Air Force
SPACE COMMAND
50 Years of Space & Missiles


1954-2004
50 Years
AIR FORCE
Space & Missiles





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Dear Friends and Colleagues,

We live in a very complicated world. Our national security depends on understanding that complexity, keeping ahead of it when we can and reacting to it appropriately when we must.

As the Strategic Forces Subcommittee Chairman for the Senate Armed Services Committee, I believe there is no effort more important to our national security than ensuring the United States' space superiority and assured access to space.

For 50 years, the Air Force space community has contributed to the national security of the United States. From the establishment from the Western Development Center half a century ago, to the successful space launches we continue to accomplish year in and year out, our capabilities in space have helped secure our safety, and continue to change the way warfare is conducted.

The military utility of Air Force space capabilities has been even more evident during our most recent conflicts in Iraq and Afghanistan. President Bush said it best when he stated,

> *"Operation Iraqi Freedom was carried out with a combination of precision and speed and boldness the enemy did not expect and the world had not seen before."*

There is no doubt in my mind that the success that we achieved during Operation Enduring Freedom and Operation Iraqi Freedom were in large part fueled by the lead taken by the Air Force Space Command in establishing our nation's space superiority.

In closing, I commend Air Force Space Command for its 50 years of service to our nation. Your commitment to maintaining our strength in space ensures our safety and security, and guarantees that the United States will continue to secure the high ground for another half century.

Sincerely,

Wayne Allard

Wayne Allard
United States Senate

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Dear Friends,

As chairman of the House Armed Services Subcommittee on Strategic Forces and a representative from Alabama – a state with a distinguished role in America's military and civilian space programs – I offer my congratulations to the U.S. Air Force on the 50th anniversary of preserving peace through the utilization of space.

Over the history of our nation, America's greatness has arisen from its recognition that frontiers exist not just to be crossed, but to be developed for the benefit of all. Even after fifty years, our reach beyond the Earth's surface for security and prosperity is only just beginning.

While high profile extra-planetary scientific exploration remains the most visible extension of America's overall investment in space, advances in rocket technology which made these historic achievements possible were pioneered and perfected by the U.S. military. The proud heritage of the U.S. Air Force Space Command (AFSPC) continues to strengthen America through greater reliance upon spaced-based assets.

Our military forces deployed in remote regions around the world depend upon real-time information from our military satellites to assess and target potential threats. At home, our families and communities will soon be protected by cutting-edge anti-missile technology designed to provide the first defense shield against ballistic missile attack in our country's history.

As the future promises an ever greater dependence upon space-based technology for civilian and defense purposes, I am absolutely certain that the U.S. Air Force Space Command, under the outstanding leadership of General Lance W. Lord, will provide the highest standards of excellence. It is my pleasure to wish all the men and women of AFSPC continued success in holding America's first line of defense: space.

Sincerely,

Terry Everett,
Member of Congress

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UNDER SECRETARY OF THE AIR FORCE
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TOWARD THE NEXT FIFTY YEARS

When General Bernard A. Schriever came to Los Angeles in 1954 to establish the Western Development Division of Air Research and Development Command, he had a clear purpose in mind: to build missiles to protect the United States. A scant five years later, the first Atlas missile launched from Vandenberg Air Force Base, California.

During those early years, when the Atlas, Thor, Titan, and Minuteman missiles were being developed and fielded, the U.S. also began reaching into space for military missions. General Schriever and his contemporaries succeeded beyond their wildest imaginations; they fielded complex systems at breakneck speed, with ever-expanding capabilities. Photoreconnaissance, communications, remote sensing, navigation, and missile warning satellites have given our Nation the comprehensive coverage and asymmetric advantage we enjoy today.

In the next fifty years, National Security Space will continue to be a vital national asset serving diplomatic, military, and economic needs in peace and war. Indeed, our land, sea, air, and space assets will be more integrated and more capable thanks to the creativity and determination of our cadre of space professionals.

Thanks to the original space professionals and those who carry on their pioneering work today, U.S. capabilities enabled by space systems affect every Soldier, Sailor, Marine, and Airman in the U.S. military. Literally thousands of men and women--military officers and enlisted, government civilians, contractors, and researchers--design, fabricate, test, integrate, launch, and operate our National Security Space systems. I salute all of our space professionals--past, present, and future--who strive to exceed the limits of the possible. Through their efforts, the next fifty years will bring unimaginable increases in our capabilities to support warfighting operations and national intelligence collection.

Peter B. Teets

CHAIRMAN OF THE JOINT CHIEFS OF STAFF
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50 Years of Air Force Space and Missiles

On behalf of the Joint Chiefs of Staff, it is my distinct honor to congratulate the Air Force Space Command on the 50th Anniversary of the US Air Force space and missile mission.

America's Armed Forces reach into space to provide communications, navigation, weather information, missile defense, early warning, force application, space control and battlespace management capabilities. Space programs form a cornerstone of our Nation's security strategy.

History reminds us that every generation is called to serve. From the early days of military aviation nearly a century ago to the War on Terrorism, Airmen have bravely defended our way of life. Today, exploiting the third dimension allows America and our allies to provide for the common defense across the globe, and take the fight to the enemy rapidly and with unmatched precision.

We have come so far in 50 years that it is difficult to imagine what new breakthroughs our children and grandchildren will see in the next 50. But we know for sure that America's liberty will be secured in no small part by today's and tomorrow's space warriors mastering the ultimate high-ground.

RICHARD B. MYERS
Chairman
of the Joint Chiefs of Staff

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AIR FORCE SPACE COMMAND

Dear Friends and Fellow Warfighters,

We have completed the transition from a Nation interested in space to a Nation with National interests in space. On our 50th Anniversary of Air Force Space and Missiles, we proudly thank and acknowledge the revolutionary efforts of our Space and Missile Pioneers. The United States will be forever grateful for the establishment of the Western Development Division in the summer of 1954, under the command of then Brigadier General Bernard "Bennie" Schriever. The technology developed for our ICBM mission formed the foundation for America's access to space for the next four decades.

Modern warfare has changed dramatically as a result of the capabilities and effects our space forces provide. We have substituted accuracy, speed and maneuverability for mass of forces. We now put less people in harm's way to achieve even greater combat effects on the battlefield. In the first fifty years of military space and missiles, our capabilities have become indispensable to national decision makers and joint warfighters alike. By extending American security beyond the earth's atmosphere into space, we have secured the ultimate high ground and became the first line of defense. Military Space is an equal partner with Air, Land and Sea Forces as demonstrated during our most recent engagements in Afghanistan and Iraq. Space capabilities have become the "oxygen" for successful joint operations. You cannot go to war and win without space; it's as necessary as the air we breathe.

Today's space professionals continue the tradition of excellence in the research, development, acquisition and operation of our Nation's space and missile capabilities. The world's greatest space and missile force stands proudly on the shoulders of our first space professionals. Congratulations to each of our 39,700 Air Force Space Command professionals on the 50th Anniversary of Air Force Space and Missiles.

LANCE W. LORD
General, USAF
Commander

GUARDIANS OF THE HIGH FRONTIER

50 Years of Space and Missiles

As the newest members of Air Force Space Command, we are extremely proud to celebrate our 50th anniversary. The Space and Missile Systems Center (SMC) traces its ancestry back to July 1954 where it began as the Western Development Division. Our founder, General Bernard Schriever, was a great visionary and his spirit of innovation and leadership continues at SMC today.

SMC is the center of excellence for space and missile acquisition for the United States. Our purpose, as we forge the shape of space for the 21st century, is to continue to provide the greatest space and missile systems on time, at cost, to meet our warfighters' needs. Our overarching goal is to provide the right capabilities and effects to our warfighters.

It's important to note that SMC space and missile programs, and the products and systems we produce here, have national and international implications for both the United States economy as well as the national security of our nation. We look forward to meeting the challenges and needs for our future warfighters for the next 50 years!

Sincerely,

BRIAN A. ARNOLD
Lieutenant General, USAF
Commander, Space and Missile Systems Center

NASA photo

FROM ATLAS TO PEACEKEEPER

By Scott R. Gourley

Named for mythological gods and American heroes, America's Intercontinental Ballistic Missiles (ICBMs) have played a critical role in the nation's defense strategy while helping to lay the foundation for the exploration of space.

America's interest in and experimentation with ICBMs actually dates back more than 50 years, to the dark days of World War II and the initial reports that the Germans had fired a "V-2" ballistic missile. Those V-2s were relatively inaccurate, with a range of 200 to 300 miles and a TNT warhead of approximately one ton. The Germans reportedly produced approximately 6,000 of the V-2s during 1944 and 1945, firing more than 3,500 of them against the Allies.

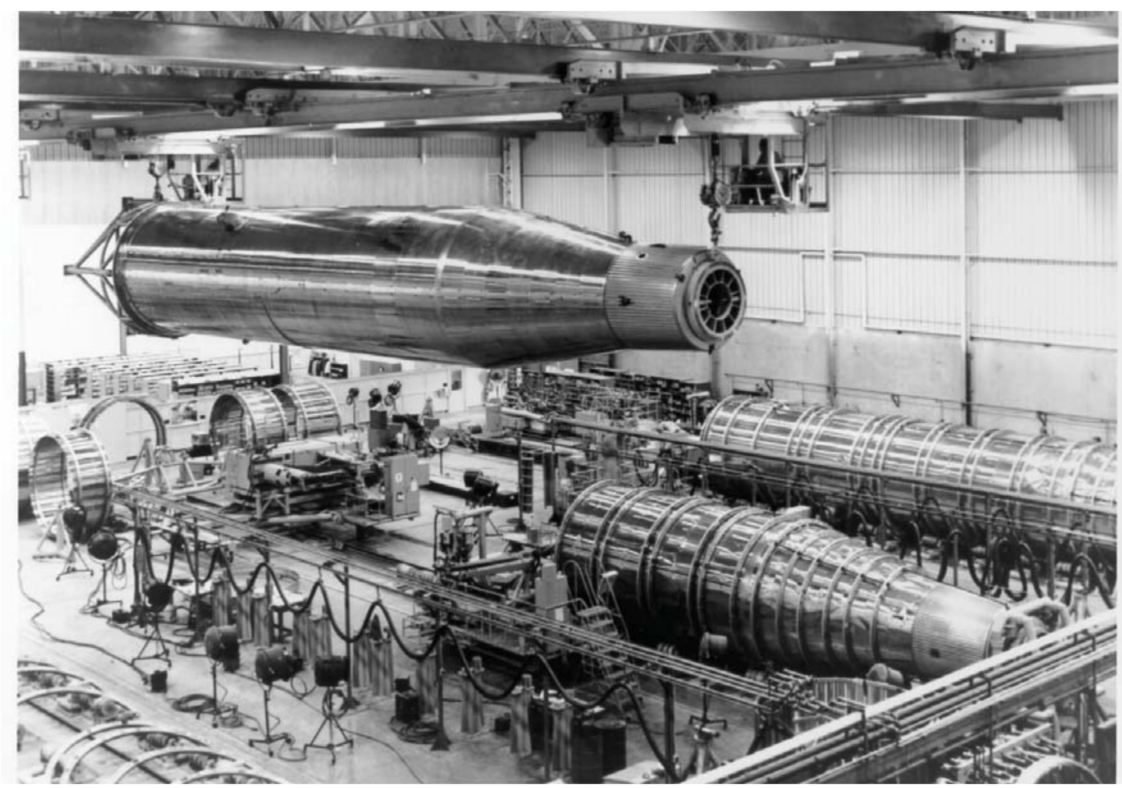
The end of the war was followed by significant levels of technical assessment involving captured V-2 (and V-1) hardware and technology. By early 1946, more than two dozen separate missile projects had been undertaken by the Army Air Force (AAF) focusing on the captured V-1s and V-2s.

April 1946 saw the start of project MX-774, designed to study rocket and missile capabilities that might be applied toward ICBM development. The MX-774 contract was with Consolidated-Vultee (later to become Convair/Convair Division of General Dynamics). Although the MX-774 project was cancelled in June 1947, contractor-funded work continued at a lower level, and three of the early test missiles were fired late in 1948.

By 1951, a new project, designated Project MX-1593, was evaluating the advantages of rockets versus glide missiles. Based in part on the earlier MX-774 work, the ballistic approach was selected for concentration in September of that year with the code name "Atlas" assigned to the newly re-focused effort.

ATLAS

Component development activities started in 1952, focusing on a 5,500-nautical-mile ICBM system that would be capable of carrying a nuclear payload. Early interest in accelerating the Atlas program helped stimulate the formal 1954 establishment of the Western Development Division (WDD) and assigning the new organization responsibility for the development program for Atlas (formally designated as Weapon System (WS)-107A-1).



Air Force Space Command photo

Opposite: The Bumper V-2 was the first missile launched at Cape Canaveral on July 24, 1950. America's initial interest in Intercontinental Ballistic Missiles (ICBMs) dates back to World War II and reports that the Germans had fired a "V-2" ballistic missile. Above: The General Dynamics Atlas assembly plant on Kearny Mesa near San Diego, Calif., is seen in this photo.

The Atlas measured approximately 70 feet in length and 10 feet in diameter. Prime contractor for the Strategic Missile (SM)-65 airframe was the Convair Division of General Dynamics, with the Rocketdyne Division of North American Aviation providing the three liquid-propellant engines (two booster engines and one sustainer engine).

Meanwhile, late in 1956, the Secretary of Defense directed that the Army transfer part of Camp Cooke, Calif., to the Air Force. The Army had operated the camp as a training facility from 1941 to 1945, and again during the Korean War. However, although the Atlas ICBM would be tested at Cape Canaveral, Brig. Gen. Bernard Schriever needed a facility closer to WDD. The first ICBM squadron was activated at Cooke Air Force Base in April 1958, with that facility subsequently renamed Vandenberg Air Force Base.

Prior to the operational arrival of America's initial ICBMs, America's strategic deterrent mission was performed by the Strategic Air Command (SAC). Built on the foundation of strategic air power demonstrated during the latter stages of World War II, SAC's bomber forces had compressed both the movement and application of decisive firepower from days to hours. The arrival of ICBMs would further compress that action timeline into minutes.

The ICBMs caused the conversion of SAC's formerly existing planning functions to mixed bomber and missile operations. To facilitate this conversion, the new ballistic missile force was integrated directly into existing SAC organizational concepts of divisions, wings, and squadrons.

While some of the integration was relatively straightforward – such as the establishment of SAC's 1st Missile Division at Cooke Air Force Base in 1958 – one early complicating factor involved the availability of missiles that had to be integrated into bomber operations. Examples of the latter category included the non-ballistic, air-breathing Snark as well as both GAM-63 and GAM-77 air-to-surface missiles.

While strategic organizational issues were being defined and refined, the Air Force used three developmental / test models of Atlas – Atlas A, Atlas B, and Atlas C – to help refine the program hardware. The first Atlas test flight, for example, took place in June 1957. Unfortunately, engine failure at 10,000 feet led to the destruction of that missile. Another Atlas engine shut down prematurely during a September test launch with that missile also destroyed. Finally, on Dec. 17, the third Atlas was successfully launched, with more successful limited range Atlas tests on Dec. 17, 1957; Jan. 10, 1958; Feb. 7, 1958; and Feb. 20, 1958.

Following the steep learning curves on the developmental models, the initial operational Atlas D was placed on alert at Vandenberg AFB on Oct. 31, 1959. The D model Atlas was stored horizontally but later E and F models were stored vertically in underground silos and raised by elevators for above-ground launch. Many of these later Atlas models would eventually be retrofit and used as space-launch vehicles, highlighting the direct contribution from early ICBM development to the U.S. exploration of space. Atlas D, for example, served as a launch vehicle for Project Mercury.

Photo courtesy of Dr. David N. Spires

THOR

In May 1955, WDD began evaluating industry proposals for an Intermediate Range Ballistic Missile (IRBM) in the tactical 1,000-nautical-mile category. Over the next year, IRBM #1 (Thor) would be assigned to the Air Force ballistic missile program, while IRBM #2 (Jupiter) would be designated as an Army development.

Designated as Weapon System (WS)-315A, the single-stage Thor missile measured approximately 65 feet in length and more than 8 feet in diameter. The SM-75 airframe was built by the Douglas Aircraft Company with North American Rocketdyne making the single engine. As with Atlas, the warhead section was made by General Electric. Together with the Army-developed Jupiter, Thor's IRBM classification (range of approximately 1,500 miles), limited Thor's role to overseas deployments.

TITAN

Formally designated as Weapon System (WS)-107A-2, the two-stage Titan I missile was approximately 90 feet

Opposite: A Titan I ICBM is raised from its silo at Vandenberg Air Force Base, Calif., in August 1961. Above: The first Minuteman III ICBM is placed in silo H-2 in 1970.

Air Force Space Command photo

in length and 10 feet in diameter. In spite of its larger size and two-stage design, Titan's range was approximately the same as Atlas – 5,500 nautical miles.

The Glenn L. Martin Company built the SM-68 airframe with the liquid propulsion system for both stages provided by Aerojet-General (then a part of General Tire and Rubber Company). Three contractors made the Titan's guidance system, with the warhead manufactured by AVCO Corporation.

Air Force representatives said that the overlapping Atlas/Titan I programs reflected Titan program origins as insurance against possible Atlas failures. Although both systems are generally considered to be first-generation ICBMs, Titan I was equipped with many of the technological refinements that were deliberately left out of Atlas in an effort to accelerate that system's deployment.

The USAF launched its first test Titan I on Feb. 6, 1959, and in April 1962, the first Strategic Air Command squadron of nine Titan I missiles was declared operational. As in the cases of Atlas E (deployed 1960 to 1966) and Atlas F (deployed 1961 to 1966), Titan I had to be lifted from the silos to the surface by elevator prior to launching. This configuration was reflected in the eventual change of the SM-68 missile designation to HGM-25A to signify its silo-stored, surface-attack, guided missile classification.

Eventually, squadrons of Titan Is were deployed at five different bases in the western United States. By 1965, however, Titan Is were being phased out in favor of the LGM (silo-launched, surface-attack, guided missile)- 25C Titan II, which offered greater range and payload and was launched from within its silo.

Just as the earlier Atlas design had been used in the Mercury program, modified Titan IIs also were used as launch vehicles in the Gemini space exploration program. Subsequent members of the Titan family were also grown into heavy-lift space boosters.

MINUTEMAN

On Feb. 27 and 28, 1958, even before the launch of the first Titan I, the Air Force received Department of Defense approval and authorized the development of its second-generation ICBM: the SM-80 / LGM-30A "Minuteman I." Formal development activities began in September, with the Boeing Airplane Company selected as the prime contractor in October.

At a length of 55.9 feet and diameter of approximately 6 feet (5.5 feet), the Minuteman I was smaller than either the Atlas or Titan series. But the most significant difference involved Minuteman's propulsion design. Unlike the first-generation ICBMs, the Minuteman design incorporated solid propellant rocket engines, allowing the system to be launched much more quickly than earlier liquid fuel designs. Due to its size and design, the Minuteman was optimized for maintenance in and launch from hardened underground silos where the missiles would remain protected from an enemy nuclear attack.

SAC's hardened dispersed launch facilities used for the Minuteman series normally covered two or three acres and were located several miles apart from each other. Each "flight" of 10 ICBMs was controlled from a Launch Control Center (LCC). Buried 50 feet below ground, the LCCs were designed as blast-resistant, shock-mounted capsules manned by two missile combat crew members. The missiles within each flight were situated in silos measuring approximately 90 feet deep and 12 feet in diameter, with two equipment rooms located approximately 30 feet below ground around the silo casing.

A Peacekeeper ICBM during a test launch at Vandenberg Air Force Base, Calif. The Peacekeeper missile is currently being phased out.

Photo courtesy of Dr. David N. Spires

Minuteman I became operational in 1962, with the first Minuteman missile on alert during the Cuban Missile Crisis of October. Initial operational capability (IOC) for Minuteman I was marked in December of that year with 20 missiles placed on operational alert. The first full squadron of Minuteman I missiles went on operational alert at Malmstrom Air Force Base, Mont., at the end of February 1963.

Minuteman I was actually installed in two sequential variants. The initial variant, Minuteman IA, reportedly featured a flaw in its first stage that reduced the Minuteman I's specified 6,300-nautical-mile range by more than 1,000 miles. However, rather than delay the introduction of this significant addition to the nation's deterrent capability, SAC allowed the installation of 150 of the "shorter range" Minuteman IAs at Malmstrom AFB. Subsequent missile deployments consisted of the Minuteman IB, with the first 150 IBs activated at Ellsworth Air Force Base, S.D., in 1963.

In 1965, SAC began to incorporate a further improved version of Minuteman, the LGM-30F Minuteman II, into its inventory. The Minuteman II looks very similar to its predecessors, utilizing the same first- and third-stage solid-propellant rockets. However, a slightly longer second stage provided Minuteman II with a length of 57.6 feet, which translated to more range than Minuteman I (8,300 nautical miles versus 6,300 for Minuteman I). Additional improvements included higher payload (the Mk 11C reentry vehicle versus Mk 11 A/B on the Minuteman I), the pre-storage of up to eight targets in guidance memory, and greater accuracy.

The first Minuteman II ICBM unit was activated at Grand Forks Air Force Base, N.D., in early February 1965. The new system became fully operational at Grand Forks in October of that year. Eventually, operational Minuteman I and Minuteman II ICBMs were dispersed across six Air Force sites in the Central and Northern Plains states.

In 1966, development started for another series of system improvements to Minuteman under the designation of LGM–30G Minuteman III. Production of the Minuteman III missiles began in 1968. At a length of 59.9 feet, the Minuteman III features an improved third stage with increased diameter to match the second stage and a new pointed arch shroud covering the warhead. The new third stage made it possible for Minuteman III to deliver a larger Mk 12 payload that includes three independently-targetable reentry vehicles and additional penetration aids to help counter anti-ballistic missile defenses.

The first Minuteman III missiles replaced Minuteman Is at Minot Air Force Base, N.D., in June 1970, with the first Minuteman III squadron reaching operational status by the end of the year.

PEACEKEEPER

Less than a decade later, development work began on another new generation of ICBMs designated as the LGM-118A Peacekeeper. Measuring approximately 71 feet in length and 7 feet, 8 inches in diameter, the four-stage missile was designed to carry up to 10 independently targetable Mk 21 reentry vehicles.

As originally envisioned at the start of full-scale development in 1979, the Peacekeeper program would include the deployment of 200 missiles in a "multiple protective structure basing mode." The multiple-basing mode, which was designed at the height of the Cold War as a way to achieve long-term ICBM survivability, placed the ICBMs in both fixed silos and in a mobile rail garrison configuration.

However, both program scope and basing modes were subsequently scaled back during the 1980s, being redesigned as a Minuteman silo-basing program. In January 1984, the Peacekeeper in Minuteman silo-basing program began the transition from full-scale development to production with the goal of 100 Peacekeepers in Minuteman silos.

In November 1985, however, the U.S. Congress reduced the number of Peacekeepers to be deployed in silos to no more than 50. Just over one year later, in December 1986, Initial Operational Capability of 10 Peacekeeper missiles in Minuteman silos was achieved at F.E. Warren Air Force Base, Wyo. Full Operational

Capability was declared in December 1988 with the turn over of 50 Peacekeeper missiles to SAC.

As the Cold War wound down at the beginning of the 1990s, the United States' land-based ICBM force consisted of 50 silo-based Peacekeeper missiles, with 10 warheads each (initially fielded in 1986), 450 Minuteman II missiles with one warhead each (initially fielded in 1965), and 500 Minuteman III missiles with three warheads each (initially fielded in 1970).

In addition to these standing protectors, other ICBM concepts had emerged and submerged during the Cold War. One concept called for the development and fielding of a one-warhead "small ICBM" system to augment the existing force. Another had resurfaced the rail-gun concept through a vision of improving Peacekeeper survivability by removing the missiles from silos and placing them on mobile platforms. Both programs, however, did not survive the Cold War that spawned them. Moreover, U.S. compliance with the Strategic Arms Reduction Treaties (START I and START II) led to further changes in U.S. ICBM force structure, including retirement of both Minuteman II and Peacekeeper missiles. Additional treaty-driven reductions dropped the number of warheads on the remaining Minuteman III missiles.

MODERNIZING FOR THE FUTURE

Clearly their job of deterrence is not over yet. As demonstrated by unfolding world affairs, the 21st century has proven to be an extremely dangerous era. The nation needs deterrent protection – perhaps now more than ever. And once again, planners are shifting their gaze to America's ICBM sentinels.

In recognition of their continuing contribution to national security, the Air Force has recently undertaken a "six-plus billion dollar" program to sustain and modernize its remaining Minuteman III fleet. The sequential modernization packages will update and enhance all aspects of the Minuteman III missile.

In addition, as these pages go to press, the Land Based Strategic Deterrent Analysis of Alternatives is looking at the possibilities of employing ICBMs in non-nuclear response scenarios, equipping the missiles with conventional warheads to provide the commander-in-chief with an immediate global response option in future scenarios.

One thing remains clear. After a half-century of service, America's ICBMs are still hard at work. It's no wonder that they're named for gods and heroes.

SIGNS FROM ABOVE

For Almost 60 Years, Air Force Satellite Programs Have Provided Insight from Space

By Eric Tegler

Today, satellites perform a range of functions unimagined by their earliest proponents. Weather forecasting, navigational aid, and international treaty verification are just a few of the satellite-enabled processes we take for granted. Though their tasks may differ, satellites share the same fundamental purpose – they provide and transmit information. By lifting our perspective hundreds of miles above the earth's surface, these largely invisible pieces of technology have provided the people and military of the United States with irreplaceable signs from above.

AN UNEARTHLY IDEA

While the notion of an object orbiting the earth by man's direction stretches as far back as the first balloon ascensions in the late 18th century, the first truly practical consideration given to operating satellites was made after World War II. In 1946, the Army Air Force's Project RAND report ("Preliminary Design of an Experimental World-Circling Spaceship") authoritatively affirmed the potential of satellites, stating, "A satellite vehicle with appropriate instrumentation can be expected to be one of the most potent scientific tools of the Twentieth Century."

Lockheed Martin photo

Interestingly, the RAND report calculated that the principal value of satellites would lie with their potential for science, politics, and propaganda. They would prove immensely useful in these areas, but eight years after the initial report, a more powerful motivation for their development came into force.

INTELLIGENCE DENIED

In the early 1950s, U.S. concern about Soviet expansionism and strategic power peaked with the knowledge that the U.S.S.R. had tested its first hydrogen bomb, had initiated operations of the Bison bomber, and was actively developing ballistic missiles. Simultaneously, the Soviets became increasingly secretive about their capabilities, rejecting a 1955 initiative to exchange aerial photographs of missile sites and other military infrastructure.

Denied access to Soviet airspace, President Eisenhower authorized an intelligence-gathering program called GENETRIX in which camera-carrying balloons drifted across the U.S.S.R. at altitudes of up to 90,000 feet photographing areas of interest. Flights began in January 1956 but were suspended in February 1956 following strong Soviet objection.

As the strategic balance between the United States and U.S.S.R. was changing, the RAND Corporation in March 1954 issued Report R-262, which called for the development of a satellite surveillance program. Following its recommendations and those of its own ICBM Scientific Advisory Group, the Air Force issued Weapon System Requirements No. 5 (WS-117L) to develop a reconnaissance satellite program. WS-117L would proceed under the direction of the Air Force's Western Development Division (WDD) at a conventional pace for two years but would swiftly accelerate.

The U.S.S.R. had made bold steps with the 1957 launch of an intercontinental ballistic missile and the placement of the first satellite (Sputnik) into orbit in October of that year. Meanwhile, the United States had attempted five high profile missile tests without a single success. The expression "missile gap" became part of the American vernacular and anxiety over Soviet strategic superiority soared.

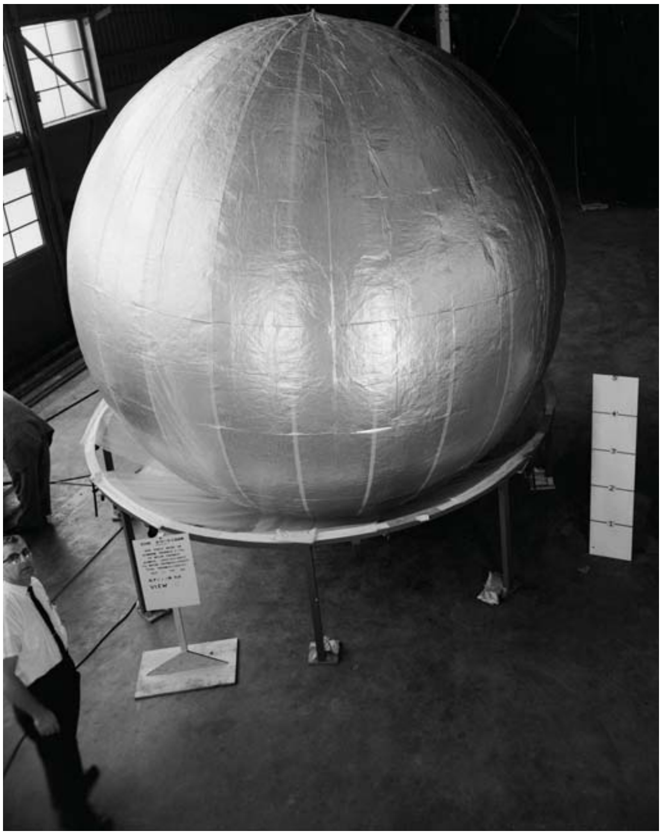
Though GENETRIX had ceased, U.S. intelligence gathering had resumed in July of 1956 with the start of U-2 reconnaissance flights. These continued sparingly until May 1, 1960, when Capt. Gary Powers was shot down during a flight from Pakistan to Norway. The United States was "blind" again. Against this backdrop, Defense Secretary Neil H. McElroy pushed for the acceleration of WS-117L as satellites became the only alternative for collecting intelligence over denied geography.

THE FIRST TASK – RECONNAISSANCE

By 1959, WS-117L had evolved into a family of programs that could carry out different missions including reconnaissance and missile warning. The

Photo courtesy of Dr. David N. Spires

Opposite: An artist's conception of a weather-observation satellite planned by Lockheed Martin for the Defense Meteorological Satellite Program (DMSP). Above: President Dwight D. Eisenhower, third from the left, and Gen. Thomas D. White, Air Force chief of staff, center, view the Discoverer XIII capsule at the White House. The capsule was the first object to be recovered from space.



Above: A 12-foot inflatable ECHO Project satellite is seen here. The passive-style satellite reflected messages sent to and from ground terminal equipment. Opposite: The Horn reflector antenna at Bell Telephone Laboratories in Holmdel, N.J., was built in 1959 for work with NASA's ECHO I communications satellite. The antenna structure, 50 feet in length and weighing about 18 tons, was used to detect radio waves that bounced off ECHO Project balloon satellites.

However, it continued secretly as CORONA until 1972. It provided the first photos of Soviet missile-launch complexes, identified the Plesetsk Missile Test Range north of Moscow, and yielded continued information on Soviet missile development.

The second system to spring from WS-117L was the SAMOS program. SAMOS satellites were heavier and designed to provide greater image detail using film and radio transmissions. The first SAMOS launch in October 1960 failed after a second-stage malfunction. SAMOS II successfully reached orbit in January 1961. Eight more SAMOS launches were attempted through August 1962, several of which encountered technical problems.

EARLY WARNING

The third derivative of WS-117L was to provide early warning (EW) by means of satellites capable of carrying infrared sensors to detect hostile ICBM launches. The satellites would work in conjunction with ground stations known collectively as the Missile Defense Alarm System, or MiDAS.

The first MiDAS satellite was launched in February 1960 but failed to achieve orbit. MiDAS II took off in May 1960 but suffered telemetry failure. MiDAS III reached orbit in July 1961 and gave scientists their first concrete test data. Like Discoverer/CORONA, the MiDAS program went "black" in 1962.

A second group of infrared EW satellites, known as Program 461, was launched in 1966. Equipped with more powerful infrared sensors capable of detecting solid propellant missiles, these satellites proved more successful than their predecessors. However, more than a dozen were required in orbit for complete EW coverage, and DoD cancelled the program, citing costs.

In the same year a proposal was made to use satellites in geosynchronous orbit. With larger sensors to compensate for their higher orbit, a few such satellites could effectively detect launches. The Air Force chose TRW and Aerojet to build the new satellites, and subsequently renamed the project the Defense Support Program, or DSP. The first DSP satellite took flight in 1971, and some 15 to 17 were launched through the early 1990s.

Improved DSP satellites demonstrated the ability to detect other heat sources, including military aircraft, surface-to-air missiles, nuclear reactor activity, and forest fires. (Six pairs of Vela satellites were placed in orbit between 1963 and 1970 to verify compliance with the 1963 Nuclear Test Ban Treaty.) DSP sensing proved particularly useful during the first Gulf War and encouraged the Air Force to embark on a new program using high-

first USAF reconnaissance satellite to fly would be a film-return satellite called Discoverer. The Air Force publicly presented the system as a scientific satellite project, but in reality it was a pure reconnaissance system known to only a few by the classified name CORONA.

Discoverer I first flew on Feb. 28, 1959. Though it carried no reconnaissance payload, the Lockheed-built satellite established orbit and was declared a success. Discoverer II, launched in April, became the first satellite to be stabilized in three axes, to be maneuvered on command, and to send its reentry vehicle back to Earth. Despite this success, the next 10 Discoverer satellites failed due to problems ranging from inadequate boost to improper reentry. Discoverer XV was the first truly successful reconnaissance satellite, returning images of the U.S.S.R. to U.S. intelligence in August 1960.

Publicly, the Discoverer program ended with the launch of Discoverer XXXVII in February 1962.

NASA Langley Research Center

and low-orbit satellites known as the Space-Based Infrared System (SBIRS).

SBIRS-High satellites are three-axis stabilized with improved sensors capable of continuously monitoring targets. SBIRS-Low satellites operate in low orbit, tracking missile trajectories with great accuracy. Presumably, SBIRS would be a key element of the U.S. missile defense anti-missile shield.

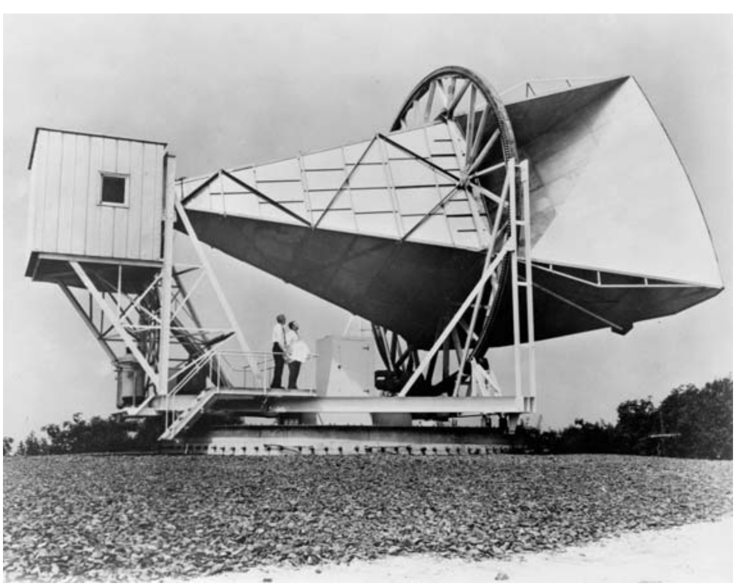
COMMUNICATION

The first Air Force communication satellite was launched under Project SCORE (Signal Communication by Orbiting Relay Equipment) in December 1958. SCORE had two primary aims; to demonstrate the ATLAS missile as a booster and the functionality of a communications repeater in a missile.

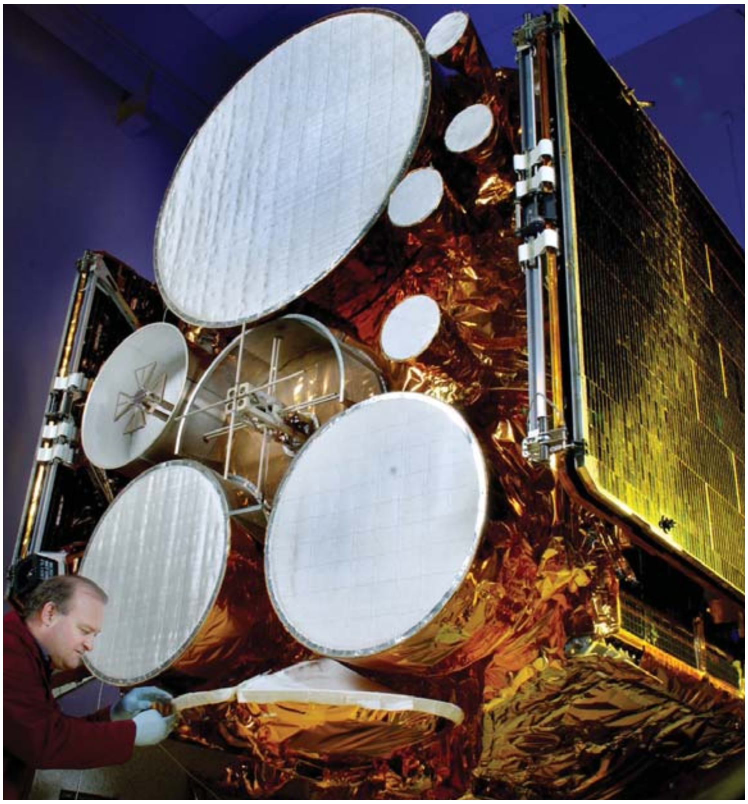
SCORE was followed by the Courier program, the chief objective of which was to develop a higher-capacity, longer-life relay satellite for testing. Unlike SCORE, Courier was a self-contained satellite. The first Courier launch (fall, 1960) suffered a booster failure, but the second was successful, facilitating testing with ground stations in New Jersey and Puerto Rico. At about the same time, ECHO I was launched. Developed at the Rome Air Development Center, ECHO I was a passive-style satellite, which reflected messages sent from and to ground terminal equipment.

While Courier went forward, the Advanced Research Projects Agency undertook a program called Advent. Courier was an experimental satellite, but Advent was to be a truly operational one. However, the project was too ambitious for the technology then available and was cancelled in 1962. Another experimental project called West Ford sought to develop a secure, survivable passive satellite using reflective copper wires. Launched in 1963, it successfully relayed voice and data but at such low capacity that it was discontinued.

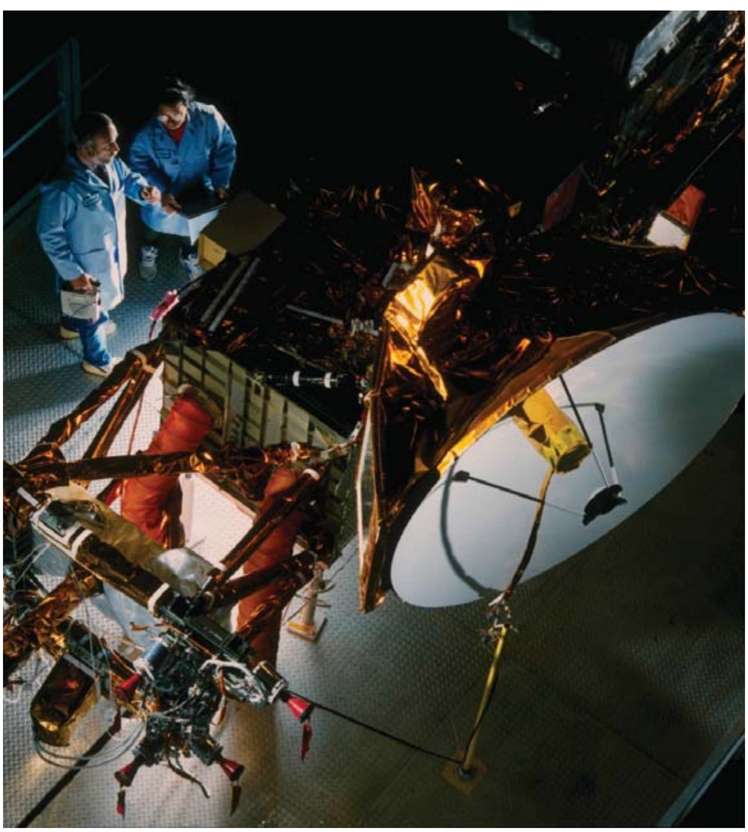
A further six experimental satellites were launched between 1965 and 1968 for the Lincoln Laboratory, which used them to perfect operations with small, fixed, and mobile ground terminals. Dubbed the LES series, the project continued through 1971.



NASA photo



Lockheed Martin Missiles & Space photo by Russ Underwood



Lockheed Martin photo

After the cancellation of Advent, a new operational communications satellite effort called the Initial Defense Communications Satellite Program (IDCSP) was launched. IDCSP consisted of small, simple repeater satellites launched in clusters. Some 28 were placed in orbit in four launches from June 1966 to June 1968. They provided strategic communications for DoD until the more sophisticated Defense Satellite Communications System (DSCS II) was fielded. Another experimental project called Tacsat simultaneously explored operations with small, mobile, land, airborne and shipborne tactical terminals.

DSCS II satellites were larger and offered greater capacity than their predecessors. They had longer operational life and were positionable by ground command. The first pair of DSCS II satellites reached orbit in November 1973, and by 1979 a full network of four DSCS IIs was in place. Sixteen DSCS II satellites were built, and the last was launched in 1989.

Planning for Phase III DSCS began in 1973. DSCS III satellites offered better jamming resistance and still more communications capacity. The first DSCS III satellite was launched in October 1982, and the five-satellite network was completed in July 1993.

The experimental trials with the LES series and Tacsat paved the way for the Fleet Satellite Communications System (FLTSATCOM), the first operational system serving tactical users. Managed by the Navy, FLTSATCOM came online in the late 1970s and would serve as a platform for another user group – nuclear capable forces. Their needs and those of the Air Force would be served by the Air Force Satellite Communications System (AFSATCOM). The system relied on transponders placed on FLTSATCOM and other DoD satellites. AFSATCOM attained full operational capability in May 1979.

The latest communication satellite system goes by the name MILSTAR. Designed for robustness and flexibility, MILSTAR satellites provide highly jam-resistant communications for the National Command Authority and tactical and strategic forces. The program was inaugurated in 1982, and the first MILSTAR satellite took off in 1994. Block I

MILSTAR satellites carry low-data-rate payloads, but Block II MILSTARs, first successfully launched in 2001, can accommodate medium-data-rate communications as well.

NAVIGATION

Experimental use of satellites for navigation has its origins in a Johns Hopkins Applied Physics Laboratory project to develop a system that would allow Polaris submarines to accurately track their locations. The system that emerged, called TRANSIT, began operating in 1964 with a constellation of five satellites. TRANSIT enabled submarines to establish their position to within 25 meters.

In the late 1960s, the Air Force and Navy were developing satellite navigation systems in parallel. The Naval Research Laboratory proposed a system called TIMATION which used precision clocks in a network of 21 to 27 satellites in medium-altitude orbits. The Air Force's Space and Missile Systems Organization developed its own 621B program. The 621B proposal envisioned a constellation of 20 satellites in synchronous inclined orbits. The system could provide altitude as well as latitude and longitude data.

DoD directed the services to merge their programs in 1973 into a new effort called the Global Positioning System/NAVSTAR (GPS/NAVSTAR). GPS/NAVSTAR combined the best elements of TRANSIT, TIMATION and 621B, and was deployed in three phases. The first Block I satellite blasted off in February 1978, and the system attained full operational capability in April 1995. Further launches have maintained the GPS network at about 25 satellites, which provide invaluable support for navigation, instrument landings, targeting, rescue missions, rendezvous, mine operations, and a host of other applications.

Lockheed Martin Missiles & Space photo by Russ Underwood

Opposite, top: A Defense Communication Satellite undergoes work in a Lockheed Martin test cell in Sunnyvale, Calif. Opposite, bottom: A MILSTAR satellite is seen during its cleanroom production phase in this 1994 photo. Above: A Lockheed Martin employee works on Global Positioning Satellite SV11.

WEATHER

Military planners have for generations recognized the value of accurate weather information. As communication, reconnaissance, and early-warning satellite programs began in the 1960s, DoD directed the Air Force's Space Systems Division to initiate a satellite weather-observation system that eventually became the Defense Meteorological Satellite Program (DMSP).

The first weather satellite launches occurred in the early 1960s. Early satellites were 90-pound, spin-stabilized craft equipped with TV cameras. The photos they obtained were relayed to ground stations at retired Nike missile sites in Washington and Maine. They were then passed to Air Force Global Weather Central at Offutt AFB, where meteorologists would assimilate them to provide commanders and flight crews with observations and forecasts.

Weather-sensing technology evolved significantly through the 1970s and 1980s by which time over 30 DMSP satellites had been launched. The operational system was comprised of two or more weather satellites in medium-altitude polar orbits. In 1998, control of DMSP satellites was transferred to the National Oceanic and Atmospheric Administration, which combined them with its own weather satellites to form a single

A Lockheed Martin Defense Meteorological Satellite is seen atop a Titan II launch vehicle at Vandenberg Air Force Base, Calif.

Lockheed Martin Missiles & Space photo by Russ Underwood

system referred to as the National Polar-orbiting Operational Environmental Satellite System (NPOESS).

GETTING THERE: BOOSTERS & UPPER STAGES

Getting satellites to the right orbit and positioning them properly proved nearly as challenging as developing their remote sensing capabilities. When serious satellite programs got under way in the late 1950s, there was but one type of platform capable of taking them to space – the ballistic missile.

Three different types were under development at the time, including the Thor Intermediate Range Ballistic Missile (IRBM), the Atlas Intercontinental Ballistic Missile (ICBM), and the Titan ICBM. For the next 45 years, these systems would be the main booster types to propel satellites out of our atmosphere.

Thor IRBMs were the first platforms, powering the early Discoverer satellites through the atmosphere. Produced by the Douglas Aircraft Company, the first Thor IRBM was delivered to the Air Force in October 1956. The first Thor/Discoverer launch fired off from Vandenberg AFB in January 1959. Thor boosters lifted most of the early KH series reconnaissance systems as well as a number of NASA and many civilian communications satellites into orbit in the 1960s.

The Atlas ICBM, designed and built by Convair, first flew in December 1957. Designed as a longer-range, single-stage missile, Atlas extended America's nuclear reach well inside the U.S.S.R. A year after its first launch, an Atlas booster rocketed the first SCORE communications satellite into orbit. Heavier MiDAS and SAMOS satellites relied on Atlas boosters, as did later KH series satellites and other low-orbit payloads. In total, some 523 Atlas boosters were launched, most successfully propelling their payloads to space.

The two-stage Titan ICBM was developed by the Martin Company as a heavier payload missile to supplement the Atlas. The Air Force took delivery of the first Titan I in June 1958 and launched it successfully in May 1959. The upgraded Titan II first launched in March 1962, and more than 140 such Titans were eventually built, becoming the USAF's most prolific booster vehicle. A wide variety of Air Force satellites relied on Titan variants to achieve medium/high orbit, from the first IDCSP satellites to the latest MILSTAR communications satellites.

Despite their obvious power, converted IRBMs and ICBMs shared a common problem as boosters. They were initially designed to deliver their payloads to the Earth's surface rather than into orbit. Upper-stage spacecraft had to be designed to kick satellites into orbit at the apogee of the booster flight and to orient the satellite payload once in orbit. The most widely used was the Lockheed RM-81 Agena.

Built around the Bell XLR81 liquid propellant rocket engine, the Agena was initially known as the Hustler, since the XLR81 was designed for use in a rocket-powered weapons pod for the B-58 Hustler bomber. The first Thor-Agena launch in January 1959 was a failure, but the spacecraft would go on to become the heart of Discoverer and many other Air Force satellite systems. As flown on a Discoverer mission, Agena was made up of a three-axis gyro guidance and control system, a battery-powered electrical system, a telemetry command and tracking system, a thermally protected reentry capsule, a parachute, and the 16,000-pound-thrust Bell rocket. The payload housed a 70-degree panoramic Eastman Kodak Itek camera.

Subsequent Agena craft offered re-fireable engines with increased fuel for extensive orbital maneuvers, more thrust, and larger payload capacity. Some 365 Agena craft were launched into space by the Air Force and NASA between 1959 and 1987.

SIGNS – PAST & FUTURE

Prior to the formation of Air Force Space Command (AFSPC) in September 1982, the development, operation, and control of Air Force satellites was divided among a number of agencies, from the Air Force Systems Command to the National Reconnaissance Office to Strategic Air Command. Today, the spectrum of military satellite programs function under the direction of AFSPC, including: GPS/NAVSTAR, DSCS Phase III, DSP, FLTSATCOM, and MILSTAR. AFSPC also provided backup command and control for NATO IV and Skynet IV systems.

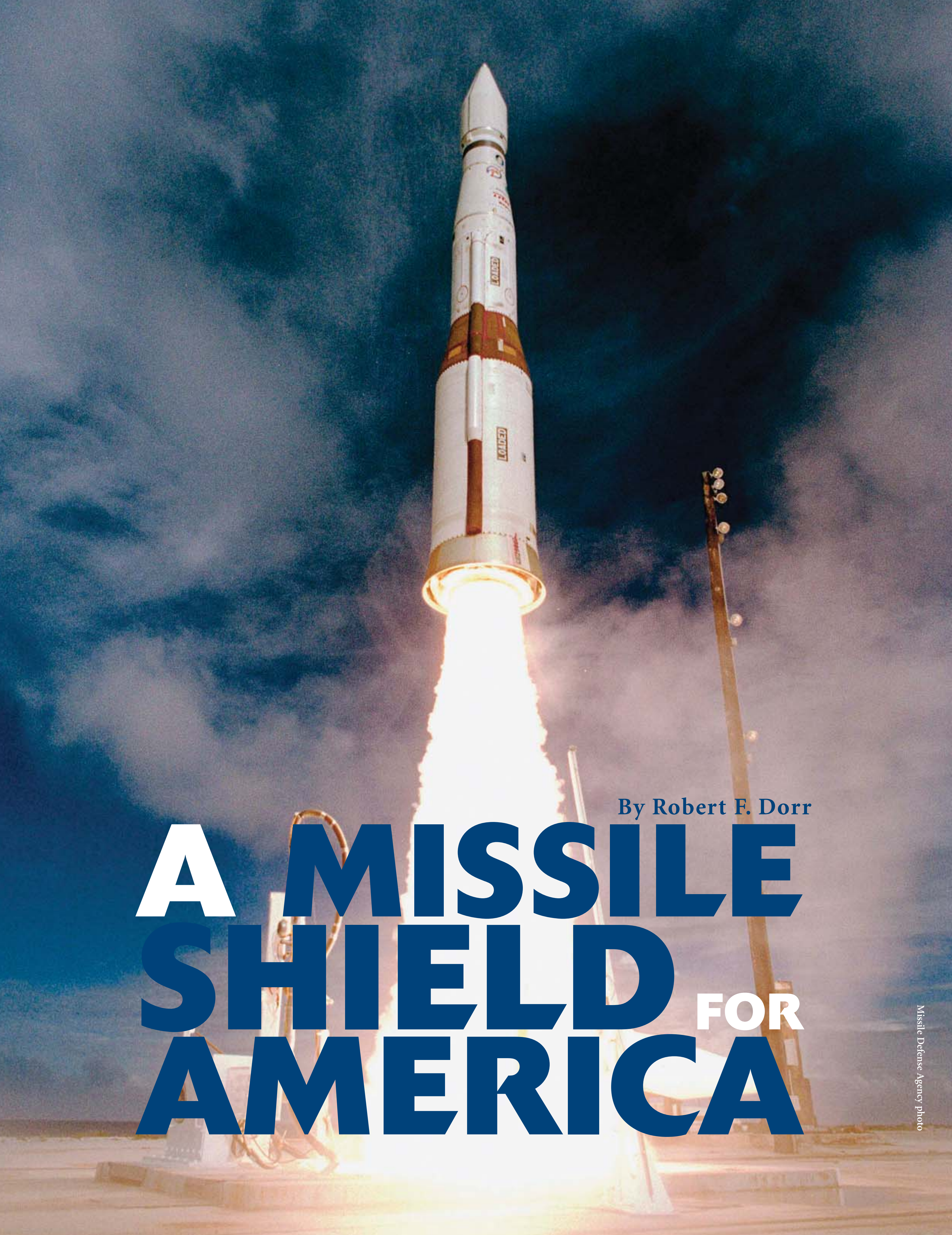
Reconnaissance satellites were the first to have a major impact on national security, offering DoD strategic planners insight into military activities behind the Iron Curtain and elsewhere. Early Warning satellites provided SAC with additional response time during the Cold War, helping prevent misunderstandings and significantly contributing to mutual deterrence. Early communications satellites facilitated better strategic communication during the Vietnam War, and meteorological satellites provided tactical planners with better weather forecasts and observations.

It was not until Operation Desert Storm that Air Force satellites truly altered the global strategic and tactical environment. With the remote sensing its satellites provided, AFSPC could effectively, intimately support the warfighter with timely information from communications to navigation to environmental sensing. Operations Enduring Freedom and Iraqi Freedom have further highlighted the value of Air Force Space Command satellites in providing comprehensive battlefield awareness and clues to successfully prosecute the war on terror.

Military and technology affairs observers predict that in the near future, rapidly proliferating commercial satellite systems will be assigned many of the tasks traditionally performed by military satellites as the government seeks to reduce costs and to leverage accelerating commercial technology. The approval of Presidential Decision Directive 23 has opened a path for a number of U.S. corporate satellite ventures, which will see AFSPC working more closely with the private sector.

By Robert F. Dorr

A MISSILE SHIELD FOR AMERICA



Missile Defense Agency photo

Long before the nation became vulnerable to ballistic missile attack, Americans began searching for ways to protect the American heartland. The search continues today with efforts to detect, identify, and track incoming ballistic missiles, but its eventual goal is a shield that will protect our cities, bases, and strategic missile forces. When this volume went to press, a limited shield was ready for initial operations, the latest development in the long history of radar, missiles, and missile defense. During the years it took to get that far, the threat was viewed with nothing less than dread.

Before an Intercontinental Ballistic Missile sat in a silo anywhere on the planet, the threat was portrayed graphically on a 1954 cover of an industry magazine in a painting that depicted an ICBM as a silvery, speeding bullet, difficult to detect and impossible to stop. The Soviet Union's unexpected Oct. 4, 1957, launch of the world's first man-made satellite, Sputnik I, used the same booster technology that could send such a speeding bullet over the North Pole toward American cities with a nuclear warhead. Sputnik shocked Americans and prompted President Dwight D. Eisenhower to order new measures, including steps to detect and defend against attack.

The Soviet Union was developing long-range missiles. The Soviet Strategic Rocket Forces, an independent military service branch, were fielding and testing ICBMs that could come down on American cities within an hour of their launch. The Russian Strategic Rocket Forces still exist today, and the United States still has no defense against ICBMs, nor is any being planned, but Air Force Space Command is very much in the business of detecting missiles. The nation has now fielded the beginnings of a partial shield against missiles in the hands of renegades, rogues, or bad-state actors like North Korea.

None of this would be possible but for radar.

MAKING RADAR WAVES

As far back as 1904, a primitive radar had been demonstrated by a German Engineer named Christian Hulsmeyer.

Just after World War I, in 1922, experts at the Aircraft Radio Laboratory at Anacostia in Washington, D.C., were experimenting with high-frequency radio transmission. A. Hoyt Taylor and Leo C. Young were trying to transmit between their radio station and a receiver located across the Anacostia River at Haines Point. At one point during the test, a passing river steamer interrupted their signal. This suggested to Taylor that radio waves might be used to detect the passage of a ship during a heavy fog or in the dark of night.

Taylor submitted a report on "radio-echo signals from moving objects" in November 1930 to the Navy's Bureau of Engineering, Navy Department. In January 1931, the Bureau assigned the Naval Research Laboratory the problem of investigating – secretly – the use of radio to detect the presence of enemy vessels and aircraft.

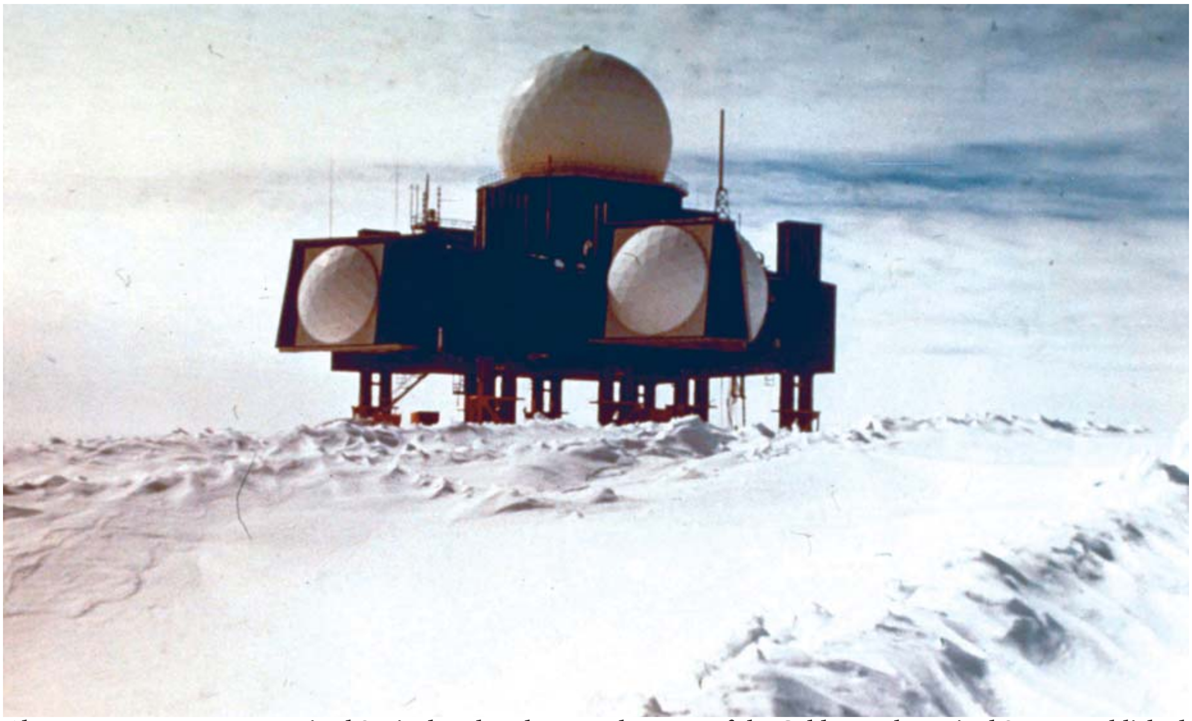
By 1934, Germany, Italy, the Soviet Union, Great Britain, in fact all of the major powers, were also working on primitive radar systems. In the same year, Taylor devised a way to send radio energy toward a suspected target in short bursts, or pulses. In 1936, Taylor demonstrated that this method could detect an aircraft 25 miles away. It was named RAdio Detection And Ranging, or RADAR. As the first operational units were developed on the eve of World War II, the term ceased being used as an acronym and took its place as a dictionary word.

In Britain in 1934, Robert Page developed a pulse radar for the detection of aircraft. The following year, Scottish scientist Dr. Robert Watson-Watt produced a report, "The Detection of Aircraft by Radio Methods." In February 1935, Watson-Watt took part in a successful trial in Britain in which short-wave radio was used to detect a bomber. In 1936, a U.S. Army Signal Corps laboratory at Fort Monmouth, N.J., began its own radar project.

By the time German bombers were attacking during the Battle of Britain in 1940, the British had a chain of

Opposite: An interceptor missile is launched from the Army's Kwajalein Missile Range in the central Pacific Ocean during a July 2000 test intercept. Above: This ground-level view of the Clear Air Force Station, Alaska, Ballistic Missile Early Warning System (BMEWS) site shows a radar fan, at left, and a tracking radar radome. The detection radars provide 30 minutes warning of an ICBM attack, while tracking radars enable operators to track most orbiting satellites.

Air Force Space Command photo



Above: In response to a perceived Soviet bomber threat at the onset of the Cold War, the United States established a Distant Early Warning (DEW) line of radar stations running across the polar region from Greenland to Alaska. Seen here is a DEW line radar station in Greenland. Opposite: An anti-ballistic missile (ABM) perimeter acquisition radar (PAR) that was used as part of the short-lived Safeguard program. Pursued for only a few months in the mid-1970s, the Safeguard missile-intercept program sought to protect the United States' stockpile of intercontinental ballistic missiles.

radar stations covering the southeast of England. Radar was a tool to the embattled Spitfire and Hurricane pilots of Royal Air Force Fighter Command, who defeated the Luftwaffe in history's first air-to-air military campaign. As the war progressed, all nations had radar, but it was of little use when Nazi Germany hurled ballistic missiles at the British Isles in 1944 and 1945. There was no practical way to detect an incoming V-2 rocket and no defense against it.

When victory in World War II gave way to the tensions of the Cold War, the United States was all too willing to invest hundreds of billions of dollars to defend itself. All along, some experts saw the V-2 rocket as an omen, but the focus was a perceived bomber threat. Experts in the West overestimated the Soviet bomber force and underestimated the willingness of the Soviets to leapfrog past the manned bomber to the missile. Even during the Korean War, from 1950 to 1953, the Pentagon spent more on defense against bombers than on fighting in Korea. The building of Thule Air Base, Greenland, begun in 1952, was one of the most ambitious construction projects ever undertaken, and the primary reason was to support a Distant Early Warning line – a DEW line – of radar stations running across the polar region from Greenland to Alaska.

The DEW Line began operations in February 1954. Radar stations dotted the tundra of northern Greenland, Canada, and Alaska, each providing overlapping coverage to detect approaching aircraft. Logistics experts brought tons of equipment to the Arctic and constructed no fewer than 58 DEW Line sites in just over two years.

It began with an experimental radar site.

In 1958, a handful of U.S. scientists, specialists, and military men went to Trinidad in the British West Indies to begin tests of a prototype for the nation's first missile-detection radar. The Ballistic Missile Early Warning System (BMEWS) Trinidad site was used to gather data on friendly missiles fired over the Atlantic, as well as an occasional meteor, but its purpose was to prove out a concept for detecting hostile missiles – a significant step toward creating a missile shield for North America.

The then Air Force Chief of Staff, Gen. Thomas D. White, is usually credited with coining the term "aerospace," a word that has been in and out of favor since the 1950s as the Air Force has continuously redefined its space, and space defense, mission. By 1959, the Air Force had officially taken responsibility for the space arena and the word "aerospace" had become part of its official vocabulary.

Photo courtesy of Dr. David N. Spires

That year, the Air Defense Command, already responsible for protecting the nation against bomber attack, assumed the ballistic missile warning mission. Also that year, the chief of naval operations, Adm. Arleigh Burke, suggested that the Pentagon create a unified space command, responsible for all space assets and missions. The Army liked the idea. The Air Force resisted. The services continued to compete for space missions, although the Air Force now held the missile-warning job firmly in its hands.

In 1963, after Soviet cosmonauts and American astronauts had been in orbit and both sides possessed operational ICBMs, the Air Force began work on the world's first phased-array radar. Work progressed at Eglin Air Force Base, Fla., on the AN/FPS-85, a powerful space track system intended to provide tracking data on thousands of space objects per day. Plans to make the system operational in 1965 were foiled by technical glitches and a major fire, but the system did achieve initial operating capability in 1969.

Becoming embroiled in Vietnam, the United States never took its eye off the Soviet Union. In the 1960s, both sides fielded not only ICBMs, but also submarine-launched ballistic missiles, or SLBMs. A submarine operating close to American shores could reduce the warning time available to U.S. defenders to 20 minutes or less. To provide timely warning against Soviet SLBMs, the Air Force began work on an interim SLBM-detection network consisting of several AN/FSS-7 radars located on the Atlantic, Pacific, and Gulf coasts. The network, eventually controlled by the 4783rd Surveillance Squadron of the 14th Aerospace Force, was fully operational by May 1972. By July 1975, the AN/FPS-85 radar at Eglin AFB had been reprogrammed to provide additional SLBM detection and warning capability along with its original spacetrack mission.

While the Air Force honed its ability to detect, identify, and track missiles, the nation put into operation its first attempt at a shield against missile attack – run by the Army. The Nike Zeus series of missiles and an aborted project called BAMBI, or the Ballistic Missile Boost Intercept system, evolved into the LIM-49A Spartan and FLA-38 Sprint ground-launched anti-ballistic missiles, each armed with a 20-kiloton W-66 thermonuclear, neutron-flux warhead. The Spartan and Sprint weapons entered service as part of the Safeguard program (initially named Sentinel) at Grand Forks, N.D.

Believing that the United States could not stop an all-out attack by the Soviet Strategic Rocket Forces, the Lyndon B. Johnson administration decided to proceed with a thin anti-ballistic umbrella to protect major U.S. cities. When Defense Secretary Robert McNamara announced the plan in September 1967, he made two points that have regained currency today: (1) deploying a comprehensive anti-missile system might exacerbate the offensive missile race, and (2) the nation needed enough of an umbrella to counter very limited threats such as that posed by the small Chinese ICBM force.

In 1972, the United States and the Soviet Union signed the ABM Treaty, which limited both sides to two anti-ballistic missile interceptor sites. A 1974 protocol reduced the two sites to one each and to 100 interceptors.

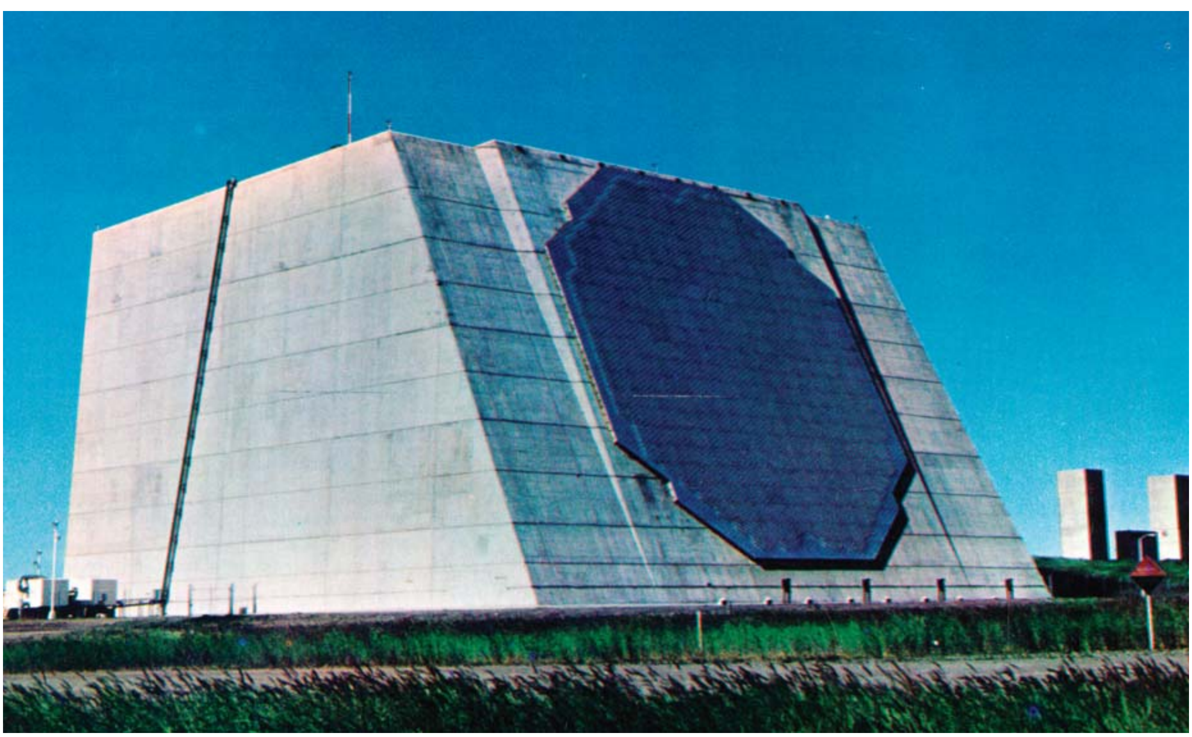


Photo courtesy of Dr. David N. Spires

The Soviets elected to defend Moscow with their nuclear-tipped Galosh system while the United States opted to defend the Minuteman missile fields in the northern tier of the nation. Safeguard became operational on Oct. 1, 1975, with 30 Spartans and 70 Sprints. Some called the system a partial "shield," but it was flawed. For one thing, its radars would have been blinded by the electromagnetic pulse from exploding nuclear warheads on the Safeguard interceptors.

Primarily because of cost, Congress immediately ordered the program shut down, and Safeguard went out of the business of shielding America in 1976. Except for radars associated with the system, Safeguard was fully operational for only a few months. The process of shutting it down was completed in 1978. The Soviet Union retained its system and has updated the Gazelle anti-ballistic missiles in place today.

By then, the Air Force had been at work for several years on an improved, phased-array radar known as Pave Paws, or AN/FPS-115. Capable of detecting missiles at greater distances and of identifying and tracking them more accurately, Pave Paws began operations at Otis Air National Guard Base, Mass., in April 1980. In due course, Pave Paws sites operated at four installations in the United States.

FORMING SPACE COMMAND

Air Force Space Command was created Sept. 1, 1982. It resulted from a major restructuring of the oversight of all space surveillance and missile warning assets, until then operated separately by Air Defense Command and Strategic Air Command. Although his predecessor Gen. James Hill and others played a significant part, Gen. James V. Hartinger is credited with the vision of a service headquarters that would operate on a par with Strategic Air Command, Tactical Air Command, and Military Airlift Command.

As soon as it was activated, Air Force Space Command began to grow. In 1983, the command assumed responsibility for a worldwide network of more than 25 space surveillance and missile warning sensors. Among the radar sites passed to Space Command were the AN/FPS-17 and AN/FPS-79 detection and tracking radars at Pirinclik, Turkey. This site had been in operation since 1955, gathering intelligence on Soviet missile launches.

On March 23, 1983, President Ronald Reagan spoke of countering the Soviet missile threat by developing defenses that would make "nuclear weapons impotent and obsolete." The Air Force was involved mostly on the periphery of the Strategic Defense Initiative, or Star Wars, which cost $100 billion over the next decade and contributed mightily to scientific knowledge, but never provided a missile shield.

The command also took over the long-operating Cobra Dane radar on Shemya in the Aleutian Islands. The site had been created, largely in secret, to track Soviet missile tests impacting on the Kamchatka Peninsula. The site's advanced AN/FPS-108 phased-array radar replaced two earlier radar systems similar to those at Pirinclik. As the decade progressed, the command added other space tracking radars to its now-worldwide network.

In 1991, Iraq used the Scud theater ballistic missile against U.S. forces and its allies in the Persian Gulf. They produced the first American combat casualties ever caused by ballistic missiles. That year, under President George H. W. Bush, the nation adopted a strategy of developing a defense against limited missile strikes – more than the theater defense mounted in the Persian Gulf but less than a strategic effort. Numerous changes in the missile bureaucracy and in terminology occurred under President Bill Clinton and President George W. Bush, while the target date for a limited missile defense, operated by the Missile Defense Agency and manned by Army National Guard personnel, kept slipping. The threat of tactical ballistic missiles was soon reinforced by the threat of intercontinental weapons in the hands of rogue states, principally the Taepo Dong 2 ICBM fielded by North Korea, which in 2004 acknowledged having nuclear weapons.

The nation's ICBM forces were merged into Air Force Space Command in 1993. They revert to U.S. Strategic Command in wartime.

The command took over the former Naval Space Surveillance System, also known as "the Fence," the nation's oldest sensor built to track satellites and debris in orbit around the Earth, during ceremonies at Dahlgren, Va., on Oct. 1, 2004. The transfer of Fence operations to the Air Force brings an end to more than 40 years of Navy control of the sensor. Lt. Col. James Hogan, 20th Space Control Squadron commander, who now operates the Fence, gave credit to the Navy for a long period of tradition: "For 43 years, Navy has stood watch over space with the Fence and has one of the first seats at the table of space surveillance," Hogan said.

MISSILE DEFENSE – AGAIN

In 2004, the nation was preparing to field its latest space shield, under an arrangement that seemingly placed operational readiness ahead of testing. Pentagon officials said they would be unable to complete an overdue flight test of critical elements of the anti-missile system before activating the system in October 2004. The decision delayed a key design review for the Missile Defense Agency's Multiple Kill Vehicles program by about four months. The Pentagon said that more work, including unspecified "additional risk reduction on critical kill vehicle subsystems," was needed.

The delay meant the system would be deployed without a flight test having been carried out for two years. After several successful intercepts in 2001, the system failed to intercept a mock enemy missile in a test in December 2002. After that failure, officials ordered a halt to more intercept tests until a newly designed booster could be completed. The Pentagon said it decided to delay the test again after learning of modifications to the test interceptor that were not checked out fully in ground tests. The Pentagon said the program is "on track and making strong progress" and that the MKV design "has matured significantly." Sen. Ted Stevens, R-Alaska, calls the deployment of missile defense "essential in today's world." A Pentagon spokesman noted that, "Although the system will initially have a limited capability when it becomes operational ... it will mark the first time the United States has a capability to defend the entire country against limited attack by a long-range ballistic missile." In addition to the kill vehicle, the interceptors rely on a booster rocket. The kill vehicle is designed to separate from the booster, identify the enemy warhead, and ram it.

Although Air Force Space Command doesn't operate the interceptors that make up this newest space shield, the command is in constant coordination with those who do. The missile agency has five interceptors in underground silos at Fort Greely in central Alaska, with plans to add 11 more by the end of 2005. Four interceptors are being put in the ground at the backup site at Vandenberg. A U.S. Navy destroyer has begun patrolling the Sea of Japan with newly upgraded Aegis radar capable of tracking any North Korean missile launches and feeding information into the missile defense network. The command's tracking radar on Shemya, and an early-warning radar at Beale Air Force Base, Calif., are both operational.

General Lance Lord, the longest-serving missileer in uniform, has commanded Air Force Space Command since April 2002. The command has two numbered air forces: 14th Air Force at Vandenberg Air Force Base, Calif., commanded by Maj. Gen. Michael A. Hamel, and 20th Air Force, at F. E. Warren Air Force Base, Wyo., commanded by Maj. Gen. Frank G. Klotz. The command's literature tells us that its assets are "a key factor" in implementing the Air Force's expeditionary strategy.

For the men and women of Air Force Space Command – headquartered at Peterson Air Force Base just outside Colorado Springs – contributing to today's reduced ballistic missile defense means staying ready at ICBM sites, monitoring telemetry, operating warning satellites and warning radar stations, and coordinating with the Missile Defense Agency and other players.

SPACE AND MISSILE PIONEERS

By Scott R. Gourley

Photo courtesy of Dr. David N. Spires

The watershed events of 1954, including the July 1, 1954, establishment of the Western Development Division (WDD) in Inglewood, Calif., form the foundation for today's Air Force space and missile capabilities. However, while WDD is considered to be the birthplace of Air Force missile and satellite development, "the division" accomplished nothing. It was the people working in, for, and around WDD and its subsequent organizations that established those capabilities. They are the space pioneers.

An example can be found in Brig. Gen. Bernard Schriever, a visionary leader who assumed command just one month after the WDD was established. Often identified as the first in a long line of space and missile pioneers, Schriever was born in Germany in 1910, immigrating to the United States with his parents seven years later. He began military service in the U.S. Army field artillery, but transferred to the Air Corps in 1932, earning his wings one year later. After time as a test pilot at Wright Field, World War II found him fighting in campaigns throughout the Pacific.

The WDD that he commanded would be credited for the design and development of national assets, including the nation's ICBM fleet, the CORONA/Discoverer satellite imagery program, and the Missile Detection Alarm System (MIDAS). But it was the individuals involved who were truly responsible for the successes.

To honor those individuals and their contributions to the nation's space posture, the Air Force used the occasion of "Guardian Challenge 2004" to assemble a panel of distinguished visitors with personal knowledge of Air Force space and missile history. Speaking to assembled participants at Vandenberg Air Force Base, Calif., the panel members shared many insights and observations surrounding the major issues, decisions, key efforts, and events over the last 50 years.

"If I have seen further it is by standing on the shoulders of Giants."

- Sir Isaac Newton

Air Force Space Command illustration by Jay Ashurst

Opposite: As a brigadier general, Bernard A. Schriever, seen at left standing behind the Discoverer 13 capsule, took command of the Western Development Division (WDD) just a month after it was established. He is now widely regarded as the father of the U.S. space and missile program. Above: In July 1954, the Western Development Division began operations in a converted parochial schoolhouse in Inglewood, Calif.





Clockwise from top left: Brig. Gen. William G. King, Jr.; Gen. Thomas S. Moorman, Jr.; Dr. Simon "Sy" Ramo; Dr. John von Neumann; and the Honorable Trevor Gardner.

Photos courtesy of Dr. David N. Spires and Air Force Space Command

The distinguished panel members included co-moderators – Maj. Gen. Michael A. Hamel, USAF (Commander, 14th Air Force) and Maj. Gen. Frank G. Klotz (Commander, 20th Air Force) – with panel members Brig. Gen. William G. King, Jr., USAF (Retired); Maj. Gen. Robert A. Rosenberg, USAF (Retired); Lt. Gen. Jay W. Kelley, USAF (Retired); Maj. Gen. Donald G. Hard, USAF (Retired); Gen. Thomas S. Moorman, Jr., USAF (Retired); Lt. Gen. Arlen D. Jameson, USAF (Retired); Maj. Gen. Thomas H. Neary, USAF (Retired); and Lt. Gen. Eugene D. Santarelli, USAF (Retired).

While some of the speakers used the occasion to address current and future challenges, the bulk of the speakers offered aspects of their personal experience that helped illuminate the pivotal roles of the early space and missile pioneers.

For example, in establishing a historical framework for the early pioneering success, Maj. Gen. Hamel opened the panel by explaining that the post-World War II era was "a very different world" from what the panel audience knew today.

"As the Cold War was developing, … we saw the development of technologies that were able to underpin our strategic nuclear deterrent and global stability for nearly half a century," he said.

"1954 was a pivotal year in the development of Air Force space and missiles," echoed Maj. Gen. Klotz. "In February of that year, the Teapot Committee, which was also known as the von Neumann committee [Dr. John von Neumann was the committee chairman], released its report, which urged the development of an American intercontinental ballistic missile. The next month, RAND Corporation released a report, R-262 – also known as "Project Feedback" – which recommended that the Air Force also develop a reconnaissance satellite program. In July of 1954, the Western Development Division was activated and began the race with the then Soviet Union to field an operational ICBM. The following month, then Brig. Gen. Bernard Schriever assumed command of the Western Development Division. In October 1954, the ICBM Scientific Advisory Group recommended integrating space and missile programs under the Western Development Division. Finally, in November of that pivotal year, the Air Force issued the requirement for weapon system 117-L, to develop a reconnaissance satellite program."

"But 1954 was just the start of Air Force space and missiles," Klotz continued. "In those early years, the Air Force fielded numerous research and development systems, many of which evolved into operational systems.

And I think that one of the things to bear in mind as we look out across this audience and see wings from both 14th Air Force and 20th Air Force, is that the ICBM business and the space business were born together. They grew up together. They were essentially part of the same family. And they still are."

Hamel's introduction of Brig. Gen. William G. King, Jr. highlighted a panelist who had been involved in the space and missile business since the 1950s, personally serving under Schriever during the formative years. Among his accomplishments, King was credited as being "the driving force behind the WS-117 program."

For his part, King categorized himself as being among "the original space ancestors," focusing his words on "what the working junior officers were doing in the mid-'50s."

"These were not really prehistoric times," he began. "But it was before space. Most of the general population did not have space in its vocabulary. And neither did the Air Force."

"In fact, one of the hardest things for us to do was to learn how to spell 'satellite,'" he joked. "If you made a lot of briefings in those early days, you were really upset when you looked at your chart and saw that 'satellite' was misspelled."

Describing a small organization located at Wright Field that he ran as a lieutenant colonel, King explained, "The 'Feedback Report' [RAND Corporation "Project Feedback"] had an important recommendation in it. And that was that the Air Force undertake at the earliest possible time to complete an efficient satellite reconnaissance vehicle. And in those days – 1954 and 1955 – you would presume that all the people had read it, because this was a very important document that came out. Absolutely not. No one had looked at it. So our job was to get out on the road with 'a dog and pony show' to try to bring this to the attention of the people in the Air Force. Our goal was to get invited to various laboratories, commands, and headquarters in Washington. We did this by networking with people that we already knew and usually the audiences were small and junior in nature."

King cited a number of frustrations in these early efforts, ranging from negative receptions at traditional photo labs to at least one audience member who privately asked, "How does that thing stay up there?"

As one invitation led to another, King and another group member eventually found themselves at the headquarters for Strategic Air Command (SAC), which was at that time commanded by Gen. Curtis Lemay. The small Wright Field team presentation raised the possibility of modifying one of the captured World War II V-2s, then stored at White Sands, N.M., to place a small "grapefruit-sized object" in lunar orbit for the International Geophysical Year [1957 – 1958]. King said that the famed general unexpectedly entered the room, listened to the presentation, and then very pointedly inquired how the briefers had obtained the travel funds to come to SAC to pitch such nonsense.

"But the landmark of the whole operation was that we did get invited to come in to see [Brig.] Gen. Schriever's operation out at the Western Development Division. We had been out there several times when they were in the old schoolhouse out there but that was to see friends and talk to them. But we finally got invited now – a legitimate invite. And, sure enough, Gen. Schriever was there, as was Sy Ramo [of Ramo-Wooldridge, later TRW] and Gen. Putt [Lt. Gen. Donald Leander Putt, who returned to Air Force headquarters in April 1954 and was designated deputy chief of staff for Development, and military director of the Scientific Advisory Board to the chief of staff, U.S. Air Force].

"When we got done giving the briefing, Gen. Schriever turned to Sy Ramo and asked, 'What do you think Sy?' And Sy said, 'I think they may be on the right track, but if this is allowed to continue in this manner, it will interfere with you, and you have the highest priority in this nation to accomplish one of the most important things that needs to be done in this nation,'" King said.

That discussion would eventually lead to the transfer of program efforts from Wright Field to WDD.

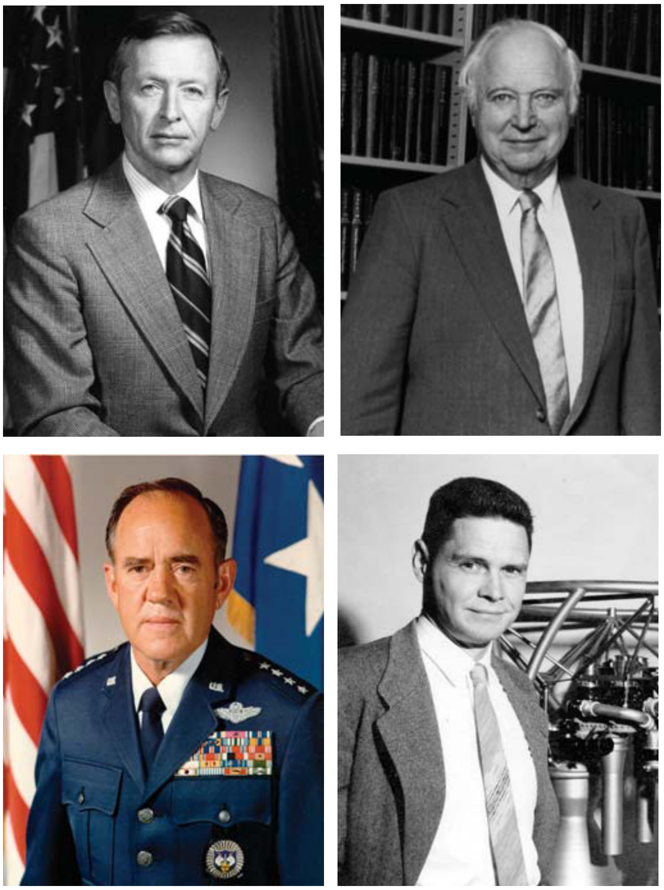
Another early highlight identified by King was a Pentagon briefing that resulted in the receipt of $2 million of funding to solicit up to four contractors to come up with the development concept for space reconnaissance. Three of the four responded, with Lockheed receiving the eventual award.

In summarizing the other early milestones, King added, "Certainly Sputnik alerted the public that space was here and it could happen, with what the Russians had done. Suddenly, there was interest and participation by the CIA. They had a mission for space and they could invoke a secrecy that allowed us to proceed. And I don't think anybody ought to doubt how important that was in getting us into space. And then the public's attention to the space activity that was in NASA – and there was a lot of exchange of information with the Air Force and NASA in the early days."

Highlighting "the priorities and leadership of Gen. Schriever," he continued, "We needed a booster. We knew that. And that's why we were happy when the eight or nine of us that were working on the program at that time did get transferred out [from Wright Field] under the special management of Schriever."

Maj. Gen. Rosenberg addressed a follow-on era when that satellite technology was evolving into a tool that served the nation during the Cold War. Coming to Vandenberg Air Force Base in 1958, Rosenberg's introduction noted that he was an early launch officer for CORONA before moving up to Sunnyvale, Calif., where he helped "push the state-of-the-art in reconnaissance satellites forward in the 1960s.

"Let's go back to the beginning of the Cold War," he said. "In the '50s, the world was a fairly frightening place. Our leadership was concerned with the bomber and missile gaps. But the question loomed in the White House, 'Was there really a gap?' We knew the Soviets had the



Clockwise from top left: The Honorable James W. Plummer; Dr. Ivan A. Getting; Capt. Robert C. Traux (USN); and Gen. James V. Hartinger.

Photos courtesy of Dr. David N. Spires and Air Force Space Command

bomb. They tested their first one over 50 years ago. But would our military buildup trigger an arms race? So on July 21, 1955, President Eisenhower proposed an 'Open Skies Treaty' at the Geneva Summit. Khrushchev took off his shoe, bashed it on the table, and said 'Nyet. Nyet. I will never permit espionage over my country.' And, as you've already heard, then came Sputnik: the launch that shook the free world's confidence in the U.S.

"[President Eisenhower] was shocked by Sputnik," Rosenberg said. "That changed everything. He had prevented the military from pursuing space initiatives publicly. When I first got here to Vandenberg, Gen. Greer stood in front of the press and told everybody that we were going to launch photoreconnaissance satellites. Then, a year later, no one was permitted to talk about it at all."

Rosenberg described one of his first assignments as a lieutenant at Vandenberg, during which he used a team of contractors to modify the software and hardware of the SAC Atlas sites to guide space reconnaissance satellite launches.

"We pushed it to the limit with the leadership of guys like Bill [Brig. Gen. William G.] King's leadership," he added. "The lieutenant didn't go through the captain to the major to the colonel to the general. As the 'targeteer,' it was my job, under his leadership, to make sure that we did everything we could to fill up those film capsules with cloud-free, high-priority imagery of the Soviet Union, the Warsaw Pact, and others."

Quickly reviewing his subsequent assignments throughout the Cold War, Rosenberg concluded, "The Soviets continued to spend 13 to 15 percent of their gross national product on military weaponry. They were able to outnumber us 2 to 1 in airplanes, 3 to 1 in tanks, and 10 to 1 in artillery, because they thought that mass gave them their superpower status. But it was that quantitative imbalance that led the leaders of the Air Force and DoD – like Lew Allen [Gen. Lew Allen, former Air Force Chief of Staff], Harold Brown [former Secretary of Defense], Bill Perry [former Secretary of Defense], and others – to adopt a strategy of 'technology leadership,' where it was quality over quantity. That led AFSAT, DSCS, MILSTAR, GPS DSMP, and the others as enablers for dramatic force multipliers to develop an awesome fighting force of land, naval, and air combat forces to deter and contain, and eventually watch the collapse of the evil empire. Satellites, along with radar and the atomic bomb, were amongst the most important military technology developments of the 20th century that led to the end of the Cold War."

Arriving in the field in 1964 and serving the majority of his early career in ICBMs, Lt. Gen. Jay W. Kelley opened his review of ICBM force development by stating, "With ICBMs and the Air Force, it all started a long time ago in a place far away, and I can tell you that it was not a natural act."

To support the assertion, he provided a quick historical review of post-World War II decisions that had given captured V-1s to the Air Force and captured V-2s to the Army.

For changing the mindsets behind that sort of decision-making, he credited "folks like Gen. King, Gen. Schriever, Gen. Sam Phillips, many others, and a lot of successes."

After quickly reviewing the evolution of ICBM equipment and strategy / tactics, Kelley shifted his presentation to the people behind the programs.

"The heritage that we have coming out of World War II came out of the bomb groups – B-17s and B-24s," he began. "And so did our leadership. My first wing commander, DO [Director of Operations], squadron commander, chief of training – were all pilots out of World War II. Nearly every other key position in that wing, down to crew commanders, was filled by aviators from other types of aircraft. Our wing structure looked just like a bomb wing. We learned operations and maintenance from our air brothers and only then, only then, were we allowed to step up. But step up we did."

Following an amazingly complex review of evolutionary terms and acronyms associated with ICBMs, Kelley succinctly concluded, "What's important is that we earned our way. We established and matured a great career field. We taught our Air Force about missiles. And we learned how to be part of an Air Force warfighting team."

Maj. Gen. Don Hard addressed the evolution of the development and requirements process supporting space and missiles. Prior to his presentation, moderators noted that his early personal Air Force space experience ranged from the Manned Orbiting Laboratory office to a "flight group in Hawaii whose purpose was to recover photoreconnaissance capsules as they returned from space."

Taking the audience on a quick walk through five decades, Hard said that, "The beginnings were all about bold exploration; pushing the envelope – by both Air Force and NASA; acceptance of risk; recognizing that there would be failures along the way – as we saw with Discoverer 13 and CORONA; and a 'less rigorous,' perhaps, management approach. We didn't talk a lot about what the requirements were. We just went ahead and did things. One wonders if there really were requirements for radar. It was pretty transforming, as was space. And I think in those days, we worried less about the requirements than about getting something to work."

After identifying some early difficulties with operations costs and other program challenges, he added, "The operations weren't quite 'routine checklist' operations. We scrambled quite a bit. And that carried us all into the '70s. By '75 we were continuing development, though, of new and improved capability across the board. Not just the 'photo recce' stuff; not just the warning; not just the weather. But now we were beginning to understand the real advantage that could be exploited from space platforms, and we were 'at that,' big time."

Those were followed by '80s milestones involving influence of the space shuttle and the increasingly complex issues of integration of space forces with other service elements.

"We began to get a lot of interest from the highest levels of the Air Force," Hard said. Pointing down the speakers' table toward Gen. Thomas Moorman, he added, "I remember at the time, our Chief [of Staff] at the time, Gen. Larry D. Welch [Chief of Staff 1986-1990], invited my comrade and I to come in and talk to him about space. It ended up with 'Professor Moorman' speaking about space for three or four hours. And that was the really significant step forward in the integration of air and space."

In addition to his significant discussions with Welch regarding the integration of air and space, Moorman's background included the development and procurement of Air Force systems ranging from surveillance, communications, navigation, weather, anti-satellite weapons, and ground-based radar systems.

Moorman's senior billets included both Vice Commander and Commander of Air Force Space Command (AFSPC), and later, Air Force Vice Chief of Staff. His presentation at the Guardian Challenge 2004 symposium focused on individuals and programs surrounding the creation of AFSPC.

"There's a big debate in the history business," Moorman explained. "And the debate is over whether history is created by events or environmental factors. Or is history created by great people? The latter is the so-called 'Great Man Theory.' In this case, I believe it's a little bit of both."

After presenting a range of operational and materiel programs that helped lead to the creation of AFSPC, Moorman highlighted the efforts of several specific individuals, beginning with Gen. Jerome F. O'Malley.

"Within the Pentagon, I need to go back to the 'Great Man Theory,'" he said. "An individual came to fore who doesn't get the credit that I believe he deserves, and that's Gen. Jerry O'Malley. At this time, he was the Air Force XO and he had a vision for Air Force Space that was actually beyond even what the 'space zealots' believed. And he kind of drove that vision – creating an entity in the Air Staff and peopled it with a lot of sharp people. Most of them have retired, but I'll call your attention to one individual that I think most of you know and have been influenced by: Maj. Roger Dekok served in that activity [as a lieutenant general, Roger G. Dekok would later serve as AFSPC vice commander].

With its creation driven by O'Malley and others, AFSPC was created in September of 1985. The first commander was Gen. James V. Hartinger.

"Gen. Hartinger, known as 'The Grrr' – that was something that you learned very early," Moorman said. "It was to get the pronunciation of his name right. But it [was] also very suitable for his personality. He was a tough customer: He was a career fighter pilot; a very seasoned operational commander; a hard-nosed commander. But he was a tremendous cheerleader and probably the best choice you could have had for the first commander. Because if you could get something through Gen. Hartinger, you could skate through the Air Staff."

"There are a couple of other great people I want to mention here," Moorman added. "One of them is out of the public eye now: Secretary [of the Air Force] Verne Orr – he was very critical for the creation of the command. And another guy who is very much in the public eye and whose track record now is 30 years of continuous involvement: Pete Aldridge [Edward C. Aldridge]. Pete Aldridge was the Undersecretary of the Air Force and he really worked behind the scenes [for the creation of AFSPC]."

RECOGNIZING THE SPACE AND MISSILE PIONEERS

As with many fields of endeavor, today's space and missile warriors stand on the shoulders of a plethora of giants who have collectively paved the way to space with five decades of personal commitment. While it would be impossible to individually recognize the complete contributions of these myriad space heroes, a small formal step forward was taken in May 1989 when the United States Air Force and the National Space Club initiated unofficially the Air Force Space and Missile Pioneers Award. Ten honorees received the award at that time:

Franklin R. Collbohm, Maj. Gen. Richard D. Curtin, Lt. Gen. Otto J. Glasser, Brig. Gen. William G. King, Jr., Col. Frederic C.E. Oder, The Honorable James W. Plummer, Dr. Simon Ramo, Maj. Gen. Osmond J. Ritland, Gen. Bernard A. Schriever, Lt. Gen. Charles H. Terhune, Jr.

In 1997, the award was formalized into an official Air Force award with a select few pioneers honored with the award since that time.

Pioneers inducted in 1997:
The Honorable Trevor Gardner
Dr. John von Neumann
Inducted in 1998:
Karel J. Bossart
Dr. Ivan A. Getting
Gen. Samuel C. Phillips
Inducted in 1999:
Col. Edward N. Hall
Col. Quenten A. Riepe
Dr. Robert M. Salter, Jr.
Inducted in 2000:
Col. Thomas O. Haig
Col. Joseph W. Kittinger, Jr.
Dr. Ruben F. Mettler
No inductions in 2001 due to world events
Inducted in 2002 (honorees selected in 2001):
Col. Clarence L. Battle
Col. Frank S. Buzard
Lt. Gen. Forrest S. McCartney
Inducted in 2002 (honorees selected in 2002):
Dr. James G. Baker
Mr. James S. Coolbaugh
Inducted in 2003:
Brig. Gen. Martin Menter
Col. Albert J. Wetzel
Capt. Robert C. Truax (USN)
Mr. John C. Herther
Inducted in 2004:
Col. Edward E. Blum
Mr. Wen Tsing Chow
Mr. Rodney C. Pratt
Rita C. Sagalyn
Lt. Gen. Kenneth W. Schultz
Mr. William O. Troetschel

For more information:

https://www.peterson.af.mil/hqafspc/history/pioneers.htm

AFSPC HISTORY

By J.R. Wilson

Photo courtesy of Dr. David N. Spires

Space is the youngest military frontier, whether dating its beginning to Oct. 3, 1942, with the first successful launch of a German V-2 rocket (although it never left the Earth's atmosphere as a weapon of war) or to 15 years and a day later, when Sputnik made the Soviet Union the first nation to orbit a satellite. For the United States, military space officially became part of the lexicon in 1954, with the creation of the Western Development Division – now the Space and Missile Systems Center (SMC), the acquisitions arm of the newly reorganized Air Force Space Command (AFSPC).

"Many in the international community point to Oct. 4, 1957, as a day that changed the world. We in the United States Air Force mark three years earlier – Aug. 2, 1954 – as the beginning of our space and missile heritage with the establishment of the Western Development Division," AFSPC Commander General Lance W. Lord told the Royal College of Defense Studies in London on Feb. 3, 2004.

It has become crowded in the near-space of Earth's orbit in the half-century since Sputnik. Today, AFSPC tracks more than 13,500 man-made objects that might present a hazard to the International Space Station, satellites launched by the half dozen nations capable of doing so, or manned flights by the United States, Russia, or, most recently, China. Fewer than 1,200 of those objects are functioning satellites – about a quarter of those U.S. spacecraft, only 60 of which are claimed by the military.

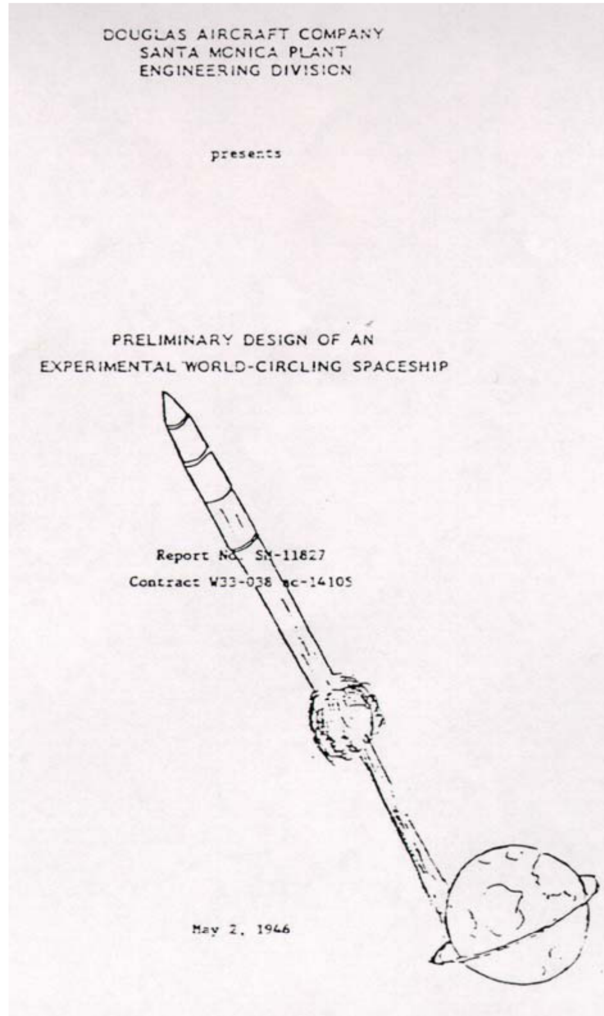
"Space is no longer for the privileged few. Worldwide industry continues to migrate missions to space, moving information vital to national and international economic well-being," General Lord told the Royal College of Defense Studies. "With regard to national security, each nation has certain national interests that are unique to that nation in space. At the moment, the United States is probably the most heavily dependent nation in the world on space."

The history of space exploration and exploitation is the history of military space, from the German rocket scientists captured by both U.S. and Soviet forces at the end of World War II, setting the stage for the "space race" that began with Sputnik and essentially ended with Neil Armstrong's "one small step" on the moon in July 1969, to today's space-dependent air, land, and sea forces. Armstrong was by that time a civilian – but the rocket science that put him there was derived from military research and development.

From the Western Development Division (WDD) and its first commander, Brig. Gen. Bernard Schriever, came the foundation of U.S. military space operations, from the original ICBM fleet to the CORONA/Discoverer satellite imagery program to MIDAS (Missile Defense Alarm System), the world's first missile detection program. But the U.S. military took its first serious look at space a decade earlier.

"The U.S. interest in long-range ballistic missiles began in summer 1943, when Allied intelligence began hearing about the testing in Germany of what became the V-2 rockets. When those began to hit London, that interest became even greater," notes Dr. Rick Sturdevant, AFSPC deputy command historian. "At that time, there was an Army Air Forces liaison – Col. W.H. Joiner – to what is now JPL [Jet Propulsion Lab, Pasadena, Calif.]. As the intel came in about Germany, he asked JPL – mostly graduate students working under Theodore von Karman – to put together a report saying we could develop equivalent missiles within a few years."

Ironically, one of those students was Hsue-Shen Tsien, who would be deported from the United States during the McCarthy era. He later became the father of the Chinese missile program.


DOUGLAS AIRCRAFT COMPANY
SANTA MONICA PLANT
ENGINEERING DIVISION

presents

PRELIMINARY DESIGN OF AN
EXPERIMENTAL WORLD-CIRCLING SPACESHIP

Report No. SM-11827
Contract W33-038 ac-14105

May 2, 1946

Previous: An early photo of the NORAD (North American Aerospace Defense Command) facility in the Cheyenne Mountain Complex. Space has become much more crowded in the intervening years, and today AFSPC tracks more than 13,500 manmade objects in space. Above: Douglas Aircraft's 1946 Project RAND study predicted that the United States could launch a 500-pound satellite into a 300-mile orbit within five years at a cost of $150 million; and it described potential satellite uses for reconnaissance, communications, meteorology, scientific research, interplanetary travel, and space-based weapons operations. The RAND report was the first comprehensive analysis of satellite feasibility, and it served as the foundation for the numerous RAND studies on missiles and satellites to follow.

RAND Corporation illustration

"It was apparent to Hap Arnold by then that the war probably would end by 1945, so he decided not to put a lot of Army Air Forces R&D money into long-range missiles when we had a substantial number of very capable

Dr. Theodore von Karman, left, chairman of the USAF Advisory Group, is seen in this photo with Brig. Gen. Donald L. Putt, director of R&D, Office of the Deputy Chief of Staff for Materiel, and Dr. Albert E. Lombard, Jr., head of the Research Division under Gen. Putt.

Photo courtesy of Dr. David N. Spires

bombers in the production line," Sturdevant said. "However, Army Ordnance said they might be interested, because missiles had some similarity to artillery.

"When the war ended, Arnold asked von Karman to send a team of experts to Europe to evaluate the German science and technology efforts. They looked at everything from ramjets and other propulsion systems to rockets. While Army artillery was interested in long-range missiles, [what would become] the Air Force was most interested in developing jet propulsion for manned systems. Both also relied on industry and academia, although the Army generally preferred to develop their systems internally."

The Navy also joined the effort in late 1945, proposing a joint research project to develop a space launch capability, but there was little interest within the budding Air Force for a joint effort. Instead, Curtis LeMay, director of research and development on the Air Staff, commissioned RAND – then a division of Douglas Aircraft – to produce its first report, one concluding the Air Force could develop an "experimental world-circling spaceship" within five years.

That report, delivered in May 1946, also elaborated on a single line from von Karman's study of German technology – "the satellite is a definite possibility." Within a decade, additional study concluded it was possible to build nuclear warheads small enough in size and weight to be delivered by long-range missiles.

"Another report, also in 1954, addressed the concept of ICBMs and recommended acceleration of their development," said Command Historian George W. Bradley III. "That led to the establishment in July '54 of the WDD. That was important because you needed good boosters to get into space, which is why 1954 was such an important year for us. The Air Force also issued a weapon system requirement that fall for development of a reconnaissance satellite program."

With the Soviet Union also developing ICBMs, President Dwight D. Eisenhower gave precedence to the development of Atlas – which became critical to space – as a direct response, saying, "Space objectives relating to defense are those to which the highest priority attaches because they bear on our immediate safety."

In the decades that followed, all three services contributed to the development of rocketry and related space technologies, from weather prediction to early warning of any missile attack against North America to verification of arms control treaties.

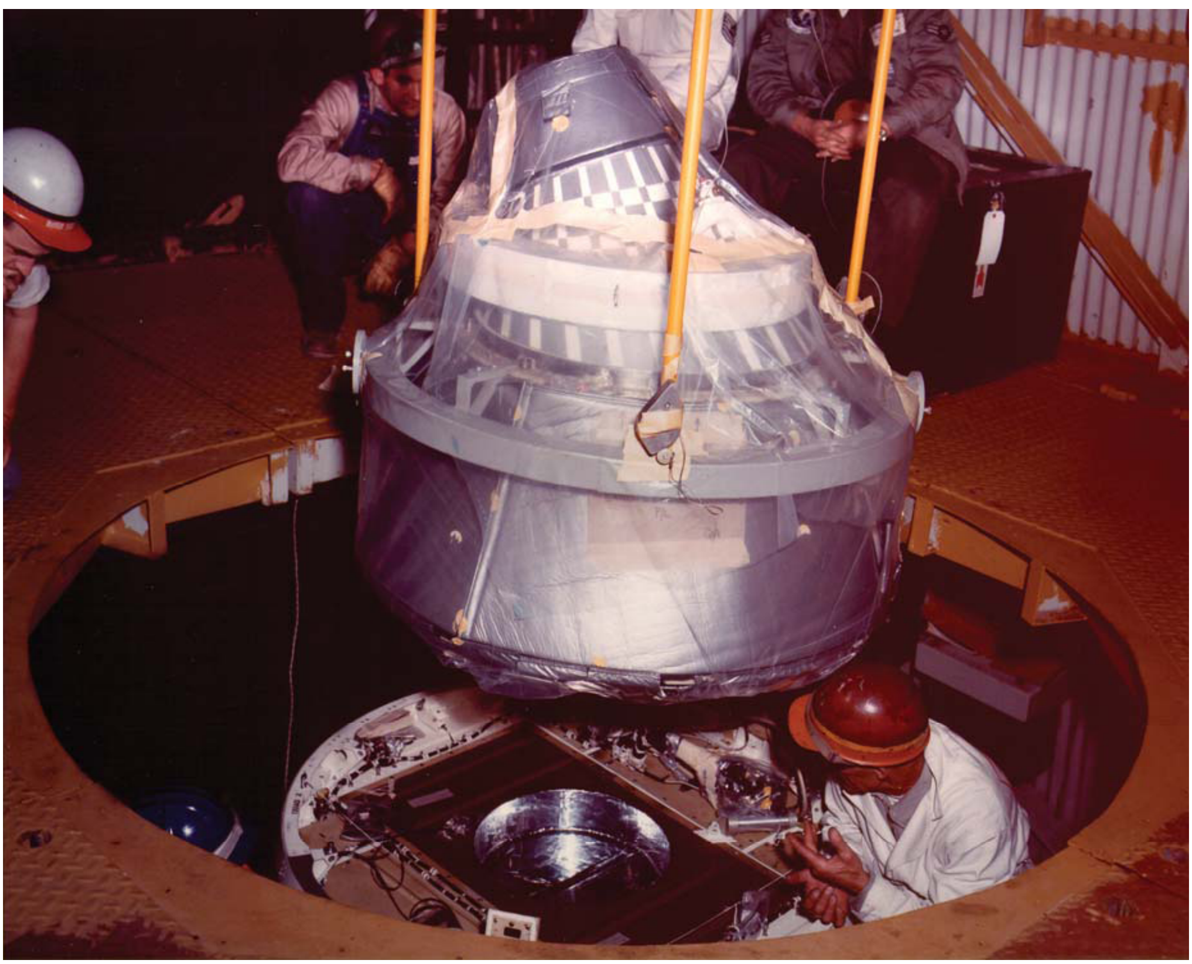
As had been the case since the U.S. military initially dismissed rocket experiments as merely interesting toys in the 1920s and '30s, proponents of new and advanced capabilities often found little support for their ideas. One such proponent was Navy Capt. Robert Truax, who felt his interest in long-range missiles would be better received by the Air Force, leading him to volunteer to work for Air Force Gen. Schriever, WDD's first commanding officer. Truax was put in charge of the Thor IRBM program, but soon became restless again when the Air Force failed to address the new primary focus of his interests – development of ultra-low-cost rocket engines and launch vehicles. Following his military retirement in 1959, Truax joined Aerojet Corporation, where he refined his concepts before establishing Traux Engineering, Inc., in 1966 and participating in several important space and missile-related efforts during the next 35 years.

The decade following World War II also saw the implementation of Project Paperclip, a military operation that brought dozens of German scientists to the United States. Under that effort, many – including Wernher von Braun – went to work for the Army. One who did not was Dr. Hubertus Strughold, who instead joined the Air Force team on a much more esoteric concept – the requirements for putting a man in space.

"In October 1957, the Soviets launched Sputnik, doing so without warning, when we didn't think they were that advanced," Bradley said. "We didn't match that until January 1958, with the launch of Explorer I, a JPL satellite using an Army launch vehicle (Jupiter).

"One consequence of Sputnik was organizational development – the 1958 establishment of NASA for civilian manned space. The Air Force had been planning for what became Project Mercury all along, under their 'Man-in-Space Soonest' effort. They gave that up to NASA; the Army gave up von Braun's team at Redstone Arsenal; and the Navy gave up its test center in Greenbelt, Md. [which NASA renamed in honor of Robert Goddard, generally considered the father of American rocketry, who had worked for the Navy Bureau of Aeronautics and the Army Air Corps during World War II until his death in 1945]."

With man-in-space now the purview of NASA, the Air Force concentrated on satellites.



Space and Missile Systems Center photo

Workers install the MIDAS 6 Series III Infrared Sensor Payload atop the Agena B during November 1962 at Vandenberg Air Force Base in preparation for launch. Although MIDAS remained a test program, it had shown conclusively that infrared satellites could provide early warning of a missile attack by detecting and tracking missiles of all sizes.

"Navigation, missile warning, communications, weather – key military missions for the Air Force, as well as important to the other services," Bradley continued. "From 1945 to 1960 was a period of growing interest in space and development of the launch capabilities to get there. In 1961, Air Force Systems Command was created and continued development of Vandenberg [AFB, the military's West Coast launch facility] and Canaveral [its East Coast equivalent at Cape Canaveral, Fla.]."

"Another important year in space history was 1959," Sturdevant added, "when the Navy proposed a unified space command, which the Air Force rejected, saying with Atlas, Titan, and Thor, space was their business."

The Navy proposal eventually was put into place, however, 27 years later, when the Joint Chiefs of Staff, acknowledging the growing importance of space to the military, created a new unified command – U.S. Space Command – with a primary goal of institutionalizing the nation's deterrence capability. The offensive side of the equation came to the fore with Desert Shield/Desert Storm in 1990-91, as space played its first major role in combat.

Even then, however, the dominant player remained the Air Force. Yet another reordering of the contributions each service was making came on Oct. 1, 2002, when U.S. Space Command was disestablished and its responsibilities transferred to U.S. Strategic Command (USSTRATCOM).

This 2002 change came on the heels of a 2001 report by the Commission to Asses U.S. National Security Space Management and Organization, which recommended considerable changes in the U.S. Air Force's approach to space. The panel, headed by Defense Secretary Donald Rumsfeld prior to his return to the Bush administration's cabinet, advised sweeping changes to the Air Force's culture of space professionals, warning of "a weak space culture resulting in unfocused career development, education, and training," and urged that the United States ramp up the security of its space assets to thwart any possible attack by those hostile to the United States. Efforts to centralize military space power under one command – including a unification within the Air Force of the Space and Missile Systems Center and Air Force Space Command under USSTRATCOM – and to develop more defined career fields among the Air Force's space professionals followed.

While the list of nations able to launch satellites into orbit continues to grow – as, on a much slower scale, does the number capable of manned spaceflight – the United States currently dominates military space to a degree that would take a massive commitment of resources to match, even if the nation stood still with its current capability and force structure – a posture at odds with the current blueprint for the further exploitation of "near space" by AFSPC and USSTRATCOM. That also means a continual effort at "counter-access" – the ability to deny an adversary access to whatever space assets are available to him – as well as defending against an attack on U.S. capability, in an effort to blind and deafen an increasingly space-dependent U.S. force, as well as those who may, literally, slip under the radar, as happened on September 11.

"For our first 50 years, we have become victims of our own success," said Maj. Gen. Mike Hamel, Commander, 14th Air Force. "Our tolerance for failure and our demand for performance have increased considerably. The launch capability we have today doesn't meet those high standards."

As a result, he added, the nation must make a focused investment in responsive, affordable, real-time launch capability that would allow access to space on a routine, low-cost basis – a validation of Robert Truax.

"A significant investment in that area has the potential to be a revolutionary shift," Hamel said, "including changing how we maintain constellations in time of crisis. We're also making big investments in the area of transformational communications. The concept that we would be able to provide expeditionary forces is adaptable, dynamic connectivity, using Internet-like access all the way from high bandwidth down to netting together fire squads dispersed across hundreds of kilometers. That, too, would be truly revolutionary, but a lot of technology needs to be developed and integrated to make that happen.

"Revolutionary warfare and conflict management means global persistent tracking and targeting, day/night, all-weather, any time of our choosing, so we can monitor adversaries, discern their intentions, note their operating patterns, and very rapidly transition from surveillance to tracking and ultimately target with long-range precision, even global strike."

AFSPC identifies five primary mission areas for which it now is responsible:

1. Space Force Enhancement – providing weather, communications, intelligence, missile warning, and precision timing and navigation in support of the warfighter, and enhancing the effectiveness of military air, land, sea, and space operations
2. Counterspace – focusing on capabilities to attain and maintain a desired degree of space superiority by allowing friendly forces to exploit space capabilities while negating an adversary's ability to do the same
3. Space Force Application – maintaining and operating a rapid response, land-based ICBM force, the Air Force's only on-alert strategic deterrent
4. Space Support – employing the Air Force satellite control network to provide satellite operations services to select DoD, National, Allied, Civil and commercial satellites
5. Mission Support – providing infrastructure, sustainment, security, and trained personnel needed to perform missions around the globe – they cut accross all five mission areas to ensure effective operations.

The Air Force has been an integral part of U.S. military space since its days as the Army Air Forces. As a result, in an arena in which success is now taken for granted and failure tends to be both very public and spectacular, AFSPC and its predecessors often have found themselves pushing the envelope of the possible while defending their record and their future.

"We've been in space and missiles for 50 years; Air Force space has been a command for 22 years, and much has been written about whether or not the Air Force has been an able steward of military space," General Lord said. "The colonels and young generals leading AFSPC today are as able as any other colonels or generals in any other command. We have room to grow and improve, but we are much healthier than many outside critics believe."

An Abbreviated Chronology of Air Force Highlights in Space

April 16, 1946 – White Sands Missile Range (WSMR), N.M., first launch in the United States of a captured German V-2 rocket

Feb. 24, 1949 – WSMR (now a unique multi-service test facility) launch of a WAC Corporal rocket, developed by the Jet Propulsion Laboratory (JPL), atop a V-2, setting a new record for altitude (244 miles) and speed (5,150 mph)

Dec. 7, 1951 – The 6555th Guided Missile Wing – predecessor to the 45th Space Wing – makes its first successful all-military "blue suit" launch from the Air Force Missile Test Center at Cape Canaveral, Fla., with a Matador, the first missile ever deployed by the Air Force

July 1, 1954 – Western Development Division established in Los Angeles, Calif.

Aug. 2, 1954 – Brig. Gen. Bernard Schriever assumes command of the Western Development Division

Oct. 15, 1954 – ICBM Scientific Advisory Group recommends the integration of Air Force satellite and missile programs and assigns them to the Western Development Division

Nov. 27, 1954 – The Air Force issues Weapon System Requirements No. 5 (WS 117L) to develop a reconaissance satellite program

May 23, 1958 – Air Force created the first distinctive missile badge that recognized and identified those individuals within the Air Force who, by virtue of their job assignment, had a direct role in missile operations and maintenance

Oct. 4, 1958 – Cooke AFB, Calif., is redesignated as Vandenberg AFB, honoring the Air Force's second chief of staff, General Hoyt Vandenberg

Dec. 16, 1958 – The first launch of a Thor Intermediate Range Ballistic Missile from Vandenberg

Feb. 28, 1959 – Discoverer I, the first polar-orbiting satellite, is launched by USAF

May 24, 1960 – U.S. Air Force orbits its first MIDAS early warning satellite and recovers capsules ejected from Discover XIII and XIV

Sept. 2, 1960 – SAC's first operational Atlas ICBM complex is on alert at F.E. Warren AFB, Wyo.

Apr. 20, 1962 – The first Titan Is were placed on alert at the 724th SMS, Lowry AFB, Colo.

1965 – Defense Meteorological Satellite Program begins providing weather data from space

June 16, 1966 – Cluster of first seven satellites in initial Defense Communications Satellite Program launched

Nov. 6, 1970 – First Defense Support Program missile warning satellite launched from Cape Canaveral

Sept. 1, 1982 – Air Force Space Command created, with headquarters at Peterson Air Force Base, Colo.

Dec. 22, 1986 – U.S. Air Force begins to deploy the Peacekeeper, first new ICBM since the 1960s

Jan. 17, 1991 – The United States uses its space assets extensively for the first time in Operation DESERT STORM. Air Force Chief of Staff General Tony McPeak calls the Persian Gulf War "The First Space War"

Jan. 13, 1993 – USAF Maj. Susan Helms becomes first U.S. military woman in space, aboard Space Shuttle *Endeavor*

Nov. 1, 1993 – Drawing on its Gulf War experience, AFSPC opens the Space Warfare Center at Falcon AFB, Colo.

Feb. 7, 1994 – First MILSTAR military communications satellite launched by AFSPC

March 9, 1994 – Full constellation of 24 Global Positioning Satellites is completed

April 9, 1997 – AFSPC establishes Air Force Space Battlelab at Falcon AFB, Colo.

Jan. 11, 2001 – Rumsfeld Commission issues "Report of the Commission to Assess United States National Security Space Management and Organization," which recommends significant changes in USAF's approach to space

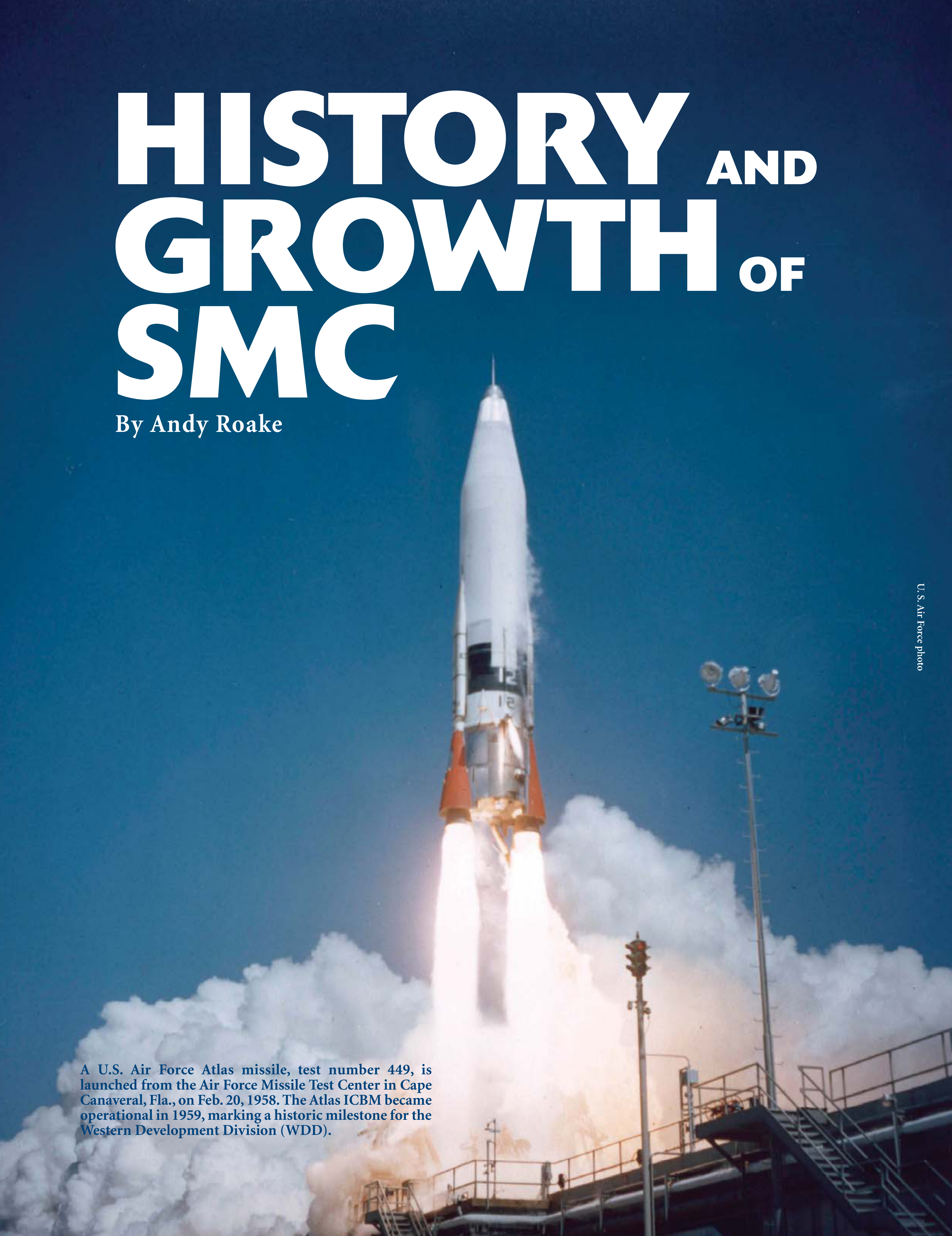
April 19, 2002 – AFSPC designated a separate four-star command and the lead for all U.S. military space programs.

Nov. 20, 2002 – First flight of Delta IV EELV – the world's first all-cryogenic satellite launcher

2004 – AFSPC celebrates the 50th anniversary of Air Force Space and Missiles

HISTORY AND GROWTH OF SMC

By Andy Roake



A U.S. Air Force Atlas missile, test number 449, is launched from the Air Force Missile Test Center in Cape Canaveral, Fla., on Feb. 20, 1958. The Atlas ICBM became operational in 1959, marking a historic milestone for the Western Development Division (WDD).

U. S. Air Force photo

"What goes around, comes around," is an old saying the seasoned Airman wisely nods in agreement to when it is used to refer to changes directed from the brass. Change is an inevitable part of the military, and an organization like the Space and Missile Systems Center (SMC) at Los Angeles AFB, Calif., which can trace its roots back 50 years, has seen more technological and organizational change over the years than any other military space organization.

SMC today is the center for technical excellence for researching, developing, and purchasing military space systems. SMC is space acquisitions. It is a dynamic organization employing over 3,500 military, civilians, and contractors worldwide. It manages between $50 billion and $60 billion in contracts at any one time. The center is also responsible for on-orbit checkout, testing, sustainment, and maintenance of military satellite constellations and other Department of Defense space systems.

This year marks the 50th anniversary of Air Force Space and Missiles. SMC is more closely tied to each of those 50 years than any other existing military organization. Its history is tightly intertwined with the history of military space, starting from a dawn that was fraught with tension in a time of national emergency.

"Historically speaking, the major difference between space acquisitions and aircraft acquisitions is that space acquisitions started at full throttle once they were combined with missile programs," said Dr. Harry Waldron, SMC historian.

SMC has its roots in the Western Development Division (WDD), established by the Air Force in July 1954 at an empty church in Inglewood, Calif.

The 1950s were a globally unstable time for the United States, with the Soviet Union perceived as being ahead in the areas of Intercontinental Ballistic Missile and satellite development. The WDD was a rare acquisition organization that hit the ground running with a Cold War objective of developing an Intercontinental Ballistic Missile (ICBM) before the Soviets.

The Air Force appointed Brig. Gen. Bernard A. Schriever to lead the WDD, and the push was on for him and his small team to fully develop and deploy an ICBM.

Jacob Neufeld, in his biographical article on Brig. Gen. Schriever in the spring 2004 issue of *Air Power History*, emphasized the seriousness and challenges of the times: "[The WDD] began with twelve officers and three enlisted men and eventually grew to some 1,500 personnel. [Brig. Gen.] 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.'"

William Maikisch, Executive Director of SMC, points out an additional inherent problem in space acquisition that was as true in Schriever's time as it is today. "When you look at an aircraft system, the vast majority of the money is spent sustaining the system over its life cycle. On the space side, the vast majority of the money is spent in the acquisition of the launch vehicle and the satellite. There's a very small portion in the sustainment of it over its life cycle. And if you don't have it right when you leave the pad, you're in a world of hurt. It's a different environment as you approach the acquisition of the system."

As the WDD conducted the concurrent development of the Atlas ICBM and the Thor intermediate range ballistic missile, Schriever proved to be both a visionary and outstanding leader during extremely rapid growth in his organization's responsibility.

"A year and a half later, in October of 1955, WDD became responsible for the first military space development program, called Weapon System 117L," said Waldron. "That was the point when SMC's predecessor became responsible for space as well as missiles, which was a profound change."

The Soviets increased the psychological and political pressure on the United States and the Air Force when they launched the world's first artificial satellite, Sputnik, using a Soviet ICBM booster, on Oct. 4, 1957.

Funding for ICBM and space programs rapidly increased due to the perceived "missile gap" between the United States and the Soviet Union. The WDD and its successor, the Air Force Ballistic Missile Division, reached historical milestones during those early years with the Atlas ICBM becoming operational in 1959, meeting the six-year deadline. Weapons System 117L evolved into three separate satellite programs in the areas of photo and electromagnetic reconnaissance and missile launch detection. The first successful U.S. military satellite program, the CORONA photo reconnaissance program, recovered its first satellite film capsule in 1960.

Over the next 40 years, the ICBM and satellite organization went through numerous changes as the Air Force worked with the development and operational structure, separating ICBM and satellite programs into separate organizations and bringing them back together again several times.

"It's unusual for an organization to be this old," said Waldron. "The origin of SMC's uniqueness is that space and missiles have always been very closely related. Sometimes missiles became such an important acquisition in themselves that they were large enough to split off, but most of the time they were managed together because they're so closely related. That's, I think, the origin of attempts to split them apart and put them

Gen. Bernard A. Schriever is seen with models of some of the missiles he was instrumental in developing as the leader of the Western Development Division.

Photo courtesy of Dr. David N. Spires

together again. They are so similar they can't really be managed separately. They use too many of the same systems. Yet sometimes they are so large in themselves that it is hard to manage both of them."

WDD started out as an organization focused on acquisition and development but transitioned into operations as ICBMs and satellite systems it developed came on-line. WDD's successors were worldwide organizations, with field units located around the world, operating remote satellite controlling, research, and launch facilities.

At the same time, these organizations were pressed with responsibility for the development and operation of some of the nation's most vital weapon systems.

Over the years, the organizations developed more advanced and economical systems. In ICBMs, the solid fuel, state-of-the-art Minuteman III and Peacekeeper missiles did their part to help win the Cold War. In satellites, numerous military satellite programs became more integrated into war fighting.

"As early as the Vietnam War we were supporting the warfighters," Waldron said. "In Vietnam, satellites, ground terminals, and data were provided for operations in weather, communications, and reconnaissance. The earlier Defense Meteorological Satellite Program ground terminals provided weather data in Vietnam that reduced the cancellation of sorties due to cloud cover, reduced the use of aircraft, and probably saved lives."

"Communication satellites were at an even earlier stage of development at that time. The first operational military communications satellite system, the Initial Defense Communications Satellite Program, became operational gradually between 1966 and 1968. It was used to transmit both voice and imagery to support military operations in Southeast Asia."

Operation Desert Storm in 1991 was called the first "space war" because satellite systems became more integral to warfighting and more visible to the public.

"Systems like the Global Positioning System (GPS) and the Defense Support Program began to be used tactically in Desert Storm," according to Waldron. "GPS had not even attained initial operational capability by the time Operation Desert Storm was carried out; but developers and operators repositioned the constellation of GPS satellites that had been launched up to that time to support operations in Iraq and Kuwait."

The Defense Support Program, in addition to its strategic mission of ICBM launch warning, began to be used in a tactical role in detecting SCUD missile launches by the Iraqis, which gave Coalition forces a vitally important capability of early warning of theater missile launches. Weather and reconnaissance satellites played even more important roles than they had in Vietnam.

In 1982, a major organizational change occurred when Air Force Space Command (AFSPC) was activated. Over the next several years, AFSPC gradually took over operational command and absorbed functions previously accomplished by SMC's operational field units. This created a 180-degree turnaround in the development and operations organizational structure from the first days of the WDD.

"Operators and acquirers were under the same organization in the early years, and they are also now, of course. But there is a difference," said Waldron. "In the early years, in the late '50s and early '60s when space operations first came into existence, the developers were at the headquarters and the operators were at the subordinate units operating the systems that the developers created. Now we have the reverse. The operators are at the headquarters, and the developers are supporting them by fulfilling their requirements."

Then in 1993, with the inactivation of the Ballistic Missile Office, SMC absorbed its mission and finally, after years of reorganization, a single unit was once again responsible for both space and missile program development.

A historical milestone and dynamic change occurred in 2001 as a result of recommendations to Congress by the Commission to Assess United States National Security Space Management and Organization, more commonly known as the "Space Commission." Headed by Donald H. Rumsfeld, now Secretary of Defense, the commission recommended realigning SMC from the Air Force Materiel Command (AFMC) to Air Force Space Command, bringing developers and operators under the one organization, as had been in the early days of the WDD.

Maikisch has been with the organization since 1973 and has seen many of the changes over the years. "The support we get from Air Force Space Command has been wonderful. We find that we're working things a lot better with the requirements community and budget activities. There's much more of a team environment. I think it has worked out to the nation's advantage."

Another major change recommended by the Space Commission and adopted by the Air Force affecting SMC, was to transfer from the Pentagon to the SMC commander the responsibilities of program executive officer (PEO) for Space. For the previous 10 years, all Air Force development program managers reported to a PEO at the Pentagon for their particular major acquisition area.

Today, Lt. Gen. Brian A. Arnold, Commander of SMC, not only reports to his major command, AFSPC, as PEO for Space; he also reports directly to Peter B. Teets, Under Secretary of the Air Force, for matters involving space acquisition programs.

"We have a much better, a more clear alignment now with Air Force Space Command," Maikisch said. "In the past, you had four organizations – AFMC, AFSPC, Air Staff, and SMC – and there were a lot of times when elements were talking to each other and not talking to the commander of SMC. With Gen. Arnold reporting directly to Mr. Teets, it's a much-simplified process. And what you're seeing happening now with the other PEOs moving out of Washington, I think that's an endorsement of the work that General Lance W. Lord, Commander of AFSPC, and Gen. Arnold and Mr. Teets have done in making this process work."

The high-priority and high-interest mentality of the early days has not diminished in 50 years, with space systems being so integrated into the warfighting processes in Iraq and Afghanistan. For example, the majority of bombs dropped in Operation Iraqi Freedom were guided by GPS to their targets. Warfighting commanders realize the vital importance of space assets and ICBM deterrence to winning future conflicts.

This system integration into warfighting processes could not have occurred without a multitude of people to make it happen, acknowledged Maikisch. It takes military members, Department of Defense civilians, contractors, and a unique nonprofit organization that does the systems engineering for space and missile programs – the Aerospace Corporation.

Photo courtesy of Dr. David N. Spires

Lt. Gen. Brian A. Arnold, Commander, Space and Missile Systems Center.

"Without the Aerospace Corporation, we would not get the job done," said Maikisch. "They are truly our Library of Congress. They know more about this business than anyone else in the world. They've got the talent, and because of their freedom from conflict of interest where they don't build any hardware, they get to see what all the contractors are doing, and nobody else in the world has that kind of perspective."

SMC is the premier acquisition and development organization today and the largest space activity in one geographic location in the world. The future of SMC promises steady growth and maturation as the nation looks to build follow-on systems for current navigation, communication, and missile-warning programs; to develop a follow-on for the Minuteman III ICBM to meet future asymmetrical threats; and to counteract the vulnerability of space systems by developing programs in space control and space superiority.

The changes to the organization over the past 50 years have brought the organization full circle in many ways. The changes recognized the ties that bind satellites and missiles and they improved SMC at the same time – which is why the brass makes all those changes in the first place.

INTERVIEW: GENERAL LANCE W. LORD COMMANDER, AIR FORCE SPACE COMMAND

By Scott R. Gourley

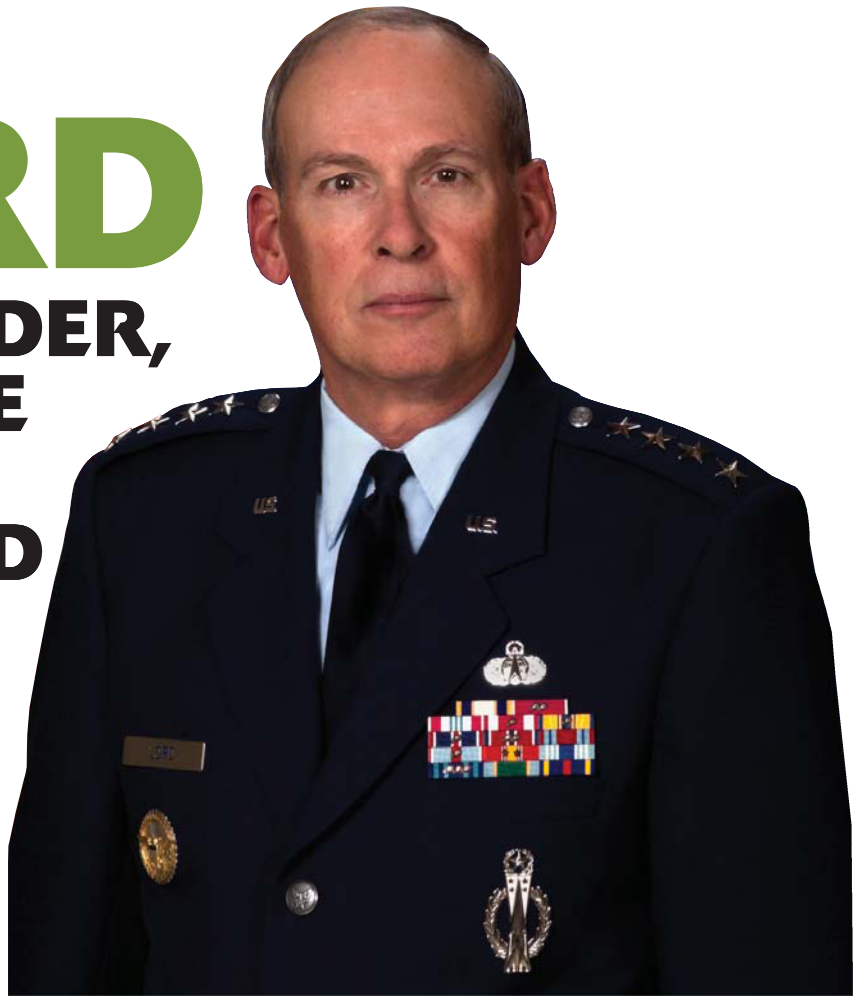


Photo courtesy of Dr. David N. Spires

From his perspective as Commander, Air Force Space Command, General Lance W. Lord looks at the current state of today's Air Force space forces with a mixture of respect and admiration for those who have gone before and pride in the individuals who are continuing the Air Force's space tradition.

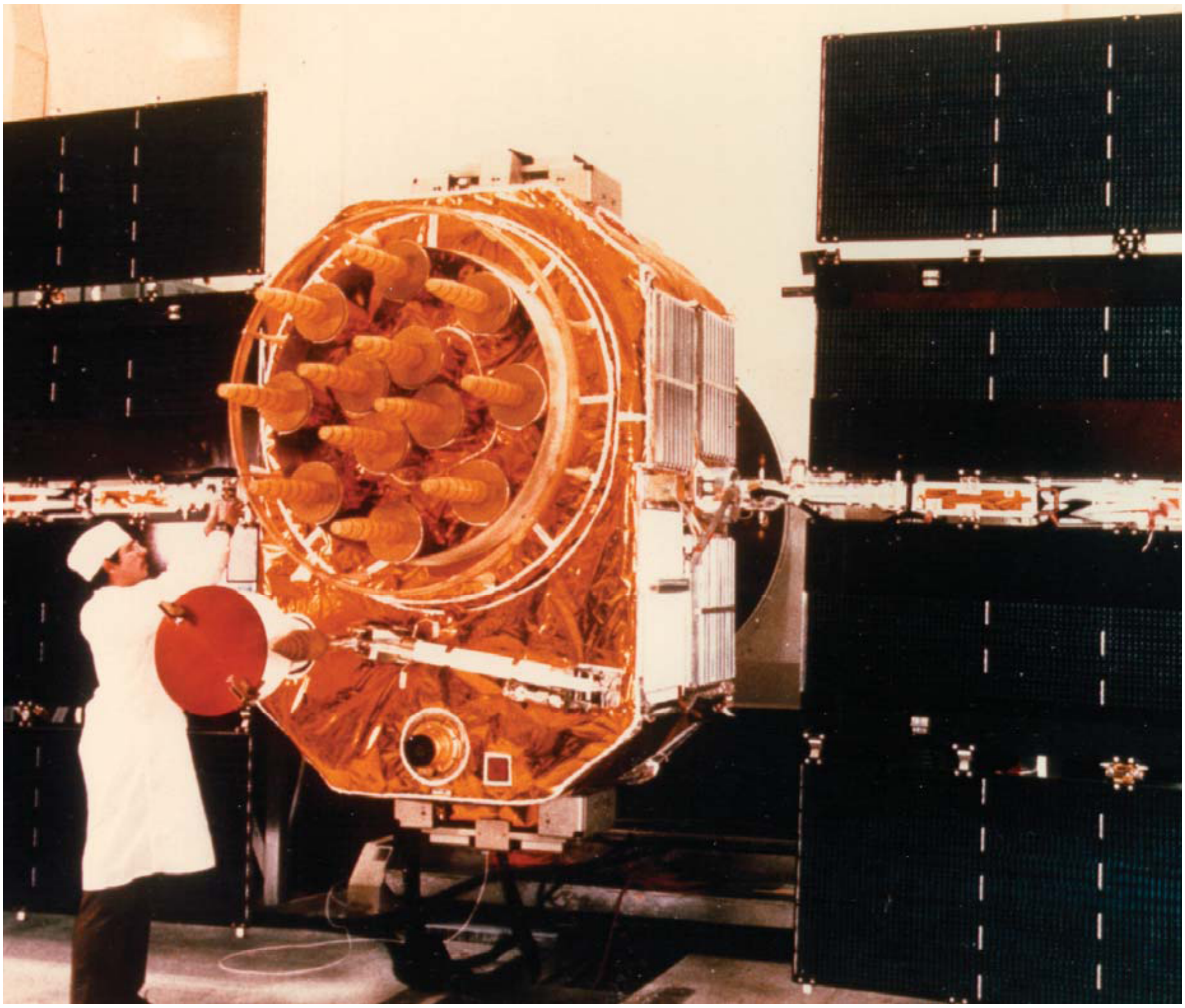
"As we look at Air Force involvement in the space and ICBM business from the half-century mark, we have to look back at what Gen. Schriever started at the Western Development Division, in Inglewood, in August of 1954," he said. "I've talked to Gen. Schriever in the years past and, as a matter of fact, spent a couple of hours with him in the last six months. He's still a vibrant force in this business."

"I think we've achieved the goals and objectives that he initially set out," General Lord continued. "In bringing our space and the missile force to the status it is today, we've brought unique capabilities to enable the forces on the ground to achieve victory. As I say, 'If you're not in space, you're not in the race.' And what we've proven is that you can't go to war and win without space. So, in the military sense, space is an essential part of what we're doing every day. In addition, in a broader national sense, space is becoming an 'economic center of gravity' for everything we do. We have an asymmetric advantage because of our space-based capabilities," he said.

As an essential element of daily military operations, General Lord observed that Air Force space assets are true enablers of other service and DoD "transformation" activities.

"For a long time, we've been talking about space as an enabler for other forces," he said. "You know, a day without space is really hard for the Army; it's hard for the Navy and Marine Corps; and it's hard for the Air Force.

"I think that space power really is transforming how we all do business," he continued, "because space provides the capability to do the things with position navigation and timing, with intelligence, with surveillance



Opposite: General Lance W. Lord, Commander, Air Force Space Command. Above: A Global Positioning Satellite (GPS) receiver undergoes testing in this photo. GPS first proved its military value in the Gulf War and became the premier system to demonstrate both military and civilian applications.

Air Force Space Command photo

and reconnaissance, with space weather, with communications. It provides the capability to shorten the distance between where we are and where we need to be. And it allows us to really be able to look over the next hill and work together in an integrated fashion with our joint partners."

In terms of joint operations, he added, "Space is inherently joint to begin with. It's really helped us shape the battlespace. It's helped us with precision engagement – to put less people at risk, to create a situation where we achieve our objective at less risk to our people, less collateral damage, and even fewer enemy lost. We've been able to substitute precision for massive forces. Space has really transformed the way we do business.

"But with every strength you have, you need to make sure you're not creating a vulnerability," he cautioned. "So we need to be smart about this transformation and make sure that we protect ourselves – to avoid making this a vulnerability. By that I mean that we really have to think seriously about 'Space Superiority.' We can't assume that space is going to be a benign environment. We have to assume that we're going to have a competition in that environment. In fact, we have already seen a little bit of that during Operation Iraqi Freedom when Saddam tried to jam our GPS systems. That competition in space is going to continue so we have to make sure that our forces are strong. Strong space forces are a deterrent, and we have to make sure that we set ourselves up to protect the assymetric advantage that we have."

"That's why I'm slowly shifting our gears from the force-enabling business to one where we actually think about defending our assets: doing the defensive kinds of things and the situational awareness things we need to do in space to make that shift. So in that sense, we're

U.S. Air Force photo by Master Sgt. Jim Varhegyi

Retired Gen. Bernard A. Schriever, 94, considered to be the father of the Air Force's ballistic missile program, joined hundreds of people gathered for the official groundbreaking and site dedication ceremony on the site of the future national Air Force Memorial on Sept. 15, 2004, in Arlington, Va. The 270-foot-tall memorial is designed to honor all those who have served in the U.S. Air Force and its predecessor organizations. General Lord credits Gen. Schriever with laying the foundation for Air Force Space Command.

starting to look at our command as a 'space combat' kind of command, if you will," he said.

In addition to the shift in mindset from force enabling to space superiority, another example of ongoing transformation activities can be found in the unfolding "Space Professional" program. According to General Lord, the program evolved out of the Rumsfeld Commission that addressed the management and leadership of space. "One of the observations that the Rumsfeld Commission made was that the nation was not yet at the point where it had created the space professionals that it needed to really prosper and continue to maintain our advantage in space," General Lord said. "The wording was along the lines of, unless we got really serious about doing space professional education and development, we could end up with a Pearl Harbor kind of event in space.

"So we had a pretty high level emphasis on making sure that the Space Professional Development Program was created," he continued. "And I think we've made tremendous strides since that document was published. Obviously, we had already had people working hard in the space business, but what this has done is to help us focus our efforts on the identification, training, and education of the cadre. It's challenging, but it certainly has a high payoff."

Space Professionals represent a subset of the broadly-defined space career field that encompasses a range of skills in communications, intelligence, maintenance, logistics, weather, and other arenas. "As a subset of that overall group, the Space Professionals consist of the scientists, engineers, program managers, and operators who are principally responsible for taking our military space programs from idea through development, through operation and sustainment of those systems," he said.

General Lord outlined a five-step program that provides the foundation for Space Professionals. "First, we identify, by name, each and every member of that cadre," he said. "It took us about six months to go through everybody's records and folders, but now we've got the individuals identified. Second, we constructed an educational continuum that had a variety of courses to better prepare these individuals. Third, we created a level of certification; what we call 'Space 100, 200, and 300,' and we'll have a corresponding 'Space Level I, II, and III,' so that we have a way to identify the kinds of education packages that we need. That certification also provides a feedback mechanism for people to know kind of where they are on track in education, training, and experiences. Fourth, we're currently taking a look at every billet that we have in the space business to make sure that we've got it codified for the right kind of people with the right kind of experience and the right kind of education – so that we make sure we have the right certified people working in those jobs. Then, when those four steps are complete, our fifth step will be to make sure that we deliberately build space professionals. I am the space career field manager, and we will synchronize the building of space professionals with all of the force development that's going on in the rest of the Air Force."

When asked to comment on what he perceives to be the greatest Air Force space successes over the last half-century, General Lord pointed to the 1954 creation of the Intercontinental Ballistic Missile force. "We can never forget that this is what Gen. Schriever laid the foundation for us to do," he said. "Then, two years after that, he was given the job of creating the first satellite program. But the things he started in 1954 with the Intercontinental Ballistic Missile force have been carried on through today by this command and the professionals that we have here."

He added, "We've got about 10,000 folks at Air Force Space Command who 'live north of Interstate 80' and work in the foundation of our business, the ICBM nuclear deterrent mission. They work in an ICBM force that has been modernized over the years. These people are proud members of the Space Professionals Team, and they're working hard to keep that mission going. It's truly amazing to me to look back to the '50s and early '60s and realize that we're still using some of Gen. Schriever's technology – albeit rapidly improved in some great ways – to underpin the fundamental national security strategy of the United States. As General John P. Jumper, Air Force Chief of Staff, says, the ICBM business is our 'Top Cover' for everything that we do. And that kind of fundamental deterrent work and operational capabilities are reflected into our other space folks as well. After all, we have a great blend of space talents in this command."

In terms of more recent success stories, General Lord observed, "Immediately following Operation Desert Storm we saw what we could do with the integration of space capabilities into terrestrial operations. The concept of precision strike was just being invented. And that concept and ability has evolved over the last 10 years. As demonstrated during Operation Enduring Freedom and Operation Iraqi Freedom, ... you can't go to war and win without space."

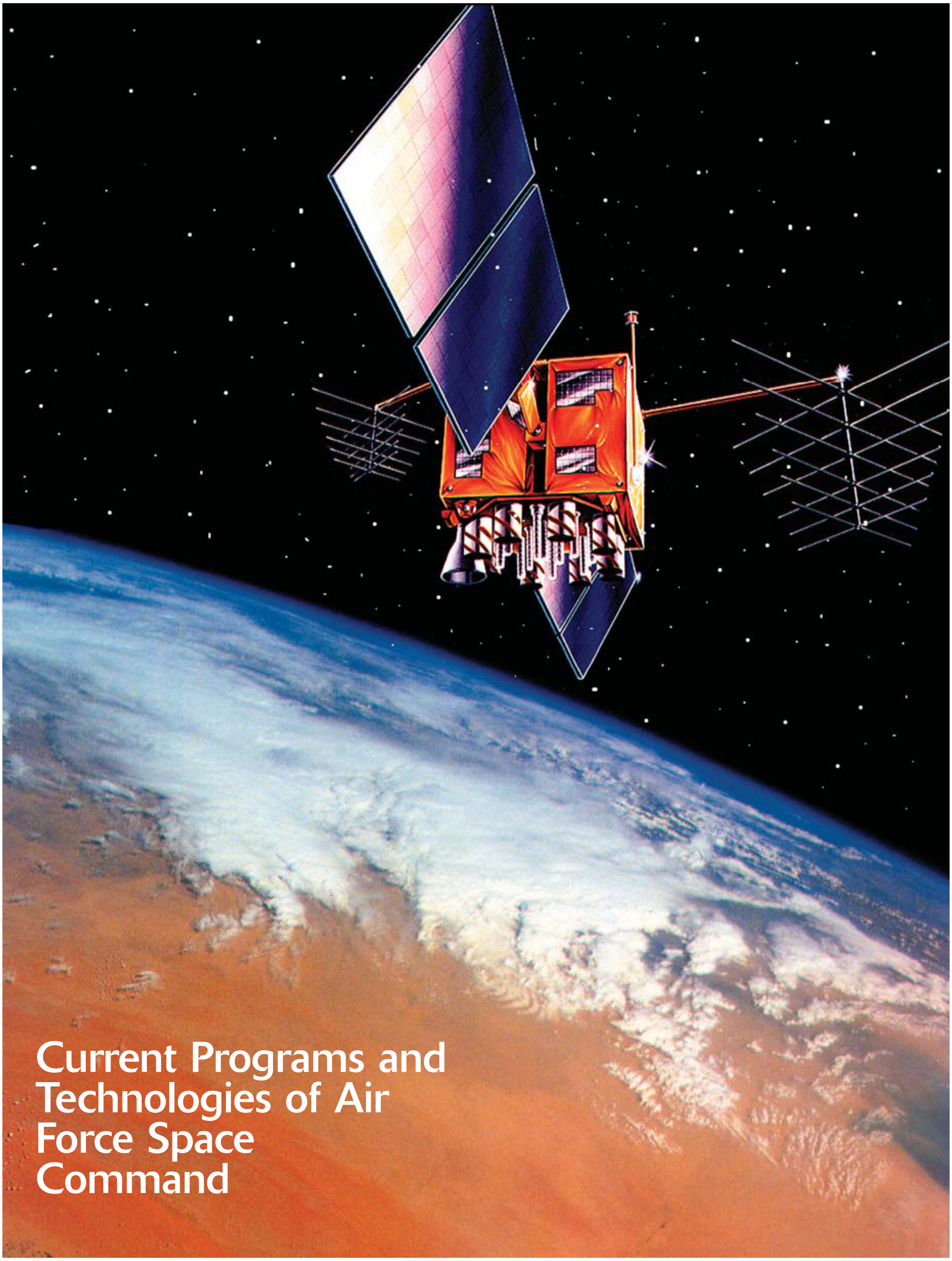
Looking toward the future, General Lord sees challenges in terms of personnel and organizational thinking. "First, from a personnel standpoint, I think we've got to make sure that we maintain, educate, and continue to track the great young people that make the system work," he said. "I sat down recently with Mr. Sean O'Keefe, the NASA administrator, and we talked about recruiting smart, young engineers and scientists from the public sector. I think we're going to face a nationwide challenge here to make sure we can re-instill interest in math and science and the kinds of things that we need to help us maintain our edge in technology, engineering, and education. Those are the fundamental drivers for what we're going to be doing. So we need to continue to track and retain the great professionals in the business.

"From an organizational standpoint, I think our greatest challenge is in making sure that our nation understands how important it is to maintain our superiority in space. It's no different than air superiority or land superiority or sea superiority. 'Space superiority' has to roll off our tongues as easily as any of those other terms. We've gone from a nation that's interested in space to a nation that's got national interests in space. And we've got to protect those interests. So we'll continue to do what we do to make sure that we're fully integrated with the air, land, and sea operations."

He reiterated, "Space is inherently joint, and we're involved in all service activities: Army, Navy, Air Force, Marines, and Coast Guard. Everybody uses position navigation and timing and our other products from space. And I think what it's enabled us to do is help us ensure precision and accuracy, allowing the substitution of precision for mass. I think that's one of the single greatest advantages of our force. As General Jumper talks about it, we're able to find, fix, target, track, engage, and assess faster. We've been able to minimize the time in that chain of events so that we can do what we need to do; getting in and getting out and achieving our objectives while putting less people at risk."

General Lord concluded, "We want to make sure that we maintain space superiority and understand that in all of our planning and in all of the things that we do, space can't be an afterthought. It can't be '*and* space.' It's got to be 'space' from the beginning. So we're working hard on what we call our Space Superiority campaign planning, getting involved with all our colleagues in the other services to make sure they understand the challenges. We're all working together to continue to protect our advantage in space."

Current Programs and Technologies of Air Force Space Command



Lockheed Martin Photo

An artist's conception of a GPS satellite. A new generation of modernized GPS satellites is being launched.

COMMANDING THE FUTURE

By Scott R. Gourley

As part of his overview of Air Force Space Command, General Lance W. Lord identified a number of evolving programs and emerging technologies that will help to maintain America's asymmetric advantage in space.

SPACE PROFESSIONALS

One underlying key to the successful application of all other technologies and programs noted by General Lord is the identification, development, and maintenance of a team of trained space professionals. In addition to their vital role within Air Force space programs, those Air Force space professionals fall within a larger DoD recognition that the most crucial element of space power is found in a nation's space professionals.

For example, in his own July 22, 2004, testimony before the House Armed Services Committee, the Honorable Peter B. Teets observed, "In my role of overseeing National Security Space activities as Under Secretary of the Air Force, Director of the National Reconnaissance Office (NRO), and the DoD Executive Agent for Space, I am committed to preserving our advantage as the world's leading 'spacefaring' nation. I am pleased that this committee shares that commitment, and that we all recognize the need to develop well-educated, motivated, and competent people who are skilled in the demands of the space medium."

Speaking before the same Congressional committee, General Lord echoed the sentiments expressed by Teets, observing, "As you know, the Secretary of the Air Force along with our Chief of Staff of the Air Force, General John P. Jumper and our Under Secretary, Mr. Peter Teets, have made developing and maintaining our space professionals a top priority for our nation. Our people remain our most important and precious resource. Personnel knowledgeable on the medium of space and highly skilled in their respective fields of operations, developmental engineering, acquisition, and research are indispensable to our success today."

General Lord went on to outline the multi-step process of developing the Space Professional Team, adding that as of late July, the majority of the requisite Space Education Courses had been consolidated into the Space Operations School in Colorado Springs, Colo., now known as the National Space Security Institute. "Our vision is to evolve the National Space Security Institute into the center of excellence for space professional development across all organizations, with the help of our partners in the Department of Defense and the Intelligence Community," he said.

In a more recent interview, General Lord revealed that considerable additional progress has been made in Space Professional training. "We've got our National Space Security Institute here in Colorado, which will be the umbrella organization that will look at all Space Professional education. We've made entrees and established agreements with universities here in Colorado, as well as distance relationships with other universities, to create a system where people come into the business and all the military training they've received transfers to college credits. Those credits will follow them and be articulated across a broad set of schools and universities interested in space education. We're really developing a center of gravity to prepare the force to do just exactly what the space commission wanted us to do."

General Lord and other Air Force representatives are also quick to highlight the contributions of the supporting contractor personnel. "We talk about 'Mission First/People Always,' and our space professionals are a wonderful group of folks," General Lord added. "We cannot accomplish our mission in Air Force Space Command without the dedication of a great team. We've got about 40,000 people in our command, and a key part of our command is the contractor force. We've got credentialed space warriors, and a lot of those folks are supported by part of our contractor team. Sometimes we think that 'blue suits' are the answer to everything, but in many cases we've got a force that's made up of some wonderful civilians as well as some wonderful contractors who are every bit as dedicated."

ASSURED ACCESS SPACE SUPERIORITY

Two other concepts that seem to go hand in hand are Assured Access and Space Superiority. "Mr. Peter Teets, the Under Secretary of the Air Force, pushes hard on mission assurance," General Lord observed. "That's something we take very seriously, and we work that hard. Obviously, challenges for the future include assured access to space – making sure that we've got what we need to put our assets in space and protect them once they are there."

Assured access to space lays the groundwork for several themes emerging from Air Force Space Command. The themes are somewhat sequential in nature, beginning with the need to enhance space situational awareness to provide planners with a better understanding of "what's out there."

In turn, that understanding will establish the groundwork for a range of defensive counterspace capabilities. These capabilities will help defend U.S. systems in space as well as the links and nodes that deliver that space product to users on Earth. An example can be found in the constellation of Global Positioning System (GPS) satellites. In FY05, the Air Force will begin launching a new generation of "modernized" GPS satellites, featuring military-code and flexible power capabilities. Even greater defensive capabilities will be incorporated in the "generation after next," known as GPS III satellites, which will reportedly include all of the legacy capabilities, plus the addition of high-powered, anti-jam military code, along with other accuracy, reliability, and data integrity improvements.

An artist's conception of the Falcon Small Launch Vehicle, which is an attempt to develop an affordable and responsive launch capability.

Lockheed Martin Photo

When defense isn't enough, the sequential themes move to offensive actions, the ability to reverse the effects or capabilities of those who might try to use space against the United States.

Finally, an emphasis on emerging command and control programs will ensure a seamless structure of nodes, links, and systems. An example of this emphasis on command and control can be seen in the Advanced Extremely High Frequency (AEHF) system that will replace the MILSTAR communications constellation. The first AEHF satellite is slated for launch in FY07 and will provide survivable, protected satellite communications for strategic and tactical users. AEHF represents a significant step forward in capability over current systems, providing up to 12 times greater capacity than MILSTAR with up to 4,000 simultaneous networks while hosting up to 6,000 users per satellite.

EVOLVED EXPENDABLE LAUNCH VEHICLE

One of the programs that will support America's assured access to space is an Air Force space lift modernization program called the Evolved Expendable Launch Vehicle (EELV). Designed to reduce the cost of launching by at least 25 percent over current Delta, Atlas, and Titan launch systems, EELV features a partnering with industry to develop a national launch capability that satisfies both government and commercial payload.

The two primary launch contractors are Lockheed Martin and Boeing, with their respective variants being the Atlas V and the Delta IV. Atlas V achieved initial launch capability in August 2002, with the Delta IV achieving the same milestone in November 2002.

"And we're working on additional breakthroughs and concepts to modernize our capabilities," General Lord added. "One of those concepts that we're really excited about is called Joint Warfighting Space, where we'll be able to launch quickly with a payload that will be available for a theater commander to use to support a particular contingency or operation. And we'll be able to do it in hours as opposed to the weeks or months that a normal payload might take.

General Lord's comments echoed a February 2004 House Armed Services Committee appearance by Under Secretary Teets. "We are proud of the success of both families of Evolved Expendable Launch Vehicles (EELVs)," Teets said. "With six successful launches in a row, three from each provider, these are the best launch vehicles we've ever produced. However, we are not finished yet. Long-term, we are pursuing vehicle concepts that can be launched on demand – in hours and days, rather than weeks and months – with the vision of fulfilling time-critical warfighter requirements. I've been in the launch business for 45 years, and we still launch satellites about the same way we did in the '60s. We can do better. The intent of Operationally Responsive Space (ORS) is to create a more responsive, reliable, and affordable lift family capable of fulfilling both current and future launch requirements, and the corresponding responsive and affordable satellites. Near term, we plan to demonstrate a more responsive and less expensive launch system with capabilities of 1,000 pounds to low Earth orbit. Concurrently, Air Force Space Command, AFRL, the NRO, DARPA, OSD's Office of Force Transformation, and our national and Service laboratories are sponsoring Tactical Satellite (TacSat) initiatives focused on responsive satellites and decreasing the size, cost, and timelines of development. The combined efforts of these initiatives – operationally responsive launch and satellite development – will transform the delivery of space-based capabilities. Similarly, our launch ranges must keep pace with modernized launch vehicles and future launch manifests."

An example of one of those initiatives can be found in the "Falcon" Small Launch Vehicle (SLV). The goal of the program is to develop and demonstrate an affordable and responsive space lift capability. In mid-September 2004, the Defense Advanced Research Projects Agency (DARPA) and the U.S. Air Force awarded funding to four teams for the second phase of the Falcon SLV effort. The teams included: Airlaunch LLC; Lockheed Martin Corp., Space Systems Co.; Microcosm Inc.; and Space Exploration Technologies Inc.

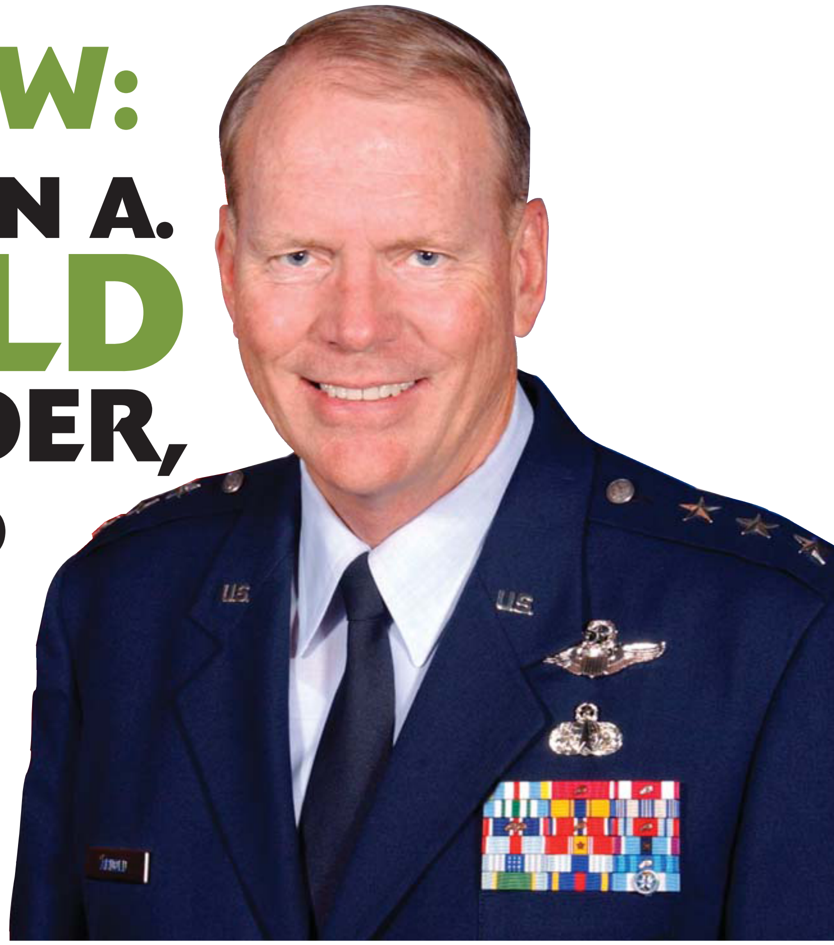
Under the 2004 award agreements, each team will conduct a 10-month phase IIA preliminary design and development effort to mature their launch vehicle designs. In addition, one of the companies, Space Exploration Technologies, will conduct an early, responsive launch demonstration. In 2005, DARPA and the Air Force will select one or more of the phase IIA teams to conduct detailed design and fabrication of their launch vehicle. That phase IIB effort will culminate in 2007 with flight tests to launch a small satellite to validate vehicle performance.

In addition to DARPA and the Air Force, NASA has also expressed interest in the Small Launch Vehicle capability and is a formal partner in the Falcon Small Launch Vehicle development program.

Along with new vehicle systems, Air Force planners are also looking at the modernization of existing platforms. "We'll also continue to modernize the ICBM force," observed General Lord. "And we'll look at the speed, range, lethality, and accuracy capabilities of an intercontinental ballistic missile and resulting potentials for offering non-nuclear options for the future. Using conventional warheads, those modified systems could give our commander-in-chief additional options should we be involved in an anti-access situation in the future."

Much of the Air Force examination of these capabilities has been conducted under a concept called the next-generation Land Based Strategic Deterrent (LBSD). Outlining the LBSD concept in a request for information (RFI) released in the fall of 2003, the government noted that, "Air Force Space Command (AFSPC) is investigating potential concepts to support the LBSD Analysis of Alternatives (AoA) Study for the next generation deterrent system. This RFI initiates a concept call for transformational delivery vehicles meeting the Land Based Strategic Nuclear Deterrent Mission Need Statement (MNS) and LBSD Concept of Operations (CONOPS). In addition, the AoA will study each concept's potential as a multiple-use platform; that is, how it might satisfy, or partially satisfy, other AFSPC mission needs such as Prompt Global Strike and Operationally Responsive Spacelift. Concepts should address enhanced performance, decreased manpower and reduced maintenance and operations footprint. Commensurate with this concept call, this RFI requests an assessment of the feasibility, technical maturity and growth potential of the enabling technologies for each concept. This is one of multiple RFIs that will address the entire next-generation deterrent system. The Air Force anticipates a future competitive evolutionary acquisition program starting in 2005 or 2006 to begin replacing the existing system in 2018. This RFI includes the following sub-system areas: propulsion, guidance, re-entry systems and re-entry vehicles. The next-generation deterrent system may be based in existing Minuteman III (MM III) silos, with significantly updated supporting infrastructure, where necessary. The system may also use innovative deployment and basing strategies in addition to or in place of existing MM III silos, including but not limited to: mobile basing, fixed basing with mobile elements, new silo schema, etc."

INTERVIEW: LT. GEN. BRIAN A. ARNOLD COMMANDER, SPACE AND MISSILE SYSTEMS CENTER



U.S. Air Force photo

By J.R. Wilson

A command pilot with more than 3,100 hours in both fighter-bombers and heavy bombers, Lt. Gen. Brian A. Arnold is no stranger to the navigation and communications needs of today's warfighter. Add to that previous postings as Director of Requirements for Air Force Space Command (AFSPC), Director of Space and Nuclear Deterrence in the Office of the Secretary of the Air Force for Acquisition, and commander of the Air Force Materiel Command's (AFMC) Space and Missile Systems Center (SMC), and he came well-equipped to his current post as commander of AFSPC's Space and Missile Systems Center.

SMC began life in 1954 as the Western Development Division for the newly created U.S. Air Force. Today, it – and its commander – are responsible for managing more than 6,500 SMC employees and a budget exceeding $10 billion each year on research and development, acquisition and sustainment of space launch and command and control for both missile and satellite systems, and Intercontinental Ballistic Missiles.

In addition, as Program Executive Officer (PEO) for Air Force space, Arnold has oversight responsibility for many of the nation's most important military space efforts, including the Air Force Satellite Control Network, space lift ranges, launch programs, the Evolved Expendable Launch Vehicle Program, the Space-Based Infrared System, military satellite communication programs, NAVSTAR Global Positioning System programs, intercontinental ballistic missile programs, and the Defense Meteorological Satellite Program, as well as emerging transformational space programs such as space-based radar, and a portfolio of space superiority system programs.

50 Years of Space and Missiles: Briefly, how would you describe SMC's role – and any significant changes to that – within the reorganized military space command?

Lt. Gen. Brian A. Arnold: Our role is the acquisition center of excellence for Air Force Space Command. We're also the center for space innovation, for new techniques, new technologies, and new ways to use space systems.

The most significant change occurred in 2001 – when we moved from AFMC to AFSPC. This was an organizational change recommended by the Space Commission.

Can you provide a brief overview of near-term new programs and SMC's role, such as:

a. GPS III

b. The Transformational Communications MILSATCOM program

c. The Advanced Extremely High Frequency program intended to replace MILSTAR?

In each of our mission areas, we're modernizing and upgrading our systems, as well as transforming and sustaining. In the area of communications, we are bringing on a new set of satellites, such as the Wideband Gapfiller Satellite (WGS), which will see the first satellite launch in December 05. Shortly after that, in the 2008 timeframe, we will launch our first Advanced EHF Satellite. And we are in the early stages of development on our Transformational Satellite Communications System, known as TSAT. So, in all areas of communications, we are increasing bandwidth and capabilities, along with protected communications for our warfighters.

In the warning area, we have one more Defense Support Program (DSP) satellite to launch, which is our non-imaging IR [infrared] system at geo [geostationary orbit]. We will be replacing those with the newer Space-Based Infrared System [SBIRS] sensors, both in the highly elliptical and geo orbits. We also are continuing to develop the Space Tracking and Surveillance System, which is really a Missile Defense Agency system, but we manage it here at the product center. It's basically a SBIRS low system. We're incorporating all of these into our warning constellation.

In the area of weather, we will continue to support the Defense Meteorological Satellite Program [DMSP] with four more DMSP satellites, while moving on to the new National Polar Orbiting Environmental Satellite System. Those are great opportunities to increase our capabilities in the weather arena.

In navigation, we have 30 operational satellites on orbit today, probably the most robust navigation constellation we've ever had. We will continue to modernize that with approximately eight of the GPS IIR-M satellites. We will continue to develop the GPS IIF and then the GPS III. In all cases, we will increase the capability, accuracy, as well as protection, of the signal.

On the GPS handheld terminal side, we've also developed an enhanced survival radio system called the Combat Survivor Evader Locator (CSEL). CSEL is needed to enhance our Combat Search and Rescue response capabilities to quickly locate, identify, and communicate with isolated personnel, independent of their location or circumstances. Fielding started this year with the U.S. Navy, and the U.S. Army will deploy to Operation Iraqi Freedom with CSEL early next year. Over 3,000 radios have already been delivered to the services. Full-rate production award is planned 2nd quarter FY05.

In ICBMs, we are continuing to modernize propulsion and guidance replacement programs and looking out to the end of the next decade replacement of this ICBM with some newer system that may even have a conventional capability.

We're interested in space situational awareness for surveillance, understanding what's out there and what other satellites are up to. To do that, we are upgrading our ground control systems as well as developing a new space-based space surveillance system, the SBSS, and will have a pathfinder of that system flying in the next two to three years.

In offensive and defensive counterspace, most of our space systems are very fragile. We have been directed by the Space Commission to prevent any kind of Pearl Harbor in space, and we are taking action to do that.

Lockheed Martin Space Systems image

An artist's conception of an Advanced EHF satellite is seen here. The first of the communications satellites is set to be launched in the 2008 timeframe.

We're upgrading our launch ranges by automating many of our systems, enabling the range to turn around much more quickly than in the past, and going to GPS metrics tracking, which will allow us to take down some of our older radars and save money.

We're also focused on some innovative areas in responsive space, such as a responsive booster and a smaller responsive satellite. We're looking at developing a small responsive booster in the $5 to $10 million neighborhood that could be responsive within a day or two of call up. Riding on top of that – a small responsive satellite. Those boosters will allow us to put a satellite on orbit in support of a theater warfighter, to fill a gap they may have in some area, such as ISR or communications.

What challenges are you facing in terms of managing requirements and what are you doing to improve the requirements process?

In terms of requirements, we have suffered through a period where we did not lock down the program requirements. This made it very challenging to manage a "floating baseline." We have now moved to a disciplined "urgent and compelling need" requirement process where AFSPC HQ controls new requirements, and we do not accept new requirements without proper funding.

What, if any, significant changes did September 11 bring about for SMC? For example, has there been an accelerated acquisition strategy to bring new technologies on line earlier, such as an emphasis on spiral development and rapid fielding?

I'm not sure there have been any accelerated strategies. But there has been a fundamental change in our thinking about the absolute necessity of the space system and its contributions, both during warfighting and our global war on terrorism.

The pressure that puts on the national security space acquisition process in terms of mission assurance and program execution has never been higher.

It also has increased the criticality of our mission and led to the [Air Force] Chief of Staff's recent push for space to be more tactically oriented, what he calls the "Joint Warfight Space (JWS)." We're working both with our transformation and development directors and with the other labs out there, such as AFRL [Air Force Research Laboratory] and DARPA [Defense Advanced Research Projects Agency], to explore a whole range of both launch and space vehicle capabilities, to be cheaper and more responsive to the tactical warfighter than the large systems we have today.

Now that we have the PEO and the commander of SMC under one hat, we have direct relationships with AFRL in what we call PEO-TEO [technical executive officer] reviews, where we continue to ensure vital linkage between the technologies we are developing in the labs and the end user, the warfighter in the field. This process enables us to rapidly transition new technology into the hands of the warfighter by ensuring that no technology is developed without an endgame in mind. We are the interface for that. We developed a science and technology roadmap, for example, to help push those leading-edge technologies into the hands of the warfighter much quicker.

What is the most challenging aspect of your business?

Probably the most challenging thing we face in space is the front-end development of a satellite. This process must be very rigorous and disciplined, because space is not a very forgiving place. It is very challenging to build a satellite. First you must put a lot of testing at the box and total system level up front, then it must go through this horrendous launch environment, with a lot of thermal and acoustic vibration, and finally the satellite is expected to work on orbit. So you have to put the satellite through that kind of rigorous test environment on the ground first to make sure it will work on orbit. All this presents a heck of a challenge. And finally the satellite is expected to last for many years, even though the environment of space is very harsh and unforgiving. It's a binary business – either it works or it doesn't. And you don't have the option of going up there to fix it.

Unlike the airplane business, which I've been in for most of my career, you also don't have the advantages you do in testing airplanes, where you can do slow-speed taxis, high-speed taxis, you can take off and leave your gear down if you have a bad day. In our business, once you light the fire on that rocket, it either goes or it doesn't. Which is why roughly 70 percent of our investment is in development and the remaining 30 percent on operation and maintenance, which is just the opposite of the airplane business.

You mentioned efforts to defend these satellites. Are there any programs coming along – or do you see a need for any specific efforts – in the area of on-orbit self-defense?

There are many areas you have to worry about in defensive counterspace. First of all, the ground control stations themselves, particularly the ones overseas, which we need to protect through normal security processes. Then you have the uplink signal, the downlink signal and, lastly, the satellite on orbit. The easiest way to attack a satellite is the signal itself, with some kind of interference. So, we are looking at various ways to protect the system, such as detecting whether or not the satellite is under attack. We are developing a new system called Rapid Attack Identification, Detection and Reporting System (RAIDRS), which we are looking at to see what is actually happening to a satellite if we see an anomaly. We don't have such a system today, so if we have a malfunction of a satellite on orbit, we really don't know whether someone is tinkering with it or it is suffering through an onboard abnormality.

In the area of offensive systems, we are looking at counter-communications systems and ways to use reversible effects against other satellites.

As the acquisitions agent for military space, what role does SMC play in dealing with diminished manufacturing sources and technology insertion strategies?

When we start a program, the first thing we do is look at what technologies are available and the maturity of those technologies. Under our new National Security in Space Directive 03-01, we form what is called an IPA – [Independent Program Assessment] – led by a senior leader who has experience in program management. The IPA does an industrial base look to see if the companies that are going to bid on this project have the capability and capacity both from the technology bases as well as from the production base – how are they tooled up, are their subvendors qualified, what is their past performance – then we get a good scope on what they are capable of producing. We also perform a detailed independent estimate of the price of the system in terms of development and production, including not only the hardware but the software. In the past we have underestimated the complexity of the software, so we have placed much more emphasis on this area.

We are focusing our independent cost assessment on what we call 80 percent cost confidence, versus the old 50 percent cost confidence we've used before.

We just had a review by the Defense Science Board, looking at areas we need to really focus on. One of their recommendations was to put more management reserve in for the program manager in order to handle those unknowns that typically pop up in our challenging space programs.

Does all this planning ahead for a loss include putting more spares on orbit?

No, I don't think so. That's been a traditional idea, but it hasn't been a very effective thing to do because the satellites on orbit are spending fuel just on station keeping. What we generally do, based on the Broad Area Review done at the end of the 1990s, is emphasize the need to order a spare satellite on the ground in case we lose one during launch.

The more we become dependent on space, don't we become more vulnerable to attacks in that arena? How do you plan to protect against those, both detection of the attack and response to it, to save the satellite and its capability?

We're really not at liberty to discuss our tactics, techniques and procedures (TTPs), but once you confirm a satellite is under attack, then the command takes the proper TTPs. That could be maneuvering. Or it may be a hardened satellite, such as what we have done with MILSTAR. We've also developed rad-hard parts because our satellites in middle Earth orbit (MEO) operate in a harsh radiation environment to begin with; as a consequence, that also protects you against some kinds of attack.

What other steps are you taking today to ensure we have the most modern systems in space?

When we build a space system today, we are interested in making sure it is horizontally integrated with our air and space systems. No longer do we have the luxury of just building a space system that is stove-piped. It must be able to send information down to the warfighters, regardless of who or where they are. Right now, space is an unrivaled advantage to the U.S. and is becoming increasingly more integral to warfighting operations. Our space capabilities are more important to the warfighter than ever before, so we need to emphasize network-centric warfare and the tactical use of our space capabilities, which I believe will continue to grow in importance as part of the ongoing transformation of our joint warfighting. It is vitally important these warfighting capabilities come to fruition. That's why our priority here at the product center is mission success.

To emphasize that, we have currently had 39 launches in a row without a failure. Typically, you lose one out of every 10, so there is a cost avoidance there that is due to an emphasis on mission success.

Lockheed Martin Missiles & Space photo by Russ Underwood

A Lockheed Martin technician inspects a U.S. Air Force MILSTAR satellite solar panel.

SPACE-BASED TECHNOLOGY

Lockheed Martin image

By J.R. Wilson

It is now conventional wisdom that Operation Iraqi Freedom was the first true space war, not only because the United States, and thereby the coalition, relied on space-based assets on nearly every front, but because the enemy attempted to block at least one of those assets – an unsuccessful effort by Iraq to jam the GPS signal that is at the heart of U.S. precision weapons.

Space made its initial entry into public awareness during the first Gulf War, where roughly 10 percent of weapons employed in ousting Iraqi invaders from Kuwait depended on orbital assets, with the remainder made up of "dumb" munitions. By the time of OIF, some 12 years later, those numbers were reversed. That was possible as the result of a decade of restructuring, which culminated in the transfer of most responsibilities from the U.S. Space Command to the U.S. Strategic Command (USSTRATCOM), with the Army and Navy Space Commands folding the bulk of their efforts into the enhanced Air Force Space Command (AFSPC), although both have retained some service-specific efforts.

Noting Air Force Secretary James Roche has said OIF represented space becoming a full and equal partner with air-land-sea, Maj. Gen. Mike Hamel, Commander of the 14th Air Force, said he sees it more in terms of space coming of age for the joint warfighter.

"The most striking thing is, while we used space extensively throughout the Cold War, OIF was the first time we really used space in a comprehensive way in all joint operations – air, land, Special Ops – all the way from planning the campaign to how we execute, to individual aircraft sorties, munitions feeds, etc. So it was extraordinary in terms of how it was integrated," he said.

Fourteenth Air Force serves as USSTRATCOM's space task force, responsible for the organization, training, equipping, command and control (C2), and employment of AF space forces to support operational plans and missions for U.S. combatant commanders and air component commanders.

"Military space will continue to grow, perhaps exponentially," Hamel predicted. "Once you put capability into the hands of end users, they begin to innovate ways to exploit capabilities we space providers can't even begin to imagine. GPS might just be considered a satellite to help navigation, but it helped precision warfare and synchronization, making it truly pervasive in terms of how different forces can exploit that kind of accuracy and precision. The same is true with other space assets, from communicating with friendly forces to tracking the enemy."

AFSPC Vice Commander Lt. Gen. Dan Leaf agrees, but said that increased awareness also has its drawbacks.

"We have a much closer connection with the developers today, but still face challenges of time and money. We are paying the piper for acquisition reform and budgetary choices made, in some cases, a decade ago. As a result, it is taking too much time and money to deliver space-based capabilities," Leaf said, a frustration only heightened by OIF. "During OIF and OEF, we had a large number of space professionals deployed to the theater, which gave us direct combat experience and a better appreciation of what the warfighters in harm's way now need."

Maj. Gen. Doug Fraser, AFSPC Director of Air and Space Operations, said most terrestrial warfighters, as well as pilots flying above them, already take for granted that the capabilities provided by space assets such as GPS will be there when they need them, even though GPS only got into aircraft on a routine basis in the last five years.

"Our ability to attack targets has improved greatly since Desert Storm, where we had a limited capability for precision guided munitions, most of which were laser-designated. Now, with GPS-aided munitions and our ability to carry those on bombers or fighters, I can attack multiple targets from the same aircraft on the same sortie. That has had a dramatic impact on our ability to support ground forces," he said.

"MILSATCOM is another area where the warfighter assumes it will be there. We've gotten so used to the communications capability – 80 percent using commercial satellites in OIF – that we've become very dependent on space-borne satellites, military and commercial. As we get more precise in our ability to apply force, the demand for information to do that precisely has grown dramatically."

But the more important those assets become to the United States, the greater effort adversaries will put into trying to thwart them, he added, making the ability to defend U.S. space assets while denying the enemy any he might have an increasingly important part of military strategy.

"We don't have anything on our books right now that will deny an adversary the use of GPS, and I think we

U.S. Air Force photo by Staff Sgt. Jessica Kochman

Opposite: An artist's rendering of a Space Based Infrared System (SBIRS) satellite in space. Above: A weapons loader prepares a GBU-31 joint direct attack munition (JDAM) for a mission at a forward-deployed location during Operation Iraqi Freedom. Smart bombs like the JDAM comprised a majority of the munitions used during the operation.

should pursue that. There was an attempt by Iran, just a few months after OIF, to deny Voice of America broadcasts by jamming the frequency," Fraser said. "I think we'll also be working that area, trying to deny the ability of others to communicate. We will look for those ways we can provide/deny the use of space effects in a reversible aspect – deny the effect, but not kill the capability."

Whatever the advance may be, it ultimately must be directed toward the ability of U.S. forces to maintain the upper hand against any enemy. From World War II to the first Gulf War, that has meant air superiority, which has become virtually a given in recent military confrontations. In the future, even that may depend in large part on a new paradigm.

"To protect our systems, we must think space superiority. We look at air superiority as an inherent right of the American warrior. The last time U.S. forces were bombed by enemy aircraft was April 1953," Leaf said. "Space superiority is assumed, not just by the military, but also by the civilian population. If we don't protect our space capabilities, the commercial economic potential is even greater than loss of the military capability. We can't allow an evil-doer, who draws no line between civil and military, to affect the world that way. We saw their lack of respect for boundaries on behavior on September 11. If al-Qaeda or a similar group wants to impact the whole world, they could do it in a heartbeat by attacking space capabilities. We can't let that happen.

"We need to be able to recognize an attack on our system with a responsive situational awareness. And we must be able to deny the enemy, which is a difficult balance to strike – denying an enemy and still allowing all the commercial applications in space to continue. Iraq demonstrated you can buy the ability to jam and do not have to be a world-class space power to try to deny space capabilities. Those also can be countered. To fully attack our space assets would require a greater level of sophistication."

Before assuming his current post of Secretary of Defense under President Bush, Donald Rumsfeld chaired a space commission in the closing years of the Clinton administration that laid out a blueprint for the reorganization of military space, while warning not enough had been done to defend orbital assets.

"A nuclear blast in orbit used to be the pre-eminent postulated threat. So we have to harden some systems, but it is much more than that, such as someone trying to affect it from the ground with high-energy beams or jamming or attacking our ground system," Leaf said. "This is not a monolithic or single-vector threat. The Rumsfeld Space Commission warned of the dangers of a space Pearl Harbor – and we must be able to correlate across the spectrum, because an attack may not be as brute force or as obvious as a nuclear detonation on orbit."

Hamel said the future of military space is fully anchored in the various transformation plans of the four services, perhaps especially so with the Army's Future Combat System (FCS), due to begin fielding around the end of this decade.

"FCS is absolutely, totally dependent on space-based assets to permit the kind of operations it envisions – moving quickly across a linear battlefield, with core teams operating via space connectivity, giving them the ability to track everyone, to push information such as threat warning and targeting directly to combat forces," he said. "And the Navy has truly depended on space for years.

"We don't get to pick when and where we go to war, so we have to bring all our capabilities with our expeditionary forces. Weather information and targeting come from space. The Navy learned that years ago as an expeditionary force at sea. The same is true with the Air Force, which is now dependent on space for GPS guided weapons, which have pushed our tactical art to a new level."

The satellites that have allowed the services to advance to the levels demonstrated in OIF are about to be replaced by a new generation of technology that will leave the United States even more alone in terms of space domination, according to Maj. Erik Eliasen, AFSPC Chief of Military Satellite Communications (MILSATCOM) Operations. Previous communications satellites fell into three areas – protected, narrowband, and wideband – an architecture the Air Force tried to maintain with different satellites in different orbits, each with its own purpose and advantages, as well as disadvantages.

"Today we are in a position, through our investment in technology, to digitize information across all systems and share it in a way we have not been able to in the past. The waveforms will still be a part of it, the three-track approach, but digitization will allow us to share information better with the joint warfighters of today and tomorrow," Hamel said. "The eventual goal is to let the sensor, wherever it may be, share that information with a shooter in a time that will allow us to get inside the enemy's decision loop. Major investments in technology are getting us to that point in time, especially with TSAT, which will be a big enabler for military and political decision-makers."

Where the aging Defense Satellite Communications System (DSCS) provided a long-haul communications system to move large quantities of data over great distances, its replacement – the Wideband Gapfiller, which begins launching in late 2005 – will increase that capacity fourfold, while providing a faster and wider "pipe," so far more data gets to users far more quickly.

On the protected side, the old MILSTAR system traded a lower data rate for increased survivability. Its three-satellite follow-on – Advanced EHF, with a first launch in 2007 – will give protected users a tenfold increase in capacity.

The current narrow-band system – UFO (UHF Follow-On) – is primarily for mobile and tactical users.

The follow-on – MUOS (Mobile User Objective System) – also will have significantly increased capacity. The current plan is to leave it with the Navy, which operates UFO, when MUOS begins launching in 2009.

Even with these new, significantly higher capacity systems, the military expects demand will far exceed capability, as it did during OIF, when the government leased every bit of available commercial satellite capacity and even moved a satellite leased from Australia into a new orbit to provide better coverage over Iraq.

"We did max out capability in OIF and may find ourselves in a bidding war in the future for a finite number of links," Eliasen said. "We are working as hard as we can to accelerate the technology and the capability, but I think what we will see, as we continue to network the warfighters, is a continued mix of military and commercial satellites.

"In the future, with a network concept, we will not have that limitation because there won't be just one line of communication between warfighters, but a massive number that can go anywhere – space, ground, RF, optical. Huge redundancies built into future systems that get away from the circuit-based mindset. We do that through the Transformational Satellite – TSAT – which provides true networked capability through all those various media. Right now we are looking at an FY12 launch for the first TSAT."

Col. Henry D. Baird, AFSPC's Deputy Director for Requirements, said a key to meeting future space force needs is a change in the way requirements are acquired.

"We are still trying to educate the combatant commanders on what kind of space assets are out there. They are still making their battle plans first, then asking how space can support them. Instead, we are trying to get them to consider space as part of putting a whole plan together," he said. "And they are beginning to ask for situational awareness and C2, being able to be connected and sharing information across all levels of the battlefield."

Baird said there are now a variety of great sensors in different categories – IR, visual, space-based radar – but tying everything together, whether for DoD or the intelligence community, in a coordinated picture utilizing information from a lot of different systems would create an extremely powerful advantage.

"There are relationship issues as to who does what for whom, but we are trying to integrate the space assets just as we are homeland security and military operations," he said. "We're moving more toward a space combat command, similar to ACC, rather than just an R&D effort."

DoD photo by Staff Sgt. Shane A. Cuomo, U.S. Air Force

Air Force Senior Airman Ricky Williams acquires Global Positioning System (GPS) coordinates for an air strike mission in Ad Dwr, Iraq, in November 2004. Williams is a Tactical Air Control Party member from Detachment 1, 2nd Air Support Operations Squadron, attached to 1st Battalion, 4th Cavalry Regiment, 1st Infantry Division.

Maj. Andy Wulfestieg, AFSPC Executive Officer to the Director of Air and Space Operations, points out systems such as GPS often have more to offer than is generally realized. While most consider GPS to be primarily a location and navigation aid, it also is heavily invested in many systems as a precision timing capability.

"The large majority of military equipment uses GPS for both positioning and timing. So when the pilot in the cockpit checks his time coming into a target zone, it is probably based on his GPS signal," he said. "We refer to it as a global utility – available for everyone to receive and so imbedded that most users don't even realize they are using it. There actually are three primary GPS missions – navigation, timing, and nuclear detonation detection. The latter is a treaty monitoring mission for which GPS is a part because of its worldwide coverage."

While GPS requires a constellation of 24 primary satellites to meet guaranteed accuracy and availability standards, there currently are 30 in operation, providing 24/7 global coverage by a minimum of four satellites. The composition of the constellation includes several versions, however, with 16 Block IIA (manufactured by Rockwell) now in orbit and another nine awaiting launch through FY07, followed by 16 Block IIR (replenishment – Lockheed Martin) scheduled for launch from 2006 through 2013. Those include eight modernized – Block IIR-M – scheduled through 2007. The next generation between IIR and III – Block IIF (Boeing) – is the follow-on, with 16 projected from 2006 through 2013.

"They are just an evolutionary component; with each block we get additional capabilities – increased accuracy and reliability and, with modifications to some of the IIR and projected in IIF, some additional power and signals, including a specific military signal, completely separate from the civilian signal. We will start getting that with the IIR-M (Lockheed Martin), with the first of those scheduled for launch next year. There will be eight of those scheduled through 2007," Baird said.

"The initial launch date for GPS III [currently in competition between teams led by Boeing and Lockheed Martin, with down-select and deadlines to be determined] is 2012. Current plans call for 64 satellites, including both on-orbit and on-ground replacements. We currently launch replacements when needed rather than keeping them in orbit. The constellation is divided into six orbital planes, and we can't move a satellite from one plane to another if one dies, but by having additional satellites in orbit, the overall importance of any one is not as great as it would be with just the required 24."

The GPS III satellites, which ultimately will replace the entire constellation, will include all of the upgraded signals and codes of previous generations, along with an increase in power that will decrease overall vulnerability to jamming or interference.

"GPS basically is a very weak signal because it doesn't require a lot of power to get it to Earth," Baird said. "It has been equated to a 40-watt lightbulb 11,000 miles out in space, so it doesn't take a lot of power to overwhelm that signal. The III is still in the initial design phase, so there isn't a final number on its signal, although the initial goal is a focused power signal. As we modernize, we always have to be backward compatible so the receivers in use today work with all satellite versions, so putting too much power on it wouldn't work."

In addition to advanced GPS, the military also is looking at a variety of new technology satellites, from space-based radar to laser communications. Those have

An artist's rendering of a Defense Support Program (DSP) satellite in orbit.

TRW image

the potential to bring the flow of information down to every tank and infantryman on the battlefield – and return data from them back up the chain of command.

"A lot of the difficulty in bringing out something completely new and different is we are getting by without it today and it's hard to anticipate what actually will be needed in 15 or 20 years," Baird admitted, "much less figuring out how to meet that need, be it ground- or sea- or space-based. But there are some amazing technologies out there."

Imperfect forecasting is evident in the DSP (Defense Support Program) constellation – 22 satellites to date, with DSP-23 in 2005 ending a 30-year program designed as a strategic asset during the Cold War and never intended to support theater operations in a global war on terrorism, something the contractor community is now working to resolve.

The follow-on will be SBIRS, with both HEO (highly elliptical orbit) and GEO (geostationary orbit) components, commonly referred to as SBIRS-HEO and SBIRS-GEO, both part of the SBIRS-high program. The first HEO satellite is expected to begin producing data in 2006, with GEO not launching until 2008-2009.

"The focal arrays are more sensitive, which is a jump in technology, and the amount of bandwidth has brought a huge increase in data," said Maj. Francis Dorion, AFSPC Deputy Chief of Space-Based Warning and command DSP lead. "The old DSP left something like 90 percent of the data on board because it couldn't process any more. These satellites will reverse those numbers."

The major problem for DSP is the difference between looking for a Cold War ICBM, which burns hot for a long time, and trying to catch a theater missile – such as Iraq's Scuds – which have far shorter and lower burns. Another difference is how data are processed – today automatically, going machine-to-machine directly to the theater rather than bouncing through a variety of ground stations.

"The expectation is it will be an order of magnitude leap in performance, although exactly what and how we can detect is classified," Dorion said. "That is based on having the entire constellation, HEO and GEO, although there will be a marked improvement with the first HEOs."

Lt. Col. J.P. Scott, Chief of AFSPC's Warning Operations Branch, says it is not only DSP satellites that have had to change from a purely ICBM watch to a mixed responsibility that includes theater missiles.

"Right now we have the missile warning mission assigned to DSP, but we in missile warning already have picked up a supporting role in theater missile defense," he said. "So we can characterize the event and report back to both the theater and national commanders an improved situational awareness and what is truly happening in theater.

"We will have global coverage from these satellites, which will be constantly monitoring, so we will be able to cover any area of the planet that is of concern. Both HEO and GEO will be a tactical sensor force, so we can focus some of their capability on specific threat areas for more accuracy. That is possible because the GEO satellites will include a 'starer,' which is something we haven't done before, focusing in on a spot on Earth to collect as much information as possible about a specific event. With the starer, we can pick up hot, fast events, which is a major technology development."

For now, Dorion adds, the United States is "the only nation designing a system that incorporates all this, but we are not the only ones developing a missile warning capability. And despite what has been written in some reports, we are very excited about what SBIRS will and can do."

Fraser says all of these programs are evolving into what Air Force Chief of Staff General John P. Jumper calls joint warfighting space – capabilities that can be provided to the theater commander promptly and efficiently.

"The real effort, in my view, is not our ability to launch or operate satellites or get the information down to the theater and warfighter – the real impact will be on our ability to do that on a prompt basis, in hours or days, not months or years," he said. "That will require a different concept of operations from what we now have, with a wing composed of different squadrons. We will have a ready supply of satellites and boosters that can be launched within hours. Then we put forward an ability to integrate that in as little as three days, to operate that system, not for 10 years, but only for six months. If we can do that and integrate it into a system of systems, that will be a big change."

In many ways, Baird notes, what is happening in military space today is a "Golden Age" in which many space capabilities are beginning to mature: "It's amazing it has taken this long to get the kind of systems the commanders depend on – 50 years. And we are just on the edge of making some truly amazing developments. The ability to know what is happening and communicate with everyone on the battlefield is just incredible."

Lockheed Martin photo

A Space Based Infrared System (SBIRS) Mission Control Station.

WARFIGHTER'S LYNCHPIN

By Scott R. Gourley

Operations Desert Shield and Desert Storm in 1990 and 1991 are generally recognized as the first military conflict to highlight the modern warfighting contributions of Air Force space technologies.

From Defense Meteorological Satellite Program (DMSP) weather satellites to Global Positioning System (GPS) receivers to the Defense Satellite Communication System (DSCS) to Defense Support Program (DSP) satellite assets, the Air Force space systems employed during Desert Shield/Desert Storm provided warfighters on the ground with a wide range of new capabilities and enabling technologies.

However, while ODS (Operation Desert Storm) is generally accepted for its milestone space status, the actual employment of United States Air Force space assets in a combat scenario occurred just 10 years after the establishment of the Western Development Division. According to Air Force historians, an experimental ground satellite system was rushed to Vietnam immediately after the 1964 Gulf of Tonkin Incident. While the initial system architecture improved communications between Washington, D.C., and Saigon, the system was expanded over the next three years to allow continuous communications between fire bases and the White House.

In subsequent decades, space assets were also employed in Operation Urgent Fury (the Invasion of

DoD photo

Grenada – 1983), Operation El Dorado Canyon (the retaliatory strike on Libya – 1986), and Operation Just Cause (Panama – 1989).

Service historians note, however, that the implications of the Vietnam application were generally not recognized inside or outside of the services and that the follow-on space asset applications were "incomplete and poorly planned."

THE FIRST SPACE WAR

As a result, it is ODS that receives the credit as being America's "First Space War." Yet in spite of that accolade, Air Force histories note that the operational planning for the use of space systems was still poorly developed when Iraq invaded Kuwait in August 1990. In fact, a recently declassified July 1991 after action assessment of these systems by Air Force Space Command notes both strengths and weaknesses in space system performance.

An example can be found in the after-action review of DMSP weather satellites. The launch of the previously-scheduled DMSP F-10 on Dec. 1, 1990, had resulted in three "healthy satellites" available to provide weather support.

In assessing their combat contributions, the report notes that, "Accurate, real-time weather data was available to aid the tactical user in selecting the most effective aircraft weapons load for selected targets based on known weather conditions over the target. This reduced missions aborted due to weapons load/weather conditions mismatch, particularly with precision-guided (laser and optical) ordnance."

Lessons learned, however, also included recognition that the existing "transportable" DMSP terminals, housed in Mark IV vans, were "difficult to move, very large and heavy, requiring a C-130 for transport."

Satellite communications (SATCOM) was also spotlighted for their ODS strengths and weaknesses. For example, while SATCOM was recognized for providing 80 percent of the intra- and inter-theater communications, it was noted that contingency communications plans had significantly underestimated the connectivity demands of the actual deployment, identifying a requirement for 12 ground terminals when it was actually 128 that were eventually deployed.

Moreover, the review authors acknowledged that the assets were not always in the right place at the right time. In the case of the Defense Satellite Communications System, for example, the need to increase ODS area of responsibility (AOR) coverage prompted the repositioning of the Western Pacific reserve satellite to the Indian Ocean for increased SATCOM capacity. Likewise, DSP Flight 15 "was repositioned to provide an additional launch detection asset to the theater."

Noting that "Desert Storm proved that current on-orbit space assets have a significant element of flexibility to respond to global contingencies," the authors added,

Air Force Space Command photo

Opposite: A U.S. satellite uplink station is deployed in the desert during Operation Desert Shield. Above: U.S. Army personnel operate a hand-held Global Positioning System (GPS) receiver during Operation Desert Shield/Desert Storm. Space-based technologies proved vital to the United States' swift victory in the conflict, generally regarded as America's "First Space War."

"Broader tactical flexibility of our satellite systems would improve AFSPC's ability to respond to contingencies."

The clear winner in ODS space assets was the GPS. Highlighting the "first widespread combat use of space based navigation," the after-action assessment noted that over 4,500 GPS receivers had been deployed by the end of hostilities on tanks, trucks, ships, planes, and with other field units.

Perhaps the most telling finding in the July 1991 report involved the essential nature of space preplanning. Observing that the five months of Operation Desert Shield had afforded needed pre-planning time to integrate additional space capabilities and coordinate requirements, the authors emphasized that future war planners "must assume more of a 'come as you are' war outlook for space equipment."

Among the highlighted lessons learned was that "AFSPACECOM needs to work with operational commanders to translate and incorporate space capabilities." Recommended actions included the need to "start the space planning process early" and "get the word [about space contributions] out to CINCs [Commanders in Chief] and Component Commanders."

Echoing the report's findings, Gen. Charles A. Horner, Commander of Central Command (CENTCOM) Air Forces during ODS (who would later become Commander of Air Force Space Command), attributed many of the challenges encountered with the space assets to a general lack of understanding of their capabilities.

And that feeling was widely shared. In his own June 1991 assessment of space force employment during ODS, Gen. Donald J. Kutyna, wartime Commander of U.S. Space Command, observed that, "Space forces were there when required, but significant effort was needed to optimize their effectiveness. We may not have the luxury of a six-month build-up period to develop procedures or procure critical equipment in a future conflict. Space systems and forces had a major impact on the execution of these two operations [Desert Shield and Desert Storm], but the capabilities of these systems must be thoroughly ingrained in our peacetime planning and training if we hope to exploit them fully in crisis or combat."

BLUE RIBBON PANEL

The multiple analyses and assessments began to pave the way for the creation of a dedicated organization to ensure that space assets would be utilized to their optimum effectiveness.

That process got even more support in June 1991. About the same time that Kutyna was making his assessment of space force contributions to ODS, Gen. Merrill A. McPeak redefined the mission of the U.S. Air Force to "defend the United States through the control and exploitation of air and space."

Obviously, control and exploitation would require the optimization of resources, and that optimization needed to be based on a more coherent space force policy, organization, and infrastructure.

With those needs in mind, the fall of 1992 saw the chartering of the "Blue Ribbon Panel of the Air Force in Space in the 21st Century." The panel charter included the review of existing Air Force space policy, organization, and infrastructure, definition of the Air Force's future role in space, and the development of a strategy to meet that goal.

Led by Lt. Gen. Thomas S. Moorman, Jr., then vice commander of AFSPC, the Blue Ribbon Panel of 30 Air

Photo courtesy of Dr. David N. Spires

The "Blue Ribbon Panel of the Air Force in Space in the 21st Century," led by Lt. Gen Thomas S. Moorman, Jr., convened at Maxwell Air Force base during 1992 and made a series of recommendations meant to optimize the utilization of the Air Force's space assets.

Force officers and civilians convened at Maxwell Air Force Base between Sept. 10, 1992, and Nov. 5, 1992.

Among their findings, the panel members observed that "Space systems provide key capabilities to integrate and deliver command, control, communications and intelligence (C3I) support to the warfighter … The ability to provide this information to U.S. forces while simultaneously denying or manipulating the enemy's information through counter-C3I operations is a potentially decisive 'silver bullet' for the theater commander."

Air Force histories note that the panel findings also included the underlying premise behind the need for a new organization designed to optimize the exploitation of space capabilities to fulfill operational needs. Referring to the notional organization as a "Space and Applications Warfare Center," the panel findings envisioned "an organization devoted to developing new applications for space systems, assisting combatant commands with space system employment, and defining requirements for new space systems and user equipment. The center should … focus on: demonstrating potential space capabilities and tactical application to users, supporting operational training and exercises and providing deployable teams to support air components."

ESTABLISHING THE SPACE WARFARE CENTER

Based on the panel's recommendations, senior service planners began the creation of the new "Space and Applications Warfare Center."

Challenges and changes in the establishment reportedly began with legal concern from the AFSPC Judge Advocate's office over the word "Warfare" in the new organization's name. However, after analysis of existing treaties, legal representatives dropped their concern. Another early change involved Horner's July 1993 deletion of "Applications" from the new name.

Organizers of the newly named Space Warfare Center (SWC) then moved to the challenges of developing an infrastructure to execute the envisioned mission and selecting a physical location for the organization.

According to an AFSPC SWC organizational history, "On 2 July 1993 Lieutenant General Moorman requested that HQ USAF approve the establishment of the SWC at Falcon AFB Colorado. Moorman chose Falcon AFB as the SWC's site for two reasons. First, as [the] present site of the National Test Facility (NTF) – the center of a national network of research facilities established in the mid 1980s to support then President Ronald Reagan's Strategic Defense Initiative – Falcon AFB offered the SWC planners an in-place, secure, government owned supercomputer facility. With main frame computers and over 500 work stations encompassed in the 22,000 square foot complex, the NTF offered an ideal environment to execute space warfare simulations. Second, the NTF had been a focus of funding from the Air Force's Tactical Exploitation of National Capabilities (TENCAP) program – a government program that emphasized the exploitation and utilization of national systems. With the proposed activation of the SWC, TENCAP's focus would shift from the NTF to the SWC."

With its physical location identified, in July 1993 AFSPC established a working group to develop a programming plan that would further define SWC's mission while identifying additional establishment actions necessary. On Dec. 20, 1993, the working group published HQ AFSPACECOM Programming Plan 93-14, which defined SWC's primary function as "ensuring that existing space capabilities were applied adequately to warfighters' needs."

The plan added that the SWC mission would be executed by "incorporating space capabilities in [Major Command], theater and campaign war plans … simulation, modeling and wargaming activities which will evolve with an aim to integrate space into other computer modeling centers. Finally, the USAFSWC will lead development efforts to improve warfighting applications of space systems and ensure that future space architects and systems are designed with combat operations inherent in them."

The organization was activated on Nov. 1, 1993, and officially dedicated on Dec. 8, 1993, less than one year after the Blue Ribbon Panel had released its supporting recommendations.

Some of the earliest application programs, designated as "Talon" programs, were all designed to ensure that America's warfighters had access to the most current and useful information necessary to execute their missions.

Another early SWC organizational effort involved the introduction of Forward Space Support in Theater (FSST) teams, groups of space experts that could be deployed to any theater of operations in contingency situations.

Those products and programs were part of a larger process of "space education" that coalesced and matured during SWC's first decade of operation.

"Products aside, the biggest accomplishment over the first decade was that we took disparate training efforts – and I say 'disparate' because so many people inside the organization felt like they had a part on trying to do training – and over a period of time we stood up a space ops school, which gave you 'one stop shopping' for space training," explained Jim Blanton, Space Warfare Center Senior Technical Advisor.

"In my mind, there have been two big changes that have taken place in our 10 years – one is how we get people trained," he continued. "So many people had been doing so many things. And they were all correct. But they weren't in one place."

He added, "General Lord very clearly understands and knows what it takes to put the people with the 'right smarts' out forward to get the right information and requests back to [AFSPC]. The smarter the people that we put forward, the better and easier are the requests from the warfighters that come back to General Lord

Senior Airman Nayibe Ramos runs through a checklist during GPS satellite operations at Schriever Air Force Base, Colo. The operations center at Schriever AFB controls a constellation of 30 orbiting satellites that provides navigation data to military and civilian users worldwide. Airman Ramos is a satellite system operator for the 2nd Space Operations Squadron.

U.S. Air Force photo by Airman 1st Class Mike Meares

that he can fulfill and make happen. If you look over the previous time span, we just did not have the right number of educated space operators forward. A commander had to pick and choose who he would go to to get that information. For instance, the lines were blurred on who the specialist was to request SATCOM; or who the specialist was to ensure that GPS was going to be there when you were going to need it. So the Space Warfare Center accomplished the means to place knowledgeable individuals forward where they became the single focal point managers for space.

"The second most important change the Space Warfare Center has made in the last 10 years is taking space-educated professionals and putting them forward in a position of responsibility, so that when that forward commander requires a space effect, that person who has the background and the knowledge knows exactly how to reach back into Space Command, through General Lord, and fulfill the request that has been placed on him," Blanton said.

Using an evolutionary spiral analogy, Blanton explained how the past decade has witnessed an evolution of project and training synergies.

"After the stand-up of the SWC ten years ago, our projects were focused around infusing space – in other words, produce for the warfighter as many tools as possible; push as many space projects forward as you can get. Get it to the people who need it to execute their war, because that's what the Blue Ribbon Panel said," he explained.

"So aside from the training, what we did involved physical things you could put on aircraft or physical things you could put in the CAOC [Combined Air Operations Center]. Those were the types of programs that we could push forward as fast as possible to 'get space into the cockpit,'" he said.

Cautioning that he was only expressing his own opinion, Blanton reiterated, "The 'bow wave' was to get as many things as we could out there as fast as we could. And we did that very successfully. Now, looking back at it, because we just inundated the world so quickly with these space tools, my personal opinion is that the education of how to apply and exploit those tools followed on the next wave – it lagged bit behind the introduction of the programs.

"But we have matured over the 10 years now from that wave of pushing things out and lagging with training to now, where we've smartly brought the training back online with those programs. More importantly, with the most recent programs that we've given out, the training and expertise has been right there with them," he said.

As an example, Blanton cited recent press reports of the extreme responsiveness of B-2 bombers to ground forces during Operation Iraqi Freedom (OIF).

"How did that happen?" he asked rhetorically. "Well, the Space Warfare Center helped make that happen. We were the ones that enabled those aircraft to have the satellite communications capabilities on board, and *trained them* to know how to bring the systems up, how to use them, and who they would be talking with. The battlefield effect was we had a special operations user on the ground that could talk to an aircraft commander and, through space programs, the command and control element of that aircraft all together inside of one conversational call – a conference call in layman's terms – of everybody who needed to be in place so that the aircraft commander could request authority to execute based on the user's request, receive that authority, and then strike right away. That demonstrates how training caught up with the delivery of programs.

"I would say that the SWC's growth spiral may have started with a 'get it out the door mentality,' with training behind it. Now we have grown into a position of saying, 'We need to get it out the door, but we've got to make sure that it is useful.' We're delivering tools and programs that are more effective because early on we've gotten with the aircrews, we've gotten with the people forward, and shown them how they can use it and make themselves more effective. The warrior on the front is 'smarter' with his space requirements than he was 10 years ago, and now the SWC is smarter on what to produce for him, ensuring a more effective use of space.

"In spite of the changes, I believe the SWC's focus was correct 10 years ago," he noted. "What we accomplished was not a negative thing. We were mandated by the Blue Ribbon Commission to infuse space. The question is, as a result of flooding the world with space projects, did we also make that user smarter? Did we make his job and effects better? Or did we just flood the world with systems? My personal opinion is we delivered but lagged in effects training. We've caught up on

DoD photo by Petty Officer 3rd Class Christopher Howell, U.S. Navy

Steam from the catapult surrounds an aviation ordnanceman as he gives a thumbs-up after checking a Joint Direct Attack Munitions (JDAM) attached to an F/A-18C Hornet before launching from the USS *Kitty Hawk* (CV 63) in August 1999. JDAM uses a GPS-aided inertial navigation system to guide its 2,000- or 1,000-pound warhead to its target with a high degree of accuracy.

that training. We've trained space operators to be smarter about the effects of the system. We go out with systems and we show the operator how to use them. Training is the one piece the recent SWC commanders and General Lord stressed that enabled the successes of OEF and OIF. In my mind, it's more than just producing. It's producing and making the person that you are producing for smarter. And when he's smarter, he knows how to make a better request 'for space.' And when that smart request comes to space, we in turn are now smarter knowing exactly what effects to provide. Some people will say that I'm completely wrong, pointing to the fact that 10 years ago when we pushed products out we did give training. Yes we did. But the training we gave with the systems we pushed out was specifically focused on the individual system delivered. It wasn't on how that system played in the big picture. It wasn't how space provides all of its effects. It wasn't how that piece applied to a bigger piece, which applied to an even bigger piece. The focus 10 years ago was in getting projects out. We did that successfully. But we pushed them out with knowledge of the project only. Now the projects are coming out with integration training, complete effects of space.

"Another example of this is the use of a Joint Direct Attack Munition (JDAM). Planners know that the JDAM needs GPS and they must work with Space Command to request GPS to be at its optimum during the time to use the weapon.' Weapon planning now involves a space operator telling them, 'If you use the JDAM at this time, five GPS satellites are available, whereas if you drop your weapon two hours later, I would only have two satellites available.' You can understand that if you're using a GPS signal, you would want to use your weapon when there are five satellites available to give you the best GPS signal possible. My personal opinion is that 10 years ago we would push things out the door and say, 'Here's a better weapon because it uses space.' We probably didn't look at it from the perspective of, 'When you use it, here's how much better its effects can be when you truly integrate all of what space provides.' Now, using the space operators, you know that if you use your GPS-guided munition during a particular timeframe, you'll have a higher probability to kill ratio."

Highlighting an early organizational accomplishment of SWC, Blanton added, "Ten years ago had the Air Force [Forward] Space Support Teams from the 76th Space Ops Squadron. Those teams were done away with because General Lord and the other commanders realized that they had accomplished their mission. They integrated space and made the operators in the field smarter. We have people graduating from our space courses that are specialists in all facets of space."

"It's been an evolutionary process," Blanton said. "It's grown over 10 years. Space education is the foundation for our growth."

To put things into another perspective, the Space Warfare Center has been in existence for about the same span of time that stretched between the establishment of the Western Development Division and the first employment of space asset capabilities in Vietnam. The difference is that the latter time span has witnessed a true appreciation and embrace of space-based capabilities by America's joint service warfighters.

Over the past 800 years, the words "linchpin" or "lynchpin" have expanded in meaning and significance from a locking device at the end of an axle or shaft to something that holds together a complex system.

Over the last 10 years, America's space assets have expanded their own significance to become an integral part of U.S. battlespace capabilities. These space assets have become, and will remain, "The Warfighters' Lynchpin."

DEVELOPING A TEAM OF SPACE PROFESSIONALS

By Robert F. Dorr

When General Lance W. Lord, Commander of Air Force Space Command (AFSPC), unveiled the Air Force's new badge for space professionals on Oct. 7, 2004, he evoked powerful feelings about the past and the future.

General Lord is the Air Force's longest-serving missileer, with more than 35 years on duty. More than most, he understands the symbolic value of the thin, vertical "pocket rocket" badge that missile launch crewmembers wore in some form since the 1950s – which will eventually be discontinued once the new badge is available for purchase. There is a "continuing vision" today about what professionalism in the space field ought to mean, General Lord said, and that requires a new icon – one that can be worn by both space and missile operations professionals.

"I commend General Lord and our Air Force for looking ahead and not dwelling on the past," said retired Lt. Gen. Jay Kelley, president of the Association of Air Force Missileers. "This new badge is not the one that is tattooed on the hearts and in the minds of missileers today, so it is indicative of the future and not the past. I will always embrace the 'pocket rocket' I earned, but I will also support this new badge that the next generation will wear. The missile career field that we so proudly and competently established is now part of a new Air Force. Thus this new badge represents far more than the mission that challenged us. We all need to support this new generation while always standing tall and confident regarding our mission and the 'pocket rocket.'"

Ultimately, a badge may be a mere piece of tin. The new one, however, represents deep-rooted changes.

General Lord is serious about bringing the space business, and especially the personnel side of the space business, into the 21st century. In 2001, Defense Secretary Donald Rumsfeld ordered the military to develop space cadres, a concept rooted in the recommendations of the Commission to Assess U.S. National Security Space Management and Organization, the panel Rumsfeld headed before returning to the Cabinet in the Bush administration. The Air Force's response is a serious effort ramrodded by General Lord to improve the quality of the airmen who develop, acquire, and operate space systems and to revamp not merely a badge, but the way the service manages people and careers.

The Rumsfeld Commission pulled no punches in describing the challenge. Within the U.S. armed forces, the commission found "a weak space culture resulting in unfocused career development, education, and training." The black-bordered report, issued Jan. 11, 2001, found a lack of depth within space career-field specialties, unqualified leaders serving short tour lengths, poor retention resulting in a shortage of scientists and engineers, and a shortage of personnel with both operations and acquisition experience. "The Department of Defense is not yet on course to develop the space professionals the nation needs," the report concluded.

CAREER FIELDS

Even those fondest of tradition in the nation's 50-year-old space program acknowledge that it was time for the Air Force to define, expand, monitor, and develop career fields for all officers, enlisted members, and civilians who work in space. The new program of education, training, and career enhancement will focus on providing, capturing, then capitalizing on space experience grouped into a series of nine skill areas for space professionals. According to a chart prepared for AFSPC, the number of individuals experienced in each of these categories (as of October 2004) is as follows:

- satellite systems – 2,474
- nuclear systems – 3,057
- spacelift – 1,100
- warning –1,733
- space control – 1,077
- intelligence, surveillance, and reconnaissance – 1,020
- kinetic effects – 160
- space warfare command and control – 634
- "other" – 4,020.

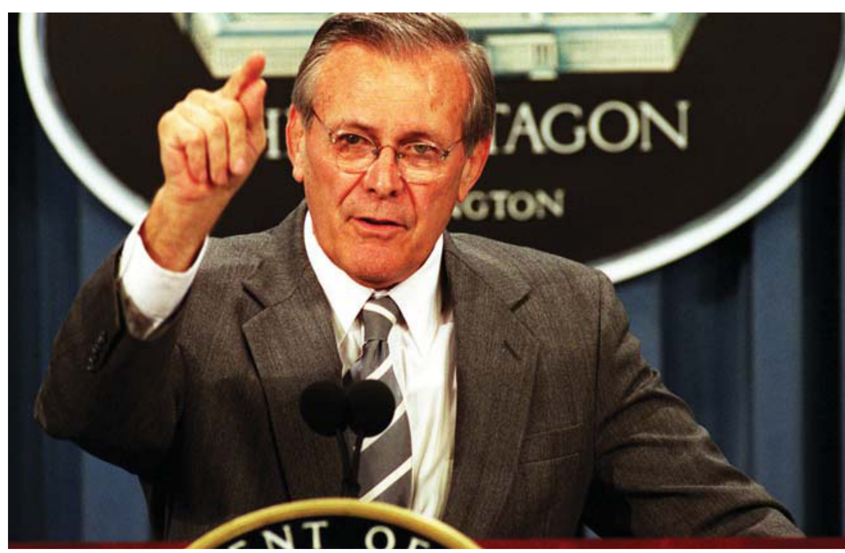
The "other" category accounts for space-related work that doesn't fit neatly into one of the other eight fields, such as scientists performing basic research.

A response to the Rumsfeld Commission is found, in part, in the white paper "Space Professional Strategy," signed off by General Lord on April 16, 2003. The strategy paper committed the Air Force to "build a team skilled and knowledgeable in the development, employment and integration of space systems, concepts and doctrine to achieve national security objectives." Within weeks of the paper's release, the United States sustained its first attack on its space assets; Saddam Hussein's forces set up half a dozen sites around Baghdad designed to jam the satellite-guided global positioning system in an attempt to confound Coalition air attacks in Operation Iraqi Freedom. A coordinated air and space effort took out the jamming sites.

The strategy paper made it clear that nurturing careers by space experts will now be measured and marked. "Space professionalism is a graded event," declares a briefing on the paper.

Instituting new personnel methods will mean a better shot at a rewarding future for young professionals such as the three lieutenants of the 1st Air and Space Test Squadron at Vandenberg Air Force Base, Calif., who were interviewed for this narrative. 1st Lt. Markyves Valentin, 2nd Lt. Mark Willoughby, and 2nd Lt. Werner Gschwendtner already know that their work is important. Now they know that it will be rewarded. In the past, the Air Force took a very informal approach toward encouraging and rewarding a space professional at the beginning, at mid-career, and at the senior level. Now, Valentin, Willoughby, and Gschwendtner will be part of something "bigger than ourselves," as Valentin put it. They will be ready for advancement, for command, perhaps even for general's stars when the time comes.

They will also be able to get more respect from a public that isn't well versed on what they do. "We're the generation that grew up on *Star Trek* and *Stargate*," said Valentin. "People watch these shows, but how many understand the importance of space in real life? During the Persian Gulf war, the public saw smart bombs and realized that the satellite-operated global positioning system was used for that." Since then, a newer generation of smart bombs has, itself, been satellite-guided. Today, as the lieutenants pointed out, satellites are used for almost every aspect of command, control, communications, and intelligence. Just to cite one not-so-obvious example: the military's new combat survival radio, the CSEL (Combat Survivor Evader Locator) is a software-programmable device that bounces messages off satellites, making it possible for a downed airman to send a message over a vast distance. When Maj. Dave Micheletti, CSEL deputy program manager, told the trade journal *Army Times* that CSEL is "only going to get better," he was referring to a new way of using space technology that's essential to human life in wartime. The professionals who'll develop and field such technology believe they're on the ground floor of a new era.



DoD photo by Helene C. Stikkel

Secretary of Defense Donald H. Rumsfeld announces major changes to national security space activities at a Pentagon news briefing on May 8, 2001. The changes were brought about in an effort to improve the leadership, management, and organization of the nation's defense and intelligence space program.

"We're in a good time for the Air Force and for the military in general," said Valentin. "What's really interesting is that young officers now are turning down pilot slots to get in at the beginning of this new and exciting field." Air Force personnel experts said they do not keep tabs on how many new officers choose space in preference to pilot training.

"I can see that in the future, one day we'll get into hypersonic vehicles and travel great distances in a very short time," said Gschwendtner. "It'll be great knowing you were in on the beginning of that."

Perhaps then, too, the United States will still be taking the first steps toward developing a hypersonic vehicle – as it has been doing for a quarter-century or more. Then, as now, "space" will probably consist mostly of missiles, satellites, and communications. But at least the Air Force will have a career plan for its professionals, even if Gschwendtner remains earthbound.

PLAN OF ATTACK

To make this happen, AFSPC accepted marching orders from Air Force Secretary Dr. James G. Roche and went about developing a plan to change how space professionalism is handled. AFSPC assigned itself to do the following:

- identify who's who among space professionals and define the unique skills that distinguish them from other careers
- institute stronger, technically-oriented space education and training programs
- implement a robust, three-level certification program to measure progress throughout an individual's career
- determine education, experience, and certification requirements for each space professional billet
- establish a permanent Space Professional Management Office.

Since the strategy paper was issued, the service has moved away from the term "space cadre," used by the Rumsfeld Commission. It prefers "space professionals." As part of the new approach, the service will use Space Experience Codes (SPECS) as a common definition for both individual qualifications and job requirements.

TRAINING AND EDUCATION

Under Air Force Space Command's new way of doing things, more than 500 space professionals will undergo classes at the National Security Space Institute, located in Colorado Springs, Colo., each year. One course is also being conducted at Vandenberg. Said Valentin: "We want people who will be better informed. The planned classes, Space 100, Space 200, and Space 300, will help us make better decisions. We will be the experts in our field, and we will make the best decisions at that point in time." The result will be a community of credentialed space professionals that includes, among others, engineers, scientists, system operators, and program managers.

On July 1, 2004, General Lord's command created an office to oversee space personnel management. Col. Cal Hutto, the first director, said the office will track the careers of military – officer and enlisted, active duty, guard, and reserves – and civilian space professionals, tailor their training to their needs, and reward those who excel. Hutto's title is chief of force development and readiness. His office will reach throughout AFSPC and the Air Force, and is a reaction to the commission's concern that the military must improve its space personnel through education and training measures and better career development.

Hutto and other officials say the Air Force hasn't always had the best arrangement for tracking space professionals and filling space positions. In the past, the service's human resources experts did not always know who was best qualified for a slot, and did not always have the best data on an individual's qualifications. Now, career management principles that are widely used in other fields will be applied to those who work in space jobs.

Hutto described the way the education and training effort will work "by providing certifications at various levels of achievement," a way of rating and monitoring space professionals that hasn't existed previously.

Space professionals who have a Level 1 certification will have one-year's experience in a space-oriented job and complete the first training course in the series, Space 100. AFSPC launched a prototype of Space 100 at Vandenberg to introduce the fundamentals of space acquisition, the systems operated by their service, and their function in combat. A typical student would be a second lieutenant (space operator or acquirer), an airman first class, or a civilian GS-9. A university degree relevant to space training is desired at this juncture in a career.

Level 2 certification will apply to space professionals who have six years of space experience and who undergo the mid-level Space 200 course. The Space 200 course has actually been under way longer than the lower-level class, having begun in March 2004. It offers what Hutto called a "broader and deeper" look at the Air Force's space acquisition and operations. It provides a refresher of the earlier course, and then delves much more deeply into space design, development, and acquisition, and into space integration and tactics in joint warfare. A typical student would be a major from any of the four services, a technical sergeant, or a GS-11.

The top-drawer professionals who reach Level 3 certification will have nine years of experience in the space field and will complete the senior Space 300 course. The course will cover strategic doctrine and policy issues. It will provide a refresher of the second-level course, and then pursue requirements, strategy, policy, doctrine, and law, and will include content tailored to prepare students

U.S. Air Force photo by Master Sgt. Thomas Deering

Air Force Staff Sgt. Brian Belam tightens down a missile silo power cable at Vandenberg Air Force Base, Calif., during a missile maintenance exercise. Belam is part of a team from the 91st Space Wing at Minot Air Force Base, N.D., that was participating in Guardian Challenge, an annual competition meant to test the wartime readiness of teams representing each missile and space wing unit from Air Force Space Command. Competition events include timed exercises in missile-crew operations, missile and space maintenance, spacelift operations, space and missile communications, missile code control, helicopter operations, and security force operations.

for senior leadership roles. That course is still being developed and is scheduled to open the doors for its first students in October 2005. Representative students will include Air Force, Army, and Marine Corps lieutenant colonels or Navy commanders, master sergeants, and GS-14s.

Having three levels of career development provides "a continuum," said Hutto. "These courses [will] bring space professionals together several times during their careers in order to stay current on evolving missions, technologies, and capabilities and to prepare the individual for the next level of responsibility."

AFSPC expects to continue with other training as well. This will include an advanced space operations course that will include travel and will typically take 1,000 students in a year, a course on Space in the Air Operations Center (AOC), and a Senior Space Officer in Theater course to focus on how space assets are leveraged in an AOC in a combat zone – typically with as few as 20 students.

The command will also continue to send professionals to the Air Force Weapons School for advanced training in weapons and tactics.

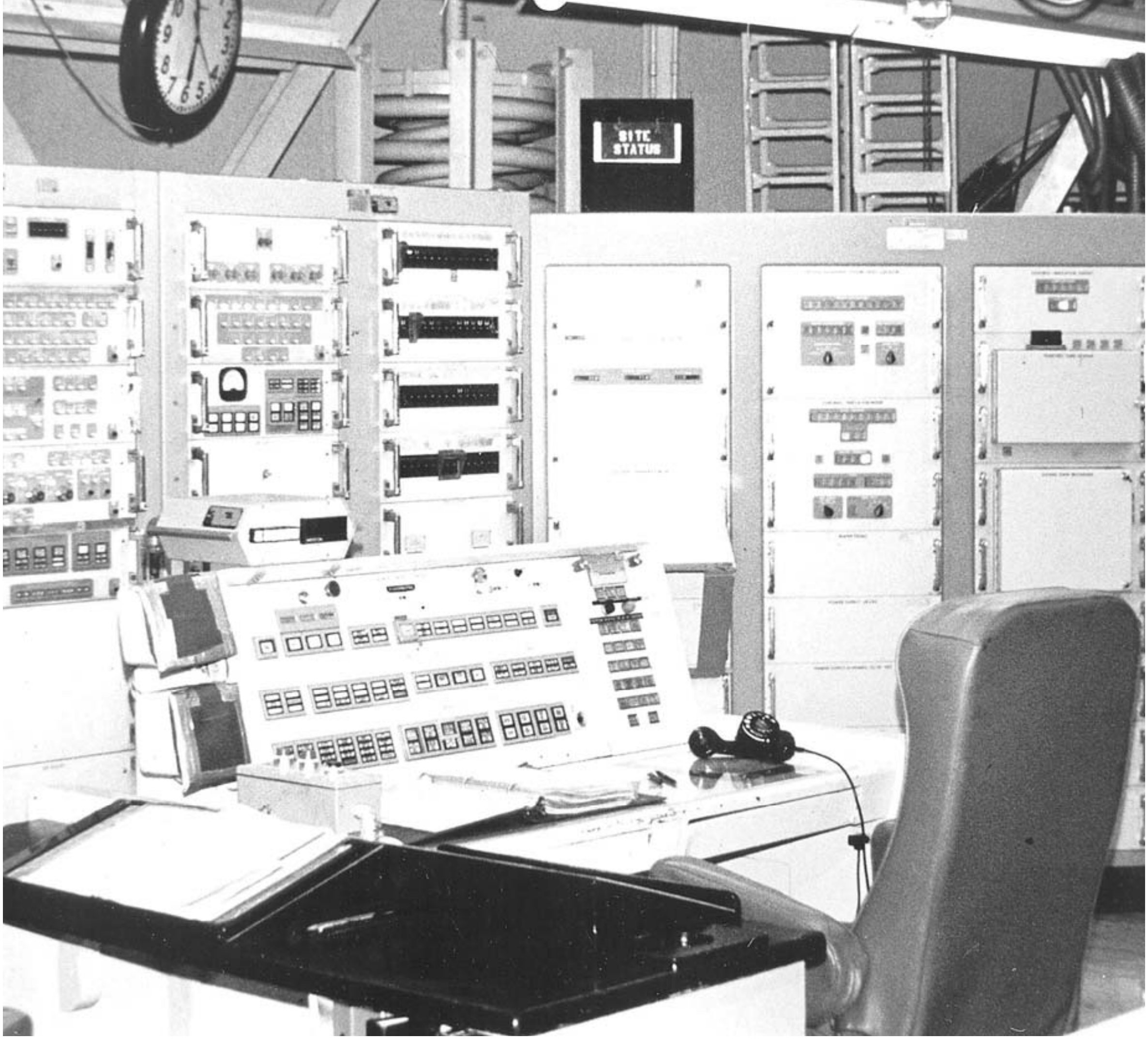
As reported by Tim Roeder in the *Colorado Springs Gazette*, AFSPC also is launching a plan to coordinate education of space experts with the University of Colorado at Colorado Springs. General Lord and University Chancellor Pam Shockley-Zalabak described the plan recently to the Strategic Forces Subcommittee of the House Armed Services Committee in Washington, D.C.

IMPORTANCE OF SPACE EXPERTS

General Lord says that the new emphasis on space development means there are now more opportunities than ever before. He emphasizes that the new approach is a permanent program – one that builds for the future. And General Lord says the new approach to professionalism will pay off.

"The military space community is frequently accused of stovepiping our operations and development efforts," General Lord said recently. "But we are working hard to eliminate that division and integrate across all aspects of space.

"Our space systems are national assets," General Lord said, "but our space professionals are national treasures … and we must ensure enduring air and space superiority by continuing to polish their knowledge and helping them grow. It is our obligation to our military forces and it is our responsibility to the nation."



Above: A Titan II Launch Control Center at Davis-Monthan AFB, Ariz., in 1978. Atlas and Titan missiles formed a crucial part of America's nuclear deterrent.

Photo courtesy of Dr. David N. Spires

OPERATING OUR NATION'S ICBM FORCE

By Scott R. Gourley

While the Cold War may be over, the nation's strategic nuclear weapons are a vital aspect of our defense, and every day Air Force personnel provide diligent deterrence for the nation.

It's the same way every morning: Young U.S. Air Force "missileers" assemble in briefing rooms at several sites across the Northern Plains to prepare for another cycle of never-ending deterrent protection for the nation. Supported by a range of highly specialized maintenance, security, and support airmen, the teams of combat crewmen will move out to widely scattered Launch Control Centers (LCCs), where they will take another turn underground in a decades-long cycle of continuing deterrence.

Headquartered at F. E. Warren Air Force Base, Wyo., the members of 20th Air Force point to a proud tradition as America's first long-range strategic force. Activated April 4, 1944, the unit's B-29 Superfortresses struck at the very heart of the Japanese home islands. Two 20th Air Force bombers, the Enola Gay and Bock's Car, forced an early end to World War II after they dropped the first atomic bombs on Japan and inaugurated the 20th as the world's first nuclear-capable combat force.

Inactivated on March 1, 1955, the unit was reactivated at Vandenberg AFB, Calif., on Sept. 1, 1991, as a component of the Strategic Air Command. During an era of tumultuous downsizing following the end of the Cold War, the 20th experienced three major command changes in less than a decade: one year as part of Strategic Air Command; one year in Air Combat Command; and, beginning in July 1993, integration under Air Force Space Command. That year also saw Headquarters, 20th Air Force move from Vandenberg to F. E. Warren.

As described in command overviews, Headquarters, 20th Air Force is unique in that it has dual responsibilities to Air Force Space Command and United States Strategic Command (USSTRATCOM). As the missile Numbered Air Force for AFSPC, 20th Air Force is responsible for maintaining and managing the Air Force's ICBM force. Designated as USSTRATCOM's Task Force 214, 20th Air Force provides on-alert, combat-ready ICBMs to the president. Combined with the other two legs of the country's strategic nuclear forces, bombers, and submarines, USSTRATCOM protects the United States with an umbrella of deterrence.

In highlighting the continuing importance of America's strategic nuclear deterrent, Maj. Gen. Frank G. Klotz, 20th Air Force commander, recently observed that the deterrent umbrella provides the nation with several further important protections more than a decade after the end of the Cold War.

"Those functions have been divided into four separate tasks," Klotz explained. "The first is to dissuade any other potential adversary, now or in the future, from developing weapons of mass destruction that it could use to threaten the United States, its forces stationed abroad, or its allies. And we do that by maintaining a significant capability in strategic nuclear forces. In a sense, what we do is to 'raise the bar' for anybody else who might think that, with a modest investment of money, they could somehow match or threaten the United States in terms of strategic nuclear capability. So we maintain our nuclear forces at such a level that we dissuade anybody else from trying to get into the game."

"The second objective that we achieve by having robust, capable, and viable strategic nuclear forces – including the ICBMs – is to assure our allies of our resolve to take whatever actions we need to provide for not only our security but their security as well. We're tied to the NATO nations and other nations by a number of different treaties and arrangements by which we extend a security guarantee to them. Our willingness to maintain this particular type of capability assures them of our purpose," he said.

Klotz continued, "The third objective we accomplish is something that our strategic nuclear forces have always done: to deter anybody from using a weapon of mass destruction against the United States, or its forces abroad, or its friends and allies."

"Finally, if deterrence fails, obviously our weapon systems are there to actually defend the United States, its forces abroad, or its allies with the capability of preventing anyone who would use weapons of mass destruction against us from doing so," he added.

Klotz was quick to acknowledge that today's ICBM deterrence missions are performed against a background that is inherently different from the one under which it was initially created. "Prior to the end of the Cold War, we were focused on the threat posed by a monolithic and hostile Soviet Union," he said. "Since then, the Soviet Union has dissolved. The Warsaw Pact has dissolved. Russia and the United States are now cooperating in a host of areas: political, economic, and security. Therefore, we're not facing the same kind of threat. But there are still people out there who, either now or in the future, might try and develop weapons of mass destruction that can threaten us. And this is one of the ways that we deter them. It's not the only way in which you deter terrorists or other nations from using weapons of mass destruction against the United States, but it is one of the ways that you do it."

The ongoing changes in the world political climate noted by Klotz have also been accompanied by significant changes within 20th Air Force's ICBM force structure. Specifically, during the 1990s alone, the ICBM force was reduced from nine wings to three with the number of missiles on alert cut in half. "That is something that's sometimes lost in a lot of the academic discussion and policy debates concerning our strategic nuclear forces," Klotz observed. "But we have gone through a significant period of down-sizing, deactivation, and even 'de-alerting.' When I personally joined the missile business, we had nine operational ICBM bases. Today we have three. When I joined we had 1,054 missiles on alert. Today we have 513, and we're going down to 500 by this time next year."

Although declining to speak on behalf of other elements within the nation's nuclear deterrent force structure, he did observe that the Navy was also in the process of reducing its number of ballistic missile submarines from 18 to 14, with two of those projected to be in overhaul at any point in time. "So we are adjusting to the changing nature of the threat and we're doing it with our forces performing the four key functions mentioned: dissuade, assure, deter, and defend," Klotz said.

That being said, he emphasized that some aspects of ICBM deterrence have remained the same in the post-Cold

War era. "Every day, we man our Launch Control Centers with a two-officer crew that perform alert around the clock," he said. "And we continue to have a very high tempo of sending out maintenance technicians and security forces to support maintenance that's going on in the field."

Emphasizing that 20th Air Force has "always taken the security and safety of our ICBM force very, very seriously," the commander highlighted several examples of existing force protection infrastructure. "We have a 110-ton blast door that sits on top of the missile silo. We have sensors both above ground and below ground that monitor any activities out on the launch facilities. We have security forces deployed out in the field to respond to any security alarm 24/7/365. We've always maintained the highest standards of training and performance on the part of our security forces. And we've been doing that for 40 years," he said.

"But since 9/11, we are focusing even more on the issue of security," he added. "And we are starting the process of adapting new types of technologies to make what I consider a very secure force even more secure – to try to convince any potential terrorist or adversary who would say, 'Let me threaten America's ICBM force or take some sort of action against it,' to come to the conclusion that it is just too difficult a task; it is just too hard a target to even try it."

Along with implementation of a wide range of unspecified security initiatives, 20th Air Force is also undergoing significant force modernization to its Minuteman III fleet. Recent program projections place the value of the ongoing ICBM modernization initiatives at approximately $6.2 billion.

One aspect of the Minuteman III modernization effort is called the Propulsion Replacement Program (PRP). "Under PRP, we are replacing the solid rocket fuel in all three stages of the missile," Klotz explained. "We have done that before with the second and third stage, and it's time to do the second and third stages again. We have never done it with the first stage." He added that the PRP had recently passed "the century mark," with over 100 of the new boosters already in the ground and approximately 400 to go.

Another modernization effort is the Guidance Replacement Program (GRP). "Basically what we're doing is taking out parts from the Minuteman III guidance system and putting in new parts to actually make it more sustainable," he said. "A lot of the technology in there is 1960s- and 1970s-era and we have better ways of doing those things now. But [GRP] does not improve the

AFSPC Photo

Above: In the 21st century, missileers remain on watch 24 hours a day. Although the size of the nation's ICBM force has been reduced, America's missile deterrent remains as vital as ever. Opposite: Test launch of a Minuteman III missile. AFSPC hopes to keep the Minuteman in service until at least 2020.

AFSPC Photo

accuracy. It's a common misconception that we're improving the accuracy of the Minuteman III. But we're not doing that. We're just making some smart changes that will extend the mean time between failures on our guidance system so we don't have to do as much maintenance on those systems. And that is the biggest driver for our heavy-duty maintenance: replacing the guidance systems."

Another Minuteman III modernization initiative is called the Safety Enhanced Reentry Vehicle. Under that program, 20th Air Force will take some of the modern warheads that are on the Peacekeeper missiles now being deactivated and deploy some of those warheads on the modernized Minuteman III missiles.

Other enhancements are focused on Minuteman III command and control facilities and infrastructure. One example can be found in the block software upgrade now being applied to the Rapid Execution and Combat Targeting (REACT) command and control consoles located in the underground alert capsules at the LCCs. First deployed in the mid-90s, the REACT consoles will have expanded capabilities through the application of the new software.

"At all our units, we're also enhancing the communications capability to allow us to make full use of the constellation of MILSATCOM MILSTAR satellites," Klotz added, explaining that the enhancement will allow "use of all the frequency spectrum that the satellites have, including encrypted capabilities, and enhancing our capability to use our various low-frequency and very-low-frequency transmitters. So we will have significantly increased communications connectivity. It's already very good. In fact, one of the advantages that the ICBM brings to the fight is the redundant communications path into a Launch Control Center – more so than with the submarines or with the bombers. The ICBMs give a very high assurance that you can both contact and be contacted by a Launch Control Center. And this upgrade will enhance that capability even further."

Finally, the enhancement package will encompass a broad spectrum of civil engineering efforts to upgrade the environmental control systems at both launch silos and LCCs. "The whole objective of all this is to sustain the Minuteman missile until the year 2020 – at least until the year 2020. By that time it's our hope that we will have a follow-on Land Based Strategic Deterrent system ready to take Minuteman III's place," Klotz said. At the same time that the transforming force is applying these significant Minuteman III upgrade packages, 20th Air Force is also continuing the deactivation of its 50 Peacekeeper missiles, a mission started in October 2002. "We're down to 13 Peacekeepers on alert right now," Klotz said, adding that the deactivation process "is not a trivial task."

Part of the work challenge stems from Peacekeeper's basic missile design. Unlike the Minuteman III missile, in which the three stages are mated at the depot and delivered or removed from the silo together as one package (with guidance and warhead sections added or removed separately), Peacekeeper requires the four larger-diameter stages to be individually stacked and destacked in the silo. "In that respect, Peacekeeper is sort of like a space launch vehicle," Klotz added. "So the deactivation of a Peacekeeper requires 10 full days on site, then two weeks or more back on base, processing all the parts and getting them ready for shipment to the point where they will ultimately be stored. It's not a trivial task, but it's one that we have done safely, securely, on schedule, and on budget. By the end of September 2005, Peacekeeper will be completely deactivated."

Looking toward the future of 20th Air Force, Klotz sees significant challenges in the need to conduct the myriad sustainment, modernization, and security upgrade programs on time, on schedule, and on budget. "It is an enormous undertaking," he cautioned. "I've heard it said by people who have been in the business since its inception that this is probably the highest operational tempo that the Minuteman force has had since we first put the missiles in the ground. I mean, we are literally changing or affecting every inch of the 60-foot Minuteman III missile – from the nose tip to the first stage nozzles – as well as everything that surrounds it, including command and control, communications, security, and environmental control systems. And we're doing it with the expectation of having most of it done by the year 2011 – much of it before that."

"That's going to be the biggest challenge," he continued, "maintaining that ops tempo with the size force we have, with the support equipment, and the vehicles that we have, over that period of time. All the while we will keep our eye firmly fixed on the need to maintain the highest levels of security and safety as we do all of this."

Closing the interview with some personal observations regarding the continuing efficacy of a missile force for the nation, Klotz noted that, "The Minuteman and Peacekeeper forces have been largely geared to strategic nuclear deterrence. But it is my sense that over the next decade or two we would be well-served as a nation by having a capability to deliver a weapon halfway across the world to any point of the globe with absolute precision in order to achieve an important military objective – an objective that you wanted to achieve before you could get other U.S. or coalition forces to the target."

"There's a lot of talk about it, but as I look at the technology that's out there now, what you can achieve in the next 10 to 20 years is probably some conventional variation of the ICBM – some variation of the current types of technology that we have. If that kind of capability was needed, then I think that would be an important arrow to put in the quiver of our national leadership. We still have to do a lot of thinking about how we would do that, but that's the kind of a capability that would be well-served for the nation to have as we look out 20 or 30 years into the future," he said.

"As we look at the last 50 years of space and missiles, we need to draw on that experience," Klotz concluded. "Not just in terms of the technology itself, but in terms of our concepts for operating, maintaining, securing, and supporting the ICBM. And then we need to use those as a springboard for how we think about developing additional capabilities for the national leadership to use in times of conflict or crisis to achieve U.S. national security objectives."

Personnel of the 91st Space Wing work on a Minuteman III. The missiles are going through a series of security and modernization upgrades.

AFSPC Photo

LIGHTING THE CANDLE

The Air Force and Manned Spaceflight

By Dwight J. Zimmerman

NASA Photos

The hope for a new world of peace following the end of World War II in 1945 was dashed by the Cold War, that period of international tension caused by irreconcilable political differences between the United States and the Soviet Union. In addition to inspiring the arms race, the Cold War was both the backdrop and impetus for another race – one that would result in mankind's greatest achievement in the 20th century: the landing of a man on the moon on July 20, 1969.

The competition between the United States and the Soviet Union to reach, explore, and conquer space was intense. The costs were enormous and the technological challenges were mind-boggling. Of rocket, satellite, and human performance and endurance in "the Wild Black Yonder" little to nothing was known, almost everything was conjecture, and the only way to know for certain was to do. The United States entered the manned space flight arena with the X-15 and astronaut programs christened Mercury, Gemini, and Apollo.

These programs were pioneering efforts, with the men involved literally writing the roadmap that others would follow. Gene Kranz, a former Air Force pilot who became one of NASA's first flight directors recalled the situation when he joined the Mercury team: "Since there were no books written on the actual methodology of space flight, we had to write them as we went along."

Because "no frame of reference" was a constant in those early days, America's manned space program took a series of what Kranz called "baby steps," carefully and thoroughly preparing for missions by conducting exhaustive simulations and unmanned tests of procedures and equipment. It was absolutely vital, totally necessary, and, to the general population, thoroughly boring – particularly because the Russians were grabbing international headlines with their space program achievements. On October 4, 1957, the Soviet Union successfully launched Sputnik 1, the world's first satellite. The "space race" was officially on, with the Soviet Union leaping to a spectacular lead. This was followed by another first on April 12, 1961, when cosmonaut Yuri Gagarin became the first man in space. The United States was in the uncomfortable position of playing catch-up, big time.

The first program in America's manned space effort was the X-15. The X-15 was one of a series of experimental ultra high-speed, or hypersonic, aircraft that included the X-1, the X-2, and the Dyna-Soar X-20.

The X-15 program contained nine phases that studied and tested everything from new engine design, hyperspeed flight, flight control systems, fuel systems, and metal durability to human survivability.

Twelve pilots participated in the program. All were either on active duty or had formerly served in the military. Five had been combat pilots in World War II and three saw combat in the Korean War. One, Neil Armstrong, would later become the first man to walk on the moon.

A lot of theory and speculation surrounded the concept of whether or not an airplane and its pilot could fly at hypersonic speeds of Mach 5 and above. The math claimed it was possible. Wind tunnel tests tended to agree. But the only way to know for certain was to build it and fly it. Milton O. Thompson, an X-15 test pilot, succinctly stated the two questions that would dominate the X-15 program, "Could we design an airplane that would be controllable outside the atmosphere at high speed and steep entry angles? More important, could a pilot survive and function adequately in this high-energy environment?" In an interview at the time, Air Force Research and Development Command General Bernard A. Schriever added, "The X-15 will provide a great deal of information about man in his environment in space – and it will be the first experiment in which man will have to perform functions in space: more functions than in [NASA's Mercury program]. . . . the X-15 has the potential of taking a large step forward in the development of man's environment – leading to his performing a useful function. [The X-15 will also] give very valuable information on aerodynamics and control characteristics – in the re-entry into Earth's atmosphere."

The original design specifications called for the X-15 to achieve a minimum top speed of Mach 6.6, or 4,430 miles per hour, and an altitude of 250,000 feet, or 47 miles. Today, popular imagination, largely fueled by *Star Wars* movies, has single or two-seat spacecraft looping, rolling, and performing split-S, Immelmann, and other aerial acrobatic maneuvers utilizing rudders, ailerons, and elevators. Nothing is further from the truth, because at that altitude no air exists for those flying surfaces to grab. Instead the X-15, because it would follow a ballistic trajectory, was installed with a ballistic control system consisting of eight small maneuvering jets in its nose and four in its wings. These were designed to achieve the correct re-entry angle – too high or too low and the X-15 and its pilot would be vaporized by atmospheric friction.

Previous: X-15 flight crew in 1966. From left to right, Air Force Capt. Joseph H. Engle, Air Force Maj. Robert A. Rushworth, NASA pilot John B. McKay, Air Force Maj. William J. "Pete" Knight, NASA pilot Milton O. Thompson, and NASA pilot Bill Dana. Above: A Mercury Atlas spacecraft on the launch pad. The Air Force's Atlas and Titan ICBMs were adapted to boost many of America's first astronauts into orbit. This one carried Gordon Cooper in *Faith 7.*

North American won the contract to build the X-15. Among the many challenges the 125 engineers assigned to the program encountered was that of creating metals that could maintain structural integrity in an environment that included temperature extremes ranging from a low of minus 300 degrees Fahrenheit to a high of 1,200 degrees Fahrenheit. As if that weren't challenge enough, the metals also had to be as light as possible. Earl Sykes, one of the engineers on the program, acknowledged that from the beginning, "The nightmare for everybody [was] weight." Every trick from the filing and shaving of unstressed parts to using different welding techniques was utilized to drop the spacecraft's weight as much as safely possible. The result was at one point a savings of 300 pounds on the 31,275-pound X-15. This yielded the potential addition of an extra 102 miles per hour to the maximum speed.

Another problem that engineers experienced was that of controlling the explosive characteristics of pressurized liquid oxygen (lox), which is highly volatile if struck. This point was brought home when a rubber gasket became permeated with lox and, during a ground test, accidentally exploded when an object tapped it.

In the nine years of its existence, from June 8, 1959, when A. Scott Crossfield flew the first mission, to October 24, 1968, the day of its final mission, the X-15 made 199 flights, set an unofficial world altitude record of 354,200 feet (67 miles) and a world speed record of Mach 6.7 (4,520 mph). Crossfield said, "The X-15 Research Airplane operation . . . created a major technological stepping stone to space." Milton Thompson, in his book *At the Edge of Space*, listed 25 accomplishments of the X-15 program. These including such firsts as the first application of hypersonic theory and wind tunnel work to an actual flight vehicle, the first direct measurement of hypersonic skin friction, and the development of the first practical full pressure suit for pilot protection in space.

The X-15 was overshadowed by the more glamorous astronaut programs. The first was Mercury, designed to carry one man into orbit around Earth. The next stage was Gemini, whose capsules carried a two-man crew, designed to test human endurance in space and the equipment and technologies that would be used for missions to the moon. The third and greatest of the early space efforts was Apollo. Its capsules contained a crew of three, and it was the program designed to fulfill President John F. Kennedy's challenge to land a man on the moon and return him safely to Earth.

On May 28, 1959, NASA announced the seven men who would become America's first astronauts. All had come from the military. These men, dubbed the "Magnificent Seven," were Donald K. (Deke) Slayton, Virgil I. (Gus) Grissom, and Gordon (Gordo) Cooper from the Air Force; John Glenn, from the Marine Corps; and Alan Shepard, Wally Schirra, and Scott Carpenter from the Navy. They were the survivors of a grueling selection process that had begun with 110 pilots. In the words of one NASA official, these seven demonstrated "the most outstanding professional background and knowledge in relation to the job requirements." NASA's announcement thrust these men into the spotlight, where they became instant heroes. One of the first questions posed to them during a press conference was which one of them expected to be the first American in space. In response, all seven promptly raised their hands, with Schirra and Glenn raising both. Glenn, among the most personable and charismatic of the group, also quipped that the reason he became an astronaut was "because it is the nearest to heaven I'll ever get." The press loved it.

The first Mercury program boosters were Redstone missiles, adapted from the Army design. While the Redstone was used for the first two suborbital flights, a more powerful booster was needed to power the Mercury capsules into orbit. The Air Force's Atlas, the first Intercontinental Ballistic Missile (ICBM), was soon adapted for the program. For the later Gemini program, named in part for the fact that two astronauts would pilot the capsule,

Astronaut Ed White makes America's first space walk during the Gemini IV mission.

the Air Force's newer Titan ICBM was used. While the Gemini program moved forward as a civilian project, the Air Force was also pushing to expand its own manned space program with a series of planned projects. One of these was the X-20 Dyna-Soar, a manned reusable space plane that began development in 1959 and would have flown almost 20 years before the space shuttle. Manned by a single pilot, the spacecraft would have been boosted into orbit by a Titan III, comprising a manned military patrol capability able to monitor ground sites and protect assets already in space. Despite positive government reviews, however, Defense Secretary Robert McNamara cancelled the program in 1963, a decision many still regard as wrong and shortsighted. At the same time, however, McNamara announced the development of the Manned Orbiting Laboratory (MOL), a small space station that would have taken on a number of reconnaissance functions. Boosted into orbit by a modified Titan missile, the crew of two would ride into orbit inside the laboratory, carry out various tasks for up to 40 days, and then use an attached Gemini capsule to return to Earth. While some information still remains classified, it is believed that both optical and radar surveillance equipment would have been carried by MOL. Would have been, that is, because the program was canceled in 1969. The next manned venture after Apollo, NASA's Space Transportation System (Shuttle), offered another opportunity for a manned military mission in space. And, the Air Force provided significant funding to NASA to develop the shuttle. In fact, a military version of the shuttle was planned, and a launch site, SLC-6 at Vandenberg AFB, was built to support the military shuttle. Funding constraints and the January 1986 *Challenger* disaster, however, ended this program. From that time on, Air Force personnel would only hope to ride into space in civilian (NASA) vehicles.

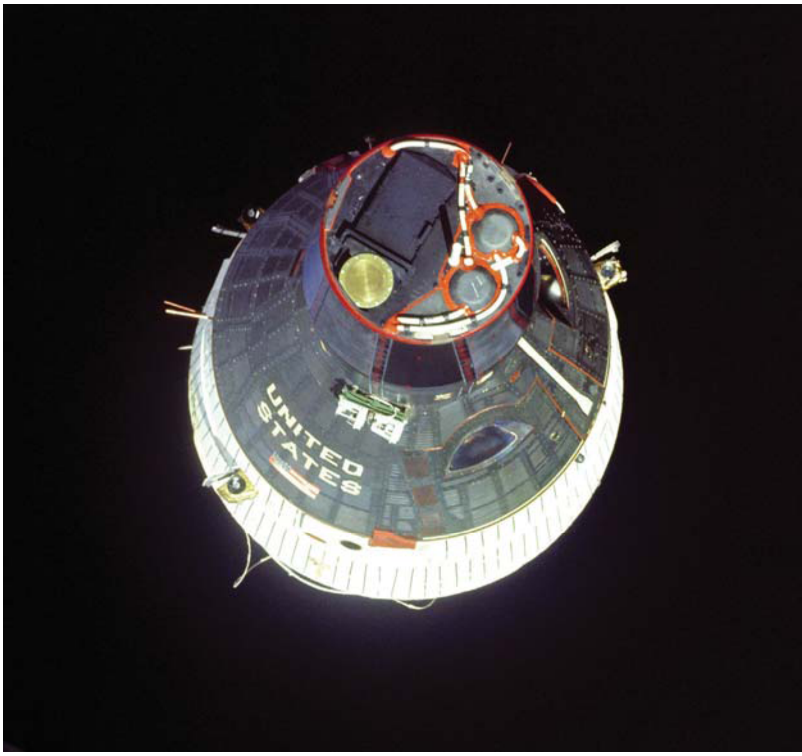
NASA's Manned Space Program incorporated the most advanced computer and communications technology of the day. But this was a period when calculations were still done by slide rule, and room-sized computers using large spools of magnetic tape and punch cards contained less memory and power than one of today's off-the-shelf desktop personal computers.

A global network of tracking stations had to be constructed. Some, such as those in California and Hawaii, were convenient. But many were remote, isolated, and sometimes, thanks to political instability, dangerous. In March 1961, a total of 21 sites, 13 of them manned, were declared operational. They were located in such countries as Australia, Bermuda, Nigeria, and Zanzibar, and on converted World War II cargo vessels sailing in the Atlantic, Pacific, and Indian Oceans. Communication was through Teletype. Initially, data packets were transmitted by Teletype tape in a process that took hours. For Gemini, high-speed digital systems were installed capable of transmitting 2.4 kilobits per second.

George Low served in a number of senior management posts in NASA's Manned Space Flight Program. In defense of America's "go slow" efforts at a time when it appeared that the Soviet Union was winning the space race, he explained to the media that with Mercury, "It has been a major engineering task to design a capsule that is small enough to do the mission, light enough to do the mission, and yet has reliable subsystems to accomplish the mission safely."

That steady commitment was rewarded when, on May 5, 1961, Alan Shepard became the first American in space. Then, on Feb. 20, 1962, John Glenn became the first American to orbit the Earth. The last Mercury mission, carrying Gordon Cooper, was launched on May 15, 1963. Of the original seven astronauts, only Deke Slayton had not flown a mission. Diagnosed with an idiopathic atrial fibrillation – a slightly "erratic" heart rate – Slayton was grounded. Slayton would remain at NASA, first as a coordinator of the astronaut corps, later as the deputy for flight operations. Eventually he would be cleared for space flight, and in 1975 would finally reach space in the Apollo-Soyuz mission.

Mercury proved that America could launch a man into space and Earth orbit. Gemini would test man's endurance in space and the technologies and equipment needed for a round trip flight to the moon. Flight plans extended to 14 days. Crewmembers participated for the

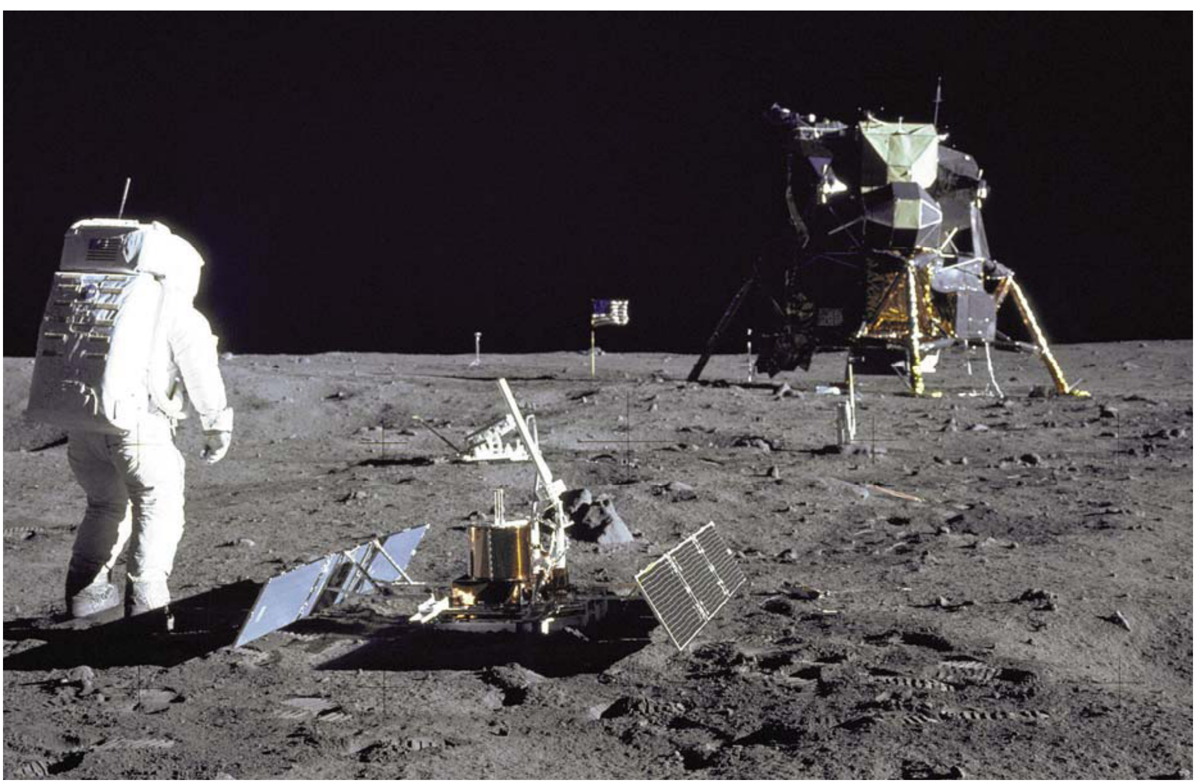


Gemini 6 and 7 proved the ability of spacecraft to rendezvous in orbit. Here, Gemini 7 is seen through the hatch window of Gemini 6.

first time in extravehicular activity (EVA), more famously known as "walks in space." Ed White in Gemini 4 was the first astronaut to do so. Attached to the craft by a tether, and maneuvering with the aid of a compressed-air gun, White reported, "This is the greatest experience; it's just tremendous." Gemini 6 and Gemini 7 performed the first rendezvous in space. Numerous problems, large and small, occurred during the program. Neil Armstrong and David Scott were almost killed when Gemini 8 spun out of control. They regained control using the re-entry control system. In overcoming all of the problems, valuable experience was gained. When the program concluded with Gemini 12 in November 1966, it appeared that America was ready to make good on President Kennedy's promise to reach the moon before the end of the decade with Apollo.

Gus Grissom, Ed White, and Roger Chaffee were announced as the crew for Apollo 1. A pre-launch test was set for Friday, Jan. 27, 1967, on Pad 34. The crew entered the module just after 1:00 p.m. At 6:31 p.m., the mission control room heard Grissom suddenly shout, "Hey!" and Chaffee report from the module, "There's a fire in here!" Within minutes, the three astronauts were dead. Autopsy reports would later reveal that the three had died of inhalation of toxic gases. A board of inquiry was formed, headed by Floyd L. Thompson, director of the Langley Research Center. The atmosphere in the command module was 100 percent oxygen under pressure. This created a potentially explosive environment. But it had been used in Mercury and Gemini without incident. That record ended on Jan. 27. It was an enormous tragedy. But, something good did come out of it. Walter Cunningham, a member of the crew of Apollo 7, the first manned launch after the accident, wrote, "The death of Gus Grissom's crew at the Cape, on the pad, made it possible to land a man on the moon on schedule. Indeed, it may have saved America's space program. So we cannot consider their deaths to have been in vain." Cunningham added that the fire did something else, as well. "It reminded the American public that men could and would die exploring the heavens."

All Apollo missions were put on hold. Every aspect of the program was reviewed. New tests were conducted. New designs of the spacecraft and the rockets were drawn up and put into production. On Nov. 9, 1967, the unmanned Apollo 4 was launched. The mission was flawless. At a post launch news conference, Wernher von Braun stated, "No single event since the formation of the Marshall Center in 1960 equals today's launch in significance." On Oct. 11, 1968, Apollo 7, containing the crew of Wally Schirra, Don Eisele, and Walt Cunningham, blasted off. The mission was not as much of a success as everyone had hoped. Part of the reason



Astronaut Edwin "Buzz" Aldrin looks back at Tranquility Base during the Apollo 11 mission.

was because Schirra had a head cold that was passed to the rest of the crew.

Apollo 8, launched on Dec. 21, 1968, with a crew of Frank Borman, James Lovell, and William Anders, was arguably the second most famous of the Apollo missions. For the first time in history, man would circumnavigate the moon. Some of the most important photographs in history, including the earthrise over the moon, were taken by the crew of Apollo 8. But what was etched in the memory of everyone who heard it was the message read by the crew on Christmas Eve. William Anders began with the greeting, "For all the people on Earth, the crew of Apollo 8 has a message we would like to send you." He then started reading from the book of Genesis: "In the beginning, God created the heaven and the earth." Lovell and Borman continued the message, reading additional passages. NASA director Chris Kraft stated, "No eye was dry in mission control. . . . [or] in the newsroom packed shoulder to shoulder with reporters covering the greatest story of their lives."

The pinnacle of Apollo and of man's achievement in space was Apollo 11, the mission that would have the first landing of man on the moon. The crew was Neil Armstrong, Buzz Aldrin, and Mike Collins (both Aldrin and Collins were Air Force officers). With Mike Collins piloting the command module Columbia, Armstrong and Aldrin entered the lunar module, named Eagle, and prepared for their historic voyage. On July 20, 1969, the Eagle separated from Columbia. At 4:17 Eastern Daylight Time, Neil Armstrong transmitted, "Houston, Tranquility Base here. The Eagle has landed." Six and a half hours later, this was followed by an even more historic message, as Armstrong stepped off the Eagle's ladder and onto the surface of the moon: "That's one small step for . . . man . . . one giant leap for mankind." It was estimated that 600 million people, a fifth of the world's population, watched the event.

Congratulations came in from all over the world. Russian Konstantini Feoktistov, a scientist who had flown with cosmonauts, praised their achievement, stating that he and his countrymen "rejoice at the success of the American astronauts." It was a gracious acknowledgment of the fact that America had won the space race.

Today there are over 50 former Air Force astronauts, as well as more than 20 who are currently serving. Many have flown into space aboard the space shuttle, and doubtless more will work aboard the aging space plane during the first decades of this century. In the meantime, new spacecraft are in development, new missions to the moon and Mars are being planned, and new challenges await. Those who wear Air Force blue will no doubt be a big part of that future.

Emblems courtesy of Air Force Space Command, the National Reconnaissance Office, Army Space and Missile Defense Command, the National Oceanic and Atmospheric Administration

WORKING TOGETHER

Interagency Cooperation

By J.R. Wilson

Space has never been a one-man show. From NASA's manned and unmanned exploration programs to the Defense Department's military applications, success has required the concerted efforts of a vast number of government agencies and private contractors, all working toward a common goal.

As Air Force Space Command (AFSPC) moves into the 21st century with new responsibilities resulting from the restructuring that closed down the U.S. Space Command, which shifted most of its activities to the new Strategic Command (USSTRATCOM) and much of the service space commands' portfolios to AFSPC, interagency cooperation becomes even more important.

"Passing the responsibility for global space to USSTRATCOM was a change, but not a revolutionary change," AFSPC Vice Commander Lt. Gen. Dan Leaf said. "That did not necessarily change the partners – theater combatant command and their components are partners in a beneficiary sense, benefiting from our space capabilities; we provide GPS as a utility they access without much day-to-day direct interaction. And we provide a component role to USSTRATCOM and, as we saw in Operation Iraqi Freedom, that is usually through a space coordinating authority, such as the joint force air component commander (JFACC).

"We still partner with the Navy and Army space elements, both in operations and in development and acquisition. We have the bulk of the budget, capability, and people, but it is in no one's interest for the other services not to be involved in space. We need the other services to advocate the development of space capabilities and, as a capability provider, we understand the unique requirements of the other services. Our other partners include other government agencies, such as NRO [National Reconnaissance Office], which has the greatest investment in terms of Air Force personnel assigned to them; NSA [National Security Agency]; NGA [National Geospatial-Intelligence Agency]; NASA; and others."

Indeed, the list of agencies playing some role in the future development of military space covers virtually every aspect of government. Within DoD, that includes the Army Space and Missile Defense Command, Marine Corps Space Integration Branch, Naval Network and Space Operations Command, Defense Advanced Research Projects Agency (DARPA), and the Missile Defense Agency, among many others. Outside the military, partnerships continue with NASA, the National Oceanic & Atmospheric Administration (NOAA), the National Space Weather Program (NSWP), the National Science and Technology Council (NSTC), the Departments of Commerce and Energy, even the U.S. Trade Representative and the National Economic Council.

Outside of government, AFSPC works with a host of universities, industry contractors and subcontractors, as well as allied governments, academia, and industry.

As with its civilian counterparts, AFSPC's technology requirements and potential customers are global in nature.

"The partnership with industry is unique for space because we have to get things right the first time, which makes development very challenging, both from the standpoint of a successful launch and ensuring it works properly once in orbit, because we can't fix it," Leaf noted. "It is not how complex what we do in space is – and it really isn't – but the physics and the extraordinarily harsh environment. So getting it right the first time requires a very close partnership with industry.

"The bridge for that partnership, even though they often provide an analytical capability, is Aerospace Corp. We rely very heavily on it for oversight, expertise, and a second opinion for doing these difficult things."

Working with academia is not quite as direct a partnership as that with other government agencies or industry, but, Leaf emphasized, it is no less important.

"MIT-Lincoln Labs, which is not exclusively a space partnership, is an important example of how we partner," he said. "As we continue to refine our development of space professionals to meet the challenges of the future, a huge part is provided by academia. That's not a receive-only partnership – the frontiers we explore and the boundaries we cross provide an impetus to civilian research."

It was not the dissolution of USSPACECOM and the transition of most of its functions to USSTRATCOM that affected most AFSPC partnerships, Leaf said.

"Many of us believe our acquisitions-reform initiatives have divested much of the military involvement and decreased our ability to interface with academia. We now have to rely more on and interact with industry," he said. "As we went to cheaper, better, faster, and all the acquisition-reform buzzwords, we divested significantly more of the development process to industry and reduced our space professional team, which cost us a lot of expertise.

"We are rebuilding that through an emphasis on space professional development and career management. It's not just the right assignment, but the experience they have and what they need and that we provide meaningful professional and academic opportunities, through the military and academia and with industry."

In one area, however – research and development – the changes increased AFSPC's control.

"AFSPC has significantly more control over the effort in general because of the transfer of SMC [Space & Missile Systems Center] from AFMC [Air Force Materiel Command] to AFSPC," Leaf said. "That is, in fact, more significant than the dissolution of USSPACECOM and the transfer to USSTRATCOM. It has increased and improved the bond and communication between the scientists, engineers, developers, and the operational community that must apply the capabilities they provide.

Photo courtesy of Dr. David N. Spires

Lt. Gen. Dan Leaf, Vice Commander of Air Force Space Command.

That is unique to space. That transfer at the same time we dissolved USSPACECOM has dramatically improved communications between provider and user.

"SMC has program executive officer responsibilities and oversees the operations of the various program offices and directors. They work very closely with 14th Air Force on the launch campaign side of space and missile systems acquisition. They have the traditional research and acquisition capability."

Under the reorganization, USSTRATCOM took on the bulk of USSPACECOM's responsibilities, which Leaf said created a far more functional relationship.

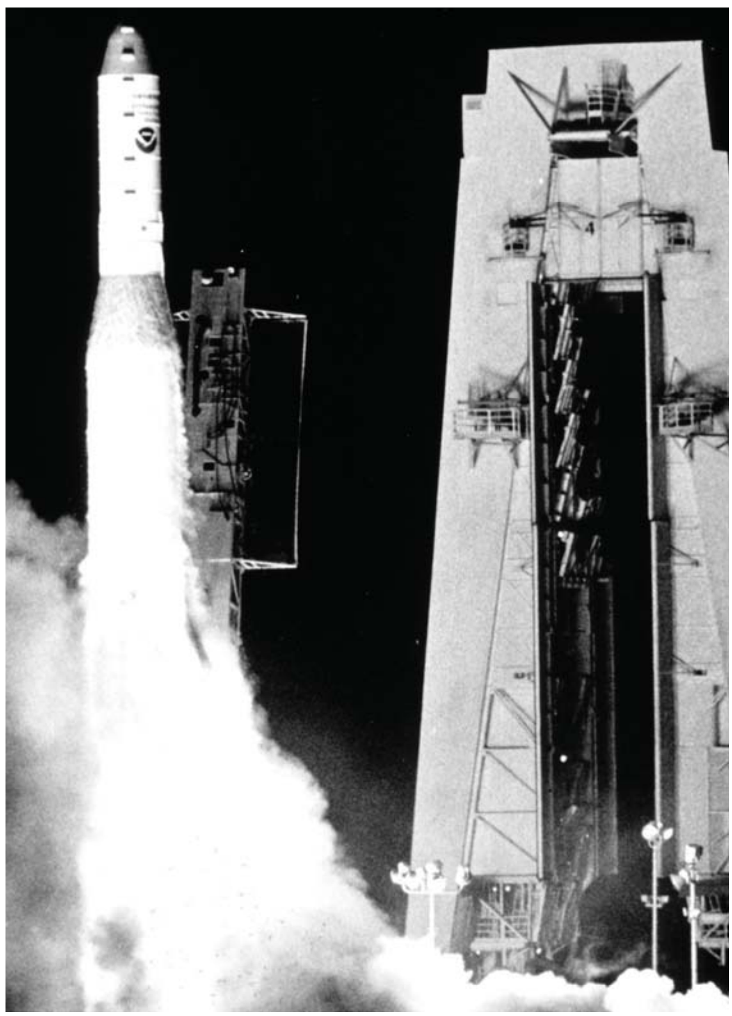
"We now have a more normal relationship – a combatant command providing strategic guidance, including mission orders and commanders' intent. I expect further refinement in that relationship over the next several months, where we will become a functional component, but in a joint sense, providing C2 capabilities as a true component, and they will be a true combatant command.

"We do need a better relationship with the operational side to the supported combatant commander. There will be a revised organizational structure that provides strong leadership on the Air Force side and the joint side. That will be a significant transition, and the change from USSPACECOM to USSTRATCOM makes that possible. I'm hopeful within a few months we will make some significant movements, but it has been a grinding effort."

Maj. Gen. Mike Hamel, commander of the 14th Air Force (14th AF), believes the reorganization will open new opportunities for interagency cooperation as it breaks the Cold War mold in which Air Force space originally was formed. As one of two numbered air forces in AFSPC, the mission of the 14th AF is to control and exploit space for global and theater operations. The 14th AF is also the Air Force Space Task Force to USSTRATCOM. The 20th Air Force, led by Maj. Gen. Frank Klotz, is responsible for maintaining and operating the Air Force's ICBM force.

"I would characterize our space capability today, in terms of technology and performance, as unrivaled in the world, but because of some of the heritage dating back to the Cold War, we still have a lot of stovepiped systems," he said. "So there is often not much integration between various space platforms. One of the most important things we can achieve is doing a better job of horizontally integrating our space capability, to develop a single integrated picture, describing the full picture on a global basis and portraying it in a useful fashion, from the private in the rifle squad all the way up to the president.

"With emerging information technology and some C2 systems now emerging, there is a great opportunity to develop this single integrated picture from space that will allow commanders from all missions to know what capabilities they have and what they can request from space. So we are working very diligently to develop the tools and their relationship, both inside the Air Force and with the other services, and, in some cases, even civil and commercial providers, so we can understand how they are deployed."



NOAA photo

The September 1988 launch of the NOAA-11 meteorological satellite from Vandenberg Air Force Base, Calif., on a TIROS-N spacecraft. The National Oceanic & Atmospheric Administration (NOAA) is one of a number of government agencies, both within and outside the Department of Defense, with which Air Force Space Command collaborates.

As they move forward toward that goal, it also is important to closely watch developments elsewhere, ensuring the United States maintains its current lead in military space and assuring combatant commanders will have the assets they need – and the enemy won't.

"That means maintaining space superiority and improving our overall situational awareness and our ability to anticipate problems and, if necessary, defend our space capabilities should they be disrupted or attacked. And we have to be able to deny the enemy's ability to access space," Hamel said. "So there will be a tremendous amount of effort in the next 10 years to increase our ability to respond to attacks. We have a lot of initiatives on the drawing board, and that will be a very high priority.

"I think we will continue to improve and enhance space integration into theater crises as well as warfighting. One of the most important things that came out of OIF was not just the support for individual systems, but a process was put in place to improve the planning, coordination of support, and integration of space into theater. For the first time, the responsibility for theater-wide space coordination was assigned to the joint force commander. That allowed us to focus all space needs within the theater, to be understood by the air component commander and reach back to home station capabilities to synchronize that. So instead of having a multitude of people seeking a multitude of things from space, we built a reasonable chain of command."

OIF provided a number of lessons learned that will be taken into consideration by all elements of AFSPC and its partners within DoD, other government agencies, and industry, as well as allied governments and even academia, to refine tactics, techniques, and procedures (TTPs) for space coordination through exercises around the world. As high as the bar was set by expectations met and exceeded in OIF, Hamel predicts it will be set even higher with each future conflict.

"There is a continuing education going on – and that's a two-way street. The deployment of space support teams into the Army, Navy, and other forces helps educate the air, ground, and sea forces and tells us what those customers need. And that can cover a lot of territory as we support forces now knowing better how to exploit space capabilities and the space community, in turn, understanding what they need to provide and anticipating that," he said.

In some respects, military space may have relied too heavily on commercial space development to help meet some of those needs.

"We devote a substantial amount of taxpayer dollars to our space capabilities – and that has grown over the past decade. The situation we find ourselves in now is that many of the programs now underway were the product of the 1990s, where we were expecting a much more robust commercial space market for launch, satellite communications, and other services that we could leverage. That didn't materialize, so we now have a number of programs predicated on that for which we will have to foot the bill beyond what we anticipated. So part of our challenge has to be getting our programs back on track and have the confidence we can deliver when needed," Hamel said. "Much of what we talk about for the future is clearly within our reach. We have to demonstrate we can deliver on what we promise, while at the same time investing in the technologies that will bring that new generation of revolutionary capabilities on line."

Another area where increased investment is needed is education, working with the Air Force Space Academy and other service academies and public universities to not only teach courses fundamental to future space development, but to recruit the next generation of space leaders.

"For a number of years, the Academy has had a number of academic majors and courses relative to space and they are doing a very good job. But we in the Air Force need to do a better job of recruiting young officers coming out of the Academy and other venues. This is a very exciting time in my 30-plus years in the space business, but we need to do a better job at recruiting the future leaders in space," Hamel said. "The development of a cadre of space professionals with the requisite education, training, and experience to become world-class leaders for space is mandatory.

"Being a student of space history, we need to understand our roots and how we have evolved as a warfighting community within the Air Force. All our upcoming space warriors need to understand what brought us to where we are today and where we are going. There is no time of more profound or consequential change than where we are today. I believe we are on the verge of a major upswing in space's role in our nation's security."

One agency with which AFSPC is having an increasing interface is the National Reconnaissance Office (NRO), where Brig. Gen. Irv Halter, dual-hatted as Deputy Director-Military Support and Deputy Director-National Systems Operations, believes a two-decade-old program – Tactical Exploitation of National Capabilities (TENCAP) – is helping move elements of military space throughout the federal system while bringing the best of other agencies to AFSPC. He also cites the national security and space office created by Under Secretary of the Air Force Peter Teets for working across NRO, all DoD agencies, and NASA to coordinate all space efforts.

"We do not produce intelligence products, but help other people do that, working through other agencies; our job is to move data – raw or finished products – down to the lowest level. We have designed, structured, and fielded ways to get data out in real time," Halter said. "We also have developed seek algorithms that allow people to locate or even manipulate that data. There are ways data are being manipulated that we had never considered before.

"We are working with all our partners on figuring out ways to have everybody able to access everybody else's data. We can't have secrets from each other within the intelligence community. It's Murphy's Law – the one piece of data you don't share, for whatever reason, is the one piece that will be critical to solving a problem. So all these databases need to be able to talk to each other."

Insofar as military space is concerned, Halter says the cooperative effort is with USSTRATCOM's new role as lead agency for space and as DoD's "global ISR guru. In both of those, NRO is a primary player, so we work very closely with them to figure out how we can best collaborate with them."

With NRO personnel at all the major combatant commands, as Teets' personal representatives, data are constantly flowing out from NRO to those commands and back up the chain. About a year ago, an NRO team headed by Halter completed a study of lessons learned from the initial combat phase of OIF.

"The overarching issue we came away with is, unlike Desert Storm, the national system played an active role in the kill chain, all the way from strategic down to tactical level. It is no longer a niche capability. People do use it – even if they don't know they are – and it makes a difference," he said.

One of the most important technological challenges facing NRO is finding new ways to get data from space.

"We have not explored all those yet. Our advanced technology folks at NRO are constantly looking for new ways and means to collect data and get it back from space. There's some exciting stuff out there," Halter noted. "Obviously, everybody has budget constraints. We and the rest of the space community spend a lot of time figuring out new ways to build and launch spacecraft. We started going down that road in the '90s and discovered when you put budgets and schedules in front of mission success, you end up paying a price you might not want to pay. SBIRS [Spaced-Based Infrared System] has been a troubled program for that very reason.

"Looking at technologies that may allow us to do things faster and cheaper, such as rapid launch, those are the breakthroughs we're looking for. In the meantime, we still have a customer base – on both the national and military side – that requires us to continue to provide the same level of service they have become accustomed to in the past several years," Halter said.

Maintaining a collaborative relationship with America's closest allies also is an important point in how NRO moves data around the battlefield – knowing whom to share data with and where to break down barriers, when appropriate.

"The NRO's main job is in space, so the way it is being used by military folks is growing. That doesn't mean we are flying more birds or putting more things in orbit, but that the data gathered is being used by more folks," Halter said. "We have the ability now to parse data, move it around, do whatever is necessary, so our data may be equally useful to the folks who brief the president and the guy on the battlefield who may need it.

"Space going to USSTRATCOM changed things for NRO. We had a very close relationship with Air Force Space Command, which was the largest piece of USSPACECOM," he reported. "We have put into place an extra liaison at USSTRATCOM and our operations center here reports the status of our systems to all relevant agencies. When USSTRATCOM took up the SPACECOM responsibility, we made sure we had the relevant connections there. And we still maintain our links with AFSPC and with 14th Air Force. So there really wasn't a major restructure."