research Projects Agency (J.E. Clark for Roy W. Johnson), "ARPA Order No. 2- 58, Amendment No. 5," 6 October 1958; T. Keith Glennan, NASA Administrator, memorandum to General Samuel E. Anderson, Commander, ARDC, "Continuation of Lunar Probe Projects," 9 October 1958; T. Keith Glennan, NASA Administrator, memorandum to Commander, ARDC, "Continuation of Work Begun Under ARPA Order No. 2-58," 9 October 1958.

[14] Asif A. Sidiqi, *Deep Space Chronicle: A Chronology of Deep Space and Planetary Probes, 1958-2000* (NASA, 2002).

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Titan II - Historical Overview

Dr. Rick W. Sturdevant
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The final Titan II launch from Space Launch Complex 4 West (SLC-4W) at Vandenberg AFB, California, on Saturday morning, 18 October 2003, completed the last chapter in a saga that began more than 40 years ago at the height of the Cold War. Planning for an upgraded version of the Titan I intercontinental ballistic missile (ICBM), one with greater range and lifting capacity, had begun in 1958. Secretary of the Air Force James H. Douglas recommended approval of the Titan II program on 9 September 1959, and the Department of Defense gave the go-ahead two months later for development of the Titan II in parallel with Titan I. On 20 June 1960, the Air Force placed a production contract with the Martin Company for the Titan II ICBM.[1]

Soon after beginning his tour as Titan program director in 1958, Colonel Albert J. "Red" Wetzel had rejected the concept of designing Titan II based on incremental, evolutionary changes to Titan I. His visionary leadership resulted in a more significantly altered configuration for Titan II. The new ICBM boasted several improvements: more rapid operational response through use of storable, hypergolic propellants instead of the cryogenic type used in Titan I; launch from hardened, widely dispersed, underground silos; a self-contained, all-inertial guidance system that allowed a "salvo" launch of the entire force; a 9,000-mile range, compared to the 6,300-mile range of Titan I; a novel "steering" system involving two main thrusters; and a much greater "throw weight" to permit delivery of heavier thermonuclear payloads anywhere on the globe. Towering 114 feet and delivering 530,000 pounds of thrust, the two-stage Titan II was the largest, most powerful ICBM ever deployed by the United States.[2]

Titan II -- ICBM Silo Launch

Development and operational deployment of the Titan II proceeded at a relatively fast pace. Captive flight tests began in December 1961, and the first test launch occurred from Cape Canaveral on 16 March 1962. On 8 June 1963, the 570th Strategic Missile Squadron (SMS) at Davis-Monthan AFB, Arizona, became the first Titan II ICBM unit to achieve operational status. Strategic Air Command (SAC) declared the sixth and last Titan II unit, the 374 SMS at Little Rock AFB, Arkansas, operational on 31 December 1963. Other Titan II units included the 373 SMS at Little Rock AFB, the 532 SMS and 533 SMS at McConnell AFB in Kansas, and the 571 SMS at Davis-Monthan AFB. A total of 54 silos dotted the landscape near those bases. For the next two decades, SAC Titan II crews would remain on alert continuously, fully prepared to launch their missiles within one minute of receiving an order. To ensure their proficiency, crews from various Titan II units launched more than 50 test flights from Vandenberg AFB from 1964-1976.[3]

Titan II -- Gemini 3

Meanwhile, in December 1961, the National Aeronautics and Space Administration (NASA) selected a modified version of the Titan II to launch its two-person Gemini spacecraft. Critical systems were man-rated, and several systems were added—radio guidance, malfunction detection, electrical, and flight control. Twelve successful Gemini launches, 10 carrying astronauts, occurred between April 1964 and November 1966. During these flights, NASA tested many techniques required for the Apollo lunar landing program.[4]

Because tailoring individual Titan IIs for specific space missions was inefficient and problematic, the Air Force undertook development of the Titan III standard space launch vehicle (SLV) in 1961. The Titan II ICBM, modified structurally to handle heavier payloads, served as the Titan III common core. Using that core in combination with solid-propellant, strap-on rockets and powerful upper stages, or in a stretched version, the Air Force sponsored production of various Titan space launchers between 1965 and 1982. In the wake of the 1986 Space Shuttle *Challenger* tragedy, the Air Force contracted with Martin Marietta to produce the Titan IV—two, seven-segment, solid rocket motors attached to a stretched, strengthened version of the Titan III core—for assured launch of heavy payloads into high orbits. Indeed, the Titan II ICBM was the progenitor of the entire Titan SLV family.[5]

By 1981, the Titan II weapon system already had served eight years longer than originally scheduled, and SAC was reviewing replacement options. Deputy Secretary of Defense Frank C. Carlucci directed on 2 October 1981 that the aging Titan II

Titan II -- ICBM Maintenance

ICBM be retired as soon as possible. The Rivet Cap deactivation program commenced when SAC took the first missile off alert on 30 September 1982 and ended with removal of the last Titan II from its silo on 23 June 1987.[6]

Martin Marietta, which subsequently became Lockheed Martin, received an Air Force contract in January 1986 to refurbish 14 decommissioned Titan II ICBMs for use as SLVs. Conversion tasks included modifying the forward skirt of the second stage; manufacturing payload adapters and a new 10-foot diameter payload fairing with variable lengths; refurbishing the engines; upgrading the inertial guidance system; developing command, destruct, and telemetry systems; modifying SLC-4W to conduct the launches; and performing payload integration. The refurbishment effort incorporated hardware and technology from the Titan III program to maximize the use of Titan II resources.[7]

Titan II SLV launches, which numbered 13, commenced on 5 September 1988 and ended on 18 October 2003. The first three flights carried classified payloads. On 5 October 1993, the fourth launch carried *LandSat-6*, a remote-sensing satellite, for the National Oceanic and Atmospheric Administration (NOAA). From a payload perspective, the most noteworthy Titan II SLV launch sent *Clementine* into space on 25 January 1994. That Ballistic Missile Defense Organization (BMDO) spacecraft performed the first United States lunar mission in more than two decades. The last eight Titan II SLV launches carried weather-related satellites—three Defense Meteorological Satellite Program (DMSP), three Advanced TIROS National Polar Orbiting Environmental Satellites (NPOES) for NOAA, the Jet Propulsion Laboratory's *QuikScat*, and the Navy-Air Force *Coriolis*.[8]

Now, with its 100-percent-successful launch record intact, only one Titan II SLV remains. Most likely destined for museum display, this survivor will remind future generations how a weapon system forged to deliver the largest nuclear warhead ever fielded by the United States became a vehicle for transporting government spacecraft to polar orbit.

Notes:

[1] Thomas S. Snyder, et al., *Space and Missile Systems Organization: A Chronology, 1954-1976* (Los Angeles AFS: SAMSO History Office, 1977), 70, 80.

[2] Biographical sketch of Col Albert J. Wetzel (USAF, Ret), on-line, Internet, October 2004, available from http://www.peterson.af.mil/hqafspc/history/Wetzel.htm.

[3] For a comprehensive history of the Titan II ICBM, see David K. Stumpf, *Titan II: A History of a Cold War Missile Program* (Fayetteville: University of Arkansas Press, 1999).

[4] On the use of Titan II in human spaceflight, see Barton C. Hacker and James M. Grimwood, *On the Shoulders of Titans: A History of Project Gemini* (Washington, DC: NASA, 1977).

[5] Art Falconer, "Epic Proportions: The Titan Launch Vehicle," *Crosslink* 4, no. 1 (Winter 2002/2003): 32-37, on-line, Internet, October 2004, available from http://www.aero.org/publications/crosslink/winter2003/07.html.

[6] *From Snark to Peacekeeper: A Pictorial History of Strategic Air Command Missiles* (Offutt AFB: SAC History Office, 1991), 25.

[7] Fact Sheet, SMC/PA, "Titan II Space Launch Vehicle Profile," 10 December 2002, on-line, Internet, October 2004, available from http://www.losangeles.af.mil/smc/pa/fact_sheets/usaf_titan_2slv_sf.pdf.

[8] Mark Wade, "Titan 2," *Encyclopedia Astronautica*, 2004, on-line, Internet, October 2004, available from http://www.astronautix.com/lvs/titan2.htm.

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General Bernard A. Schriever: Technological Visionary

Jacob Neufeld
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A technological visionary... a pioneer in the research and development of new ballistic missile and space programs... a dynamic, innovative leader, and valued advisor. These are some of the attributes that have characterized the life of General Bernard A. Schriever and marked his career of outstanding achievement.

Born on 14 September 1910, in Bremen, Germany, Schriever was only six years old when he came to the United States on the eve of our nation's entry into World War I. Shortly after the family settled nearby to San Antonio, Texas, his father was killed in an industrial accident. His mother, Elizabeth, worked at a variety of jobs to raise "Bennie" and his younger brother, Gerhard. She instilled in the boys the importance of education and somehow provided them the opportunity to attend college. Both sons graduated from Texas A&M. In 1931, Bennie Schriever earned an engineering degree and an Army commission through the ROTC. He soon caught the flying bug and transferred from Artillery to the Air Corps. Schriever also became a superb golfer, and in 1932 won the state's amateur golf title by defeating Captain Ken Rogers, later one of his flight instructors at Kelly Field.

Shortly after pinning on his wings in 1933, Schriever was assigned to March Field, Riverside, California, which was then commanded by Lt. Col. Henry H. "Hap" Arnold. Also serving at March Field then were some of the Air Corps's future leaders, including Carl A. "Tooey" Spaatz, Ira C. Eaker, and Clarence Tinker. In the winter of 1934, Schriever flew the Air Corps's disastrous air mail missions. Piloting antiquated, ill-equipped planes, Schriever saw many of his companions plunge to their deaths. This experience underscored for him the consequences of technical inferiority and demonstrated the importance of modernizing and strengthening American air power.

The scientifically minded Schriever was soon drawn to flight testing and an engineering career. After completing the Air Corps Engineering School [forerunner of AFIT] course at Wright Field, Ohio, he went on to earn a Master's degree in aeronautical engineering from Stanford University, just as the United States entered World War II.

From July 1942 until the end of 1945, Schriever served in the southwest Pacific. Beginning as a B-17 pilot with the 19th Bombardment Group, he flew thirty-six combat missions. Also assigned as a maintenance officer, Schriever succeeded at solving problems and introducing innovations. His superiors soon recognized Schriever's technical and leadership abilities and steadily promoted him in rank from captain to colonel, and in position from Chief of Maintenance and Engineering to Chief of Staff, Fifth Air Force Service Command. By September 1944, the thirty-four year old Schriever commanded the Advanced Headquarters, Far East Air Service Command that supported theater operations from bases in New Guinea, the Philippines, and Okinawa.

After the war, Schriever's leadership and accomplishments attracted the attention of senior officers, notably "Hap" Arnold, now the Commanding General of the Army Air Forces. Recognizing his protégé's rare combination of engineering training and operational experience, Arnold assigned Schriever the delicate job of maintaining the close ties forged during the war between the air force and nation's leading scientists. Working with the world famous Dr. Theodore von Kármán, chairman of the Scientific Advisory Board (SAB), and with RAND Corporation staffers, Schriever focused on long-range scientific planning. He helped to refine a methodology that matched long-range military requirements with ongoing research and development. Plans were drawn for all major elements of air power—strategic and tactical warfare, air defense, intelligence, and reconnaissance; RAND, the SAB, and university researchers performed the systems analysis studies. As a result, the Air Force did not have to wait for technological change to mature, but could lead and direct it. Put another way, Schriever's staff combined operational requirements with technologies, strategies, and objectives to establish objectives for future systems. "Technology push" thus prevailed over "requirements pull."

Schriever also headed an Air Staff study group seeking to improve development and maintenance practices. Issued in April 1951, their report, "Combat Ready Aircraft Study: How Better Management Can Improve the Readiness of the Air Force," concluded that short-term needs typically required continuous modifications. To avoid this, the study group proposed that all of the components of a weapon's life cycle be coordinated early in development.

Generally, there were two alternatives. Under the prime contractor method, a single company managed and integrated an entire weapon system. This approach granted to industry substantial authority for development and production, and enabled the Air Force to purchase management services. A second way was through the associate contractor method, where the government hired one company to create specifications and oversee development, while other companies were hired to develop hardware components. Under the latter method, Air Force officers served as the integrators. Known as the systems approach it subsequently became the centerpiece of Schriever's management methodology.

The opportunity to test these theories arose during an SAB meeting, in March 1953, when Schriever learned about the encouraging results of recent thermonuclear tests. Subsequently,

the newly inaugurated Eisenhower Administration directed a thorough review of major weapons systems, especially guided missiles. The task fell to the Secretary of the Air Force's special assistant for research and development (R&D), a hard-charging, blunt-speaking engineer named Trevor Gardner. In October 1953, Gardner appointed Dr. John von Neumann to chair a committee to consider building an intercontinental ballistic missile (ICBM). In its February 1954 report, the Teapot committee recommended that the Air Force initiate a crash program to produce an ICBM. In May, the Air Force made the Atlas ICBM its top priority and Gardner selected Brigadier General Schriever to head the program.

Activated on 1 July 1954, in Inglewood, a suburb of Los Angeles, Schriever's Western Development Division (WDD), was housed in a former parochial school. It began with twelve officers and three enlisted men, and eventually grew to some 1,500 personnel. Schriever had to create an organization to manage extremely varied and novel science and technology, build facilities for testing and production, integrate the missile systems, fit together the nuclear weapons they would carry, and provide the launching sites, equipment, and ground support necessary to bring the missiles to operational status. Moreover, he had to accomplish all of this within six years and *before* the Soviets could themselves build, deploy, and target their missiles against the United States! It was a deadly serious, real-life contest of "beat the clock."

Convinced that the Air Force lacked the requisite technical expertise, Schriever hired the Ramo-Wooldridge Corporation for systems engineering and technical development. He also acted quickly to gain control over the procurement apparatus. Consequently, he arranged for the Air Materiel Command to co-locate with WDD a special contracting office assigned to him. Schriever also instituted the Gillette Procedures, a simplified decision chain that helped him to avoid administrative micromanagement and reduced the approval authority to two high-level ballistic missiles committees—one representing the Air Force, the other the Department of Defense (DoD). Thus, Schriever gained complete authority over all aspects of the Atlas program and transformed WDD into a virtually autonomous organization.

Schriever and Maj Jack Dougherty

Meanwhile, the USSR had dealt a stunning blow to America's pride by launching the world's first artificial satellite, Sputnik, on 4 October 1957. Although the administration tried to minimize the military significance of the Soviet feat, political opponents noted that the satellite was launched by a ballistic missile and they raised an alarm of a "missile gap." Recently imposed funding restrictions, were quickly lifted and funding increased,

The Atlas ICBM experienced several early test failures, before achieving its first successful flight from Cape Canaveral, 575 miles over the South Atlantic, on 17 December 1957. But reliability improved with more testing. The next three tests were successes, including the December 1958 launch of Project SCORE (Signal Communications Orbiting Relay Equipment) satellite that went into orbit, playing President Eisenhower's Christmas message. The operational Atlas Series D tests had a somewhat checkered record at first, but recovered in time for the Air Force to declare operational a three-missile launch complex at Vandenberg AFB in September 1959. By year's end the Atlas D became combat ready. An alternate ICBM, the Titan, and an intermediate-range ballistic missile (IRBM), the Thor, were added to the missiles "family."

Between 1957 and 1960, Schriever appeared frequently before congressional committees, spending more time in Washington than in California. But, he had worked well with Congress since his experience on the Air Staff and the early days at WDD. An ardent, persuasive, and respected advocate for the missile program, his engaging personality, quick wit, and excellent golf game helped him to form friendships. Thus, even as Congress attacked President Eisenhower and the missile gap, their relationship with Schriever was always good.

In April 1959, Schriever was promoted to lieutenant general and named head of the Air Research and Development Command (ARDC), which was charged with developing and maintaining the Air Force's air and space weapons. ARDC managed more than 6,400 research and development contracts, engaging some 1,500 major companies. ARDC employed the Cooke-Craigie Plan, instituted in the late 1940s, which had revised the Air Force's sequential development planning practice to a limited production run while a system was still in initial development. The operative philosophy was that a steady supply of test vehicles would be available to enter into production.

The ICBM program advanced to a "second generation" Titan II, which was powered by a storable liquid propellant, could be launched from an underground silo, and had all-inertial guidance; and the solid-fueled Minuteman, which completed its first flight in February 1961, three years after being approved, and went on alert beginning in October 1962, during the Cuban Missile Crisis—incredible achievements by today's standards.

* * *

Even as he was preoccupied with acquiring ICBMs and IRBMs, Schriever foresaw the potential of outer space systems

Col Schriever, Chief of Maintenance for the 5th AF in the Southwest Pacific

and the need to extend the Air Force's interests into the "high frontier." While many of his achievements in the space field remain classified, we can acknowledge his pivotal role in developing the requirements for intelligence and reconnaissance satellites and manned space flight. Schriever's enthusiasm for space exploration tapped his fortitude in sometimes standing up alone to his superiors. Indeed, although some people tried to muzzle him, Schriever never shrank back from what he believed in.

Schriever assigned responsibility for the reconnaissance satellite program WS-117L to Navy Captain Robert C. Truax. In October 1955, ARDC moved the program from the Wright Air Development Center, in Ohio, to WDD. On 2 April 1956, Schriever approved the plan for full-scale development of the advanced reconnaissance satellite. In January 1958, he reminded the Senate Armed services Committee that: "...we [the Air Force] have been interested in satellites since 1946 when we started the RAND Corporation."

The Eisenhower administration was more circumspect about the potential of space. In February 1955, the Killian Committee report to President Eisenhower did not place much confidence in a space satellite. Therefore, the U-2 and balloon reconnaissance programs received priority over the USAF's Advanced Reconnaissance [Satellite] System (ARS), later the WS-117L. WDD recommended a five-year full-scale development of the ARS, costing approximately $117 million.

However, only $4 million was allotted for follow-up studies. WDD pressed on, nonetheless. By 1956 it had acquired Camp Cooke (renamed Vandenberg AFB). Secretary of Defense Charles Wilson approved the transfer, provided that the Navy kept the Point Mugu site and disallowed live firings from Cooke. In February 1957, Schriever delivered a speech on space in San Diego, saying that space would be important for national security. The next day, Secretary Wilson directed: "Do not use the word 'space' in any of your speeches in the future." Everything changed after Sputnik was orbited. People became space minded. Suddenly, Schriever flew "like a shuttlecock in a badminton game" between the West coast and Washington, D.C., as the Pentagon and Congress demanded what USAF needed to go faster in space, to do something. In the autumn of 1960, the Air Force Discoverer XIII program (its classified project name was Corona) recovered in mid-air its first satellite film capsule.

The growing importance of space technologies and missions was the catalyst for a major reorganization. Continuing squabbles had inspired the Eisenhower administration and Congress to create NASA for civilian space and the Advance Research Projects Agency (ARPA) for military space. Initially, USAF, which had managed space technology through its WS-117L program for military reconnaissance satellites, lost out to ARPA. The ARPA effort foundered.

Thanks in part to Schriever's relationship with Roswell Gilpatric, the new Deputy Secretary of Defense, the Air Force regained control of space R&D in 1961 when Gilpatric gave USAF space technology responsibility on condition that it resolved its flawed acquisition process between AMC and ARDC. General Thomas White, the Air Force Chief of Staff, backed Schriever. In April 1961, Air Force Systems Command (AFSC) was established, incorporating ARDC and some elements of Air Materiel Command; Air Force Logistics Command was established to handle logistics matters. Promoted to four-star rank and head of AFSC General Schriever conceived and effected the consolidation of Air Force technical and logistical efforts into a single organization. More significantly, he transformed the concept of materiel development and acquisition from a functional to a systems approach—the focal point for virtually all-new weapons.

Schriever's role in this transformation was pivotal with respect to his insistence on technologically superior performance standards, adherence to preestablished production schedules, and reliance on cost-control measures. While AFSC commander, he fostered research and oversaw the acquisition of systems that provided strategic deterrence; early detection, warning, and air defense; advanced aircraft and spacecraft designs; command, control, and communication systems; and aerospace medicine. By 1963, AFSC organization employed some 27,000 military and 37,000 civilians, operated an annual budget of over

General Schriever sits among models of the "family of missiles" he helped build.

$7 billion (about 40 percent of the USAF's total), and managed eighty major weapons systems. General Schriever defined and institutionalized the acquisition process by demonstrating the interrelationship between technology, strategy, organization, and politics.

Meanwhile, Office of the Secretary of Defense had also gained greater authority, especially under the 1958 DoD Reorganization Act. The Defense Secretary could reassign combat functions and the development and operation of new weapons without Congressional approval. The Act also laid the groundwork for a strong manager, such as, Robert S. McNamara. An advocate of centralized control through quantitative measurement. McNamara implemented the Planning, Programming and Budgeting System, i.e., centralized civilian control. DoD evaluated proposed systems primarily on the basis of cost effectiveness and then subjected programs to continual reviews. With respect to Titan III and Dyna-Soar, Schriever estimated that additional studies would delay the projects from six months to one year. Dyna-Soar was replaced by the Air Force's Manned Orbiting Laboratory.

In 1963, in response to Air Force Secretary Eugene Zuckert's request for a futuristic study, Schriever launched Project Forecast—one of the most comprehensive long-range assessments ever undertaken of the nation's position in military science and technology. Participants included 40 government agencies, 26 colleges and universities, 70 corporations and 10 non-profit organizations. Published in 1964, this landmark report concluded that rather than leveling off, technology was only beginning its exponential growth. Project Forecast identified several promising areas of exploration that would lead to quantum improvements in air and space weapons: notably in the fields of advanced composite materials, computers, flight design, and propulsion.

For twenty years, from the end of World War II until his retirement in 1966, General Schriever was at the locus of events as the Air Force developed its organization and processes for complex technology. Schriever helped create the SAB, ARDC and AFSC. In the Development Planning Office, he helped establish systems analysis as the procedure to set requirements for new technologies. From 1953 to 1959 he headed the ballistic missiles effort. Thanks in large part to Schriever's brilliant management, the United States deployed on time its first ICBMs—Atlas and Titan—and the intermediate range Thor. These were succeeded quickly by the more advanced Titan II and revolutionary, solid-fueled Minuteman ICBMs. Even today, some forty years after they were first deployed, advanced models of the Minuteman still provide the backbone of our nation's defense.

In September 1966, after devoting thirty-three years of service to his country, Schriever retired from the United States Air Force. Since then the general has served in many advisory roles for the US government and worked tirelessly to further research in some of the nation's leading corporations. Among his most notable endeavors, he was chairman of the President's Advisory Council on Management Improvement, served on the President's Foreign Intelligence Advisory Board, the Defense Science Board, and with the Ballistic Missile Defense Organization Advisory Committee.

Although Schriever will be best remembered as the architect of the Air Force's missiles and space programs, his influence extended far beyond that. He also introduced the Air Force to the systems approach, including operations research, project management, and systems engineering. In addition, he merged scientific and engineering visions with military procedures to create methods that have become standard throughout the Department of Defense.

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Indispensable: Space Systems In the Persian Gulf

General Donald J. Kutyna
USAF (Ret.), Vice President, Advanced Space Systems

General Kutyna's essay was originally presented to the Air Historical Foundations' Space Symposium on 21-22 September 1995 and published in the proceedings, *The US Air Force in Space: 1945 to the 21st Century*, (Washington D.C.: Air Force History and Museums Program, 1998). This historically significant piece was later published in the 1999 Spring issue of *Air Power History*.

The Persian Gulf War was the first conflict where space played a major role with our land, sea, and air forces. It also marked the first time combatants at all levels felt the presence and effect of our space systems in their missions. Indeed, our space forces were available before the war, during the war, and after the war, because they were already on orbit and in use. In peacetime and wartime, worldwide navigation and weather information require the same satellites on orbit. Intelligence garnered from space is probably more important *before* a crisis starts to prevent surprise attacks.

In 1991, our major organizational entities in space were the United States Space Command and its Army, Navy, and Air Force Space Command components. While the Air Force held the lion's share of the funds, Army and Navy's contributions also were vitally important.

To most observers, space suggests satellites on orbit. However, a large infrastructure of bases, command and control networks, and space sensors support those satellites. At the time of the Gulf War, there were nearly 60 bases around the world, including Vandenberg, Patrick, and Peterson Air Force Bases, as well as many installations on remote mountaintops manned by only four or five people responsible for maintaining and operating space equipment.

Launch Capabilities

Bringing space capabilities to Coalition Forces in the theater provided a considerable challenge, yet it was a challenge we were able meet. The nature of spacelift operations, for example, made it difficult for us to respond quickly to developing requirements half way around the world. In 1991, space launch remained a deliberate, time-consuming process, one that did not lend itself to the demands of combat operations.

The spacelift ranges are just one piece of this puzzle, but their development over time and their operation illustrate some of the issues we faced. A cursory look at our range facilities today suggests that they are in good shape. Upon closer inspection, however, a different picture emerges. The genesis of the problem stems from the early 1970s, when the United States decided to develop the Space Shuttle as a reusable launcher. Then in February 1978, Congress halted production of additional expendable launch vehicles, which later went out of production in 1986. Coincidentally, that same year, the Challenger accident occurred and the Shuttle was grounded. As a result, there were no launchers available to substitute for the Shuttle. Although other expendable launch vehicles were still in operation, a series of accidents in 1985 and 1986 involving these systems coupled with the *Challenger* accident brought the nation's launch program to a standstill. Fortunately, the Defense Department already had begun reviving expendable launch vehicle programs, efforts that resulted in the introduction of the medium lift Delta II and the heavy lift Titan IV systems.

So, although the Defense Department no longer relied exclusively on the Space Shuttle, we still struggled to make spacelift operations more responsive to operational requirements. The Titan IV carried heavy payloads to orbit, but the process to get that booster off the ground took anywhere from 200 to 270 days. Because the Gulf War was much shorter than that, it proved impractical to even consider getting off the ground in time to augment our satellite forces. The same was true of the Atlas, where processing time took from 60 to 90 days. The Thor/Deltas and Titan II vehicles had similar problems; it took 70 to 80 days to process a Delta and almost 140 days for a Titan II. To convert from a Titan to an Atlas launch setup requires going through a control room, pulling out cables, and reconfiguring them. Since the Gulf War, we have begun acquiring new programs, such as the Evolved Expendable Launch Vehicle, which promise to fix many of these ills, and the space budget has risen significantly to modernize the ranges so that we can be more responsive in the future.

Artist's concept of a Defense Meteorological Satellite Program satellite.

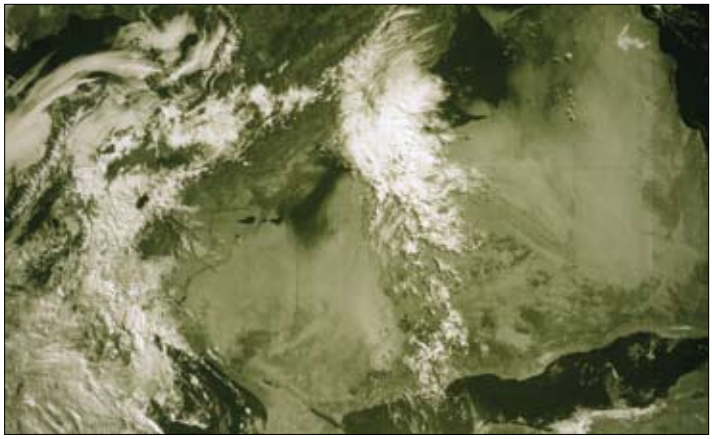
Combat Effects

During my tenure as Commander, some satellites on orbit experienced time-consuming problems. We had a Defense Meteorological Support Program (DMSP) satellite fail, while the second one—one of only two in the constellation—malfunc-

tioned. The first satellite "died" in September 1990, and despite our best efforts, we could not launch a replacement until April of the following year.

Considering these limitations, which had characterized the space "business" from its earliest days, we were fortunate that our satellite force structure sufficed for the Gulf War. There were several "birds" on orbit, including warning, communications, weather, multi-spectral imagery, and navigation satellites. The Global Positioning System (GPS) constellation had 24 satellites supporting the war effort. Also, the intelligence community had a full complement of operational satellites on station.

Force enhancement is one of our primary missions in space. Space applications enhance our military forces' capabilities beyond ground-based systems. Among the most important are weather satellites, the Defense Meteorological Satellite Program (DMSP). During the first day of the Gulf War, we learned that the so-called featureless desert was hardly *featureless*. There was a great deal of cloud cover in Iraq and, in fact, during the war we experienced some of the worst weather ever recorded over the region. However, DMSP pinpointed the wet areas in the environment and provided much-needed data to the warfighter.



Defense Meteorological Satellite Program photo of Iraqi theater on first day of DESERT STORM.

Among the missions weather satellites supported were strike planning, redirection, weapons loading, air refueling, and displaying flood plains. These were vital to General H. Norman Schwarzkopf, Commander, US Central Command, whose "Hail Mary" maneuver succeeded because the general knew the weather and was able to move his tanks effectively. The one drawback was the need to have a Mark 4 weather van in theater to get weather information. Only 37 Mark 4 vans were distributed worldwide to the Army, Navy, Air Force, and Marines. We did not have one in Saudi Arabia when the crisis occurred because of the van's low priority on the "Tip Fiddle" (TPFDL, or Time-Phased Force Deployment List) until the Marines brought in a van a month before the war began.

Army Space Command bought some commercial computers and displays and used the Television Infrared Observation Satellite (TIROS), a civilian satellite, to get their weather. Later in the war, we acquired more vans. General Robert Yates, Commander of the Air Force Materiel Command, tried a "fix" by installing a portable setup. In the future, we will have better and smaller equipment capable of accompanying the troops anywhere in the world.

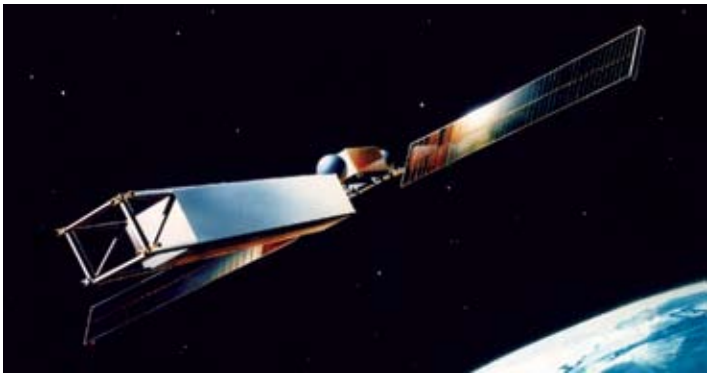
Another force enhancement is the GPS spacecraft, a wonderful system of 24 on orbit satellites. The GPS boasts great accuracy and is controlled by Air Force crews from the Consolidated Space Operations Center serving the Army, Navy, Air Force, and Marines, as well as a large civilian market. Although a full constellation of GPS satellites was not yet on orbit for the Gulf War, what was available performed very well. Seven years earlier, we conducted tests using GPS and an F–4 to determine bombing accuracy from 10,000 feet. We obtained a Circular Error Probable (CEP) of between 20 and 30 meters. When the war started, the CEP was improved to about 10 meters. However, only 72 Air Force fighters—F–16Cs and F–16Ds—carried GPS. Furthermore, only 37 B-52s, 21 Rivet Joints, a couple of helicopters, and two Joint Stars had GPS receivers. The Army had installed seven sets on their U-21s. The Navy had 10 installed on mixed aircraft, while the Marines were without GPS receivers. Although we were slow in getting this system operational, the GPS worked wonders in combat.

The Army was especially resourceful. Before the war, Colonel Roland Ellis, who headed Army Space Command, demonstrated GPS receivers to fellow Army officers in the field, showing them GPS capabilities and employment opportunities. Although the Army failed to recognize their value immediately, Colonel Ellis demonstrated the GPS effect on sighting artillery with incredible accuracy, and keeping troops from getting lost in the desert and mountains. Thus, the Army was prepared to use GPS. The Army had 200 sets, and the Air Force provided another 100. The Army used duct tape to put them on helicopters, tanks, and all kinds of vehicles. They ordered 7,500 sets once the war started and by the end of conflict had almost 3,500 sets in the field. Soldiers also used a commercial receiver called Magellan (many were sent from relatives back home) to avoid getting lost in the desert. Captain Scott O'Grady, our Airman who was later shot down in June 1995 over Bosnia, had a commercial GPS receiver, as opposed to a military-supplied unit. On the first night of the Gulf War, Apache helicopters carried GPS receivers to position and launch their Hellfire missiles. Our tanks would not cross mine fields unless they had GPS receivers and coordinates for that field. GPS also helped deliver Meals Ready to Eat to the troops out in the desert.

Multi-Spectral Imagery (MSI) was another force enhancement capability. It involves taking pictures of the ground at different frequencies, providing images that the human eye cannot see. One particular MSI image pointed out Kuwait Airport was off by a mile-and-a-half from previously validated navigational charts. To counter such inaccuracies and produce better maps, Army Space Command started using MSI photos of different areas where its troops were deployed. MSI brought out and showed in broad scale Saddam Hussein's tank traps, trenches, and other defenses, enabling US forces to maneuver around them. In another MSI image, one could pick out swamps that might not otherwise be seen. When the Iraqis tried to escape near war's end using "Highway of Death," we determined from

an MSI image that they could not maneuver into the fields and had to stay on the highway. We cut off the highway and destroyed the Iraqi forces.

In yet another MSI image, the dark areas known as sabkhats were identified. To a tank commander, these appear as white sandy flats over which he assumes he can drive. However, underneath the sabkhats is deep water, in which a tank would sink up to its turret. Space systems helped our forces to see through the sand and revealed these lurking dangers. One limitation to MSI was that LANDSAT came around only once every 14 days. In the future, we will obtain information from commercial satellites circling with greater frequency.



Artist's concept of MILSTAR Satellite.

Total Connectivity

During the Gulf War, 90 percent of communications into the theater were via satellites. We knew where the Iraqi communication nodes were located, targeted all of Saddam's fiber optics, and took out his communications links. Our forces had a variety of communication systems: DSCS with spot beams and highly jam resistant; and the Navy FLEETSAT, which had a broad area of surveillance coverage but was not jam resistant. While Saddam did not jam our satellites, our own transmissions did. Unfortunately, we did not have MILSTAR—a totally secure, jam free system with a terminal that can be carried in a suitcase and set up in two-and-one-half minutes.

General Schwarzkopf required total connectivity with his troops. Even though the Saudis had some in-country communications, most of General Schwarzkopf's in-country communications were via satellite. The general's plan was to set up a mobile communications station, then move his forces forward with another mobile station. As soon as that mobile station was set up, the first station was deactivated and then leapfrogged to the next position. General Schwarzkopf kept continuous communications connectivity throughout the conflict. As for terminals, we had big 20-footers for FLEETSAT, as well as small ones for unique applications. Our special forces went behind the lines looking for SCUDs using small, commercial INMARSAT terminals.

Because launch constraints were a problem, the answer was to use whatever was already on orbit. While military satellites are necessary for more critical functions, commercial satellites can be used to report routine data. Cellular systems, including Global Star, Iridium, and a couple of other commercial ones, are free of DoD development funding and profit from the civilian market, rather than the military. Still, they are on orbit, and we ought to factor them into our plans, because wherever our troops are in the world, day or night, twenty-four hours a day, they are going to see at least two of these satellites.

The SCUD Threat

Missile warning has always provided a wonderful communications structure, but this construct centered on the strategic mission. NORAD and Space Command communications were designed to inform the National Command Authority of a Soviet attack and to execute our aircraft, missiles, and submarines retaliatory force. We had ballistic missile warning radars around our borders protecting the United States. However, since we wanted to pick up missiles at launch, we had placed three or more DSPs on orbit, giving us worldwide coverage. Although not designed for small tactical ballistic missiles, such as SCUDs, they were used by our crews at NORAD and US Space Command to track some 600 of these smaller missiles during the wars in Afghanistan, Iraq, and Iran, before the Gulf War. Therefore, we knew their characteristics, what they looked like when launched, and their ranges.

We used those communications when the Gulf War was about to start. Saddam did us a great favor when he test-fired three SCUDs on 2 December 1990. Although he fired them from east to west toward Israel, we knew they were going to fall short because of their range. Saddam wanted to test his capabilities. We picked up all three, but when the first SCUD was fired, the console operator could not believe his eyes and failed to report it. When we looked at the tapes afterward, we observed the launch. We picked up the next two SCUDs and administered the proper warning, which took about eight-and-a-half minutes to broadcast. A SCUD flies for seven-and-a-half. In effect, we told those in the target area that the blast they heard a minute ago was a SCUD. We worked on improving that differential throughout the war.

SCUD Missile kill during DESERT STORM

Coalition Forces had difficulties locating Iraq's mobile SCUD missiles. We identified possible mobile launch sites and tried to calculate how far and where a mobile SCUD would move over time after launch to allow our fighters to search and destroy. Although we did not strike a mobile or transportable launcher during the war, we refined procedures and will produce better results next time.

We received access to Strategic Air Command's worldwide communications network. Now, we could get SCUD warning from DSP. This allowed warning of SCUD launches to the troops in Saudi almost at the speed of light. It worked perfectly. Our troops in the Gulf had time and opportunity to put on their chemical gear, while the Patriot missiles had time to arm up and intercept. SCUD warnings were a success because we had a "lock" on what was going on in space. We knew what the birds up there could do, their condition, their idiosyncrasies, and had the best intelligence. Furthermore, we had seasoned professionals on the consoles, and that really counts. In the Tonkin Gulf incident, a misinterpretation of radar signals caused our ships to start shooting at each other, prompting the congressional resolution that led us into the Vietnam War. Before the Gulf War started, there were 400,000 Iraqis on one side of the border and about 300,000 American troops and Allies on the other. We could not afford a Gulf of Tonkin-type false warning. I remember telling my people, "I cannot explain giving a false missile alert which causes retaliation, and then Bingo, 700,000 people are at war" because of a mistake. Our space professionals always came through and were decisive in the Gulf War.

Although it was true that SCUDs were tactically insignificant during the Gulf War's air campaign, they were extremely significant politically. Every night we viewed scenes of SCUDs coming in and hitting arbitrary targets, and then scenes of innocent men, women, and children being carried out. These attacks had the attention of the American public. It became very important to our wartime Coalition to do something about the SCUD threat. We moved DSP, took off dual coverage from other areas, and positioned DSP satellites to look down at Saddam. We had excellent coverage, but at the same time, we were worried about the vulnerability of our ground stations to terrorist attack. As a result, we moved our half-dozen pairs of mobile ground station vans in New Mexico to clandestine safe places where they could back up our fixed ground station, should a terrorist take one out.

A Force for the Future

General Bernard Schriever said, "We must have control of space as we have control of the seas." As far back as 1985, we had an anti-satellite capability. When an F–15 fired a small canister toward a low altitude satellite in space, the canister hit the middle of the discarded satellite. Political considerations preclude their use today, but in the future, should our forces be targeted by enemy satellites, we are sure to revisit this matter. Are we going to neutralize those satellites or not? The capability certainly is there if we need it.

Space must be ingrained into our planning and practice. We should have space courses in every school at every level. We must practice to use space systems. Unless we practice it in every exercise, it will not be used in war—a fact that I believe our CINCs are starting to appreciate.

General Donald J. Kutyna, USAF (Ret.). Before retiring on 30 June 1992, he commanded NORAD, the US Space Command, and Air Force Space Command. A graduate of West Point, he also earned an M.S. degree in aeronautics and astronautics from MIT. After his first USAF assignment as a B-47 combat crew commander he became a student and then staff director at the Aerospace Research Pilot School at Edwards AFB. During the Vietnam War, General Kutyna served with the 44th Tactical Fighter Squadron, completing 120 missions aboard the F–105. In 1982 he became deputy commander for space launch and control systems, where he managed the DOD Space Shuttle Program. In 1984 he was named Director of Space Systems and Command, Control, and Communications at Headquarters USAF. In January 1986 he served as a member of the Presidential Commission that investigated the Space Shuttle Challenger accident. After retirement, General Kutyna transitioned to the space industry in early 1993 working full time in corporate level strategic, space technology, and mission success areas for the Lockheed Martin and subsequently Loral Corporation. He retired from Lockheed Martin in January 1999 and from Loral Space and Communications in September of 2004. He has participated on a number of academic, industry and government boards and is currently a member of the National Research Council's Air Force Science and Technology Board.

Space Law: Past, Present, and Future

Col Carol Hattrup, Maj Elizabeth Waldrop
AFSPC/JA

Space Law, a specialized body of international law, is very permissive, despite many misconceptions about what it allows and prohibits. As the first in a three-part series, this article will summarize the main principles of the major space treaties. It is important to recognize, however, that other international law provisions and treaties also apply to outer space and may impose additional restrictions on the use of space, particularly the use of force in space. The second article in the series will address some of those key international law provisions and show how they are implemented for the United States armed forces (even in space) through the Standing Rules of Engagement (SROE). The final article will discuss United States domestic law and policy that further shapes how the US military uses space.

As early as 1945, both the Soviet Union and the United States had considered the potential use of satellites for military purposes, but it wasn't until 1954 that the US Air Force was first authorized to develop a reconnaissance satellite.[1] However, the Soviet Union preempted the early United States satellite-development effort when in October 1957, it successfully launched Sputnik I. The Soviet Union's placement of the first satellite into orbit around the earth sparked a sense of urgency in the United States to prove its mastery of the space dominion, arguably initially for prestige purposes.[2]

Satellites soon became important to the United States from a practical perspective as well. In 1960 the era of United States aerial reconnaissance flights over the Soviet Union ended, and the United States was forced to depend on reconnaissance satellites to obtain strategic information about its adversaries.[3] Thus began the United States' consistent reliance on space systems that has only increased in the ensuing four decades.

In the earliest years of the "Space Age," satellites were useful primarily in maintaining peace and stability through reconnaissance, intelligence-gathering, early warning, and as the National Technical Means (NTM) of verification for monitoring arms control compliance.[4] In part to assure the continued availability of satellite reconnaissance (especially of the highly-secretive Soviet Union during the Cold War), the United States had a strong interest in establishing early on that the law of space is different from the law of the air, with perhaps the most important distinguishing aspect being a "right of overflight" by satellites over the territory of other sovereign nations (the opposite of existing air law, which recognizes sovereignty over a State's territory).[5] This concept of an outer space "right of overflight" was effectively established through United States and Soviet satellite operations with no formal opposition from other States, and the concept was formally recognized in the 1967 Outer Space Treaty.[6]

There are four main treaties that comprise the specialized body of space law: the Outer Space Treaty (1967); the Rescue and Return Agreement (1968); the Liability Convention (1972); and the Registration Convention (1975).[7] The Outer Space Treaty, recognized as the cornerstone of space law, sets out its major guiding principles: the common interest principle (Article I); the freedom principle (Article I); and the non-appropriation principle (Article II). These principles taken together establish the general idea that outer space (including the moon and other celestial bodies) is not and can not be owned by anyone, but that everyone is equally free to use it.

Some of the greatest misconceptions about space law, however, concern limitations on weapons in space. In fact, the Outer Space Treaty only provides two "arms control" provisions limiting military uses of space:

(1) nuclear or other weapons of mass destruction will not be placed in orbit around the Earth, on the moon or any other celestial body, or in outer space, and

(2) the moon and other celestial bodies will be used exclusively for peaceful purposes; establishing military bases, testing weapons of any kind, or conducting military maneuvers on the moon and other celestial bodies is forbidden.[8]

Consequently, ICBMs carrying nuclear warheads can traverse space without violating the treaty, considering they do not go into orbit, and they aren't installed or stationed in space or on celestial bodies. In addition, there is no prohibition against anti-satellite weapons (ASATs).

However, there has been much debate about the Outer Space Treaty's statement that the moon and other celestial bodies must be used only for "peaceful purposes." It is from this language that other States and scholars have argued that space is a "sanctuary" that should be protected against weaponization. In reality, recent years have seen a continuous escalation of the uses of space for military purposes. As space powers reiterate their commitment to the use of space for "peaceful purposes," they also now routinely and overtly use satellites and space systems in direct support of military operations, stating that this direct support is "peaceful."[9] Such direct support includes the use of satellites for communications between forces engaged in armed combat, intelligence-gathering for selection of targets, precision-guidance systems to accurately steer weapons to their targets, and data-collection by remote sensing for battle damage assessment. These uses, coupled with a lack of formal protests regarding them, have led some experts to conclude that all military uses of space other than those specifically prohibited by

treaty are lawful, so long as they do not violate other international law provisions.[10]

Thus the definition of "peaceful" seems to be expanding according to State practice. For example, for more than 40 years the United States has defended the position that "peaceful" means "non-aggressive," so that any military use is lawful, so long as it does not violate either Article 2(4) of the UN Charter, which prohibits "the threat or use of force," or Article IV of the Outer Space Treaty.[11] One United States official has expressed the view that "non-aggressive" is itself too restrictive a description, stating that "[t]here are times when 'aggression' is permissible (*e.g.*, for the common interest, peace-keeping or enforcement, or individual or collective self-defense)."[12] He further argues that there is an important distinction between peaceful "purposes" and peaceful "uses." Thus satellites may be "used" to support armed military operations as long as the "purpose" of the use is to restore a "climate of peace."[13] Under this interpretation, the development and deployment of weapons in space—as long as they are not weapons of mass destruction prohibited under Article IV—if used for "peaceful purposes" would not violate the Outer Space Treaty.[14]

"Space Law, a specialized body of international law, is very permissive, despite many misconceptions about what it allows and prohibits."

The Outer Space Treaty and the Liability Conventions make *States* responsible and liable for all activities that occur in outer space, even those conducted by civilians and private entities. For example, if a foreign country or its nationals are damaged by space activities of the fictional United States corporation "Space Bus," that country would file its claim against the United States, not "Space Bus." The United States maintains control over this *responsibility* by imposing licensing requirements on commercial entities, and protects against its governmental *liability* through insurance requirements.

The Liability Convention further expands on the idea that "Launching States" are liable for damage caused by space objects (including debris). If a space object is damaged <u>in outer space</u>, liability is based on fault. In other words, State A is liable to State B for damage by State A's space object to State B's object **<u>only if</u>** A was at fault. On the other hand, if damage is caused by a space object <u>on Earth or to an aircraft in flight</u>, liability is absolute. For example, if State A's space object causes damage on Earth to State B, State A is liable <u>regardless of whether State A was at fault</u>. However, States are liable only for *direct* damage caused by a space object (*i.e.*, loss of life, personal injury or other impairment of health, or loss of or damage to property).[15] Notably, there can be more than one "Launching State," which is defined as any State that launches an object, procures the launch of an object, or from whose territory or facility an object is launched. If there is more than one launching State, the States may apportion liability between them.

While space law was first being established, astronauts often returned to Earth in capsules that landed in the ocean and were recovered. Accordingly, it was important to the space-faring States that provisions be made to ensure the safe return of astronauts (and the space craft) to the launching State. In this context, the Rescue and Return Agreement established some key principles. It requires proactive, prompt, and safe rescue and return of spacecraft personnel who land in foreign countries. The treaty also prohibits taking such persons hostage or imprisoning them.

While still protected by the treaty, space *objects* receive less protection than spacecraft *personnel*. If a State A's space object lands in a foreign country, State A must request its return. If State A does so, the foreign nation must take steps to recover the object, if practicable, and to return it. It is important to note that there is no requirement to return an object in the same condition in which it was found; therefore, the foreign country can inspect the object, reverse-engineer it, take it apart, etc., prior to returning it. The launching State is responsible for costs of the recovery and return. If State A learns that a space object has returned to Earth in its own territory or the high seas or anywhere not under the jurisdiction of any State, State A must inform the launching state and the UN.

Finally, this article will briefly discuss the Registration Convention, which sets up a UN registry for space objects and requires States to establish their own national registries. This Convention has been criticized for its "loopholes" that enable States to avoid providing detailed information about their space objects:

1) States are not required to mark the space objects with the registration number; therefore, we won't necessarily always know to whom an object belongs.

2) States are only required to notify the UN "as soon as practicable" after launch. The treaty does not define "as soon as practicable;" therefore, the country decides for itself when it's practicable to notify the UN, which could be years after the launch or even never.

3) Because the treaty only requires a general description of the function of the satellite, countries do not often provide a very helpful description of the function of the objects (USSR entry "to explore the cosmos;" United States entry "to conduct practical applications such as weather or communications").

4) States are only required to provide notice on the *initial* orbital parameters. Therefore, if they move the object later, there is no requirement to amend their initial notification or to provide the updated information to the UN.

This brief summary of major space law principles illustrates that space law is quite permissive. The 2002 withdrawal of the United States from the 1972 Anti-Ballistic Missile (ABM) Treaty Anti-Ballistic Missile Treaty and recent US ballistic missile defense efforts have prompted many States and international non-governmental organizations to urge a ban on arms in outer space and/or a strengthening of space law in a new overarching convention or treaty.[16] The United States opposes these efforts

based on its belief that the "...existing multilateral arms control regime adequately protects States' interests in outer space and does not require augmentation."[17]

Given the backdrop of relatively permissive international space law, it is important to look at other constraints on United States military use of space imposed by other treaties and bodies of international law such as the Law of Armed Conflict, as well as domestic restrictions on the use of space weapons. In addition, given widespread mischaracterization of United States space policy in political rhetoric as well as academic and legal writings, it is important to understand what United States space policy governing the military uses of space really says. The next two articles in this series will address these topics.

Notes:

[1] Paul B. Stares, "Space and US National Security" in William Durch, ed., *National Interests and the Military Use of Space* (Cambridge, Mass.: Ballinger, 1984), 35 [Stares, "US National Security"]; Paul B. Stares, *The Militarization of Space: US Policy 1945-1984* (Ithaca, N.Y., Cornell University Press: 1985), 13 [Stares, *Militarization*].

[2] Although the United States launched its first satellite in 1958, this sense of urgency is still evident in President John F. Kennedy's address to the US Congress in 1961:

> *This is not merely a race. Space is open to us now; and our eagerness to share its meaning is not governed by the efforts of others. We go into space because whatever mankind must undertake, free men must fully share.*

Statement of the President, Special Message to Congress on Urgent National Needs, 25 May 1961.

[3] Stares, "US National Security," *ibid.*, 37. The shoot-down of Gary Powers' U-2 over the Soviet Union on 1 May 1960 ended the era of United States aerial reconnaissance over the Soviet Union. The National Reconnaissance Office (NRO) was created in September 1961 to consolidate United States reconnaissance efforts.

[4] Recognition of the important role played by NTMs was and is still evident in many arms control treaties, which explicitly prohibit interference with them. Thus, for example, the 1972 Anti-Ballistic Missile (ABM) Treaty provided for the use of NTMs (with satellite observation as a critical component) to verify compliance with strategic arms limitations. The ABM Treaty recognized the importance of the role played by NTMs and therefore prohibited interference with them. *Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems*, 23 UST. 3435 (entered into force 3 October 1972, but no longer in effect as of 13 June 2002 due to United States withdrawal), Art. XII [ABM Treaty]; US White House, Press Release, "Statement by the Press Secretary Announcement of Withdrawal from the ABM Treaty," 13 December 2001, on-line, Internet, White House, http://www.whitehouse.gov/news/releases/2001/12/20011213-2.html. Many other treaties still in force today contain this same prohibition, for example START I, INF, CFE.

[5] To complicate matters, the delineation of "air space" from "outer space" has never been defined. Throughout the space age, the prevailing view has been that there is no real need to establish any boundary between air space and outer space, since the absence of such a boundary has, thus far, not created any major problems, and the utmost freedom of action in the peaceful exploration and use of outer space is both necessary and desirable. However, there have been repeated attempts to define such a dividing line (for example, the Russians propose that 100km be the dividing line.) Convention on International Civil Aviation, 7 December 1944, 15 U.N.T.S. 295, ICAO Doc. 7300/6 [Chicago Convention].

[6] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies*, 27 January 1967, T.I.A.S. 6347, 610 U.N.T.S. 205, Articles VI and VII [*Outer Space Treaty*].

[7] *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space*, 22 April 1968, 672 U.N.T.S. 119, 19 UST. 7570, T.I.A.S. No. 6599, 7 I.L.M. 151 [*Rescue and Return Agreement]; Convention on International Liability for Damage Caused by Space Objects*, March 1972, 961 U.N.T.S. 187 [*Liability Convention*]; *Convention on the Registration of Objects Launched into Outer Space*, 14 January 1975, 28 U.S.T. 695 [*Registration Convention*]. Although there is technically a fifth space treaty (the *Moon Treaty* of 1979), I will not discuss it in this article, because it only has 9 parties, none of which is a space power (however, France (which does has a viable space program) is a signatory). The US is not a party or signatory to this treaty. *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies*, 5 December 1979, 1363 U.N.T.S. 3, 18 I.L.M. 1434 [Moon Treaty].

[8] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies*, 27 January 1967, T.I.A.S. 6347, 610 U.N.T.S. 205, Article IV [*Outer Space Treaty*], which states:

States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.

The Moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden.

[9] See e.g., the US White House National Science and Technology Council, National Space Policy, 19 September 1996, on-line, Internet, White House, available from http://www.ostp.gov/NSTC/html/pdd8.html (stating "The United States is committed to the exploration and use of outer space by all nations for peaceful purposes and for the benefit of all humanity. 'Peaceful purposes' allow defense and intelligence-related activities in pursuit of national security and other goals.")

[10] *See, e.g.*, Ivan A. Vlasic, "The Legal Aspects of Peaceful and Non-Peaceful Uses of Outer Space," in B. Jasani, ed., *Peaceful and Non-Peaceful Uses of Space: Problems of Definition for the Prevention of an Arms Race* (New York, Taylor & Francis: 1991), 45.

[11] *Ibid.*, 40.

[12] *Ibid.*

[13] *Ibid.*

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[14] Arguments have also been made that Article IX of the Outer Space Treaty, which allows each State Party to request consultation if it believes the space activities of another State might cause harmful interference to the peaceful use of space, could be used to challenge and constrain a particular military activity. *Outer Space Treaty, supra* note 8, Article IX.

[15] A launching State will NOT be liable if the State claiming damage was itself grossly negligent or committed an intentional act or omission causing the damage. *Liability Convention, supra* note 7.

[16] *Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems*, 23 U.S.T. 3435 (entered into force 3 October 1972, but no longer in effect as of 13 June 2002 due to United States withdrawal), Art. XII [ABM Treaty]; US White House, Press Release, "Statement by the Press Secretary: Announcement of Withdrawal from the ABM Treaty," 13 December 2001, on-line, Internet, White House, http://www.whitehouse.gov/news/releases/2001/12/20011213-2.html.

[17] Eric M. Javits, "Statement to the Conference on Disarmament," Geneva, 7 February 2002, on-line, Internet, US Mission Geneva, Permanent Representative to CD, http://www.usmission.ch/press2002/0207javits.htm.

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Major Waldrop attended Duke University and received a Bachelor of Science degree in Electrical Engineering in 1989. After serving four years as a satellite operations officer performing on-orbit command and control of the Global Positioning System (GPS), the Air Force selected her to attend law school at the University of Texas. Since becoming a Judge Advocate General (JAG) in 1996, she has served in various legal positions in military criminal law (both prosecution and defense), administrative personnel actions, labor law, military operations law, international law, and space law. She received her LL.M in Air and Space Law from McGill University, Montreal, Canada in 2003.

MILESTONES IN SPACE HISTORY

2 Aug 1954

The visionary leader Brigadier General Bernard Schriever takes command of the Western Development Division

28 Feb 1959

First US Air Force satellite, Discoverer I, is launched

17 Sep 1963

Ballistic Missile Early Warning System (BMEWS) becomes operational in Yorkshire, England

23 Mar 1988

Strategic Defense Initiative Organization breaks ground for permanent National Test Facility at Falcon AFS to spearhead development of technologies for ballistic missile defense

17 Feb 1994

Air Force Space Command launches the first MILSTAR Satellite, beginning a new era in military satellite communications

Space Warfare Center

Lt Col (Ret) John Ottino,
Space Warfare Center (SWC) Plans

DESERT STORM combat operations relied on space support more than any previous conflict, and the post-war analysis of that support revealed shortfalls in the ability to take advantage of all the capabilities space has to offer. DESERT STORM lessons learned revealed that planners and troops were unfamiliar with space capabilities, and that space products were difficult to acquire and use due to the lack of a space support plan, the high classification of many space products, and a bureaucratic tasking process.

In the fall of 1992, a Chief of Staff Blue Ribbon Panel on Space determined that inadequate attention was given to the exploitation of space. The panel recommended the establishment of the Space Warfare Center (SWC) to examine the capabilities and benefits of space-based assets. As a result, the SWC, a direct reporting unit to Air Force Space Command (AFSPC), was established at Falcon AFB (now Schriever AFB) in December 1993.

Talon Foglite

Since the SWC's inception, it has continued to grow, taking on new missions and enhancing war-fighter capabilities through rapid prototyping, training, testing, tactics development, distributed mission operations, war-gaming, and modeling and simulation. The current SWC mission is: **"Advance Air Force, joint and combined space warfare through innovation, testing, tactics development, and training."** The SWC accomplishes this mission through its major developmental and support directorates. These directorates include the 595th Space Group, the Air Force Tactical Exploitation of National Capabilities (AF-TENCAP) program, the Air Force Space Battlelab, and the Warfighting Integration Division.

The largest organization in the SWC is the **595th Space Group**. The group's mission is to *"enhance and provide confidence in Air Force War-fighting capabilities through advanced training, education, tactics development, and operational testing."*

Six squadrons combine efforts to achieve that mission. The **595th Operations Support Squadron** provides support to ensure the Space Group and all of the units within can perform their missions.

The **17th and 14th Test Squadrons** conduct Force Development Evaluations (FDE) of operational space systems for AFSPC.

The **576th Flight Test Squadron** conducts the FDE program for operational test launches of Intercontinental Ballistic Missile (ICBMs) and controls a test range from Vandenberg AFB to the Kwajalein Atoll in the South Pacific. The missile test launches certify reliability and accuracy to USSTRATCOM and our nation's leadership, providing greater insight into force capabilities and their role into the nation's Integrated Tactical Warning and Attack Assessment (ITWAA) program.

The **527th Space Aggressor Squadron** operates much like the Air Aggressors at Nellis AFB. Using foreign equipment or emulators of that foreign equipment, the 527th looks to replicate the threat a "Space Capable" nation would pose to our forces. Acting as this space-capable adversary, the 527th identifies vulnerabilities and works with our forces, providing training on the threats posed and how to counter them.

The following examples show this squadron enjoys one of the most exciting and critical mission areas of the SWC. The Space Aggressors, supporting Red Flag 04-1, received Secretary of Defense permission to jam GPS and SATCOM signals. The aggressors demonstrated the jammed effects to the many aircrews flying missions and quickly moved up on the targeteers' priority list. The Aggressors also trained United States and coalition forces prior to their deployment to Iraq on potential Iraqi jamming capabilities and how to counter them—another SWC success story in support of Operation IRAQI FREEDOM.

The last squadron in the 595th Space group is also the most recently activated, the **25th Space Control Tactics Squadron**. This squadron is responsible for a new and rapidly growing area in Air Force Space Command—space control Tactics, Techniques and Procedures (TTPs). Space assets are in place and integral to the very nature of today's warfare. Space capabilities, through their unique abilities to collect, transmit, and disseminate information around the globe, are the key enablers of precision warfare. Not only do our forces need unhampered access to space-based services, our forces also must be prepared to operate in an environment in which adversaries have access to similar space-based services. The squadron's TTP role ensures our space forces are able to maintain their capabilities and are prepared to deny an adversary of the benefits of space capabilities.

The SWC's legacy comes from the oversight it provides to the **Air Force Tactical Exploitation of National Capabilities (AF TENCAP)** program. Congress directed the services to stand up TENCAP programs in 1977 with a goal of making National systems more accessible to the warfighter. The tasks set forth in the Congressional Charter include: *Exploiting* National Technical Means for warfighting application, *Influencing* National Systems design and operation for better warfighting support, and *Educating* and training warfighters.

AF TENCAP utilizes a non-traditional acquisition program known as rapid prototyping. The goal is to develop a prototype,

demonstrate it within 12 months, then transition material solutions to users in an additional six months, for a total acquisition period of 18 months—significantly less than traditional acquisition timelines.

The AF TENCAP program is comprised of five AF TENCAP divisions. **Programmatics (TCP)**, whose responsibilities include AF TENCAP Charter execution, program management, and reporting, is the USAF representative for the MERIT program. TCP conducts conferences as required to assimilate operational requirements and mission needs, as well as to disseminate advances in technology. TCP coordinates efforts with Combat Air Forces and other affected agencies to ensure widest application of program results. TCP also maintains dialogue with the national community and other services' TENCAP programs to leverage efforts and avoid duplication.

Kinetic Effects (TCW) is focused on improving both targeting and bomb delivery accuracy.

C4ISR (TCI) emphasizes Horizontal Integration of Tactical and National Assets. TCI is AF TENCAP's division for overcoming the "stovepipes" for our frontline warriors.

Blue Force Tracking (TCB) is responsible for improving command and control, force protection, and situational awareness for joint and coalition forces.

Lastly, **Special Applications (TCZ)** works the application of special technologies to augment terrestrial and airborne war-fighting capabilities.

An example of an AF TENCAP project is **Talon REACH**, a system that exploits the Iridium constellation of satellites, providing a significant amount of bandwidth for military applications. One of **Talon REACH's** applications is Blue Force Tracking, which can be shared with our allies and coalition partners and provides better coverage than National systems.

Other exciting technologies AF TENCAP is developing include a system to detect, locate, and predict the effects of GPS jamming; and exploitation of polarized imaging to provide target characterization to help determine an object's structural properties. The imaging capability can assist from the ground, looking at our adversary's space systems to help with materials identification.

The SWC's **Air Force Space Battlelab** is one of seven Air Force Battlelabs. The Space Battlelab, which is funded with Operations & Maintenance money, focuses on the purchase of available government-off-the-shelf and commercial-off-the-shelf hardware and software. They then use these products in innovative ways to meet war-fighter needs. The goal of the Battlelab is to demonstrate war-fighter utility within 18 to 24 months, from initiative approval through after-action reports.

Examples of Space Battlelab projects include: **Combat Eye**, which utilizes short-pulse lasers to provide 3-D images through obscurants, such as clouds, fog, sandstorms, or camouflage netting; and the **Virtual Mission Operations Center (VMOC)**, which uses Internet protocols for satellite command and control. VMOC uses the Internet for "tracking, telemetry, and control" of space assets as well as requesting sensor information/data. The "knowledge database management" system in VMOC provides for machine-to-machine integration of those tasks.

Other Space Battlelab projects include ICBM security enhancements, short-pulse laser communication, near-space concept development, and continuation of integration of virtual technologies into space control activities.

The **War-fighting Integration Division**, or **SWC/XI**, is chartered to develop and integrate space capabilities and tools that assist warfighter planning, operations, and training. The division performs a number of functions, including development of new Space Situation Awareness (SSA) capabilities, planning and execution of military utility assessments for Advanced Concept Technology Demonstrations, evaluation of promising SSA initiatives via the SSA Command & Control Testbed, and providing space capabilities for wargames and exercises through the division's Distributed Mission Operations Center-Space (DMOC-S).

The division operates two facilities dedicated to accomplishing the above mission areas: the Space Application & Integration Facility (SPAIF) and the Aerospace Fusion Center (AFC). XI is also responsible for the planning and execution of the Schriever Series of War-games, the largest space-related wargames in the DOD.

Since its inception in 1993, the SWC has worked to provide the most up-to-date technology, training, testing, and tactics for the warfighter. The SWC provides unique capabilities for AFSPC: using cutting-edge technology to deliver rapid solutions through AF TENCAP and the Space Battlelab; providing operational testing through FDEs of space systems, as well as helping to ensure the reliability and accuracy of our aging ICBM force; conducting vulnerability assessments and tactics development for employment and defense of our critical space and C4ISR systems; and training the next generation of space professionals who will continue to lead our advancements in the space arena.

To find out more about SWC capabilities, please visit https://swcweb/index1.html.

Lt Col (Ret) John Ottino (BA, Southern Colorado State College; MA, University of Northern Colorado) provides contract support in the Space Warfare Center (SWC) Plans, Programs and Requirements (XR) division. His primary responsibilities include the identification of warfighter- needed capabilities, and the subsequent vetting of those needs throughout the SWC and other mission partners in search of new and emerging technology to provide solutions to those needs. During his 28-year active duty Air Force career, Lt Col (Ret) Ottino served in a multitude of worldwide command and staff positions, earned numerous unit and individual awards, and completed Squadron Officer School, Air Command and Staff College, and Air War College. Lt Col Ottino retired from active duty on 1 January 1999.

Pioneers Influence Space Professional Development

Lt Col George R. Farfour,
Deputy Director, Commander's Action Group,
HQ Air Force Space Command

"…to reach into the future, yet never neglect the past."[1]
- General of the Army Douglas MacArthur

The past 50 years of space and missiles can teach us a great deal about Space Professional Development (SPD). As we move forward in this vital area, it is important to note that as space professionals, we have a long history on which to reflect and from which to learn.

SPD has already involved learning new terms, developing new certifications, and even implementing a new badge. We face these changes even as we struggle to understand the implications and adjustments within the Air Force's evolving force development construct. Some have recommended a "wait and see" approach, rather than getting involved. In operator lingo, that would be a critical error.

SPD is more than just an administrative exercise. It is a fundamental shift, not only in the way our expertise is tracked and taught, but also in the singular direction to develop the expertise needed for the future. Though we use words such as "human capital" that tend to dehumanize the overall objective of SPD, make no mistake, people are the central focus.[2]

Our leadership agrees. AFSPC Commander General Lance W. Lord put it this way: "Without question, our most vital resource is people, and that's why we are working hard to create a strong program that will professionally develop our next generation of Space Professionals."[3] Under Secretary of the Air Force, The Honorable Peter B. Teets agrees, adding that space professionals are the crucial element of space power.[4]

Before you throw your hands up, attributing this effort to just another bureaucratic program, there are a few things we can learn from the pioneers who started and sustained 50 years of Air Force space and missiles. These 50-year pioneers can teach us a great deal about how we should shape our future.

Air Force space and missile pioneers worked and fought in an environment largely devoid of examples from which to draw inspiration. What kept them motivated and moving forward was an internal compass which allowed them to see how important their work was to the United States. How successful would these pioneers have been if they had given up at the first signs of frustration, failure, or change? Sure, they were smart, but technical expertise and intellect was not all that sustained them. The core traits examined below serve to illustrate how we might frame our experiences as we move forward in SPD.

They were true professionals. Not only did they know their particular duty responsibilities, they also knew they were part of a larger Air Force and even larger military. They understood the best way to make their case was to be professional Airmen. Being an advocate without any grounding in your environment makes you a zealot. Having that grounding makes you technically smart and worthy of a seat at the table.

We must be smart in our areas of expertise, but we must not forget how we fit into the bigger picture. Our Command's unofficial slogan acknowledges our attachment and contribution to the larger Air Force: "Skilled in Air, Experts in Space." Space doctrine, policy, and attitudes must become so prevalent that planning for any military action begins with the considerations of what space brings to the fight.[5] Integrating our systems into every war-fighting construct is how we will bring the unprecedented power of space to protect our nation.

Our space and missile pioneers also demonstrated a strong work ethic. Developing the systems that we have today was no easy task, especially considering the rigors of space and our extremely limited knowledge of operations in that environment. Although they had no roadmap or defined destination, they worked and experimented tirelessly to invent and produce concepts, designs, and systems we now know by name. Beyond that, these space pioneers often acted as the salesmen to a skeptical audience, whether for funding, integration, or the need for new innovative programs.

A healthy dose of self-improvement was also part of their character. Our space pioneers' work would have been of limited use, had they failed to appreciate the tremendous power of self-improvement. Many of their lives are a study in continuous learning. Professional publications, whose subjects cover the waterfront of history, current events and future strategies, deserve a place on our reading shelf. Professional Military Education and force development, which are always important,

become even more so while developing space professionals.

More than anything else, our pioneers had vision. Not a single vision, perhaps, but vision to see into the future and take resolute action to shape it. They recognized vision as an enabler. This vision enabled them not to be afraid of the challenges of technology or of the mind. At every turn, there were positive lessons that kept them moving forward. Men and women of less character and fortitude would have easily surrendered to the apparent frustration and hopelessness that lay before them.

No other trait is more important than the ability to see farther and with more clarity than those around you. A focused vision of what needs to be done and the steps that bring goals to fruition represents the heart of our vision for SPD.

At the 2004 Space and Missile Hall of Fame inductions held at Peterson AFB, General Lord called these heroes "a national treasure."[6] The pioneers are national treasures, not only for what they have already accomplished, but also for the inspiration they continue to give this Nation.

As a fitting tribute to our pioneers, we must strive in that same vain, for we are today's pioneers in the making. We have a responsibility to them, our country, and ourselves. SPD will enable us, like our pioneers, to see farther and achieve great things for our nation. Anything less is failure on all fronts.

Notes:

[1] Richard I. Lester, ed. *Concepts For Air Force Leadership* (Maxwell AFB, AL: Air University Press, 2001), 383. In his famous address to the Corps of Cadets at West Point, General MacArthur outlined how officers must remain focused on the core competencies of officership while also becoming experts and understanding a wide variety of disciplines to better serve the nation.

[2] GAO Report., US Government Accountability Office, GAO-04-697, "Defense Space Activities: Additional Actions Needed to Implement Human Capital Strategy and Develop Space Personnel," 11 August 04.

[3] General Lance W. Lord, "Developing Space Professionals," *High Frontier,* Summer 2004, 7.

[4] Mr. Peter B. Teets, "NSS Plans Strategy for Developing Space Professionals," *High Frontier,* Summer 2004, 5.

[5] General Lance W. Lord, Remarks to the Air Force Association Conference, 14 September 2004, on-line, Internet, October 2004, available from https://www.peterson.af.mil/hqafspc/Library/speeches/Speeches.asp?YearList=2004&SpeechChoice=79.

[6] Notes, General Lance W. Lord, Comments to Space Pioneers, 30 August 2004.

Lieutenant Colonel George R. Farfour (BS, East Carolina University, MA, Webster University, MMOAS, Air University) is the Deputy Director, Commander's Action Group, HQ Air Force Space Command, Peterson AFB, Colorado. He is responsible for overseeing and providing direct, unfiltered advice for the Commander, Air Force Space Command and senior staff on operations, training and support issues. He has held a variety of operational and staff duty positions in ICBM Operations, Satellite Command and Control, joint planning and the Air Staff. While on the Air Staff, Lt Col Farfour was responsible for strategy and concepts planning for nuclear policy and was the Air Force's Action Officer for the Nuclear Posture Review. He also was responsible for the Air Force's policy and compliance with Space Arms Control treaties and agreements. Lt Col Farfour is a graduate of Squadron Officer's School, Air Command and Staff College and Air War College (by correspondence). He is a Senior Space and Missile Operator.

"Without question, our most vital resource is people and that's why we are working hard to create a strong program that will professionally develop our next generation of Space Professionals."

- General Lance W. Lord

Global Positioning System (GPS) A Look Ahead

Col Wesley A. Ballenger, Jr.,
System Program Director,
Navstar GPS Joint Program Office

On 1 July 1954 Western Development Division was established marking the beginning of 50 years of tremendous growth in space and missiles for this country. During the past five decades, US Air Force spacepower leadership has been critical in winning the Cold War, enabling successful military operations in distant lands and assuring security and economic stability in the United States homeland in the 21st century.

Global Positioning System (GPS) contributes significantly to the definition, development, production, and fielding of advanced GPS capabilities for the Department of Defense, foreign military allies, and civilian users around the world to ensure continued outstanding service well beyond the 21st century.

GPS is a space-based, radio-positioning system nominally consisting of a minimum of a 24-satellite constellation that provides navigation and timing information to military and civilian users worldwide. As of September 2004, there are 29 satellites—well above the nominally required 24—in orbit. GPS satellites circle the earth every 12 hours, emitting continuous navigation signals on two different L-band frequencies, L1 and L2. A dual-use system, GPS is available to United States military and allies as well as civilian and commercial customers worldwide, providing the highest quality of service to meet constantly evolving user requirements in building and launching satellites.

GPS gained military prominence during Operation DESERT STORM in 1991 when United States and Coalition partners used it in actual combat. This new weapon system guided troops through the featureless desert, enabling synchronized movements. GPS transformed iron bombs into precision munitions, which in turn led to a swift victory on the battlefield. GPS proved to be a force multiplier that would transform the way America fights—at the same time it delivered tremendous benefits to the civilian and commercial communities.

Since the first Block II delivered position navigation and timing capability to the warfighter and the world, the Navstar GPS program office has been working aggressively to modernize the constellation. Begun in the mid-1990s, the GPS modernization initiative focused on providing enhanced capabilities to both the military and civilian communities. The military enhancement included the introduction of new military code (M-Code) on both L1 and L2 links. The anti-jam capabilities also are enhanced on both links. The second civilian signal (L2C) capability provides dual frequency capability to all equipped civilian users, allowing removal of ionosphere errors, which increases accuracy.

L2C, a redundant signal, is the first signal truly dedicated to the civilian community. Its pseudo-random civilian code features several performance-related enhancements when compared with the Coarse/Acquisition code (C/A) on L1. These improvements provide greater accuracy, better resistance to jamming, and enhanced performance for current and future missions. The M-Code signal will provide the war-fighter with a more robust, jam-resistant signal, enabling effective munitions targeting in stressed environments.

Within the Space Segment, new rubidium frequency standards are being deployed on the Block IIF vehicles, and an improved GPS navigation message is being developed for M-Code and L-5. Both will contribute to improved accuracy for military and civilian users. The Block IIR-M and the IIF not only will enhance the current system, making it more precise, they also will leverage new technologies unheard of 10 years ago.

In addition, the incorporation of the Accuracy Improvement Initiative (AII) will add 11 National Geospatial-Intelligence Agency (NGA) monitor sites. This will greatly enhance active monitoring capability and increase signal in space accuracy by 30 percent. These new sites support the NGA mission of providing timely, relevant, and accurate Geospatial Intelligence in support of national security.

The launch of the first IIR-M, scheduled for calendar year 2005, will be the first step toward the addition of L2C and the M-Code signal. Initial operational capability is projected for 2008.

Following behind the IIR-M will be the launch of the first IIF satellite, scheduled for summer 2006. This satellite will feature an additional third civilian signal, L5, as well as flex power. The more robust L5 aviation spectrum band will support increased international aviation satellite navigation needs.

Both new civilian signals will include a new navigation message known as New and Improved Clock and Ephemeris (NICE), which will bring with it the ability to provide improved accuracy. The new monitor and operations control center

package also will be improved to include monitoring of the civilian signals, L1C/A, L2C, and L5. Flex power will allow the signal strength to be increased when operating in a stressed environment, ensuring that the user has GPS when he or she needs it most.

Another addition to the next generation of improved satellites is the Block III, which is referred to as GPS III. This improved space and ground segment is intended to assure a more reliable and secure delivery of enhanced position, velocity, and timing signals to serve the evolving needs of civilian and military users for the next 20 years. GPS III will eliminate numerous existing shortcomings and vulnerabilities that threaten to severely impact vital civilian commerce, transportation, public safety, and military operations in the future. GPS III strives to enhance United States leadership in space-based navigation to meet the stated Presidential goal of sustaining GPS as the world standard for navigation. Initial launch capability is projected in FY12.

The GPS III satellites will transmit a significantly higher-powered military signal referred to as a "spot beam." This regional spot beam will allow military aircraft, troops, and precision weapons to use GPS signals in extremely hostile jamming environments with no effect on civilian GPS users.

Another feature will be "integrity." With today's GPS, it is difficult for the user to easily confirm the quality of the received positioning signal. The GPS III system will have enhanced signal monitoring, fault detection, and alert systems to prevent the potentially tragic consequences that could arise from faulty positioning signals.

Also, GPS III will have a cross-link capability between satellites and a larger ground station network, allowing for improved signal monitoring and integrity from all GPS satellites, as well as improved accuracy for all GPS users. Cross-links currently being explored allow one satellite to be uploaded with a fresh navigation message and this satellite to propagate the updated message to all other GPS satellites. This allows for a constellation-wide update very quickly, translating into a fresher navigation message. The cross-link capability will reduce dependencies on overseas ground stations. GPS III will provide an overall improvement in service quality through gradual increases in system accuracy and availability.

The latest developments within the GPS user equipment technologies involve improvement in the antenna systems. Emerging systems include:

- GPS Antenna System–1 (GAS-1)
- Advanced Digital Antenna Production (ADAP)
- Simultaneous L1/L2
- Digital Space-Time Adaptive Processing (STAP)/Space-Time Frequency Processing (SFAP)
- Digital Multi-beam Steering Antenna electronics (AEs), i.e., G-STAR
- Multi-element Small Antenna (S-CRPA) for space constrained platforms
- Receivers with Ultra-Tight GPS/INS Coupling
- Improvements in receiver timing (i.e., chip-scale atomic clocks)
- Real-Time Kinematic (RTK) capable receivers
- Receivers with Receiver Autonomous Integrity Monitoring (RAIM)/Improved RAIM algorithms

The success of the GPS program has prompted military and civilian users to embed GPS receivers into products essential to our national and international infrastructure. Currently in production is the Defense Advanced GPS Receiver (DAGR) a next-generation, lightweight, GPS handheld receiver programmed to replace the currently fielded Precise Lightweight GPS Receiver (PLGR). The DAGR is a dual-frequency, affordable, modernized, handheld GPS receiver with increased anti-jam/anti-spoof capabilities for ground and special operations

forces. The DAGR weighs less and provides both a graphical user interface and situational awareness capabilities for the warfighter. DAGR was approved for full-rate production (FRP) in August 2004; fielding will begin in November 2004.

The Combat Survivor Evader Locator (CSEL) survivor radio system is designed to quickly locate, identify, and communicate with a soldier, sailor, airman, or marine upon activation. CSEL is currently in Low Rate Initial Production, with more than 2,500 radios already delivered to the services. The FRP contract award is scheduled for December 2004, with the first Air Force units expected to begin operational use of the system in early 2006.

Air Combat Command has already delivered CSEL radios and radio-loading equipment to the Survival Evasion Resistance and Escape (SERE) training squadron at Fairchild Air Force Base (AFB), Washington and Life Support training squadron at Sheppard AFB, Texas in preparation for initial training and fielding. Both units are conducting "Train the Trainer" sessions. Additionally, Air Force Special Operations Command (AFSOC) at Hurlburt Field, Florida is training Life Support and SERE instructors on the use of the CSEL system. CSEL also has been in use by Carrier Air Wing 14 aboard the USS Stennis since May 2004.

By direction of the Under Secretary of the Air Force, the Navstar GPS program office was tasked to develop a receiver that processes GPS Y-Code, M-Code, and C/A Code (YMCA). The YMCA receiver provides a bridge between legacy receivers and new M-Code receivers. A YMCA solution allows for a single upgrade, instead of a Y-Code, followed by an M-Code. Additionally, it allows for flexibility while the constellation becomes populated with M-Code-capable space vehicles and the OCS upgrades are completed. Most importantly, a YMCA receiver installed on a platform would be able to "communicate" with legacy and M-Code munitions.

Final requirements for modernized user equipment (MUE) are in development. The MUE Capability Development Document (CDD) is scheduled to be presented to the Joint Requirements Oversight Council (JROC) late fall 2004. It then will feed into a key decision point (KDP) in the January-February 2005 timeframe, with contracts scheduled to be awarded in the March-April 2005 timeframe.

Due to the success of the GPS program, other satellite navigation systems have been considered by other administrations, such as GLONASS by the Russians, the Quasi-Zenith Satellite System (QZSS) by the Japanese, and Galileo by the Europeans. After several years of negotiations, the European Union (EU) and the United States have agreed on a cooperation agreement between European and United States satellite navigation systems. The US/EU GPS/Galileo agreement, signed by Secretary of State Colin Powell and his European counterpart on 26 June 2004, ensures compatibility between America's GPS and its future European counterpart, Galileo.

At the US/EU Summit press conference, President George W. Bush remarked, "Earlier today, we also signed an agreement that ensures compatibility between America's global positioning system and its future European counterpart, Galileo. This agreement will protect our common security, improve the delivery of emergency services, and further our economic cooperation. This was a hard agreement to make, and because we worked together, we now have an agreement. The two systems will be compatible and interoperable. And users from business to science to government in America and Europe will benefit."

From the dawn of Air Force space and missile programs and its early pioneers to the future visionaries who will meet new challenges, the US Air Force takes great pride in our space contributions spanning half a century and beyond. GPS, which has evolved as a global utility vital to both commerce and the security of the world, ranks as the center of excellence for all future space-based navigation.

Colonel Wesley A. Ballenger, Jr. (BSEE, University of Virginia, MSEE, Air Force Institute of Technology, MBA, and George Washington University) is the System Program Director for the Navstar Global Positioning System (GPS) Joint Program Office, Space and Missile Systems Center, Air Force Space Command, Los Angeles Air Force Base, California. He is responsible for a multiservice, multinational organization, which conducts development, acquisition and sustainment of all GPS space segment, satellite control (ground) segment, GPS user equipment, and Combat Survivor Evader Locator (CSEL) resources. The $19 billion GPS program maintains the Department of Defense's (DoD) largest satellite constellation and the largest avionics integration and installation programs in the DoD.

Colonel Ballenger was commissioned through the ROTC program in May 1980. He is a career acquisition officer with experience managing the development and procurement of multiple weapon systems including aircraft, intercontinental ballistic missiles, space launch vehicles, satellites, and intelligence systems.

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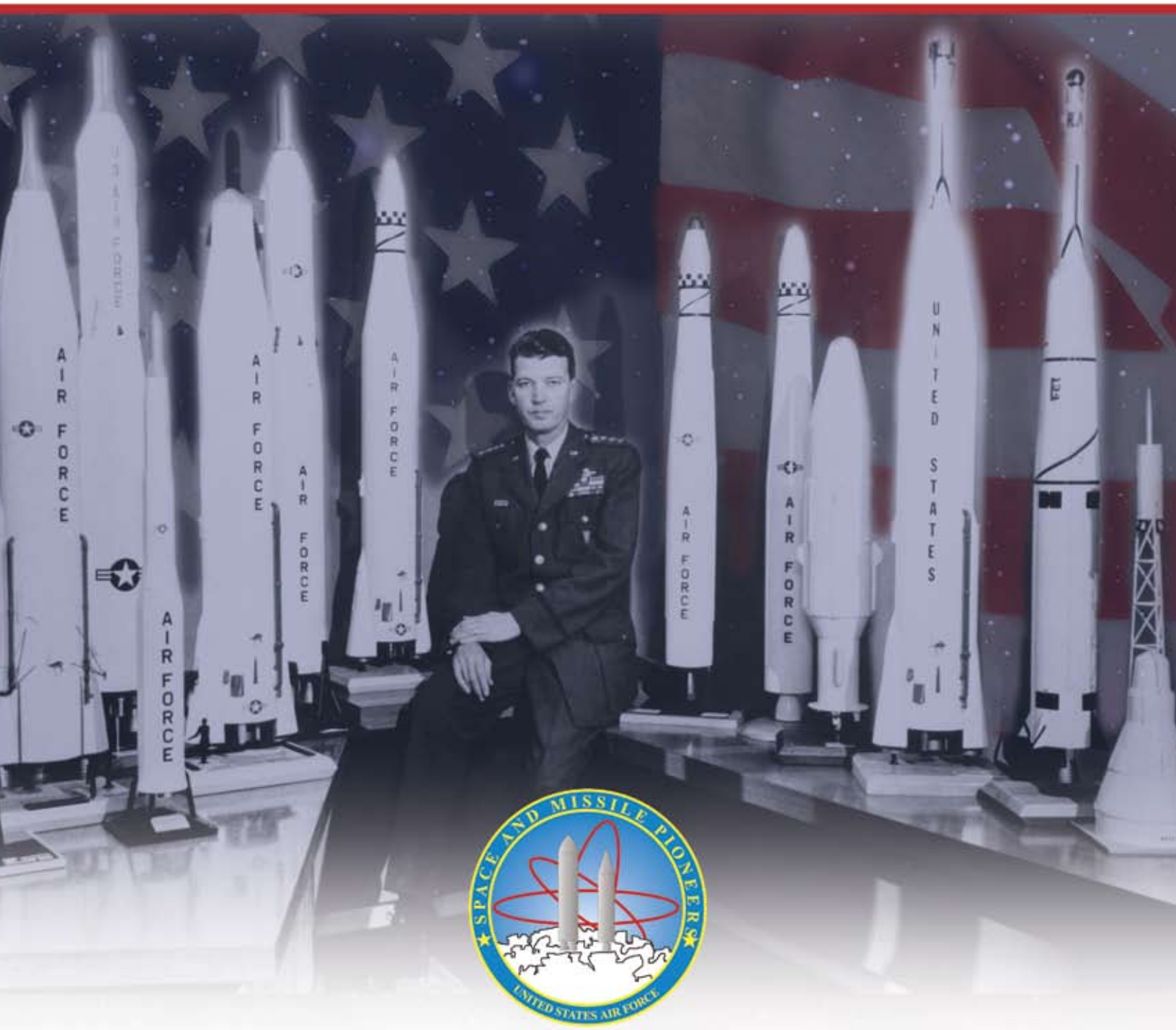

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