WINTER 2024 - Volume 71, Number 4
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Journal of the Air Force Historical Foundation

U.S. Space Force 5th Anniversary Edition

know the past
.....Shape the Future

On December 20, 2019, the U.S. Space Force was established, creating the first new branch of the U.S. armed services in 73 years. The need for a separate, space-oriented branch of service was driven by the quickly evolving space domain, and a growing threat posed by near-peer competitors in space. The space domain empowers the U.S. military to be faster, better connected, more informed, precise and lethal because of its investment to strengthen its presence in space. While the U.S. grew its space enterprise, so did the military forces of other countries, creating congestion in a once benign area of operations. While the idea of a separate space force had been debated for decades, it was not until 2018 that the highest levels of government began to advocate for a separate force. Nearly five years after it was created, the Space Force and its Guardians continue to "secure our nation's interest in, from and to space."

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List of reviews continues on page 3

FRONT COVER: Rick Herter's *High Ground Intercept*, shows a futuristic American spacecraft hunting down an orbital weapon system before it can reach a nearby American satellite.
BACK COVER: Photograph of the Gemini 4 EVA as Ed White backs away from the Gemini spacecraft over the Pacific Ocean northeast of Hawaii. *(NASA photo.)*

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Book Review List (cont.)

2024 State of the Foundation

Dear Readers,

"So there I was … " As anyone with a passing knowledge of the military knows, those four words are the start of many war stories and tall tales in squadron heritage rooms throughout the Air Force and Space Force. In my case, so there I was … like all good officers, I arrived at the hanger on Andrews Air Force Base for the ceremony early. I went through security and immediately secured a seat in the back row. As expected, a nice but very insistent Airman approached me and asked me to move towards the front row, where another nice Airman asked me to move to the center of the row. That's how a got a front row, center seat to history in the making. If you look at pictures of the President signing the National Defense Authorization Act creating the United States Space Force in 2019, that's the back of my bald head shining in the crowd in front on him.

While December 20, 2019, will be remembered as the birthday of the Space Force, every historian knows that any significant event is the culmination of many threads and preceding events. What were these events and who were the protagonists? Immediately before December 19, there was the work of a Secretary of the Air Force directed planning team working at the Pentagon. However, this team leveraged the work of an earlier, 2000 Senate study led by past and future Secretary of Defense Donald Rumsfeld. Nicknamed the Space Commission or Rumsfeld Commission, their report identified challenges with the current management of space operations within the DoD and recommended an eventual Space Force or Space Corps. Going even further back, even before there was an Air Force, General Hap Arnold saw the potential of the space domain and commissioned a RAND Corporation study, the "Preliminary Design of an Experimental World-Circling Spaceship," which identified military uses for satellites.

The fifth anniversary of the establishment of the United States Space Force gives the Air Force Historical Foundation the opportunity to reflect back on this event. This comes at a great time as memories are already fading. I recently met up with another veteran from the SECAF's Space Force Planning Team. Even though we're only five years removed from the establishment of the Space Force, we both had forgotten details and events … events that will be of interest to future historians as well as members of both the Space Force and Air Force.

Over the coming year we will also have podcast episodes focused on the establishment of the Space Force, where we interview different participants to capture their part in the process. One of our first podcasts in this series will interview members of the various working groups at the White House, Headquarters Air Force and Air Force Space Command that created the structure of the Space Force. Our hope is to preserve these stories and make them available to to our membership. If you are not one already, become a member now!
https://www.afhistory.org/support/become-a-member/

Col. Stu Pettis, USAF (Ret.)
Foundation Vice Chair for Space

Don't miss our Podcast and Newsletter

The Air Force Historical Foundation sponsors additional streams of historical information. We have a podcast that you don't want to miss and a newsletter full of items of interest. The podcast is at www.afhistory.org/podcast/. The next series will focus on the birth of the Space Force. Lots of behind-the-scenes actors and info.

We have also launched a newsletter, called *Raider Chronicles*, which can be found at www.afhistory.org/research/newsletter/ and appears quarterly. The upcoming Winter issue will have a focus on women, with the feature article being about the history of the Women Military Aviators organization, which was established in 1982, and our "Member Spotlight" and "When I Served" columns both featuring women.

From the Editor

Our theme in this issue is obviously the 5th Anniversary of the creation of the U.S. Space Force, officially on December 20, 2024.

Our opening article is a republication of an article by Maj. Gen. Thomas D. "Tav" Taverney (USAF, Ret.), who sets the stage for the development of the space mission into a new military force.

Our next article is by return contributor David Arnold, who writes about space history as represented by six artifacts held by the National Museum of the U.S. Air Force.

Our third article is from our our unparalleled missile expert, David K. Stumpf. His explanation of how the USAF dealt with the vulnerability of land-based ICBMs is a great read.

Our final article is by a return author (and previous award winner), Jayson Altieri. This article is about the contributions of the Guggenheim Institute to aeronautics.

We have lengthened this issue in order to publish a large number of reviews, 41 in all, to try and publish a backlog of this year's reviews. The Spring issue will probably contain just as many.

This publication is also continuing the process of replacing our magazine editor. Submissions to the Foundation should be in by now. When there is news on that, we will announce it.

The Leadership's Message can be found on page 4. It's worth the read. Don't miss Upcoming Events on page 82. And the issue closes with the Mystery on page 84. Enjoy!

Richard I. Wolf, Editor

2025 Air Force Historical Foundation Awards

The James H. "Jimmy" Doolittle Award

Space Delta 4 (DEL 4) is a United States Space Force unit responsible for providing strategic and theater missile warning to the United States and its international partners. It operates three constellations of Overhead Persistent Infrared (OPIR) satellites and two types of Ground-Based Radars (GBRs) for the purpose of conducting strategic and theater missile warning. Additionally, DEL 4 provides tipping and cueing to missile defense forces, battlespace awareness to combatant commanders and technical intelligence for further analysis and manages weapon system architectures and ensures operations are intelligence-led, cyber-resilient, and driven by innovation, while postured to operate in a contested, degraded, and operationally limited environment.

Activated on 24 July 2020, the delta is headquartered at Buckley Space Force Base, Colorado.

Air Force Outstanding Training Unit (award recognizes a unit whose primary USAF/SF mission is training.

Located west of Phoenix, Luke Air Force Base is home to the 56th Fighter Wing, the largest fighter wing in the world and the Air Force's primary active-duty fighter pilot training wing. As part of Air Education and Training Command, and home to 24 squadrons with both F–35A Lightning II and F–16 Fighting Falcon aircraft, the 56th graduates more than 400 pilots and 300 air control professionals annually. The wing is also responsible for six additional squadrons under the 54th Fighter Group located at Holloman AFB, New Mexico, where F–16 training will move in the interim as Luke AFB transitions to become the primary pilot training center for the F–35A, the Air Force's newest multi-role aircraft. Additionally, the 56th Fighter Wing oversees the Gila Bend Air Force Auxiliary Field and is steward of the Barry M. Goldwater Range, a military training range spanning more than 1.7 million acres of Sonoran Desert.

The Inaugural Lifetime Achievement for Space Award
Space Lifetime Achievement Award

General Kevin Chilton is a retired four-star General and former commander of the United States Strategic Command. With a career spanning over three decades, General Chilton has left an indelible mark on national security, space operations, and the aerospace community. His leadership extends beyond military service, shaping global strategies in space and nuclear deterrence. As a combat pilot, astronaut, and senior leader, General Chilton exemplifies the qualities that define such an award.

As an astronaut, General Chilton conducted vital missions that advanced space exploration and technology. His leadership as the commander of U.S. Strategic Command reinforced America's nuclear and space deterrent strategies at a pivotal time in global security. General Chilton spearheaded the integration of cyber operations with space and missile defense capabilities, shaping U.S. strategy in these emerging domains. He championed a modernized nuclear force posture, advocating for the responsible use and control of nuclear weapons.

I.B. Holley Award 2025

From 1982 to 1990, Roger Launius held several positions as a civilian historian with the United States Air Force. Between 1990 and 2002, he was the chief historian for NASA. In 2001, he held the Charles A. Lindbergh Chair in Aerospace History at the Smithsonian. From 2002-2006 he was Chair of the Division of Space History at the Smithsonian National Air and Space Museum. From 2006-2013 he was Senior Curator, and from 2013-2016 Launius was Associate Director for Collections and Curatorial Affairs at the same institution.

Launius contributed space policy analysis in the wake of the Columbia Accident Investigation Board 2003 report. He has been a regular commentator on space-related issues for the news media. He was president of the Mormon History Association in 1993–94 and was president of the John Whitmer Historical Association in 1991–92. Launius has written more than twenty books and 100 articles on the history of aerospace. He has twice won the AIAA History Manuscript Award, for *Coming Home: Reentry and Recovery from Space* in 2011, and for *Space Stations: Base Camps to the Stars* in 2003.

Roger D. Launius is former chief historian of the National Aeronautics and Space Administration and most recently Associate Director for Collections and Curatorial Affairs at the Smithsonian Institution's National Air and Space Museum. He is also a recipient of the NASA Exceptional Service Medal and the Exceptional Achievement Medal.

The Carl A. "Tooey" Spaatz Award

David A. Deptula is the Dean of the Mitchell Institute of Aerospace Power Studies. He transitioned from the U.S. Air Force in 2010 at the rank of Lieutenant General after more than 34 years of service. Deptula was commissioned in 1974 as a distinguished graduate from The University of Virginia Air Force ROTC program, and remained to complete a master's degree in 1976. During his military career he took part in operations, planning, and joint warfighting at unit, major command, service headquarters and combatant command levels, and also served on two congressional commissions outlining America's future defense posture. He was a principal author of the original Air Force White Paper "Global Reach—Global Power." In the early 1990s he was instrumental in the formation and development of the concept later known as "effects-based operations," having successfully applied it in building the attack plans for the Operation Desert Storm air campaign. He has been cited as having "... fostered the most significant change in the conduct of aerial warfare since Billy Mitchell...Deptula's framework influenced the successful air campaigns in Operations Allied Force, Iraqi Freedom, and Enduring Freedom. Today, joint targeting cells and Air Force doctrine reflect Deptula's theory of airpower and the changing nature of warfare."

Deptula began his USAF career as a pilot earning his wings in 1977. Upon graduation, he was assigned an F-15C air superiority fighter and went on to serve in fighter squadrons in a variety of roles to include duty as an F-15 aerial demonstration pilot. He attended the USAF Fighter Weapons School, and became a squadron, and then wing weapons officer. His first staff assignment was in the office of the USAF Legislative Liaison. The remainder of his career he spent alternating between operational assignments commanding fighter units and in joint operations, with staff assignments at Headquarters USAF, Major Air Force Commands, and with the Office of the Secretary of Defense.

Deptula was the first Deputy Chief of Staff for Intelligence, Surveillance and Reconnaissance at Air Force Headquarters, and was involved in shaping and managing military use of unmanned aerial vehicles. Responsible for policy formulation, planning, and leadership of AF ISR and remotely piloted aircraft (RPA)—also known as drones—he initiated and built the Air Force's first ISR Strategy, established the Air Force ISR Agency, and constructed an Air Force ISR flight plan that established processes to optimize ISR decisions to resource that strategy. He published the first USAF RPA/drone flight plan that together with the ISR strategy formed an ISR enterprise intended to transition the military from an era of industrial age warfare to the information age.

Deptula's post-military life involves research, education, and advocacy on matters relating to national security. He has served as a senior scholar at the U.S. Air Force Academy Center for Character and Leadership Development; on the Defense Science Board task force on innovation for the future; participated in the crafting of "A New Defense Strategy for a New Era" as a member of the Peter G. Peterson Foundation Defense Advisory Committee; as a senior adviser to the Gemunder Center for Defense & Strategy; and as an adviser to the NATO Joint Air Power Competence Center future vector project.

In addition to his primary occupation as the dean of the Mitchell Institute for Aerospace Studies, Deptula is a board member at a variety of institutions; an independent consultant; and is a commentator around the world on military issues; strategy; and ISR. He has appeared in numerous publications, on national and international television and radio, and authored articles in public, and professional magazines, journals, and books.

2023 Air Force Historical Foundation Air Power History Book Prize

Sean Maloney, *Emergency War Plan: The American Doomsday Machine, 1945-1960*. Lincoln, NE: Potomac, 2021.

Emergency War Plan examines the theory and practice of American nuclear deterrence and its evolution during the Cold War. Previous examinations of nuclear strategy during this time have, for the most part, categorized American efforts as "massive retaliation" and "mutually assured destruction," blunt instruments to be casually dismissed in favor of more flexible approaches or summed up in inflammatory and judgmental terms like "MAD." These descriptors evolved into slogans, and any nuanced discussion of the efficacy of the actual strategies withered due to a variety of political and social factors.

Drawing on newly released weapons effects information along with new information about Soviet capabilities as well as risky and covert espionage missions, *Emergency War Plan* provides a new examination of American nuclear deterrence strategy during the first 15 years of the Cold War, the first such study since the 1980s. Ultimately what emerges is a picture of a gargantuan and potentially devastating enterprise that was understood at the time by the public in only the vaguest terms but that was not as out of control as has been alleged and was more nuanced than previously understood. This is a definitive work on a complicated subject.

Dr. Sean M. Maloney is a Professor of History at Royal Military College of Canada and served as the Historical Advisor to the Chief of the Land Staff during the war in Afghanistan. He previously served as the historian for 4 Canadian Mechanized Brigade, the Canadian Army's primary Cold War NATO commitment after the re-unification of Germany and at the start of Canada's long involvement in the Balkans. He completed his PhD in 1998. From 2003 Dr. Maloney focused nearly exclusively on the war against Al Qaeda and its allies. He traveled regularly to Afghanistan from 2003 to 2014 to observe and record coalition operations in that country and was the first Canadian military historian to go into combat since the Second World War. He has authored 19 books.

2023 AFHF Space History Book Prize (for a series or multiple titles)

John J. Klein, *Understanding Space Strategy: The Art of War in Space* (London, UK: Routledge, 2019)

This book examines the rise of great power competition in space, including the relevant and practical space strategies for China, Russia, the United States, and other countries. The work discusses the concepts and applicability of past strategists, such as Thucydides, Sun Tzu, and Clausewitz, in relation to warfare initiated in or extending into space. This analysis underscores why polities initiate war based upon an assessment of fear, honor, and interest and explains why this will also be true of war in space.

John J. Klein, *Fight for the Final Frontier: Irregular Warfare in Space* (Annapolis, MD: Naval Institute Press, 2023)

This book uses the concepts associated with irregular warfare to offer new insights for understanding the nature of strategic competition in space. Today's most pressing security concerns are best viewed through this lend because incidents and points of potential conflict fall outside the definition of armed conflict. While some universal rules of combat apply across all domains, war in space would upend and flip those standards of understanding.

Dr. John Klein, callsign "Patsy," is a subject matter expert on space strategy and instructs space policy and strategy courses at the undergraduate, graduate, and doctorate levels at several universities in the Washington, DC area. He routinely writes on space strategy, deterrence, and the Law of Armed Conflict. Dr. Klein is also a retired Commander, United States Navy, receiving his commission through the Naval Reserve Officers' Training Corps program at Georgia Tech. He served for 22 years as a Naval Flight Officer, primarily flying in the S-3B Viking carrier-based aircraft. Dr. Klein supported combat operations in Iraq and Afghanistan. His tours included the Executive Officer of Sea Control Squadron Twenty Four and the final Commanding Officer of Sea Control Weapons School.

Dr. Klein holds a bachelor's in Aerospace Engineering from Georgia Tech, a master's in Aeronautical Engineering from the Naval Postgraduate School, a master's in National Security and Strategic Studies from the Naval War College, and a Ph.D. in Strategic Studies from the University of Reading, England.

2024 AFHF Space History Book Prize

Aaron Bateman, *Weapons in Space: Technology, Politics, and the Rise and Fall of the Strategic Defense Initiative*, MIT Press (2024)

In March 1983, President Ronald Reagan shocked the world when he established the Strategic Defense Initiative (SDI), derisively known as “Star Wars,” a space-based missile defense program that aimed to protect the US from nuclear attack. In *Weapons in Space*, Aaron Bateman draws from recently declassified American, European, and Soviet documents to give an insightful account of SDI, situating it within a new phase in the militarization of space after the superpower détente fell apart in the 1970s. In doing so, Bateman reveals the largely secret role of military space technologies in late–Cold War US defense strategy and foreign relations.

In contrast to existing narratives, *Weapons in Space* shows how tension over the role of military space technologies in American statecraft was a central source of SDI's controversy, even more so than questions of technical feasibility. By detailing the participation of Western European countries in SDI research and development, Bateman reframes space militarization in the 1970s and 1980s as an international phenomenon.

Aaron Bateman is an assistant professor of history and international affairs at George Washington University. His other academic work has been published in the *Journal of Strategic Studies*, *International History Review*, *Intelligence and National Security,* and *Diplomacy and Statecraft*. His policy commentary has appeared in Foreign Affairs, Bulletin of the Atomic Scientists, and War on the Rocks. He received his PhD from Johns Hopkins University. Prior to graduate school, he served as a U.S. Air Force intelligence officer.

Lt. Gen. Michael A. Nelson
1937 - 2024

Lieutenant General Michael A. Nelson was President of the *Air Force Historical Foundation* from 2003 to 2009 and also CEO from 2006 to 2009. Prior to that, he was President of *The Retired Officers Association* from 1995 to 2002.

General Nelson was born in 1937, in East Los Angeles, Calif., and graduated from Alamo Heights Senior High School, San Antonio, in 1955. He earned a bachelor's degree in international relations from Stanford University in 1959 and a master's degree in comparative politics from the University of Arizona in 1969. He completed Squadron Officer School in 1967, Air Command and Staff College In 1972, and National War College in 1976.

After receiving his commission in June 1959, via the ROTC program, he entered the Air Force and completed pilot training in September 1960, at Laredo AFB, Texas. A year later, after F–100 training, he was assigned as a pilot with the 493rd Tactical Fighter Squadron, 48th Tactical Fighter Wing, RAF Station Lakenheath, England.

In August 1965 the general returned to the United States and was assigned as an F–100 instructor pilot with the 4515th CCTS, Luke AFB, Ariz. From July 1967 to July 1968 General Nelson was a member of the TAWC's Anti-Surface-to-Air Missile Combat Assistance Team, Takhli Royal Thai AB, Thailand. There he worked on fighter electronic warfare and also flew F–105s with the 333rd Tactical Fighter Squadron of the 355th Tactical Fighter Wing, completing 100 combat missions over North Vietnam.

Once he completed his master's degree in 1969, General Nelson was assigned as operations and plans adviser to the Korean air force in Seoul from October 1969 to June 1971. He then attended ACSC, graduating in May 1972. In June 1972 he returned to the 355th, which had transferred to Davis-Monthan AFB, Ariz. There he served successively as an A-7 instructor pilot, chief of wing scheduling and operations officer, and commander of the 358th TFS..

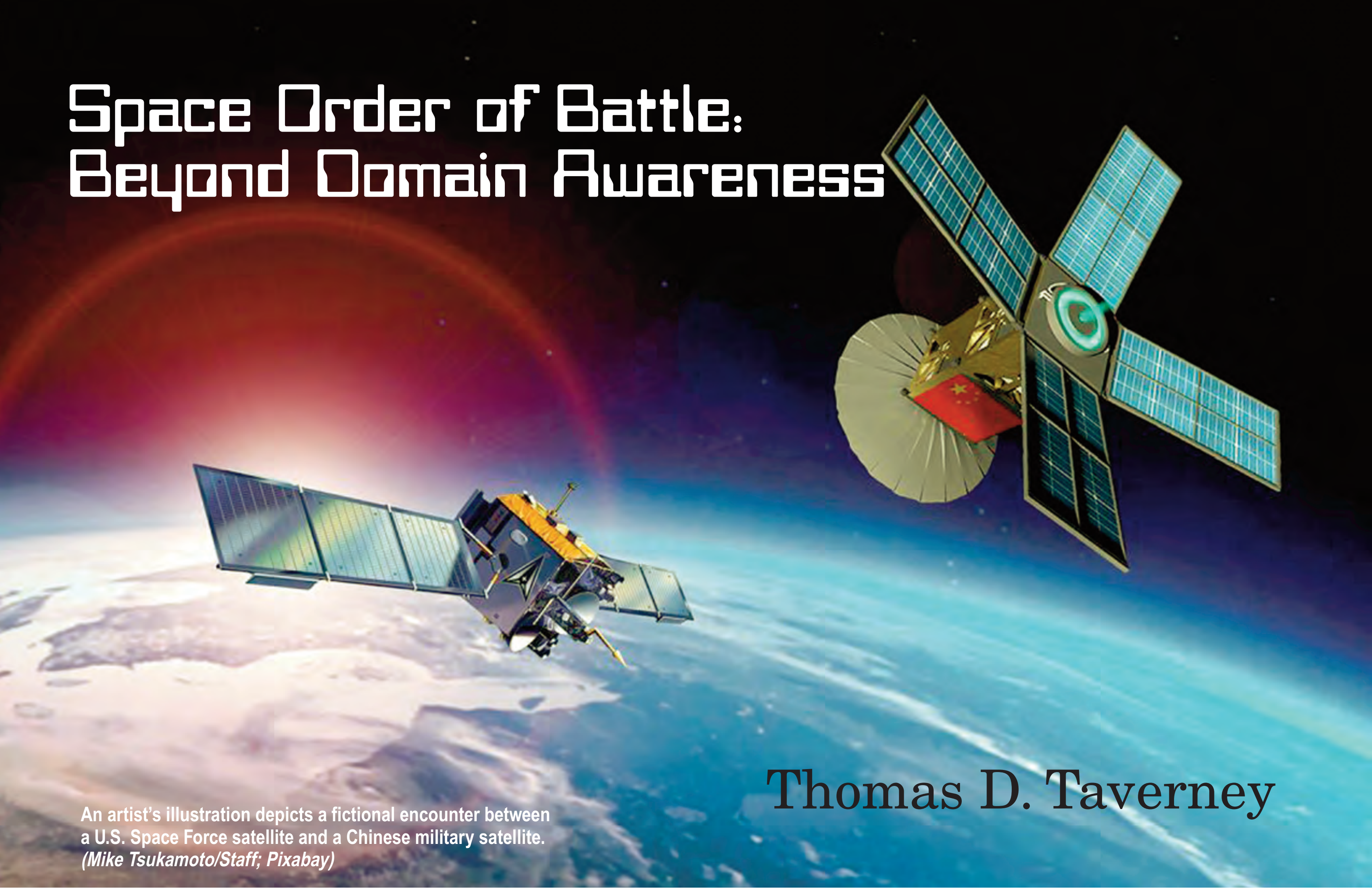
Upon graduation from National War College in August 1976, he was assigned to the Directorate of Plans, Headquarters U.S. Air Force, Washington, D.C., first as chief of the Europe-NATO Division, then as an Air Force planner in the Deputy Directorate for Joint and National Security Matters. From April 1979 to March 1981 he commanded the 21st TFW, Elmendorf AFB, Alaska. General Nelson then served as director for operations, Headquarters U.S. Pacific Command, Camp H.M. Smith, Hawaii. In June 1983 he was assigned as commander of the 313th Air Division, Kadena Air Base, Japan, and in July 1984 he became commander of 13th Air Force, Pacific Air Forces, Clark Air Base, Philippines.

General Nelson returned to Air Force headquarters in June 1985 as deputy inspector general. He subsequently moved to Ramstein Air Base, West Germany, where he became chief of staff, U.S. Air Forces in Europe. In July 1987 he was assigned as assistant chief of staff for operations, Supreme Headquarters Allied Powers Europe. He became commander of the Sheppard Technical Training Center, Sheppard AFB, Texas, in July 1989. In January 1991 he again returned to Air Force headquarters as deputy chief of staff, plans and operations and was promoted to lieutenant general. He assumed command of Ninth Air Force in June 1992.

The general is a command pilot with more than 3,000 flying hours in the F–100, F–105, A–7, F–4 and F–15. His military awards and decorations include the Distinguished Service Medal, Defense Superior Service Medal, Legion of Merit with oak leaf cluster, Distinguished Flying Cross with oak leaf cluster, Bronze Star Medal, Meritorious Service Medal, Air Medal with 10 oak leaf clusters, and Air Force Commendation Medal with oak leaf cluster.

Gen. Nelson passed away on his 87th birthday and was preceded in death by his wife, Barbara Wigdale "Barbie" Nelson, on April 2, 2022. The two were married for nearly 60 years. He is survived by four children — Wendy (Jim) Miller, Holly (Mike) Blais, Tracy (Chris) Herwig, and Michael A. Nelson Jr. (Becky) — 11 grandchildren, and five great-grandchildren, as well as sisters Linda Simms and Marilyn McClees, brother Tom Nelson, and numerous cousins, nieces, and nephews.

Space Order of Battle: Beyond Domain Awareness



An artist's illustration depicts a fictional encounter between a U.S. Space Force satellite and a Chinese military satellite. *(Mike Tsukamoto/Staff; Pixabay)*

Thomas D. Taverney

The U.S. has been the dominant player in space for over 40 years. That has enabled commercial development of space capabilities to grow and thrive, freely and openly, both domestically and across much of the industrialized world. Today, a thriving global commercial space industry supports more than 60 nations in space.

However, today threats in space are significant. Increasingly, U.S. space capabilities are contested, as Russia and China pursue threatening capabilities to challenge what was once U.S. dominance and have become near parity. Each has been provocatively demonstrating capabilities, announcing intent for a variety of individual space weapons and even deploying systems that challenge U.S. superiority in space. This means the U.S. can no longer simply provide the space situational awareness (SSA) needed for observing and tracking and the space domain awareness (SDA) necessary to determine intentions, capablilities, and behaviors, but must be ready to conduct a space battle at speed. This requires that we gain a full understanding of the entire space order of battle (SpOB) to underpin the ability to execute "Dynamic Space Operations" if these capabilities do not deter our adversaries.

Three years ago, Secretary of the Air Force Frank Kendall defined seven Operational Imperatives and listed "Defining Resilient and Effective Space Order of Battle and Architectures" at the top of his list. It was at once the broadest and most impactful of the imperatives, given that U.S. space capabilities are the foundation of America's ability to project power not just beyond the Earth, but in every domain on Earth—air, land, sea, undersea, and even cyberspace. As Chief of Space Operations (CSO) Gen. B. Chance Saltzman said in March: "We see an incredibly sophisticated array of threats, from the traditional SATCOM and GPS jammers to more destabilizing direct-ascent anti-satellite weapons across almost every orbital regime, to on-orbit grapplers, optical dazzlers, directed-energy weapons, and increasing cyberattacks both to our ground stations and the satellites themselves."

The Space Force's chief of intelligence and the National Space Intelligence Center (NSIC) assess threats by evaluating the capabilities, performance, system limitations, and vulnerabilities of potential adversaries. Thus informed, the CSO is responsible for developing and tailoring the space capabilities U.S. joint forces need to ensure access to space for U.S. and allied operators and to ensure the U.S. can hold at risk the space capabilities adversaries depend on for their own military operations.

Editor's Note: This article was previously published in *Air and Space Forces Magazine* (July/August 2024), the official publication of the Air & Space Forces Association.
https://www.airandspaceforces.com/article/space-order-of-battle-beyond-domain-awareness/

62 Years of History

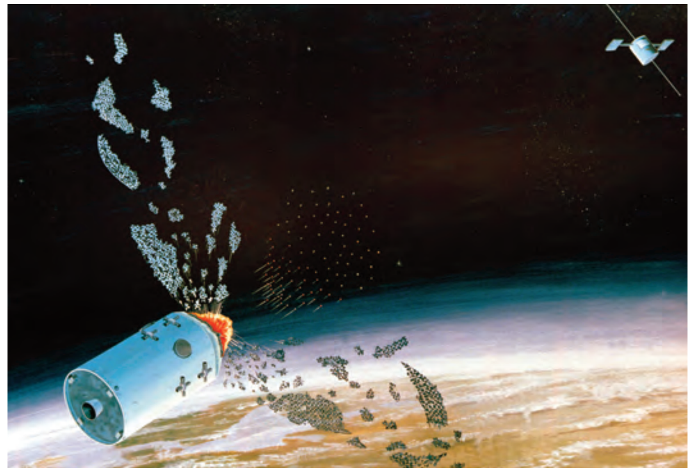
Space has been a warfighting domain since 1962, when both Russia and the U.S. first pursued anti-satellite (ASAT) weapons. The Air Force's Program 505 conceived of a prototype Nike Zeus anti-ballistic missile with a 1 megaton warhead to destroy potential space weapons threatening the U.S. Tests at White Sands Missile Range, N.M., began in December 1962 with dummy warheads. After several successful tests, the system was deployed to Kwajalein Island in the Pacific, where it remained operational until its retirement in May 1966. Program 437, a Thor-launched Direct Ascent ASAT missile, operated from June 1964 to May 1970; the system was tested at Johnston Island eight times, always without the nuclear warhead.

Russia developed and demonstrated a co-orbital kinetic satellite interceptor called the Istrebitel Sputnikov (IS-Destroyer of Satellites) from 1967 to 1983. The system used radar and a heat-seeking guidance system to get within 1 kilometer of its target, at which point it would deploy a shrapnel warhead to kill the satellite. In February 1970, the Soviet Union conducted its first successful intercept with the weapon, firing on the Kosmos 217 target. Some 23 launches, including seven intercepts, followed, and it was declared operational in February 1973. Each intercept created between 80 and 109 trackable fragments. Russia's Polyus, Almaz, and Aryad ground lasers followed.

The U.S. military demonstrated the Airborne ASAT in September 1985. Since then, China, Russia, and India have demonstrated numerous on-orbit, direct-ascent, and ground-based weapons, all of which could potentially threaten U.S. satellites. In September 2006, China used a ground-based laser to dazzle a U.S. classified optical reconnaissance satellite, temporarily blinding the system. China and Russia have also attacked American space assets with cyber technology.

In those days, U.S. forces could provide only space traffic management and minimal space systems awareness, for collision avoidance from intentional threats. Over time, however, space situational awareness would grow, supported by sensors on the ground and in space. On January 11, 2007, the Chinese anti-satellite missile test occurred. Then-Col. Stephen Whiting the Joint Space Operations Center commander noted, "We watched that test unfold over time, and we led the response for U.S. STRATCOM. We spent weeks and weeks figuring out how we would notify national leadership in real time. And those of us who were there, including then-Maj. Gen. Willie Shelton, Lt. Col. Chance Saltzman, and Maj. DeAnna Burt, knew the world had changed, on that day."

Thomas D. "Tav" Taverney is a retired Air Force major general and former vice commander of Air Force Space Command. General Taverney entered the Air Force in 1968 as a graduate of the U.S. Air Force Academy. He was involved in space operations and space systems development for 38 years. He has performed satellite design and development at the systems level, and he has also designed and developed software for satellite spaceborne and ground systems. He was recalled to active duty twice before his final retirement in October, 2006.



The Soviet-era Istrebitel Sputnikov anti-satellite system, shown here attacking another satellite, used radar and a heat-seeking guidance system to get within 1 km of its target, where it could deploy a shrapnel warhead to kill the satellite. ***(DOD illustration)***

We subsequently moved from SSA to SDA, which meant thinking about activities in space globally, rather than on specific systems in isolation. The threats affecting the space environment have advanced significantly since 2007 and by 2019, expanded to include ground-based lasers, signal jamming, direct-ascent weapons, co-orbital threats—some equipped with robotic grappling arms—and even threats of nuclear ASAT weapons in space. This (along with other threats of hypersonic missiles and fractional orbital bombardment systems), has raised the stakes enough that Congress saw the need for an independent Space Force, with its mission to "Secure our nation's interests in, from, and to space."

Joint Publication 3-14, Joint Space Operations, describes space as a region "defined by altitudes rather than a nation's borders or latitude/longitudinal coordinates." Beginning 100 kilometers (54 nautical miles) above mean sea level and continuing into deep space, this area of operations is virtually limitless. Today, we know that threats in space no longer just reside in Earth orbit. As we move to the moon and Mars, the competition with China will certainly continue, and because of the great distances, responses will become more complex. JP 3-14 specifically defines the near-term area of concern as "ex-geosynchronous (XGEO)" orbit—that is, beyond about 36,000 kilometers (about 19,000 nautical miles), to include cislunar space, lunar orbit, and the Earth-moon Lagrange points.

To ensure access to the XGEO environment for both commercial and exploratory objectives, the U.S. faces a challenge unseen since the struggle to ensure freedom of navigation across the Earth's oceans. Like the seminal work of Rear Adm. Alfred Thayer Mahan, who defined the naval strategies and doctrine needed to secure our sea lines of communication over a century ago, we must now do the same to protect and defend our vast space area of responsibility.

Ready for War in Space

The United States would prefer to be in a state of competition with the People's Republic of China and Russia rather than in crisis or open conflict. That requires deterrence.

In General Saltzman's CSO C-Note 20, he lists current USSF goals and objectives to include "conducting low-intensity operations without compromising high-intensity readiness. The military of a great power must have the capacity to engage in protracted, day-to-day competition with its rival. Failing to do so cedes advantage and endurance. At the same time, a great power military must also prepare for high-intensity conflict, demonstrating the combat-ready credibility that underscores deterrence."

He goes on to say the Space Force must develop a space warrior mindset via the following measures:

The U.S. Space Force will need to be able to fight through disruption by improving defensive capabilities and increasing options for reconstitution, while assisting allies and partners in doing the same.
Provide assured delivery of capabilities to our warfighters.
Provide capabilities and tactics, techniques and procedures (TTPs) for suppression of enemy space capabilities.
Shift from static to dynamic operations.

A space war could be very short, over in just 24 to 48 hours, because of the relatively limited number of key satellite assets both sides possess. A move to blind early warning, jam GPS and critical comm systems, and otherwise cripple critical space capabilities would likely occur with simultaneous or nearly simultaneous attacks. Therefore, the United States must be ready to fight and win a conflict in space within minutes of warning. To do so requires a comprehensive offensive and defensive space order of battle, to enable Guardians to fight dynamically with speed and exercised and rehearsed tactics, techniques, and procedures from the moment conflict begins.

There are two foundational elements to this approach: First, the Space Force's posture and order of battle and capabilities available, and second, USSF's ability to understand and monitor our adversaries' posture, capabliities, and order of battle. The Space Force has made significant progress developing a resilient U.S. space architecture and space order of battle capable of operating while under attack. However, work remains in developing and understanding the U.S. space "dynamic offensive & defensive response" needed to rapidly respond to the potential actions of an adversary.

This requires a further evolution beyond space domain awareness to a full understanding of the "offensive and defensive" space order of battle. While we would obviously prefer to be in a state of competition with our adversaries, the risk of crisis or open conflict demands we prepare for the worst.

Competitive Endurance

In C-Note 15, General Saltzman defines his concept of "Competitive Endurance" as engaging strategic rivals long-term in pursuit of U.S. national interests without compromising the safety, security, stability, or long-term sustainability of the space domain. To do that, he wants Guardians to think critically, to challenge assumptions, test new ideas, share those ideas broadly, and to do these things with a clear sense of urgency.

"Our adversaries must never be desperate enough or emboldened enough to pursue destructive combat operations in space," General Saltzman wrote in that forcewide note. "We must have the capability and fortitude to endure in a long-term state of competition because doing so is preferable to crisis or conflict in the domain. The goal of Competitive Endurance is to ensure our ability to achieve space superiority when necessary while also maintaining the safety, security, stability, and long-term sustainability of space."
The Space Force must maintain "stability in Space and contest, deter and, when directed, fight in and control the space domain," he wrote, in order to "assure delivery of capabilities to our warfighter—without interruption—and deny adversary space capabilities that threaten our warfighters."

To achieve these goals, USSF must have the means to stop aggression before it starts; quickly respond at the time, location, and method of its choosing, and contain potential conflict before it grows into something worse.

To avoid operational surprise and prevent conflict in space, USSF must be able to "identify behaviors that become irresponsible or even hostile, and to detect and preempt any shifts in the operational environment that could compromise the ability of the joint force to achieve space superiority." This means not just knowing when adversaries make a move, but also understanding the implications of the move and the TTPs available to counter it.

The predictability of orbits gives the offense a particular first-mover advantage in space, which is why resilience—that is, the ability to take losses, adapt, and survive despite an attack—is crucial to denying that first-mover advantage. The United States must be able to absorb losses and continue to operate, leveraging responsive launch capabilities that enable USSF to rapidly restore or reconstitute degraded capabilities. Strong offensive and defensive capabilities will allow us to defend against attacks and to conduct attacks of our own, if warranted. The Space Force strategy today seeks to make an attack on satellites impractical, even self-defeating, to discourage adversaries from taking such actions in the first place.

Deterrence can come in both offensive and defensive forms. Offensive deterrence discourages threats by holding selected adversary space capabilities at risk using means that will neither destroy nor damage the space environment. The offensive TTPs need to have been rehearsed and the operations team prepared to implement in a pre-approved fashion so that we can operate at the speed of our adversaries.

Defense can also deter aggression in space, through the ability to defeat threats by overcoming them without being destroyed. With the speed of activities in space, we need to have defensive responses that we have rehearsed and exercised immediately available to our space operators. A third form of deterrence is resilience: Both proliferated constellations that can absorb losses without impact to operations and responsive space, with which lost capabilities are rapidly reconstituted can provide a deterrent effect.

Offensive and defensive space operations may be necessary to prevent adversaries from leveraging space-enabled targeting to attack our forces—but we must balance our counterspace efforts with the need to sustain allied space assets in every orbit. We must protect the joint force from space enabled targeting, while simultaneously understanding that we cannot have a Pyrrhic victory in this domain. In other words, efforts to control the domain cannot inflict such a devastating toll on the domain itself, that our orbits become unusable for operations. The critical element in this battle will be speed, and this needs to be built on a foundation of understanding and being prepared built upon a robust SpOB.

If we cannot stop an adversary from being the first to move, we must be prepared to be faster in our responses than they will be in their aggression. We cannot take time to contemplate the situation, or the war will be over before we can act. We must understand where all the potential threats are and have exercised and rehearsed responses with well-trained Guardians. If we cannot stop an adversary from being the first to move, we must be prepared to be faster in our responses than they will be in their aggression.

Competitive endurance, therefore, is the driver to a more robust understanding of our adversaries and the need to evolve from domain awareness to a clear understanding of the space order of battle.

"Do we have the tools that pull data together and contextualize it, so decision-makers can make timely, relevant operational decisions?" General Saltzman asked, in a rhetorical challenge to industry at the Mitchell Institute's Spacepower Security Forum in March. The Space Force needs "tools that actually make the most out of the data that we are collecting and will be able to take on even more data and make more sense of it faster," he added. "We cannot, as a country or a service, miscalculate the capabilities, force posture, or intentions of our potential adversaries. We must have timely and reliant indications and warnings to help us avoid operational surprise in crisis where appropriate to take defensive actions."

Space operators must be able to quickly tell the difference between routine operations like refueling, refurbishing, and debris removal from potentially hostile activity, such as detecting the start of a kill chain. Timely and relevant SpOB should help avoid operational surprise in crisis and, when appropriate, dynamic offensive or defensive actions to counter adversarial moves.

As part of the new "warrior mindset" Lt. Gen. John E. Shaw, deputy commander, U.S. Space Command, and Gen. Michael A. Guetlein, vice chief of space operations, have discussed a shift from static to dynamic space operations (DSO). U.S. adversaries are now deploying satellites that can maneuver and rendezvous with other objects, which puts the U.S. at a disadvantage.

SpaceX delivered 10 communications and missile tracking satellites into orbit for Tranche 0 of the Space Development Agency's missile warning and tracking constellation. The low-Earth-orbit constellation will enhance the Space Force's space situational awareness. *(SpaceX)*

U.S. Space Command has stated the importance to be able to maneuver without regret and that dynamic space operations, maneuvering satellites, and refueling support would give the military options to better defend its assets in space by:

Putting additional focus on attribution of malicious actions within the space domain or against space architectures, including how allies and trusted commercial partners can participate in attributing irresponsible or threatening behaviors toward their own space assets.

Cultivate partnerships to build advantages. For example, hybrid space architectures incorporating U.S. government, allied, and commercial satellites—while spanning multiple orbital regimes—can help disincentivize an adversary's potential attack.

Build on changes made to implement a mission planning crew commander (who is dedicated to effects-based dynamic mission planning), so that we can better orient forces when it comes to space battle management. This member pairs resources (sensor network) to support a healthy space picture in support of current/future ops.

Implement mission type orders, where we can hone sensor specific effects to better capitalize on intentional planning, and to measure the effectiveness of those mission plans. This would help build the initial space picture on the aggregate level for operations.

Finally, in coordination with other U.S. departments and agencies, the Space Force must increase collaboration with the commercial space industry, leveraging its technological advancements and entrepreneurial spirit to enable new capabilities that support integrated deterrence. However, as the Space Force inevitably involves commercial

The 5 Functions of Space Operations

	SPACE OPERATION FUNCTIONS	KEY OUTCOMES
1	**Space Traffic Management/Collision Avoidance (STM/CA)** Charting the present position of space objects and plotting their anticipated orbital paths; detecting new man-made objects in space and producing a running catalog of man-made space objects; determining which country owns the space object; informing countries when objects may interfere with satellites and International Space Station orbits; predicting when and where a decaying space object will reenter the Earth's atmosphere, and ensuring that returning objects do not trigger missile-warning sensors to issue a false alarm.	• Generating the space catalog. • Providing a Civil Space Traffic Coordination System. • Monitoring space objects for safety, security, and sustainability. • In-space servicing, assembly, and manufacturing (ISAM). • Debris removal. • Monitoring space weather, solar activity, and major electromagnetic radiation events, such as coronal mass ejections, radio bursts, solar flares and solar wind, and high energy solar particles. • Tracking all orbiting objects, including space debris. • Providing conjunction assessment and warning. • Monitoring and reporting on meteoroids, asteroids, and comets.
2	**Space Situational Awareness (SSA)** Providing current and predictive knowledge and characterization of space objects and the operational environment upon which space operations depend, including tracking all launched and orbital objects to ensure awareness of and the future location of space objects.	• Search, discover, and track spacecraft and events. • Distinguish and recognize objects as belonging to certain types and missions. • Detect, track, catalog, and identify artificial objects like active/inactive satellites, spent rocket bodies, and fragmentation debris. • Identify, characterize, and understand all factors in space that could affect space operations and the security, safety, economy, or environment of the United States. • Track, identify, and predict future positions of objects in space.
3	**Space Domain Awareness (SDA)** Achieve an understanding of the space domain to enable decision-making throughout. Ensure rapid detection, warning, characterization, attribution, and prediction of potential threats; distribute as appropriate warnings to national, allied, civil and commercial space systems. Understand the operational space environment, assessing operational capabilities and intentions, and predicting future positions and potential threats.	• Identify, characterize, and understand all factors in space that could affect space operations and thereby affect the security, safety, economy, or environment of the United States. • Characterize and describe each spacecraft tracked and identified by terrestrial or orbital sensors, including the spacecraft's potential employment, tactics, intent, and activity, to provide the joint force commander and other decision-makers with the knowledge and confidence to assess adversary space capabilities. • Integrate and exploit data as the final step in delivering decision-quality, fused, correlated, and integrated multisource intelligence to enable timely decision-making.
4	**Space Order of Battle (SpOB)** Understand adversary space forces and organization, including how they are structured, organized, and equipped for combat; their satellites and ground systems; and the technical capabilities of potential weapons in space and the doctrine for how they could be used. All of this must be maintained and updated continuously. Provide threat warning and assessment to decision-makers to ensure awareness of potential and actual attacks, effects, and space system anomalies.	**1. Adversary Nations or Organizations** • What are their primary goals and objectives? **2. Capabilities** • Type of weapon (kinetic or nonkinetic), maneuverability of weapon, and speed. • Potential attack timelines. • Strategic and tactical intent. • Weapon effects: reversable, non-reversable. **3. Disposition of Current Threats** • Tactical deployment, orbital location for space threats, movement history. • Weapons and equipment capabilities, intent. **4. Adversary Strategy, Tactics, and Doctrine** • Strategic doctrine. • Tactical doctrine. • Deployment doctrine. • Space strategy (government, civil, commercial). **5. Projected Combat Effectiveness** • Adversaries' projected weapons effectiveness. • Adversaries' space systems expertise. **6. Attribution of Attacks** • Ability to infer patterns, trends, and associations. • Sensor availability (number, capability, and location). • Find, fix, and track. • Maintain custody of potential threats. • Target, engage, assess, respond. • Damage assessment.
5	**Dynamic Space Operations** Conduct rapid and effective offensive and defensive space operations when called upon to do so.	• Detect movement if it is a space threat. • Detect ground action if it is a ground threat. • Assess and characterize. • Maintain custody. • Provide command and control of assets • Implement tactical planning. • Conduct response planning (including rehearsals and exercise). • Execute response - Disrupt Kill Chain - Maneuver - Direct Fires • Assess effectiveness of action.

space assets in tactical surveillance, reconnaissance, and tracking, and gathering SSA data and developing SDA data to support our SpOB capabilities, we need to be fully cognizant that we must protect these assets as if they were USSF assets, whether these be civil or commercial. Commercial space systems contributing to the defense of Ukraine have been declared by Russia as legitimate targets, and if we use them, we need to be prepared to defend them.

The new USSF Doctrine (SDP 3.0-July 2023) states the Space Force will undertake operations in three "baskets:"

Shape the Operational Environment. *Space operations include activities to promote security and stability, preserve freedom of action, and deter adversary activities to the contrary. Space Force communicates with other DOD and Intelligence Community organizations, while building relationships with allies, partners, commercial entities, and academia. Along with data sharing and collaboration, where appropriate and authorized, these relationships help build support for operations in all domains, increase overall security in the space domain, promote appropriate behavior in space, and deter adversaries.*

Prevent Conflict. *Space operations to prevent conflict in, from, and to space include all activities to deter undesirable actions by an adversary. Space operations enhance safety and security of Joint operations and deterrence in all domains. As part of the joint force, the Space Force is focused on actions to deter dangerous or unlawful adversary behavior in all domains through a range of reversible and non-reversible effects.*

Prevail in Combat. *Should deterrence fail, the Space Force is prepared to enable lethality and effectiveness of the joint force by delivering space combat power to ensure the United States prevails in conflict. Space Force, as part of the joint force, will take actions to deter undesirable adversary behavior and deny, disrupt, damage, or destroy adversary space capabilities across all domains. Planners may also consider deceptive operations with appropriate authorities.*

Responsible Counterspace Campaigning

"If a near peer competitor makes a movement, we need to have it in our quiver to make a counter maneuver," said General Guetlein, in January. "Tactical relevance could mean acting within minutes or just a few hours, not a day."

In a paper titled "Dynamic Space Operations" published in AETHER, the *Journal of Strategic Airpower and Space Power*'s Winter 2023 edition, the authors make the case for better space maneuver capabilities as a key element in both offensive and defensive dynamic space operations.

The authors argue for decentralized execution to create "reversible decisions that can be pushed to lower levels with less risk and opportunities for more expansive and resilient use of artificial intelligence (AI) and autonomy." The payoff, they said, "decreases response times and increases the ability to improvise and pursue fleeting opportunities." Given the speed of potential space wars, there is little time to go up and down the chain of command.

The paper also argues for preparedness. "Improved readiness enables routine and robust live training with on-orbit forces without sacrificing long-term mission success," they wrote. "It establishes better avenues to reversibly explore new operating concepts, provides more robust testing opportunities for new systems and tactics, improves deterrence through demonstrated strength, and ensures capabilities can be quickly reconstituted to deter opportunistic third parties."

To achieve these objectives, the U.S. should normalize space and treat it as any other warfighting domain. That means clearly and unambiguously stating a willingness to conduct both offensive and defensive space operations, including both "direct capabilities"—that is, "fires that impact an adversary"—and maneuver. U.S. Space Command is the combatant command responsible for such operations.

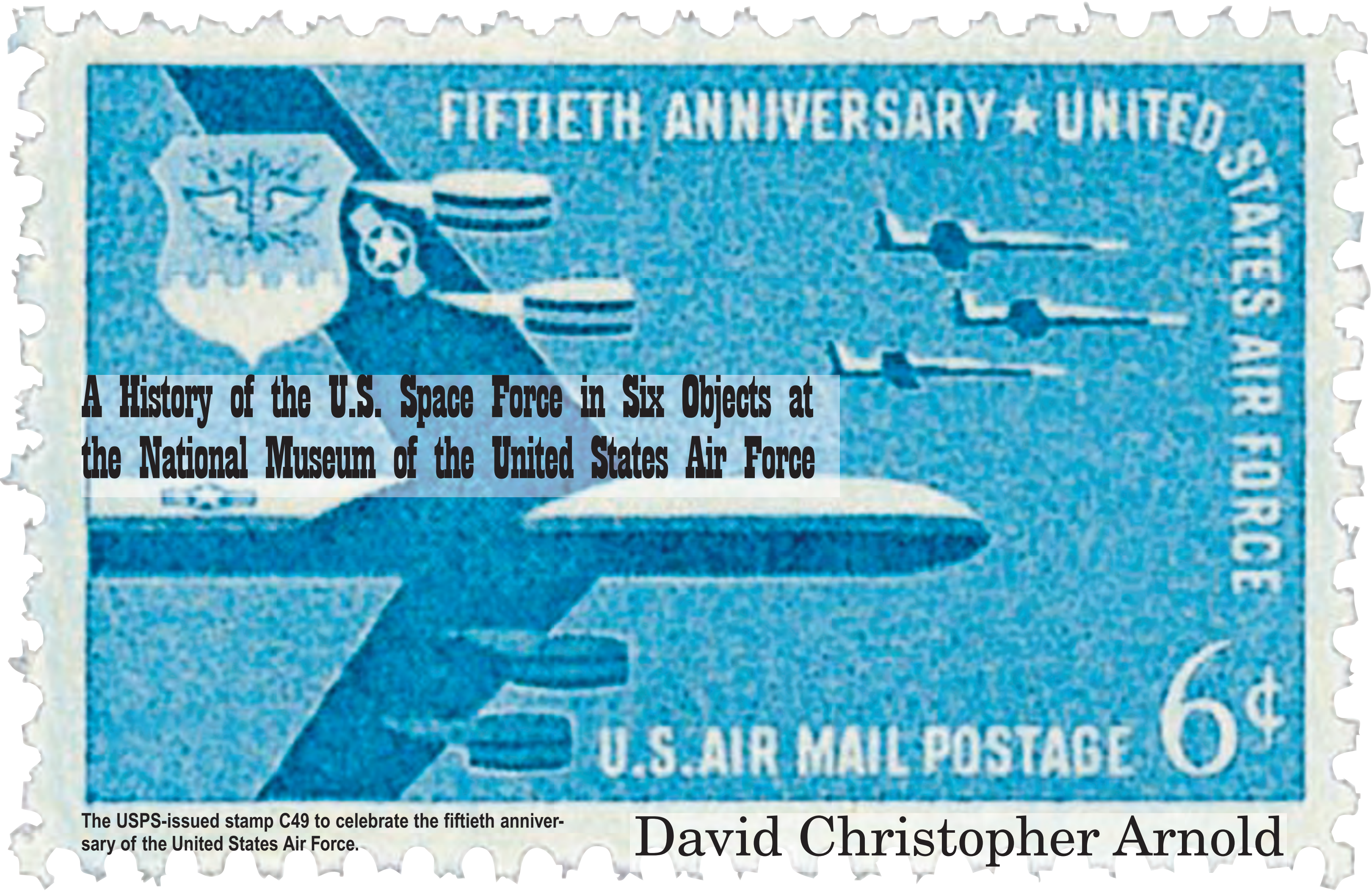
To make sound strategic and tactical decisions, USSF will rely heavily on its deep knowledge of the characteristics and current state of the Space AOR, both from LEO to GEO and beyond to XGEO (specifically cislunar) and intelligence regarding our adversaries' capabilities both in space and on the ground.

Consideration of the natural environment of space, coupled with its current congested nature, implores us to keep track of what is there and what those objects are doing, which includes a growing amount of uncontrolled space debris. It is however, the adversaries that are of greatest concern, and information about their space capabilities and intent is difficult to obtain and process. This information is precisely the space order of battle that Space Command needs to be effective. SpOB refers to the intelligence and knowledge of any military force involved with the Space AOR. This includes not only our enemies or potential enemies, but also friendly and neutral forces since debris and inadvertent actions can cause misunderstandings in space.

Since our beginnings in space, it has not been a benign environment. While mostly unknown to U.S. citizens, provocations and dangerous tests have occurred from the major powers to assert their dominance over the domain. Demonstrating offensive space capabilities have damaged the environment of space, and since the provocative Chinese test in January 2007, things have become more and more dangerous.

This does not necessarily mean there will be a space war, but it has become a possibility. Like the first Space Race based on nuclear missile capabilities, deterrence will be critical in averting a space war. China and Russia must be convinced that a space war cannot be won by them. Toward this end we must demonstrate to them we can operate at the potential speed of a space war. Moving to SpOB and dynamic space operations will assure that, buoyed by constant training and delegated T&T's that can be executed at the speed of a potential space war, and this will deter that terrible event from occurring. ■

A History of the U.S. Space Force in Six Objects at the National Museum of the United States Air Force



The USPS-issued stamp C49 to celebrate the fiftieth anniversary of the United States Air Force.

David Christopher Arnold

On August 1, 1957, the United States Postal Service issued stamp C49 to celebrate the fiftieth anniversary of the United States Air Force. This six-cent air mail stamp featured a B–52 bomber and three century-series fighters in shades of blue. Although 1957 was the tenth anniversary of the U.S. Air Force, the issue date was the fiftieth anniversary of the stand up of a predecessor organization, the Aeronautical Division of the U.S. Army Signal Corps, which was responsible for balloons and heavier-than-air craft. In 1909 a Wright Model A became the U.S. military's first airplane. Of course, USAF history did not begin on September 17, 1947, and the history of the United States Space Force did not begin on December 20, 2019, either. Just as the air service traces its history back to the army of 1907, the space service's history dates back to the USAF of 1947, and even earlier.

Two legs of the space history stool are found in two recent books focused on the standup of an independent space service and the pioneers whose visions led to its creation.[1] Organizations, leadership, and artifacts all depend on one commonality—people; the people who write laws, lead servicemembers, and build and use tools. In this case, then, even as we look at artifacts, we take a "wider view" on space history.[2] The third leg of the military space history stool is artifacts, objects that are created by human beings and through which we can also tell history. The predominant narrative that explains the advent of technological artifacts is that they appear suddenly, causing things to happen: rockets beget satellites, which eventually result in an independent military space service. But machines themselves do not make history and inventions do not have a life of their own.[3] While today satellites come to mind when considering the artifacts of USSF, what the artifacts in this article show us are both the legacy of technological innovation in USSF's history and that, as historian Melvin Kranzberg pointed out, sometimes non-technological factors take precedence in technology policy decisions.[4] The objects in this article remind us that our history is neither inevitable nor linear.

One of the greatest locations for military space artifacts is the National Museum of the United States Air Force (NMUSAF), which, since 1923, has grown from a small collection of airplane engines into the world's largest aviation museum. Today, according to its website, the collection has over 350 air and space vehicles, thousands of smaller objects, and includes twenty acres of indoor displays. The museum's mission is to collect, research, conserve, interpret, and present "the Air Force's history, heritage and traditions...."[5] NMUSAF's mission includes the Space Force and so this article recounts key aspects of military space history through NMUSAF's collection. The objects in this article are two spacecraft, two missiles, a simulator, and an airplane.

Fairchild C–119 Flying Boxcar.

Fairchild C–119 Flying Boxcar

It may seem odd to start an article about space artifacts by talking about an airplane but in this case, the airplane performed a space mission. The C–119 Flying Boxcar in the museum is on display not in the Cold War gallery with other aircraft from its era but instead in the Space gallery. The C–119 is not a missile or a spacecraft, but this F-model C–119, serial number 51-8037, callsign *Pelican 9*, had a very important role in military space history. When Air Force Capt. Harold Mitchell felt a tug on the controls of *Pelican 9*, he became the first person to "catch a falling star," which in this case was a military satellite returning from orbit in outer space.[6]

The Fairchild C–119 is a twin-engine, high wing, monoplane of all metal construction, designed for use as a cargo carrier, troop/paratroop transport with an aerial delivery system, or as a medical evacuation aircraft. A pair of supercharged Pratt & Whitney R-4360 engines drove the four-bladed, constant speed, reversible-pitch propellers, that could get the airplane to 253 mph (normal cruise speed was 162 mph). The tricycle landing gear system gave it a level floor to facilitate loading and unloading. The floor height was four feet above the ground—truck-bed height. The cargo compartment, eight feet high, nine feet wide, and almost 37 feet long, was rectangular, permitting the carrying of a wide variety of equipment and configurable for any of its four missions. Instead of the standard large clamshell doors in the rear, *Pelican 9* had "beavertail" doors.[7] When it was designed, no engineer had any idea it would be further configured to retrieve objects from outer space.

To the average eye, this C–119 has an odd paint scheme. During the 1950s, the Air Force used a special red paint for most aircraft flying in snow covered areas like the Arctic. Paint covered 25% of the upper and lower surfaces of the outer wing area while the back quarter of the aft portion of the fuselage and the tail sections were also painted red. The Air Force applied a similar paint scheme in orange to Air Training Command aircraft to reduce training accidents. By mid-1959, all Air Force aircraft, according to NMUSAF historian Charles Worman, were supposed to have "conspicuity marking consisting of four or six-foot bands about the nose, aft fuselage, and wing tips or center line tip tanks or pods." Active combat aircraft, helicopters, century-series fighters, and delta-wing aircraft did not have the orange paint scheme so it would not have been unusual at all to see an Air Force cargo plane with orange paint flying over the Pacific Ocean near Hawaii.[8]

Before the Corona photoreconnaissance satellite or the U–2 aircraft, the United States had a balloon-based photoreconnaissance program because of the desperate need for intelligence about the USSR. RAND had proposed a solution that was not space-based because they felt the state of the technology at the time would not provide the kind of resolution photo interpreters needed for military purposes. Instead, RAND put forward a suggestion the Air Force use high-altitude balloons to fly over the Soviet Union in a program called Genetrix or Weapon System 119L. RAND scientists William Kellogg and Stanley Greenfield had studied the Japanese balloon program in World War II and in 1950 determined that "a balloon made a suitably stable platform for high-altitude photography."[9] Genetrix used polyethylene balloons in test flights over New Mexico. In 1955, with an official cover story from the Navy as a meteorological program called Moby Dick, the United States launched balloons with cameras and radios into the jet stream from Western Europe, then left them to drift over the USSR so the balloons could be recovered over the Western Pacific. C–119s of the 456th Troop Carrier Wing based in Japan flew over the balloons and caught them.[10]

Capt. Harold Mitchell trained in C–119s for the balloon recovery mission in a program called Drag Net. A pair of special antennas in the nose and homing equipment aboard the aircraft helped direct the pilots to a balloon. The crew that flew in the airplane's cargo hold trained as winch operators and pole handlers. It took a total of five Airmen to operate the recovery system. The airplanes had extra fuel tanks to stay aloft for 13 hours and were modified so the doors could be opened in flight. This configuration allowed two 34-foot-long poles to be extended from the rear of the aircraft. Loops of rope with hooks were strung be-

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tween the poles and the hooks caught the balloon as the C–119 flew over it.[11]

After some classroom instruction, Mitchell and his crew trained for aerial recovery operations by flying up to 12,000 feet. Another C–119 was at 15,000 feet and released a sand-filled 50-gallon drum or 300-pound concrete block simulating a balloon gondola. The "gondola" was attached to four 28-foot personnel parachutes that were attached by a 100-foot nylon riser to a 15-foot reinforced drogue chute. The crew of Mitchell's plane deployed their recovery equipment and attempted to snag the drogue chute by flying over it close enough to snare the chute in a nylon loop attached to two poles that were lowered from the back of the airplane. If they could make five catches, they were certified for aerial recovery.[12] But they could just as easily miss the parachute and need to fly around for another pickup attempt. If the pilot of the recovery airplane wasn't careful, he could also fly right into the parachute, covering the nose of the airplane or chewing up the parachute in the propeller.[13]

In December 1955, President Dwight Eisenhower approved two months of balloon flights, during which the Air Force launched between 400 and 500 balloons from West Germany. The Drag Net crews recovered only 46. The rest were lost in flight. The Soviets called them "espionage balloons," shooting down as many as they could and then displaying recovered "gasbags, cameras, and transmitters" to the public in a February 1956 press conference. The Soviets protested the balloon flights as a "gross violation" of their airspace.[14] Ike claimed the balloons were for "monitoring high-altitude weather conditions," an argument he would make about other systems in the near future but leaned towards cancelling Genetrix even though the "military gains of the balloon flights outweighed the political damage created by their discovery." The Genetrix coverage was "spotty," according to historian Curtis Peebles, and photos that were useable were mostly of the southern part of the Soviet Union when the most desired information was in the north.[15] Walter Levinson who was the project manager for the balloon cameras said that the balloons that made it all the way across the USSR provided photographs of over a million square miles of the Sino-Soviet bloc. But Soviet protests of the flights with captured balloons as evidence and stories in the media led to the end of the Genetrix program in March 1956.[16]

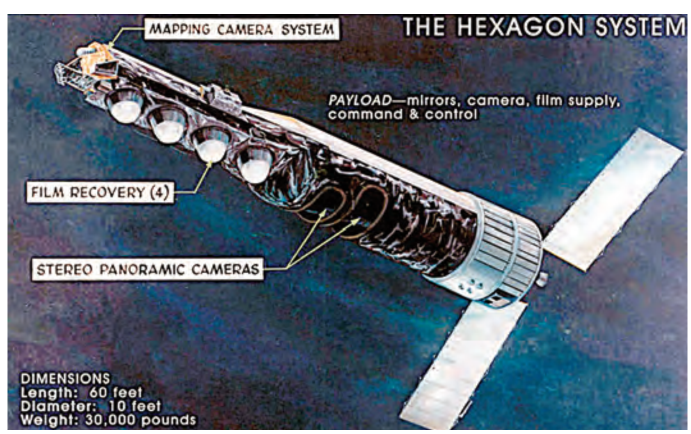
Sputnik in October 1957 was the great game-changer for U.S. military space programs. Recalled USAF Maj. Gen. Osmond Ritland, commander of the Air Force's Ballistic Missile Division (AFBMD), "With that event, the Defense Department, the Secretary of the Air Force, everybody said, 'Say, what was that [space] program you were trying to sell a few months ago in here? Come back in and tell us about it.' So then, after the fact, we went back in and began to tell them, informally."[17] Gen. Bernard Schriever recalled many years later in an interview with the author, "When Sputnik went up...everybody was saying, 'Why the god dammed hell can't you go faster? Who's in charge here?'"[18] Of course, Schriever oversaw Air Force space programs, but he was hamstrung by U.S. policy. At first, he could not work on military space programs publicly; then after Sputnik, he could not get them launched fast enough.

Simultaneously, the USAF had been working on the U–2 reconnaissance aircraft in a partnership with the CIA. With the U–2 ready to fly, Genetrix cancelled, space-based reconnaissance technology not looking promising, and his Open Skies proposals rejected, Ike approved the joint USAF/CIA plan for U–2 overflights of "denied areas," starting with flights over the Eastern Bloc and then authorizing flights over the USSR itself. The U–2's "life expectancy was put at two years or less, during which time it was supposed to collect intelligence from deep inside the USSR. John Foster Dulles later quoted Ike as saying: "'Well, boys, I believe the country needs this information, and I'm going to approve it. But I'll tell you one thing. Some day, one of these machines is going to be caught, and we're going to have a storm.'"[19]

Despite the rush to completion, the U–2 came in on schedule, under budget, and above capability. Amazingly, ten months after the first test flight, they had their first operational missions. But the excitement of the first U–2 successes, including a flight over Moscow itself, did not last. On May 1, 1960, President Eisenhower got bad news. The CIA reported a U–2 was flying 1,300 miles inside the USSR when the pilot relayed an engine flameout. Nearly two days went by, and they still got no word on the fate of the pilot, Francis Gary Powers, who was among the most experienced U–2 pilots with about 600 hours in the plane.[20] Then on Friday, May 6, Soviet premier Nikita Khrushchev announced that Powers and his U–2, along with much of his equipment, was in Soviet hands. A week later Ike cancelled all further planned U–2 flights over Soviet territory for two reasons, first, because in his words, "the U–2 was probably no longer a reliable plane to use for this purpose. The second was that considerable progress was now being made in photography of the earth from satellites," like the one below.[21]

Hexagon KH-9 reconnaissance satellite

The whole point of having something to catch was because military missions were moving into space to achieve better results for warfighters. Military space systems were



Hexagon KH–9 reconnaissance satellite.

growing into an integrated system to deter the Soviet Union. Wrote Ritland in 1960,[22]

In substance, the attack-alarm satellite (Midas), strangely enough, is not often identified with our deterrent posture. Yet it is obvious that, with ballistic missiles traveling 5,000 miles in approximately 30 minutes, the value of early warning of missile launchings has assumed unprecedented importance. Such satellites would provide us a manifold means of extending our present military capabilities in these areas...Integrated with these two systems is a communications satellite which will provide secure and instantaneous worldwide communications so essential to the operational environment of any conflict....[T]he deterrent contributions of such operational aerospace systems cannot be overemphasized.

What he did not mention was that reconnaissance satellites formed the core of that integrated system of systems.

Corona was not the first American reconnaissance satellite, but it was certainly the most revolutionary. According to NRO historian Perry, "In the context of its operational utility, exploitation of technology, and enhancement of the nation's fund of intelligence information, Corona had to be rated an outstanding success. Originally considered an interim system and assumed to have at best, three or four years of operational utility, Corona remained the sole source of overflight intelligence for the United States for nearly five years, and was a primary source of basic information used to shape national defense policy for 12 years."[23] During those twelve years, "Corona cameras exposed more than 2,700,000 feet of film covering 750,000,000 square miles of the earth's surface. The last Corona satellites each carried more than 31,000 feet of 70-millimeter film, could provide resolution of from six to ten feet, surveyed about seven million square miles during each mission, and returned cloud-free coverage of about three million square miles."[24] Perry wrote that:[25]

when the program ended [there] was a list of "firsts" that ranged from "first satellite in polar orbit" through "first dual-capsule reentry capability" to "first low-altitude satellite to utilize a solar array." Corona was the first satellite to be recovered, the first to operate in stabilized flight, the first to be recovered from the water, the first to be caught in descent, the first to incorporate an engine restart capability, the first to carry a stereo camera (and, of course, the first to carry any camera at all), the first to perform orbit adjust maneuvers, the first to carry "piggyback" satellites, and the first to utilize explicit guidance equations in its control circuitry.

The 1958 estimate for the original 12 launches was about $59 million. The total cost, through May 1972, according to NRO historian Perry, "was between $810 and $950 million." He added, "A great many totally valueless programs of the 1960s had cost more and had been cancelled before producing any results."[26] On November 25, 1972, the only surviving Corona satellite became a museum artifact. Today the vehicle is in the National Air and Space Museum.

Corona may have been a revolution in gathering intelligence, argued historian Peebles, but it grew out of the previous decade's work in the balloon reconnaissance and the U–2 programs. These efforts represented technological evolution. The technology used in the early Corona program was the same used in the balloon programs. The photointerpreters analyzing the film were the same. Many of the C–119 recovery pilots like Capt. Mitchell had been both a balloon recovery pilot and a Corona recovery pilot, because even the airplanes, which had been modified to catch balloons, were the same ones used to catch the film return capsules. And both programs had the total backing of national leadership, especially President Eisenhower, which was especially important during the string of 14 straight Corona failures and after the U–2 shootdown.[27]

When Capt. Mitchell caught that first bucket in August 1960, his was the first aerial recovery of a program, Corona, that lasted until 1972, a total of 145 missions.[28] But Corona lacked the high-resolution that photo interpreters wanted and so NRO began work on new systems. One of those programs, the declassified program code named Hexagon first launched in 1971, improved upon Corona's ability to provide coverage of wide areas of "denied territory" in the USSR and China. The spacecraft, launched on a Titan IIID booster, was sixty feet long, ten feet in diameter, and weighed 30,000 pounds at launch, and, according to NRO, when on orbit flew between 80 and 370 miles in altitude.[29]

One frame of Hexagon's film covered 370 nautical miles, about the distance from Rochester, NY, to Washington, DC. Hexagon had an improved camera system that could provide better search coverage at better resolution than Corona and, according to the NRO, "global geodetic positioning, accurate point locations for military operations, and data for military targeting." It now also flew four film buckets to return to Earth independently instead of Corona's one return capsule. This more-efficient approach gave Hexagon spacecraft a much longer life span on orbit – months now instead of mere days – and a larger spacecraft that could now carry 320,000 feet – sixty miles – of film. Wrote the NRO, "The United States depended on these search and surveillance satellites to understand the capabilities, intentions, and advancements of those who opposed the United States during the Cold War. Together they became America's essential eyes in space."[30]

The USSR developed its own overhead systems and the two sides came to accept the fact of satellites flying over each other's territory in a way that they would not accept with airplanes. Beginning in 1971, the superpowers legalized space-based systems for monitoring strategic arms, using the phrase "national technical means of verification" in arms control treaties. President Jimmy Carter officially acknowledged that the United States had overhead imagery systems when in October 1978, during a visit to NASA's Kennedy Space Center, he mentioned that "photoreconnaissance satellites have become an important stabilizing factor in world affairs in the monitoring of arms control agreements…" And because the strategic arms control treaties had limits on large and small missiles, NRO systems had to have the capability to distinguish between them. As the NRO put it, "The treaty language, in effect, became requirements for the capabilities of NRO satellites."[31]

While film return satellites were strategically useful, they were not always timely. For example, according to the NRO, the Intelligence Community did not get satellite imagery of Soviet forces preparing to invade Czechoslovakia in August 1969 until *after* Soviet tanks rolled into Prague. Similarly, the October 1973 Egyptian and Syrian attacks on Israel happened "faster than the NRO's imaging systems could respond." These events and the "insatiable drive to improve technology" drove the NRO to develop electro-optical systems to replace the film return systems.[32] Yet, satellites cannot access orbit and the buckets do not get caught without a reliable booster to propel them into space.

Douglas Thor Agena-A

Although ICBM programs were the "Air Force's highest priority" and Assistant Secretary of the Air Force Trevor Gardner advocated President Eisenhower give the ICBM a top national priority, Ike decided to give his blessing to both the ICBM and IRBM programs then underway. Thor was the Air Force IRBM and Jupiter was the Army's and Navy's joint IRBM program.[33] Thus, the three military services were all working on missile programs at the time. Farthest along was the Army's Jupiter IRBM that the Wernher von Braun team was evolving from the V-2 missile; the Air Force's Thor IRBM; and the Navy's Polaris missile, which was planned to be a storable missile with solid fuels. Ritland recalled the period as,[34]

…a very difficult time. I don't think it hurt anything from the national development point of view. It cost us money because there was a duplication of efforts, especially between the Thor and the Jupiter, and I think in hindsight, everyone knows that either one of them could do the job with enough money. But the question was who was going to get the money and who was going to win out from a role and mission point of view. It was a real deadly argument and I was kind of in the middle between Schriever and Medaris [Maj. Gen. John B., USA, commander of the Army Ballistic Missile Agency]… They [the missile programs] both had all of these deficiencies so that the programs, from a strategic point of view, weren't quite as important. However, the personalities involved were vicious, and man, it was a real knock down drag-out battle of who was going to win…. I know that Schriever, one night at his house—there were several people there at his home in Santa Monica—he made an announcement to a few of us and he said, "Ozzie, I'm going to go after that Jupiter." Namely, he was going to attack the duplication of effort between the Army and the Air Force, and that he was going to win that battle. From that moment on, he worked on it with the press and with politicians in Washington. And of course, as you know, the program, the Thor, did in fact win out, but not because of any technical capability, because the Jupiter was performing equally as well….[T]he Polaris program did not seem quite as competitive to the ballistic missile program the Air Force was pursuing because of the submarine aspects of it. However, from a comparative strategic weapons system point of view and the value of both of them, they were indeed tremendously competitive and we used to work like the devil on figures and facts and alternatives and tradeoffs and comparative studies to shoot down the Polaris program.

Douglas Thor Agena-A.

The Thor IRBM was a simpler missile that did not have a requirement for intercontinental range so AFBMD could get the missile fielded sooner. On one trip to DC, Ritland briefed Secretary of Defense Charles Wilson and British Minister of Aviation Duncan Sandys on the IRBM concept. The missile, which only had a 1,300-1,500-mile range needed basing closer to the USSR than ICBMs did. Ritland gave AFBMD's "canned" briefing on the Thor and Atlas, showing the similarities and differences between the missiles. He remembered it as "a very relaxed presentation" and said at one point, "So now then, you can see the Thor IRBM just falls out of the Atlas [ICBM] program without any new development other than the AC Spark Plug inertial guidance system." Wilson responded, "Yes, it fell out, but it sure cost an awful lot of money." At the meeting, though, Sandys agreed to the deployment of Thor missiles to England, where they were operational until the UK returned the missiles to the United States in 1963.[35]

The Thor IRBM was paired with an upper stage called Agena to lift the first Corona satellites into Earth orbit. CIA's Richard Bissell and Ritland created a cover story for Corona about studying the environment. They used the program name Discoverer, for which they said they planned to use Thors and Agenas to put experimental satellites in orbit. The public face of the program was that before you could put humans in space, you had to show that "you could launch small mammals, small vehicles in space, orbit the earth, and recover them" and that program was Discoverer.[36] The Air Force therefore had public authorization to develop a prototype demonstration satellite capability using a Thor IRBM with the Agena upper stage, aimed at providing a demonstration of launch, orbit, and recovery.[37]

The need for a launch site for reconnaissance satellites drove the Air Force from Florida to California. At the newly renamed Vandenberg AFB, engineers could launch tests to the south or southwest without worrying that an errant rocket might land on populated areas. While the Corona reconnaissance satellite team was awaiting formal approval, the launch pads for the Thor IRBM were under construction as part of the requirements and operational training for SAC personnel who would eventually operate the Thor as a weapon system. Engineers oriented the pads for southern trajectories for polar launches, "which most people didn't even recognize or understand," Ritland recalled.[38] Any launches to the south could head for polar orbit, ideal for the first reconnaissance satellites, without passing over any land until Antarctica.

Thor also had a life beyond the Air Force's strategic and space missions. According to historian David Spires, "As early as 1959, NASA saw in the Thor the reliable and adaptable medium launch vehicle it needed for its expanding communications, weather, scientific, and planetary exploration programs."[39] NASA designated its variant as Thor-Delta, which was eventually shortened to just Delta, and which in its various configurations launched literally hundreds of satellites into orbit. Today's satellite boosters are technological descendants of the Thor missile, initially intended to launch nuclear weapons but peacefully launching satellites instead ever since. Yet as with many new military technologies, counter-technologies soon arrived in the fight.

Vought ASM-135A anti-satellite missile

In the early days of the use of space for military purposes, the United States debated whether it needed the ability to destroy the space assets of its enemies. The Thor IRBM, once again demonstrating its versatility, became the basis for a direct-ascent ASAT called Project 437, which lifted a nuclear weapon to destroy an enemy satellite. But the cost to maintain Project 437, and a subsequent system based on the Nike-Zeus ABM system, led to the ASAT programs' cancellation. The Soviets, too, built and tested a co-orbital ASAT system that could snuggle up to an American satellite and, without using a nuclear weapon, explode, thereby destroying itself and the U.S. satellite.[40]

Vought ASM-135A anti-satellite missile.

In September 1964, President Johnson and Secretary McNamara revealed that the United States had an operational satellite defense system.[41] In Congressional testimony in March 1965, Air Force Chief of Staff Gen. John McConnell acknowledged the existence of Program 437 to show the United States had the capability to defend against Soviet space systems and to counter a gap in the public's mind about what the United States could do. According to historian Clayton Chun, the admission of an ASAT program also served to counter Johnson's opponents' claims that he was "soft" on defense. But, Chun suggests, the ASAT program fell victim in the late 1960s to the pressures of the Vietnam War's "size and intensity" and later to the brief détente between the United States and Soviet Union in the 1970s.[42]

But when the superpower relationship encountered difficulties after the resignation of President Richard Nixon, the Soviets resumed testing of their co-orbital ASAT program. In response, DOD's Director of Research and Engineering, Dr. Malcolm Currie, testified to Congress in February 1976 that "satellite vulnerability has to be a major issue for us, a major topic of study and of planning over the next few years. The question is, can we maintain space as a sanctuary or not?"[43]

What followed was a decision from President Gerald Ford on a replacement for Program 437, which eventually led to the LTV Aerospace ASM-135A anti-satellite missile, a non-nuclear system, to restore the United States' ASAT capability. Recalled Maj. (later Maj. Gen.) Wilbert D. "Doug" Peterson, "Our program was challenged to develop a dynamic weapon system that could respond rapidly, accurately, and with flexible targeting capability. That led us to an air-launched weapon."[44]

The missile was a prototype intended to be launched at high altitudes from the belly of an F–15 fighter jet, which performed the function of a first stage rocket. The missile, nearly 18 feet long and 2,700 pounds, had three main components: a modified Boeing AGM-69 Short-Range Attack Missile solid-fuel first stage and a Vought Altair III second stage. The small (12 x 13 inches) Miniature Homing Vehicle up front used eight cryogenically cooled infrared telescopes to acquire a target satellite.[45] In the collision of the satellite and the missile in space, there was no need for a nuclear blast because "the energy released by the collision of two spacecraft rushing toward each other at closing speeds of almost 36,000 feet per second" was enough to destroy the satellite.[46]

According to Pearson, "The F–15 was a real racehorse.... We could fly supersonic and we could maneuver it to be in the right kind of a climb, and we could integrate all the required systems into the airplane to communicate with the missile. It could physically hold the ASAT weapon. It was a very large missile so it needed a big enough airplane. An F–16 didn't have the ground clearance; you couldn't put the missile on the centerline of the airplane and take off with it without hitting the ground. We could take operational F–15A airplanes and with fairly minimal modifications turn those into ASAT-killer airplanes."[47] That was the idea after all—to develop an operational capability.

In the September 13, 1985, live test, Peterson flew the F–15 nicknamed "Celestial Eagle" for three and a half hours into an area below the path of the Sun-observing satellite *Solwind* P78-1. Flying 200 miles west of Vandenberg AFB, he lit his afterburners and pulled up into a 3.8g climb at a steep angle of 65 degrees. Slowing to .95 Mach and 1.9g's, at 38,100 feet above the ocean Pearson launched the missile.[48] He rolled Celestial Eagle so he could see the rocket take off. "It was just a beautiful sight to see the missile suspended there and the flame come out of the rocket motor. And then it took off like a bandit." At that moment, *Solwind* was over Hawaii, traveling at 23,000 feet per second, while the missile screamed up to it at 13,000 feet per second.[49] The satellite shattered on impact, making Peterson the first pilot to shoot down a satellite and colloquially, the first "space ace."[50]

The F–15 ASAT test was controversial, however. First, the test resulted in a debris field of 285 pieces of broken satellite that would take almost 20 years for all of it to burn up in the atmosphere. Second, the satellite, while degraded from its original battery capability and with only two of seven instruments still working, was still being used researching the Sun's corona.[51] And finally Congress, concerned about an arms race in space, banned further orbital testing and the Air Force cancelled the F–15 ASAT program.[52]

With low Earth orbit full of satellites, including over 6,000 satellites in the Starlink internet satellite constellation, destroying a satellite in orbit has far more serious consequences than ever before. Destruction of a single satellite, either on purpose or by accident, could start a process known as the Kessler Syndrome, in which pieces of debris catastrophically collide with satellites, generating more debris until the process eventually makes an orbital regime unusable.[53] This process could be the equivalent of the loss of the entire Pacific Ocean to commerce, let alone the military capabilities that would be lost.

Satellites were an important part of the national space effort and helped both in deterring Soviet aggression and exploring the physical universe. And, argued, Ritland in a March 1959 speech, "Let me emphasize the point that we are going to place man in space. We are not going to be content with merely sending instruments out there. Man will just have to go out there and see for himself. In such adventures, we expect that our Air Force Ballistic Missile Division will continue to have a constructive role to play."[54] Just six months after NASA's creation, the Air Force was staking its claim for human spaceflight.

McDonnell Gemini B spacecraft.

McDonnell Gemini B spacecraft

Few people know the military had a human spaceflight program before NASA, including the Navy's Manned Earth Reconnaissance program and the Army's Project Adam, both of which literally went nowhere. There was also Project Man High that floated researchers in a balloon to over 100,000 feet at the edge of space and the X–15 rocket plane that went even higher. Another sophisticated program that pre-dated NASA and whose requirements AFBMD first developed in 1957 was the Air Force's poorly-acronymed program, Man-In-Space-Soonest, or MISS. On June 25, 1958, the Air Force briefed its preliminary list of nine candidates to fly in the MISS program, including some very familiar names like Neil Armstrong, Scott Crossfield, and Iven Kincheloe, whom the press had dubbed "Mr. Space" for his Bell X–2 flight to 126,200 feet in 1956.[55]

The Air Force wanted to figure out what astronauts could do for the military, resulting initially in a program called "Blue Gemini" or simply "Gemini B." Ritland's team in California developed plans in February 1962 to use NASA's "Gemini hardware as the first step" in a program to develop "a kind of military space station with Gemini spacecraft as ferry vehicles" to and from a kind of space station. Ritland argued in April that "to preserve and strengthen the peace, we must be able to conduct in space the same kind of military operations we have learned to perform in the air during the last 50 years. We will best succeed in this objective when we make man as useful in space as he is within the atmosphere."[56]

Blue Gemini was meant "to develop rendezvous, docking, and transfer for military purposes, using Gemini spacecraft." USAF space advocates wanted to develop a proto military space station they called the Manned Orbital Development System by using Gemini spacecraft as ferrying vehicles for astronauts. An August 1962 proposal asked for six Gemini missions flown by military pilots.

Space stations were to "be placed in orbit to develop techniques for reconnaissance, interception and inspection of possible hostile satellites," according to a newspaper article written about a Ritland speech. The "space laboratories" would be constantly "remanned and resupplied by smaller craft shuttling between earth and space. The shuttle craft would resemble the Gemini manned capsules" that NASA was using.[57]

USAF Chief of Staff Gen. Curtis LeMay feared Blue Gemini would hamper his preferred Air Force space program called Dyna-Soar and civilian leaders in the Pentagon saw no "clear-cut military need for manned operations in space." NASA liked the idea because it infused more money into the Gemini program until Secretary McNamara proposed combining NASA's Gemini with DoD's Blue Gemini under DoD leadership. According to a NASA official history of Gemini, combining the two programs under the DoD "was too much for NASA." NASA Administrator James Webb felt that the approach took away some of the "peaceful" character of the NASA program.[58] The two agencies eventually created the Gemini Program Planning Board, co-chaired by NASA and DoD, to advise on experiments for Gemini flights, including military experiments.[59]

On Saturday, August 21, 1965, after two days of delays, Guenter F. Wendt, the McDonnell Aerospace pad leader, squeezed USAF Lt. Col. L. Gordon Cooper, on his second and last spaceflight through the left hatch, and spaceflight rookie USN Lt. Cdr. Charles "Pete" Conrad through the right hatch of their two-person Gemini spacecraft nicknamed *The Covered Wagon*. The spacecraft, Cooper remembered in a 1998 interview, was "absolutely crammed" with equipment for their flight. "We had the first fuel cell. We had the first radar. We had the first all-up [reprogrammable] computer. These were all things that needed to be tested and proven. And we had some 20-some-odd cameras of different types and several hundred rolls of film of different kinds."[60]

At 9 am the Titan II's engines roared to life and Gemini V lifted off on what was planned to be the longest spaceflight humans had ever attempted, depicted in their crew motto, "Eight Days or Bust." Launch, according to his biographer and wife Nancy Conrad, "was the same G-pulling feeling as a really tight turn in the F–4 going Mach-plus and then some, which was right up there with sex for Pete Conrad. They'd pull seven Gs before they were out of the atmosphere."[61] Recalled Cooper later in his memoir, "In fact, compared with the thin-skinned Atlas [on which he had flown during his Mercury mission], the Titan, a solid, thick-walled booster, was like cruising down the road in a Cadillac."[62] Conrad wrote in his *LIFE* magazine piece that after they had achieved orbit, "I was sure we had our eight days, too. It was the cat's bandana!"[63]

Cooper and Conrad carried Hasselblad cameras, including a ten-inch telephoto lens. The astronauts were demonstrating that they could survive on their own in space by repairing broken sighting equipment and even cameras. Conrad also used a commercial camera lens known as a Questar, modified to fit into the Gemini capsule. Said Conrad, a "9,000-foot runway up here fills the whole lens up..." of the runways, taxiways, and buildings of Dallas's Love Field.[64]

The crew also practiced their visual observational techniques. "They saw smoke at Laredo, Texas, for example, but did not see a huge checkerboard pattern that had been laid out for them on a field." Over the next couple of days, "they saw a rocket sled test as they flew over Holloman Air Force Base, New Mexico. Over Vandenberg, on the next pass, they sighted the contrail of a chase plane just before they glimpsed the ignition of a Minuteman missile." When he spotted the ICBM launch, Conrad shouted "I see it, I see it!" According to one report, they were able to track the rocket and obtain infrared signature data on the missile. While flying over the Atlantic Ocean, Cooper and Conrad took photos of their recovery carrier, USS *Lake Champlain*, with a destroyer astern, using the 1,270 mm telephoto lens.[65]

Still, *The Covered Wagon* continued to have problems with a major issue being "the orbital attitude and maneuvering system (OAMS), [which] grew sluggish, and [then] one thruster quit." Flight director Christopher Kraft then canceled all experiments that required fuel, and the crew turned off the electrical system to help reduce the water buildup" in the bladders supporting both fresh water and the fuel cells. When they eclipsed the Soviets' spaceflight time duration record, ground crews suggested the crew do a victory roll but Conrad radioed back, "I ain't got the fuel, sorry!"[66] When a second thruster quit, they could no longer hold the spacecraft steady and they began to slowly tumble in orbit.[67] They corrected some of the attitude, Cooper recalled later, by purging hydrogen and oxygen from the fuel cells and even dumping urine to give themselves "three more attitude thrusters," which helped them get a few more experiments done.[68]

According to NASA's official history, "Despite all the problems, the crew did a creditable job on the experiments," high bureaucratic praise for these two astronauts. One important DoD experiment was scrubbed, D-2, Nearby Object Photography, because it depended on rendezvous with a target pod, which could not be accomplished when the OAMS failed. Two other military photography experiments were successful. According to NASA's official Gemini program history, "Experiment D-1, Basic Object Photography, proved that the crew could acquire, track, and photograph" objects in space like the booster, rendezvous evaluation pod, and natural celestial bodies such as the Moon. The crew used a 35mm Zeiss Contarex camera, very similar to any single lens reflex camera of the time, mounted on Conrad's right-side window, using a 1270 mm lens for celestial body photographs. Weather conditions somewhat hampered [experiment] D-6, Surface Photography, but Cooper and Conrad did obtain photographs of Merritt Island, Florida; Tampico, Mexico; Rocas Island, Brazil; and Love Field, Dallas, Texas.[69] Experiment D-2 would have shown how astronauts could get "high resolution photographs of an orbiting object while maneuvering, station keeping and observing in a manual control mode," according to the press package handed out before the flight. After maneuvering around the rendezvous evaluation pod, they would have used a 200mm lens to photograph it. (Instead, the pod burned up over California.) In Experiment D-6, they investigated their ability to acquire, track, and photograph objects on the Earth. They had a list of areas to be photographed including "cities, rail, highways, harbors, rivers, lakes, illuminated night-side sites, ships and wakes," all within the United States and Africa, according to the press package.[70]

They expected to see five active volcanoes in their flight path, including Kilauea in Hawaii and three others in Central America. "Defense experiments D-4/D-7, Celestial Radiometry and Space Object Photography, were combined to make irradiance measurements on celestial and terrestrial backgrounds and on rocket plumes. The final defense experiment — S-8/D-13, Visual Acuity/Astronaut Visibility — combined use of an inflight vision tester and the observation of rectangular marks in fields near Laredo, Texas, and Carnarvon, Australia." Conrad recalled later that he "was impressed with how well we could see from 140 nautical miles (high) in orbit. I remember seeing red roofs in China. We could pick out interstates and large clusters of buildings. We could figure out what cities we were looking at during the night just by lighting patterns."[71]

Deorbit, descent, and splashdown all went smoothly. While they were still aboard *Lake Champlain*, some of the film was immediately processed and shown to the astronauts. Cooper recalled someone walking into the wardroom and telling him "that all the photos and negatives" from one of their cameras "were being confiscated and the experiment classified." He recalled in his memoir being "livid, but there was nothing I could do." A couple of weeks later, at the White House to receive medals for their space flight, President Lyndon Johnson told them he had ordered the pictures classified. "The commander-in-chief had spoken, and there was nothing else to say," wrote Cooper later.[72] It was not all the photos that were classified, only certain ones. Many were released to the public.[73] There is a beautiful cover and photo spread in the September 24, 1965, edition of *LIFE* magazine of some of the photos they took on orbit.[74]

Other attempts to determine missions for military members also occurred, including the X-20 Dyna-Soar and Manned Orbiting Laboratory but high costs and changes in the international political environment led to their demise. By the 1980s, no one really thought that humans could perform military missions such as surveillance, navigation and communications in space better than robots, or needed to.[75] Added to that concern were issues about the survivability of such a spacecraft in time of conflict. Thus, ideas about what military pilots could do on orbit slowly faded away, until the arrival of the space shuttle.

Rockwell Space Shuttle Crew Compartment Trainer

In January 1977, NASA and the Air Force agreed all military space launches would be on the shuttle. In 1981, President Ronald Reagan officially designated the space shuttle the primary means for launching government payloads because the system promised lower costs through reusability and frequent launches. The bonus was a role for military astronauts.

Rockwell Space Shuttle Crew Compartment Trainer.

The Air Force and other government agencies began optimizing their programs to fit into the space shuttle's payload bay.[76] Shuttle proponents suggested 60 flights per year (40 from Florida and 20 from California's Vandenberg AFB) at half the cost of expendable boosters. Then delays in the shuttle's development, and a reduction in estimates of the launch rate down to five in 1984 and maybe 13 in 1986, led the Air Force to contract for development of the Titan IV expendable space launch vehicle. When testifying about space launch before Congress, Under Secretary of the Air Force Pete Aldridge "expressed concern about the Shuttle's ability to support all scheduled Defense Department flights in addition to NASA's domestic and foreign commitments."[77] But the shuttle-first policy remained. The Air Force, therefore, tried to use a mix of a few expendable boosters and shuttle flights to get its payloads into orbit until the shuttle was fully operational, which was planned for the late 1980s.[78]

On January 27, 1986, disaster struck when shuttle *Challenger* came apart during launch with the loss of all hands. While this was not a military mission, the impact was catastrophic because the military had put so many of its eggs in the proverbial basket that was the shuttle payload bay. The loss of two Titan 34D boosters during launch and shuttle *Challenger* in less than six months of 1985-86, grounding both programs, in the words of space historian David Spires, "put the military space program into a tailspin." The Air Force estimated that at least 25 satellites were in the queue for launch, particularly the new GPS navigation satellites, but they would have to wait. By the time the shuttle finally returned to operations in 1988, the Air Force had made the decision to go with Atlas, Delta, and Titan expendable boosters as its workhorses and to use the shuttle only for R&D missions.[79] (The damage had been done, though, as there were, for example, merely sixteen GPS satellites on orbit at the start of 1991's Operation Desert Storm.[80])

When NASA picked Fred Gregory to be an astronaut in 1978 as part of Astronaut Group 8, he had to adapt from a military test pilot environment to "an astronaut environment." Yet he found the adaptation easy because his formal training as an engineer and as a test pilot helped him with the still-unflown test vehicle. As he recalled later, "it was kind of the same kind of job that we had had before, except it was a much more complex vehicle that we were going to go fly, in a different environment."[81] After six months of NASA academics, the new crop of astronauts finally got into the simulators. Washington, DC, native Gregory was a 1964 graduate of the USAF Academy with over 6,500 hours of flying time in over 50 types of aircraft, including 550 combat missions in Vietnam.[82] (Gregory went on to become Chief of Astronaut Training, responsible for academic and simulation training before astronauts could fly, and later NASA Associate Administrator for safety and in 2002, NASA Deputy Administrator.)

The crew compartment simulator, which NASA used to train crews for every shuttle mission, was one of the places astronauts practiced procedures, including on-orbit tasks, training for emergency escapes, and problem solving. More than 75 Airmen trained as astronauts in this mockup, which could sit level or tilt straight up to simulate pre-launch activities, thus its nickname "the one-G trainer." The flight deck was a replica of a shuttle flight deck with the same instruments, panels, lights, and switches, though mostly non-functional. The mid-deck replicated a shuttle's crew living space and gave astronauts a chance to practice cooking in the galley, sleeping, stowing their gear, and even going to the bathroom. The small area had room for only three people to stand but, astronaut Mike Bloomfield explained, was "roomy in the microgravity environment of low earth orbit, where suddenly all the available nooks and crannies become accessible." One astronaut estimated he spent nearly 500 hours in the simulator while training for his two shuttle flights.[83]

NASA flight director Wayne Hale wrote that "The job of the training team is to ensure that the astronauts and the flight controllers are prepared for any eventuality. Not only if things go as planned, but what to do if something goes wrong." Astronaut and Air Force Col. Terry Virts thought being a shuttle crew member was "busier than being an F–16 flight lead" or a military test pilot. As a shuttle pilot in the right seat of the orbiter, his main job was to watch the three main engines. "[E]lectrical failures would definitely grab my attention. Except, after giving us an electrical malfunction, the Sim Sup [simulation supervisor] would pile on ten additional malfunctions, each one having a unique interaction with another, gradually building up a doozy of a worst-case scenario." Gregory recalled, "We always joked that the training team constantly tried to kill us and the crew tried to make them look ridiculous." During one simulation, Hale counted 47 malfunctions in about ten minutes. The simulation supervisor told him they wanted the flight crew "to learn to prioritize between problems that could kill ya now and stuff that could wait until later."[84]

In 1983, NASA assigned Gregory as pilot of the crew of STS-51B, the seventh flight of space shuttle *Challenger* and the third flight of Spacelab. He estimated in an interview that they spent two years and three months training for the mission and when they finally flew, they were ready.[85] "Other than the sensations, such as going weightless when the main engines cut off on ascent, I think that the simulations that we had probably gave us 95 percent of that which we would have seen on orbit. Obviously it could not do the weightless part of it, and it was amazing when I first released my seatbelt" on orbit.[86] Air Force astronaut Col. John H. Casper recalled in his memoir that as he ascended into space aboard *Atlantis* on a classified mission in February 1990, he was unable to see the displays well because of the vibrations from the solid rockets. He thought, "*Hundreds of hours of ascent training simulations and now I can hardly read the gauges.*" Then Casper lifted his head slightly off his headrest and finally could see the gauges clearly.[87] Not everything can be simulated, even in a simulator.

When STS-33 took off from Florida November 22, 1989, Gregory became the first African American to command a spaceflight, this time a classified mission, which lasted five days. Two years and two days later, he commanded the crew of STS-44, another DoD mission, which put a Defense Support Program missile warning satellite into orbit from the payload bay of *Atlantis*. In a callback to an earlier time in human spaceflight, STS-44's Military Man in Space experiment evaluated "the ability of a spaceborne observer to gather information about ground troops, equipment and facilities." Those experiments, known as M88-1, were designed to assess a human's "visual and communication capabilities from space" using "small aperture, long focal-length optics, and a charge-coupled device (CCD) camera to produce a high-resolution digital image that can be stored, manipulated, and evaluated on-orbit. Pertinent findings [could] then be communicated via UHF voice to tactical field users seconds after the observation pass [was] complete."[88]

Final Thoughts

Lt. Gen. Forrest McCartney argued that "if you're not violating the laws of physics, you can do anything with enough resources. You can go to the Moon in 10 years. This country did that. The challenge is trying to get the job done on limited resources. That's the challenge of the Air Force today."[89]

Military space history is incomplete without an understanding of the people who built the organizations and who led in the performance of their missions. Just as important are the tools these people use to "Secure our Nation's Interests In, From, and To Space."[90] What is truly important for the history of the USSF is not that the artifacts themselves are the important pieces, although they are part of that three-legged stool of USSF history. Fundamental for understanding USSF history are the people like Maj. Gen. Osmond Ritland, Col. Fred Gregory, Maj. Doug Peterson, or Capt. Harold Mitchell, because they built and used these artifacts and thus created the history of the USSF. ■

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A Question of Vulnerability

David K. Stumpf

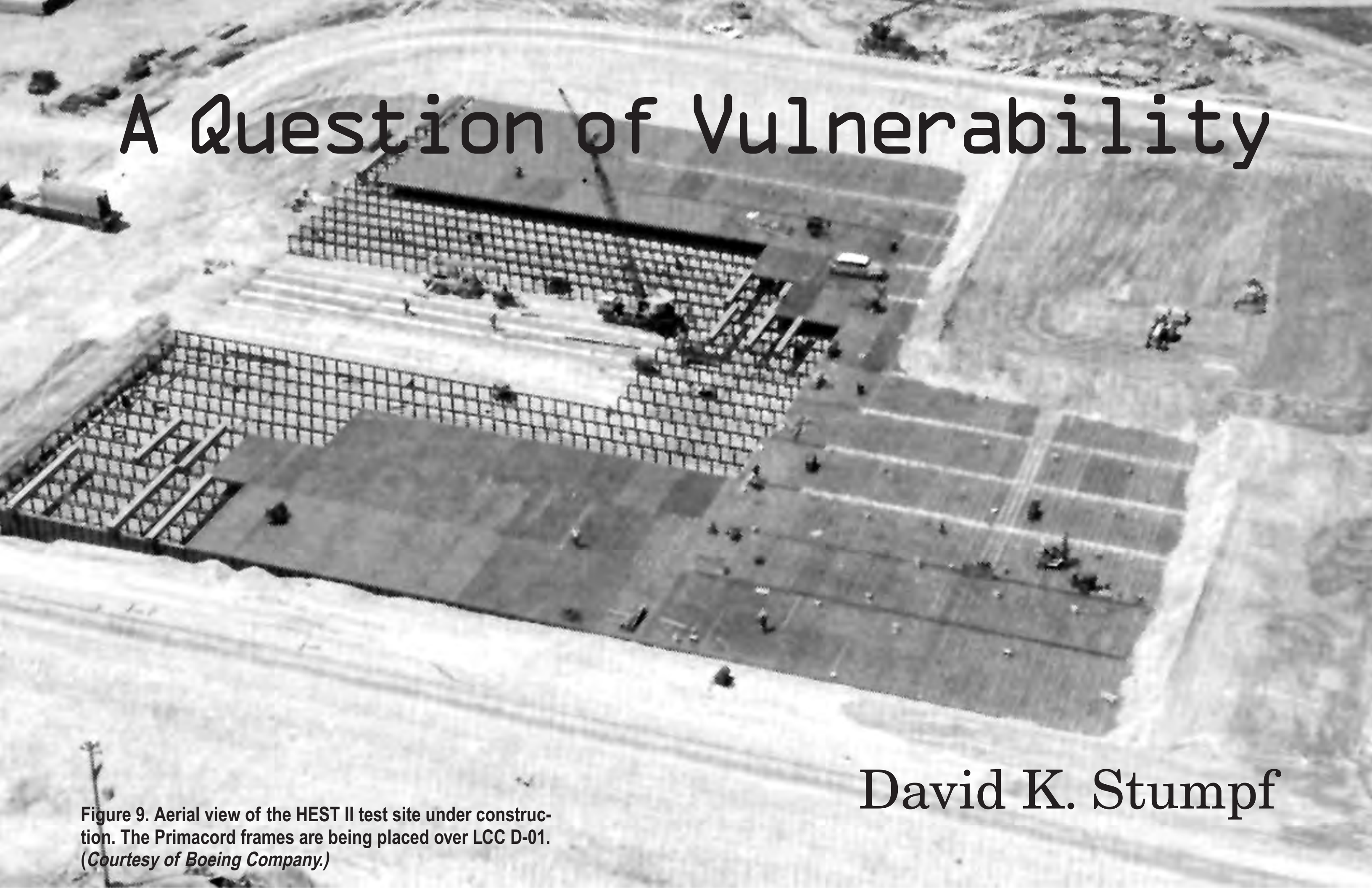

Figure 9. Aerial view of the HEST II test site under construction. The Primacord frames are being placed over LCC D-01. (*Courtesy of Boeing Company.)*

On September 24, 1963, the United States Senate ratified the Limited Test Ban Treaty which prohibited nuclear weapons testing in the atmosphere, space or underwater. President Kennedy signed the treaty on October 7, 1963 and the treaty went into effect on October 10, 1963, the Russians having ratified the treaty in August 1963.

The treaty presented a quandary to the Air Force and the other military services. In the case of the Air Force, design of the Atlas, Titan and Minuteman launch and launch control facilities had relied, in part, on the results of experiments during the 1957 Operation Plumbbob nuclear weapon test series. The signing of the Limited Test Ban Treaty meant that a new method for verifying the design of missile base facilities was needed.

This article describes the two major techniques that used conventional explosives to simulate the air-blast and surfaceblast shock environments from a nuclear weapon detonation.

High-Explosive Simulation Technique (HEST) was used to evaluate as-built Minuteman launch facility and launch control center vulnerability to air-blast induced ground motion.

The Direct-Induced High-Explosive Simulation Technique (DIHEST) simulated the ground motion from a surface burst, and in combination with HEST, was used to evaluate the feasibility of the Hard Rock Silo (HRS) basing concept. HRS was the proposed rebasing mode for a portion of the Minuteman fleet, as well as the WS 120A Advanced ICBM, both of which would serve to counter the deployment of the highly accurate Soviet SS-9 ICBM.

HEST was also used to evaluate the M-X/Peacekeeper basing options in conjunction with Giant Reusable Airblast Simulator on Vertical Shelter (GOVS), Compact Reusable Airblast Simulator (CRABS), and Dynamic Airblast Simulator (DABS). These are described in less detail.

Developing Alternative Testing Methods

Five months after the treaty went into effect the Air Force Weapons Laboratory began a three-phased project to simulate, with conventional explosives, the air-blast-induced ground motion associated with an air-burst attack. Phase I involved small-scale experimental method development; Phase II consisted of a large-scale field experiment to validate the Phase I method development and Phase III was a proof test at an operational hardened facility. Several simulation techniques were evaluated and discarded before the selection of two techniques for further development, detonable gas and Primacord.[1]

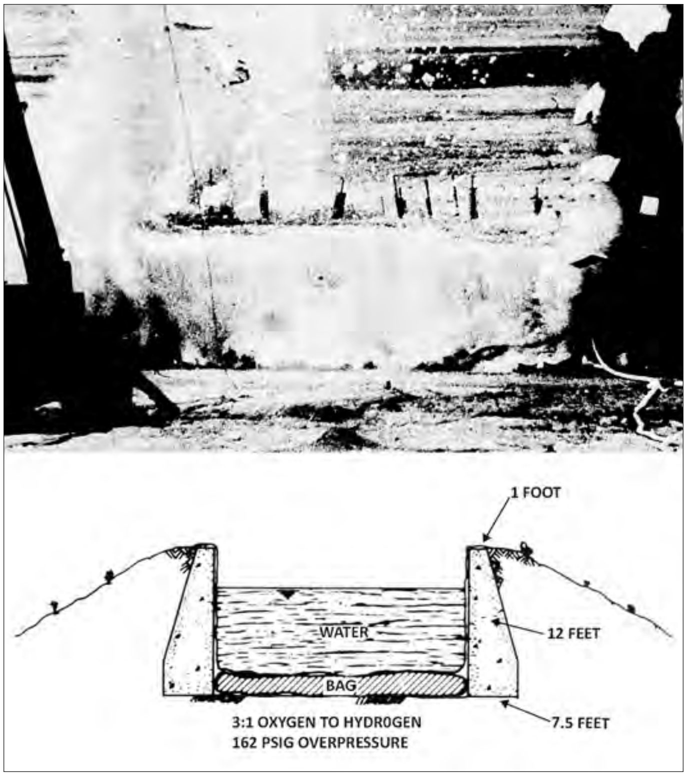

Figure 1. HEST Phase I Primacord Experiment, August 1964. Upper: Primacord with water overburden explosion; Lower: Design of the test bed. ***(Unless otherwise noted, photo credit is the United States Air Force.)***

Detonable Gas

The detonable gas technique was first investigated by the Stanford Research Institute. The near stoichiometric mixtures of hydrogen and oxygen used resulted in detonation velocities that were too high. The Air Force Weapons Laboratory investigators varied the hydrogen and oxygen ratio and were able to produce overpressures from between 300 to 1,200 psi.

The next step in development of this technique was to predict the effect of the motion of the overburden. The overburden was necessary to contain and maintain the overpressure for the desired duration. This involved varying the size of the flexible container of the gas mixture, the weight of the overburden, and the distance from ignition. The test apparatus to verify the calculations was a 20 x 40-feet pit lined with concrete, 1-foot thick at the top and 7.5-feet thick the base. The 12-feet-deep pit held a flexible container for the low-pressure gas mixture. A waterproof cover was placed over the bag and then the calculated amount of water overburden was added to the pit. The bag was inflated with the gas mixture at 0.12 atm and detonated at one end. The combustion products from the explosion acted like a piston by loading the cylinder of air in front of the detonation, which then formed a shock wave closely simulating the passage of the shock wave from a nuclear detonation. As the overburden moved upward as a result of the detonation, the cavity volume was increased and caused a corresponding decrease in pressure, as would be seen with a nuclear detonation blast wave passing over a launch facility (Figure 1).

Three tests were run which successfully demonstrated the required shock front. The overburden served to generate a greater duration of the pressure pulse. The gas mixture was ignited on one edge to form a pressure wave which moved through the container and over the ground. Finding a suitable container for the higher-pressure system, 2 atm, proved elusive. Development of the proper container was abandoned due to the success of the simultaneous Primacord experiments.[2]

Primacord

The initial Primacord technique used a steel and wooden structure to support layers of Primacord 2-3 feet above the soil. The Primacord racks were covered with plywood, forming a platform for the soil or water overburden. The wrap angle of the Primacord determined the rate at which the combustion products were formed along the length of the cavity. This was necessary because the detonation velocity for Primacord was higher than needed for the desired shock front simulation (Figure 2).[3]

High-Explosive Simulation Technique

Both the detonatable gas and Primacord techniques produced a reasonable simulation of the air-blast-induced ground motion from a large nuclear weapon. The detonable

Figure 2. One-fourth scale model of a Minuteman launch facility used in the HEST Phase II experiment.

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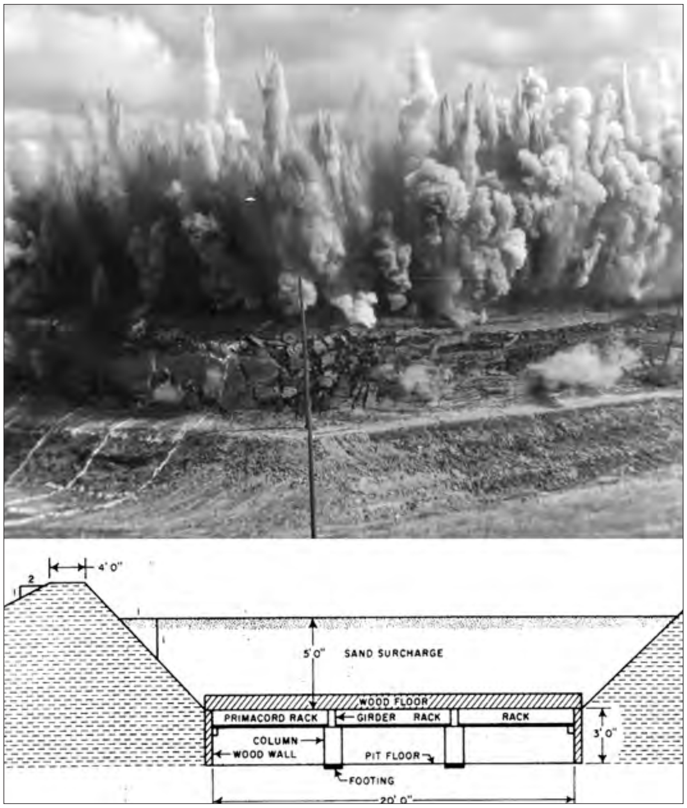


Figure 3. HEST Phase II. Upper: Seconds after detonation on December 15, 1964. This was the first large HEST structure test, 151 x 97 feet. Lower: Test bed details.

gas method required a flexible container that could hold a 2-atmosphere mixture while supporting the overburden weight. Additionally, it required a much larger facility than the Primacord technique. The Primacord technique was much safer and was more flexible as a wider range of peak overpressures could be produced. The General American Research Division of General American Transportation Corporation won the contract to further develop the Primacord technique in conjunction with AFWL.[4]

On December 15, 1964, the first large HEST structure, HEST Phase II, 151 x 97 feet, was used to expose a one-fourth scale structural model of a Minuteman launch facility to a 300-psi peak overpressure from a simulated 1 MT air-burst explosion. This overpressure would occur at a ground range of 2250 feet from the point of detonation. The test bed was a grid of Primacord assemblies attached to 5-by-7-feet wooden frames of 2-by-4-inch lumber. A continuous strand of Primacord was laced to each frame, thereby approximating the properties of a solid sheet explosive. The experiment produced a peak overpressure of 312 psi. The overburden reached a height of 125 feet at the firing end. There was mention of a structural displacement of the scale-model silo but further details were not given (Figure 3).[5]

The system was further refined through six additional tests which focused on studying the parameters controlling the air-pressure time histories. The grid sizes varied from 1,024 to 7,748 square feet. At the end of the development program, the HEST system was able to simulate overpressures up to 3,000 psi for approximately the first 200 milliseconds of air blast. This meant that simulations up to 10 MT were now possible:[6]

It should be recognized that at the present time this simulation technique will not reproduce the exact pressure-time history with more than a 400-millisecond duration. The system is best suited for testing shallow buried and surface flush structures since their principal failure mode was directly related to overpressure loading. Since the peak overpressure was uniform over the entire test area, structures with large surface areas could now be more realistically tested.

Minuteman Operational Base Testing

The Air Force now had a tool to investigate the as-built hardness of the Minuteman operational facilities. A Space and Missile Systems Organization (SAMSO) hardness review panel, which had been organized in 1963, had identified 40 problem areas in Minuteman Wings I-V. Twenty-seven items such as blast valve mechanisms, missing conduit attachment points and similar items did not meet design specifications. Launch facility and launch control center construction was basically sound but when all factors were considered, the launch facility, designed for 300 psi overpressure protection was now rated at approximately 70 psi. The launch control center, designed to survive 1,000 psi overpressure, was now estimated to have only 125 psi protection.[7]

Immediately after this announcement, SAMSO Plan 1 was developed to restore a satisfactory degree of protection, 500 psi for launch control centers and 125 psi for launch facilities, by fixing the most serious problems as quickly as possible. The $30 million cost would be spread across seven years with the goal of completing the program simultaneously with completion of the Force Modernization program. Force Modernization was designed to bring Wings I-V to the standard of Wing VI (Grand Forks AFB) and the 564th Strategic Missile Squadron (Malmstrom AFB).[8] Secretary of Defense Robert McNamara accelerated the program, saying “It is absolutely essential to correct hardness deficiencies as soon as possible and the Air Force should spend whatever funds are required.” McNamara added $28.6 million in Fiscal Year 1966 and $4.8 million for Fiscal Year 1967 for the hardness test program using the HEST system. By the end of the Minuteman and Hard Rock Silo (see below) programs in 1970, $56.4 million had been spent on 16 experiments during the HEST program (Table 1, following page).[9]

QH 1 (HEST I)

On August 2, 1965, the Air Force authorized Boeing, serving as a subcontractor to the Air Force Weapons Laboratory, to proceed with planning for the first HEST hardness evaluation of a Minuteman launch facility. Codenamed Gas Bag Hardness Test (Quick HEST, QH-1, later renamed HEST I), the test was conducted at the 90th Strategic Missile Wing (90 SMW) F. E. Warren AFB.

Table 1. HEST Test Summary 1964-1968[a]

Date	Test	Location	Pit Size (ft)	Purpose
Feb-Aug 64	HEST Phase I	Kirtland AFB	20x40	evaluate gas mixture/water overburden and detonating cord with sand overburden
15 Dec-64	HEST Phase II	Kirtland AFB	96x150	determine pressure area and instrument requirements for a full-scale Minuteman facility, using 1/4 scale model
5 Feb-65	(HEST-2)	Kirtland AFB	32x36	study parameters controlling the HEST air-pressure time histories
10 Mar-65	(HEST-3)	Kirtland AFB	40x48	Double overpressure, change surcharged containment, and improve instruments, using same test structures as for Phase II
6 May-65	HEST Phase IIA	Kirkland AFB	88x100	Double overpressure, change surcharge containment, and improve instruments, using same test bed structures as Phase II.
30 Oct-65	(HEST-1)	Kirtland AFB	32x36	Study parameters controlling the HEST air-pressure time histories
1 Dec-65	HEST I (Quick Test)	F. E. Warren AFB Wing V	302x304	OPERATIONAL TEST: Test at an operational Minuteman launch facility and a ground test missile on simulated alert
15 Mar-66	(HEST-6)	McCormick's Ranch, Albuquerque		Study free field ground motion
May-66	HIP-1	Kirtland AFB	40x60	Improve HEST environment
Jun-66	HIP-1a	Kirtland AFB	40x60	Improve HEST environment
22 Jul-66	HEST II	F. E. Warren AFB Wing V	304x352	OPERATIONAL TEST: test at an operational Minuteman launch control center
14 Sep-66	HEST III	Grand Forks AFB Wing VI	304x302	OPERATIONAL TEST: test the hardness at a Minuteman II launch facility
29 Jul-67	Backfill (HEST-4)	McCormick's Ranch, Albuquerque	56x72	Study free field ground motion
Oct-67	(HEST-5) demonstration	Grand Forks AFB Wing VI	64x83	Demonstrate maximum SOR environment; evaluate surcharge disposal; evaluate gauge placement techniques; provide planning bases for HEST Test V. Used smaller pit
5 Sep-68	HEST V	Grand Forks AFB Wing VI	300x300	OPERATIONAL TEST: determine structural survivability and functional capability of launch-essential equipment; obtain data useful for force hardness assessment
21 Nov-68	ROCKTEST I	Estancia Valley, NM	180x204	Evaluate design for increased overpressure for use with the HEST-DIHEST series of tests

a) Designing Facilities to Resist Nuclear Weapons Effects Hardness Verification; Simulation of Airblast-Induced Ground Motion Phase IIA

Launch Facility Q-04 was selected for the test and electronically isolated from the remainder of the squadron. A ground test missile was emplaced and preparations for the test commenced. The test took place on December 1, 1965, generating an estimated 300 psi over the 91,000 square feet structure with no serious damage to the launch facility or the ground test missile. The refurbished site was returned to the Strategic Air Command on November 10, 1966 (Figures 4, 5, 6) .[10]

HEST II

With the success of HEST I, the overpressure goal for HEST II, testing the hardness of a launch control center, was increased from 600 to 1000 psi. The 90 SMW Launch Control Center D-01 was isolated from the rest of the squadron on February 15, 1966, aboveground structures removed, and the test structure (107,000 square feet) installed with 80,000 pounds of Primacord. The test took place on July 22, 1966 and was again successful, as the launch control center and launch control equipment building continued to function despite damage from the blast.

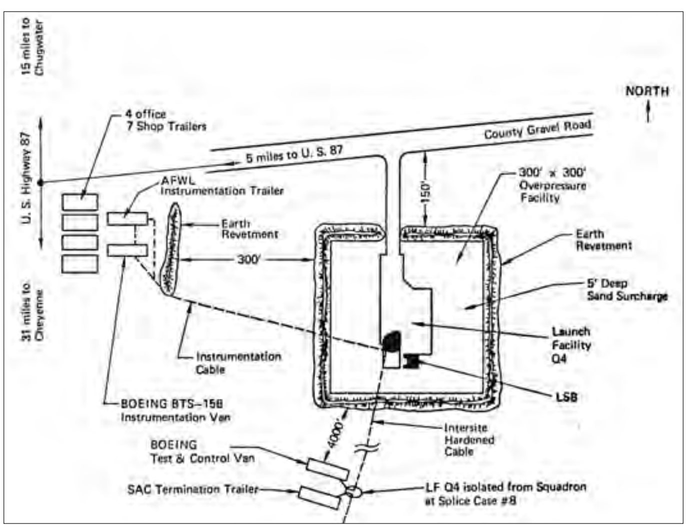


Figure 4. Layout of the QH-1 (HEST I) test facility at LF Q-04, 90th Strategic Missile Wing, F. E. Warren AFB. *(Courtesy of Boeing Company.)*

Figure 5. Minuteman IA Launch Facility.

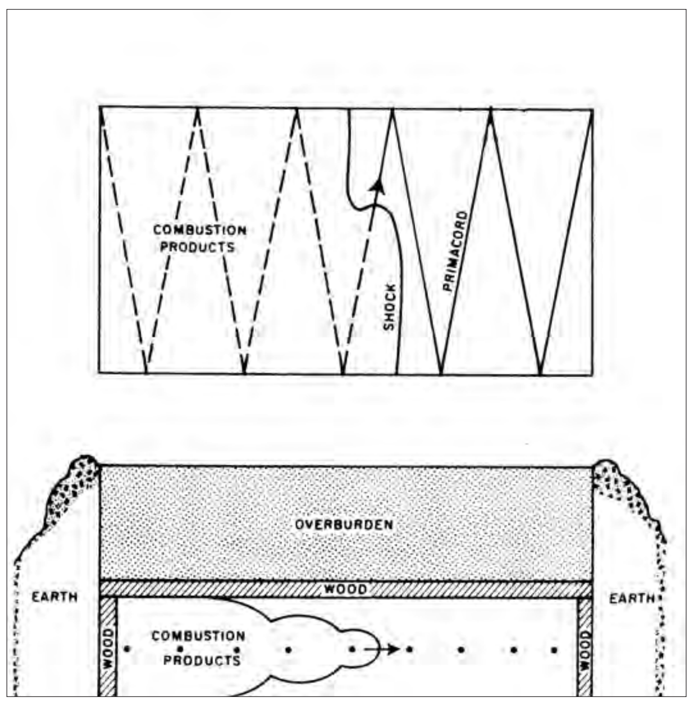


Figure 6. HEST-I. Upper: The Primacord had to be laid at a specific angle, 8.6 degrees, to achieve the wavefront needed for the experiment. Lower: propagation of the combustion gases took place in the air gap. This illustration does not show the movement of the overburden.

Figure 7. HEST-I. Workers are laying out the floor before installing the frames with Primacord. *(Courtesy of Boeing Company.)*

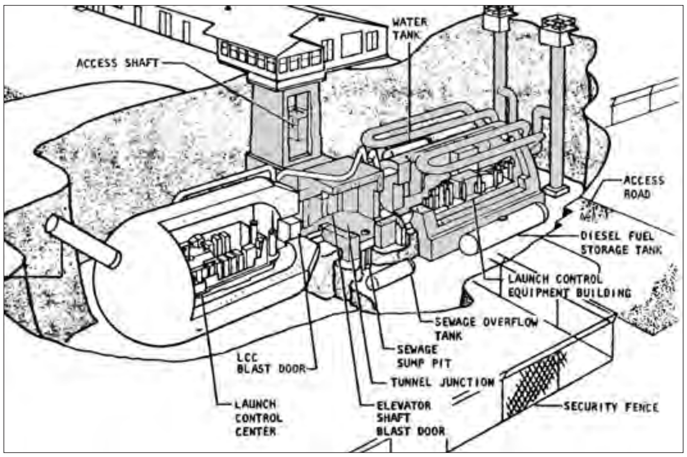


Figure 8. Typical 90 SMW Launch Control Facility. All the aboveground structures had to be dismantled. The structures highlighted with gray indicate what needed to be repaired after the test.

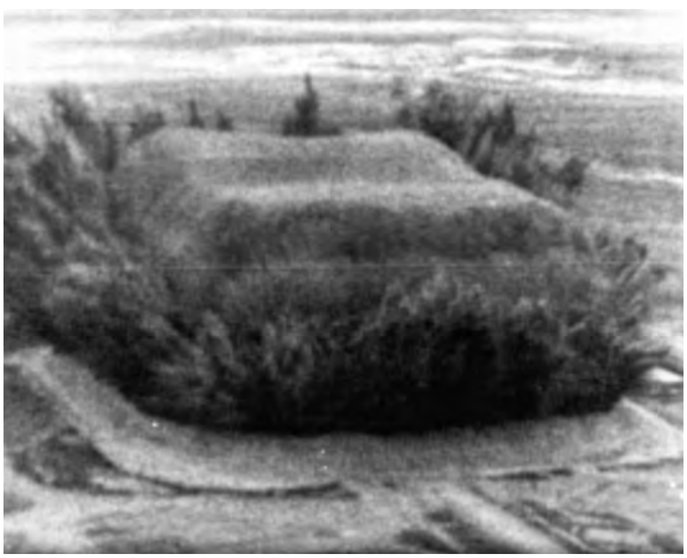


Figure 11. HEST II shortly after detonation. The overburden could be lifted as high as 180 feet depending on the amount of Primacord used. One complication was the need to remove all the overburden from the surface to investigate the damage, if any, to the test structures. *(Courtesy of Boeing Company.)*

The launch control equipment building had to be rebuilt along with the tunnel junction and access elevator shaft (Figure 7, 8, 10, 11).[11]

Figure 10. HEST II. Detail showing the layers of Primacord laced on 2x4 frames. *(Courtesy of Boeing Company.)*

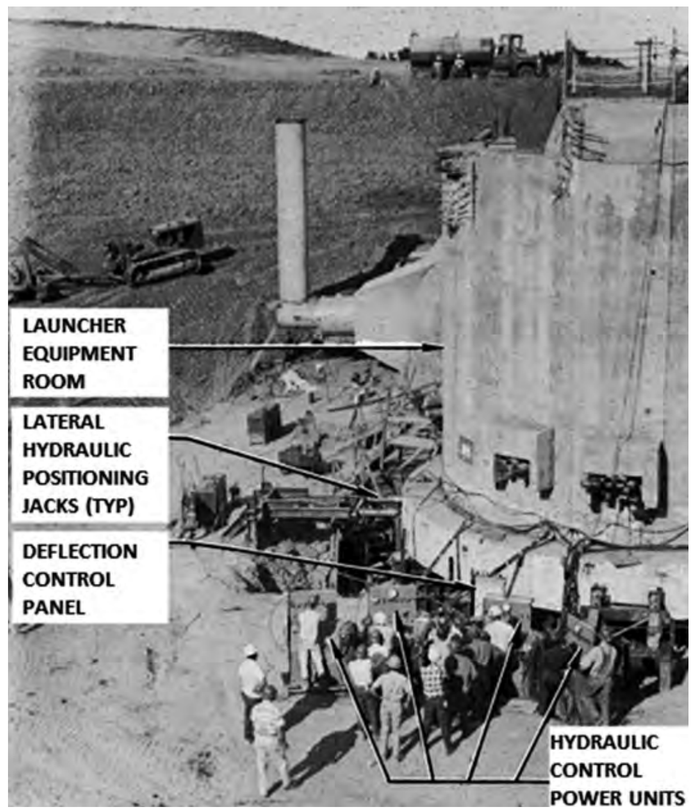


Figure 12. During construction at Grand Forks AFB two of the launcher equipment rooms settled beyond specifications. The structures were excavated and repositioned using massive hydraulic jacks. A similar technique was used to repair LF-28. *(Courtesy of Boeing Company.)*

HEST III

Though the 321 SMW, Grand Forks AFB, North Dakota, was not fully activated, the Air Force moved the HEST program to Grand Forks to investigate the hardness of the newly completed Minuteman II operational facilities. On September 22, 1966, HEST III took place at Launch Facility M-28 with a test facility of 91,000 square feet. (Figures 12, 13) The explosion generated the expected 1000 psi overpressure. While the launch facility remained operational for

Figure 13. Upper: HEST III one second before detonation; Middle: one second after detonation; Lower: 15 seconds after detonation. (*Courtesy of Boeing Company.)*

72 minutes following the blast, it suffered significant damage. There was flooding in the lower level of the launcher equipment room as well as in the launch tube. The launch tube flooding would normally have been taking care of by a sump pump but the movement of the lower level of the launcher equipment room had been sufficiently violent to break the emergency power line, preventing the pumps from operating. The blast also forced mud into the air-conditioning system and covered the emergency power batteries as well. That the facility remained operational for slightly more than an hour after the blast was encouraging. The amount of damage validated the value of the test in revealing problems in the hardness of Minuteman II at Grand Forks as well as the 564 SMS at Malmstrom AFB.[12]

Repairs to Launch Facility M-28 involved not only cleaning and repairing the interior of the launcher equipment room and launcher equipment building, both had to be repositioned. Fortunately, during initial construction at Grand Forks, two launcher equipment rooms had settled beyond acceptable limits and a technique for repositioning the 3-million-pound structure had been developed. Twenty-five 100-ton hydraulic jacks were used to raise the launcher equipment room to the required elevation for placement of the lateral movement system. The next step was to place 12 lateral movement assemblies under the launcher equipment room footing and wedge them firmly in place. The structure was then lowered onto the lateral movement assemblies and four sets of horizontal jacks were used to move it into position. After an optical survey to assure the building was in the proper location, steel wedges were positioned between the bearing surfaces, locking further movement. The wedges were welded in position and the bearing assemblies left permanently in place. The lateral position jacks were removed and the space filled with concrete to within 4 inches of the foundation. The remaining space was filled with non-shrinking pressure grout. The 1-million-pound launcher equipment building also had to be repositioned using a similar technique. Repairs to Launch Facility M-28 were completed on November 30, 1967.[13]

HEST V

Results from the first three tests generated hardening improvements throughout the six Minuteman wings. While the Air Force Systems Command recommended abandoning the program after the third test, Gen. John P. McConnell directed that it should continue. HEST IV was deferred, and later canceled. In October 1967, the Air Force conducted a scale model test to correct a flaw in the simulation technique. The problem was a secondary shockwave caused by the collapse of the earth overburden onto the test site once the explosive gases had escaped. The revised design caused the overburden to scatter, reducing the secondary jolt without interfering with the desired rolling shockwave.

HEST V, simulating a 10 MT blast with 300 psi overpressure, took place on September 5, 1968, at 321 SMW Launch Facility L-16. This time the air conditioning continued to function, there was no flooding and a simulated launch was successfully conducted almost 6 hours after the blast.[14]

FOAM HEST

The HARDPAN Event 3, December 1975, was the last large-scale test employing the original HEST design. A more cost-effective design known as FOAM HEST replaced the expensive and complicated steel and wood platform with planks of beaded polystyrene in direct contact with the soil.[15]

Hard Rock Silo

In the Fall of 1963, the Soviets began flight testing the Soviet R-36 ICBM (NATO designation SS-9 Scarp). Deployment started in 1966. The SS-9 was similar to the Titan II, using both hypergolic propellants and an inertial guidance system. The SS-9's improved accuracy and large payload, 10 to 25 MT, represented a direct threat to the Minuteman force. As far back as 1961, the Air Force had known that once the Soviet missiles had sufficient accuracy to target the 100 launch control centers, the hardness protection evaluation needed to include direct crater-induced ground motion from a surface burst. With the SS-9, relatively few missiles would be necessary to eliminate Minuteman in a first strike on the launch control centers compared to targeting all 1000 launch facilities.[16]

There were three possible solutions to this new problem: (1) Reinforce the existing Minuteman launch facilities and launch control centers as Minuteman III had been designed to be launched from the existing facilities; (2) build dual-capable launch facilities that at first could house Minuteman III but which would be replaced in the not-too-distant future with the proposed Advanced ICBM (AICBM); (3) build new facilities designed specifically for the AICBM. The Force Modernization Program addressed hardening improvements for the Minuteman launch facilities and launch control centers. Force Modernization did not involve substantial construction.[17]

On November 1, 1966, the Advanced Research Project Agency contracted with the Institute for Defense Analysis (IDA), DAHC I-15-67-CV-0011, Task Order T-56, to evaluate alternative basing concepts for the WS 120A.[18]

Research by the Department of Defense and industry teams, including Boeing, indicated that an increased hardness Minuteman launch facility for Minuteman III would provide an effective solution to counter the new threat of the SS-9. The dual-capable launch facility concept was to build a new launch facility (hardened to 3000 psi) adjacent to existing Minuteman launch facilities size to accommodate a 100-inch diameter, 7000-pound payload missile at some future date. In the interim, the facility would house Minuteman III.[19]

The IDA alternative basing report, known as STRAT-X, was released in August 1967. The report was:[20]

a technological study to characterize US alternatives to counter the possible Soviet ABM deployment and so the Soviet potential for reducing US assured-destruction-force effectiveness during the 1970's. It is desired that the US alternatives be considered upon a uniform cost-effectiveness well as from solution sensitivity to Soviet alternative actions. Particular attention to US technology and production limitation versus time during the mid-1970's is desired. The studies should consider further proliferation of our current forces and/or protection of these forces as well as new system concepts, both land-based and sea-based.

The STRAT-X report reviewed one hundred twenty-five basing concepts and recommended only eight for further consideration. The land-based alternatives studied included: hard rock silo (HRS), soft silo, rock tunnel, soft tunnel, canal-based and land mobile. The HRS basing concept was selected for further study.[21]

On October 4, 1967, McNamara denied the Air Force the start of development of the WS-120A missile. He directed the Air Force to look instead at the development of HRS for Minuteman III.[22] On May 1, 1968, Headquarters USAF issued a System Management Directive to initiate the Hard Rock Silo (HRS) Development Program for Minuteman III. The goal of the program was to develop and test a new, significantly harder basing system that would be dual-compatible with a future advanced ICBM.

There were six major components to the Hard Rock Silo program:

Demonstrate the capability to survive a nuclear attack of significantly higher magnitude than the current Minuteman system.
Accommodate the Minuteman III missile with its associated command control system modified to provide increased communication survivability.
Accommodate the future installation of the AICBM and its related systems.
Minimize lead time to the IOC date.
Preserve the Minuteman relocation/proliferation option as long as possible.
Demonstrate high confidence for achieving technical objectives at low development program costs.[23]

Experimental facilities would have to be designed to demonstrate the efficacy of using a hard rock environment. This required construction of subscale to full-scale facilities and testing these facilities to demonstrate the required hardness could be achieved.[24]

Direct-Induced High-Explosive Simulation Technique

The deployment of the SS-9 and its greatly improved guidance system meant that surface bursts and subsequent cratering would likely be the mode of attack. In 1967, AFWL researchers began development of a modified HEST system named DIHEST. DIHEST was designed to simulate the crater-induced horizontal ground shock motions that occur as result of a surface-burst nuclear weapon detonation. DIHEST used buried vertical arrays of explosives to produce a blast wave characteristic of a surface detonation. Coupled with the HEST system modified to generate higher overpressures, the HEST-DIHEST combination pro-

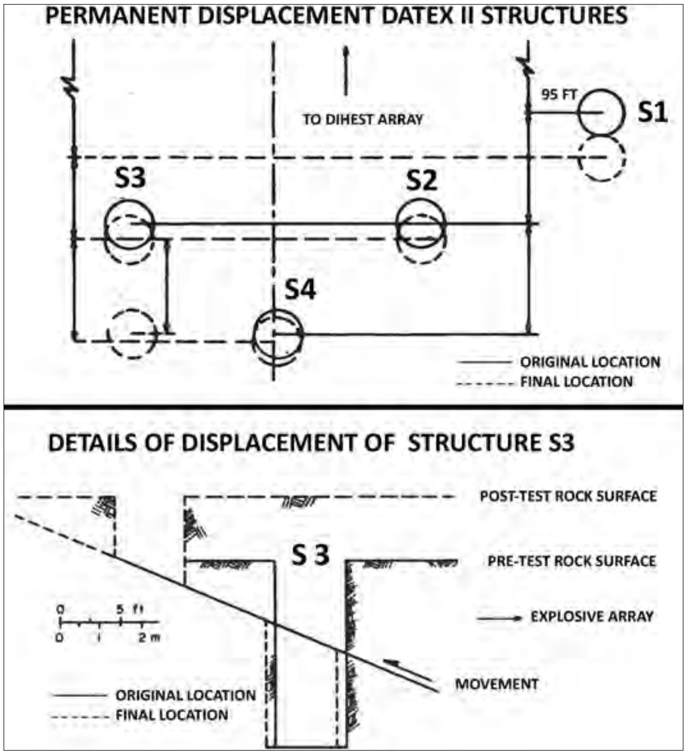


Figure 14. DATEX II. Upper: Plan view showing displacement of the four test structures. Structure S4, within 20 feet of Structures S2 and S3, was only slightly damaged. Lower: elevation view of the displacement for S3.

Figure 15. DATEX II. Close up of the top of Structure S3. S3 was 6 feet in diameter and 15 feet deep with a liner consisting of a 6-foot diameter section of steel culvert backfilled to the rock walls with approximately 9 inches of non-reinforced concrete. The top 5 feet was sheared off the silo and moved 13 feet laterally. The lower portion of the silo also moved approximately 6 inches laterally.

vided simultaneous simulation of both air-burst and crater-induced ground motion.

PLANEWAVE and DATEX

The PLANEWAVE and DATEX test series developed and refined the DIHEST concept. The fourth DIHEST experiment, DATEX II, fired on July 17, 1969, served as a proof test for a more effective explosive, DBA-X2M slurry aluminum ammonium nitrate. Four silo models were used: Structures 1, 2 and 4 were unlined, smooth walled, 6-feet in diameter and 15-feet deep. Structure 3 was also 6-feet in diameter with a steel culvert liner backfilled with 9 inches of nonreinforced concrete. Structures 1, 2 suffered relative displacements of approximately 2 feet along horizontal joints. Structure 4, only 20 feet away from Structures 1 and 2, suffered little damage. Structure 3 suffered a severe relative displacement with the top 5 feet of the structure displaced 13 feet relative to the bottom section. (Figures 14, 15) Other nearby structures showed minor damage. These results pointed out the inability to predict block motion prior to the explosion.[25]

HANDEC

The HANDEC (HEST And DIHEST Combined) test series developed the parameters of combining the two techniques to: (1) produce an overpressure and air-blast induced ground motion environment; (2) simulate a ground shockwave similar to that produced by the cratering from a nuclear explosion as specified by AFWL in rock media; (3) test the time phasing of HEST and DIHEST; (4) test an instrumentation system in protective piping; (5) test instrumentation anchored to the rock versus cable and trench excavation.

The HANDEC I and II tests were fired with a 54 and 42.5 millisecond delay, respectively, between the HEST and DIHEST explosions. This allowed the two shockwaves to be induced into the rock with timing similar to that of a specific yield nuclear explosion. The DIHEST component of HANDEC I consisted of 11 holes, 9 inches in diameter, 10 feet on center, 13 feet below the test bed floor, in a line parallel to and located 25 feet from the inside face of the test facility concrete wall. The total explosive force was 4400 pounds of aluminum ammonium nitrate. HANDEC II had explosives in 29 holes 12 inches in diameter and spaced 7 feet 2 inches on center. The holes formed a 200-foot line parallel to and located 96 feet from the inside face of the test facility wall and extended approximately 70 feet below test bed elevation. Approximately 92,440 pounds of aluminum ammonium nitrate slurry explosive was used. To reduce rock ejecta, an earth berm was constructed 60 feet wide by 290 feet long directly over the 29 holes. The berm height was approximately 50 feet.

Nine test structures were built for HANDEC II. Structure S11, a concrete lined silo model 6-feet in diameter and 20-feet deep, suffered major structural damage below a depth of 10 feet due to a relatively minor horizontal displacement of 0.3 feet. Structure S12, also a silo model of similar dimensions, located 45 feet to the northwest showed no appreciable damage.[26]

ROCKTEST I

Validation of the increased overpressure component of the HEST-DIHEST system took place on November 21, 1968 at Estancia Valley, New Mexico. ROCKTEST I gen-

Figure 16. ROCKTEST I. The upper full-scale closure liner for the 30-foot-deep Stub Silo S01. The liner was 7.5 feet tall with an interior diameter of 17 feet and was fabricated from 2-inch-thick steel. The walls of S01 were 5-feet thick. The closure doors were cast in place.

erated the expected 3,000 psi peak overpressure using a 3,300 square feet test array which covered 13 experiments (there was no DIHEST component in this test).[27] In the center was a 17-feet interior diameter, 27-feet exterior diameter, 30-feet-deep stub silo and closure door. A one-quarter scale model silo closure, four 6-feet diameter and two 3-feet diameter experimental silo closures were also part of the experiment. Intersite cable samples were exposed to the blast, as well as antenna housings. Damage to the structures was slight.(Figures 16, 17) [28]

ROCKTEST II

The first full-scale HEST-DIHEST experiment, ROCKTEST II, took place on March 26, 1970, on the eastern slope of the Three Peaks Mountain Range, west of Cedar City, Utah. The primary goals were: 1) to test a full-scale half depth, heavily reinforced conceptual missile silo, S01, and 2) to demonstrate the ability to simulate a combined nuclear air-blast overpressure and subsequent ground motion followed by the direct-induced pulse on a large-scale.

Structure 01 was composed of six vertical cylindrical openings cast in a 56-feet diameter reinforced concrete cap; a 19-feet diameter launch tube, an 18-feet diameter equipment tube, two 2.5-feet diameter air entrainment shaft, a 17-feet diameter personnel access shaft and a 6.75-feet diameter closure column, all 75 feet in depth. The thinnest exterior wall section, located at the launch tube, was 4 feet thick.[29]

Figure 17. ROCKTEST I test facility under construction. The large diameter circle is the top of 30-foot-deep stub silo wall. The full-scale closure liner has not been installed. The smaller diameter circle is an access tube for post-test inspection of the closure.

A total of 10 experiments included: S01, the conceptual silo; site-by-side silo models S02 and S04, half scale, 35-feet deep; S03A, 12-feet diameter, 10-feet deep; S05, S06, S07, 6-feet diameter, 40-feet deep. S05 was lined with a reinforced concrete liner; S06 was unlined and S07 was lined with a reinforced concrete liner surrounded by a foam back packing. Additionally, antenna elements, samples of hardened intersite cable and samples of silo closures of various diameters were tested. The test bed covered 100,000 square feet.

The DIHEST explosion displaced a 140x150-foot block causing a horizontal displacement of approximately 10-12 inches encompassing the top portions of S03A, S06 and S07. The S03A closure was upturned by the movement of the block. The top of S07 was displaced 6.5 inches horizontally and 2 inches vertically. The further damage details remain classified.[30]

Evaluation and Termination of Hard Rock Silo Program

Nine DIHEST/HEST-DIHEST experiments in rock were conducted between October 1967 and November 1970 as part of the HRS test program (Table 2).[31] Five of the nine experiments produced significant block motions which disrupted the model structures:

The lack of ability to predict exact block motion locations in advance of an experiment where the location and properties of the dynamic loading are known, present difficult design and analysis problems. It is vital that these uncertainties be incorporated into any design philosophy for hardened structures in rock.

Based on a very limited amount of data generated by the DIHEST series, it would appear that a "sure safe" zone from a cratering burst in rock might begin beyond three crater radii from the burst point. The accuracies of today's weapons delivery systems however make the utilization of such a "sure safe" zone impractical, so that the system designer is left several options, all of which require extensive

Table 2. DIHEST and HEST-DIHEST Test Summary 1967-1970[a]

Experiment	Type	Date	Location	HEST Bed Dimen. (ft)	HEST Design Overpressure (psi)	DIHEST Array length x depth (ft)	DIHEST Array weight (lb)
PLANEWAVE I	DIHEST	Oct-67	Estancia Valley, NM	na	na	20x20	800
PLANEWAVE II*	DIHEST	Mar-68	Estancia Valley, NM	na	na	45x20	4200
DATEX I	DIHEST	Apr-69	Cedar City, UT	na	na	100x38	4400
DATEX II*	DIHEST	Jul-69	Cedar City, UT	na	na	200x36	82000
HANDEC I	HEST-DIHEST	May-69	Cedar City, UT	40x60	6000	100x38	4400
HANDEC II*	HEST-DIHEST	Aug-69	Cedar City, UT	60x90	1000	200x40	92000
PRESTARMET II	DIHEST	Jan-69	Pedernal Hills, NM	na	na	50x38	2400
ROCKTEST II*	HEST-DIHEST	Mar-70	Cedar City, UT	250x400	classified	500x40	234000
STARMET*	DIHEST	Nov-70	Pedernal Hills, NM	na	na	100x38	4360

a) Blouin   * indicates significant block motion

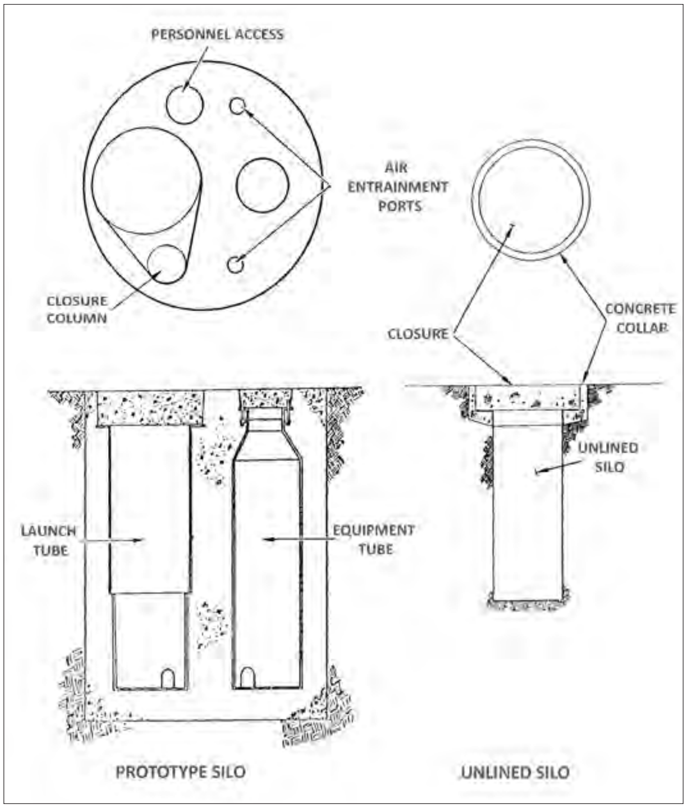
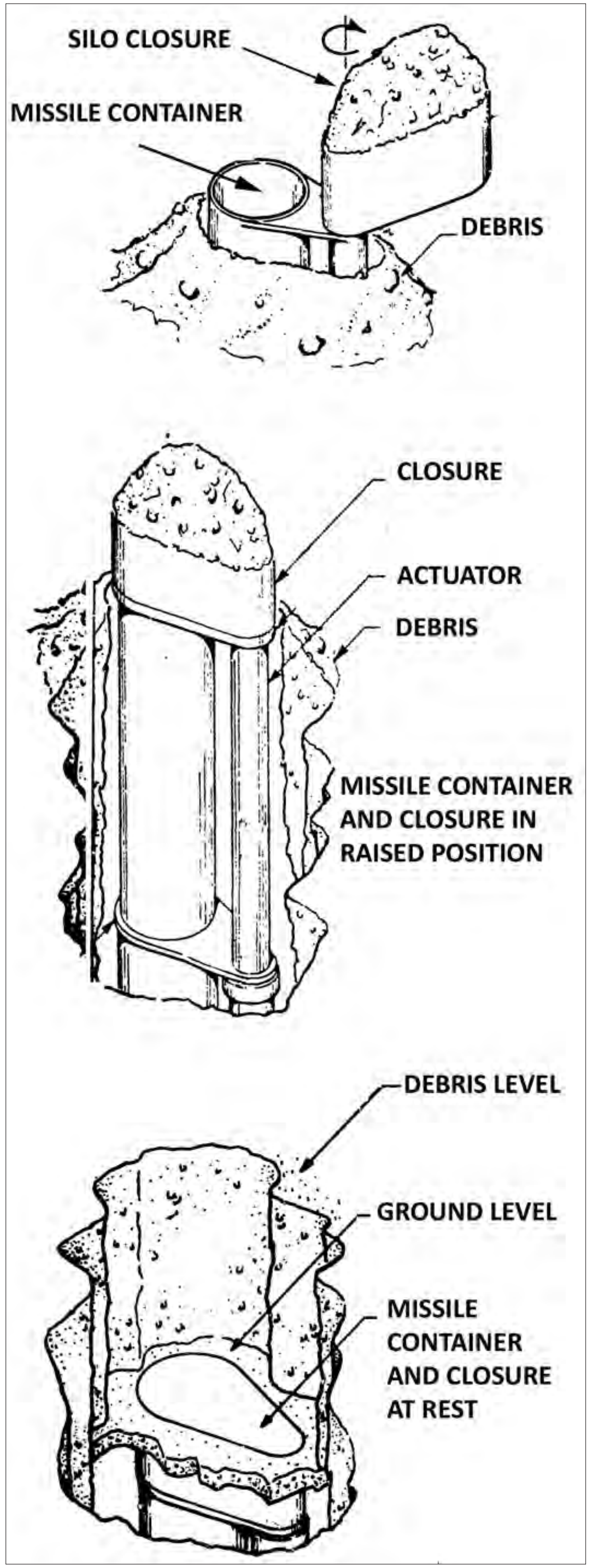


Figure 18 (Above). Side view of an early conceptual design of a HRS configuration. Note that the closure door is flush to the ground plane and there does not appear to be any consideration for debris capture. Minimum thickness of exterior walls of the prototype silo, S01, was 4 feet.

Figure 19 (Right). One of the early conceptual designs of a HRS closure. Lower: the lid is completely flush with the ground surface. Middle: on command, the missile container and actuator shaft would be pushed upward through the debris. Top: the lid then rotated to clear the silo opening. While this matches the conceptual design of Figure 18, it was rated as not feasible due to the bending loads of the cantilevered closure as well as having no provision for clearing the debris from the top of the closure prior to rotation. ***(Courtesy of the Boeing Company.)***



additional analysis and proof testing. (Figures 18, 19) These actions are the following:

1. Make near-surface components non-critical to system performance. In other words, the designer would "write off" near-surface portions of the system in the event of attack (this, of course, leaves the definition of near-surface to future research).
2. Use redundant and dispersed critical near-surface components; i.e., make the attacker use an unacceptable number of weapons to assure a hit on the system.
3. Design critical system components to absorb anticipated relative displacements. This might be accomplished by the inclusion of soft back-packing, rattle space, etc. This option depends on the development of a prediction technique for both near-surface and deeply buried displacement magnitudes.
4. Mitigate both the occurrence and magnitude of relative displacements by using rock reinforcement, such as bolts and grouting. Other schemes, e.g., dewatering or aeration might be effective in saturated rock were dynamic for pressure buildups would lower effective stresses.
5. Employ combinations of options 1-4.[32]

On April 30, 1970, Gen. O. J. Glasser testified before the House of Representatives Subcommittee on Appropriations that $51.2 million had been spent on the Hard Rock Silo program through Fiscal Year 1970. "As a result of the information gained from these and other tests, we are confident we can construct silos to survive the hard rock silo environment, but we are learning that they will be quite expensive."[33] On August 21, 1970, Headquarters USAF announced the termination of the HRS program for Minuteman.[34]

M-X Enters the Picture

The Nixon administration revived the idea of the advanced ICBM. On November 19, 1971, Headquarters Strategic Air Command issued a Required Operational Capability for an advanced ICBM. Four months later, on April 4, 1972, the resurrected AICBM was designated as Missile-X (M-X) .[35] Concomitant with the need for a new missile was the need for a new basing concept.

The STRAT-X report basing modes were re-investigated over the next seven years, encountering strenuous political and environmental opposition as well as funding delays. A summary of the major basing options studies listed 30 possibilities. The selection was narrowed down to land-based concepts and eight reached various levels of development: Midgetman, HRS, covered trench, hybrid trench, Minuteman multiple protective shelter and M-X multiple protective shelter.[36]

On June 12, 1979, Pres. Carter approved M-X full-scale engineering development but did not choose a basing option. Congress moved swiftly and on June 27, 1979 passed a supplemental spending bill funding the development of M-X as well as advocating the choice of Multiple Protective Structure (MPS). This concept involved concealing the actual location of the missiles among a large number of hardened launch points under the assumption that an enemy would not want to expend the large number of missiles necessary to cover all of the possible location. On September 7, 1979, Pres. Carter announced his decision to use the MPS basing mode.[37]

The Reagan administration reviewed the M-X program and on October 1, 1981, Pres. Reagan abandoned MPS in favor of deployment in the existing Minuteman III launch facilities. This MPS costs had risen dramatically and political opposition was even more strenuous. Uncertainty with the overpressure environment in the trench and the detectability of the missile during normal operations promised increased costs:

In the dry deep alluvial valleys under consideration for basing, the surface/vertical shelter design would reduce the effective peak blast loading by as much as a factor of eight and, as a result, the hardness and cost required to survive a given threat. The primary advantage of the horizontal concept was the ability to rapidly move the missile (termed a "dash" capability) between shelters since the trench concept had on-site garages for the various transportation vehicles. With the vertical concept, the transfer vehicle had to pick up the missile at one shelter and unload it at another. As the M-X system evolved, the requirement for a "dash" capability was reevaluated and dropped. With this change in requirements the vertical shelter became the preferred basing mode.[38]

On November 22, 1982, Pres. Reagan officially designated M-X missile as the "Peacekeeper" and announced his decision to deploy the missile in the Closely Spaced Basing (CSB or Dense Pack) which gave rise to the concept of the Superhard Silo. The rationale behind CSB was that the missiles were super hardened in the single Soviet missile could not destroy all of them but would instead cause fratricide of other incoming Soviet reentry vehicles. This assumed one warhead per missile which again meant an inordinate number of missiles would be necessary to destroy the CSB.

With the advent of multiple independently targetable reentry vehicles the argument for CSB was no longer valid.[39] Pres. Reagan, meeting continued opposition to the need for M-X or its deployment in the CSB mode, formed the President's Commission on Strategic Forces on January 3, 1983. Named after its chairman, Brent Scowcroft , the Scowcraft commission was tasked with the review of the strategic weapons modernization programs with particular attention to the future of the ICBM forces and to recommend basing alternatives.

The Scowcroft Commission report was released on April 6, 1983. It endorsed Pres. Reagan's decision to deploy up to 100 M-X missiles in the current Minuteman III launch facilities as an interim measure while the final basing method was determined. The commission members noted that new developments in hardening the Minuteman facilities meant that launch facilities and launch control centers could be hardened to levels much greater than that which had been available just a few years earlier. The commission report also called for specific program or programs to resolve the uncertainties regarding silo or shelter hardness.[40]

Members of Congress were skeptical of his decisions, both the need for M-X and need for such vast deployment areas. Legislation passed in 1985 required a firm basing decision that had to be approved by Congress if there was to be any hope of more than 100 Peacekeeper missiles deployed.[41]

Basing System Concepts

By the time of the Scowcroft Commission, five basing concepts had reached physical modeling stage: continuously hardened buried trench; hardened aim point buried trench; horizontal shelter; vertical shelter; and verifiable horizontal shelter. Each of these had to be evaluated against thermal issues, radiation issues, depth of the ejecta from craters due to surface or subsurface bursts as well as electromagnetic pulse. The horizontal shelter and buried trench concepts were designed to be hardened against 400 to 600 psi overpressure; the vertical shelter silos were designed to withstand 1,000 to 1,500 psi overpressure. Testing was completed by the end of 1981.[42]

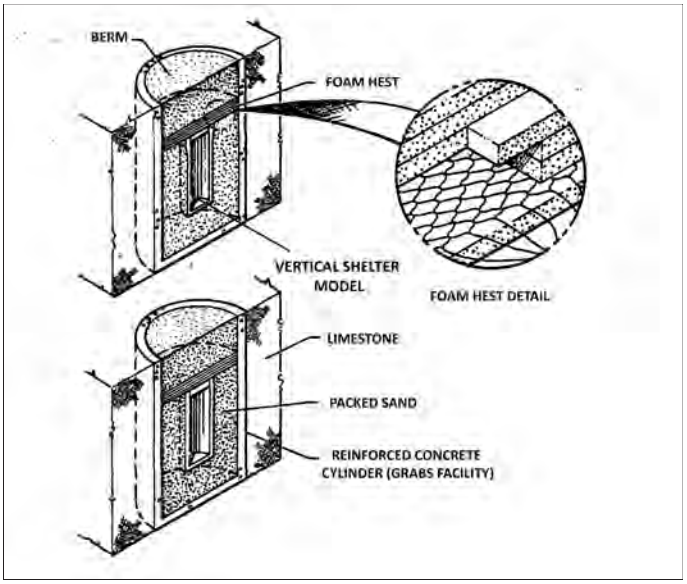


Figure 20. GRABS On Vertical Shelter (GOVS) program evaluated the response of vertical shelter models to vertical airblast and airblast-induced surface-blast loadings.

M-X Basing Modes Hardness Evaluation

Airblast and surfaceblast simulation for the evaluation of M-X basing modes utilized HEST as well as the Giant Reusable Airblast Simulator (GRABS) and Dynamic Airblast Simulator (DBS) as well as the Compact Reusable Airblast Simulator (CRABS).

GRABS

The GRABS facility was located at Kirtland AFB, New Mexico. It consisted of an 18-foot diameter, 50-foot-deep reinforced concrete cylinder emplaced in a massive limestone formation with 1.75-foot-thick walls and base. The cylinder interior was lined with 0.25-inch steel plate.[43] The GRABS On Vertical Shelters (GOVS) test series used the HEST system to achieve a peak overpressure of 12,000 psi, simulating a 3 MT blast within the GRABS test cell. The three 1/6 scale vertical shelter models, one model of configuration A and two models of configuration B reinforced canisters with a removable closure, were evaluated (Figure 20). There were two major findings from this experiment: (1) a vertical shelter should not be placed directly on bedrock and (2) that the headwork structure transition to the launch tube was susceptible to increase flexure. (Figure 21)[44]

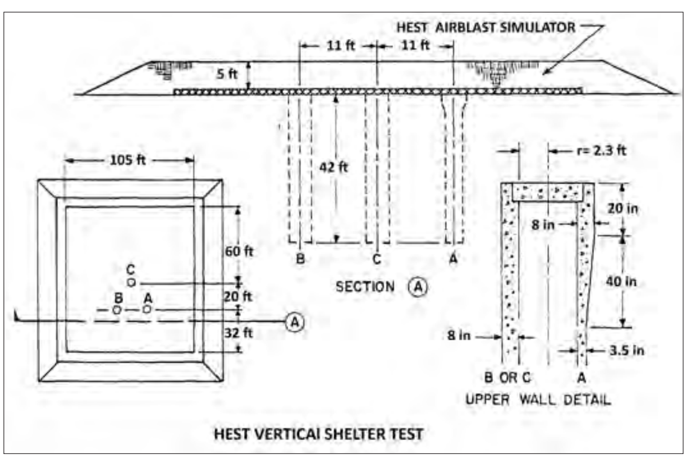


Figure 21. Phase III Vertical Shelter Test (HEST) 1/3 Scale. Three similar models were tested, two designed to respond without significant damage (B and C) and one (A) designed to have major longitudinal compression damage in the launch tube wall. The test was extremely successful and proved not only the value of the mathematical model but also the value of subscale testing.

Dynamic Airblast Simulator

The purpose of the DABS was to simulate the airblast loading that would be developed by a nuclear device at a given range. A typical installation consisted of a tunnel or trench with an arched concrete roof covered with overburden. The high explosive charge was placed at the closed end of the tunnel and as the blast wave traveled down the tunnel subscale vertical shelter closures were exposed to the blast wave (Figure 22.)[45]

Compact Reusable Airblast Simulator

1/30 and1/6 scale vertical shelter experiments were carried out in the CRABS facility at the Stanford Research Institute. It was geometrically similar to the GRABS device but on a much smaller scale.[46]

A comparison of the responses of the 1/30 and 1/6 test showed that the direct loading wave, reflections from the base of the closure, the base and the closure fixture, interface fiction, and soil resistance to punch down while accurately reproduced at 1/30 scale. Concrete surface change measured in the 1/30 scale test in the reinforcing steel strains measured in the 1/6 scale test showed excellent agreement.[47]

HAVE HOST

On April 28, 1977, the first of 12 HAVE HOST vulnerability tests were conducted at Luke AFB, Arizona. Over the next four years, high explosive simulation tests were conducted at Luke AFB, Arizona as well as Kirtland AFB and White Sands Missile Range, New Mexico. These tests included the HEST as well as GRABS, GOVS and DABS.

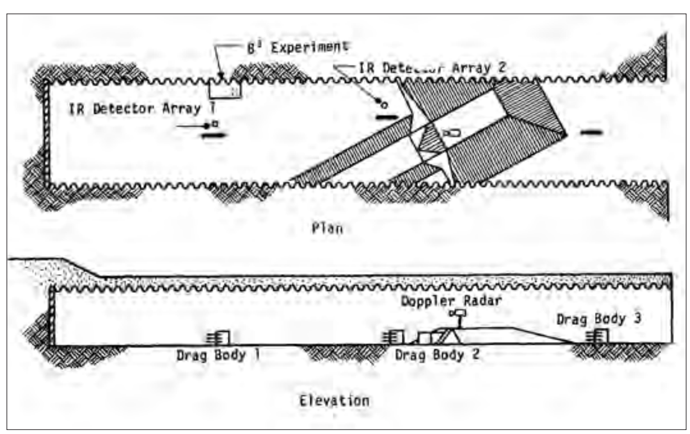


Figure 22. DABS Phase II S3 Event Test Layout.

Extensive modeling, from small-scale 1/100 to 1/40 up to 1/2 to 3/4 models of complete structural systems for the buried trench, horizontal and vertical shelter concepts help further define the designs. These early experiments resulted in increased cost estimates for the various trench concepts. By the early 1980s, the horizontal shelter and buried trench designs were abandoned in favor vertical shelter systems. One year later, the concepts came full circle as the vertical shelter designs had arms limitation complications. Work resumed on a more austere horizontal shelter concept (Figure 23).[48]

On May 23, 1985, the Senate approved the Nunn–Warner Amendment to the Department of Defense Authorization Act of 1986, limiting Peacekeeper deployment to 50 Minuteman III LFs. Four months later, on September 18, 1985, the Senate and House Conference Committee approved the amendment.[49] Peacekeeper LF conversion began on January 3, 1986 at the 400 SMS's LF Quebec-02 at F. E. Warren AFB. Peacekeeper became fully operational on December 30, 1988 with final installation at LF Quebec-10.[50]

Superhard Silos

On May 29, 1969, the Air Force awarded Bechtel Corporation $41.8 million for construction and testing of a superhard underground missile platform built in solid rock.[51] Superhard silos were intended to survive the detonation of a large yield nuclear weapon surface burst within a football length of the launch control center or the launch facility. An improved understanding of nuclear weapons effects indicated that such an idea was conceivable. A superhardened silo would be in the shape of a thermos bottle with exceptionally heavy steel reinforcement coupled with high-strength concrete. The missile-canister shock isolation system of Peacekeeper coupled with an external shock mitigation system of energy absorbing material surrounding the outer walls of the silo completed the design.[52]

A key component was a new form of concrete, slurry-infiltrated fiber concrete (SIFCON), developed by David Lankard at the Lankard Materials Laboratory, Columbus, Ohio. SIFCON has both high-strength as well as ductility not found in typical concrete applications.

Limited funding and time precluded building a HEST or DIHEST environment for testing a full-scale structure. The Air Force Weapons Laboratory utilized the already

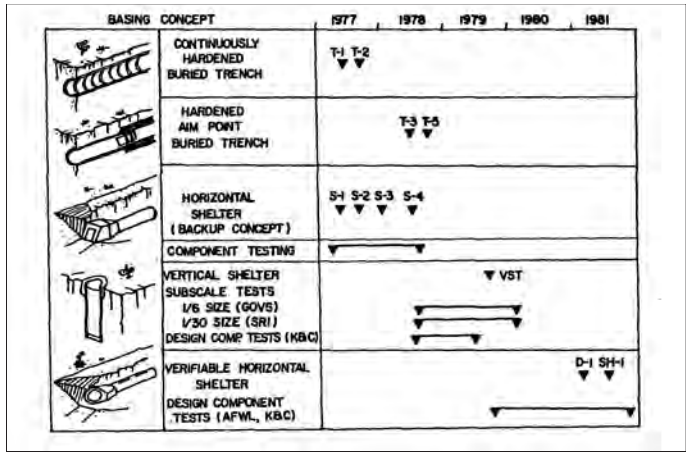


Figure 23. Basing Concept and Test Chronology.

scheduled Intercontinental Ballistic Missile Silo Superhardening Technology Test Program, Fall 1983, at Yuma, Arizona, to evaluate this new concept. The results demonstrated the potential of SIFCON as a key ingredient for hardened structures.[53]

Summary

Concern over the as-built hardness of the Minuteman launch facilities and launch control centers led to the development of the HEST system. Now the Air Force had the ability to simulate the air-blast and the induced ground motion effects of nuclear weapons. In the case of the HEST and DIHEST systems, entire operational facilities could be evaluated. The HEST program revealed substantial deficiencies in the Minuteman facilities, especially at Grand Forks AFB. It was not so much they were built incorrectly; it was more a matter of local geology. The problems were mitigated, to a large extent, by the system-wide Force Modernization program.

The DIHEST program clearly demonstrated that while the hard rock silo concept was "feasible," it would be extremely expensive to implement. Hindsight says this was a reasonably obvious conclusion which has not changed with the passing of half a century. However, at the time, the question of the vulnerability of our land-based strategic forces opened a debate that continued through the deployment of the Peacekeeper system. ■

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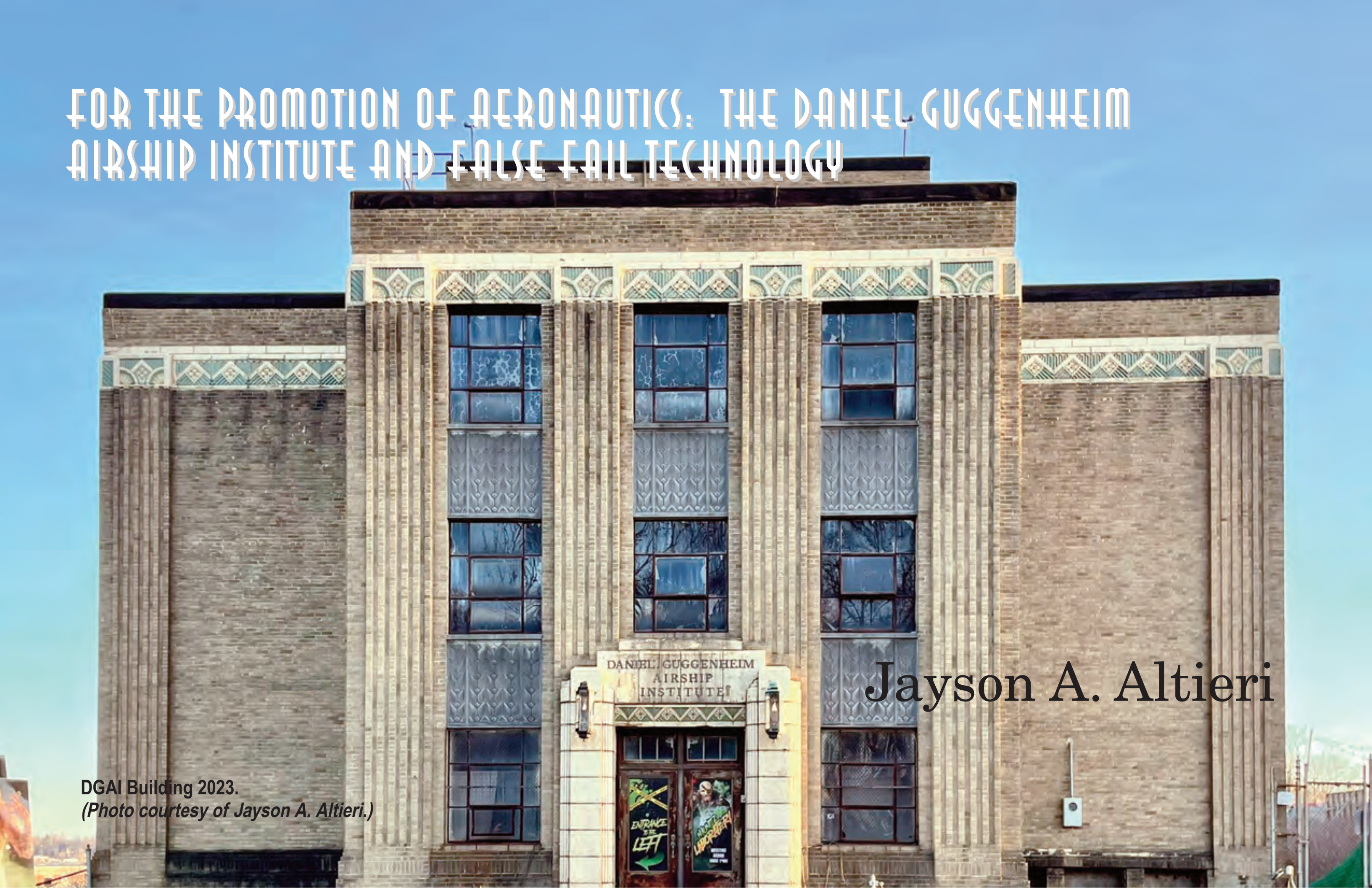
For the Promotion of Aeronautics: The Daniel Guggenheim Airship Institute and False Fail Technology

Jayson A. Altieri



DGAI Building 2023.
(Photo courtesy of Jayson A. Altieri.)

The 20th century saw a transitional bridge from 19th century aeronautical developments like early gliders and lighter-than-air technologies (balloons and early dirigibles) to 21st century technologies including fixed wing, rotary wing, and rockets, which continue to be an integral part of the globe's economic and military foundations. Like today's Silicon Valley "Big Tech" companies serving as centers of excellence (CoE) to help shape artificial intelligence and other cyber technologies, in the first half of the 20th century, similar aeronautical CoE helped shape the emerging field of civilian and military aviation.[1] One such center of excellence was the Daniel Guggenheim Airship Institute (DGAI) operated by The University of Akron from 1932 – 1949. As part of the College of Engineering, the institute provided researchers with opportunities relating to military and civilian lighter-than-air flight, heavier-than-air flight, and meteorology. Opportunities that were created by a need to collectively improve the development and safety of emerging aviation innovations also set the stage for the False Fail of Lighter-than-Air (LTA) technologies in the first half of the 20th century.[2]

U.S. Army Colonel Willilam "Billy" Mitchell clearly outlined in 1925 a need for a CoE (like the DGAI) to develop aviation technologies when he wrote, "The second great requirement [after personnel] in the organizing of air power is the creation of aircraft and equipment for the men that fly them. These [aircraft] must be devised, tried, experimented with, and manufactured in an efficient manner. To blindly follow what another nation does is merely to invite disaster."[3]

Mitchell would also go on to advocate for private business development to help create an innovative aeronautical development environment to avoid, "[the government owned industrial] system [which] stifles initiative on the part of citizens and in many instances…crowded out private and civil factories, increased the cost…and resulted very largely in holding back invention."[4]

One of the first to provide financial and political backing to the ideas espoused by Mitchell was a Philadelphia born mining industrialist with no aviation background – Dainel Guggenheim.

The Guggenheims

Daniel Guggenheim and his son, Harry, connected to a very well-known business and philanthropy family (Manhattan's famous Solomon R. Guggenheim Museum is named after Daniel's brother), contributed significantly to the growth of aviation and aviation technology in the United States.[5] The two functioned as catalysts for a number of significant technological advances that the aviation industry widely adopted and that would prove beneficial to everyone who flies today.[6] They believed they had an obligation to return to society some of the benefits they had reaped, so in 1924, Daniel,

Daniel Guggenheim. ***(Photo courtesy of Wiki Commons.)***

one of eleven children, and his wife Florence established the Daniel and Florence Guggenheim Foundation to promote a variety of charitable and benevolent causes.[7] Daniel's son Harry, born in 1890, was intrigued with flying and served as a pilot during the First World War. Daniel never learned to fly but became interested in aviation for both military and civilian purposes. After the war, Daniel was impressed by the postwar aeronautical work he saw in Europe, and the father-son team decided to put some of the family fortune into furthering aviation in the United States, investing between 1925 and 1930 more than $2.5 million in a series of aviation-related programs.[8]

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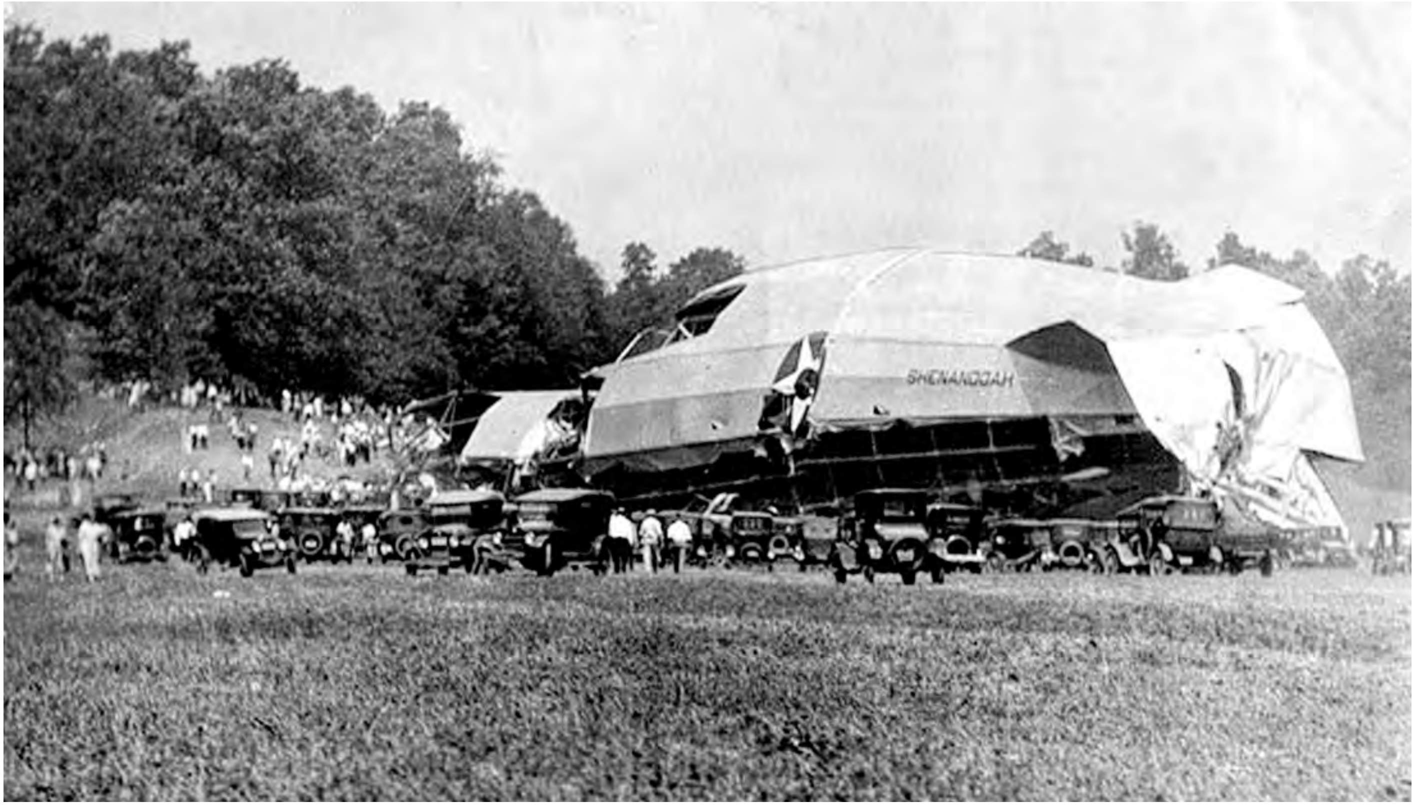
The Daniel Guggenheim Fund for the Promotion of Aeronautics was formally established on June 16, 1926. Its major objectives were aeronautical education, aeronautical research, the development of commercial aircraft and aircraft equipment, and the application of aircraft to a variety of economic and social activities. According to U. S. Centennial of Flight Commission researcher Judy Rumerman,[9]

After World War I, aviation in the United States was in a depressed state. Not only had the surplus of planes from the war eliminated the market for new aircraft, but also most of the American public had little interest in flying, largely because of its risky nature. And it was extremely risky, plagued by accidents and fatalities. But there was no pool of trained aeronautical engineers to improve the design and construction of aircraft. Thus, the Guggenheims set out to establish schools or research centers at universities around the country. They also set about to make air travel safer by using their funds to pay directly for aviation research. This research led to the development of more reliable aircraft engines and instruments, and eventually, public acceptance of aviation as a safe and fast method of transportation.

The Guggenheim's educational activities began in 1925 with a grant for the founding of a school of aeronautical engineering at New York University.[10] Over the next four years, Guggenheim schools or research centers were established at the California Institute of Technology, Stanford University, the University of Michigan, the Massachusetts Institute of Technology, the University of Washington, Georgia School (later Institute) of Technology, Harvard University, Syracuse University, Northwestern University, and the University of Akron.[11] The Guggenheims even recruited the noted aerodynamicist Theodore von Kármán to emigrate to the United States to head the Guggenheim Aeronautical Laboratory at the California Institute of Technology (CIT).[12] Among the projects in the 1920s sponsored by the Guggenheim fund were: Blind-flying and radio navigation research, a "Model Airway" between San Francisco and Los Angeles operated by Western Air Express (which eventually became part of Delta Airlines); a Safe Aircraft Competition with an award for the safest aircraft that could be built at the time; and a special weather reporting service along the "Model Airway" route that all pilots could use.[13] It was during this era of improving aviation technology, both in heavier-than-air and LTA, that the DGAI was created.

The Institute

The University of Akron operated the DGAI from 1932-1949. As part of the College of Engineering, the Institute provided students with research opportunities relating to LTA flight, heavier-than-air flight, and meteorology.[14] Dr. George F. Zook, president of The University of Akron, working with Jerome C. Hunsaker, an American naval officer and aeronautical engineer, thought the Institute should be dedicated to a specialized field of aeronautical engineering that would simultaneously benefit the Akron airship indus-



U.S.S. Shenandoah Crash. ***(Photo courtesy of Wiki Commons.)***

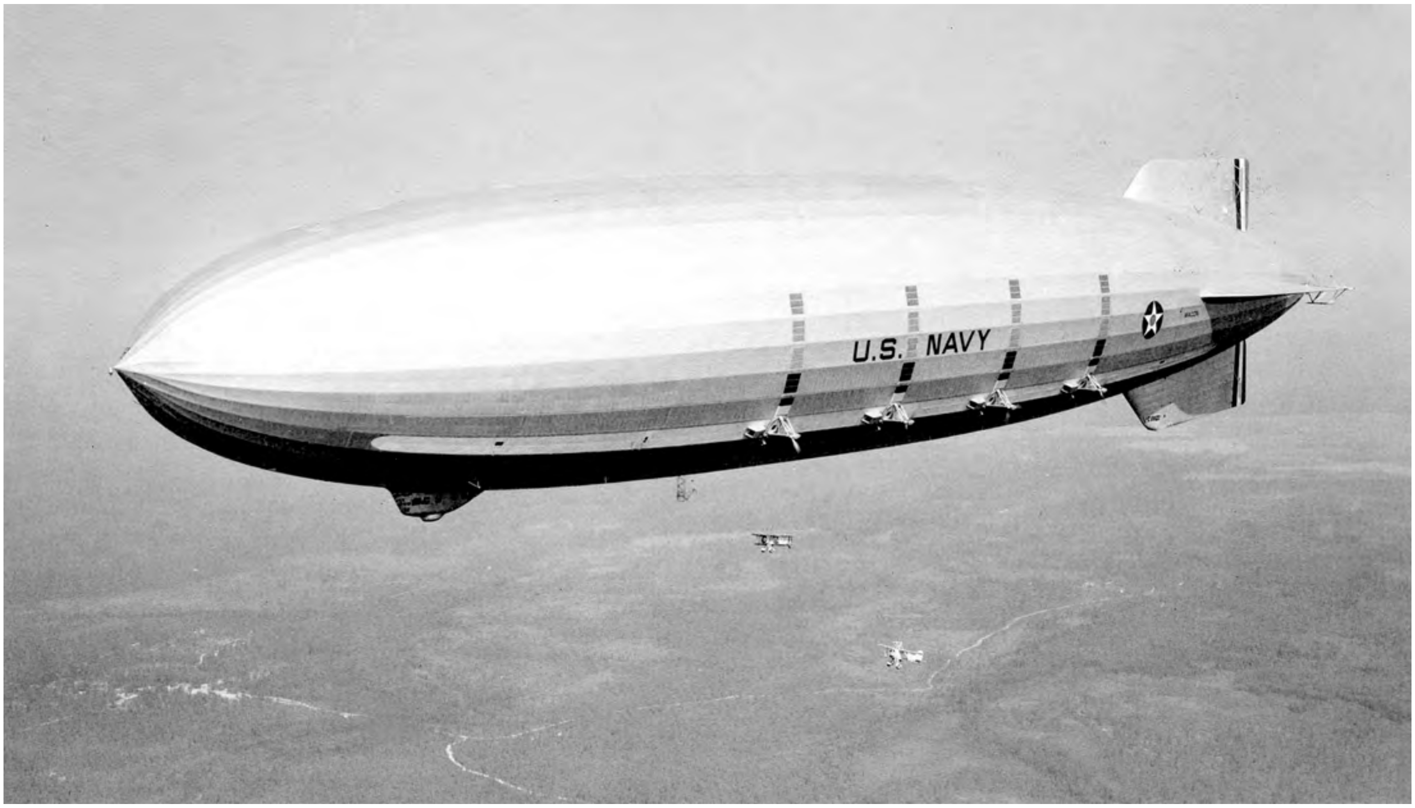
try and be of interest to post-graduate engineering students.[15] As early as October 28, 1926, Dr. Zook began the formal process of requesting funds in the amount of $250,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics for construction of the Institute.[16]

Dr. Zook foresaw a need for such an institute because of the inefficient approach employed by the U.S. Navy to solve research and development problems and address very public operational mishaps like the Zeppelin Rigid -1 (*ZR-1)* (*USS Shenandoah*) and *ZR-2* (*R-38*) airship disasters. Until that time, the Navy had relied on various independent government agencies such as the Weather Bureau, the Bureau of Mines, and the National Advisory Committee for Aeronautics to solve its research and design challenges.[17] Dr. Zook envisioned that the Institute would bring the specialized equipment and knowledge possessed by these diverse organizations together in the interest of safety and standardization. Dr. Zook reasoned that the Institute should be in Akron because the city was home to the Goodyear Zeppelin Corporation and the municipal airport was the "center of airship activity in the United States."[18] Ultimately, the potential for cooperation with Goodyear was a major factor in the decision to place the Institute in Akron. Dr. Karl Arnstein, the Chief Engineer of Goodyear Zeppelin, went on to serve as a consultant for the research staff at the Institute.[19]

On October 19, 1929, an agreement concerning the construction and operation of the DGAI was made between The University of Akron, CIT, and the Daniel Guggenheim Fund for the Promotion of Aeronautics.[20] Under the agreement, costs of the construction, equipage, and maintenance of the facility were to be split between the Guggenheim Fund and the City of Akron. CIT was to pay the salaries of a director (Dr. Theodore van Kármán), and an Akron-Resident Director (Dr. Theodore Troller), as well as fund five fellowship positions.[21] CIT agreed to oversee the Institute for five years, and it formally handed over control of the Institute to The University of Akron on February 18, 1935.[22]

Construction of the Institute on the Akron Municipal Airport grounds took place during the winter of 1931-1932 and when completed, the new *Art Deco* style building with an ornate colored fresco of a winged Icarus in pilot attire cradling an airship overlooking the airport, was four-sto-

DGAI Building Fresco 2023. ***(Photo courtesy of Jayson A. Altieri.)***



U.S.S. *Macon. (Photo courtesy of Wiki Commons.)*

ries tall and 75-square-feet. The Institute boasted a C-shaped vertical wind tunnel, then the largest in existence, and a 52-foot-high meteorological tower on its roof.[23] The vertical wind tunnel was the crown jewel of the Institute as it was designed to cancel out lift as a variable by hanging airship models vertically, permitting more accurate measurements of drag and turbulence, both major concerns for large rigid airships.[24] Meteorological observations were also conducted in cooperation with Goodyear Zeppelin and the U.S. Weather Bureau. A whirling arm (an older type of aeronautical research device that fell out of favor with the improved development of wind tunnels) was added to the complex prior to 1934.[25] The whirling arm was used to conduct experiments on how airships behaved in curved flight.[26] A small wind tunnel placed within the test circuit simulated the upward wind gusts that aircraft would experience as turbulence.[27]

The dedication of the DGAI took place on June 26, 1932, with representatives from the national aeronautical community, local business leaders, and government officials present for the ceremony. Among those invited to the dedication, but unable to attend were First World War German Zeppelin *LuftSchiff 71* Commander, Koverttekapitan Martin Dietrich and Chief of the Navy's Bureau of Aeronautics, Admiral William A. Moffitt, the latter who wrote in his R.s.v.p., "You are correct in estimating my especial interest in Lighter-than-aircraft, and also in this Institute, to which I look for great results in its field."[28] The speakers for the dedication ceremony included Hunsaker, who read a letter from Harry F. Guggenheim, who was unable to attend; City of Akron Mayor C. Nelson Sparks; Akron University President Dr. Zook; and Chairman of the Executive Council of the CIT, Dr. R. A. Millikan.[29] Among the guests present for the two-day event were Chairman of the Firestone Tire and Rubber Company, Harvey S. Firestone, and Chief of the U.S. Army's Material Division's Lighter-than-Air Branch, Major William E. Kepner (later a U.S. Air Force Lieutenant General).[30] The dedication day also included a tour of the Goodyear-Zeppelin plant and hangar where the *Akron* class *Zeppelin Rigid Scout-5* (*ZRS-5*) (*U.S.S. Macon*) airship was under construction, as well as a one-day conference at the local Mayflower Hotel focusing on lighter-than-aircraft research.

The equipment housed at the Institute soon found applications outside the field of airship testing. The centrifuge was used to evaluate aircraft models, and the wind tunnel was used to ascertain how various building designs/materials and parachutes faired in strong winds. However, the local airship industry would eventually suffer from the effects of the *ZRS-4* (*U.S.S. Akron*) and *U.S.S. Macon* accidents that destroyed both airships and, in the absence of extensive rigid LTA funding, was sustaining itself on the revenue generated through conducting mostly non-rigid airship experiments for the U.S. Navy and various industrial tests. Due to the Second World War improvements, both in airplane designs and powerplants, the LTA industry never developed militarily or commercially to the extent that proponents originally expected. Despite the downturns in the economic viability of LTA technologies, during the 1930's and 40's, the Institute attempted to remained relevant by conducting a broad range of aeronautical research involving LTA flight controls, radio guided munitions, and rotorcraft programs.

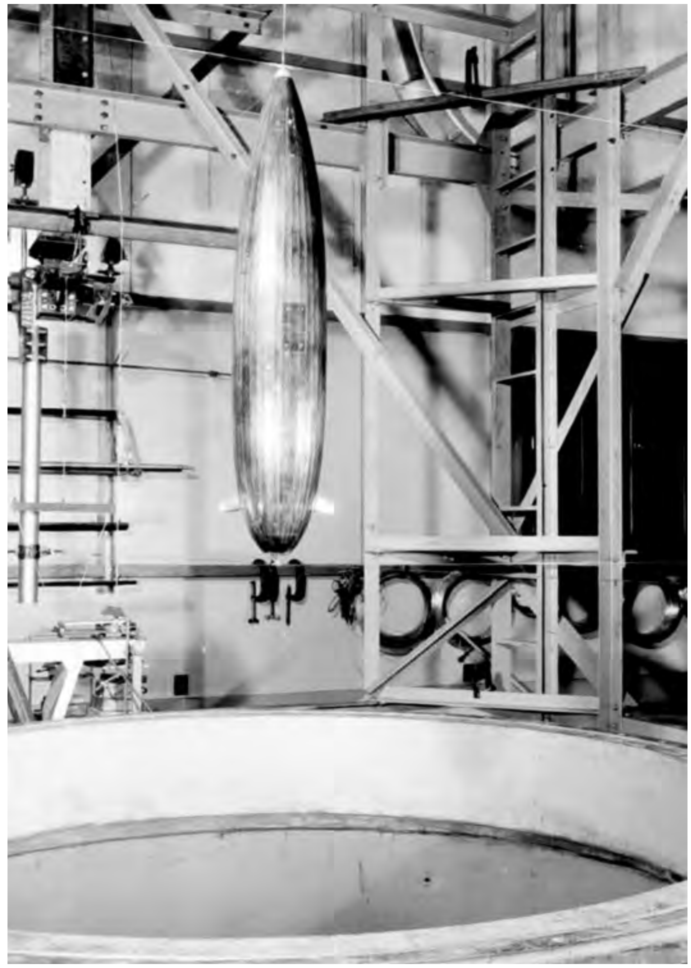
Goodyear-Zeppelin Bow Elevators

The United States (US) military's LTA program had its beginning during the American Civil War when the U.S. Army contracted Dr. Thaddeus Lowe to employ tethered hydrogen balloons to provide real time intelligence on Confederate troop movements. The Army continued to use balloons sporadically for the rest of the 19th century including the Spanish-American War. By the 1900's, military balloons, both tethered and un-tethered were used for observation, training, and played an integral part in artillery spotting during the First World War. In 1908, the first US military airship was the Army's *Signal Corps-1* (*SC-1*), a small non-rigid airship that was used for testing until 1912. The U.S. Navy's first airship, the Connecticut Aircraft Company's *Dirigible Navy-1* (*DN-1)* based on a German Parseval design, was built in 1917. The *DN-1's* first flight at Pensacola Navy base was so overweight, the airship's gondola sank in the waters of Pensacola Bay.[31] As neither the Army or Navy had a great deal of experience with LTAs, the services relied heavily on British and French non-rigid designs both during and just after the First World War until American LTA companies like Goodyear began producing homegrown non-rigid designs.

The first semi-rigid and rigid airships used by the US military included the Italian built *Model T-34* (*Roma*) and the British built *R-38*, both which used Hydrogen as a lifting gas and crashed with significant loss of life. The results of these two mishaps resulted in changes in airship designs including the use of Helium on all future US military airships. It was the loss of the *Roma* (crashed when the controls failed in flight) and *U.S.S. Shenandoah* (lost in a thunderstorm) that precipitated the founding of the DGAI. Subsequent US airships, (with the exception for the German built *LZ-126* (*U.S.S. Los Angeles*)), the *U.S.S. Akron*, and *U.S.S. Macon*, were lost in storms that highlighted the design flaws in American made airships. One shortcoming, identified by H. R. Liebert, Manager of Projects Department, Goodyear-Zeppelin Corporation, was stability and controllability, [32]

Stability and controllability are very extensive problems… certain problems which are still not very completely solved [by 1932], and which should be the subject of further investigation. Stability can be divided into three parts: Stability in straight or directional flight, stability at large angles of attack in pitch flight, and combined stability and controllability, controllability during maneuvers…A ship can be made stable if ideal weather conditions exist. Under other conditions it is not desirable to have the ship quite so dynamically stable.

The 1930 British *R-101* airship crash in France, with the loss of forty-seven lives including Lord Christopher Thomson, Secretary of State for Air, along with the US airships *Roma* and *U.S.S. Shenandoah* mishaps, highlighted the need to build better rigid airship control designs.[33] Liebert would go on to write of this crash,[34]



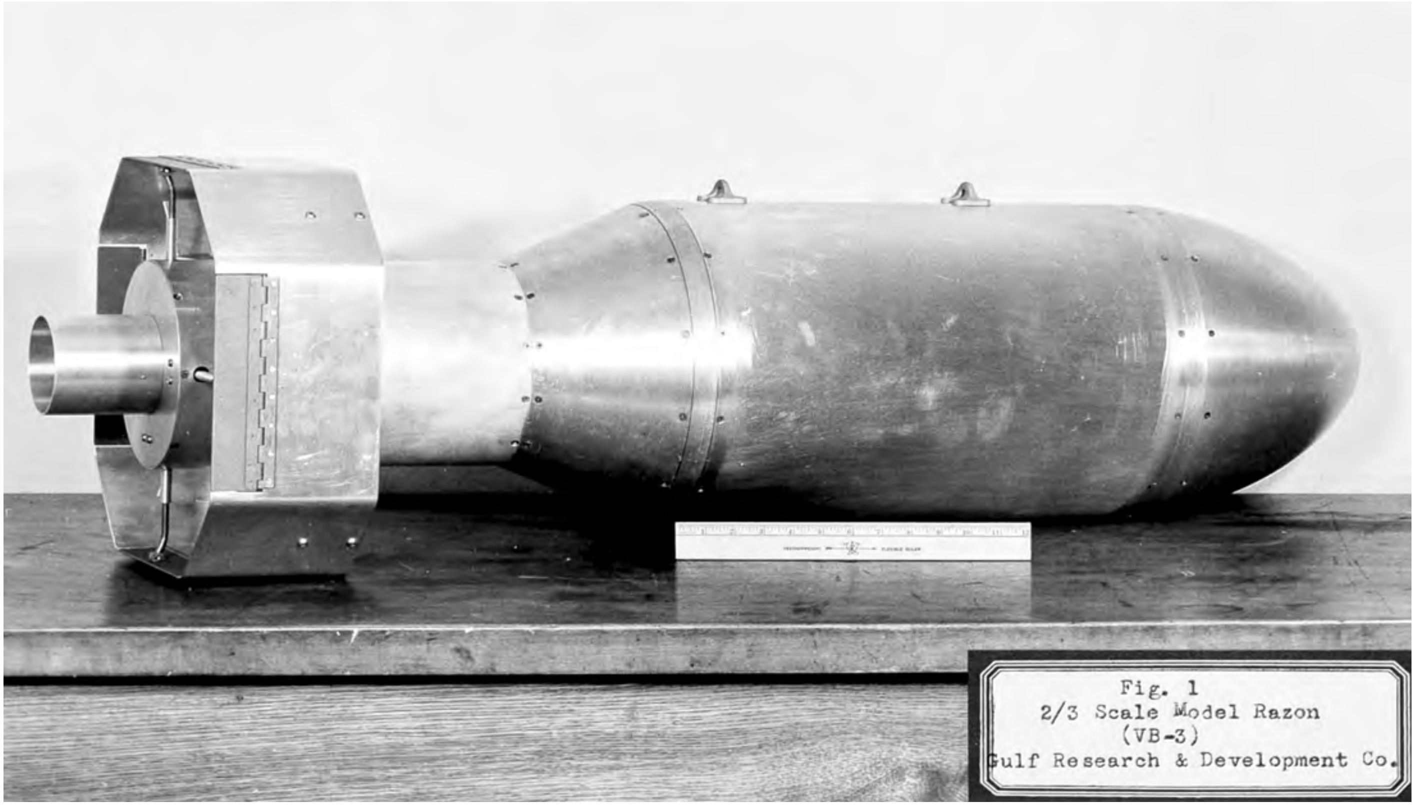
DGAI Airship Bow Fin Test. ***(Photo courtesy of University of Akron.)***

the R-101 [accident] might possibly be regarded as a case where an [airship] became unstable and uncontrollable when operated in this condition [when attempting to fly at high-angles of attack]. When an airship is nose heavy, the elevator operator is not always fully aware of the general heaviness of his ship, and if such cases are to be met, a large margin of controllability must be provided.

It was this problem that the newly established DGAI began conducting research on improving the safety of airships.

In 1934, the DGAI conducted research on the possibility of using bow elevators to help improve the stability of airships in the same way that submarines use diving planes (also known as hydroplanes) which allows the vessel to pitch its bow and stern up or down to assist in the process of submerging or surfacing the boat, as well as controlling depth when submerged. As airship and submarines both operate in a fluid dynamic, and as the latter use of bow fins to help improve control and stability, the theory was the same principle could be applied to the former.[35]

The result of these tests, conducted in the DGAI vertical wind tunnel, was summarized in a report entitled *Wind Tunnel Tests on G-Z Airship Model 6R0123 with Bow Elevators*. According to the report, written by F. D. Knoblock,[36]



DGAI Razon Bomb Wind Tunnel Test Model. ***(Photo courtesy of University of Akron.)***

An investigation of pitching moments on an airship produced by the use of bow elevators, was carried out by model test in the vertical wind tunnel of the Daniel Gugenheim Airship Institute for the Goodyear-Zeppelin Corporation… [Bow] Elevators of only type used to determine such facts as: the sensitiveness of their [the bow elevators] longitudinal location on the hull, the merits of various arrangements around the hull…the advantage of using four elevators instead of two, and the effect of the downwash from the bow elevators upon the rear fins and therefore on the pitching moments.

The bow elevator tested, using a wooden airship model (similar in shape to the *Akron* class) provided by the Goodyear-Zeppelin Corporation with fixed metal bow elevators, was suspended with wires over the vertical wind tunnel, demonstrated that the bow elevator would give an airship greater stability over the normal two elevator configuration used by airships of the period.[37] The addition of the two elevators did increase drag considerably as soon as the elevator deflection exceeded 80 degrees, which was to be expected during the test.

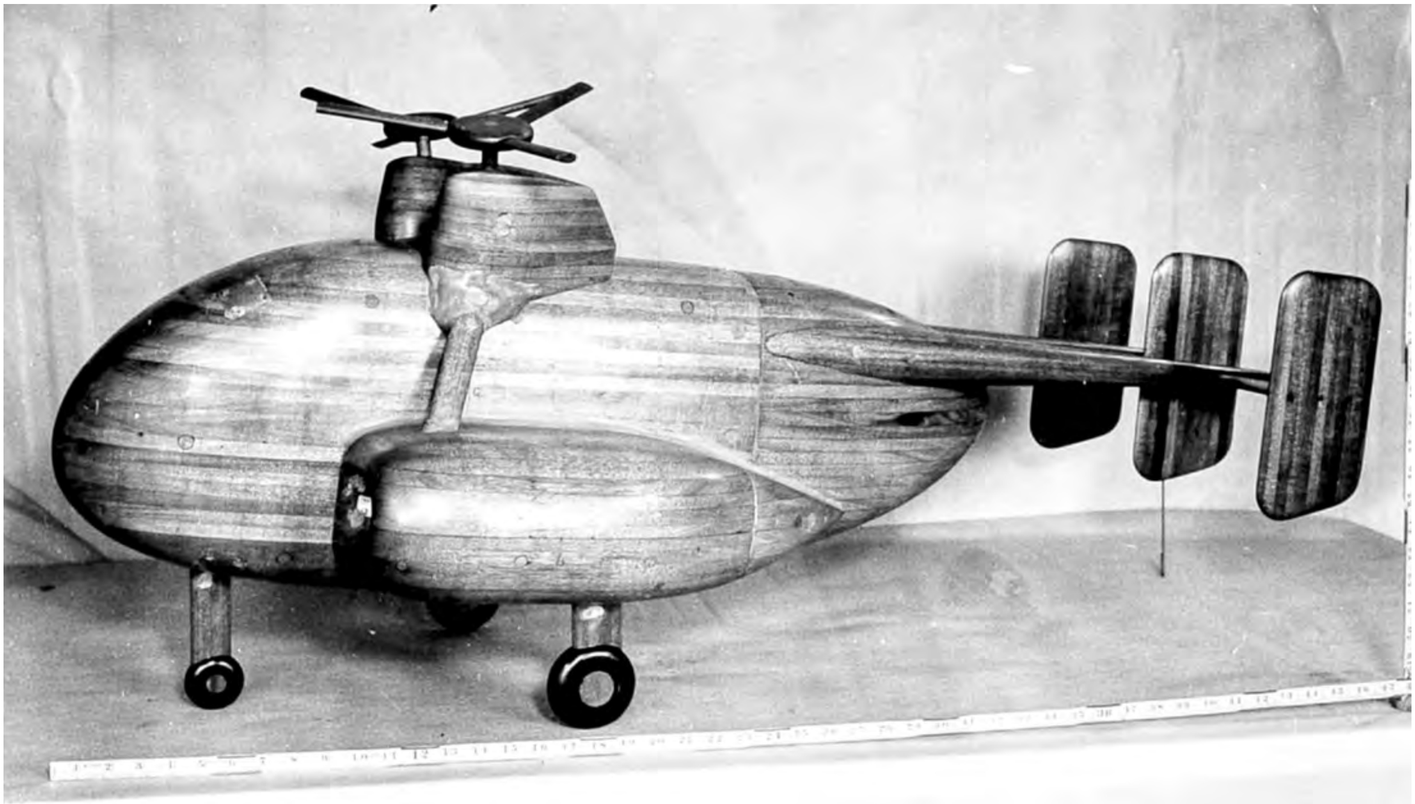
Bow elevators were not adopted by the Goodyear-Zeppelin Corporation in their rigid *ZRCV* (*CV* was the U.S. Navy abbreviation for aircraft carriers) design or the series of U.S. Navy non-rigid airships built during the Second World and Cold Wars.[38] None-the-less, forward mounted combined bow elevators and adjustable ducted propellers, are becoming the norm on 21st century airships like the Hybrid Air Vehicles' *Airlander 10*, Goodyear-Zeppelin's *Zeppelin New Technology LZ N07-101* (*Wingfoot One*) and Lockheed Martin's *P-791*, demonstrating that time spent testing bow elevators at the DGAI had value, albeit 90-years later.

Razon Bombs

The Second World War provide the DGAI with new opportunities to employ their unique abilities to test the *Range and Azimuth (Razon) Vertical Bomb-3 (VB-3)* glide bombs for use by the US Army Air Forces. The VB-3 was a standard 1,000-pound general purpose bomb fitted with flight control surfaces. Development of the Razon began in 1942, but it did not see use during the Second World War.[39] The *Razon* weapons systems tests were conducted in 1944 by the Pennsylvania based Gulf Research and Development Company (then a subsidiary of the Gulf Oil Corporation) at DGAI.[40]

Imperial Germany first experimented with glide bombs on Zeppelins and multi-engine R-bombers during the First World War, but the Armistice ended the project.[41] During the Second World War, Germany did successfully develop glide bombs like the Ruhrstahl *SD 1400* (*Fritz-X*), which were employed operationally against Allied warships and convoys. Both the United Kingdom (UK) and US began developing glide bombs as early at 1939. By 1942, the UK ended their program while the US eventually developed the auto-pilot equipped Aeronca *GB-1*, which was used operationally in 1944 against military targets in Cologne, Germany.[42]

In April 1942, the USAAF's Materiel Command (which became the Air Technical Service Command (ATSC) in



Kellett XR-10 Wind Tunnel Test Model. ***(Photo courtesy of Wiki Commons.)***

1944) began developing television and radio controlled models like the *Azimuth* (*Azon*) family of guided bombs.[43] The initial variant, designated *VB-1*, was based on a standard 1000-pound bomb (initially the *Munitions 44* series, but later models apparently switched to the standard *Army Navy – Munition 65* series which was modified with a new tail unit.[44] The latter consisted of a gyroscopic unit to prevent the bomb from rolling, a flare for optical tracking, an octagonal shroud with control surfaces, and a radio-command receiver.[45] When a *VB-1* was dropped, the bombardier could track it through his bombsight and use a joystick-type control to send corrective commands to the bomb.[46] The *Azon* guidance system allowed only lateral course corrections, but errors in range could not be corrected.[47]

The ATSC also developed a more advanced variant of the *Azon* called *Razon*, which the operator could control both range and azimuth. The designations *VB-3* and *VB-4* were assigned to the 1000-pound and 2000-pound *Razon* versions, respectively.[48] The *Razon* guidance kit had two octagonal shrouds in a tandem arrangement. The most problematic part in *Razon* development was to build a suitably modified bombsight, which would allow the bombardier to correctly judge the bomb's deviation in range so that the range control could be used effectively.[49] The Razon also had an improved radio-command link with forty-seven separate channels, effectively eliminating the Azon's problems with concurrent drops by a multitude of bombers.[50]

Gulf Research and Development Company's VB-3 research at the DGAI was designed to test the side force, drag, and yawing moments on a two-thirds scale model.[51] The VB-3 model tests were run in the DGAI vertical wind tunnel, utilizing test standards from previous wind tunnel models.[52] The VB-3 test results, published in a confidential report written by Robert S. Ross, focused on the variations of drag on the bomb with changes in the VB-3's rudder angles and comparisons of shrouded and non-shrouded VB-3s control surfaces, the latter which gave far greater control than a non-shrouded surface.

These DGAI tests ultimately allowed the *VB-3* and *VB-4* to be combat-ready in summer 1945, and about three thousand *Razons* were subsequently produced, but none of them were used before the Second World War ended.[53] However, the *VB-3* was operationally evaluated five years later during the first months of the Korean War. The US Air Force's 19th Bomb Group B-29s dropped four hundred and eighty-nine *Razons* during the Korean War, the first in August 1950.[54] *Razons* were not ideal weapons. For instance, a single warhead was usually not big enough to destroy a bridge (it took on average four *Razon* hits to do so).[55] Also, about one-third of those dropped did not respond to radio control. Despite these difficulties, *B-29* bombardiers destroyed fifteen bridges with *Razon* bombs, thanks in part to the work done at the DGAI.[56]

Kellett *XR–10* Helicopters

One of the 20th century's greatest aeronautical innovations, one that help displace the utility of airships for commercial and military purposes, was the development of helicopters. While the idea of the rotor craft dates to Da Vinci, practical helicopter design only began to materialize

Kellett XR-10 Helicopter. ***(Photo courtesy of Wiki Commons.)***

K-Max Helicopter. ***(Photo courtesy of Wiki Commons.)***

in the second half of the 19th century with separate designs from Frenchmen Launoy and Bienvenu and Englishman Sir George Cayley. By the early 20th century, only with the development of high-performing, light-weight gasoline powered engines, did both airplanes and helicopters become viable. During and after the First World War, rotorcraft of various autogiro and helicopter designs garnered attention from the Austrian, French, German, Soviet Union, UK, and US militaries. One rotorcraft manufacturing company was the Kellett Autogiro Company of Philadelphia, Pennsylvania, was formed in 1929 by W. Wallace Kellett, Rodney Kellett, C. Townsend Ludington, and Nicholas Ludington, using tested autogiro designs licensed from the Pitcairn Aircraft Company.

Throughout the 1930s and early 1940's, the Kellett company built a series of autogiros that were tested by both the US Army and Japanese War Office for the short take-off and landing capabilities and one, a *K-3* with a Kinner *C-5* engine, was used by Admiral Richard E. Byrd's 1933—34 Antarctic expedition.[57] In 1942, Kellett realizing that the U.S. Army favored the Sikorsky *VS-300* helicopter design over autogiros which could not hover or take-off and land vertically, proposed to the U.S. Army Air Forces an intermeshing helicopter design that eliminated the need for a tail rotor for yaw control.[58] Kellet's inspiration came from German helicopter designer Anton Flettner, who built the world's first intermeshing helicopters (or synchropters), the *Fl 265* prototype and the *Fl 282 Kolibri* (*Hummingbird*) reconnaissance helicopter.[59] The Army Air Force approved Kellett's proposal on January 7, 1943, and on September 11 of that year issued a contract for Kellett to build two prototypes, one with three-bladed rotors designated the *XR–8* and another with two-bladed rotors the *XR–8A*.[60]

The Kallet *XR–8* helicopters were egg-shaped in appearance, with the two rotors separated by only 12-1⁄2 inches, leading those who saw it to nickname it the "Eggbeater".[61] The non-rigid rotors were made of plywood with steel tubes inside, much like the fuselage's tubular-steel construction, which was then covered in fabric and sheet metal.[62] The *XR–8* was powered by a Franklin *O-405* 6-cylinder inline 245 horsepower engine.[63] By January 23, 1946, the *XR–8* was finally accepted for official flight testing with the U.S. Army.[64] However, almost immediately after it was submitted for evaluation, the Army Air Force canceled the *XR–8* program due mechanical difficulties that plagued the program and would ensure that the *XR–8* would remain only a testbed.[65] Never-the-less, Kellett's design had successfully demonstrated the flight capabilities of a synchropter and led to a larger synchropter design, the *XH-10*, that would also eventually never leave the prototype stage.

The *XR–10* was designed in response to a published requirement by the US military for a transport helicopter that could move passengers, cargo and wounded within an enclosed fuselage.[66] It was the *XR–10* design that was assessed at the DGAI by the Kellett Aircraft Corporation engineers in early 1945. The *XR–10* tests used three wooden models with different tail configurations for the protype that included either a short tail boom, long tail boom, or twin boom configurations with various dorsal and either two and three fin attachments.[67] The purposed *XR–10* wind tunnel tests, according the DAGI test engineers Robert S. Ross and Robert R. Ruggles, was to,[68]

[Conduct a] series of wind tunnel force tests made on the XR–10 Helicopter Model in order to determine the relative effectiveness of various component parts and tail designs. These tests were made for the Kellett Aircraft Corporation in the 6'6" vertical wind tunnel of the Daniel Guggenheim Airship Institute. The forces measured were lift, drag, side force, pitching moment, rolling moment, and yawing moment. All force tests were made at approximately one hundred miles per hour.

Besides the force tests on the models, visual flow pictures and movies were taken of various *XR–10* models fitted with rows of short (cloth) tufts while the tests were run at a wind tunnel velocity of sixty-five miles per hour.[69] The test results were generally positive, identifying design flaws in the different tail boom prototypes and by 1947 the first flight of the Kellett *XR–10* with a triple tail fin configuration was made North Wales, Pennsylvania.

When the *XR–10* took flight, it was the largest and most powerful rotorcraft to ever fly in the United States at the time.[70] However, the *XR–10* robust design was not enough to overcome the challenges of control instability during high winds, rotors blades colliding in flight, and being underpowered due to the limitations of the twin 525 hp Continental *R-975-15* engines.[71] These problems were never satisfactorily resolved and although two prototypes were built, after the first prototype had a control failure crash in 1949 killing Kellett's chief test pilot, Dave Driskill, the Air Force abandoned the project.[72]

Kellett's *XR–8* and *XR–10* helicopters were not a commercial success, but they were engineering marvels, and the work done by the DGAI on the *XR–10* design would indirectly influence later 20th century synchropters.[73] Helicopters like the Kaman *HH-43 Huskie* used by the Air Force, Marine Corps, and Navy during the Vietnam War for firefighting and rescue close to airbases and later Kaman's *K-MAX* manned and unmanned synchropters used both commercially and militarily still to this day utilized many of the design features found on the Kellett *XR–10*.[74]

DGAI Original Logo Design. ***(Photo courtesy of University of Akron.)***

False Fail Technology

For seventeen years the DGAI provided a diversity of technical and academic support to the greater aviation development community, with projects ranging from airships, radio guided bombs, and helicopters.[75] And although the institute was born in the heyday of airship travel, like the technology it was designed to benefit, neither would prosper in the post Second World War aviation environment. Quite simply LTAs, in the mid-20th century, had become a False Fail technology not unlike the early 21st century's BlackBerry PDA-style cell phones.[76] By the mid 1940's, while airships (especially non-rigid designs) were shown to be both practical, reliable, and safe, their utility value had been surpassed by the development of long-range transport and bomber aircraft, helicopters, and radar. In 1949, the DGAI facility was no longer generating enough research revenue to sustain itself when competing against more modern facilities created during the Second World War's Allied technology race against the Axis.[77] A January 10, 1949, letter written by Jerome C. Hunsaker, then at the Massachusetts Institute of Technology's Department of Aeronautical Engineering, to P. W. Litchfield, Goodyear Tire and Rubber Company, outlined in blunt terms the DGAIs future,[78]

We spoke of the Guggenheim Institute at Akron University. This is to confirm my somewhat hurried advice to the effect that, in my opinion:

(a) The Institute has outlived its usefulness, its equipment is no longer important, and its staff is not needed.

(b) The National Advisory Committee for Aeronautics [(NACA)] would not be interested in the whirling air, water channel, or wind tunnel for its own research. I doubt that the Air Force or Navy have problems which need this equipment.

(c) Goodyear Aircraft has access to expert staff and modern equipment for special problems at M.I.T. and NACA (Cleveland and Langley).

In conclusion, I suggest that we let Akron University dispose of this facility as they may wish.

Finally, per university president Hezzelton E. Simmons' recommendation to the Akron University Board of Directors, on June 30, 1949, the DGAI formally closed its doors on July 1, 1949, and the remaining twenty-four employees moved on to other opportunities or retired and the Institute's library and machinery were transferred to the University of Akron main campus.[79] What little remains of the DGAI and its founders visions of safe and efficient LTA travel can be found in the papers, photographs, and technical reports located in the files stored in the basement of the old Polsky department store building, where the University of Akron's Archival Services are located. As for the DGAI building itself, opened with great fanfare in 1932, like the memories of the great airships of another era, the empty, graffiti, and weed covered structure and elegant façade have faded, now only occasionally used as a Halloween haunted house for kids. ■

NOTES

1. A center of excellence is a team of skilled knowledge workers whose mission is to provide the organization they work for with best practices around a particular area of interest. The concept of creating special-interest groups for thought leadership originated in lean manufacturing which focuses on minimizing waste. "Center of Excellence (CoE)," *TechTarget: WhatIs?* 2018. https://www.techtarget.com/whatis/definition/center-of-excellence-CoE#:~:text=A%20center%20of%20excellence%20%28CoE%29%20is%20a%20team,best%20practices%20around%20a%20particular%20area%20of%20interest. (accessed March 30, 2024).
2. False Fail, which means there may be no defect and the system may be working as expected. Ruchika Gupta, "Test Automation Challenges – False Failures," *Webomates*, July 16, 2021. https://www.webomates.com/blog/automation-testing/the-bane-of-automation-false-failures/ (accessed March 30, 2024).
3. William Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power Economic and Military*. (NYC: G. P. Putman's Sons, 1925), 181.
4. William Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power Economic and Military,* 193.
5. Judy Rumerman, "Daniel and Harry Guggenheim – Supporters of Aviation Technology," *U.S. Centennial of Flight Commission*. https://www.centennialofflight.net/essay/Evolution_of_Technology/guggenheim/Tech3.htm (accessed March 20, 2024.
6. *Ibid*.
7. *Ibid*.
8 *Bulletin of The Daniel Guggenheim Fund for the Promotion of Aeronautics, Inc, No 1.* (NYC: the Daniel Guggenheim Fund for the Promotion of Aeronautics, August 14, 1926), 1, The University of Akron Archival Services.
9. Judy Rumerman, "Daniel and Harry Guggenheim – Supporters of Aviation Technology," *U.S. Centennial of Flight Commission*.
10. *Bulletin of The Daniel Guggenheim Fund for the Promotion of Aeronautics, Inc, No 1,* 1, The University of Akron Archival Services.
11. Judy Rumerman, "Daniel and Harry Guggenheim – Supporters of Aviation Technology," *U.S. Centennial of Flight Commission*.
12. Dik Daso, *Architects of American Air Supremacy: General Hap Arnold and Dr. Theordore von Karman.* (Maxwell Air Force Base, AL: Air University Press, 1997), 101.
13. Judy Rumerman, "Daniel and Harry Guggenheim – Supporters of Aviation Technology," *U.S. Centennial of Flight Commission*; *The Daniel Guggenheim Safe Aircraft Competition.* (NYC: The Daniel Guggenheim Fund for the Promotion of Aeronautics, Inc., 1927), 1, The University of Akron Archival Services, Akron, OH.
14. "Inventory of the Daniel Guggenheim Airship Institute Records, 1926 – 1952, Record Group Number: 22/8," *Daniel Guggenheim Airship Institute Records.* (Akron, OH: The University of Akron Archival Services, 2010), 1.
15. "Inventory of the Daniel Guggenheim Airship Institute Records, 1926 – 1952, Record Group Number: 22/8," *Daniel Guggenheim Airship Institute Records,* 2.
16. The City of Akron, Ohio also matched the Guggenheim Fund contribution with a grant to cover the institute's operations for a five-year period. Alva Russell letter to Theodore Zook, Akron, OH, October 28, 1926, The University of Akron Archival Services, Akron, OH; William F. Trimble*, Jerome C. Hunsaker and the Rise of American Aeronautics*. (Washington, D.C.: Smithsonian Institution Press, 2002), 119.
17. "Inventory of the Daniel Guggenheim Airship Institute Records, 1926 – 1952, Record Group Number: 22/8," *Daniel Guggenheim Airship Institute Records*, 3.
18. *Ibid*.
19. *Ibid*.
20. *Ibid*.
21. Doctor Theodore von Kármán (1881 – 1963), was a Hungarian born mathematical prodigy who was known as the father of supersonic flight. Von Kármán made major contributions to aviation and space technology, aerodynamics, and improved aircraft performance during an illustrious career. *Ibid*.
22. *Excerpts for the Minutes of the Board of Directors of the University of Akron dated October 11, 1935, Vol. 2.* (Akron, OH: University of Akron, 1935), 362-363, The University of Akron Archival Services, Akron, OH.
23. "Inventory of the Daniel Guggenheim Airship Institute Records, 1926 – 1952, Record Group Number: 22/8," *Daniel Guggenheim Airship Institute Records*, 3.
24. William F. Trimble, *Jerome C. Hunsaker and the Rise of American Aeronautics*, 120.
25. Theodore Troller, "The New Whirling Arm," *Journal of Aeronautical Sciences, Vol.1* (Easton, PA: Institute of the Aeronautical Sciences, Inc., October 1934), 195, The University of Akron Archival Services, Akron, OH.
26. Theodore Troller, "The New Whirling Arm," *Journal of Aeronautical Sciences, Vol.1*, 195.
27. *Ibid*., 197.
28. Martin Dietrich letter to L. O. Schumaker, Hamburg, GE, June 10, 1932. The University of Akron Archival Services, Akron, OH; William A. Moffitt letter to George F. Zook, Washington, D.C., May 31, 1932. The University of Akron Archival Services, Akron, OH.
29. Program for "Dedication Exercises, The Daniel Guggenheim Airship Institute and Conference on the Progress and Problems of Research in Lighter-than-Air Craft." *Daniel Guggenheim Airship Institute,* Akron, OH, June 26-27, 1932. The University of Akron Archival Services, Akron, OH.
30. Acceptances to "The Guggenheim Dedication," *Daniel Guggenheim Airship Institute,* Akron, OH: n.d., 1-2, The University of Akron Archival Services, Akron, OH.
31. Robert H. Rankin, "*DN-1*, The U.S. Navy's First Dirigible," *The American Aviation Historical Society Journal*. (Huntington Beach, CA: American Aviation Historical Society, 1958), 10.
32. "Discussion of Airship Problems," *The Daniel Guggenheim Airship Institute, Publication No. 1.* (Akron, OH: The Daniel Guggenheim Airship Institute, 1933), 61.
33. An investigation into the *R-101* crash was initially thought to be caused by windshear, but later determined that a tear in the airships outer fabric caused the deflation of several gas cells in the forward part of the airship, leading to an uncontrollable nose down attitude resulting into a controlled flight into terrain.
34. "Discussion of Airship Problems," *The Daniel Guggenheim Airship Institute, Publication No. 1,* 62.
35. The use of dive plane like devices are used today in both canard aircraft and many racing cars, the latter use to help create a downward force to help balance the car.
36. F. D. Knoblock, *Wind Tunnel Tests on G-Z Airship Model 6R0123 with Bow Elevators*. (Akron, OH: Daniel Guggenheim Airship Institute, February 5, 1934), Introduction.
37. F. D. Knoblock, *Wind Tunnel Tests on G-Z Airship Model 6R0123 with Bow Elevators*, 8-9.
38. The ZRCV program was cancelled by the US Congress following the 1935 crash of the U.S.S. Macon due to economic necessities and developing radar technologies. Massimo Morreale, "The U.S. Navy's Rigid Airship Program, *U.S. Navy Institute Blog*, 2018. https://blog.usni.org/posts/2018/06/21/the-u-s-navys-rigid-

airship-program (accessed March 24, 2024).
39. "*VB-3 Razon* Bomb," *National Museum of the United States Air Force*. https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196093/vb-3-razon-bomb/ (accessed March 24, 2024).
40. The Gulf Research and Development company had ten research divisions, one of which focused on aircraft research. Gordon H. Stillson, "Gulf Research and Development Company," *Science*, March 6, 1953. https://www.science.org/doi/10.1126/science.117.3036.3.s (accessed March 25, 2024), 3; Robert S. Ross, *Wind Tunnel Tests on 2/3 Scale Model Razon (VB-3)*. (Akron, OH: The Daniel Guggenheim Airship Institute, August 28, 1944), 1.
41. Douglas H. Robinson, *The Zeppelin in Combat: A History of the German Airship Division, 1912-1918*. (Atglen, PA: Schiffer Publishing Ltd., 1994), 266.
42. Richard Riley Johnson, *Twenty-Five Milk Runs (and a few others): To Hell's Angels and Back*. (Victoria, CA: Trafford, 1995), 105-08.
43. Andreas Parsch, "VB Series: (VB-1 through VB-13)," *Director of U.S. Military Rockets and Missiles, Appendix 1: Early Missiles and Drones*, 2003. Https://www.designation-systems.net/dusrm/app1/vb.html (accessed March 24, 2024).
44. Andreas Parsch, "VB Series: (VB-1 through VB-13)," *Director of U.S. Military Rockets and Missiles, Appendix 1: Early Missiles and Drones*.
45. *Ibid*.
46. *Ibid*.
47. *Ibid*.
48. *Ibid*.
49. *Ibid*.
50. *Ibid*.
51. Robert S. Ross, "Wind Tunnel Tests on 2/3 Scale Model Razon (VB-3)," *The Daniel Guggenheim Airship Institute*. (Akron, OH: The Daniel Guggenheim Airship Institute, August 23, 1944), 1.
52. Robert S. Ross, "Wind Tunnel Tests on 2/3 Scale Model Razon (VB-3)," *The Daniel Guggenheim Airship Institute*, 1.
53 Carlo Kopp, "The Dawn of the Smart Bomb, Technical Report APA-TR-2011-0302," *Air Power Australia*, 2012. https://www.ausairpower.net/WW2-PGMs.html (accessed March 25, 2024), 1.
54. "VB-3 Razon Bomb," *National Museum of the United States Air Force*.
55. *Ibid*.
56. *Ibid*.
57. According to some sources, the Japanese government, after acquiring and testing a later model Kellett *KD-1A* in 1939, turned the aircraft over to the Kayaba Industrial Co, which subsequently built an inline-engine version of the aircraft as the *Ka.1*. This was powered by a 240 hp *Kobe* engine (license version of the German Argus *As.10C*); the first *Ka.1* was flown on 26 May 1941 and eventually some two hundred and forty aircraft of this type were built. They were employed during the Second World War by the Imperial Japanese Army for artillery observation and cooperation duties, and by the Imperial Japanese Navy for coastal or carrier-based antisubmarine patrol carrying two 60 kg bombs or depth charges. "Kellett KD-1," *All the World's Rotorcraft*, n.d. https://www.aviastar.org/helicopters_eng/kellett_kd-1.php (accessed March 30, 2024).
58. "National Museum of the U.S. Air Force's Kellett *XR-8* Restoration," *Vintage Aviation News*, September 30, 2023. https://vintageaviationnews.com/warbird-restorations/national-museum-of-the-u-s-air-forces-kellett-xr-8-restoration.html (accessed March 25, 2024).
59. National Museum of the U.S. Air Force's Kellett *XR-8* Restoration," *Vintage Aviation News*, September 30, 2023.
60. *Ibid*.
61. The Kellett's egg-shaped fuselage design was a precursor to the Hughes *OH-6* (*MD-500* civilian model) *Cayuse* light observation helicopter. In terms of its basic configuration, the OH-6 had an atypical teardrop-shaped fuselage, a feature that led to personnel sometimes referring to it as the "flying egg". This shaping, combined with the provision of internal bulkheads, has been attributed as giving the rotorcraft its uncommonly strong crashworthiness properties. *Ibid*.
62. *Ibid*.
63. *Ibid*.
64. *Ibid*.
65. *Ibid*.
66. "Kellett *XR-10* Helicopter," *Heli Start*, 2020, http://www.helistart.com/helicopters/Kellett/XR-10 (accessed March 30, 2024).
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Hawker Hunter: A Classic British Jet Fighter. By: Philip Birtles. Stroud UK: Fonthill, 2024. Photographs. Appendices. Pp. 320. $50.00. ISBN: 978-1-78155-893-5

The Hunter is an iconic aircraft in the context of British aviation. Its design harkens back to the mid-twentieth century when designers and manufacturers were actively using the technical data captured from Germany at the end of World War II as well as active contributions from German engineers whose services were obtained through Operation Paperclip. Many of these design elements pushed airframes beyond the power capabilities of available jet engines. So, the 1950s were rife with beautiful aircraft of minimum speed, range, and performance.

Birtles is clearly a fan of the Hunter. His discussion of each prototype is detailed—warts and all. But, once the design was approved for full production and operational deployment, Birtles loses focus. There are fewer and fewer anecdotes and more mundane paragraphs filled with numbers, acronyms, and names of people and places significant only to British aviation aficionados.

Given the period of initial design and construction and the shared use of swept wings, flying tail, and supersonic speed, comparison with the F–86 is inevitable. But the F–86 was a mature weapon system, while the Hunter was working out aerodynamic bugs and finding a way to stretch its range into something worthwhile. In fact, Birtles shows that Canadair-built F–86s were being used by the RAF and were replaced as the less-capable and problematic Hunter became operational. When your most modern air-to-air fighter flames out its engine any time it fires its guns, that would seem to be a problem of some significance.

Birtles is an adequate if uninspired writer. His fact-heavy narrative becomes monotonous and lacks life or animation. It is like he throttled back his writing to fit with the endless stream of black-and-white photographs that make up the bulk of the book. He talks about the unique tiger markings on a Swiss-operated Hunter, then provides a black-and-white snapshot to make his point. The photos feel like something from a plane-spotters' guide, not a serious reference book.

And that is the problem. It was difficult to determine for whom Birtles was writing. The book has no index or bibliography. There are no citations or endnotes. There is little to draw a serious researcher to read the book. Birtle mentions that the US Government passed an "Offshore Procurement Bill" in 1954 to allow it to funnel money to "offshore" defense concerns. Birtles uses this fact to show that the US actually paid a sizable portion of the Hunter's development costs. I spent several fruitless hours with Google trying to find the referenced bill. A serious book would have included it in the bibliography. The lack of color or profile drawings is a serious limitation to any modeler. And the limited information on operational employment by the RAF or foreign users is a serious omission to any armchair historian.

Given the shortcomings of the work, the $50.00 price tag is something of a deal breaker. The Hunter is an iconic airframe. Several hundred still exist, and more than a handful are still flying. If you are lucky enough to be near an example, use the $50.00 to fund a visit to see the real deal.

Gary Connor, docent, National Packard Museum, Cortland OH

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Pathfinder Pioneer: The Memoir of a Lead Bomber Pilot in World War II. By Colonel Raymond E. Brim, USAF (Ret). Haverstown PA: Casemate Publishers, 2024. Photographs. Appendices. Pp. xxi, 265. $24.95 paperback. ISBN: 978-1-63624-463-1

This volume is a reprint of Brim's 2016 autobiography. He passed away in 2019 at the age of 96. Whereas Brim recalls his life, he focuses on his service in World War II flying Boeing B–17 bombers in the Eighth Air Force. About 60 percent of the text covers that period.

As with most biographers, Brim begins at the beginning. He revisits his childhood and teenage years during the Depression in the mining town of Dividend, Utah. In December 1941, he was attending the University of Utah as a 19-year-old sophomore. Rather than wait to be drafted, he enlisted in the Army Air Forces, intending to become a pilot. He entered pilot training in early 1942 at the Rankin Flight Academy operating out of Tulare Field, California.

After earning his wings, Brim flew the B–17 for the first time in the fall of 1942 at Spokane, Washington. Now the co-pilot in a 10-man crew, he moved on to Casper, Wyoming. Early in 1943, Brim and his crew transited Salina, Kansas, where replacement crews trained before going overseas. Perhaps because of the hazards caused by winter weather in the North Atlantic, Brim's B–17 took the southern route via Brazil, West Africa, and North Africa to the United Kingdom. His 17-day journey ended in April after 60 hours of flight time.

Beginning in May 1943, Brim completed seven missions with the 92nd Bomb Group. In June, Eighth Air Force leaders selected Brim and his crew for the pathfinder mission. Starting in September, Brim would help lead large bomber formations. Using airborne mapping radar in a few select aircraft, such as Brim's, B–17s and Consolidated B–24s could strike targets in Germany without visual acquisition. Of course, Army Air Forces bomber advocates, when pressing the case for precision daylight bombing, had ignored the challenges posed by the persistent winter overcast in northern Europe. By March 1944, Brim completed his 25 combat missions, including the historic March 6 attack on Berlin.

The narrative provides exceptionally detailed accounts of his 25 missions. In addition, Brim offers interesting insights into the effort that went into each mission and the challenges he and his crew faced.

Back in the United States, he held several different positions before leaving the military after the war. In 1947, Brim resumed his career. Assignments included flying B–17s to collect radioactive materials during the atom-bomb tests in the Pacific, teaching ROTC at Purdue University, and commanding small installations in Alaska's remote Aleutian Islands.

This book is exceptionally well written. Readers unfamiliar with Eighth Air Force operations—as well as curious descendants of crewmembers—will find it quite informative.

Steven D. Ellis, Lt Col, USAFR (Ret); docent, Museum of Flight, Seattle

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Flying in the Face of Fear: A Fighter Pilot's Lessons on Leading with Courage. By Kim Campbell. Hoboken NJ: John Wiley & Sons, 2022. Photographs. Notes. Index. Pp. xxi, 217. $23.27. $17.00 eBook. ISBN: 978-1-394152-353

In April 2003, Colonel (then-Captain) Kim Campbell achieved a degree of fame in the US Air Force when she became one of the few pilots to successfully land an A-10 in "manual reversion" mode after it sustained major damage from an Iraqi missile over Baghdad. Drawing on that experience and many others throughout her 24-year Air Force career, Campbell has developed a valuable list of guidelines for leaders—guidelines that can be used by leaders both inside and outside the military.

Campbell's commitment to a lifetime of service began when, as a young girl, she witnessed the loss of the space shuttle *Challenger* on TV. Her mother explained that people sometimes accept dangerous tasks and risk their lives for things that are more important than they are. This resonated with her, and she decided at that moment that she wanted to become an astronaut. Her father, an Air Force Academy graduate, helped her determine that the best way to achieve that goal would be to attend the Academy and become a fighter pilot. Although the astronaut goal faded over time, her commitment to serve remained strong and enabled her to succeed at the Academy and throughout her career.

Flying in the Face of Fear reads like an autobiography, because it describes Campbell's experiences from one assignment to the next in chronological order, as she grew from cadet to young pilot to senior officer. But the book's real value lies in her description of how those experiences—both successes and failures—taught her lessons in how to lead others.

One of the key lessons is that the leader of any team is responsible for establishing the team's culture—the standards and norms that guide everything the team does. The Academy introduced the idea of "wingman culture," a culture in which airmen take care of airmen. This idea, and all that it entailed, is a recurring theme throughout the book. Other important guidelines include:

Take ownership of your actions and create a culture in which mistakes and failures are seen as opportunities for improvement.

Learn to prioritize and to focus first on what's most important.

Be calm in chaos, because your team will be watching to see how you respond and will emulate your behavior.

I would recommend Campbell's book for anyone who has an interest in the art and science of leadership. It would be particularly valuable for young officers. Many of Campbell's guidelines for leaders seem obvious to an experienced leader, but they are not self-evident at the early stages of a career. If I knew someone about to enter the military, I would give that man or woman a copy of the book and encourage them to scan it often so that they can benefit from the experiences of a highly successful leader.

LTC Joseph Romito, USA (Ret), docent, National Air and Space Museum

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How Drones Fight: How Small Drones Are Revolutionizing Warfare. By Lars Celander. Barnsley UK: Casemate, 2024. Photographs. Diagrams. Glossary. Appendices. Bibliography. Index. Pp. 183 paperback. $29.95. ISBN: 978-1-63624458-7

*How Drones Figh*t positions itself as a resource for understanding the evolving role of drones in modern warfare. However, despite its ambitious scope and timely subject, the book falls short in two significant and fundamental areas: defining the term "drone," and thoroughly explaining how remote piloting enhances operational efficiency. These shortcomings evoke an unfortunate comparison to the often-criticized 1990s *For Dummies* books, which, while accessible, were notorious for oversimplification and lack of depth.

One of the most glaring issues with Celander's book is his failure to clearly define what he means by a "drone." The term is used broadly and inconsistently, leaving readers to infer distinctions between diverse types of unmanned systems. In a field where the technical specifications and operational roles of drones vary significantly—from tactical Unmanned Aerial Vehicles (UAV) to strategic Unmanned Combat Aerial Vehicles (UCAV) and commercial drones—a precise definition is crucial for understanding the material. This oversight is reminiscent of the *For Dummies* approach: foundational concepts were often glossed over or inadequately defined, leading to confusion rather than clarity. In Celander's case, the lack of a clear definition undermines the book's analytical rigor and leaves the reader without a solid grounding in the subject.

Moreover, Celander's discussion of remote piloting as a mechanism for improving drone mission efficiency is similarly lacking in depth. While he touches on basic advantages, such as reducing risk to human operators and enabling prolonged missions, his analysis stops there. The more complex and critical aspects (e.g., integration of artificial intelligence, the impact of latency on decision-making, and the psychological challenges faced by remote operators) are barely addressed. This superficial treatment of a complex topic is again reminiscent of the *For Dummies* books, where the goal was often to provide just enough information to be useful without challenging the reader. However, in a book that aspires to be a serious study of drone warfare, such an approach feels inadequate and unfulfilling.

The comparison to the *For Dummies* books is further reinforced by Celander's simplistic writing style and erratic organization. While accessibility is an important quality, particularly in technical subjects, there is a fine line between being clear and being overly simplistic. Celander's attempts to make complex military concepts "understandable" often result in a diluted narrative that fails to fully engage the reader with the intricacies of drone technology and warfare. Again, this mirrors the *For Dummies* ethos, where the emphasis on readability sometimes came at the expense of depth and accuracy.

In conclusion, *How Drones Fight* fails to clearly define key terms and tends to oversimplify a complex topic. While it offers some useful insights, its erratic organization and lack of depth and precision in critical areas leaves much to be desired. Readers looking for a comprehensive and nuanced exploration of drone warfare will find themselves disappointed, much like those who found the *For Dummies* books to be a helpful, yet ultimately shallow, introduction to their chosen topics.

Gary Connor, docent, National Packard Museum, Cortland OH

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Turning the Tide: The USAAF in North Africa and Sicily. By Thomas McKelvey Cleaver. Oxford UK: Osprey, 2024. Photographs. Glossary. Maps. Bibliography. Index. Pp. 320. $32.00. ISBN: 978-1-4728-6025-5

The air war in North Africa was a crucible of American tactical airpower in World War II. This book energetically recounts how American airmen adopted effective offensive airpower tactics in their first year of aerial combat against the Axis. Cleaver has written extensively on the World War II air war, with *Clean Sweep* (2023) and *Cactus Air Force* (2022), among other works, to his credit.

This book covers US fighters and bombers flying combat in Egypt in support of the British Eighth Army; Operation *Torch*; and the subsequent aerial campaigns against Pantelleria, Sicily, and Italy. Arriving in the Middle East in August 1942, US air forces in Egypt quickly learned effective escort, fighter-bomber, and air superiority tactics from the British Western Desert Air Force. However, US fighter units assigned to *Torch*, that arrived in November, did not have such an advantage. Infantry commanders ordered American fighters to fly protective orbits over ground troops instead of attacking enemy airfields. With the initiative thus ceded, the Luftwaffe inflicted heavy losses on the Allies. In mid-February 1943, after the Kasserine Pass disaster, General Eisenhower finally permitted airmen to control airpower. Thereafter, US fighters took the offensive, driving the enemy air force out of North Africa by May 1943. These hard-won tactical skills were vividly apparent in the reduction of Pantelleria, the drive on Sicily, and the invasion of Italy in September 1943.

Cleaver's style is lively and approachable. Combatants tell the story through extensive eyewitness accounts. Based on original sources, interviews, and secondary works, the book has an extensive bibliography but, unfortunately, no endnotes. Photos are newly sourced from participants. Maps assist in following geography of the air war in North Africa. Just a few things seemed out of the ordinary. Although the combat experiences in North Africa of such future USAF luminaries as two-war ace Brig Gen Harrison Thyng and master air-warfare tactician Gen William Momyer are mentioned, their later career accomplishments are not cited. Noted Luftwaffe fighter ace Adolf Dickfeld is cited as "Alfred."

Detailed descriptions of life on austere desert bases convey the difficult conditions of the campaigns of 1942 and 1943. The focus throughout is on relentless, daily aerial combat. The familiar stories (e.g., airpower in the battle of El Alamein, and the Palm Sunday Massacre) are told from a fresh perspective.

The air war in North Africa is a popular subject, most prominently in Porch (2004) and Ehlers (2015) who concluded that the Mediterranean theater was critical to the Allied war effort. Aside from numerous unit and aircraft-type histories, Shores and Massimello's *History* (2016) is the standard reference for statistics, chronology, and combat accounts. Craven and Cate's official history (Vol. II, 1949) is colorful, but a bit dated. *Turning the Tide* combines the best of these works to vividly relate the first year of the Mediterranean air war in a fast-paced, relatable narrative. This book is a welcome addition to historiography of the World War II air war.

Steven Agoratus, Hamilton NJ

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The US Eighth Air Force in World War II: Ira Eaker, Hap Arnold and Building American Air Power, 1942-1943. By William J. Daugherty. Denton TX: U. of North Texas Press, 2024. Glossary. Photographs. Notes. Bibliography. Index. Pp. 283. $34.95. ISBN: 978-1-57441927-6

William Daugherty served as a flight officer in the Marine fighter/attack community, serving aboard an aircraft carrier in the Vietnam War. He earned a bachelor's degree from the University of California Irvine and a subsequent doctorate from the Claremont Graduate School. After serving in the CIA, Daugherty began a second career as a professor at Armstrong State University (now Georgia Southern University). He has authored *In the Shadow of the Ayatollah* and *Executive Secrets: Covert Action and the Presidency*.

His latest book is a comprehensive guide to the evolution of the US Army Air Forces in Europe. Its 31 short, concise, and well-written chapters provide a detailed account of the complex command structure and operations and offer a wealth of photographs. Readers will come away from this book with a thorough knowledge of the subject.

Once the US became involved in World War II, General Henry "Hap" Arnold became the Commanding General of the Army Air Forces. Arnold's orders were simple: stand up the Eighth Air Force in England and implement high-altitude, precision daylight bombing in Europe. This task fell to General Ira Eaker, commander of VIII Bomber Command.

Daugherty gives an excellent and detailed account of just how this monumental task was achieved, although his primary focus was thought to be the relationship between Arnold and Eaker. Intentionally or unintentionally, Daugherty has essentially written two books in one: the history of how the Eighth Air Force came to be, and the command and personal relationship between Arnold and Eaker. I found the book to be confusing at times, since I was looking for a focused narrative about Arnold and Eaker exclusively rather than a comprehensive history of the origins and operations of the Eighth. Realistically, both were parallel and difficult to separate. A reader may miss Daugherty's main focus—Arnold and Eaker—but it is there.

Daugherty brings it all together in an unbiased and logical conclusion: Arnold and Eaker's relationship was complicated, and each may have been both right and wrong in his actions and how one related to the other. A more focused account of how the two dealt with each other with a less comprehensive history of the Eighth Air Force would have been more straightforward for the reader to follow.

The book cites, but needs examples of, primary sources for the reader, specifically copies of the plethora of letters between Arnold and Eaker. Seeing some of these letters would have been invaluable.

Daugherty's book is meticulously researched, cited, and written with neutrality. His unbiased approach and thorough research ensure the book's accuracy and reliability. He could have been biased toward Eaker or Arnold but stopped short of this, thus making this work a trustworthy resource.

This book is a must-read for students with a keen interest in the Eighth Air Force's infancy and development. It provides a wealth of information and insights that will enrich understanding of this crucial period in military history.

John Hladik, MA; gallery guide, National Museum of the United States Air Force

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F–8 Crusader: Vietnam 1963-73. By Peter E. Davies. Oxford UK: Osprey Publishing, 2023. Maps. Diagrams. Illustrations. Photographs. Bibliography. Notes. Index. Pp. 80. $23.00. ISBN: 978-1-47285-754-5

In September 1952, the Navy outlined specifications for a new carrier-based fighter that could surpass the speed of sound in regular level flight. The bid was won by Chance-Vought, securing the contract for its F8U Crusader design (later designated as the F–8). The F–8 maintained 20mm cannons as its primary armament at a time when radar-guided missiles were becoming standard, earning it the moniker "Last of the Gunfighters." Renowned for its exceptional performance, the F–8 was credited with downing 18 enemy aircraft during the Vietnam War.

It is the Vietnam chapter of the Crusader's history that author Davies focuses on, giving us enough of a look at the aircraft specifications, weapons, and tactics to provide context to the main theme of this book: the dogfights that F–8 pilots got into over Vietnam. Davies has written an insightful look at the units and some of the more memorable combat missions flown by the Crusader pilots.

Osprey's Dogfight-series books are what might be considered snapshot briefings on their specific topics. More of an appetizer than a main course, this book does not provide an exhaustive, in-depth exploration of the F–8. Instead, it serves a taste that will give readers enough to either move on to the next thing or spark a hunger for more, should the topic be to their liking.

Davies interviewed several former F–8 pilots for the book. According to Jerry "Devil" Houston, the Crusader "captured your heart right from the start with its elegance and, for its era, its formidable power." Phil Vampatella recalled, it was "an extraordinary aircraft that could be quite unforgiving if mishandled, but everyone who piloted it had a deep affection for it." In one chapter, Dick Schaffert vividly recounts his intense ten-minute engagement with ten MiG–17s and MiG–21s, pushing his F–8C to its utmost limits in defense of an Iron Hand A–4E Skyhawk. His exceptional piloting during this encounter earned him the Distinguished Flying Cross. The book also delves into other Crusader airmen's dogfights, offering detailed examinations and ribbon diagrams to illustrate the maneuvers. First-person pilot insights and striking illustrations by skilled artists Gareth Hector, Jim Laurier, and Tim Brown also enrich the narrative by illustrating tactics and armament.

In summation, this is a brief, but comprehensively researched and very accessible book that provides a view into the experiences and challenges faced by the F–8 Crusader pilots who flew combat missions over Vietnam. While the Crusader had a brief service history when compared to its successor, the F–4 Phantom II, the moniker "Last of the Gunfighters" still conjures up a romantic vision of the men who carried the fight in close in the skies over Vietnam.

Mark Winslow, docent, Smithsonian's National Air and Space Museum

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Copper Wings: British South Africa Police Reserve Air Wing Volumes 1 and 2. By Guy Ellis. Warwick UK: Helion, 2023. Maps. Tables. Diagrams. Illustrations. Photographs. Notes. Appendices. Glossary. Bibliography. Pp. 56 and 74. $29.95 each paperback. ISBN: 978-1-804513-97-2 and 978-1-804513-62-0

This is not the usual fare for readers of the *AFHF Journal*. It is definitely not about Spitfires, P–51s, Zeros, F–86s, and SPADs flown by aces engaged in great dogfights and bombing campaigns. Rather, it is story of farmers flying general-aviation Mooneys, Pipers, Beechcraft, Cessnas, Austers, and Luscombes in the bush country of South Africa. It is different!

The basic background is Rhodesia's separation from the UK in 1965. The new minority-White government of Ian Smith was soon locked in guerilla warfare with two black nationalist groups that had Soviet and Chinese backing. The Whites really didn't want to lose control; but, with great international pressure to go to majority rule, they certainly didn't want to see Communism spread through southern Africa. The war lasted until early 1980, when the two sides compromised, and Zimbabwe was created.

The Rhodesian Army was quite capable, and the Rhodesian Air Force gave the government an advantage over the guerillas but was equipped with largely obsolete British equipment. These armed forces were supported by a paramilitary British South Africa Police force backed up by an even-larger Police Reserve. The air wing of the Reserve (PRAW) is what this story is all about.

Ellis is well-equipped to write this story. Once a volunteer in the South African Air Force Museum, he has a degree in history, has written several books and numerous articles, and likes to examine lesser-known stories from history. He certainly hit that goal with this topic.

The idea for PRAW stemmed from the successful use of civilian "airpower" during the Mau-Mau Rebellion in Kenya in 1952. Since the Rhodesian Police had no funds to expend on aircraft, they set up PRAW. Volunteers—mostly owner-pilots—flew their private aircraft across a country that had few roads and a lot of remote villages and farms that were separated by long distances. The result was an effective communications, transport, and emergency-medicine network that could support both police and regular forces in their ground operations. It had an efficient, decentralized management structure and flew from a number of airfields around the country. PRAW was used to fly personnel and much-needed supplies from place to place. It transported wounded to medical facilities and provided communications with remote forces, often by dropping message cannisters. Reconnaissance became one of the duties as well—spotting guerilla forces in the bush and providing ground forces with their locations.

Armament was never considered at the beginning; but, as the war ran on, and government forces with spread thin, PRAW was often used to escort convoys (nobody travelled unless they were in a convoy). They were even used to attack targets when other air assets were unavailable. A Cessna 206 with a machine gun sticking out of the aft door and anti-personnel bombs strapped to the fixed-landing-gear strut is definitely unusual!

Ellis' story is generally told from the perspective of the participants. It is well-written and every bit the quality expected of a Helion publication. For those interested in one part of the very complex story of Africa's transition from colonial holdings to independent countries and the role of a really unique form of airpower, these two volumes are well worth reading.

Col Scott A. Willey, USAF (Ret), Book Review Editor, and former National Air and Space Museum docent

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Tally-Ho: RAF Tactical Leadership in the Battle of Britain July 1940. By Patrick G. Eriksson. Stroud UK: Amberley Publishing, 2023. Maps. Notes. Bibliography. Illustrations. Charts. Index. Pp. 344. $32.00. ISBN: 978-1-3981-1162-2

In his study of RAF tactical leadership in the opening weeks of the Battle of Britain, Patrick Eriksson deconstructs the air combats over England and the English Channel during July and early-August 1940. His objective is to determine and compare, as best he can, the actual claims and losses of the British Royal Air Force and the German Luftwaffe—a task that is not easy to do. In the process, he brings out the tactical lessons the RAF learned through hard fighting and applied during the Battle of Britain.

Eriksson brings to his effort a wealth of knowledge of Luftwaffe fighter combat gained through his *Alarmstart* series of books on the experience of German fighter pilots on several fronts during World War II.

His focus in this book is on the RAF's small-unit leaders—the squadron leaders and flight commanders who led their formations into battle with the Luftwaffe. As he notes, their innovations in these early weeks were critical to winning the Battle of Britain. The RAF's pre-war Fighter Area Attacks tactics assumed that Luftwaffe formations attacking Britain would be composed only of bombers without fighter escort. The fall of France in June 1940 brought Britain within range of Luftwaffe fighters, the Bf 109s and Me 110s of the fighter Geschwader. More often than not, the small RAF formations of Hurricanes and Spitfires intercepting raids on convoys in the Channel found themselves facing formations of bombers, with escorting fighters waiting above. Getting through to the bombers meant risking attack from the Luftwaffe fighters at higher altitudes. RAF formation leaders had to assess the tactical situation carefully and rapidly and, as Eriksson describes, balance aggressiveness with calculated risk. Positioning and timing of the interception were critical. The RAF formation leaders had to develop new tactics and formations to cope with the Luftwaffe escort formations, often incurring losses as they experimented.

What comes out in his description and analysis of these combats is how difficult it was at the time—and still is—to determine claims versus actual losses in a rapidly changing air battle. Often several RAF and Luftwaffe pilots would fire at the same enemy aircraft in turn, each believing his efforts were successful in downing the opposing fighter. The other observation that comes through these accounts was how difficult it was for the RAF Hurricanes and Spitfires to shoot down German bombers with their .303-caliber machine guns. Eriksson relates numerous accounts where it took the combined efforts of three RAF fighters, using all their ammunition (at times over 7000 rounds) to down a bomber. The lesson learned was the need to harmonize the guns for a shorter distance and to close the range on a bomber before opening fire, though this increased the risk of running into return fire from the bomber under attack. As the RAF's controllers gained experience intercepting German formations, the Luftwaffe escorts found it difficult to cope with Air Marshal Keith Parks' strategy of having multiple small formations of RAF fighters attacking from different directions and altitudes in close sequence.

Though a specialized study, Eriksson's book is a valuable addition to the literature on the Battle of Britain. Highly recommended.

Edward M. Young, PhD, volunteer, Museum of Flight, Seattle WA

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Seabees and Superforts at War: Tinian's Critical Role in the Ultimate Defeat of Japan. By Don A. Farrell. Tinian, CNMI: Micronesian Production (CNMI) LLC, 2024. Maps. Photographs. Notes. Appendices. Glossary. Bibliography. Index. Pp. xxv, 520. $30.00. Available at https://shop.micronesianpubs.com/ or by sending a check to Don A. Farrell, PO Box 5, Tinian MP 96952. ISBN: 978-0-930839-04-8

Don Farrell is a historian based on the island of Tinian in the Mariana Islands, well-known for his research and publications on the history of the Marianas. His goal in this book is to tell the story of how Tinian was converted into one of the greatest military installations in history and how it performed its important role in the defeat of Japan. He achieved this goal in fine style, with an excellent work that thoroughly describes a complex military operation.

Although Farrell's stated intent was to focus on Tinian, the book is much more than that. It is an extensive story, told in great depth and breadth, of US operations in the Central Western Pacific and how the US planned for and carried out the invasion, capture, and utilization of the islands.

One of the key tasks in the Pacific was to build forward bases from which the US could bring the war to Japan. To accomplish this critical mission, the Navy recruited experienced construction workers from civilian life to form ***c***onstruction ***b***attalions, which led to the adoption of the name Seabees.

In 1943, Allied leaders agreed that defeat of Japan would call for a blockade and sustained bombing of Japanese cities from forward bases in the Marianas.

The invasion of Tinian began in July 1944, with the primary objective of capturing Hagoi Airfield. This was later renamed North Field, where hundreds of forward-based B–29s turned it into the world's busiest airport. After Tinian was secured, the key commanders became USMC MajGen James Underhill and USAAF BG Fred Kimble (successive island commanders), and the Navy's CAPT Paul Halloran, the officer in charge of the 6th Naval Construction Brigade. Farrell credits the superb cooperation between these officers for playing a critical role in the success of the Tinian mission.

The scope and complexity of the Seabees' mission on Tinian can be difficult to grasp. The Tinian population—more than 68,000 military personnel and their equipment—would require housing, hangars, maintenance facilities, expanded runways, taxiways, hardstands, roads, power- and water-generation facilities, fuel depots, pipelines, and a functional harbor. The fact that the Seabees accomplished all this on schedule was a remarkable achievement. In effect, they built the equivalent of a fully functional, medium-size American city in just a few months.

The first B–29s arrived in December 1944. In addition to conventional bombing missions, these aircraft conducted three major operations. Under *Meetinghouse*, they shifted from high-altitude bombing to low-altitude, night firebombing of Japanese cities. The attacks had devastating impact. Operation *Starvation* employed B–29s to mine Japanese ports and waterways. This mining would prevent raw materials from reaching Japan and prevent the supply and redeployment of Japanese forces. Operation *Centerboard* was the culmination of the Manhattan Project. Manhattan had developed the atomic bomb, and *Centerboard* was the actual use of atomic bombs over Hiroshima and Nagasaki in August 1945.

I hesitate to criticize such an outstanding book, but there is one shortcoming. Force deployments occurred frequently in the Marianas, and Farrell describes these in chronological order as part of the overall narrative. This was difficult to follow. The book would have benefited from the addition of tables or wiring diagrams to show how the force structure, both US Army Air Forces and US Navy, developed over time.

That criticism aside, *Seabees and Superforts at War* is a superb book, one that far exceeds its stated objective. It is an excellent telling of the story of the Central Western Pacific.

LTC Joseph Romito, USA (Ret), docent, National Air and Space Museum

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Me 163 vs Allied Heavy Bombers: Northern Europe 1944-45. By Robert Forsyth. Oxford UK: Osprey, 2024. Photographs. Maps. Diagrams. Illustrations. Pp. 80. $23.00 paperback. ISBN: 978-1-4728-6185-6

This book is a brief history of the development, testing, and operational life of the Me 163 Komet, a Luftwaffe rocket-powered, single-seat fighter used to intercept Allied bombers in World War II. Used as a point interceptor (because of its limited fuel supply), Me 163s were based under the flight path of Allied bombers. Taking off when notified bombers were approaching, Me 163s climbed to 30,000 feet in under three minutes. After diving through the bomber formation at over 500 mph, firing their two 30-mm cannon, they glided back to base to land on a fuselage-mounted skid. The first time Eighth Air Force crews observed the Me 163 in action on July 28, 1944, the aircraft's speed came as a rude shock. Adjustments came quickly, however, and Allied fighters soon were able to down Me 163s despite their fleeting appearance in gunsights.

The Me 163 was almost as dangerous to its handlers as it was to enemy bombers. The highly corrosive propellants caused ground crews to don protective gear to refuel the plane. Take-off accidents took the lives of pilots when the rocket motor malfunctioned. The aircraft required special tugs to move around the airfield and was mounted on a two-wheel, droppable dolly for takeoff.

The Komet is often seen as an improvised, last-minute development in the enemy's desperate effort to oppose Allied heavy bombers over Europe. However, Forsyth offers evidence that it was the product of technology research and development originating in the post-World War I years, with experiments and prototyping of rocket propulsion for aircraft stretching through the 1930s. As with the Me 262, the aircraft could have been in action sooner than it was. Rapidly shifting priorities, bureaucracy, and endless tinkering delayed manufacturing and deployment. With only a relatively few examples in action at any given time, the Me 163 made a distinctly minor contribution to the war but left an indelible mark on aviation history.

Forsyth is an experienced aviation historian and artist with such Osprey titles as *Fw 190 D-9 Defence of the Reich* (2022) to his credit. His text is easy-to-follow and aimed at the general reader. He focuses on the Luftwaffe pilots who flew the plane, letting extensive quotes relate what it was like to fly and fight in the Me 163. Eyewitness accounts from Allied fighter and bomber crews who faced Me 163s give the reader a vivid impression of the aircraft in action.

The book is based on official records, interviews, correspondence, and secondary sources. Rather than endnotes, the text itself cites such sources as the account of Wolfgang Späte (1995) on his experiences as commander of JG400, the only operational Me 163 unit. Readers desiring more detail will find the memoirs of Me 163 pilot Mano Ziegler (1963) informative, as well as Ethell's classic account (1978) and the comprehensive Ransom and Cammann (2021).

This heavily illustrated book's drawings, illustrations, and diagrams—many created by Forsyth himself—bring the reader into the cockpit to demonstrate how an Me 163 bomber-intercept mission evolved. Detailed captions tie carefully selected photos of planes and pilots to the text. This is the most readable, balanced work yet available on the Me 163.

Steven Agoratus, Hamilton NJ

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The F–100 Units of USAFE. By Doug Gordon. Stroud UK: Fonthill Media, 2023. Glossary. Photographs. Appendices. Notes. Bibliography. Pp. 190. $55.00. ISBN: 978-1-78155-910-9

Doug Gordon, a native of Oxford, spent his formative years within sight and sound of the USAF base at RAF Bentwaters. His connection to the subject, coupled with his deep interest in military aviation during the Cold War, is evident in his work. Among his various works on Cold War military aviation, he published *USAFE Tactical Units in the UK in the Cold War 1950-1992*.

F–100 Units of USAFE is a comprehensive work that meticulously traces the evolution of the F–100 from its inception to its retirement. The F–100 Super Sabre, also known as "The Hun," was the pioneering aircraft in the USAF's "century series" and the first to achieve supersonic speed in level flight. This book, comprising 12 detailed chapters, explores the F–100 and its variants, units, and missions. Gordon has included numerous photographs (both color and black-and-white) of unit personnel, unit emblems, and the F–100 in various configurations and paint schemes. The book's layout and photographic detail are of the highest quality, ensuring a comprehensive understanding of the subject matter.

The F–100 met the USAF's need for an air superiority fighter (initially) and, later, a fighter bomber. The F–100A and C models were air superiority fighters, while the F–100D was developed as a fighter bomber. Gordon nicely explains the ominous fighter-bomber role of the F–100D—a delivery vehicle for nuclear weapons.

During the madness of the Cold War, NATO doctrine was that of massive retaliation and first-strike use of nuclear weapons in the event of a Soviet invasion of Europe. The debate continues today regarding NATO's ability during that period to win a conventional war against the Soviet Union. At that time, NATO had no confidence in that regard. As Gordon wrote, "NATO should carry out strategic bombing promptly by all means possible with all types of weapons, without exception." This is an example of just how close humanity was to annihilation.

Gordon does an excellent job explaining how the F–100D was used for nuclear deterrence and attack. F–100D pilots sat at "Victor Alert," which meant that a designated number of aircraft were armed with nuclear weapons and were ready to deploy with a mere 15-minutes notice. The aircraft at Victor Alert were sequestered at a particular base area, heavily guarded with limited access. The pilots assigned were on a 15-minute alert 24/7 for one week at a time, and sometimes longer. Gordon pays special attention to the psyche of the pilots, all of whom knew that if the alarm sounded and the attack order was given, it would likely be a one-way mission. Many doubted they could outrun a nuclear fireball, and others knew, based on their assigned target, that they would not have enough fuel to return home.

This book is not only an excellent read, but also a necessary one for anyone interested in military aviation during the Cold War. Gordon skillfully places the F–100 within the context of the global situation during the Cold War, highlighting its crucial role and the perilous proximity to mass destruction. In today's world, where geopolitical tensions continue to shape our reality, understanding the lessons of the past is more important than ever.

John Hladik, MA, National Museum of the United States Air Force Research Division

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Hueys Over Khe Sanh: Flying Missions with VMO-6. By Peter Greene. Haverton PA: Casemate, 2024. Photographs. Pp. viii, 184. $34.95. ISBN: 978-1-63624-445-7

This book is a chronological recollection of Greene's service as a Marine from his enlistment in 1966 to his discharge in 1968. During his service, he served a tour as a crew chief on helicopters assigned to Marine Observation Squadron 6 (VMO-6) in Vietnam.

While a personal narrative in nature, rather than a unit history, the book's value is in providing insight to the motivation, training, combat duties, and experiences of the young Marines who crewed the gunship (attack) helicopters in Vietnam. It has been written in the first-person style that generates an easily readable story. Greene's experiences are typical of the helicopter gunship crews of the period in both the Marines and the Army. The crew chiefs of the helicopters spent their days flying with the bird and a considerable part of their evenings ensuring it was in operational condition for the next day's mission.

Greene provides a detailed description of the duties and actions required of the helicopter crewman in combat while describing various mission environments and recollections of actual missions. How he got to his position as crew chief (much earlier than one might expect) is an all-too-typical example of how things happen in the military. It turns out the Marines were short of manpower in his unit, and people were pushed up into more responsibility on an accelerated basis—not an uncommon situation. The performance of the unit speaks to the efforts and adaptation of Greene and his contemporaries.

The combat narratives, as well as other situational anecdotes, are compelling and varying; although, for the most part, Greene was not really specific at times on dates, locations, and operations. Unfortunately, there are no maps in the book to orient the reader to the actions described. The reader does, however, get a pretty good idea of what these young airmen went through on a day-to-day basis. Despite generally being the lowest-ranking crewmember, their importance to mission success cannot be overlooked. Most of those who experienced flying armed helicopters owe their lives, in one way or another, to men such as Greene.

There are a significant number of personal photographs picturing the helicopters and several of the places Greene fought and lived. They do give the feel of the landscape of Vietnam and the terrain in which this unit operated. The book is a mini-album of Greene's tour.

Greene admirably describes what seemed to be a typical journey for untold numbers of young men at the time (mid-to-late 1960s). The country was in a hot war, and they were facing the draft. The thoughts that went through their minds that eventually put them in a helicopter over Vietnam, and their observations afterwards are well worth exploring.

Bill Staffa, Col., USAR (Ret), NASM and NMUSA Docent.

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Tactical Air Power and the Vietnam War: Explaining Effectiveness in Modern Air Warfare. By Phil Haun. Cambridge UK: Cambridge University Press, 2024. Pp. xvi, 294. Maps. Tables. Diagrams. Photographs. Notes. Appendices. Bibliography. Index. $34.99 paperback. ISBN: 978-1-009-36419-5

Haun, a professor at the Naval War College, retired from the US Air Force as a colonel. He flew the Fairchild A-10 Thunderbolt II in the Balkan conflicts, Afghanistan, and Iraq. He previously has written *A-10s over Kosovo: Coercion, Survival and War; Lectures of the Air Corps Tactical School and American Strategic Bombing in World War II,* and *Air Power in the Age of Primacy.*

Using an analysis of air power in the Vietnam War, Haun argues that the Air Force has neglected doctrinal development of tactical air power. He offers a compelling argument why the Air Force should emphasize this mission. The book begins with an examination of the use of air power in general, wherein Haun suggests a tactical approach that he believes the Air Force should embrace.

The United States introduced air power to the Vietnam War in 1965 when it initiated the campaign known as *Rolling Thunder.* For presentation and analytical purposes, Hahn initially examines that campaign's effectiveness in 1965 and 1966. He follows that chapter by reviewing air power's influence in 1967 and 1968, emphasizing how air power affected the North Vietnamese Army's defeat at Khe Sanh. On the other hand, he notes how the North Vietnamese largely thwarted *Rolling Thunder*'s attempts to interdict men and materials moving into South Vietnam and the neighboring countries of Laos and Cambodia. Meanwhile, the Air Force experienced significant losses in its attacks on strategic targets in the North.

After President Lyndon Johnson basically ordered the Air Force and Navy to cease bombing North Vietnam in 1968, the Air Force launched interdiction campaigns *Commando Hunt I, II* and *III* focusing on Laos and Cambodia in 1969 and 1970. He examines *Commando Hunt* operations in 1971 and 1972 before considering the debacle of Lam Son 719, the South Vietnamese Army's bold offensive maneuver. Hahn argues that inadequate air-ground communication contributed to operational failure. He reviews the 1972 use of air power that stopped North Vietnam's Easter Offensive. He finishes with an analysis of *Linebacker I* and *Linebacker II*.

In the end, Haun concludes that properly employed tactical air that relies on timely intelligence and solid coordination with ground forces discourages enemy forces from effectively massing superior combat power. Tac air thus becomes a significant deterrent.

This book undoubtedly will have its critics among Air Force decision-makers. Haun argues many of them fail to value the benefits of a combined-arms approach with the Army when it comes to winning wars. Among his recommendations, Haun suggests the Air Force should adopt the Marine Corps' approach of closely coordinating air-ground operations.

Anyone interested in Air Force doctrine, the impact of air power on the Vietnam War, or both must read this book.

Steven D. Ellis, Lt Col, USAFR (Ret), docent, Museum of Flight, Seattle

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Operation Inherent Resolve. By Jordan Hayworth, ed. Maxwell AFB AL: Air University Press, 2023. Notes. Abbreviations. Diagrams. Index. Pp. 308. Free online. ISBN: 978-1-58566327-9

After finishing this book**,** I heard Central Command announce that Operation *Inherent Resolve* would begin a phased drawdown to end the mission in 2025. I considered the mixed success the US and our coalition partners have enjoyed ending regional conflicts and extracting ourselves without leaving things worse than they were when we arrived.

Hayworth's book is a collection of essays by various Air University faculty members, which offers a broad analysis of the multinational military campaign against ISIS over the past decade. These explore aspects of the operation ranging from military strategy and ground operations to political dynamics and coalition coordination. What emerges is a nuanced view of how *Inherent Resolve* was shaped by the varying objectives, capabilities, and sometimes self-serving interests of coalition partners.

The authors generally agree on the effectiveness of airpower and the crucial US role in providing technological and logistical support. Several essays highlight how US airstrikes were pivotal in degrading ISIS's infrastructure, leadership, and capacity to control territory and form their caliphate. Air dominance allowed coalition forces to support local partners, including the Iraqi Security Forces (ISF) and Syrian Democratic Forces (SDF), in ground operations without committing large numbers of Western troops to ground combat.

Another area of consensus is the importance of local ground forces. Empowering local fighters, who were more familiar with the terrain and had a personal stake in the outcome, was essential for liberating cities such as Mosul and Raqqa. Though under-equipped and sometimes poorly coordinated, they were key to defeating ISIS on the ground, while coalition forces provided the necessary air and logistical support. Surprisingly, no one chose to discuss the impact of this liberation objective. Lawrence's *Seven Pillars of Wisdom* clearly showed that the goal of liberation and autonomy is a timeless and powerful force in regional conflicts.

However, several essays diverge on the overall effectiveness of the coalition's coordination and the long-term strategy. Some authors criticize the lack of unified command among coalition members. Turkey often focused on limiting Kurdish influence in Syria. That conflicted with the US strategy of relying on the SDF (which included highly effective and motivated Kurdish fighters). This created friction within the coalition and led to operational inefficiencies. Several essays argue that differing political objectives hindered a fully unified effort and could have prolonged the conflict. It went unmentioned that such friction could compromise the success of the operation and leave the door open for an eventual resurgence of ISIS.

There is also disagreement about post-ISIS stabilization efforts. Some criticize lack of a clear, coordinated plan for rebuilding liberated territories, arguing that the vacuum left by ISIS's defeat has allowed other destabilizing forces to emerge. Others believe that stabilization should have been prioritized sooner—particularly in Iraq, where sectarian tensions remain unresolved. While the military aspect of the operation was successful, the long-term political and social reconstruction remains a point of contention among authors.

The essays present valuable lessons for future multinational military campaigns, especially where coalition members have divergent objectives. One is the need for better coordination and communication among partners. In *Inherent Resolve*, the overall objective of defeating ISIS was shared, but some political agendas were obstacles. Future operations should emphasize clear, unified, command structures to mitigate such conflicts.

Additionally, without a robust stabilization and reconstruction strategy, military victories can be undermined by political instability and the resurgence of extremist groups. Future coalition partners must not only agree on military goals but also develop a cohesive vision for the political future of the region.

This book provides a broad, critical examination of the successes and challenges faced during the campaign against ISIS. The differing perspectives illustrate the complexity of multinational operations. The lessons gleaned from this operation—particularly the need for coordination and post-conflict planning—are crucial for future multinational efforts.

I would have liked a chapter on ISIS and its organization and objectives. At the superficial level, there appear to be similarities between The Prophet's use of military force to spread Islam and the ISIS use of military force and terror to advance their caliphate. And the use of military force to advance religious/cultural goals is not limited to Islam and the Middle East. The absence of discussion of the complications caused by the intervention of Russia and their para-military Wagner group, as well as Iran and China, was a noteworthy omission, as was the absence of discussion of the role Bashar al-Assad played during the operation and will play in the future. The lessons Hayworth and his coterie offer are valid, but they are limited in scope.

Gary Connor, docent, National Packard Museum, Cortland OH

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Eastern Front 1945: Triumph of the Soviet Air Force. By: William E. Hiestand. Oxford UK: Osprey. 2024. Photographs. Index. Maps. Drawings. Charts. Pp. 96. $25.00 paperback. ISBN: 978-1-47285782-8

The latest literary hors d'oeuvre in the Osprey Air Campaign series, *Eastern Front 1945* brings the reader a unique breakdown of the Soviet Army's final push across Eastern Europe and into the heart of Germany. The discussion of the Eastern Front is woefully underserved in the west. When it is discussed, it is mostly presented a single monolithic war machine, overwhelming the outnumbered, under-equipped, and planless forces of the Reich. Hiestand breaks the Soviet offensive into its component parts, and shows how the goals and objectives of the components contributed to the final victory.

Hiestand is very neutral in his presentation. He deftly avoids coming across as an apologist or a fanboy of the Red Army. While there is no question that the campaign objective is Berlin, he shows how the distinct phases of the campaign contributed to the goal. Some of his strongest work was in showing how the Soviets benefited from effective leaders; while the German war machine, especially the Luftwaffe, had leaders in name only and lacked any strategic vision after the catastrophic failures of the Ardennes Offensive and *Bodenplatte*.

The narrative offers sufficient detail to make the case that, by January 1945, the Reich was so hopelessly outnumbered on the Eastern Front that even the marginally effective wonder weapons had negligible impact. Hiestand dropped an interesting fact: in June 1944, the Luftwaffe's own records show it used 90,000,000 gallons of fuel but would have only 95,000,000 for the rest of the war. Once the Ploesti oilfields were liberated in August 1944, Germany had to rely solely on synthetic fuels. When the Allied Combined Bomber Offensive focused on the synthetic fuel industries, the Luftwaffe's ability to conduct operations and training was severely curtailed. This only magnified the numerical inferiority of Germany's combat arms.

Hiestand does make the case that the Luftwaffe did not quit and constantly tried to leverage its remaining forces to slow the Soviet juggernaut. He offers an anecdote about the Luftwaffe deployment of a Focke-Achgelis Fa 223 helicopter from Berlin Tempelhof to Danzig only to find the destination under attack, thus necessitating an escape along an improvised route along the Baltic coast.

The author, editors, and illustrators follow the Osprey recipe to the letter. The narrative is clear and concise. Photographs are curated to support the narrative. The numerous maps were extremely helpful in breaking the campaign into its component parts. The book offers a "Further Reading" chapter in lieu of a bibliography, but Hiestand's opinion of other works was interesting. Oddly, there were a few typos: e.g., Ju 87 became Ju 97 in a caption—a minor glitch, but one out of character for the Osprey machine.

Eastern Front 1945 clearly fulfills its contract with the reader. It offers a clear explanation of the final five months of the war on the Eastern Front. But I was left with a feeling of sadness, realizing that the war was lost for Germany in Aug of 1944. The Allied breakout from Normandy was underway, The Luftwaffe was numerically and qualitatively incapable of stopping marauding Allied aircraft from attacking the tactical and strategic targets at the time and place of their choosing on the Eastern and Western Fronts. But the war would grind on for ten more bloody and tragic months.

Gary Connor, docent, National Packard Museum, Cortland OH

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Operation *Barbarossa* 1941: The Luftwaffe Opens the Eastern Front Campaign. By William E. Hiestand. Connor Hill UK: Osprey, 2024. Maps. Tables. Diagrams. Illustrations. Photographs. Bibliography. Index. Pp. 96. $25.00 paperback. ISBN: 978-1-4728-6150-4

Hiestand has established himself as one of Osprey's regular contributors to the publisher's different series of high-end paperbacks. Over the years, he has written numerous books about armored warfare. More recently, he has examined air power and German-Soviet operations in World War II. Other works cover topics such as the German airlift to Stalingrad, air power and the Battle of Kursk, and the eventual Soviet Air Force dominance.

All of Osprey's air-campaign books follow the same format: a brief introduction, a chronology, the attacker's capabilities, the defender's capabilities, the campaign, and the aftermath and analysis. More than half of this book's narrative covers the campaign. When Germany attacked the Soviet Union on June 21, 1941, the *Luftwaffe* achieved surprise, devastating enemy airbases and aircraft on the ground. The first month of the campaign marked the zenith of German air power. The rapidly moving German ground forces repeatedly encircled enormous numbers of Soviet troops. All this success reinforced Germany's expectation that its armed forces could achieve victory before the end of 1941.

As his army moved deeper into the Soviet Union, Adolf Hitler chose to deemphasize the drive on Moscow in favor of capturing Leningrad (St. Petersburg) in the north and resource-rich Ukraine and—farther southeast—the oil fields. These diverging axes challenged Luftwaffe leaders to mass sufficient air power in either region.

Furthermore, Hitler and his generals ignored history and Napoleon's failed nineteenth-century offensive. The Germans underestimated the logistical challenges of sustaining combat power as their lines of communication rapidly extended into the western Soviet Union. A rainy Fall compounded transportation challenges as the roads turned to mud.

In September, the Germans launched Operation *Typhoon,* a belated effort to capture Moscow. The still-confident German leaders dispatched significant numbers of aircraft to other theaters. They would regret that action as progress slowed, and they recalled those units. Now operating on a shoestring from increasingly austere airfields, the *Luftwaffe* mounted fewer and fewer sorties.

The Russians, despite having relocated their factories east of the Ural Mountains, produced more improved aircraft—better fighters (such as the MiG-3) and attack aircraft (the Il-2 was the best example). Their pilots, however, lacked experience. Meanwhile, many German flyers had been tested in prior combat—supporting the Nationalists during the Spanish Civil War and fighting the western Allies.

Ultimately, the Germans failed to reach Moscow, but they continued their drive to the southeast while simultaneously besieging Leningrad. Russian air strength continued to increase. The Germans never again would experience the advantages achieved in June and July.

This book is best suited for readers unfamiliar with the impact of air power on Operation *Barbarosa.* Hiestand has attempted to emphasize key elements, but readers seriously interested in this subject might be better served by reading longer, more-detailed accounts.

Steven D. Ellis, Lt Col, USAFR (Ret), docent, Museum of Flight, Seattle

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Calculated Risk: The Extraordinary Life of Jimmy Doolittle—Aviation Pioneer and World War II Hero. By Jonna Doolittle Hoppes. Solana Beach CA: Santa Monica Press, 2022. Photographs. Bibliography. Index. Pp. 338. $24.95 paperback. ISBN: 978-1-59580117-3

This book offers a deeply personal glimpse into the relationship between Jimmie Doolittle, the legendary aviator, and his wife, Josephine "Joe" Daniels Doolittle. Unlike many other works that focus on Jimmie Doolittle's military exploits—particularly his famous Doolittle Raid during World War II—Hoppes' book shifts the spotlight onto the couple's relationship and family life, exploring the emotional dynamics that shaped their lives.

The narrative is richly informed by Hoppes' familial connection—she is Jimmie and Josephine's granddaughter—giving the book an intimate and heartfelt perspective. Her memories are of loving grandparents and a warm welcoming home. Rather than recounting just the vast number of major historical milestones in Doolittle's life, Hoppes delves into how those moments impacted his relationship with his wife. The book highlights how she was an integral part of his success, providing emotional and practical support while raising their children and managing the challenges of being married to a larger-than-life figure in a time of war and rapid technological change. The picture Hoppes paints will resonate with most service families. Interestingly, unlike many of the tech/history tomes I review, this story could be enjoyed by service personnel and their families.

One of the central themes of *Calculated Risk* is how the challenges of Doolittle's career affected their marriage, particularly during World War II when he was often away for extended periods. The couple's letters and correspondence provide unique insight into their struggles and deep affection for each other, balancing the weight of his duty to his country with his devotion to his wife and family.

Hoppes also emphasizes the emotional strength and resilience of Josephine, who often had to manage the household alone while dealing with the uncertainty of her husband's safety. She is portrayed as more than just a supportive spouse and emerges as a strong, independent figure who had to navigate the emotional strain of being married to a military hero whose obligations frequently took him away from home. Their partnership is presented as one of mutual respect and love, with both partners making sacrifices for the greater good of their family and country.

While Jimmie Doolittle's wartime exploits and contributions to aviation history are unavoidable in any discussion of his life, *Calculated Risk* focuses on the quieter, personal moments that defined the couple's bond. The book provides a fuller picture of Jimmie Doolittle as not just a war hero, but as a devoted husband and father whose relationship with his wife anchored his life through its most turbulent moments.

Calculated Risk is a refreshing and deeply personal take on the Doolittles' lives, offering readers a glimpse into the private world of a public hero and his equally remarkable wife. Hoppes' portrayal of their enduring love and partnership is the heart of the book, making it a standout biography that explores the human side of one of America's greatest aviators. I highly recommend this book.

Gary Connor, docent, National Packard Museum, Cortland OH

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The Hill: The Brutal Fight for Hill 107 in the Battle for Crete. By Robert Kershaw. Oxford UK: Osprey, 2024. Maps. Photographs. Notes. Bibliography. Index. Pp. 368. $30.00. ISBN: 978-1-4728-6455-0

Kershaw served in in the British army, retiring as a colonel in 2006. Since then, he has immersed himself in military history. Over the years, he has led battlefield tours in Europe and the United States. He also has authored more than ten books on military history.

In the spring of 1941, the German army pushed British Commonwealth forces from mainland Greece to Crete, about 200 miles south of Athens. The Royal Navy deterred German efforts to launch an amphibious assault. However, the German *Luftwaffe* had chased the Royal Air Force back to Africa. German air supremacy would prove decisive in the battle for Crete.

Kurt Student, commander of Germany's airborne units, had seen his troops proven almost invincible as they achieved repeated success in the first 18 months of the war in Europe. He convinced the German high command that his forces, with sufficient air-land reinforcements, could defeat the enemy with limited seaborne support. Student proved correct in his assessment, but at an enormous cost in men and material. German casualties on the battle's first day exceeded the number of losses for any single day to that point in the war. Furthermore, Germany never again would launch a large-scale airborne operation, whereas the Allies embraced the use of paratroopers.

Kershaw relies on official accounts and personal reminiscences to describe the fierce fighting around Maleme airfield and nearby Hill 107 at the northwest end of the island. After German airborne troops failed to capture other airfields, the airfield near Maleme became essential to German success.

The early chapters discuss German operations in Greece, the British withdrawal to Crete, Student's strategic vision, and deployment of Commonwealth units. Forces from New Zealand (particularly 5 Regiment) defended the island's west.

As the battle unfolds, Kershaw alternates each side's perspective at a particular time. Despite having superior forces, the New Zealanders withdrew from Hill 107 during the night of May 20-21. Kershaw carefully examines that decision. For various reasons, the 5 Regiment commander failed to exercise proper command. The three battalion commanders, who expected orders to counterattack the Germans, instead remained in defensive positions. The continuous pounding by the *Luftwaffe* affected their decisions.

The infantry, meanwhile, felt they were winning; because they could see the losses they were inflicting on the paratroopers. The Germans, on the other hand, knew they were losing, unless they took Hill 107. Controlling the hill enabled mountain troops to land the next day. Having at last achieved an advantage in combat power near Maleme, the Germans eventually forced Commonwealth commanders to evacuate Crete.

This book is highly recommended for anyone interested in airborne or air-land operations or both. It reinforces the importance of aggressive leadership—a quality in which the Germans excelled, to the detriment of the New Zealand forces.

Steven D. Ellis, Lt Col, USAFR (Ret), docent, Museum of Flight, Seattle

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The Fight of Their Lives: A 21st Century Primer on World War II. By Andy Kutler. TX: Black Rose Printing, 2024. Maps. Bibliography. Index. Pp. 373. $32.95. ISBN: 978-1-68513-479-2

There are some wonderful, scholarly works available that cover mankind's greatest conflict: Winston Churchill (all six volumes), Liddell Hart, Martin Gilbert, John Keegan, Rick Atkinson (three volumes) are among the very best of these. Thousands of authors have provided books on specific battles, campaigns, units, and individuals that provide vastly more details about the war. What is in short supply are books that provide—at the general readership level—an overall perspective of the war in easy-to-understand language. Andy Kutler has provided such a book.

Kutler is neither an historian nor a military specialist. He is a strategic communications professional with decades of experience in both industry and government. He must have been very good at his job of communicating, because his book brings the entirety of the war—the big picture—to the reader in wonderfully crafted prose.

The book breaks the story of World War II into three distinct sections: the European Theater, the War at Home, and the Pacific Theater. Three things really stood out as I read the book. The first is that Kutler provides in both of the combat sections—Europe and the Pacific—very adequate histories of the events that led up to eventual war. The actual combat events oftentimes don't make much sense without an understanding of what led to those events. The second standout is the use of vignettes at the end of each chapter that briefly discuss various people, events, or things associated with that chapter (all of which, by the way, are fairly short). The people he covers are not only the Pattons and Nimitzs, but also the Sgt Basilones and Lt Boucks. The third item that made this book great is the entire middle section—the war at home. This is just as important—and, perhaps, even more meaningful in today's context—as the two combat sections. Here, Kutler covers the economy of the 1920s and 30s, America's industrial capacity, the roles of women and blacks, sexism and prejudice, the injustice of the Japanese-American solution, and the Manhattan Project. World War II was important not only for the territory gained and lost, but also for the political, economic, and social changes it brought about.

One question readers of the *AFHF Journal* might have is why a general book such as this is included among aerospace history reviews. I feel that, every so often, it is good to understand the broader picture and air and space power's roles within that larger context. This book certainly covers air power along with sea, ground, and economic power.

Another question is to whom this book is applicable. My answer is nearly everyone. In 45 years of giving tours at the National Air and Space Museum, I was always appalled at the lack of even fundamental understanding of this seminal period in US history. It wasn't just the kids who had no idea what this war was about or who fought it and where it was fought, but their parents as well. Kutler has provided what he promised: a primer that outlines the war in its entirely. Most Americans should read and digest this excellent book.

Col Scott A. Willey, USAF (Ret), Book Review Editor, and former National Air and Space Museum docent

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Operation *Allied Force* 1999. By Brian D. Laslie. Oxford, UK: Osprey, 2024. Photographs. Maps. Diagrams. Illustrations. Bibliography. Index. Pp. 96. $25.00. ISBN: 978-1-47286030-9

March 2024 marked 25 years since the United States military and its allies waged an air war to stop Yugoslavian atrocities in Kosovo. Planners intended the operation, codenamed *Allied Force*, to last 72 hours. Instead, the operation lasted much longer: 78 days.

The latest entry to Osprey's Air Campaign Series covers this brief, but important, chapter in military history. Dr. Laslie is Command Historian at the US Air Force Academy. There may be no better man to survey the operation, since he has written extensively on US air power and doctrine in the Cold War and post-Cold War eras.

Laslie begins the book with an introduction and chronology that provide context to the conflict. Yugoslavia's socialist federation began to unravel after the death of its longtime president, Josip Tito, in 1980. By the early 1990s, ethno-nationalist ambition turned into war as four of Yugoslavia's six republics tore themselves from the federation. Yugoslavia's president, Slobodan Miloševi , determined to stamp out an ethnic insurgency in Kosovo, a breakaway province, by expelling its Albanian majority. The subsequent humanitarian crisis, which flooded neighboring countries with refugees, provoked the United States and its European allies into action on March 24, 1999.

Laslie next examines the units, command, and weaponry of both sides. Thirteen NATO nations mobilized crews and craft that included US F–15 Eagles, UK Harriers, and French Jaguars. By contrast, Yugoslavia could field a mere two fighter regiments, only one equipped with fourth-generation aircraft. Even then, the regiment's Mikoyan MiG-29 jet fighters suffered from broken avionics and poor maintenance. Where the Yugoslavs would prove their mettle would be in anti-aircraft (AA) defenses, where they studied NATO tactics and monitored airbases. This defensive acumen showed itself in the loss of a USAF F–117 Nighthawk in the operation's first week.

The campaign itself occupies two-thirds of the book. The operation's initial scope of 50 targets in three days gave way to almost 1000 targets struck over two-and-a-half months. The region's notorious weather hindered NATO missions, while Yugoslavian AA crews' selective targeting preserved defensive strength. Rather than exhausting willpower, the failure to achieve a swift victory pushed NATO members to increase attacks on Yugoslavian units in Kosovo and threaten a land assault. Faced with a ground war and the loss of Russian support, Miloševi withdrew his forces and accepted a NATO occupation of Kosovo.

Laslie ends the book with a short analysis of the operation and its aftermath. NATO's victory in *Allied Force*, achieved with few losses (two crewmen killed in an accident), reinforced the idea (one pushed by eminent historian John Keegan, no less) that war can be won by air power alone. Laslie argues that air power is a crucial dimension to ultimate victory but refuses to consider it the sole dimension. Twenty-five years of hindsight show *Allied Force* was the exception, not the rule.

Andrew Montiveo, Los Angeles CA

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Fighting From Above, A Combat History of the US Air Force. By Brian D. Laslie. Norman OK: University of Oklahoma Press, 2024. Notes. Bibliography. Index. Pp. 270. $29.95 paperback. ISBN: 978-0-8061-9367-0

Laslie is the Air Force Academy Command Historian and the author of numerous articles and books, including *Air Power's Lost Cause: The American Air Wars of Vietnam.* He was Deputy Command Historian at both NORAD and US Northern Command. A 2001 graduate of The Citadel, he received his PhD from Kansas State University in 2013.

This book offers an in-depth exploration of the history and development of the USAF from its earliest days to modern times. Laslie discusses key strategies, technologies, and missions that have shaped the Air Force into a global power, emphasizing combat operations, innovations in air warfare, and its role in shaping military tactics and national defense policy.

Tracing the origins of American air power, Laslie looks at the early years of military aviation during World War I and the formation of the Army Air Service. He highlights the vision of early pioneers, such as Billy Mitchell, who advocated for a separate air force and emphasized the strategic potential of air power. The Air Service was initially seen as an auxiliary to ground forces, but experiences in World War I and the interwar years began to lay the foundation for a new understanding of air warfare.

The book examines the critical role of air power during World War II, when the military's focus on strategic bombing came into full force. Laslie discusses key campaigns and the pivotal role played by the USAAF in gaining air superiority over the Axis powers. He particularly highlights the development of long-range bombers which allowed the US to conduct far-reaching bombing campaigns. The atomic bombings were the culmination of this strategic bombing approach, forever altering the landscape of warfare and international relations.

Laslie notes that these wartime experiences significantly shaped the service's postwar development. The creation of the independent USAF in 1947 marked the beginning of a new era, where air power would play a central role in American defense strategy.

During the Cold War, the Air Force became the linchpin of US strategic deterrence, particularly through development of nuclear-capable bombers and ICBMs. The USAF was structured to conduct both conventional and nuclear missions, maintaining a constant state of readiness during the tense standoff with the Soviet Union. Laslie reflects how the Strategic Air Command, under the leadership of General Curtis LeMay, epitomized the Air Force's focus on nuclear deterrence. The book details how the threat of nuclear war shaped air strategy and global military posture during this time.

Laslie addresses the modernization of the Air Force and its role in recent conflicts. From the Gulf War (where precision-guided munitions and stealth aircraft revolutionized air combat) to the Global War on Terror, Laslie highlights the increasing sophistication of air technology and tactics. He emphasizes how technological advances, such as drones and cyber capabilities, have changed the nature of air warfare.

This is a general and historical synthesis of the USAF that focuses not only on its combat history, but also on its broader strategic and technological developments. It is based almost entirely on the work of other historians, flyers, and scholars. However, its solutions and historical analysis are Laslie's alone. It is well worth the read.

Frank Willingham, NASM docent

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Nightstalkers: The Wright Project and the 868th Bomb Squadron in World War II. Richard Phillip Lawless. Havertown PA: Casemate Publishers. 2023. Photographs. Notes. Bibliography. Appendices. Pp. 406. $44.95. ISBN: 978-1-63624-205-7

Richard Lawless tells the story of one of the Army Air Forces' lesser-known bomber squadrons and its unique mission in the Pacific theater. Unlike other traditional bomb squadrons, the 868th's mission was night bombing. For this mission, its B–24s were equipped with the classified Low Altitude Bombing (LAB) system. The LAB consisted of four key components: airborne search radar (SCR-717-B); interrogator-responder (SCR-729); radio altimeter (AN/APN-1); and a low-altitude, precision-bombing attachment/computer (AN/APQ-5). Combined, the LAB components enabled the aircraft to fly at low altitude and detect and attack ground targets, including ships.

To fully tell the story of the 868th, Lawless devotes the early chapters of the book to the development of the LAB system. He explains the pivotal role Col William "Bid" Dolan played in the system's development, initial testing on the Douglas B–18 (against German submarines), and later installation on the B–24 Liberator. Those aircraft were designated as SB–24s. Because of Dolin's importance to the development of other airborne radars and the highly classified nature of his work, he was not selected to lead the unit when it deployed to the Pacific in August 1943. That job went to Col Stud Wright. This is how the unit's capability came to be referred to as the "Wright Project."

Once in the Pacific, the unit's designation changed several times until it finally became the 868th Bomb Squadron (*Snoopers*). Initially based on Guadalcanal, its mission was sea attack and night harassment. Squadron aircraft operated individually to search for and attack Japanese shipping during missions known as "heckling runs." When Japanese maritime targets became scarce, the 868th mission grew to include serving in a pathfinder-type role to lead daylight bombers to their targets.

Written to fulfill a promise made to squadron veterans, the book tells the *Snoopers'* story with a great level of detail. Lawless includes multiple excerpts from official reports, interviews, and personal memoirs. He wisely chose to directly quote those sources rather than conveniently edit them to a shorter length. His inclusion of these original sources provides an up-close and thorough history of the unit. The 868th's story is advanced month-by-month, sometimes mission-by-mission, as the unit hopped across the Pacific theater. Lawless also includes details of the politics of the unit's employment and provisioning and its place in the Pacific Forces command structure. Finally, the book includes numerous pictures and twelve appendices filled with additional information that brings the unit's story to life.

The inclusion of all these details, photos, and appendices adds to the complete nature of the work. The ultimate result is a complete history of the 868th Bomb Squadron. *Nightstalkers* will appeal to readers wanting to know more about bomber operations in the Pacific theater, the SB–24 Liberator, and the Army Air Forces' use of radar technology for night operations. For readers looking for a book of "there I was" stories, *Nightstalkers* includes numerous stories and personal remembrances to keep readers engaged. This fascinating narrative delivers on target.

Lt Col Daniel J. Simonsen, USAF (Ret), Alexandria VA

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Carnation Revolution, Volume 1: The Road to the Coup That Changed Portugal, 1974 *and* **Volume 2: Coup in Portugal, April 1974.** By Jose Agusto Matos and Zelia Oliviera. Warwick UK: Helion. 2023 and 2024. Photographs. Maps. Tables. Diagrams. Illustrations. Index. Bibliography. Notes. Pp. 78 and 74. Cost: $29.95 paperback each. ISBN: 978-1-80451366-8 and 978-1-80451492-4

Portugal was once a great power in global exploration and colonization. Five hundred years ago, the Portuguese Empire spanned the globe. But, by the early 1970s, the tides of history had changed; and the Empire was a shadow of its former self under unrelenting pressure by national liberation movements seeking freedom and autonomy. In the early 1930s, Portugal overthrew its monarchy, and the fascist/autocratic movement that found fertile ground in Spain found equal success in Portugal. While nominally a popular democracy, democratic institutions were a sham. A secret police organization kept domestic order, and the small Portuguese Military fought unpopular and unsupported wars in Africa. That is the stage for Matos and Oliveira's excellent work covering the Carnation Revolution. It is not an easy read: the translated text of this two-volume set is readable, but the politics and personalities are extremely complicated.

The first volume lays the groundwork by detailing the socio-political climate in Portugal before the coup. The authors meticulously outline the discontent within the military, rising revolutionary sentiment, and organizational efforts of the Armed Forces Movement (MFA). Interestingly, they specifically include a discussion of the role airpower played. After reading and re-reading the narrative, I grouped the airpower tasks into three broad categories.

Strategic Planning: Airpower was considered a critical element in the coup. The MFA understood the importance of controlling the skies to ensure swift and unimpeded movement of troops and prevention of counter-actions by forces loyal to the regime.

Air Force Alignment: Airpower alignment with the revolutionary forces was essential. The authors highlight how key figures within the Air Force were persuaded to join the movement, ensuring that this branch would not be used against the revolutionaries.

Communication and Coordination: Here, airpower played an important, if not pivotal, role. Air assets were used to relay messages and ensure that movements of different factions of the MFA were coordinated.

A complicating factor was that a sizable portion of the small and ill-equipped Portuguese Air Force was stationed in the colonies along with its air and ground crews.
Volume 2 focuses on the actual coup execution and its aftermath. It provides a blow-by-blow account of the events on April 25, 1974, and the days that followed, including immediate political shifts and establishment of a new government. Given the large logistics "tail" that any Air Force brings to an operation, as well as the inherent complexity of mid-century aircraft, I was surprised that the Portuguese Air Force was so effective in its critical tasks:

Securing Strategic Locations: One of the key operations involved securing locations such as airfields and communication centers. The Air Force played a crucial role in these operations, ensuring that these critical points were under revolutionary control.

Preventing Loyalist Resistance: Counter actions by loyalist air units was a significant concern. The authors describe how revolutionary forces preemptively neutralized these threats by grounding aircraft and securing airbases.

Psychological Impact: The regime's forces, aware of the MFA's control over the air, were less inclined to mount an armed resistance, knowing they would face not just ground forces, but also air strikes.

Post-Coup Stability: In the immediate aftermath, the Air Force was instrumental in maintaining stability. Aerial reconnaissance and quick deployment of troops helped the new government consolidate power and address pockets of resistance or unrest.

Today, Portugal is considered a stable functioning democracy and key NATO contributor. The dissolution of the Portuguese Empire continues, replaced by the Community of Portuguese Language Countries (CPLC), a cultural and intergovernmental NGO that serves as a successor.

These volumes provide a detailed and nuanced account of the April 1974 coup, with a surprising emphasis on the multifaceted role of airpower in its success. Extensive bibliographies and notes make them useful to serious historians. There are copious photographs throughout, as well as large sections of full-color drawings. The narrative is not an easy read, but it is worth the time the reader invests. Matos and Oliveira make a compelling case that the integration of air assets into the coup's planning and execution highlighted the strategic foresight of the MFA and highlighted the importance of air superiority in mid-20th century revolutionary movements. Through meticulous research and compelling narrative, they illustrate how airpower was not just a supportive element but a decisive factor in the success of the revolution.

Gary Connor, docent, National Packard Museum, Cortland OH

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The AVRO Shackleton: The Long-Serving 'Growler.' By Jason Nicholas Moore. Stroud UK: Fonthill, 2023. Photographs. Illustrations. Diagrams. Glossary. Bibliography. Index. Appendices. Pp. 329. $60.00. ISBN: 978-1-78155886-7

It seems that whenever air advocates needed to demonstrate the superiority of airpower over land and sea power, the easiest target was the navy. Mitchell's sinking of the *Ostfriedland*, LeMay's 1940 sortie over the *Rex*, and the non-stop, around-the-world flight of *Lucky Lady II* were all designed to demonstrate airpower's fundamental superiority with regard to global power projection. So why do maritime patrol aircraft feel like the red-headed stepchildren in most nation's orders of battle? All major global powers field some form of maritime-patrol aircraft to secure trade routes and establish defense in depth. Maritime nations such as the UK invest heavily in aircraft with long range, high endurance, and adequate anti-shipping/submarine weapons. *AVRO Shackleton* is an in-depth analysis of one of the longest serving maritime-patrol aircraft to surveil the world's waters.

Moore presents an in-depth analysis on how the Shackleton came to be, The superb designer Ray Chadwick built on the strengths of the basic Manchester medium bomber to create the Lancaster and Lincoln bombers. He also borrowed from the B–17s, B–24s, Catalinas, and Hudsons provided under Lend-Lease, as well as other British-manufactured airframes (e.g., Whitley, Anson, Halifax, Warwick, Wellington, and Sunderland). Moore provides details on all these aircraft, usually in easy-to-read chart form. In fact, the entire book is easy to read. His conversational style flows effortlessly. Whether discussing technical minutia, historical personalities, or world events, he leads the reader through the information. So many aircraft books tend to drown the layperson in details of little relevance to the big picture.

That is not to say Moore ignores details. There has always been a question as to whether Packard-built Merlins were installed on RAF aircraft or reserved for P-51 Mustangs only. Moore shows that Packard Merlin 65s were used on Lancaster B.IIIs as well as some Lincoln B.IIs, since they produced the same 1750 bhp. If there was a significant logistics/support difference, it was not great enough to prevent the exchange.

The Shackleton served for over 40 years. Moore presents its many missions and the bases that were used. But there are no "people" stories in the book (other than a few brief sentences about the noise level of the Griffon engines with their counter-rotating props) to humanize the story. He talks about the "Shackleton Ear" condition caused by the combination of noise and inadequate hearing protection and discusses cold cockpits and hot aft fuselages, but there is little "human" in his narrative.

A discussion of weapons is also noticeable for its absence. Moore talks a lot about gun configurations and talks about the large weapons bay but says nothing about what weapons were carried. On the topic of weapons, Moore talks a lot about the development of the Lincoln and its superb capabilities. Interestingly, America loaned the UK a number of B–29 Washingtons at the same time the RAF was devoting significant resources into developing the Lincoln and the Tudor transport. Why? Was sustaining the Manchester line all a bit of "buy Britain" political posturing? Moore takes a brief detour when discussing the British Nimrod AEW program to label it as such.

The omissions aside, *AVRO Shackleton* is a quality book, using paper that shows the photos and profiles in excellent detail. The glossary will help the non-aviation-oriented reader. Given the strong research and citation, this book will be useful to many contemporary historians. Most assuredly, if there are oceans, aircraft will patrol them.

Gary Connor, docent, National Packard Museum, Cortland OH

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The Mighty Eighth: Masters of the Air Over Europe 1942-45. By Donald Nijboer. Oxford UK: Osprey, 2022. Illustrations. Photographs. Index. Pp. 320. $35.75. ISBN: 978-1-4728-5421-6

This is not Roger Freeman's classic *The Mighty Eighth*, but it is a very good introduction to the USAAF's Eighth Air Force in World War II. The book itself is a very well-made hardback with heavy semi-gloss paper that permits very good reproduction of photographs and color illustrations.

The text is comprised of an introduction and seven chapters. Nijboer chose to organize the book more or less by subject rather than chronologically. The "Introduction" is actually a chapter describing the background to operations in Europe. As examples, it discusses the Boeing 299 (prototype of the B–17) and the evolution of the Eighth Air Force into a vast organization comprising a bomber command, a fighter command, an air service command, and a ground support command. It also touches on the issues surrounding appropriate defensive formations of the bombers, the need for escort fighters for the bombers, and what sorts of aircraft these escorts should be. As an example of the latter, Nijboer discusses the unsuccessful use of the YB–40.

Chapter 1 discusses the daily lives of not only the combat crews, but also the lives of the more numerous support personnel. Chapter 2 presents the actual strategic bombing of Germany and the process of working out the escort issues. Chapter 3 describes the organization of the Eighth Air Force as it evolved over its life. Chapter 4 is made up of short histories and descriptions of the aircraft flown by the Eighth. Chapter 5 looks into how the personnel were trained, the equipment they used, and the evolution of tactics employed over the three years of combat. Chapter 6 is entitled "The Experience of Battle" and describes what combat was like, perhaps as well as can be done in a short text. Chapter 7 is a useful collection of short biographies of the leaders of the Eighth; its commanders; the commander of the USAAF, Gen Henry Arnold; and some of the better-known aircrew.

While the book does not claim any appendices, functionally, it has four quite useful ones. This book is very well written, though I must say that it was the description of the fighters in Chapter 4 (particularly a mention of the use of the Mustang by the Chinese) that tipped me off to the fact that this book is actually a pastiche! When I checked the "Acknowledgements" section, it said, "This book is a compilation of the following Osprey books:" and goes on to list 35 Osprey titles. It is a very skillful pastiche.

Leslie C. Taylor, NASM docent, Smithsonian Institution, Washington DC

Against Hitler's Luftwaffe In The Balkans, The Royal Yugoslav Air Force At War In 1941. By Djordje I. Nikoli and Ognjan M Petrovi . Barnsley UK: Air World, 2023. Photographs. Appendices. Index. Bibliography. Pp. 224. $42.95. ISBN: 978-1-39908-897-8

For most readers, knowledge of the role Yugoslavia played in World War II is thin. When this book showed up, I jumped at the chance to learn more about that role.

The first chapter familiarizes readers with Yugoslavian aviation from the end of World War I until early 1941. Yugoslavia used aviation equipment and aircraft left by evacuating occupying forces to lay the foundation for both the Royal Yugoslav Air Force (RYAF) and a domestic aviation industry that survives today. The 1929 global depression placed numerous obstacles in the path of that growth. But the gathering of war clouds of the mid-1930s started a period of intense growth in size and capability. Yugoslavia began to shop the global aviation market for state-of-the-art equipment to create combat and support arms as well as a domestic airline.

The best analogy to their efforts is with the current cultural trend toward fantasy sports teams, where "managers" can choose the members of their "dream team" regardless of the real-world team allegiance of their preferred players. In the aviation counterpart, Yugoslavia could buy from the UK, Germany, France, Italy, and the US, as well as domestic designers. Fighter squadrons could be equipped with Bf 109Es, Hurricane Mk Is, and domestic Ikarus designs. Bombers could include Blenheims; Dorniers; and, their favorite, the Savoia-Marchetti 79s. After a brief shopping comparison, the domestic airline settled on standardizing with the dated, but still elegant, Lockheed Electra 10. Copious photographs, technical data, and detailed service histories are included on all of these, and more.

The service deployment history section is short. The RYAF was taken by surprise on 6 April 1941 and lost between 30-50% of its aircraft. The remainder was constantly outnumbered and suffered grievous losses in both offensive and defensive operations. The war was over in eight days. Many RYAF aircraft supported evacuation of the royal family and government officials, while the Axis powers divided the country and spoils.

The extraordinary photographs of aircraft, personnel, and facilities set this book apart. However, the narrative is occasionally hard-to-read. The authors' English is not the problem: Serbian rank and organizational abbreviations are. Numerous charts show Allied and Axis equivalents for these organizational names, but the constant stopping to find and interpret the charts makes for an awkward reading experience. The last two-thirds of the book discuss each aircraft type in detail and the modifications made by domestic technicians to make them more supportable. For example, Hurricanes got German DB 601 engines along with new aircraft model designations; and Do 17s got new defensive armament along with their new model designations. The result was there were almost twice as many model designations as there were aircraft. The photographs were extremely useful for keeping everything organized.

The authors did not mention the inevitable blue-on-blue encounters by Bf 109s from both sides. Luftwaffe bomber crews must have been extremely wary when approached by any 109s. Several photos show Yugoslav 109s wearing more-visible, modified national insignias. Also, there was no discussion of early-warning systems or command-and-control. The Order of Battle information was interestingly tedious; but, without lines of command, it was of minimal use.

I give this book a qualified endorsement. Without question, I am a lot smarter about the RYAF in April 1941 than I was before reading. But I have the nagging feeling that there is a lot of related subject matter to be discovered.

Gary Connor, docent, National Packard Museum, Cortland OH

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The Berlin Airlift: Remembering the Humanity. By Francis Gary Powers, Jr. Midlothian VA: Lulu Press, 2024. Maps. Diagrams. Illustrations. Pp. 102. $25.00 paperback. ISBN: 978-1-304-53061-5

This graphic novel is a poignant and insightful reflection on one of the major historic events that took place during the Cold War. Powers is the son and namesake of the famous U–2 pilot Francis Gary Powers. He brings a personal touch to the story as he explores the impact of the Berlin Airlift on the people involved.

This book delves into the humanitarian efforts of the Western allies to supply the isolated city of West Berlin with essential supplies (food, fuel, medical supplies, et al.) during the Soviet blockade in 1948. Powers highlights the selfless acts of the pilots and civilians who came together to help their fellow citizens, showcasing the power of human compassion and resilience in times of crisis.

Throughout the book, Powers emphasizes the importance of remembering the humanity behind the Berlin Airlift, arguing that it serves as a powerful reminder of the potential for unity and cooperation in the face of adversity. He also discusses the legacy of the airlift and its lasting impact on international relations, emphasizing the lessons that can be learned from this historic event.

Overall, this fine little book is a compelling read that sheds light on a pivotal moment in history and celebrates the spirit of solidarity that prevailed during a challenging time. Powers' perspective as the son of a renowned Cold War figure adds a unique dimension to the storytelling, making this book a must-read for anyone interested in the Berlin Airlift and its enduring significance.

Col Charles P "Chuck" Wilson, USAF (Ret), KC–135Q, U–2 Pilot, NASM docent

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Survival in the South Pacific: A Lost Airman's Desperate Rescue amid the Maelstrom of War. By Robert Richardson. Havertown PA: Casemate Publishers, 2024. Maps. Tables. Diagrams. Illustrations. Photographs. Notes. Appendices. Glossary. Bibliography. Index. Pp. 318. $37.95. ISBN: 978-1-63624-415-0

How does one tell the story of a man's struggle for survival after an aircraft crash in the jungles of a South Pacific island while providing context of what led him to be there in the midst of the Second World War? Add to this the perspectives on the indigenous peoples who were also affected by this airplane incident. Robert Richardson does just that, and he does so within a masterfully told story. He is the son of the subject of his book, Lieutenant Leonard Richardson of the 403rd Troop Carrier Group. His research into his father's crash and survival enabled him to provide a perspective on the Second World War in the Pacific that is unique and fascinating.

The story Richardson presents tells of the struggles to maintain and gain a better foothold in the South Pacific in the early months of World War II. The focus, though, is not on the battles. Rather, it is on the establishment of a secure logistics base from which combat operations could be adequately supported. With Coral Sea and Guadalcanal as striking backdrops, Richardson tells of the struggles of the men in construction battalions (Seabees) and air units to establish airfields and resupply depots on islands with inhospitable weather and deadly tropical diseases. Once established, the operational tempo continued to beat on them physically and mentally.

It was into this maelstrom, after completing over a year of various training in the states, that a young navigator arrived on one of these small tropical islands, Espiritu Santo, to fly missions in support of operations in the South Pacific. On one of these seemingly routine missions, Lieutenant Richardson found himself in a struggle for life after his plane crashed just miles from his home base. With two broken legs and other life-threatening injuries in an unforgiving environment, he struggled for days, dragging himself through the jungle down steep, rocky terrain. It was during this struggle for survival that Lieutenant Richardson encountered the third facet of his son's account, the indigenous people of Espiritu Santo.

The people of the South Pacific islands in the reports of early explorers were savage and hostile, with some reports of cannibalism. The people that the lieutenant encountered were far from that. They helped to not only bring him to a safe area, but also found and guided the American military search party to their village to take Richardson back to the air base and medical treatment facilities.

Richardson's telling of his father's story is a well-crafted account of the three levels of history in the South Pacific during World War II: a man, a people, and a war. This is a well-written text with plenty of personal accounts of both Richardson's father and others who were there with him. In his appendices, he goes a step further to tell of what happened to many of these men after the crash of 1943. The personal accounts from the men themselves are invaluable sources that fill out this truly personal story.

Robert J. Shipp, Jr, Ph.D., Maj, USAF (Ret)

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The Argentine Flying Fortress: The Story of the FMA IA-58 Pucará. By Santiago Rivas. Great Britain: Air World, 2023. Tables. Diagrams. Illustrations. Photographs. Bibliography. Index. Pp. 272. $49.95. ISBN: 978-1-39909-792-5

Rivas is an authority on Latin American aviation who has published 24 books and numerous magazine articles worldwide. Here, he has produced a comprehensive and remarkably detailed operational history of the Argentine Pucará, a counterinsurgency, twin-engine light attack/observation aircraft, manufactured by Fábrica Militar de Aviones (FMA). Think of the Pucará as a South American cousin to the North American Rockwell OV–10 Bronco.

He claims ". . . the Pucará represents the pinnacle of the Argentine aerospace industry, given that it was one of the most manufactured aircraft, the first to enter combat in an international conflict and the first to be sold abroad." It was designed to counter the growing threat of rural guerrillas in Argentina after World War II and was created, in large part, by former Axis aeronautical engineers who emigrated from Europe to Argentina in the 1940s and 1950s.

In the 1960s, the government began developing a guerrilla-focused aircraft that was "slow," had a good deal of "endurance," and possessed "high firepower." Jets, for practical tactical reasons, were ineffective in meeting this insurgency challenge. Thus, the Pucará was conceived.

The FMA IA-58 Pucará was a twin turboprop, low-wing, all-metal, two-place, T-tailed, retractable tricycle-gear aircraft manufactured to carry heavy internal weapons and capable of landing on roads or rural fields. The Pucará's first flight was in 1969, but it was not delivered to the Argentine Air Force until 1975 due to a myriad of manufacturing birthing issues.

The Pucará and the OV–10 were both close-support/light attack/observation aircraft and competed in the international market. They first flew within a year of each other. Four times as many Broncos as Pucarás were produced, and the former had twice the success in number of international buyers. Rivas believes "lack of experience and trained sales personnel" and "inefficient(cy) in after-sales support" limited Pucará's foreign sales. Only Colombia, Uruguay, and Sri Lanka, all burdened with similar guerrilla issues, were Pucará buyers.

The Pucará was marginally larger than the Bronco, slightly faster, and had a higher ceiling. Pilots who had flown both aircraft, Rivas reports, seemed to prefer the Pucará because of its better cockpit visibility, greater armament capability, superior aerobatics, and more dependable one-engine performance. Criticisms between the Argentine aircraft and the Bronco were that the former had less range, consumed more fuel, and had a history of mechanical issues.

Pucarás were the first Argentine aircraft to land on the islands during the Falklands/Malvinas War of 1982. Runways there were too short for the Argentine jet fighters. Unfortunately, they didn't fare well against the British; ten were destroyed. Rivas blames the poor performance in battle on the "lack of training of most units in air combat against aircraft other than those of the unit itself." Two Pucarás were credited with shooting down a British Westland helicopter, the only air victory for Argentina during that conflict.

The book has three parts: Development of the Pucará, Operational History in Argentina, and Operational History Abroad. Pilot narratives from the Falklands/Malvinas conflict (which, unfortunately, lack detailed attribution) were most interesting. They would have been enhanced with maps showing operations in that 74-day conflict. At times, the book was difficult to read because of its detail. However, having said that, this book will certainly serve as one of the most informative resource volumes about the Pucará's manufacturing and service history.

David S. Brown, Jr., volunteer, Museum of Flight, Seattle

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The Beagle Conflict: Argentina and Chile on the Brink of War, Volume 1: 1904-1978 *and* **Volume 2: 1978-1984.** By Antonio Luis Sapienza Fracchia. Warwick UK: Helion, 2023 and 2024. Photographs. Maps. Charts. Drawings. Index. Bibliography. Notes. Appendices. Pp. 108 and 92. $29.95 paperback each. ISBN: 978-1-80451373-6 and 978-1-80451466-5

I must thank Helion for investing the time and resources in their several *Regions At War* series. While familiar with many of the locations and vaguely aware that various regions were not the most stable, I seldom knew or understood the "Why." Argentina/Chile is a classic example. I knew Argentina did not have good relationships with its neighbors. I remembered the Chilean populist/Marxist experiment that somehow resulted in assassinations in Washington DC. But the region seldom made the "Top Ten Flashpoints" lists, and neither party had nukes, so I relegated them to the back burner. These two books taught me how wrong I was and how close these two regional powers came to war. Peace was not in the best interests of Argentina's unstable military junta so, when a war with Chile did not provide the necessary civil distraction, it provoked a war with Great Britain over the Malvinas a few years later.

Before reading, I researched why, in the twentieth century, with every square inch of the earth's surface mapped and surveyed, there were still border disputes. In 2024, Venezuela and Guyana sounded the war trumpets over border sovereignty and natural-resource issues. Perhaps the Spanish are the cause. As their empire collapsed, treaties referenced unreliable geographic boundaries that were not always agreed upon by the principals involved. Add in numerous imperialist/capitalist/national liberation actors who helped local governments interpret the boundaries in a self-serving manner, and the stage for never-ending conflict was set.

Argentina and Chile could not agree on which country "owned" a group of islands just south of the east-west Beagle Channel. Whoever controlled these could control the channel, a key waterway that offered a gentler passage around Cape Horn. This remote area is about 1400 miles from both Santiago and Buenos Aires. With neither country possessing significant force-projection capacity, the logical military instrument for any confrontation would be air power.

Sapienza excellently enumerates both countries' air orders of battle. Both possessed good aircraft and skilled air and ground crews capable of using them. Argentina even possessed an aircraft carrier capable of operating jet attack aircraft. When aircraft operated by national airlines were added to the mix, the numbers and capabilities of the adversaries exponentially increased. Both countries had systems obtained through US Military Assistance and Foreign Military Sales programs. American bureaucrats often rationalized that providing military equipment to "unstable" clients kept them on a short lease and prevented them from acting against their own, or America's, best interests. The rationalization is flawed. That short leash did not impede Chile or Argentina, just as it has not really slowed many other ex-friends (e.g., Iran).

Fortunately, there was an international actor of some influence with both countries who was able to relieve the immediate pressure and encourage the actors to prepare a treaty which clarified boundaries and protocols to avoid future "misunderstandings." But this intervention came at the last moment. An H-hour and D-Day had been identified, and military assets were deployed. Both countries appeared willing to use their full range of available weapons. The region's remoteness might have limited civilian casualties, but once the martial genie was out of the bottle, there was no way to predict an end game with any accuracy.

I highly recommend these for anyone with an interest in the region or with a broader interest in international conflict. Helion is doing an excellent job constantly improving this series. The bibliography and notes are excellent. The photographs and artwork advance the very readable narrative. While the referenced treaty did bring an end to the Beagle Conflict, it did not answer all of the open questions. Diplomats must still address the differences in the Chilean and Argentine Southern Economic Zones. And with increased third-party fisheries exploitation, other untapped Antarctic resources, and internal problems, conflict in the region is still a possibility.

Gary Connor, docent, National Packard Museum, Cortland OH

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Battle of Britain: Attack of the Eagles: 13 August 1940 – 18 August 1940. By Dilip Sarkar. Barnsley UK: Air World, 2024. Glossary. Map. Bibliography. Index. Photographs. Pp. 269. $49.95. ISBN: 978-1-39905-791-2

Dilip Sarkar, MBE, has written over 60 books. He is a globally acknowledged expert on the Battle of Britain, currently working on an eight-volume official history for The Battle of Britain Memorial Trust and National Memorial to The Few. Other volumes include *Airfields Under Attack, The Breaking Storm, The Gathering Storm,* and *Target London.* His evidence-based approach and discovery of new material are well-known. He is a fellow of the Royal Historical Society, has exhibited and spoken internationally, and has worked on many TV documentaries.

The Battle of Britain, fought between July and October 1940, was a crucial World War II conflict where the Royal Air Force (RAF) defended the United Kingdom against large-scale attacks by Nazi Germany's Luftwaffe. The RAF's use of radar, effective tactics, and the resilience of its pilots led to a decisive victory, preventing a German invasion. Failures of key elements which were crucial for the invasion combined to thwart Germany's attempt to gain air superiority. These elements included underestimation of RAF strengths and British use of radar; shifting tactics from bombing of airfields and infrastructure to the bombing of cities (which diverted pressure from the RAF, allowing it to rebuild); lack of a coherent long-term strategy for achieving air superiority; insufficient aircraft production and pilot training necessary to maintain a prolonged conflict; and failure to destroy radar-based early-warning systems.

Sarkar alludes to these problems by quoting selectively from available Fighter Command pilot's combat reports and station-operations record books. He presents actual reports over an almost one-week period from 13-18 August 1940. This enables the reader to review past history through the words of the combatants. While this often provides quite a different historical record, it must be realized that official records are often contradictory, with combat claims wildly exaggerated. Sarkar reminds us that the difference between a claimed and confirmed enemy casualty is often disturbed by visual imperception, chaos of large numbers of aircraft engaged, simultaneous attacks on the same target, and misidentification of aircraft.

Sarkar thoroughly researched and constructed this detailed narrative after careful deconstruction and forensic analysis of primary sources. His work as a trained detective and historian are evidence-based with actual facts driving the narrative. While the combat report vignettes are obviously somewhat repetitive, there are interesting differences between the action scenarios, aircrew backgrounds, aircraft performance, pilot and gunnery skills, and combat objectives to make it a very interesting read. The map that relates geographical proximity and location of both British and German bases, radar range for low and high-altitude aircraft approach, and attacking Luftwaffe aircraft operational ranges with various armament loads was especially good. It will be interesting to see how this volume complements Sarkar's other works on this topic.

Frank Willingham, NASM docent

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Messerschmitt Me 262: Development and Politics (Second Edition). By Dan Sharp. Horncastle UK: Tempest Books, 2024. Appendices. Notes. Bibliography. Index. Photographs. Illustrations. Tables. Charts. Pp. 326. $55.00. ISBN: 978-1-911658-27-6

Dan Sharp studied history at the University of Liverpool before beginning a career in journalism. Having spent several years as the news editor of a regional daily newspaper, he switched to motorcycle magazines. Sharp has written a series of books on German wartime aircraft development (examples are *Secret Projects of the Luftwaffe, Blohm & Voss Bv 155, Focke Wulf Fw 190, Heinkel He 162, Breaking the Luftwaffe,* and *D-Day Operation Overlord*).

This book covers the design and wartime development of the Messerschmitt Me 262 jet fighter. Sharp well explains the technological development of the aircraft. He also examines the decision-making process taking place within the German Air Ministry, the Luftwaffe, the Messerschmitt company, and other organizations which would determine the jet's course of development and entry into full series production.

Sharp has divided the development process into four stages. In the first phase, the German air ministry commissioned Messerschmitt to begin work on a jet fighter beginning in April 1939. Next, Messerschmitt suspended work on the jet in the summer of 1940 to concentrate on manufacturing of existing types (e.g., Bf 109) due to losses during the Battle of Britain and development of its failed Me 210 project. Phase three saw the German Air Ministry again increase its interest in the Me 262 in early 1943. Preparations for full production were again halted by Adolf Hitler who ordered that the Me 262 could be built and operated only as a pure bomber. In the final phase at the end of 1944, the bomber-only decision was overturned, and attention was switched to how the aircraft might be equipped to destroy allied bomber formations. Research began on development of a range of schemes for arming the aircraft with high-caliber cannon and rocket-propelled weapons and improving aerodynamic performance and range. After all of this, combat introduction of this advanced fighter was too late to afford Germany any real help in winning the war.

This work is a fantastic reference resource! It is comprehensive and contains much well-researched data to support Sharp's conclusions. He includes copies of many original aircraft development design diagrams, cutaways, and perspectives; wind tunnel and operational test photographs; Junkers and BMW engine photographs and diagrams; and various armament attachments and aircraft variants. Of particular interest are the concise appendices which cover topics on the Me 262's directional stability problems (snaking); its use, qualities, and systems as a combat aircraft; notes on development and production; handling of the aircraft on takeoff, landing, and in flight (with tactics for use in combating allied bomber formations); and the German manufacturing rights agreement with Japan.

For anyone interested in this particular aircraft type, or on aircraft development and procurement and the politics that often accompanies these, this superb book is well worthy of a position on your bookshelf.

Frank Willingham, docent, National Air and Space Museum

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The Boeing B–29 Superfortress: Giant Bomber of World War Two and Korea. By Graham M. Simons. Barnsley UK: Pen & Sword Aviation, 2024. Maps. Tables. Diagrams. Illustrations. Photographs. Bibliography. Index. Pp. 256. $24.95 paperback. ISBN: 978-1-39907-880-1

If you're looking for a book that tells the story of the B–29—the complete life cycle of the program from early conception through World War II, Korea, and post-war programs such as the B–50, X-plane launches, even "Stratovision" broadcasting—this could be the book for you. I'm always looking for new stories to share with visitors at the National Air and Space Museum and was excited to read professional aviation writer Simons' book.

There's a lot to it. The first few chapters give a solid grounding on how the B–29 came to be and what it took to get it flying in a time of great upheaval in the aircraft industry. Then, Simons discusses the initial operational use of the B–29 in India and China, deftly explaining why that's where they were sent and how huge the stakes were for General Arnold, who had "bet the farm" on the B–29. Simons tells just enough "mission stories" to give a good feel for the challenges both crews and machines faced in the early days of their campaign.

Then, of course, comes the campaign against Japan from the Marianas and, while it accounts for only 18 of the book's 256 pages, his description is certainly adequate to tell the story. By contrast, he devotes 35 pages to Operation *Centreboard* (note the spelling—he's British and corrects many words that we Americans spell so poorly) to describe the B–29's role in the atomic bombing missions. He tells that story quite well.

Most B–29 books end about there, but Simons goes on to give an excellent description of the B–29's early successes and later challenges in the Korean conflict. He explains how they were modified to handle new threats. He devotes half a chapter to the RAF's postwar Washington B.1 programme, in which the B–29 was used by the UK to bridge the Avro Lincoln-to-Canberra and V-Bomber gap between 1950 and 1955. He describes the RAF's innovative use of B–29s for ELINT surveillance. He then goes on to discuss, in very adequate detail, the rarely-told B–50 story and the B–29's (and B–50's) role in the early operational days of aerial refueling.

There are two fun chapters at the end: one describes the Soviet program to reverse-engineer captured B–29s to create the Tupolev Tu–4 strategic bomber, and the other talks about B–29 variants used for everything from dropping experimental aircraft to broadcasting television to classrooms and households in the middle of the US.

Before you rush off to buy the book, let me warn you about its two downsides. Simons has packed it with details (and with many excellent photos and illustrations). But some of his details are just wrong. He uses no citations—none at all—to back up his facts, and I have a gnawing feeling in the pit of my stomach that I shouldn't quote anything from this book without factchecking it first. A second, very annoying observation is that the book was clearly neither edited nor proofed. It is full of misspelled words. Its many missing words lead to nonsensical sentences. Considering that it was first published in 1990, and then again in 2012 and 2024 (after the introduction of spellcheckers), this mystifies me.

I learned a lot by reading it, though, and definitely recommend it to streetwise B–29 fans.

Maj Gen John B. Handy, USAF (Ret), NASM docent

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Spitfire, Mustang and the 'Meredith Effect': How a Soviet Spy Helped Change the Course of WWII. By Peter Spring. Yorkshire UK: Air World, 2024. Index, Notes. Bibliography. Tables. Illustrations. Pp. 325. $46.95. ISBN: 978-1-52677-350-0

Back when I gave tours of the National Air and Space Museum, I always included the Hurricane, because there were so many tales to tell. But I took more-advanced visitors on a deep dive into the Meredith Effect—a process where cold air could be forced across a hot radiator and slowed. Once heated the air would be forced out the back of the radiator to provide thrust. The escaping hot air acted like a jet engine. The thrust provided was small but enough to offset the drag induced by the radiator housing and make the aircraft faster and more efficient. Peter Spring introduces F.W. Meredith, who documented and propagated the Meredith Effect in mid-1930's academic papers. He believes Meredith was one of the great aeronautic engineers of his time.

An Irishman, Meredith joined the Royal Aircraft Establishment (RAE), the pre-eminent mid-20th century British aeronautic research establishment. He rose through the ranks by virtue of his intellect and problem-solving abilities. A prolific writer, speaker, and self-promoter, he headed several departments and was an internationally recognized expert in fluid dynamics, remote control aircraft, bombsights, and spy craft. He was also a spy for the Soviet Union.

Meredith openly admired all things Soviet and travelled to Russia to meet with Russian counterparts and his Russian handler. His RAE bosses and British counter-intelligence officers were aware of these activities but agreed that he and his contributions to aviation were so important, that they were willing to turn a blind eye toward his Soviet sympathies. Only when American experts requested meetings with Meredith did his British bosses limit his work and deny him access to American data and projects. They did not mind him sharing British secrets but thought Americans might be upset if he was so generous with their information! I wonder if the British took a similar hands-off approach with the scientists (Klaus Fuchs, Allan May, et al.) they sent to work on the Manhattan Project.

The second half of the book discusses the Meredith Effect itself. Once Meredith published his findings, they became international public knowledge. Designers in the UK, US, USSR, France, and Germany experimented to determine if they would incorporate it into their next-generation fighters. Britain did in its Spitfire, and America used it in the P–51 Mustang.

Spring covers the long-running feud between North American's Lee Atwood and Ed Schmeud. Atwood often said he directed the Mustang be designed around the Meredith Effect. Schmeud said the design team was aware of the Meredith Effect but that it was only one of many factors. Spring goes to great lengths to "prove" Atwood could not have been correct, given the publication dates of the relevant papers and the Mustang developmental timeline.

The book is not an easy read. Spring jumps back and forth between dissecting complex aerodynamics and thermodynamics to picking apart Meredith's political and social beliefs. He restates many facts and anecdotes numerous times, as though he is afraid the reader might have forgotten some minor point.

In his epilog, Spring re-explains why Meredith was a devout communist. In the 1930s, Meredith was aware of Germany's military buildup and, despite the German-Russian Non-Aggression Pact, believed that Germany would eventually attack Russia. As a communist, it was his duty to help the Soviets better defend themselves. As a dutiful apologist, Spring seems to believe that, since history proved Meredith correct, his betrayal should be excused. Our British allies did us no favors in how they handled Meredith and his "Irish perversity."

Gary Connor, docent, National Packard Museum, Cortland OH

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Combat in the Stratosphere: Extreme Altitude Aircraft in Action During WW2. By Steven Taylor. Barnsley UK: Pen and Sword, 2024. Photographs. Appendices. Notes. Bibliography. Index. Pp. 247. $42.95. ISBN: 978-1-39903-693-1

Steven Taylor is a British fiction and non-fiction author and a journalist specializing in military history. He has contributed to over forty magazines and newspapers, including the *Sunday Telegraph, Sunday Express, FlyPast, Britain at War,* and *Military History Matters*. He is the author of *Air War Northern Ireland*, and the Falklands War thriller, *Rock Scorpion*.

During the mid-1930s, advances in cockpit pressurization, aircraft design, and specially designed pressure suits, allowed pilots to reach then-incredible altitudes over 40,000 feet. With rapid advances in fighter performance, it steadily became clear that speed alone would not be enough for bomber or reconnaissance aircraft to survive in airspace over the modern battlefield. Major military powers grasped the obvious strategic benefits of having warplanes that could gather timely intelligence above the ceiling of potential enemy aircraft. Equipped with the latest long-range, high-resolution cameras, reconnaissance aircraft could fly over hostile territory without fear of being brought down by antiaircraft guns or interceptors. Similarly, pressurized bombers cruising at high altitude reduced the risk of being interdicted.

High-altitude-aircraft design involved many technological innovations: more powerful and reliable engines, turbochargers and superchargers to maintain engine performance at high altitude, pressurized cabins with greater structural integrity, incorporation of advanced aerodynamics to improve performance and stability, and the ability to maintain proper engine temperature to avoid overheating.

But many new problems had to be faced: aerodynamic control surfaces were less responsive in thinner air, instrument accuracy and reliability were affected by temperature, navigation was challenged by requiring more precise systems to fly longer distances at higher speeds, crew health and exposure were challenged by low pressure and extreme temperatures, high altitude missions were more susceptible to weather conditions brought on by jet streams and turbulence, and high-altitude aircraft were more complex and expensive to produce and required specialized maintenance and repair procedures.

Addressing these challenges required significant ingenuity and adaptation leading to many repeated failures. Solutions often resulted from a trial-and-error approach but, in the end, led to many advancements in aero engineering. Taylor describes the problems, failures, and successes encountered by combatants during World War II. He focuses on successful high-altitude aircraft including British (de Havilland Mosquito, Supermarine Spitfire); German (Arado Ar 240, Focke-Wulf Ta 152H, Junkers Ju 86P and Ju 388L, and Messerschmitt Bf 109H); US (Lockheed P-38, Republic P–47 and XP–69, and Boeing B–29 and F–13); Soviet (MiG–3 and I–210), and Japanese (Nakajima Ki–87) types.

Other projects which sometimes did not get off the drawing board are also discussed. He points out that the vast majority of extreme altitude aircraft developed by both the allied and axis powers during the Second World War did not enter operational service. In addition to the aircraft descriptions, Taylor provides short vignettes of actual flights and combat interactions revealing performance and flight procedures used to shoot and avoid being shot down. He draws on a wide range of sources including combat reports, British files and documents, and first-hand accounts of engineers and the pilots who flew these aircraft. It is an interesting read.

Frank Willingham, docent, National Air and Space Museum

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Air Force Disappointments, Mistakes, and Failures: 1940–1990. By Kenneth Werrell. College Station TX: Texas A&M University Press, 2024. Notes. Index. Photographs. Pp. 338. $55.00. ISBN: 978-1-64843-129-6

Werrell graduated in the second class of the Air Force Academy in 1960 and went on to pilot weather-reconnaissance aircraft flying into Pacific typhoons and observing the last above-ground nuclear test. After leaving the service in 1965, he attended Duke University, where he earned an MA and Ph.D in history. He is the author of a wide spectrum of books covering air-power topics, to include *Death from the Heavens: A History of Strategic Bombing; Sabres over MIG Alley: The F–86 and the Battle for Air Superiority over Korea; Chasing the Silver Bullet: US Air Force Weapons Development from Vietnam to Desert Storm;* and *Blankets of Fire: U.S. Bombers Over Japan During World War II*.

Several factors have contributed to the failures in military aircraft development since World War II. These include:

Technological complexity leading to increased development costs and risks. Incorporation of cutting-edge technologies, such as novel propulsion systems, advanced materials, stealth capabilities, and advanced avionics present unforeseen technical challenges and reliability issues during development.

Political interference that often prioritizes political goals over technical feasibility and operational effectiveness. Budget constraints result in compromises in design, testing, and production.

Overambitious operational goals, revolutionary technologies, and mid-development variations in requirements that result in costly failures and delays.

Werrell provides a series of case studies from World War II through the Cold War where he describes untold stories of disappointments, mistakes, and failures in the procurement of USAF systems. Using these, he describes the details of development, testing, and operational service which are faced with obstacles of politics, resources, competing technologies and timing.

Werrell selected nearly three-dozen aircraft project examples covering bombers (e.g., XB–40/41, B–32, a series of dive bombers from the Second World War, XB–43, YRB–49, YB–60, XB–70), fighters (e.g., XF–85, F–111), and transports (e.g., C–76, C–99, C–133) with various types of propulsion, performance goals, and missions. He also includes chapters on various missile systems including cruise, standoff, surface-to-air, and air-to-air systems (e.g., Rascal, Skybolt, Rail Garrison Missile, AIM-4D). He concludes with a chapter on an electronic battlefield intelligence system (*Igloo White*). Each chapter begins with the system's operational need and requirements background followed by political, technological, testing, and operational performance obstacles. After highlighting the system problems and criticisms, Werrell ends with an overall project summary and conclusion. Sources and endnotes are provided for each chapter along with a detailed index, making this book an excellent reference source.

I loved this book! If you've ever had the thought, "I wonder what ever happened to the XYZ aircraft or missile system and why I never heard of it again," this is the book for you! It is well written and has the appropriate level of detail for an upfront overview with more than adequate resources for further study.

Frank Willingham, docent, National Air and Space Museum

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How Strategic Airpower Has Changed the World Order: From the 100th Bomb Group in 1943 to the Falklands and Beyond. By Nigel David MacCartan-Ward and Dr Anthony Wells. Barnsley UK: Pen and Sword Military, 2024. Photographs. Index. $36.95. ISBN 978-1-03610-656-0

Commander "Sharkey" Ward flew the Phantom F–4K from the deck of HMS *Ark Royal IV* before going to the Ministry of Defence to oversee the final development of the Sea Harrier fighter aircraft. He was then appointed to receive the aircraft into service and to bring the aircraft and its crews up to full combat readiness. His success as "Mr. Sea Harrier" was demonstrated in the Falklands air war, where he served with distinction in command of 801 Naval Air Squadron.

Dr. Anthony Wells is unique, insofar as he is the only living person to have worked at the highest levels for British Intelligence as a British citizen and for US Intelligence as a US citizen. He has also served in uniform at sea and ashore with both the Royal Navy and the US Navy. He was trained and mentored in the late 1960s by the very best of the Second World War intelligence community, including Sir Harry Hinsley, the famous Bletchley Park codebreaker.

This book describes eight decades of strategic airpower-related events that support the continuing special military relationship between the United States and the United Kingdom. It also describes several cases which, in turn, reveal a lack of appropriate investment wisdom in the UK and poor allocation of operational control and air-power deployment in the field. The story is split into three parts.

Part 1 is meant to exemplify the value of the United States as the key UK ally. It addresses the Second World War, US Army Air Forces participation, and its major contribution to allied victory via daytime precision bombing.

Part II characterizes the consummate need for tactical naval airpower. It covers post-war naval engagements and the Falklands War and provides a detailed summary of the CVA 01 aircraft carrier project cancellation which, according to the authors, was engineered by RAF dishonesty. This part also describes difficulties faced and overcome by the Royal Navy's then-new air defense fighter, the Sea Harrier.

Part III focuses on the era beyond the Falklands War and provides valuable insight into the major strategic significance of the USAF presence within the United Kingdom. The book ends with a plea to balance Royal Air Force tactical elements with increased strategic naval air power. This in turn would enhance the UK's effectiveness as an ally in its collaborative alliance with the United States.

The authors have provided an interesting and often eye-opening read. They argue how an effective maritime-deterrence strategy is critically supported by enhanced strategic naval air power. Not everyone may agree with their conclusions. I would perhaps have entitled it *British Strategic Naval Air Power: The Need for Change.* But, whatever the title, the points they make are worth the read and provide a starting point for discussions of how best to employ strategic air power.

Frank Willingham, docent, National Air and Space Museum

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The Hercules: The Other Engine That Helped Win The War. By Gordon A.A. Wilson. Stroud UK. Amberley Publishing, 2024. Photographs. Bibliography. Tables. Index. Pp. vii, 286. $36.99. ISBN: 978-1-3981-1168-4

In his new book on the Bristol Hercules engine (built in numbers second only to the more famous Rolls-Royce Merlin), Gordon Wilson attempts to provide the reader with both a "layman's description" of the Hercules and its contribution to Allied victory in World War II, and an account of its use in postwar military and civil aviation. If only his ambition had been greater. While a somewhat useful compendium of information on the Hercules and the airplanes it powered, it is not the broader history of the Hercules that one would have wanted.

Wilson begins with a history of the Bristol Aeroplane Company, focusing primarily on the Company's aircraft built from 1910 to 1962. He then covers the career of Sir Roy Fedden, Bristol's chief aircraft-engine designer, drawing this chapter from Bill Gunston's *Fedden: The Life of Sir Roy Fedden*. He then looks at all the Bristol piston aircraft engines that led up to the Hercules, with a brief section on Fedden's development of sleeve-valve engines. Much of this chapter stems from Alec Lumsden's *British Piston Aero-Engines and their Aircraft*. His chapter on the Hercules engine begins with another brief section on the development of the Hercules, followed by a description of the engine and its components (taken from Bristol manuals). This chapter ends with a listing of all Hercules engine models and the aircraft the Hercules powered.

One chapter is devoted to the aircraft manufacturers who built airplanes using the Hercules engine. Then, in the longest chapter in the book, Wilson describes all these aircraft covering their development and operational histories, with tables listing the variants of each aircraft. He devotes just 22 pages to the history of the Hercules in RAF service (covering Fighter, Coastal, Bomber, and Transport Commands) before ending with another list of Hercules-powered aircraft, this time by RAF squadron. In this chapter, Wilson states that the Hercules certainly helped win the Second World War but doesn't explain how, apart from the fact that a lot of RAF airplanes used the Hercules. The book ends with a chapter on the Hercules and the Bomber Command Museum of Canada which, oddly, is mostly devoted to restoration of a Lancaster bomber and less to restoring a Hercules engine to running condition.

In fairness, Wilson goes some way to achieving his limited objectives for his book, but his reliance only on secondary sources and on information already widely available limits the book's utility. He spends far too much space describing and discussing the aircraft that used the Hercules and not enough describing and discussing the Hercules engine itself. His effort to evaluate the contribution of the Hercules to Allied victory would have benefited from a more detailed analysis of how the Hercules, in effect, rescued the Handley Page Halifax bomber and extended the life of the Vickers Wellington to the end of the war. Similarly, while he makes a brief reference to the shadow factory scheme that built the Bristol Mercury and Pegasus engines, there is no mention of the far-larger shadow factory scheme that built the Hercules. Some commentary on the postwar service of the Hercules in comparison to American Pratt & Whitney and Wright Aeronautical aircraft engines would also have been useful.

Edward M. Young, PhD, volunteer, Museum of Flight, Seattle WA

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America's First Aircraft Carrier: USS *Langley* and the Dawn of US Naval Aviation. By: David F. Winkler. Annapolis MD: Naval Institute Press, 2024. Photographs. Notes. Bibliography. Index. Pp. 383. $ ISBN: 978-1-68247501-0

A book on the USS *Langley* is long overdue, and I can think of no one better qualified to write it than Winkler. It was the first of 66 fleet aircraft carriers commissioned in the US Navy that have served as the bulwark of US naval power for more than 80 years. The US Navy has commissioned more aircraft carriers than all of the other navies in the world combined, and it started with the *Langley*.

The importance of the *Langley* cannot be overstated. Her flight deck was used to perfect and choreograph the highly dangerous procedures needed to launch and recover aircraft as quickly as possible—something that has become the hallmark of US carrier operations. She was also the platform that fostered the aviation prowess of ADM Joseph Mason Reeves, rightly called the father of US carrier aviation. He was the first US Navy flying officer to achieve flag rank, the first to command a carrier division, and the first airman to become Commander-in-Chief, US Fleet. *Langley w*as also the training ground for the nascent naval aviators that were destined to command the US carrier campaign in World War II.

Although parts of *Langley*'s story have appeared previously in biographies and memoirs of famous naval aviators, no book dedicated to the *Langley* has been written before. It is a valuable addition to the history of US naval aviation.

Winkler begins the ship's story by describing the *Jupiter*, a Navy collier that was converted into the Navy's first aircraft carrier and renamed the *Langley*. Unfortunately, while describing the *Jupiter*'s early relationship with aviation, he wrongly states that "*Jupiter*, along with *Neptune*, ferried Kenneth Whiting's squadron of seaplanes to France." Both ships transported elements of the First

Aeronautical Unit to France, but no aircraft were on board. Winkler later compounds his mistake by claiming "the first American combat force to arrive in France [supposedly on the *Jupiter*] was a Navy seaplane squadron." This is an inexcusable error given his stature as an historian and is regrettable, as he writes well and has an otherwise excellent command of his subject matter.

After a rather overly detailed operational history of the *Jupiter,* Winkler moves on to describe the British efforts to the develop the first aircraft carriers, before explaining the bureaucratic wrangling that preceded the Navy's decision to convert the *Jupiter* into an experimental aircraft carrier. This is followed by an in-depth account of how the *Jupiter* was transformed to accommodate aircraft.

The heart of the book documents how the *Langley* was used as the test bed to develop the processes, equipment, aircraft, and personnel that would form the basis for US flight deck operations in World War II. Winkler includes fairly detailed biographies of all of the key players, which is useful for those not fully familiar with the history of US naval aviation. Also included is *Langley*'s contributions to the annual Fleet Problems, which were instrumental in evaluating the importance of aircraft to the fleet and the best methods for their implementation.

Winkler summarizes with a description of *Langley*'s operations with the Asiatic Fleet just prior to, and at the beginning of, World War II. He concludes with the *Langley*'s demise after being attacked by Japanese land-based bombers off the Java coast on February 28, 1942.

Despite the two errors previously mentioned, Winkler has produced a highly detailed study that will appeal to serious scholars as well as those with a general interest in the history of the US Navy. However, with 308 pages of text, his magnum opus is chock full of operational details of insignificance—too many in my opinion. A more readable work would have been produced if he had concentrated on the contributions that *Langley* and her personnel made to US carrier development. Nevertheless, I highly recommend it to anyone who would like to know more about the early development of US carrier aviation.

Thomas Wildenberg, Tucson AZ

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Aviatik in Wiener Neustadt (1909-1912): Geschichte auf Postkarten (Aviation in Wiener Neustadt: History on Postcards). By Marcus F. Zelezny. Salzburg, Austria: Stanger-Verlag, 2022. Photographs. Illustrations. Pp. 289. 68.00 ($73.00). ISBN: 978-3-9505136-1-5

This interesting book offers an extraordinary glimpse into the nascent stages of Austrian aviation history, focusing on the Wiener Neustadt airfield. Meticulously curated over years, this book assembles an extensive collection of postcards and photographs, documenting the vibrant aviation scene during this pivotal period. The inclusion of more than 600 photos and illustrations allows readers to visualize the technological and social context of early aviation. Notably, Zelezny connected with the descendants of early aviators such as Karl Illner, Rudolph Stanger, Josef Sablatnig, August Warchalowski, and Phillip Blaschke von Zwornikkirchen, gaining access to unique primary sources.

Each image provides different facets of the airfield's history, from groundbreaking flights to daily operations and challenges faced by aviators. This visual richness offers a perspective on a transformative period in aviation history, producing an exceptional-quality volume that can be described as "the completest thing."

The Wiener Neustadt airfield, often regarded as the cradle of Austrian aviation, was ideally situated on weather-resistant soil, making it perfect for testing aircraft designs, hosting competitions, and breaking world records. The book captures this pioneering period, highlighting significant events such as visits by Emperor Franz Joseph and the first public displays by military pilots. On fair days, tens of thousands of spectators would gather at the airfield, showcasing the public's fascination with aviation.

Zelezny's book stands out for its detailed documentation of aviation events and exploration of aviation-related memorabilia, particularly postcards. These postcards—the social media of their time—shared news and excitement about aviation, offering a unique view of public engagement with this new technology.

Aviatik in Wiener Neustadt serves as a poignant reminder of the Austro-Hungarian Empire, preserving the legacy of the airfield and its contributions to aviation. The book provides valuable insights into a forgotten era, capturing both the technological achievements of early aviators and the cultural and historical milieu of a nation on the brink of profound change. Meticulously researched and visually captivating, this work is an essential resource for enthusiasts and historians alike, offering a comprehensive portrayal of a pivotal time in aviation history.

Carl J. Bobrow, Research Associate, National Air and Space Museum

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PROSPECTIVE REVIEWERS

Anyone who believes he or she is qualified to substantively assess books for the journal should contact our Book Review Editor for a list of books available and instructions. The Editor can be contacted at:

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Compiled by
George W. Cully

January 3-6, 2025
The **American Historical Society** will hold its 138th annual meeting in New York City, New York. For registration details, reach out to the Society at **annualmeeting@historians.org**.

March 26-29, 2025
The **National Council on Public History** will deliver its annual gathering bilingually at Le Centre Sheraton Montreal in Montreal, Canada. This year's theme will focus on "Solidarity" and its meaning in the field of public history. For registration and other details, see the Council's website at 2025 Annual Meeting | National Council on Public History (ncph.org).

March 27,30, 2025
The **Society for Military History** will offer its 91st Annual Meeting at the Battle House Renaissance Mobile Hotel and the Renaissance Mobile Riverview Plaza Hotel in Mobile, Alabama. For further details, see the Society's website at Welcome to the Society for Military History (smh-hq.org).

April 3-6, 2025
The **Organization of American Historians** will hold its annual gathering at the Sheraton Grand Chicago River Walk Hotel in Chicago, Illinois. For a presentation schedule and registration, see the Organization's website at OAH | 2025 OAH Conference on American History.

April 7-10, 2025
The **Space Foundation** will open its 40th annual Space Symposium at the Broadmoor Hotel in Colorado Springs, Colorado. Get details in due course via the Foundation's website at Space Foundation | Advocating Space Education & Exploration.

April 10-13, 2025
The **Vietnam Center** and the **Sam Johnson Vietnam Archive** at Texas Tech University in Lubbock, Texas will hold a conference entitled " 1975: The End of the Vietnam War." For more details, see the Center's website at The Vietnam Center and Sam Johnson Vietnam Archive: Calendar of Events (ttu.edu).

May 21, 2025
AFHF Symposium and Museum Conference, Chantilly, VA, Smithsonian National Air and Space Museum, Udvar-Hazy Center Executive Board Room (8 AM to 5 PM). Details: afhistory.org/events

May 22, 2025
AFHF Annual Awards Banquet and Celebration of the US Space Force 5th Anniversary. Chantilly, VA, 6-10 PM, Smithsonian National Air and Space Museum, Udvar-Hazy Center, Space Hangar. Details: afhistory.org/events

June 29-5 July, 2025
The **International Committee for the History of Technology** will hold its 52nd annual congress in Dunedin, New Zealand. The general theme of the congress is "Peoples, Places, Exchanges, and Circulation." For additional information, see the Committee's website at International Committee for the History of Technology (icohtec.org).

November 13-15, 2025
The **History of Science Society** will hold its annual symposium in New Orleans, Louisiana. See the Society's website at Future and Past Meetings - History of Science Society (hssonline.org) as they become available.

Note from the Editor

The number of meetings and symposia listed here has dropped. Even with the aftereffects of the COVID pandemic, listings have been reduced to half their previous number. If you have, or know of, a meeting that you believe the membership would find interesting, please contact our POC for this list at the address in the box below. It's a service to your fellow members, so if you are uncertain whether we know about it, drop an email to George. Thank you.

Readers are invited to submit listings of upcoming events Please include the name of the organization, title of the event, dates and location of where it will be held, as well as contact information. Send listings to:
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Answer: Derived from the C–97 "Stratofreighter," the KC–97 entered the Air Force inventory in 1950. Equipped with a "flying boom," the KC–97 represented a major shift in Air Force Aerial Refueling away from the previously used probe and drogue. The flying boom increased the speed at which fuel could be pumped to the receiving aircraft. This would become an essential component of the global reach of the Air Force. Initially, the KC–97 was equipped with four radial engines. As the Air Force transitioned to a Jet force, the KC–97's lower operating speed and lower altitude proved to be inefficient for refueling faster jet aircraft. To address this issue some KC–97 were equipped with 2 J-47 turbojet engines. Even with the two jet engines, KC–97s would perform a "tobogganing" maneuver of connecting with their receiver and then descend so the KC–97 could pick up speed. In the approximately half decade of production, over 800 KC–97s were built. With the Air Force's transition to faster jets, the KC–97 would slowly be replaced by the KC–135 "Stratotanker." As a side note to this point, the last KC–97 and the first KC–135 rolled off the Boeing production lines on the same day in 1956. Even though the KC–135 became the Air Force's primary tanker, the KC–97 would see combat action in Vietnam and service as an important part of Cold War Air Force. The KC–97 would retire from the Active Duty Air Force in 1973 and from the Guard and Reserves later in the decade. Before the KC–97's would retire, the F–15, F–16, and A–10 would be certified to refuel from the it as part of their respective test programs. Today, surviving KC–97 can be found at various Air Force bases and aviation museums.

Use the following links to learn more about the KC-97 and aerial refueling;

Aerial Tankers in the Jet Age:
https://media.defense.gov/2022/Jun/30/2003028574/-1/-1/0/LOOKBACK_TANKERS-FINAL-SMALL.PDF
The First 75 Years of Aerial Refueling:
https://media.defense.gov/2010/Sep/29/2001329785/-1/-1/0/75%20years%20red.pdf
History of the Importance of AF Aerial Refueling:
https://media.defense.gov/2015/Sep/11/2001329836/-1/-1/0/Air%20Refueling_Without%20Tankers,%20We%20Cannot_Oct%2009%20(Optimized).pdf
KC–97:
https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196737/boeing-kc-97l-stratofreighter/
KC–10: https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104520/kc-10-extender/

New History Mystery

by Dan Simonsen

This Issue's Quiz:

Question: In September 2024, the Air Force retired its final KC–10 "Extender." It's retirement came after 43 years of service. It's only fitting as a tribute to this Cold War stalwart for this edition's question to be about air refueling. This early Cold War tanker, was the first Air Force tanker to have a flying boom. More than just an oddity with a boom, this tanker serviced from the 1950s into the early 1970s. Can you name this Cold War tanker?

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