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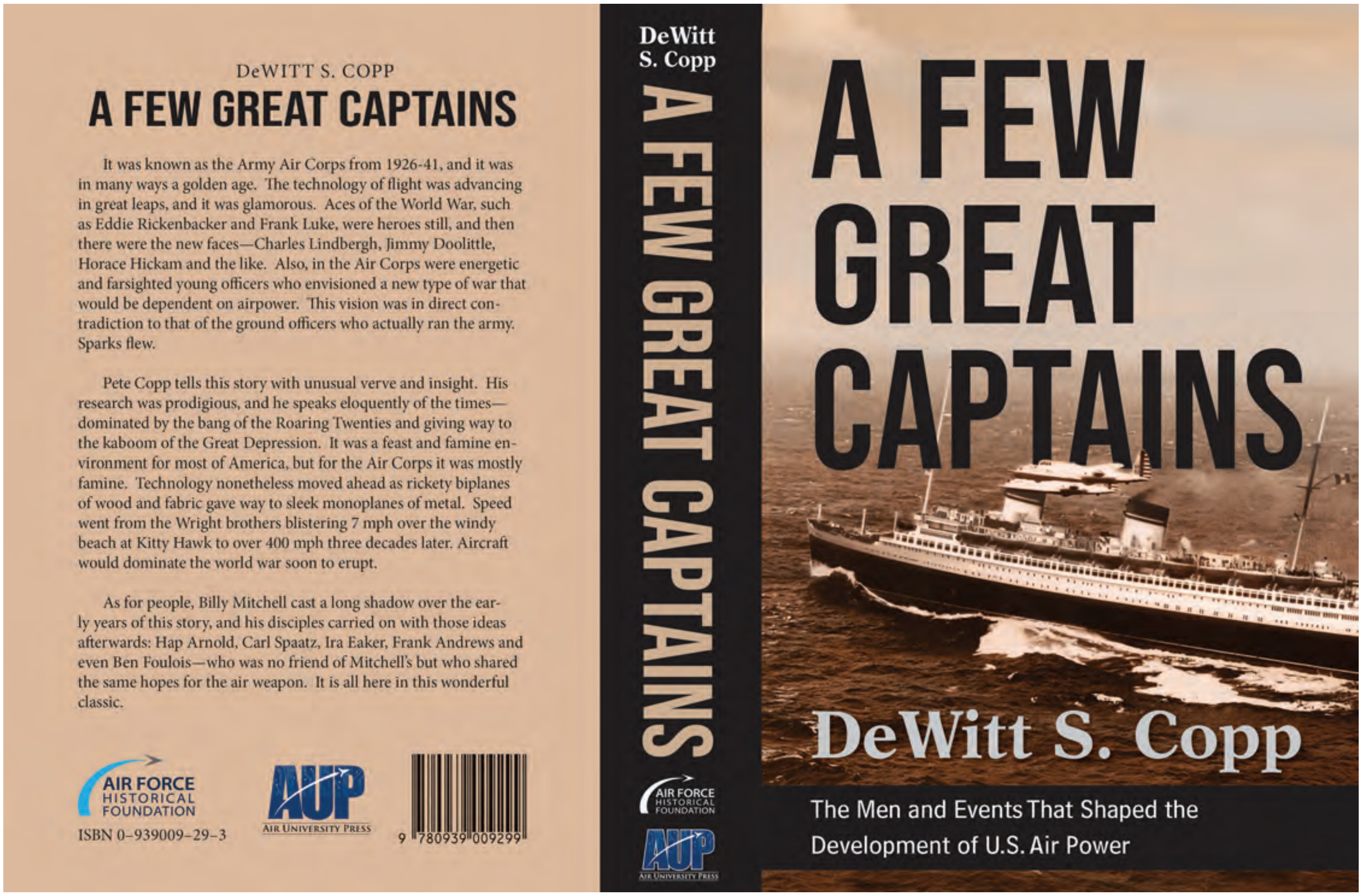
Journal of the Air Force Historical Foundation

U.S. Space Force 5th Anniversary Edition

know the past
.....Shape the Future



In a joint program with the Air University Press, AFHF is proud to announce the publication of Pete Copp's air power classic (now expanded), *A Few Great Captains: The Men and the Events that Shaped the Development of U.S. Air Power*. The free digital version will be available soon from the Air University bookstore.

A Few Great Captains is a terrific book, suitable for airmen of any rank. Pete Copp wrote a masterpiece that takes the Air Corps and its leaders, both senior and junior, through the tumultuous period of the 1920s and 30s. Ground-oriented Army leaders felt threatened by the new weapon of the airplane and therefore labored to control it and those who flew it. For their part, the airmen refused to be bridled by the ground zealots and instead foresaw a future where the airplane would dominate war. The visions of the airmen were not completely accurate, but they were far more so than those who saw the airplane as just another weapon to support ground operations.

This publication marks the Foundation's return to publishing and disseminating important, relevant, and readable history to all.

KNOW THE PAST...SHAPE THE FUTURE!

Order of Ceremony

AIR FORCE HISTORICAL FOUNDATION

AWARDS BANQUET 2025

1800-1900 SOCIAL HOUR

1905 Welcome
Maj Gen John Barry, USAF Retired, Foundation Chair

Posting of the Colors

National Anthem

SponsorRecognition

Introduction of Distinguished Guests
Lt. Col. Dik Daso, USAF Retired, Ph.D.
Executive Director, AFHF

AFHF President's Advisory Council
Joe Burke (Space), David Byrd (Media),
Mike Devine (Student Awards),
Tobias Naegele (ASFM Editor),
Pepe Soto (at large),
Bill Strandberg (JOAT),
Richard Wolf (JAFHF Editor)

AFHF Board of Directors
Executive Officers:
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Lt. Col. John Terino, USAF, Retired, Ph.D.
Brig. Gen. Paul Tibbets, IV, USAF, Retired
Col. Darrel Whitcomb, USAFR, Retired

Office Manager: Angela Bear

Honoring our Service Heritage
BG Paul W Tibbets, IV, Grandson of legendary WW II Pilot, BG Paul W. Tibbets, Jr.
Robert B. Arnold, Grandson of Gen of the Air Force,
Henry Harley "Hap" Arnold and Donald Douglas
Jonna Doolittle Hoppes, Foundation Board President and
Granddaughter of Gen James H "Jimmy" Doolittle

Tonight's Table

The Summer Special Journal
(includes Programs for Symposium and Banquet)
Challenge Coin
A Few Great Captains

AFHF Student Awards

Arnold Air Society
2025 Hap Arnold Saber Award
Cadet Shawn Horn, AAS Region II Commander,
Independence Hall Squadron, St Joseph's University

AFIT
Gen Bryce Poe II Award
1Lt Alexander B. Krawietz, USAF

Two Air Forces (USAF/RAF)
Squadron Leader F J MacDonald

ACSC 2024
Mr. Philip R. Povolish Jr.

SAASS David Mets Award 2024
for Best SAASS Thesis in History—to Maj (USAF) Tom J. Heistuman

JAFHF BOOK REVIEW EDITOR, COL SCOTT A. WILLEY, USAF (Ret.)
For Dedication and Determination above and beyond the call of duty as Book Review Editor, Journal of the Air Force Historical Foundation since 2002. Col Willey has assembled, written, and edited nearly 2,000 book reviews during these decades of volunteer service.

AFHF Change of Command, President of the Board of Directors
Outgoing, Ms. Jonna Doolittle Hoppes
Incoming, Mr. Robert B. Arnold

Dinner Service
Please charge your glasses, one with water and one with wine

We honor and remember those who have made their final flight
R Cargill Hall, NRO Historian and 2019 Holley Award Recipient
Dr George M. Watson, Jr., USAF Historian
Dr Martin Collins, National Air and Space Museum Curator
Mr. Ed Mautner, NASM restoration specialist
BG Malim Wakin, USAF Academy, Permanent Professor
Wade Holmes, DC ANG Pilot

TOASTS:
Jonna Doolittle Hoppes: to those departed

Robert B. Arnold: to The Foundation

Blessing and Meditation

DINNER IS SERVED

MENU

FIRST COURSE
Burrata cheese, and heirloom tomatoes with wild arugula and San Danielle prosciutto with aged balsamic vinaigrette and mini French baguette
MAIN COURSE
Filet of Beef Crowned with Grilled Florida Gulf Shrimp served with pear shaped potato croquette, Spring vegetables, roasted shallots and wild mushroom sauce
***VEGETARIAN**: Grilled Cauliflower Steak with wild rice, butternut squash batons, and haricot vert*
DESSERT
Chocolate and Raspberry Marquise: Dense Belgian chocolate cake layered with rich chocolate mousse and fresh raspberries, wrapped in a pistachio crust
Coffee and Tea Service

COMFORT BREAK

Foundation Awards Dinner Speech

Chris Browne, Director, National Air and Space Museum

Recognition of AFHF Award Recipients

AFHF Literary Awards

Articles

John A. Schell
"The SA–2 and U–2: The Rest of the Story," JAFHF, Summer, 2023

David K. Stumpf, Ph.D.
Special AFHF Literary Award for original primary source technical research
"Ballistic Missile Shock Isolation Systems," JAFHF, Winter 2022
"Operation Button Up: Security at Minuteman Launch Facilities," JAFHF, Fall 2023
"Some Technical Aspects of the Evolution of the Titan Weapon System," JAFHF, Summer 2024
"A Question of Vulnerability," JAFHF, Winter 2024

Books

2023 AFHF Book Prize for Air Power History
Sean Maloney*, Emergency War Plan: The American Doomsday Machine, 1945-1960*. Lincoln, Neb: Potomac, 2021.

2023 AFHF Book Prize for Space History (for a series or multiple titles)
John J. Klein, *Understanding Space Strategy: The Art of War in Space*
(London, UK: Routledge, 2019).
John J. Klein, *Fight for the Final Frontier: Irregular Warfare in Space*
(Annapolis, MD: Naval Institute Press, 2023).

2024 AFHF Book Prize for Space History
Aaron Bateman, *Weapons in Space: Technology, Politics, and the Rise and Fall of the Strategic Defense Initiative*, (MIT Press (2024).

The 2024 Major General I.B. Holley Award is given for Lifetime Achievement in research and documentation of USAF and Space history.

Roger Launius, Ph.D.

From 1982 to 1990, 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 NASM.

The James H. "Jimmy" Doolittle Award recognizes an active Air Force or Space Force unit for gallantry, determination, esprit de corps, and superior management of joint operations in accomplishing its mission under difficult and hazardous conditions in multiple conflicts.

Space Delta 4 is a United States Space Force unit responsible for providing strategic and theater missile warning to the United States and its international partners. Space Delta 4 (Mission Delta 4 since late 2024) operates and supports three constellations of Overhead Persistent Infrared satellites and two types of Ground-Based Radars for the purpose of conducting strategic and theater missile warning. Accepting: Col "Bobby" Schmitt, USSF, CC/MD 4

The Hub Zemke "Thunderbolt" Trophy Outstanding Unit award for Training represents contributions made by an active Air Force or Space Force unit whose primary mission is training, for gallantry, determination, esprit de corps, and superior management while executing the mission.

The **56th Fighter Wing** is the largest fighter wing in the world and the Air Force's primary active-duty fighter pilot training wing. 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, the 56th graduates more than 400 pilots and 300 air control professionals annually. Accepting: Brig Gen David J. Berkland, USAF, CC/56 FW.

The Gen. Carl A. "Tooey" Spaatz Award is given in recognition of an individual who has made significant contributions in their lifetime to the making of Air Force history.

Lt Gen David Deptula

David A. Deptula is the Dean of the Mitchell Institute of Aerospace Power Studies. He transitioned from the USAF 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. 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.

AFHF Lifetime Achievement for Space recognizes an individual who has made significant contributions in their lifetime to the making of Air Force history in the Space realm and shaping the future of continued development of the U.S. Space Force

General Kevin A. "Chili" Chilton

General 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 this 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.

The **CSAF Award for Exceptional Public Service** is given to those who exhibit "dedication, patriotism and personal sacrifice resulting in significant contributions to the Air Force."

Jonna Doolittle Hoppes

As a Lifetime member of the Air Force Historical Foundation and while serving on the Board of Directors of the Foundation, founded by the first CSAF, Gen Carl Spaatz, in 1953, Ms. Doolittle Hoppes has been at the forefront of establishing policies and programs that directly support the mission of the United States Air Force. AS PRESIDENT of the AFHF, Ms. Doolittle Hoppes' leadership is directly responsible for establishing the groundwork for the explosive growth in Foundation membership, the establishment of public communication programs like the AFHF Official Podcast, the Raider Chronicles newsletter, and This Day in AF and SF history. Looking to the future, she has encouraged and supported the restructuring of the AFHF leadership to include the new Space Force organization. In a day and age when the study of history has fallen to the wayside nationwide, the projects, and programs envisioned and encouraged by Ms. Doolittle Hoppes reflects selfless dedication and patriotism like that of her grandfather, Gen James H. Doolittle—she is an inspiration to those who work with her. Jonna Doolittle Hoppes is a gifted writer, speaker, and representative of the Doolittle family, the Reserve forces, and the Air Force Regular Force. Jonna's service to the Foundation reflects tremendous credit upon herself and the United State Air Force. **Since 2009, only 29 decorations have been approved. Ms. Doolittle Hoppes Award is the first awarded since 2019**.

19th USAF Chief of Staff General Norton A. "Norty" Schwartz, General Gregory S. "Speedy" Martin, Jonna Doolittle Hoppes, General Kevin P. "Chili" Chilton, and General James C. Slife (left to right). General Schwartz presented the award to Jonna.

Concluding Words
Mr. Robert Arnold, Board President

AIR FORCE HISTORICAL FOUNDATION

AFHF SYMPOSIUM and MUSEUMS CONFERENCE

21 May 2025, Steven F. Udvar-Hazy Center Executive Board Room

8 AM to 5 PM

0810-0820 **Welcome**

0820-0855 **Kickoff Address** (Roger Launius, PhD, IB Holley Award recipient)

The Frontier Military Experience as a Model for the Military in Space

Learning from History to Shape the Future

0900-0955 **Columbia Accident** (MG John Barry, Executive Director/ Space Shuttle Columbia Accident Investigation)

1000-1130 **AFHF Literary Awardees Panel**
All Article Winners and Book Prize recipients talk about their challenges and triumphs in documenting Air and Space history

1145-1215 **Lunch Talk**: Back to the Books: The rebirth of *A Few Great Captains* (AFHF/AU Press Imprint) Phil Meilinger (Contributor), Abbie Hoffman (Editor), Dik Daso (Contributor)

1225-1400 **Behind the Scenes: The Birth of Space Force with Those Who Were There**
General David D. Thompson, Maj. Gen. Clinton E. Crosier, Col Stu Pettis, Chair

1410-1500 **Origins of the Space Force Through Artifacts** (David Arnold, Emily Margolis)

1510-1645 **The Military-Academic Zone: Teaching Spacepower in PME and at USAFA**
Chair, DFHAA-L Weaver, ACSC-P.J. Springer, DFH-T. Givler, AU-J Terino

1650-1700 **Conference Summary and Farewell**

Panelist Bios and Panel Abstracts

0820-0855 Kickoff Address
(Dr Roger D. Launius)

Roger D. Launius, IB Holley Award Recipient
From 1982 to 1990, Launius held several positions as a civilian historian with the United States Air Force. he is the 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 the author, most recently, of NACA to NASA to Now: The Frontiers of Air and Space in the American Century (NASA SP-2022-4419, 2023); Apollo's Legacy: The Space Race in Perspective (Smithsonian Books, 2019); Reaching for the Moon: A Short History of Space Race (Yale University Press, 2019); and The Smithsonian History of Space Exploration: From the Ancient World to the Extraterrestrial Future (Smithsonian Books, 2018). He is also a recipient of the NASA Exceptional Service Medal and the Exceptional Achievement Medal. He has been a guest commentator on space history for all the major television and news radio networks.

0900-0955 Columbia Accident
(MG John Barry, Executive Director/Space Shuttle Columbia Accident Investigation)

John L. Barry, Maj Gen, USAF (Ret) is the Chair of the Air Force Historical Foundation. John served as the President and CEO of the Wings Over the Rockies Air & Space Museum (WOTR) from 2017-2025, located in Denver, Colorado. he served in the United States Air Force for over 30 years as a combat veteran with 270 hours of combat time, fighter pilot, Fighter Weapons School Graduate, winning team member at the "Top Gun" international Air-to-Air William Tell Competition, Military Assistant to the Secretary of Defense, and commander multiple times at the squadron, twice at the group command level and twice at the wing command level. He is also a survivor of the 9/11 attack on the Pentagon while serving as the lead Strategic Planner for the USAF. He retired in 2004 as a Major General and finished his USAF career as Board Member and Executive Director for the Space Shuttle Columbia Accident Investigation.

1000-1130 AFHF Literary Awardees Panel

John Schell graduated with a BSEE and MSEE in April 1970 from Penn State University and a reserve commission in the USAF. Entering active duty at Wright-Patterson AFB, he worked as a radar research engineer at the Air Force Avionics Lab (now Sensors Directorate). There he became a project engineer on the spotlight mode synthetic aperture radar. That radar was the world's first high resolution (SAR) imaging system with controlled errors and consistent image quality. Subsequently, in 1976, he was assigned to the SR–71/U–2 Project Office at WPAFB. There he led the development of ASARS-1 and ASARS-2 radar prototypes for the SR–71 and U–2R, also serving briefly as the Chief Avionics Engineer, responsible for all SR–71 and U–2 mission systems. After separating from the Air Force in 1980, he supported ASARS testing and fielding, development of several image exploitation systems, and development of the RQ-4 Global Hawk. Retiring from industry in 2016, he lives in Dayton, Ohio and serves as a volunteer at the National Museum of the USAF. His passion is the Cold War era, about which he has made multiple presentations and written papers on the U–2 and SR–71 including: "Flight of the First Habu" , NMUSAF Friends Journal, Winter 2020, "The SA-2 and U-2, Secrets Revealed", Air Power History, Summer 2021, "The SA-2 and U-2: The Rest of The Story, Journal of the AFHF, Summer 2023, "Flying the World's Fastest Jet", Presentation 2020, Building The World's Fastest Jet. Presentation 2024.

David K. Stumpf, Ph.D. is a retired plant biochemist living with his wife, Susan, in Tucson Arizona. He has written three nuclear weapon histories, Regulus the Forgotten Weapon, a history of the Navy's Regulus I and II cruise missiles; Titan II: A History of a Cold War Missile System and Minuteman: a technical history—The Missile that defined American Nuclear Warfare, published February 2021. Dr. Stumpf volunteered at the Titan Missile Museum, Sahuarita, Arizona, as an historian and as a tour guide for 15 years. He was instrumental in the effort to gain National Historic Landmark status for the museum. *This year, David has been awarded a Special AFHF Literary Award for original primary source technical research across three articles.*

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. After returning to Royal Military College, Dr. Maloney has re-focused back on the Cold War, releasing Deconstructing Dr. Strangelove: The Secret History of Nuclear War Films in 2020 and, in 2021, Emergency War Plan: The American Doomsday Machine, 1945-1960, a reconstruction and analysis of nuclear war plans in the 1950s.

Dr. John J. 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. He is 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. Patsy 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. Patsy is a distinguished graduate of the U.S. Naval Test Pilot School. He has over 2,700 flight hours in 27 different types of aircraft and over 600 carrier arrested landings.

Aaron Bateman, PhD, is an assistant professor of history and international affairs at George Washington University. He is the author of Weapons in Space: Technology, Politics, and the Rise and Fall of the Strategic Defense Initiative (MIT Press, 2024). 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.

1145-1215 Lunch Talk:
Back to the Books: The rebirth of A Few Great Captains

Col. Phillip S. Meilinger, USAF, Retired, PhD received a BS degree from the United States Air Force Academy, an MA degree from the University of Colorado, and obtained a PhD in military history from the University of Michigan. A command pilot, he has served as a C-130 aircraft commander and instructor pilot in both Europe and the Pacific. He was also assigned to the Doctrine Division of the Air Staff at the Pentagon. Meilinger was the director of military history and deputy department head at the Air Force Academy, a professor of strategy at the US Naval War College and was founder and third Dean of the School of Advanced Airpower Studies—now the School of Advanced Air and Space Studies—the Air Force's only accredited graduate school for the education of future strategists. SAASS has produced some of the most innovative leaders in the USAF.

Lt Col Paul "Abbie" Hoffman, USAF, Retired, PhD, is the former director of Air University Press at Maxwell AFB. An intelligence officer with operational deployments to Saudi Arabia, Bahrain, Iraq, and Afghanistan, he taught at the Air Command and Staff College until his retirement in 2019. As the former director of Air University Press, he oversaw academic book, journal, and paper publishing for the Air Force. He received his BS in History from the United States Air Force Academy, a Master of Public Administration from Oklahoma, and his PhD in international relations from Indiana University.

Lt Col Dik Daso, USAF Retired, PhD, is former adjunct faculty in the department of history at the University of South Carolina where he taught a variety of courses that focus on the history of technology and science. He retired from the USAF in 2001 and then served at the Smithsonian National Air and Space Museum as the curator of modern military aircraft until retiring from that post in 2012. He earned his B.S. from the USAF Academy in 1981 and his doctorate in history from the University of South Carolina in 1996. Daso flew T-38, RF-4C, and F-15 aircraft during his service. He was assigned to the Air Force Scientific Advisory Board during the visionary New World Vistas S&T study in 1995 and held the position of Chief, Air Force Doctrine, as a member of the Air Staff in the Pentagon. Lt. Col. Daso retired after 20 years of active service in 2001.

1225-1400 Behind the Scenes: The Birth of Space Force with Those Who Were There

Maj. Gen. Clinton E. Crosier is the Director, Space Force Planning, Office of the Chief of Space Operations, U.S. Space Force, the Pentagon, Arlington, Virginia. In this capacity, he is directly responsible for formulating the Department of Defense plan for the stand-up and operation of the U.S. Space Force. Included in his responsibilities are the macro-organizational design of the U.S. Space Force, stand-up of initial force elements and development of funding and manpower requirements, policies and processes that will govern the establishment of the first new military service in 72 years.

General David D. Thompson is the Vice Chief of Space Operations, United States Space Force. As Vice Chief he is responsible for assisting the Chief of Space Operations in organizing, training and equipping space forces in the United States and overseas, integrating space policy and guidance, and coordinating space-related activities for the U.S. Space Force and Department of the Air Force.

Colonel Stuart A. Pettis, USAF, (ret), Air Force Historical Foundation Vice Chair for Space, is the Director of STEM Education for the Air & Space Forces Association where he oversees the AFA's CyberPatriot and StellarXplorers competitions for over 20,000 high school and middle school students around the United States each year. Colonel Pettis retired from the United States Air Force in September 2021 after a 29-year career. He served in a variety of assignments at the Headquarters Space Force and Air Force, major command, numbered air force, and unit levels. In 2019, he was a member of the Secretary of the Air Force's Space Force Planning Team. He also commanded Thule Air Base, as well as the 1st Air Support Operations Squadron where he also served as the Air Liaison Officer for the United States Army's 1st Armored Division. Between October 2007 and May 2008, he led the 1st Expeditionary Air Support Operations Squadron during the surge in Iraq.

1410-1500 Origins of the Space Force Through Artifacts

Dr. David C. Arnold is a Professor and Chair of the Department of Security Studies at National War College in Washington, DC, where he has been on the faculty since 2013. He received his PhD from Auburn University, his MA from Colorado State University, and his BA from Purdue University, all in history. He is a career space and missile professional who retired from the Air Force in 2015 as a colonel. Dr. Arnold has taught history at 7,258 feet, 750 miles north of the Arctic Circle, and in cyberspace, and written extensively on space. His most recent book is the edited volume Space Force Pioneers: Trailblazers of the Sixth Branch, out last November from Naval Institute Press. His most recent article is "A History of the U.S. Space Force in Six Objects at the National Museum of the United States Air Force" in the winter 2024 of the Journal of the Air Force Historical Foundation.

Emily A. Margolis, PhD, is Curator of Contemporary Spaceflight at the Smithsonian's National Air and Space Museum. She is also responsible for the Museum's Mercury and Gemini collections. Margolis is co-curating two forthcoming exhibitions, Futures in Space and At Home in Space

1510-1645 The Military-Academic Space: Teaching Spacepower in PME and at USAFA

The military presence in and use of space has been a fact for decades. The education of military officers on the subject has developed in fits and starts over that same time frame. Over the last decade, space education has steadily grown in importance. This roundtable will present views and analysis of developments in space education in both PME and at the Air Force Academy in the recent past with an eye towards what it may mean in the near future as well. Space as a part of the curriculum in military education has expanded steadily from a few lessons to entire blocks of instruction. Over the last decade, coincidentally with the establishment of the Untied States Space Force, it has taken on a greater institutional presence as well, evolving form a single specialized seminar to a concentration and ultimately its own service sponsored PME institution. This panel has members who have taught in and developed curriculum for all of these entities as well as those who were there as the Air Force planned to move forward from being an Air and Space Force to a Space and Air Force as the importance of military space was publicized in the 1990s after Operation Desert Storm.

Lt Col Theodore (Teddy) Givler is currently a PhD student at the University of Colorado Boulder studying Cold War Diplomatic & Intelligence History and Space History. He is a career space & missile operator, serving in various operational and leadership roles. After spending much of his career in the United States Air Force, he is a current United States Space Force officer. He most recently served as a Senior Instructor and Associate Department Head of the History Department at the United States Air Force Academy and as the course director for the History of Spacepower. He edited and contributed to Space Force Doctrine Publication 1, Personnel in 2021. He has also presented numerous conference papers about Spacepower History. Just before embarking on his academic career, Teddy served as an original member of Task Force-Tango, the pre-legislation multidisciplinary team tasked with designing the macro-organizational structure of what would become the United States Space Force, specializing in the force development components of the then-theoretical service.

Dr. Gregory Miller is Dean of Space Education for the United States Space Force. Previously, he served as Chair of the Department of Spacepower at the Air Command and Staff College, Chair of the Strategy Department at the Joint Advanced Warfighting School and held faculty positions at the College of William & Mary, the University of Oklahoma, and Oklahoma State University. Dr. Miller received bachelor's degrees in political science and history from the University of California, Los Angeles, a master's degree in security policy studies from the Elliott School of International Affairs at

George Washington University, and a master's degree and Ph.D. in Political Science from The Ohio State University. His research interests include international relations theory and international security, terrorism and political violence, strategy formulation and evaluation, and the application of international relations and political violence concepts to space power theory. His scholarship appears in more than a dozen journals, including recent space-related articles in Astro politics, Space Policy, Air and Space Power Journal, The Space Review, and The Strategy Bridge, and he has a chapter in the recently released Routledge Handbook of Space Policy. His latest book, Sun Tzu in Space: What International Relations, History, and Science Fiction Teach Us about Our Future, was published by Naval Institute Press in 2023.

Dr. Paul J. Springer is a Professor of Comparative Military Studies in the Department of Airpower at the Air Command and Staff College at Maxwell Air Force Base, Alabama. He holds a PhD in military history from Texas A&M University. He is the author or editor of more than a dozen books, including America's Captives: Treatment of POWs from the Revolutionary War to the War on Terror; Military Robots and Drones: A Reference Handbook; Transforming Civil War Prisons: Lincoln, Lieber, and the Laws of War; Cyber Warfare: A Reference Handbook; and Outsourcing War to Machines: The Military Robotics Revolution. In addition, he has published hundreds of shorter pieces, on a variety of subjects including military history, terrorism, strategy, technology, and military robotics. Dr. Springer is a Senior Fellow of the Foreign Policy Research Institute, and the series editor for both the History of Military Aviation and Transforming War series, produced by the U.S. Naval Institute Press. Currently, he is completing a collective biography of the West Point Class of 1829, tentatively entitled *Brothers in Peace and War: The West Point Class of 1829*.

Dr Larry A. Weaver graduated from the Air Force Academy in 1976, completed pilot training at Craig AFB in Selma AL and Reese AFB in Lubbock TX and flew B-52s at Barksdale AFB, LA. He was selected to return to the Air Force Academy to teach history and completed his master's degree and PhD at Indiana University where he concentrated on the history of American foreign relations. Larry served as an Assistant Professor of History at the Air Force Academy before being selected to attend Air Command and Staff College in Montgomery, AL. Following graduation, he remained on faculty and served as the Dean of Academics before his Pentagon assignment. Following retirement from the Air Force in 1997, Larry wrote the official history of Operation Enduring Freedom and Iraqi Freedom before starting his own consulting business focusing on strategy, leadership and organizational development. Dr Weaver began teaching for the US Naval War College in 2004 and has taught Joint Maritime Operations and Strategy and War. In addition, he has taught at the Samford School, Duke University, and George Mason University. His latest writing includes a coauthored chapter on the strategic air campaign against Japan in World War II that will be included in a new history of the Pacific War published by the Naval Institute Press.

Dr. John Terino is an Associate Professor of Military and Security Studies at the Air Command and Staff College. He was the Chairman of the Department of Airpower when the Schriever Scholars Seminar Program was established. At ACSC, he teaches courses on Military Theory, Airpower, Contemporary Warfare, Joint Planning, Joint Air Planning, and an elective on the Air Force in Fact, Fiction, and Film. Prior to that, he was a professor at the School of Advanced Air and Space Studies (SAASS). Before coming to Air University, he taught for four years at the Air Force Academy in the Department of History. He retired from the Air Force in the grade of Lieutenant Colonel as a Logistics Readiness Officer after serving for almost 23 years. Recently, he authored a chapter, "The First Guardian: Bernard A. Schriever" in Space Force Pioneers: Trailblazers of the Sixth Branch. He received his BA, MA, and PhD in History and Sociology of Science from the University of Pennsylvania.

Journal of the Air Force Historical Foundation

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.....*Shape the Future*

Features

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COVER: U.S. Space Force Background *(U.S. Space Force Graphic)*

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Book Review List

U.S. Space Force 5th Anniversary Edition

Dear Readers,

Since December 2024, AFHF has focused on the Birth of the Space Force. The nation's newest military branch and the keeper of the high ground. As part of our expanded coverage of USSF, the Foundation Podcast "Know the Past…Shape the Future," produced a series of ten episodes tracing the technological origins of space history within the USAF followed by the creation of the Space Force itself. Those who made it happen behind closed doors at all hours of day or night have recorded their experiences to preserve the fast-paced effort before the stories fade into the night. One interview which dropped on February 5, featured Col Jack "2Fish" Fischer, USAF (ret), the leader of Task Force Tango. Tango (the origin of THAT name is not what you think), became the creative force that assembled the guidebook for the USSF in little more than a month—working 18 hour days and nights. https://afhistory.org/podcast/

Jack wrote a letter when he retired—but not just any letter. It was written to the CSO thirty-five years into the future. The vision and certainty projected in his words seem a fitting addition to this Special Space Force Edition of the Journal of the Air Force Historical Foundation which includes several space-related article reprints from the earliest days of the USAF.

"Know the Past…Shape the Future." Here is Col. Fischer's letter…

Dear Chief of Space Operations,

Thirty-five years ago today, I retired – at the very dawn of your incredible Space Force. It tore me up to leave back then, as I really wanted to help, but the past 3 and half decades have shown – you didn't need the help, as you've realized the potential 15 as you've realized the potential of your infinite domain and talented cadre, to set the stage and provide security for humanity's permanent expansion into the stars.

After a competitive wakeup call from Russia, China and others in the 2020s, you rose to the challenge, building a position of power that helped define the norms and processes for a prosperous, open and limitless future in space.

Our nation and the whole world are dependent on the largest, most technologically advanced branch of our military now more than ever. You are charged with great responsibility, in carrying on a proud heritage. One built on the foundations set by our founding legends: Raymond, Towberman, Thompson, Whiting, Shaw, Liquori, James, Burt, Miller, Endicott, Saltzman – and so many more – years of leaders who attacked an almost unfathomable challenge with their fangs out.

Today's Space Force includes brilliant minds from more diverse backgrounds than any other service, people who would have never dreamed of joining the U.S. Military –And that diversity has made you stronger. So why did they join? Because space is cool – it's unbounded. It is the very definition of the mysterious and almost magical unknown, whose lure can make us better and serve as the fuel which stokes the fire of our imagination.

You've taken that diversity of thought, and you've been bold, you've been brave – failing fast and growing, daring to unify the best parts of the space revolution, and defined the foundation of our future.

You have instilled in our fighting men and women a rare blend of a warrior's spirit, with a mad scientist's mindset – and that has served the nation well. While you serve up orbital butt-kicking with unparalleled lethality to any adversary that would dare to challenge our superiority, you have also led the charge on cutting-edge exploration and research. You've guaranteed a space economy we could only dream of 35 years ago.

You've created footholds on our surrounding celestial bodies, serving as springboards to expand our connections even further. Back then, we were merely scratching the surface in low Earth orbit, and had only a small, yet burgeoning commercial space enterprise. The progress over the last few decades has been nothing short of remarkable – enabled by the blanket of security that you provide the domain.

Simply put, you dumped a huge bucket of piping-hot awesome sauce on our future. Thank you, and thanks to all the men and women before and after for the sweat you've spent, and sacrifices you've made to make a truly extraordinary impact on our world.

Very Respectfully,
Colonel (retired) Jack Fischer

At the end of his retirement speech, 2fish then went on to say:

That's the future you're building today, the boundless potential that can be realized if you do this right. To the entirety of the U.S. Space Enterprise, I challenge you to do just that. While I won't be in uniform anymore, I'm still in the space neighborhood. As I said, there's a lot of gas still left in this tank, and just like Maverick, I'll be your wingman anytime - to help achieve that vision.

Become a Foundation Member Today!! https://www.afhistory.org/support/become-a-member/

Col (ret) Jack "2fish" Fischer is a senior space ops leader, combat fighter pilot, astronaut, and flight test expert with 29 years of experience across the spectrum of operational levels. He is a distinguished graduate of the U.S. Air Force Academy and a Massachusetts Institute of Technology Draper Fellow with Bachelors' and Masters' degrees in Astronautics. He is also a command pilot astronaut with over 3,000 hours in over 40 aircraft, Society of Experimental Test Pilots Associate Fellow, and has 136 days in space with two spacewalks. 2fish is currently serving as the Senior VP of Production & Operations at Intuitive Machines, managing all production and mission operations to include IM's worldwide lunar-distance ground network, production, spacecraft manufacturing, security and facilities. An active member of the community, he is also a member of the Texas Aerospace Research and Space Economy Consortium Executive Committee as part of the Texas Space Commission.

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.

This issue continues our process of providing a larger than normal issue for Summer, which in this case includes the Awards Banquet Program to lead off, the AFHF Symposium and Museums Conference Program following, and finally the normal Summer issue which begins on page 13. If you were unable to attend the events in May surrounding our two events, you can at least get a good idea of what transpired.

We have striven to provide mainly contributions which focus on space in all its manifestations. We have included the Winter 2024 issue of our Journal, a couple of new and fascinating articles which are not directly space-focused, and a half-dozen older articles which were primarily discussing space issues. We have also included 32 book reviews, encompassing 35 titles in all.

The Leadership's Message can be found on page 16. It's worth the read. Don't miss Upcoming Events on page 158. And the issue closes with the Mystery on page 160. Enjoy!

Richard I. Wolf, Editor

Historical Summary of the Birth of the Space Force

Gen. John Raymond, commander of United States Space Command and Air Force Space Command, left, Secretary of the Air Force Barbara Barrett, center, and Chief of Staff of the Air Force Gen. David L. Goldfein sign memorandums related to the authorization of the United States Space Force on Dec. 20, 2019. Later that day, the President appointed Raymond as the Chief of Space Operations for the newest branch of service. (U.S. Air Force photo by Tech. Sgt. Robert Barnett)

Peter Garretson

Guardians deserve to know their history, both in "deep time"—the imaginings of spaceflight and military power, and origins of the technology which enabled it—as well as the proximate political history of how the service came to be.

The Idea of a Space Force is Older than you think

It was the 1898 *Edison's Conquest of Mars*[1] which first depicted a military force doing battle in the space domain. Written by American astronomer and science fiction author Garrett P. Service, this would-be sequel to War of the Worlds was written during Thomas Edison's lifetime, prior even to World War I, and before powered flight. The following years would see the development by Russian Konstantin Tsiolkovsky of his ideas for spaceflight and the rocket equation (1897-1903) and the experiments by American rocket pioneer Robert Goddard (1926-1941). These would inspire the German Rocket Society, whose members were recruited by Nazi Germany resulting in the spectacular development of the V2 in World War II, and begin the ideation of space force application concepts such as satellite mirrors which could burn cities, and trans-atmospheric hypersonic skip bombers.

At the conclusion of World War II, the United States captured the German rocket scientists and their designs. The post-World War II years saw extensive experimentation with rocket technology by the Army, Navy and Air Force.In 1946, the U.S. launched a V2 to take the first image of Earth from Space, and RAND would publish first groundbreaking publication of the theoretical possibility of a groundbreaking World Encircling Spaceship[2], and a full decade before Sputnik

The first serious proposal by military officers for a Space Force came shortly after World War II, in 1947—before even the birth of the Air Force! Visionary naval officers, Lt. Caleb Laning (later rear admiral) and former Lt. Robert A. Heinlein (later the dean of American science fiction writers) published "Flight into the Future" in *Colliers*[3] where they laid out the rationale for a dedicated space service just 50 years after Serviss' novel.

Sputnik 1 was launched by the Soviet Union on October 4, 1957. It was the first artificial satellite to orbit the Earth, marking the beginning of the Space Age. It surprised and shocked the U.S. public, and the U.S. created the Defense Ad-

Editor's Note: When Space Force stood up in December, 2019, it was the culmination of a years-long process which resembled the struggle to create a separate Air Force. The author was an active participant in this process and tells the story with an insider's perspective.

vanced Research Projects Agency (DARPA), NASA, the National Reconnaissance Office (NRO), and others, all in an effort to catch up in space.

The U.S. military services initially had ambitious plans for space, including designs by the Army and Air Force for Lunar bases and space-based nuclear deterrents. But in the context of fears of nuclear escalation, civilian leadership in the White House and DOD forced the services to scale back their ambitions. Formerly military missions of peacetime exploration (such as crewed spaceflight and robotic exploration) were given to NASA, reconnaissance was assigned to the new NRO. DOD leadership failed to support Air Force and Strategic Air Command (SAC) ambitious 1962 plans for its Strategic Orbital Base, the Manned Orbiting Laboratory, Dyna-Soar, and TRIM space-based strike concepts.[4] The Air Force had ambitions to develop nuclear propulsion via NERVA and Project Orion, but the Partial Test Ban treaty of 1963 killed both.[5] Military ambitions focused on the Moon and space-based nuclear deterrents collapsed with the signing of the Outer Space Treaty of 1967, which removed the Moon as an object of military, competition and forbid the stationing of nuclear weapons on orbit.

Collectively, these greatly limited the tools available, and constrained the military services focus to a narrow portfolio of space related missions: ICBMs and launch vehicles and unmanned satellites supporting nuclear operations: nuclear detonation detection, weather satellites supporting spy satellites, and communications supporting nuclear command. Nevertheless, military visionaries still saw vast potential in developing spacepower.

Early Advocacy

In 1981, at the request of the Secretary of the Air Force, the U.S. Air Force Academy hosted a Military Space Doctrine Symposium, concluding that, "Over the long-run, a dedicated space organization structure is inevitable."[6] In fact, at every point of the Space Force story, links to Professional Military Education (PME) have been important.

Lasers and SDI

A year later, the influential document High Frontier which paved the way for Reagan's SDI articulated the case for a space-based missile defense capability using kinetic interceptors and lasers, and noted, "There is also support in and out of the Defense Department for a U.S. Space Force with relationships to the Air Force akin to the Marine Corps relationship to the Navy, or even as an entirely new military service."[7]

In 1983, President Reagan outlined his Strategic Defense Initiative (SDI), which would create an organization which would pursue a number of important lines of effort for a space-based missile shield, which would also lay the seeds for what would enable both the small satellite and reusuable launch revolutions. The multi-service U.S. Space Command (USSPACECOM) was created with the expectation it would assume the missile defense capabilities created by the Strategic Defense Initiative Organization (SDIO). Initial optimism over the potential of space-based lasers led to an early legislative proposal for a separate space force called the "strategic force," which failed to launch.[8]

General Ronald R. Fogleman, Air Force Chief of Staff.

Raising Expectations

In the mid 1990's there was an intellectual renaissance under the visionary General Ronald Fogleman, Air Force Chief of Staff. A slew of visionary documents— SpaceCast 2020[9], AF2025[10], and New World Vistas[11] –provided an exciting vision of what might be technologically possible for military spacepower. It was in this early period that most Space Force advocates began developing their ideas at Air University.

General Fogleman talked about "an Air and Space Force transitioning to a Space and Air Force." USSPACECOM's General Estes created a bold Command Vision for 2020 [12] and Long Range Plan[13] which are still unmatched in reality.

USAF efforts to integrate and normalize space resulted in the very first class of Space Officers to attend

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USAF weapons school. This resulted in a cultural collision—it both exposed space officers to combat and integrative thinking, but also to tribal denigration of space officers by fliers, further widened a deepening cultural rift between aviation and space.

Senator Bob Smith & The Rumsfeld Commission

The first political entrepreneur who sought to create an independent Space Force was senator Bob Smith, who wrote The Challenge of Spacepower in 1999.[14] His efforts to create an independent Space Force in that year failed, but he was able to get enacted the creation of the Rumsfeld commission,[15] which was the first serious discussion of the possibility of a Space Force. While the actual recommendations of the committee suggested interim stewardship of a rechartered Air Force, the commission raised expectations by stating, "A Space Corps within the Department of the Air Force may be an appropriate model in its own right or a useful way-station in the evolution toward a Space Department" and "The Commission believes that once the realignment in the Air Force is complete, a logical step toward a Space Department could be to transition from the new Air Force Space Command to a Space Corps within the Air Force. This would be, in essence, an evolution much like that of the Army's air forces from the Army Air Corps, into the Army Air Forces and eventually into the Department of the Air Force. The timetable, which is not possible to predict, would be dictated by circumstances over the next five to ten years."[16]

As documented by the AFHRA,[17] the USAF did not appreciate the scrutiny, and originated many of the talking points which would re-emerge 15 years later.

General Ryan and the Period of Buzz and Push-back

The early 2000's was a period of intellectual vibrancy with a number of important publications. The USSPACECOM strongly pushed intellectual development, and wrote personal letters to space officers in Air Command and Staff College (ACSC) urging them to attend the School of Advanced Air and Space Power Studies (SAASS). At SAASS there was a vibrant conversation about separation. Dr. Ev Dolman wrote his ground-breaking work on realist space strategy, *Astropolitik* in 2001.[18] Brig Gen Simon Worden and Lt Gen John E. Shaw wrote *Whither Space Power* in 2002, a text still used today.[19] Air Force Space Command (AFSPC) also began a command publication *High Frontier*, a command magazine in 2003[20] for spacepower debate, which created an intellectual community. An early outspoken spacepower advocate, Worden[21] would mentor many of the advocates who played prominent roles in the final Space Force push, and play a supporting role himself.

However, as fiscal realities set in, Chief of Staff Gen Michael E. Ryan's[22] concept departed from Fogleman's formula and re-introduced the Aerospace concept, which saw air and space as a single indivisible medium. While the advocates seemed content to embrace a vision of an Air & Space Force in the process of transforming into a Space and Air Force, they lined up against Ryan's formulation, which they saw as backsliding. The reversal left many advocates disappointed and embittered at the lack of forward movement anticipated by the Rumsfeld report.

9/11 and the Forever War Distraction

Rumsfeld's leadership on the Space Commission suggested to many that President George W. Bush and Secretary of Defense Donald Rumsfeld were on a path to create a separate Space Force in early 2001. However, the terrorists attack on 9/11 refocused attention away from Rumsfeld's "transformation" and focus on major combat operations toward and infantry-centric and infantry support focus for the Global War on Terror, largely submerging the spacepower debate. In the crisis mode immediately following 9/11, there was an urgency to create a USNORTHCOM for homeland defense. To enable USNORTHCOM to be created within general officer personnel caps, USSPACECOM was disbanded and its functions transferred to USSTRATCOM. One USAF general apparently remarked, "this will shut down that pack of Billy Mitchells at USSPACECOM." Space had lost its organizational sponsor.

The NSSO, The Spacepower Theory Project & Networking of the Advocates

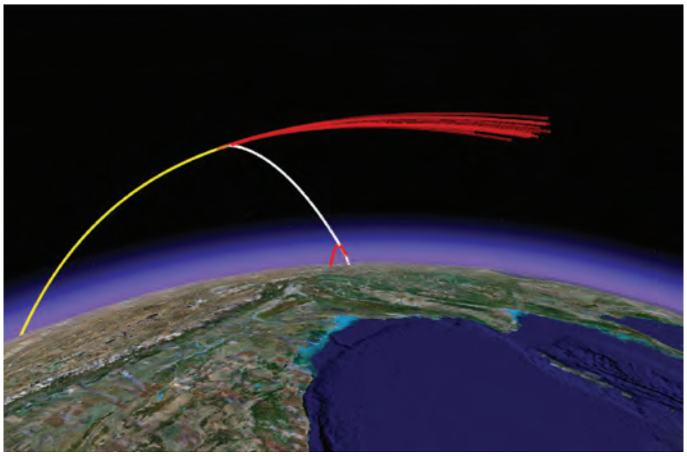
By 2004, the DoD had created the National Security Space Office (NSSO), a sort of pre-cursor to a Space Force staff, which created and evaluated plans for both DoD and IC space. NSSO was populated with a number of spacepower thinkers who would advance spacepower thinking. For example, NSSO sponsored the National Defense University Spacepower theory project[23], which would knit together most of the visionaries and advocates, including Worden, Smith, Scott Pace, and Garretson. Regrettably, NSSO's advocacy—especially on budget matters—would run afoul of the services, and it would be first neutered (2005) and then disbanded(2010).

A Second Failure to Launch: The Allard Commission 2007

As it became clear that insufficient progress was being made, and recommendations must be formulated for the next administration, a second space commission was sponsored by Senator Wayne Allard of Colorado. Spacepower advocates hoped the Allard Commission[24] would recommend a Space Force, but they were once again disappointed. The Allard commission reflected the realities of having to balance the demands of the Global War on Terror, but they noted there had been little improvement and that "no one was in charge."

A failed wakeup call: PRC ASAT 2007

On the anniversary of the release of the Rumsfeld report, the People's Republic of China (PRC) conducted the first Anti-Satellite (ASAT) test since the Cold War.[25] The



Computer depiction of Chinese ASAT test in 2013. Image downloaded from Google Earth, reference to Geoffrey Forden, "GUI_Missile_Flyout: A General Program for Simulating Ballistic Missiles", submitted to *Science and Global Security,* December 2006.

test shocked many in the U.S. Space community who felt it indicated the need for military space reform, but 2007 was also the year of The Surge in Iraq—the nation had other things it was focusing on. Moreover China's path was not yet clear, and the U.S. was still hopeful that China would democratize as it got wealthier, that the U.S. and China were too coupled to go to war, and most hoped it was a one-off event rather than a trend. Nevertheless, this began increased threat work at the National Air and Space Intelligence Center (NASIC) and in the broader intelligence community (IC), and began work led by the NSC to develop a plan. Generally, advocates saw this as a failed wake-up call that should have galvanized greater action.

The 2013 ASAT Test

However, while the U.S. was distracted by GWOT, the PRC was developing multiple lines of effort in its ASAT capabilities. In May 2013, the PRC tested what the U.S. believed was a capability to attack geostationary orbit. While the ability to attack Low Earth Orbit (LEO) was alarming, the ability to attack higher orbits (GEO and MEO) was much more serious, since the crown jewels of Missile Warning, Nuclear Command and Control, and GPS were now under threat.

Advocates in the White House

At the direction of Deputy National Security Advisor Antony Blinken, the NSC wrote a memo to the President. President Barak Obama came back wanting a plan with budgetary implications. For the next couple years, Chirag Parikh, Director of Space Policy and Director of Defense Policy and Strategy in NSC and Matt O'Kane,then Senior Program Manager for national security space in the Office of Management and Budget (OMB) (along with sympathizers Doug Loverro in OSD Policy and Gil Siegert in OSD Acquisition Technology and Logistics (ATL)) would develop options and attempt to push the DoD toward organization and management reform through a standing Interagency Policy Committee (IPC) [one of three formal levels of NSC coordination] process, totalling some 40 IPCs. While the DoD pushed back hard, this "softened the ground" and provided an analytic underpinning for what followed. Loverro and O'Kane would remain critical players through the entire process.

The Jump to HASC (2014)

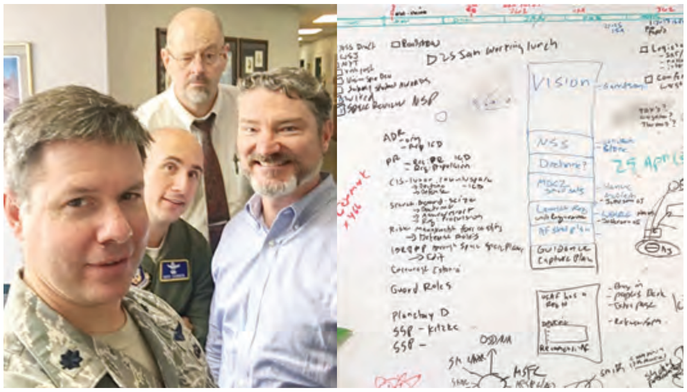
Faced with intransigence on the part of the Pentagon, the advocates had made their case to Steve Kitay, a staffer for House Armed Services Committee (HASC) Strategic Forces Chairman Mike Rogers. Rogers and HASC Ranking Member Representative Jim Cooper were becoming increasingly concerned about the threat and its pace, and becoming aware of concerns by industry that "no one's in charge." HASC supported the idea of a Hard Major Force Program (a fenced budget) for space, and also asked GAO to examine the issue.

A Concentration of Advocates at Air University

In 2014 there was suddenly a critical mass of spacepower advocates at Air University who were frustrated and wanted to catalyze forward movement (this included at various times, Dr. M.V. "Coyote" Smith, Lt Col. Peter Garretson, Dr./Maj. Brent Ziarnick, Dr. Ev Dolman, Maj. Chris Stone). In early 2015 several of the Air University spacepower advocates gathered for a Saturday planning session to map out what the nation needed. They subsequently developed a multi-year plan with lines of effort to improve space professional development, space education, and organizational space reform. They organized and begin a multi-year writing campaign. They would find a sponsor in OSD Net Assessment (Dr. Matt Daniels), and develop the Space Horizons Task Force (a precursor to Space Force Schriever Scholars / West Scholars PME). They would receive the sponsorship of Air University Commander Lt Gen Steven L. Kwast,[26] and become networked with Newt Gingrich, a long-time spacepower advocate and inner-circle Trump advisor. They would perform multiple activities and studies, including the Fast Space Report[27] which laid the groundwork for SDA and National Security Space Launch (NSSL). They would develop a Space Corpsman's handbook.

The Most Important GAO study in History

The results of the GAO study[28] requested above, so impressed the HASC staff, that Rogers and Cooper would form an internal tiger team, and would proceed to have a large series of meetings on 'Space Reform'. Rogers would make a crucial decision to pursue this is in a bipartisan fashion with Ranking Member Jim Cooper, and they would signal their intention to make significant reforms.[29] Represenative Jim Bridenstine (later Trump's NASA Administrator) was another significant advocate, who showcased significant long-term vision.[30]



(Clockwise from lower left) The author, Dr./Maj. Brent Ziarnick, Dr. Ev Dolman, and Dr. M.V. "Coyote" Smith, the "frustrated" advocates at Air University and their multiyear strategic planning board.

Space: The Battle Above and Space as a Warfighting Domain

DoD was uninterested in organizational Change. Howeever, DoD was increasingly concerned about the threat, and took a number of actions to begin transitioning towards a more warfighting culture. This was the period where the Space Enterprise Vision, Space Mission Force, Space Tactics Forum, Joint Interagency Combined Space Operations Center (JICSPOC) (predecessor to the National Space Defence Center (NSDC)), and Principal DoD Space Advisor (PDSA) were formed. DoD also began pushing the talking points up the chain that Space was a warfighting domain. At the end of the Obama presidency, Gen John E. Hyten[31] (commander of U.S. Strategic Command) was featured in a 60 minutes special "Space: The Battle Above." The special was so impactful that Chairman Rogers brought in the entire subcommittee to watch it.

America Needs a Space Corps (2017)

In early 2017, following three earlier publications by the Air University (AU) faculty aimed to grab presidential attention,[32] Dr. M.V. "Coyote" Smith published his "America Needs a Space Corps."[33] This began a regular correspondence between Smith and Kitay, and Smith would later travel to meet with Rogers. Rogers would also make multiple trips to meet with Gen Kwast and his Air University space faculty. Smith's proposal for a Space Corps would find fertile ground.

Rogers at Space Symposium

At Space Symposium, Rogers laid out the results of their study and his conclusions of what would be required: a Space Corps within the Department of the Air Force.[34] He would follow with proposed legislation.

The AF and DOD Push Back

Air Force Secretary Heather Wilson, Secretary of Defense Mattis,[35] and AF sympathizers in the Air Force Association (AFA)[36] and the American Enterprise Institute (AEI)[37] pushed back, publicly denouncing the idea, and working to defeat the legislation in both the House and Senate. The Senate was never sympathetic to the idea, but was open to a trade on cyber reform. In conference, the House and Senate could not agree on the Senate's plan for Cyber reform, and so McCain withdrew his support[38] and the Space Corps failed.[39] [40] But Rogers and Cooper succeed in getting the National Defense Authorization Act (NDAA) to force the Deputy Secretary of Defense to study of the the need for major space reorganization. It also dissolved PDSA, A11, and removed some SECAF authorities in preparation for a unified solution.[41]

Resurrecting Lazarus From the Dead

The DoD "1601 report" was well on its way to delivering a report recommending only very incremental changes, and not recommending a major military space reform. Then, to everyone's surprise, President Donald J. Trump floated the idea of a Space Force in Miramar on March 13, 2018.[42] While the White House staff was certainly aware of the issue and its progress in Congress, neither the NSC nor the National Space Council had prepped the President, and both were surprised by the President's remarks. While Miramar was first to garner much news, Trump first indicated interest in the topic in a March 8, 2018 cabinet meeting. Evidence suggests the president first heard about it from Representative Kevin McCarthy on a plane ride shortly after the Space Corps was defeated. Trump would later receive supportive counsel from his new NASA administrator Jim Bridenstine, and advisor Newt Gingrich.

The Gag Order Pushes the Advocates Underground

Facing significant uncertainty with regard to its future, the SECAF sought to tightly control the message.[43] This was interpreted by AFSPC public affairs as a nearly complete gag order on space, which was also to silence those with the most developed ideas on a Space Force from articulating them in a critical window of public discourse. Advocates at Air University nevertheless continued advocacy within government channels, with OSD, with HQ USAF, with AFSPC, with HASC, and with the White House, and with external other advocates such as Doug Loverro, Tim Cox, Lamont Colucci, and Newt Gingrich. The faculty personally delivered a paper copy of "The Case for Space: A Legislative Proposal for a Department of the Space Force"[44] to National Space Council Secretary Scott Pace, a mere five days before the President's verbal order.

Pinning the Rose on the Chairman

President Trump had resurrected the Space Council and saw the members of the Space Council's advisoryboard as "his people" and looked forward to meeting them. A Space Council was to convene in the White House for the release of SPD-3[45] on Space Traffic Management on June 18, 2018. During the prep session, the President decided he wanted to use this opportunity to announce "we were going to do Space Force." This caught the staff unprepared, and his remarks had to be edited on the spot, causing a 30-minute delay. Quite unusual for major organizational change, this announcement was not coordinated through the usual interagency process, and came as a significant surprise to the DOD and USAF leadership when the Deputy Chairman of the JCS, Gen Dunford received a direct verbal order to begin planning for a separate Space Force.

Getting Alignment / Developing the Options

Although Dunford had been tasked, it was rapidly apparent that this belonged to the highest levels of civilian DoD leadership. SECDEF Mattis, burned by his earlier opposition to Space Corps, had delegated to his DEPSECDEF Patrick Shanahan. Kitay, formerly supporting Chairman Rogers in HASC, was now the Deputy Assistant Secretary of Defense (DASD) for space policy. Everyone between Kitay and the President seemed to have a different idea of what the President meant, and what problem it was supposed to solve. Was it an acquisition problem? (requiring a new Space Development Agency or Defense Agency like MDA or NRO). A warfighting problem? (requiring a new Sub-unified or Unified Combatant Command perhaps with Acquisition authorities). An Organize, Train, and Equip Problem? (necessitating a military service (Space Corps) or a new Military Department? What was the best solution? Should it include NRO? How much would it cost? How many people would it take? Who would lose budget and people and units to make it happen? What was within the power of the DoD or executive to do without Congress? What is the minimum to satisfy the President? The Chairman and Joint Staff took the position it should be a SOCOM-like combatant command.[46] The Undersecretary for Research and Engineering (U.S.DRE) Mike Griffin (former SDIO Director and NASA Director) advocated for a Space Development Agency.[47] SECAF Wilson opposed legislative change, but a leaked proposal floated a proposal for a full department[48] that touched many "3rd rails" such as including NRO. The inclusion of NRO touched off a war between the SECAF and the IC. The proposal also provided cost estimates which were labeled as "malicious compliance"[49] and created a backlash in the White House. Scott Pace at the White House would drive planning and analysis, but was reported to have lamented that "no one is doing what the President wants."[50] Various DoD and AF documents were leaked to the press, causing the White House to take a firmer hand.

A Firm Hand from the VP

In order to get the DoD in line with the White House position, Vice President Pence had to personally travel to the Pentagon to make clear they needed to be considering a separate service (besides just a USSPACECOM and SDA), and to later give a speech to "come in and litigate by committing in public over the top" at the reception of the report. That same day, Air Education and Training Command (AETC) commander Lt Gen Steve Kwast would become the only USAF general officer to support the movement towards a Space Force with his publication of "There won't be many prizes for second place." Subsequently an intense internal bureaucratic battle began to shape the contents of the Space Policy Directive which would create the policy contours of the Space Force (SPD-4). Against the proclivities of the advocates on the White House staff,[51] the AF, Joint Staff and DOD would argue strongly against a separate department, and convince both the Vice President and President. The President would codify his written order to develop a legislative proposals as SPD-4 released on Feb 19, 2019.[52]

Lt. Gen. Steven L. Kwast, commander of Air University and later AETC.

From Shirking to Working

Faced with a direct written order from the President in clear and unambiguous language, the DoD and Air Force fell in line. OSD Policy provided the key guidance and OSD and DAF lawyers began writing a formal legislative proposal, and accompanying rationale.[53]

At the urging of Gen Thompson,[54] the CSAF and SECAF asked Gen Clint Crosier[55] (who had already put in his retirement papers), to delay his retirement and rapidly build a plan. Crosier was to set up the Space Force Planning Task Force (SFPTF), to examine immediate actions and HQ structure and personnel structure.[56] Air Force leadership would also task AFPSC "Task Force Tango," led by Col Jack "2fish" Fisher to develop a plan for how to restructure the MAJCOM.[57] The SFPTF would receive the sponsorship of the DEPSECDEF and receive an execute order.

A significant portion of the Air Force staff saw this as a "paper chase," and few believed that there was sufficient will in Congress to make it happen. However, this work would prove crucial. Gen Thompson would also personally ask another retired AF Space Officer, and spacepower advocate, J.R. Riordan (who had written about Space Force as part of his PME[58]), to suspend his civilian career to work as a senate staffer.

Following reports she had irked the president with her opposition, SECAF Wilson announced her retirement and was succeeded by Matt Donovan (acting)[59 60] and Barbara Barrett[61] who both proved to be strong advocates, reversing the previous Air Force position.

The Hill Campaign

With the release of the budget, the White House and DoD rolled out the Space Force proposal. OSD Policy made numerous Hill visits.[62] While this was arguably the #1 priority of the administration for this budget, White House personnel were nonplussed at the support from the DoD and DAF in their testimony. The senate was particularly skeptical, and held a hearing.[63] This was a nervous moment, because many staff knew that neither SECAF Wilson nor Chairman Dunford was a true advocate, but "we walked into the hearing without a DoD position and we walked out of the hearing with a consolidated DoD position."

Despite the significant work and effort on the part of the DoD to explore the options and develop a proposal, from the point of view of Congress, it was a side show. Neither the House or the Senate used the extensive DoD legislative proposal as their basis. The House recycled their Space Corps legislation. The House had flipped to Democratic leadership, and it was only the history of bi-partisan support that allowed the House to support a Trump initiative. The Senate "began from first principles" leaning on J.R. Riordan, who looked back to the Key West Accords and forward to Crosier's lean headquarters plans. Crosier's detailed homework that they could immediately stand up a headquarters diffused a natural tendency to delay implementation. Gen Kwast's advocacy helped secure senate appropriations. Nevertheless, the legislation did not line up, and each had only part of what the White House wanted. Negotiations continued.

Conference

The state of the Space Force was still uncertain going into conference and for most of conference. It was "every day, we lost it." Key to selling it was the threat, and open source reports from CSIS and SWF, NASIC and DIA were crucial in making the case—"it was the threat that sold it." Ultimately though, Vice President Pence had to become personally involved in securing the support of the Senate to convince Sen Inhofe to gain his support. The USSF would be one of the final things to be negotiated, and would depend on a deal between President Trump and democratic leadership to include paid family leave.

Space Force Birthday

The legislation had included a provision that would allow dual-hatting of the AFSPC commander. The AF Space Officer on the National Space Council wanted no ambiguity about when the USSF was born (signing of law, appointing of first commander), and proactively worked to ensure the package was signed and available at the NDAA signing ceremony. Even Gen Jay Raymond himself did not know if he would be Chief of Space Operations (CSO). And in fact, there had been voices arguing to put a non-Air Force Officer as the first commander. Moreover, Mike Rogers, Newt Gingrich, James Woolsey all appear to have supported visionary Gen Steve Kwast for the role—who the AF forcibly retired for his Space Force advocacy. Others favored Hyten and Thompson.

Implementation

Raymond was to focus on the core of what it meant to be a service and to try to keep things lean. Of particular interest is the "remarkable collegiality" of Raymond and CSAF David L. Goldfein. The USSF was to perceive the USAF generally as good partners in the transition, and the CSAF as "no better friend to the Space Force." Dual hatting would prove to be challenging. Raymond would discover that the battle rhythm of the Pentagon would not allow him to be a service chief in Colorado Springs and he would have to move to DC. The progress of the standup was helped by COVID lock-down, which reduced the number of meetings which would have distracted the stand-up. But Space Force members still found themselves woefully undermanned for the business of the Pentagon, and found that the plan, was really a plan-to-plan that anticipated a one-year stand-up, when the Congress had made Space Force a thing on day 1. They would have to stand up a headquarters, build their own doctrine, budget, get new emails, ID cards, work the politics of service transfers, readiness all while deciding on cultural issues of flag, shield, rank, uniform, and songs—the same small group of people, with this diversity of overlapping issues at the same time.

Observations

Many people deserve credit for forwarding the ball at various stages. But for the precursor initiative and work under Obama (Antony Blinken, Chirag Parikh, Matt O'Kane, Doug Loverro, and Gil Siegert) the options would not have been developed and passed to HASC. But for the work of Rogers & Cooper, and assisted by their staff (Tim Morrison, Steve Kitay, Sarah Mineiro, and Leonor Tomero) this would not have happened. But for the "uranium rod" of President Trump, assisted by Vice President Pence, and their staffs (especially, Scott Pace, JP Parker, Matt O'Kane, Keith Kellogg, Earl Mathews and AF officers Bill Liquori, Michelle Edmondson, Troy Endicott, Curtis Hernandez) it might have failed. But for the work by OSD Policy to develop and sell the proposal (Justin Johnson, Steve Kitay, Audrey Shaffer, and AF Officer Casey Beard); OSD and AF JAGs to write the legislation (Bill Castle, Tom Ayers, Allison Devito) it might not have survived. But for Gen Thompson's personal intervention to task Clint Crosier and send J.R. Riordan to the SASC, and Crosier's diligent efforts to develop (and make the White House and Congress aware of an actionable plan, this might never have crossed the finish line. But for the efforts of the HASC and SASC staffers (Sarah Mineiro, Leonor Tomero, and J.R. Riordan), the OSD policy crew and the VP to sell the idea, this might not have crossed the finish line—and but for the efforts of threat developers and briefers (Joe Rouge, Andy Cox, and Larry Gershwin), NASIC, DIA, CSIS and SWF they would not have had the winning story (classified and unclassified) to win over Congress. Those people lent their time and effort to advancing the proposition of a Space Force.

The Space Force is a tale of high drama and bureaucratic warfare. The central causal factors were a changing threat landscape, unhappiness with acquisition, and a broader change in the environment leading visionaries to militate for faster progress, and the emergence of political entrepreneurs in the HASC and White House to institute a change.

The key dynamic that emerged was a continuous call to upgrade the focus and consolidate authorities, which was resisted by the DoD and Air Force. An advocacy coalition emerged with nodes in DC and at Air University who formed behind-the-scenes connective tissue to share data, build proposals, ghost-write speeches and legislation, strategize and plan, and make the public case in various venues.

Most of the advocates emerged from the Air Force, as frustrated visionaries who felt we were underperforming or backsliding on the vision and promise space showed in the 1990's. In fact, there were only a few combatants and entrepreneurs who tried to bend the bureaucracy to make a Space Force happen in environments where it was difficult, unpopular, when it was not their job, and when it was above and beyond their job. The strong advocates were embedded within broader advocacy coalition cells that were fairly well networked. Two separate "cells" of advocates emerged, one in DC, and one at AU.

The DC node emerged as a result of a change in administration that freed former internal advocates in the executive to begin advocating externally, and featured a group of pragmatic and experienced individuals. The two groups acted mostly independently, but had nodes in common. They first helped the HASC Strategic Forces leadership to justify the need for change with various facts and arguments, helped explore the options, and then settle on the idea of a Space Corps, and later provided support to the White House (authoring proposals, writing speeches, writing legislation, writing for the public). The DC cell included Doug Loverro, Steve Jacques, Matt O'Kane, Todd Harrison, Tim Cox and Clint Crosier.

The Air University node emerged when a critical mass of spacepower advocates and friends happened to receive simultaneous assignments, and began strategy sessions to change the world—this group was visionary and saw the Space Force as necessary to securing future lines of commerce in a broader space economy. The AU Cell included Steve Kwast, M.V. 'Coyote' Smith, Brent Ziarnick, Peter Garretson, Chris Stone, and Ev Dolman. Both cells enaged internal parties in both the executive and legislative branches. The two were mostly independent, but though the AU cell maintained regular coordination with Cox and Loverro.

Of these, nearly all the strong advocates who developed proposals, wrote advocacy pieces, lobbied internally and externally, and generally went against the grain were current or former Air Force officers (though not all space officers): Doug Loverro, Steve Kwast, Matt O'Kane, Dr. M.V. "Coyote Smith, Dr. Brent Ziarnick, Pete Garretson. Perhaps not surprisingly, all proved knowledgeable about Air Force founding history, and most had a connection with PME.

Throughout the period from 2014-2019, whether the advocates, the HASC, or the White House had the initiative, it was opposed by the Pentagon at both OSD and Department of the Air Force levels, which opposed externally-driven change, until the White House made personnel changes with supporting SECDEFs and SECAFs.

Not unlike the resistance innovators encountered in developing tanks and aircraft (as documented in Fast Tanks and Heavy Bombers), the advocates encountered significant resistance from the Air Force, which paradigmatically saw space as an extension of Air, and spacecraft as auxiliaries to Air Forces, saw spacepower as potentially competing against its preferred systems, and which institutionally saw independence as a loss of resources (budget and people) which ensured a buffer freedom of action and prestige.

Nearly every element of the Pentagon (and STRATCOM and AFSPC leadership) opposed, or were ambivalent to, the move toward independence. The JCS was unanimous in its opposition. The Pentagon tried every way to satisfice and offered numerous options short of a Space Force: a Space Command, a Space Development Agency, a Rapid Capability Office. Only executive pressure overcame the strong resistance of the existing rice bowls.

However, the final form was a negotiation that fell short of the desires of either the administration or the advocates for a fully independent department, and who believed along with Senator Bob Smith that, "to achieve true dominance, we must combine expansive thinking with a sustained and substantial commitment of resources and vest them in a dedicated, politically powerful, independent advocate for space power."[64] ■

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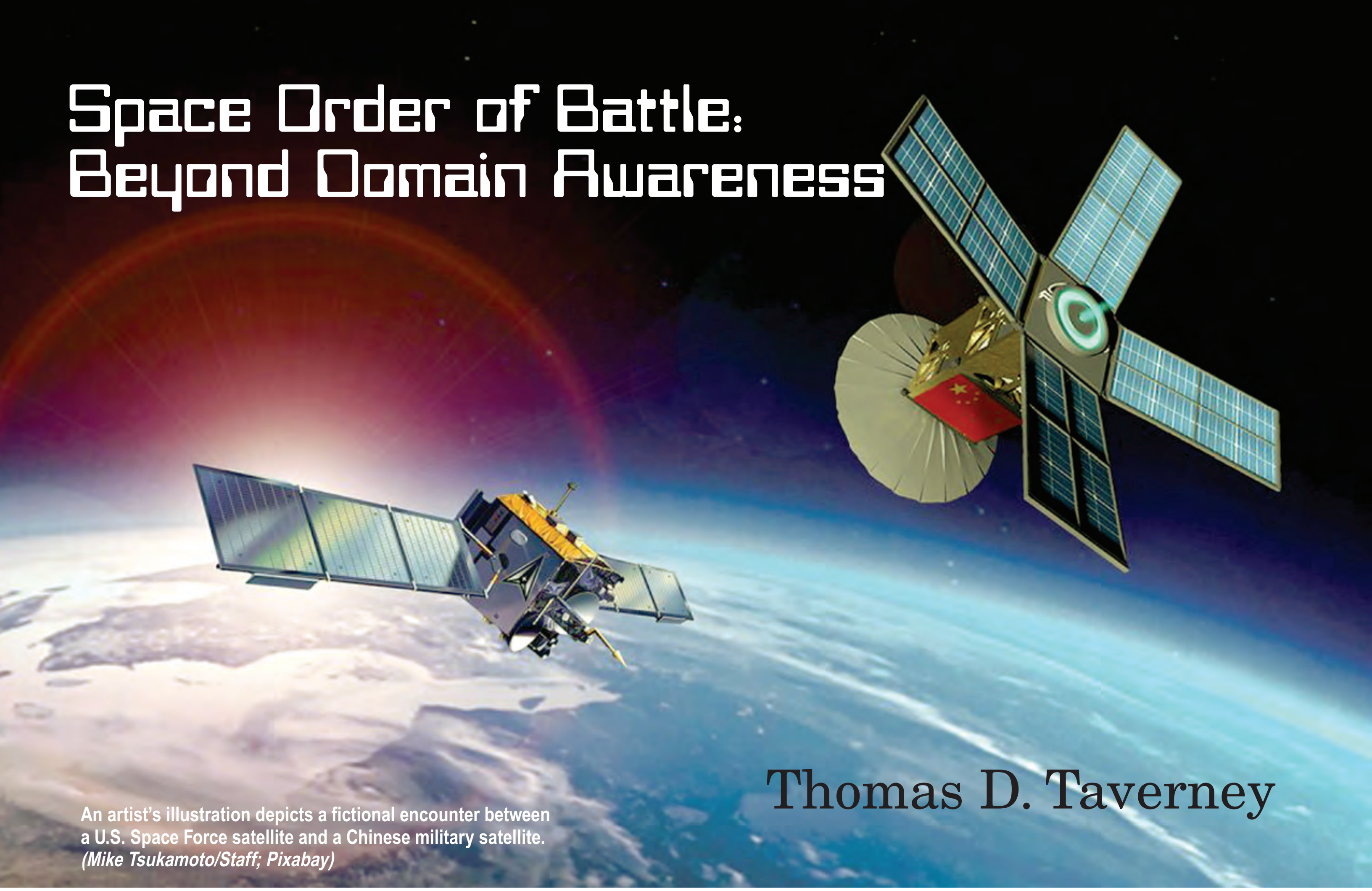
Space Order of Battle: Beyond Domain Awareness



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.

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https://www.airandspaceforces.com/article/space-order-of-battle-beyond-domain-awareness/

62 Years of History

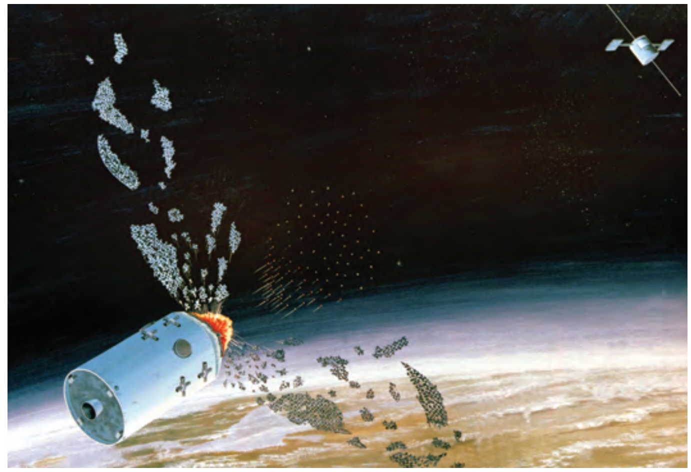
Space has been a warfighting domain since 1962, when both Russia and the U.S. first pursued anti-satellite (ASAT) weapons. The Air Force's Program 505 conceived of a prototype Nike Zeus anti-ballistic missile with a 1 megaton warhead to destroy potential space weapons threatening the U.S. Tests at White 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

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)***

(DSO). U.S. adversaries are now deploying satellites that can maneuver and rendezvous with other objects, which puts the U.S. at a disadvantage.

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.

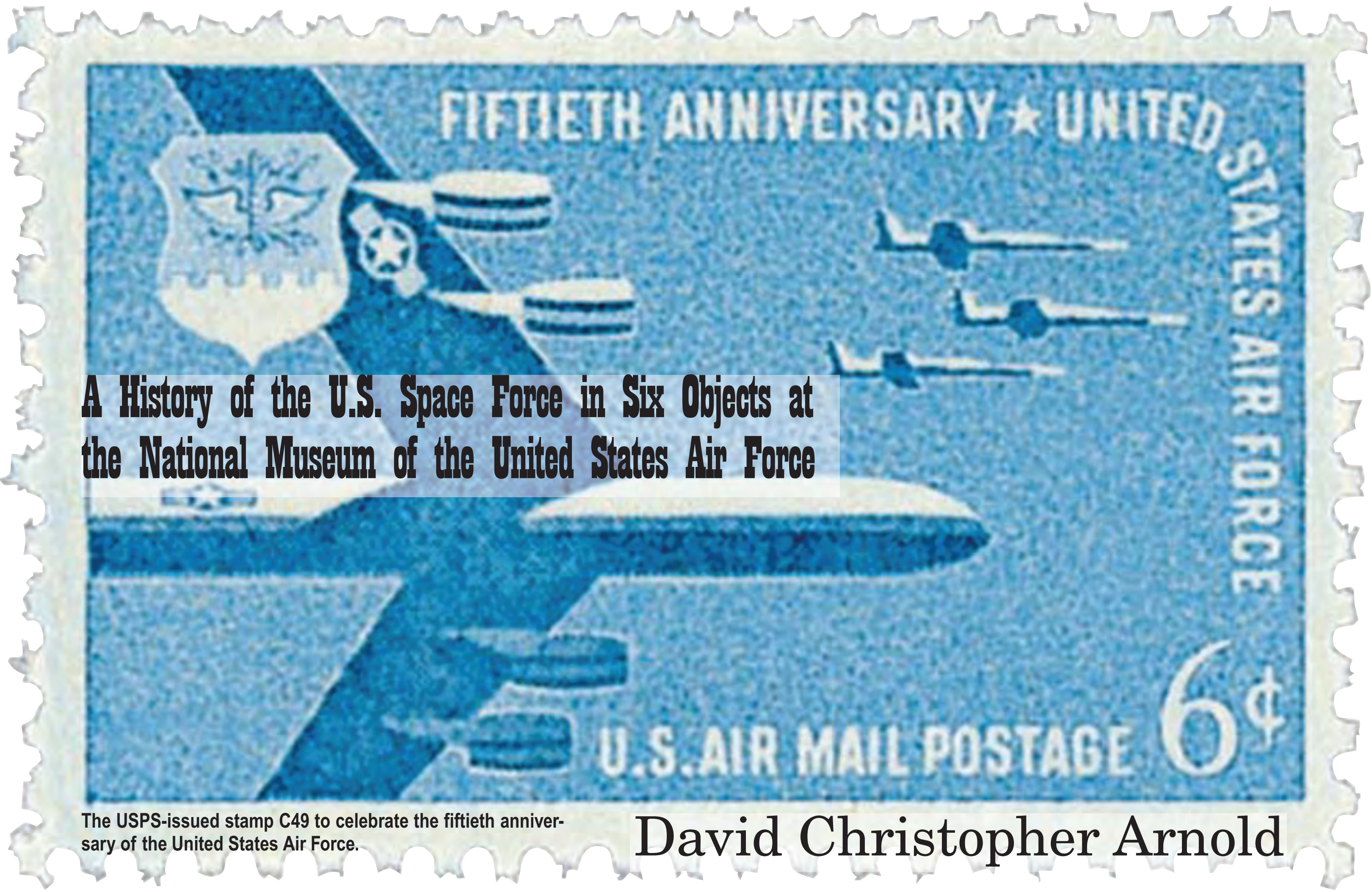
To make sound strategic and tactical decisions, USSF will rely heavily on its deep knowledge of the characteristics and current state of the Space AOR, both from LEO to GEO and beyond to XGEO (specifically cislunar) and intelligence regarding our adversaries' capabilities both in space and on the ground.

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]

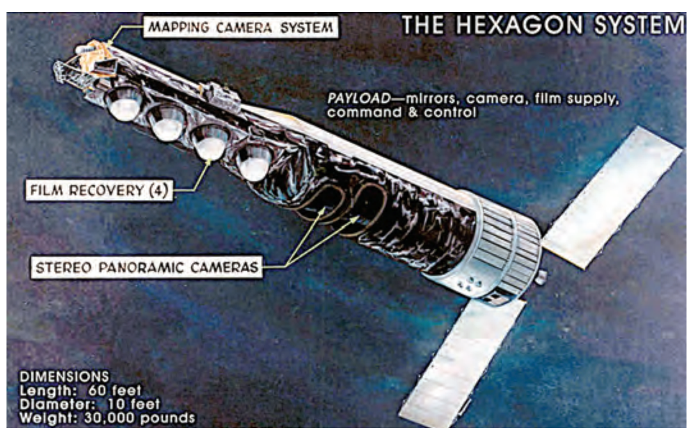
Sputnik in October 1957 was the great game-changer for U.S. military space programs. Recalled USAF Maj. Gen. Osmond Ritland, commander of the Air Force's Ballistic Missile Division (AFBMD), "With that event, the Defense Department, the Secretary of the Air Force, everybody said, 'Say, what was that [space] 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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Project Spotlight

This was what it was all about, the Royal Thai Air Force Flying School. Its presence at Korat Royal Thai Air Force Base (RTAFB) precluded the addition of two F–105D Thunderchief squadrons. The photo shows seven Thai T–6 Texans on Korat's flight line in May 1965 with four F–105Ds launching on a combat mission in the background. *(Ed Skowron)*

Theo van Geffen

As F–105 Thunderchief losses were increasing and the Air Force needed more aircraft to strike targets in North Vietnam, possibilities were explored to increase the number of tactical fighter squadrons in Thailand, specifically at Korat Royal Thai Air Force Base (RTAFB). In March 1966, rumors started at Kadena (Okinawa) and Yokota (Japan) Air Bases (AB) that their Tactical Fighter Wings (TFW), the 18th and 6441st respectively, were to permanently transfer one of their Thud squadrons to Korat. Before this was realized, a lot of water had to flow through the Mississippi.

Phase I

Phase I of the buildup planning for Southeast Asia (SEA) was initiated as a result of decisions made by Secretary of Defense (SecDef) Robert McNamara, following his trip to Saigon, July 16-20, 1965, for a significant buildup in U.S. forces. It was defined as a period when the U.S. would "stop losing the war." It was to extend into the early months of Calendar Year (CY) 1966.

In an August 24, 1965, message "Deployment of Units to SEA," the Chief of Staff of the Air Force (CSAF), General John McConnell, informed several addressees that SecDef McNamara had approved resources for additional deployments to SEA. Final force decisions were pending and the message also served as a warning order for the planned movement of units. The number of tactical fighter squadrons was 23, eight of which were equipped with F–100Ds, five with F–105Ds, and ten with F–4Cs. Five of the F–100D squadrons would be stationed at Bien Hoa/Phan Rang, one at Clark, and two at Misawa. Three of the F–105D squadrons would find their new home at Takhli and two at

In Phase I of the Air Force buildup in Southeast Asia (SEA), five F–100 Super Sabre squadrons were deployed PCS to South Vietnam, four to Bien Hoa and one to Tan Son Nhut. The two F–100Ds of the 481st TFS in the photo are on alert at Tan Son Nhut in July 1965. The 481st was TDY from Cannon AFB (NM) in the June 29 – November 30, 1965 period. *(USAF])*

Korat. Of the F–4C squadrons, three would be stationed at Cam Ranh Bay, four at Ubon, one at Clark, and two at Qui Nhon. TAC and PACAF were requested to forward their reactions by 18:00Z on August 26. As will be seen, the ultimate result was different.

According to the PACAF history for the July-December 1965 period, there were five (TDY) strike squadrons in South Vietnam in July 1965, three with F–100D/Fs, one with B-57Bs, and one with F–104Cs. SecDef McNamara approved the deployment of eight additional squadrons in Phase I. By December 31, 1965, there were nine strike squadrons in South Vietnam: one squadron with F–4Cs and one with B-57Bs at Da Nang, four with F–100Ds at Bien Hoa/Tan Son Nhut, and three F–4C squadrons at Cam Ranh Bay. Scheduled to deploy to Nha Trang in 3FY66 were three F–4C squadrons and one F–100D TFS to Bien Hoa to complete the 13-squadron deployment.

Prior to Phase I, there were five (TDY) strike squadrons in Thailand. Three additive squadrons were approved in Phase I, two of which deployed in August 1965, and one was scheduled to deploy in February 1966.

The deployments started on October 20. Almost 80 percent of the force moved in November and December. The final squadron, the 389th TFS, closed at Phan Rang on March 15, 1966.

Programming Plan (PP) 167-65 "Deployments of Units to SEA," which was published on September 3 as a draft, showed as to the F–105 units at Korat that the 357th TFS (355th TFW, McConnell, KS) and the 335th TFS (4th TFW, Seymour Johnson, NC), which were TDY to Korat and Yokota, respectively, would be assigned to the PACAF Provisional Wing. The 357th TFS would operate with personnel initially in a TDY status and to be replaced later with PCS personnel. The 333rd TFS would be PCS-ed from the 4th TFW, With Personnel Only (WPO), to absorb the aircraft and equipment of the 335th. Its designator and personnel would then be returned to Seymour Johnson. Regarding Takhli, "167-65" stated that the 355th TFW was to deploy PCS with the 354th TFS. Its 421st TFS would deploy from McConnell on or about January 29, 1966. The third F–105D squadron, the 562nd (23rd TFW, McConnell), which was TDY at Takhli, was to exchange unit designation with the 469th TFS (355th TFW). The 562nd personnel was to remain in a TDY status until replaced by the incoming PCS personnel.

There were subsequent changes to the Programming Plan. The first update proposal, of circa September 17, also reflected changes involving the PCS of F–105 units. The update proposal stated that it had become clear that the original basing proposal of F–105 units was not logical and thus inefficient. In the update, the 421st TFS would deploy to Korat versus Takhli on November 23, With Personnel and Equipment (WPE), to replace the 43rd TFS with its F–4Cs, which was to move to Ubon. The 354th TFS would replace the 562nd, rather than the 469th TFS. The 357th TFS was to bed down at Takhli versus Korat and to absorb aircraft and equipment of the 334th TFS, which was TDY from Seymour Johnson and would redeploy to Seymour Johnson.

The resulting F–105D bed-down on January 31, 1966, was as follows:

F–105D Bed-down on January 31, 1966:

Base	Wing	Unit	Remark
Korat	6234th	421st TFS	WPE
		469th TFS	Replaced 357th TFS
Takhli	355th	333rd TFS	Replaced 335th TFS
		354th TFS	Replaced 562nd TFS
		357th TFS	Replaced 334th TFS

At the completion of Phase I, the following USAF strike squadrons were in SEA.

Country	Air Base	Number	Type	Squadron
South	Da Nang	2	F–4C	390, 480*
Vietnam#		1	B-57B	8/13 BS**
	Cam Ranh Bay	4	F–4C	391*, 557, 558, 559
	Phan Rang	1	F–4C	389
	Bien Hoa	4	F–100D/F	90, 308, 510, 531
	Tan Son Nhut	1	F–100D/F	416
Sub-total		13		
Thailand	RTAFB			
	Korat	2	F–105D	421, 469
	Takhli	3	F–105D	333, 354, 357
	Ubon	2	F–4C	433, 497
	Udorn	1	F–4C	555
Sub-total		8		
Total		21		

* These two units were scheduled to move to Phan Rang after the base had reached its Initial Operational Capability (IOC) on March 15, 1966.
** On rotational duty.
# The Marines also had six strike squadrons in-country, two F–4B squadrons at Da Nang, and four A-4E squadrons at Chu Lai.

Phase II

Earlier, Phase II had been defined as the period "… in which we would start winning." On his seventh trip to South Vietnam, November 28-30, 1965, SecDef McNamara reported, "We have stopped losing the war." Planning for Phase II got underway in Saigon on September 1, 1965. Commander in Chief, Pacific Command (CINCPAC), Admiral Ulysses Grant Sharp, forwarded his plans to the Joint Chiefs of Staff (JCS) on October 7, which approved them on November 8. CINCPAC was scheduled to report

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modifications of Phase II to the JCS on December 10. Discussion items during a PAC Phase II conference in the week of September 27 included subjects like the development of a concept, force needs, and supporting logistic data for the new phase. An increase of seven USAF and three Marine Corps strike squadrons was indicated by the Commander, U.S. Military Assistance Command, Vietnam (COMUSMACV), General William Westmoreland, bringing the number of Phase I and II strike squadrons to 30. At the conclusion of the Phase II conference, it was learned that CINCPAC had adjusted the Phase I planning factors by reducing the six sorties per day per battalion to just four sorties. By the end of Phase II, this would result in a reduction of in-country strike squadrons from 30 to 24, USAF with 16 and the Marine Corps with eight squadrons. This resulted in a net reduction of six strike squadrons in South Vietnam, including two Marine Corps squadrons. However, CINCPAC planned an additional three USAF strike squadrons in Phase II, to be stationed at base X, probably Tuy Hoa, South Vietnam.

The actual bed-down as of December 31, 1966, was as follows.

Country	Base/Wing	Num.	Type	Squadron
South Vietnam	Da Nang/366	3	F–4C	389, 390, 480
	Cam Ranh/12 Bay	4	F–4C	391, 557, 558, 559
	Phan Rang/35	4	F–100D/F	352, 612*, 614, 615
		1	B-57B	13**
	Bien Hoa/3	4	F–100D/F	90, 416, 510, 531
		1	F–5C	10
	Tuy Hoa/31	3	F–100D/F	306, 308, 309
Sub-total		20		

* As Det 1, with the unit's home station remaining Misawa, Japan.
** Was on rotational duty. Was attached, but assigned to the 405th FW at Clark, Philippines.

Thailand	Korat/388	4	F–105D/F	13*, 34**, 421, 469
	Takhli/355	3	F–105D/F	333, 354, 357
	Ubon/8	3	F–4C	433, 497, 555
	Udorn/8	1	F–104C	435
Sub-total		11		
Total		31		

* Was attached, but assigned to the 18th TFW at Kadena.
** Was attached, but assigned to the 6441st TFW at Yokota.

The Marine Corps had eight strike squadrons stationed in-country, three squadrons at Da Nang, one each with F–4Bs, F–8Es, and A-6As, and five A-4C/E squadrons at Chu Lai.

In Phase I, ten F–4C squadrons were scheduled to PCS to SEA, seven to South Vietnam and three to Thailand. The photo shows F–4C 40708 of the 431st TFS at Ubon on November 14, 1965. The Squadron was TDY from George AFB (CA). When the 497th TFS PCS-ed from George to Ubon in December, "708" joined the 497th. The aircraft is configured with eight M-117 bombs and two camera pods. *(USAF)*

Korat

The first F–105s to arrive at Korat were those of the 36th TFS, which deployed from Yokota on August 9, 1964, after the Gulf of Tonkin "incidents". The other two squadrons of the 41st Air Division (41AD), the 35th and 80th TFS, followed suit until the 80th was replaced on December 29 by Kadena's 44th TFS. All three squadrons of the 18th TFW, which also included the 12th and 67th TFS, TDY-ed to Korat until TDY squadrons were replaced by PCS units. The second F–105 unit to arrive at Korat was the 354th TFS (355th TFW, McConnell), which initially deployed to Kadena on March 3, 1965, but was directed to deploy to Korat on March 18. Although Takhli ultimately housed three TDY strike squadrons (all equipped with F–105s), Korat did so for just two (F–105/F–4C) squadrons. Due to congested conditions and the lack of certain base facilities, USAF was able to station only two strike squadrons at Korat.

As early as May 1965, the RTAF Flying School subject had been broached by Air Chief Marshal Boon Choo and his staff during a visit to Korat, Takhli, Ubon, and Udorn. At Korat, concern was expressed about the student flying training program, which was conducted at the same base as U.S. tactical fighter operations. The staff mentioned that moving the School to another base might be possible. In July, Colonel Stehling, PACAF's Deputy for Civil Engineering, discussed the Fiscal Year (FY) 1966 Emergency Military Construction Program (EMCP) with U.S. Ambassador to Thailand, Graham Martin. In his July 20 message, "FY 1966 EMCP", to PACAF, Martin foresaw no difficulty obtaining Royal Thai Government (RTG) approval, provided also approval was received for the relocation of certain Korat facilities. The Ambassador wrote, for instance,

The solution proposed by the Thai, endorsed by the Ambassador, and which appears to be the most logical way to eliminate potential bottlenecks and to solve the congestion problem is: A. Provide RTG relocation funds for Korat Fly-

Pilots of the 44th TFS in front of their Ops building at Korat in late May 1965. The TAC pilot was assigned to the 354th TFS. Lieutenant Colonel Bill Craig became commander of the Vampires on May 16. ***(Ed Skowron)***

ing School. The actual amount of funds and related negotiations would be conducted by the Embassy with RTG, actual funds would be provided as construction of new Flying School projects were completed on a reimbursement basis. In this manner, all costs of relocation probably will not have to come out of FY66 money. The actual location of the new Flying School had not yet been determined. The estimate of total Thai facilities existing at the Flying School, based on information by MAAG, is nine million dollars.

In his August 24 message, the Charge d'Affaires at the U.S. Embassy in Bangkok informed CINCPACAF, General Hunter Harris, that the approach by the Embassy was either to co-locate the Flying School with the USAF Special Air Warfare Detachment, which would be moved from Udorn or to use many of the facilities, which were then being planned for "Thailand Base X" and construct the minimum additional required for the School. One week later, PACAF, referencing all previous correspondence about the relocation, sent a message "Relocation of RTAF Flying School", to Hq USAF and stated that there were three sites under consideration: Phitsanulok, Koke Kathiem, and the area of Hua Hin in southern Thailand. The key consideration was the selection of a site, which would be least likely to be needed for USAF operational requirements.

In the meantime, Lyons Associates, Inc. had submitted a study on August 7, 1965, to the Embassy in Bangkok, which listed possible sites for airfield locations in Thailand. The RTAF informed that site A-5(1) in Nakhon Phatom Province was preferred for the location of the Flying School. PACAF then directed 13th Air Force (13AF) to develop a proposal, in coordination with the Air Force Resident Civil Engineer (AFRCE), Bangkok and the Joint U.S. Military Assistance Group (JUSMAG), for the development of site A-5(1). It was to include both Embassy and RTG approval. By September 21, 13AF had sent its plans to PACAF and the 11.2-million dollar package had been inserted in the FY66 MCP. Almost a month later, on October 19, the Secretary of State (SecState), Dean Rusk, authorized the Embassy in Bangkok to proceed with the RTG negotiations. In an October 22 message, the U.S. Military Advisory Command, Thailand (USMACTHAI) informed 13AF that RTAF requirements exceeded counterpart provisions of the USAF proposal. The Embassy in Bangkok recapitulated the political situation in a 27/10:08Z Oct message to SecState. After Air Chief Marshall Dawee was told that funds would be made available for the relocation of the RTAF Flying School as required, he responded that the whole matter of additional USAF deployments to Thai facilities had been discussed at great length over the past few weeks within the RTG and had also been the subject for discussion at a recent special meeting of the cabinet with the King. Both the Prime Minister and the King expressed "a deep concern about overcrowding of bases and increasing tendency to crowd RTG forces off their own facilities, with no concurrent or visible benefits to those forces." The Charge d'Affaires of the Embassy in Bangkok pointed out the following issues,

1) The RTAF was still flying obsolete F–86s and the Philippine Air Force had recently received F–5s.
2) The flight safety hazard for light aircraft of the RTAF would be imposed by the addition of the proposed third squadron at Korat. It would also simply compound complaints that were already being made by the RTAF, stemming from heavy traffic that was created by the two squadrons already at Korat.
3) The magnitude and visibility of USAF operations were causing concern to the RTG.
4) Could a squadron of F–105s not be introduced into South Vietnam so that the origin of the F–105 strikes into Laos and North Vietnam would not be so obvious?
5) There should be no optimism regarding the immediate favorable response to basing additional KC–135s at Takhli.

In the October 27 conference at Korat between RTAF and USAF representatives, the Thais indicated that they expected larger buildings for operations, administration and classrooms, and a larger theater and medical facility than contained in the 13AF proposal. Four days later, PAC submitted a revised estimate of the total cost of the Flying School relocation, to be $M13-15. On December 23, AFRCE Bangkok notified PACAF and 13AF in a message, "RTAF Flying School" that real estate requirements had been confirmed for 3,950 acres in the vicinity of Nakorn Pathon, 42 miles west of Bangkok. The study of the existing facilities of the present School location was completed on the 27th. As 1965 ended, negotiations between MACTHAI and RTAF to select the final facility listing for a new location were still in progress.

The Thai attitude resulted in some changes in the deployment of PCS squadrons to Thailand. This was based on the premise that Korat would be a three-squadron base. This forced PACAF, for instance, to deploy the 335th TFS on December 1 from Yokota to Takhli versus Korat, setting in motion a chain reaction, like rescheduling the 333rd TFS

Eight of the F–105Ds assigned to the 13th TFS came from the 44th TFS inventory, one of them being 24248. From March 1967 to February 1968, it flew 1,012 combat hours. The aircraft survived the Air War but was lost as Okie 72 on July 17, 1974, in a flying accident at Poinsett Gunnery Range (SC) while assigned to the 465th TFS at Tinker AFB (OK). F–105D 10201 on the right wing of Yokota's 421st Air Refueling Squadron's KB-50J 0-90265 was assigned to the 12th TFS. *(Jim Sandin)*

for deployment to Takhli versus Korat. 2nd Air Division (2AD) then pointed out that the diversion would have an impact on the ten-aircraft KC–135A force at Takhli, as the base also hosted 14 B–66B/RB–66C aircraft. In its November 18 message "Aircraft Loading at Korat", PACAF informed 2AD as to the space problem at Takhli, that completion dates of the first and second increments of the new ramp construction program, and the proposed establishment of a reconnaissance Main Operating Base (MOB) at Udorn with the consequent relocation of recce aircraft from Takhli, were expected to provide adequate relief. PACAF did not want to contemplate further action at the time to press RTG approval for a third strike squadron at Korat. The 13AF Bed-down and Deployments Report of December 22 did not reflect a projected increase of F–105 squadrons in Thailand for 1966.

5AF held to the belief that major benefits could be derived by sending its assigned tactical units to SEA for TDY tours versus sending the units on PCS. This sentiment was voiced at a 5AF Commanders Conference which was held on April 15 in the Command Conference Room at Fifth Air Force at Fuchu Air Station. When plans were set to move part of 5AF's F–105 strength to Southeast Asia, 5AF made its views known to Hq PACAF. This was part of the explanation for the eventual withdrawal of the equivalent of two F–105D squadrons from the 5AF inventory in June 1966, leaving them assigned to 5AF. However, In April PACAF still held to its position that the squadrons would be taken on a PCS basis. As for the units themselves, they would be considered temporarily withdrawn from the 5AF inventory with the understanding that they would be returned eventually to 5AF resources or replaced by similar units.

Smoothly

The U.S. Embassy in Bangkok appeared to have finally overcome the reluctance of the RTG to approve two additional F–105 squadrons at Korat. On April 19 and 20, PACAF alerted subordinate units that, "… two additional tactical fighter squadrons would be assigned to Korat in May 1966…" According to the document, "The U.S. Air Force Buildup in Thailand – 1966", ordinarily, from that point, things should have proceeded smoothly according to the plan, the deployment supposedly having been programmed and held in a state of readiness for quite some time. However, the long delay and the unpredictability of the RTG seemed to have cast a cloud of uncertainty over it and caused some deterioration in the mechanism of what was otherwise a fairly dependable operation. In a 22/06:13Z April message, "Tactical Fighter Squadron Assignment to Korat AB, Thailand" the 388th TFW requested PACAF, because of MCP slippages, the deployment to be phased so that one squadron would arrive in early May and the other at the end of the month. The 388th TFW was activated at Korat on March 14 and assigned to PACAF. It was organized effective April 8, assigned to 13AF, and attached to 7AF as per PACAF Special Order (SO) G-86 of March 24, 1966. The Wing absorbed personnel and equipment from the 6234th TFW, which was discontinued per PACAF SO G-76 of March 23, 1966. PACAF SO G-101 of April 5, assigned the 421st and 469th TFS from the 6234th to the 388th TFW effective April 8.

Another problem was that it had not yet been determined what the source of the two squadrons would be. In a 21/22:25Z April message, CSAF told PACAF that two considerations were of overriding importance in the selection of the second F–105 squadron for deployment to Korat in May 1966. The first was the concern that CSAF shared with PACAF about the drawdown of units stationed in Japan. It was also agreed with PACAF that difficulty might be encountered in the return of units to Japan at a later date. The second consideration, which the Air Staff was still reviewing, was the possibility that PACAF resources might be required to support an F–105 RTU. If this should prove to be the case, the retention and consolidation of the remaining F–105s at Yokota would provide the resources required. CSAF also remarked that a significant Single Integrated Operational Plan (SIOP) posture could be maintained at Kadena by the Mace Bs, even after a drawdown of two F–105 squadrons at that base. CSAF recognized the factor of personnel problems. To permit PACAF to man the squadrons with SEA-eligible personnel, intra-theater transfers of personnel and families might be accomplished. PACAF was requested for these reasons to reconsider the selection of a Kadena squadron.

A Vice Chief of Staff of the Air Force (VCSAF) Conference took place at Hickam on April 25 and 26. A number of Fact Sheets were prepared for General William Blanchard. Two of them dealt with the planned deployment of PACAF TFSs. The first one was called "Degradation of PACAF SIOP Posture". It stated that the planned deployment of PACAF Tactical Fighter Squadrons to Southeast Asia would degrade PACAF's capability to support SIOP. The Quick Reaction Alert (QRA) capability would be reduced from 80 to 40 sorties (32 Mace missiles and eight F–105Ds), while the non-alert sorties would drop from 92 to 16 sorties. The result would be that the total SIOP

Freshly painted F–105D 24286 of the 13th TFS on "last chance" just before launching to Korat on June 14. It was also an ex-44th TFS bird. It was claimed on November 6, 1967, by a North Vietnamese SA-2 while assigned to the 469th TFS. The pilot, Major Robert Hagerman, Crossbow 02, was killed. *(Jerry McGauley)*

(QRA/non-alert) capability would drop from 172 to 56 sorties. The discussion about possible courses of action was to include,

1) To temporarily degrade the SIOP commitments for forces deployed to SEA.
2) To reduce the QRA commitment and maintain advanced readiness and non-alert commitments. Tactical fighters would deploy from SEA to SIOP launch bases in case of a Defense Readiness Condition (DEFCON) 2, of receipt of an "A"-hour, or when directed by higher headquarters.
3) To reduce the SIOP commitment to the capability as stated earlier.

PACAF recommended and received USAF approval for the policy of a temporary degradation of the SIOP commitments for its forces deployed to SEA. The tactical fighters which were required to meet the SIOP commitments, would deploy from SEA to SIOP launch bases at the DEFCON 2 level, receipt of the A-hour, or when directed by higher headquarters.

The subject of the second Fact Sheet was "F–105 Redeployments". CSAF, General John McConnell, had directed the deployment of two F–105 squadrons from Kadena. In an April 18 message, PACAF cited the following reasons to drawdown one F–105 squadron from Kadena and one from Yokota. They included,

1) It would allow the deploying unit to draw from wing resources for the deployment.
2) It would result in less personnel turbulence as the shifting of personnel between Yokota and Kadena would be avoided.
3) There would be more flexibility for operations and training with two squadrons at each base.
4) A balanced SIOP posture, as basing a significant number of delivery aircraft at the weapons storage locations would be continued.
5) A significant TFS strength would be maintained in both Japan and Okinawa, which was regarded as a political advantage.
6) It would permit maintenance of the Korean and Taiwan pads, although on a reduced basis.
7) It would permit RTU training to be conducted at Kadena if required. The base had better weather, while the Tokyo area faced airspace crowding.

Ultimately, USAF accepted PACAF's recommendation to draw down one F–105D squadron from Kadena and one from Yokota.

Approval

CSAF, in his 06/13:43Z May message, "CY66 TFS Deployments" to PACAF, referred to his April 12 and 22 messages, which contained advance information about programmed SEA deployments which were incorporated in USAF PD 68-2. CSAF message of May 3 had proposed that the 13th TFS (18th TFW) and 34th TFS (6441st TFW) be organized at Korat in May as the fourth squadron of each wing (four squadron-18 UE versus three squadron-24 UE) and personnel from parent wings to be PCS-ed to Korat to satisfy the manning requirements. In its May 4 message, PACAF requested clarification of its authority to move the Kadena F–105 squadron. CSAF stated that paragraph two in the April 12 and 22 messages had to be changed to reflect the following:

Unit	UE	Source	Destination	Ready Date
13th TFS	18/F–105	Kadena	Korat	May 25, 1966
34th TFS	18/F–105	Yokota	Korat	May 25, 1966

In addition, note 2 in the April 12 message was to read that the units would be organized at Korat AB, Thailand, on or about May 8, 1966, and attached to the 388th TFW. The DAFOMO letter was to follow.

PD (referenced above) stands for USAF Program Bases, Units & Priorities. It was published quarterly by the Directorate of Aerospace Programs, DCS/P&R, Hq USAF, and comprised USAF's five-year program for all units and installations. Each PD had a "Cutoff Date" and a "Publication Date". PD 67-3 (June 14 and July 27, 1965) programmed 75 F–105D/Fs each at Kadena and Yokota. PD 67-4 (September 23 and November 2, 1965) decreased the number of F–105D/Fs at Yokota and Kadena to 72 aircraft. Korat was to receive 36 F–105Ds from ConUS in the second quarter of Fiscal Year 1966 (2FY66, October-December 1965) for the 469th and 333rd TFS, and Takhli 54 F–105Ds for the 421st, 354th, and 357th TFS. Seventy-two of the 90 F–105Ds would move from McConnell and 18 from Seymour Johnson (see earlier). All aircraft were programmed to return to ConUS in 1FY68 and to be replaced by TDY F–105D/F and F–4C squadrons. The 355th TFW with the 354th and 357th TFS would redeploy to McConnell and the 333rd TFS to Seymour Johnson. Kadena was programmed to start the conversion to 72 A–7As in 1FY71 and Yokota to 72 F–4s in 1FY68.

In the foreword of PD 68-1 (December 15, 1965, and

January 28, 1966) it was said that SecDef McNamara had directed that SEA programming actions were to be planned only through FY67 and that the Thailand deployment phasing was subject to adjustment because of country clearance requirements. The PD showed the 421st and 469th TFS now at Korat and the 333rd, 354th, and 357th TFS at Takhli.

The foreword of PD 68-2 (March 29 and May 3, 1966) stated that "the following were late changes to data reflected in Section II (Overseas), to be reflected in PD 68-3,

1) The activation of the 13th TFS was to be accomplished in May 1966 at Korat vice Kadena and of the 34th TFS at Korat in May 1966 vice Yokota in June 1966.
2) To retain the 44th and 67th TFS at Kadena vice moving them to Korat in 4FY66."

The programming for Kadena showed for May 1966 that the UE of the 12th TFS would decrease from UE 24 to 18 and convert to 24 A–7As in 1FY71. Section II (Overseas) showed that the 44th and 67th TFS would move to Korat in May to join the 421st and 469th TFS with all four squadrons having a UE of 18 F–105D/Fs. In 1FY68, the 44th and 67th TFS were to redeploy to Kadena where they would each convert to 24 A–7As in 2FY71.

The changes that were announced in the foreword of PD 68-2 were reflected as follows in PD 68-3 (June 29 and August 4, 1966).

1) 388th TFW at Korat with the 13th, 34th, 421st, and 469th TFS with a total UE of 72. The 388th would remain at Korat, but the 421st and 469th would PCS WOPE to McConnell in November 1966 and February 1967 respectively. The 13th and 34th TFS were to be discontinued or to cease operation in 1FY68. It was programmed that the 421st would be replaced by Yokota's 35th TFS and the 469th by Kadena's 12th TFS, both through Calendar Year (CY) 1967.
2) 355th TFW at Takhli with the 333rd, 354th, and 357th TFS with a 54 UE. To redeploy WPE to Conus in 1FY68 with the Wing, 354th, and 357th going to McConnell, and the 333rd TFS to Seymour-Johnson.

Six 13th TFS pilots with their F–105Ds en route to their new home, Korat Royal Thai Air Force Base. ***(Jerry McGauley)***

3) 18th TFW at Kadena with the 12th, 44th, and 67th TFS with a UE of 54.
4) 6441st TFW at Yokota with the 35th, 36th, and 80th TFS, with a UE of 54.

PACAF informed 5AF, 13AF, et al that its 10/13:39 May message had to be regarded as a warning order of movement to Korat AB, Thailand "of designated personnel, aircraft, and equipment of the 6441st TFW to activate the 34th TFS. The movement date is 27 May 1966." The message authorized, for instance, commanders to inform involved military personnel that they were scheduled for early deployment to SEA. It also stated that the warning order did not authorize the unit to depart home station. The authorization would be contained in PACAF Operations Order (OPORD) 514-66. Information would not be released to the news media. Declassification of the message would be authorized on departure of the first tactical aircraft of the unit involved.

5AF/VC was informed on May 10 by his DOPP that

1) An order was received for the move of Det 1, 612th TFS to Phan Rang AB in South Vietnam. The authorized UMD will then be one officer and one airman.
2) PACAF stated that the 18th TFW at Kadena and the 6441st TFW at Yokota were to reorganize from three squadrons with 24 UE to four with 18 UE F–105D/F in May 1966. The two new squadrons, the 13th TFS (18th TFW) and the 34th TFS (6441st TFW) would activate at Korat on or about May 25. Personnel from the parent wings would be PCS to Korat to satisfy manning requirements. A movement directive had not yet been received.
3) The 356th TFS at Misawa would remain equipped with F–100D/Fs while deployed to PACAF.

On May 11, 5AF/VC was informed, among others, that the warning orders were received on moving squadron equivalents from the 6441st TFW and 18th TFW. They would form the 13th and 34th TFS. The 6441st TFW moving date was May 27 and the one for the 18th TFW was May 31. A movement directive for the 18th TFW was received late the night before (Tuesday). An execution directive was to be sent to the Wing on the 11th. One day later, on May 12, DOPP informed 5AF/VC, for example, that

1) A firm airlift schedule was worked out with both F–105 wings and 5AF staff to move the squadron equivalents from Kadena and Yokota to Korat. As of Thursday morning the movement directive on the 6441st TFW had still to be received (it was received the next day, and an execution order and additional planning guidance were then dispatched to the Wing).
2) Tanker support to deploy 36 F–105Ds (and 18 F–100s) was requested from 3rd Air Division (3AD).
3) A message was sent to PACAF that requested clarification of manpower spaces as a result of deployments and Special Order G- series authority, and date of publication to organize the 13th and 34th TFS, and Det 1, 612th TFS.

5AF was informed by PACAF's 13/03:30Z May message, "CY66 TFS Deployments" that three 18 UE squadrons each at Yokota and Kadena would remain active for the time being. Future attrition aircraft would be provided from these units so that their active status would undoubtedly change. Although the 13th and 34th TFS were to be organized at Korat, it was recommended that squadron cadres be formed at Kadena and Yokota respectively before the move of personnel. Crew authorizations would be withdrawn at a 1.25 ratio with 66 F–105 crew authorizations each to remain at Yokota and Kadena. The number of maintenance authorizations to be withdrawn from Yokota would be 337 and from Kadena 329. Sixty-seven BOS authorizations each would be withdrawn from Yokota and Kadena, which equated to about 18 percent.

In a 15/04:40Z May message, "SEA Deployment", the 388th TFW informed 7AF that there were no factors that precluded the acceptance of two F–105 squadrons. The Royal Thai Government had finally approved the deployment of two additional F–105 squadrons, and Korat and the 388th TFW were ready to receive them. The document "The U.S. Air Force Buildup in Thailand – 1966" stated in this respect, "But what could go wrong at this point? All that remained was to accomplish it." To continue with, "This particular deployment, however, would have to be recorded in the history of the U.S. Air Force in Thailand as one that couldn't be made to follow a definite plan." The 388th TFW was to have a UE of 72 F–105D/Fs and the 355th TFW of 54 F–105D/Fs.

The DoD-approved Information Plan 5AF 190-16-66 for the deployment of Tactical Fighter Squadrons to SEA was forwarded by 5AF on May 20 to 39, 41, 313AD et al. The guidance was classified and the approved responses were unclassified for use in accordance with the Plan. Answers were given for subjects like the general situation (for instance, the Government of Japan had been notified of the change in 5AF forces in Japan), policies (for example, no mention of unit moves from Japan or Okinawa would be made in response to any inquiry), responsibilities (like 5AF Director of Information had overall information responsibilities, under the Plan); authorized responses (for instance, the question "Is it true that some 5AF [313AD] units are being transferred from Japan [Okinawa]?" would be answered with, "Units themselves will not be involved, only personnel from 5AF units, now based in Japan [Okinawa] will be affected.)" The Commander of 39AD was authorized to advise prefectural and local officials, and the Commander of the Northern Air Defense forces off the record and in strict confidence of the deployment of Misawa AB forces as he deemed necessary in accordance with the Public Affairs Plan. PACAF/DOI was informed that a "No comment" answer was less desirable in Japan, based on known Japanese media reaction. 7AF, 13AF, and Deputy Commander 7/13AF were requested that all releases that were authorized after the unit arrivals, would delete all references to Japan in the background of the "new" squadrons or former assignment of personnel.

Kadena, over a thousand miles from Korat, was not only the home of the 18th TFW with its F–105D/Fs, RF–101Cs, and Mace missiles but also host to the 4252nd Strategic Wing (SW) with its fleet of KC–135 Stratotankers. It was decided that its runway had to be repaired immediately. To do this without seriously degrading the Wing's tanker mission, five of the KC–135s had to be moved to another base to continue operating. As Takhli had been housing KC–135s since November 1965, the base was the most logical choice. The problem of saturation at Takhli could be solved by moving two of its three F–105D squadrons. As Korat was the only other base in Thailand with F–105Ds, it was the most logical choice. To accommodate both Takhli squadrons, it would be necessary to delay the deployment of the 13th and 34th TFS to Korat until the runway work at Kadena was completed, which was scheduled to be June 30. On 24/23:00Z May, the first flight of four F–105Ds of the 34th TFS, call signs Yule 01 through 04, departed Yokota and arrived at Kadena at 25/00:55Z.

24221 was one of the 18 F–105Ds that were transferred from Kadena to Korat. It was one of the five aircraft reassigned from the 12th TFS. "221" was also claimed by an SA-2 in November 1967, on the 18th, on a COMMANDO CLUB mission against Phuc Yen Airfield. The pilot, Colonel Ed Burdett, was the 388th TFW Commander. He was captured and died in captivity. It was a very bad day for the Wing, as it lost two more F–105Ds and an F–105F Wild Weasel aircraft, two to MiGs and one to an SA-2. Three of the crewmembers were killed and one was recovered. All within seven minutes. To evade the SA-2s, pilots in the strike flights jettisoned their ordnance. It proved to be the highest single-day loss of 1967. The next day, the Wing lost another two F–105Ds with one pilot being captured and one was killed. ***(Jerry McGauley)***

The information about the move of the Squadron to Kadena must have arrived at Headquarters Pacific Air Forces at Hickam as a surprise. At 25/04:20Z May, PACAF/DOCPD was directed to prepare a complete briefing for PACAF/DCO to include reactions to the following questions,

1) Why was the move not briefed that morning at the DCO briefing?
2) What authority did the unit have to move from Yokota to Kadena?
3) Who gave the "go".
4) Who controlled the move?
5)) Did PACAF send out a movement order?
6) Why had Movement Control not been following the flight?

In addition, PACAF/DOCPD was directed to compile all the figures about the total primary aircraft, support aircraft, the passengers, cargo, aborts, status of aircraft, etcetera.

At 25/04:30Z May, Major General Joseph Kruzel, PACAF's DO, advised his Command Center that the deployment of the 34th TFS from Yokota to Korat and of the 13th TFS from Kadena to Korat was delayed 30 days. Both Air Divisions, 41AD and 313AD, were informed accordingly. At 05:48Z, PACAF's Commander, General Hunter Harris, approved a message, authorizing a 30-day delay of the deployments.

With regard to the return of the F–105Ds of the 34th TFS from Kadena to Yokota, 5AF stated in its January 1 - June 30, 1966 history that the indecision, which resulted from the cancelation of the deployment of the 34th TFS after a large party of personnel and equipment had departed Yokota, came about due to other shifts of forces that left the runways and ramps in Thailand crowded with too many aircraft, including the KC–135s which deployed to Takhli because of Kadena's runway repairs. To accommodate the extra tankers there, two of Takhli's F–105D squadrons were shifted to Korat. After Yokota's personnel and equipment had arrived at Korat, there was no room left for the aircraft and Kadena's personnel and equipment. My fellow Thud historian Howard Plunkett put it this way,

However, this is not exactly what happened. None of Takhli's three F–105D squadrons deployed to or operated from Korat in May 1966. It is clear from the historical record that PACAF headquarters intended to send two of Takhli's Thud squadrons to Korat, but it did not work out that way. What is also clear, is that PACAF badly coordinated this aircraft transfer.

Captain Ted Rees was TDY from Kadena's 44th TFS to the 469th TFS at Korat when the 13th TFS arrived. Ted in this respect, "I had voluntarily gone to Korat to replace some losses in the 469th Squadron and flew several missions with them until I got my 100 missions. At the same time, the 44th was sent to Korat and was designated the 13th TFS. So I stayed to help my 44th/13th TFS get oriented and up to date on current subjects in the flying arena. I flew about ten missions. That's how I got more than the usual 100!" Pilots of the 469th made the banner, which says, "Welcome 13th. Compliments 469th." ***(Jerry McGauley)***

Fifth Air Force received PACAF Fastel 141 of 25/08:15Z May. Information was requested about the 34th TFS deployment from Yokota to Korat via Kadena, including the number of passengers, cargo, support aircraft, and rationale for the early move as opposed to the original date of May 27, 1966.

PACAF Fastel 142 of 25/08:45Z May, was dispatched, directing a 30-day delay in the movement of the two F–105 squadrons to Thailand to provide space for KC–135 tankers at Takhli. Pacific Command was requested for approval of the course of action. 7AF at Tan Son Nhut was requested to re-compute tanker requirements during June. The reason for the actions was the need to relocate KC–135 tankers from Kadena during runway repairs.

In a 26/01:25Z May message, "Air Force Deployments", PACAF informed PAC that due to runway peculiarities, neither Takhli RB–66s nor Kadena KC–135s could be operated effectively from Korat. With the obtained RTG approval to station two additional F–105 squadrons at Korat in May, PACAF did not see a problem with this temporary substitute deployment from Takhli to Korat. PACAF pointed out that in this way the scheduled RB–66 deployment to Takhli could be accomplished. PAC was requested to approve the course of action.

In its 26/03:12Z May message, 5AF reacted to PACAF Fastel 141 of 25/08:15Z May. All questions were answered in an attachment. The number of F–105Ds deployed was 18 primary and two spare aircraft. Twenty-three support aircraft were involved, of which 22 offloaded at Korat and one at Clark for the En Route Support Team (EST). After landing, the support aircraft were used for other missions. The number of passengers was 234, which did not include the advance party of pilots (four) and maintenance/administrative personnel, which had left on May 21 by C–130 for Korat via Kadena, the aircrews or EST. Cargo tonnage airlifted was 191 tons, which was 100% of the required equipment. According to 5AF, the aircraft deployment was in accordance with 5AF OPORD 514-66 of May 12. The PACAF Command Center was an info addressee of 5AF/DCO message 00099 May 1966, with which the OPORD was forwarded. One of the four pilots of the advance group was Captain Bob Pielin. On June 3, he was Oak 03 in a flight of four F–105Ds of the 469th TFS on an armed reconnaissance mission in Route Package 1. His aircraft, 81171, was hit by AAA 27 miles north-northwest of Dong Hoi. Pielin was able to fly his Thud to the Gulf of Tonkin, where he ejected and was recovered.

One of the items that was discussed at the meeting on May 26 of the 5AF Program Action Committee was the PACAF request to identify two F–105 squadrons, one at Kadena and one at Yokota, which would revert to a non-equipped status in November 1966 and February 1967. The Committee was informed that PACAF had delayed the deployments of the 13th and 34th TFS and that details would be forwarded by message later.

As the hold order was issued after personnel and support equipment had deployed or were en route to Korat, 5AF in a 27/07:36Z May message, "Air Force Deployments", attempted to have personnel and equipment temporarily returned to their parent organizations to enable compli-

The 13th TFS "Boss", Lieutenant Colonel Dick Baugh with the design of the very first 13th TFS emblem. Dick is carrying a three-foot plaque with pilot's wings with the Edsel grill in the center instead of the shield. It was hung in the Officer's Club and taken down when the Wing had VIPs. *(Dick Baughn)*

ance with its flying hour program, but PACAF turned the request down.

On May 27, 5AF sent a message, "Air Force Deployments" to 13AF, 7AF et al. Reference was made to PACAF Fastel 142, which directed delay in the deployment of two F–105 squadrons from Kadena/Yokota, and the message from the Deputy Commander for Operations (DCO) of 5AF, which included the concept for the interim employment of the two squadrons during the delay period. Regarding the materiel, the DCO stated that aircraft 780 equipment, mobility equipment, and Mobile Support Kits (MSK) were moved into place at Korat to support the 18 F–105Ds. The residual equipment at Yokota to support the remaining (18 UE) squadrons and MOB functions was considered the absolute minimum. To support the continuation flying hour program for the 34th TFS, the minimum essential 780 and support equipment needed to be returned to Yokota. With regard to personnel, 5AF stated, for instance, that the 388th TFW be directed to issue orders returning identified and necessary people to Yokota and Kadena in a TDY status for 59 days. Also, that all personnel assigned to the two squadrons be held in a "freeze status" until their deployment. Planning was underway at 5AF to return equipment and personnel as necessary. PACAF was requested to issue instructions, as soon as possible, to 13AF and other concerned agencies, which provided for the return of the necessary equipment and issuance of appropriate orders on the personnel involved. However, later that weekend, 5AF proposed to PACAF that the movement of the 34th TFS be completed minus aircraft and that the personnel and equipment of the 13th TFS, which was in place at Korat, could remain there with the additional personnel, equipment, and the F–105Ds to deploy when rescheduled by PACAF.

Concerning the 34th TFS, PACAF, in its 29/00:15Z May message, "Air Force Deployments", made the recommendation to PAC that its personnel and equipment remain at Korat, rather than returning them to Yokota for the short delay period. Further, that the Squadron pilots be transported to Korat with their aircraft remaining at Yokota. PACAF mentioned seven reasons for the two recommendations, including, for instance,

1) Keeping personnel and equipment at Korat would relieve the serious airlift problem.
2) The 6441st TFW could effectively utilize and support the "extra" F–105Ds until they would be forward-deployed.
3) Pilots and support personnel of the 34th TFS could be integrated into operations during May, thereby gaining much valuable experience prior to receipt of their aircraft at a later date. This should also improve the standardization of tactics/techniques with the 34th commencing normal operations.

It proved that facilities construction at Takhli progressed in such a way that the base could already accept the five KC–135As, plus two more on a turn-around basis, without having to deploy the two 355th TFW F–105D squadrons to Korat. The 388th TFW was to accommodate its counterpart, the 355th TFW, at Takhli by loaning him 15 of its "new" F–105D pilots to alleviate an acute aircrew shortage caused by aircrew losses and normal rotation.

In its 31/05:05Z May message, "TDY of F–105 Aircrews to SEA" to PACAF and info 18th and 6441st TFW, reference was made to PACAF message of May 21 (a levy on 5AF to assign 15 F–105 pilots to SEA for 59 days, reporting on or about June 1), to its May 23 message (a levy placed by 5AF on units to support the PACAF levy), and to its May 28 message (proposal to complete the move of the 34th with holding the aircraft at Yokota), 5AF stated that if its proposal was favorably considered by PACAF, it would provide a resource of 27 pilots to Korat, of which 12 were now in place. A portion of this resource could be utilized at Takhli. 5AF requested authority to withhold the TDY of the pilots levied by PACAF's May 21 message until a decision was reached on the referenced proposal. In case it was accepted, it was requested that the TDY levy be held in abeyance until the aircraft of the 34th TFS would be in place. An expeditious reply was requested given the June 1 reporting date. The 18th and 6441st TFWs were directed to hold their deployment action in abeyance, pending a response to the message.

The Program Action Committee (PAC) of 5AF was briefed by DOPP on May 31 on the latest of the F–105 movement. The members were informed that all personnel and equipment of the 34th TFS had deployed to Korat, except 18 pilots, 18 F–105Ds, the En Route Support Team (EST) and a few maintenance personnel at Yokota. The 13th had sent four C–130 loads to Korat with 41 support personnel. The F–105 deployment would involve 700+ personnel. With regard to the deployment delay, it was emphasized that any action taken would consider the individual and not place him in jeopardy of repayment of monies or other expenses at a later date. In its June 14 meeting, the PAC members were informed that additional guidance was received from PACAF on the conversion of two F–105 squadrons, the 44th TFS at Kadena and the

When the 13th TFS arrived at Korat on June 15, the 388th TFW had received five F-105F WILD WEASEL aircraft, the first in Southeast Asia. In the photo, WW-F 38298 with "Little Angel" on the left front wheel door and "SAM Slayer" under the intake. "298" was lost on December 7, 1969, in a flying accident, 16 nautical miles northeast of Kadena while assigned to the 12th TFS. Both crewmembers were killed. [Don Ayer]

36th at Yokota, to an unequipped status in respectively February 1967 and November 1966. 5AF informed the 6441st TFW on August 12, 1966, that it was authorized to adopt an unequipped status for one squadron, the 36th TFS, effective August 15. This left the Wing with two 18 UE F–105 squadrons, the 35th and 80th TFS.

5AF/DOPP informed 5AF/VC on June 2 that PACAF had concurred with 5AF's request to delay the requirement for 15 TDY pilots (ten Kadena pilots to Korat and five Yokota pilots to Takhli) to SEA. PACAF had advised Strategic Air Command (SAC) that they were authorized to deploy five additional KC–135As to Takhli to bring the number to 15. In addition, two aircraft were authorized for turnaround operations only. 5AF was advised by PACAF at 02/05:00L June that PAC was expected to advise shortly on the F–105 deployment. As a result, the EST was to remain at Clark until further advised.

In a 02/12:30Z June message to PAC, MACTHAI referred to several earlier messages. On May 29, PACAF had recommended the approval of a plan which, in summary, held aircraft for the 13th and 34th TFS at Kadena and Yokota respectively, while deploying to Korat the pilots and support personnel for these two squadrons. Squadron aircraft were delayed to make room at Takhli for the KC–135s by deploying Takhli-based F–105s to Korat. In its June 1 message, MACTHAI reported clearance for the deployment to Takhli of five KC–135s and support personnel, and for the turn-around operation of two additional KC–135s pending the completion of the runway repairs at Kadena. In a message on the same day, June 1, PAC asked if the RTG clearance covered the deployment to Korat of personnel as outlined in referenced MACTHAI's earlier message and as PACAF recommended in its May 29 message. Concerning PAC's question, MACTHAI suggested obtaining from PACAF a copy of the May 30 message from Deputy Commander 7/13AF which stated in summary that it was possible, for a temporary period only, to accept 15-17 KC–135s at Takhli without deploying the F–105s to Korat. 7/13AF also recommended that the deployment of the two 5AF F–105 squadrons to Korat be completed and the crowded conditions on a temporary, repeat temporary, basis at Takhli be accepted by approving 15 KC–135s at Takhli. MACTHAI stated that it was apparent that the initial plan as submitted by PACAF in its May 29 message had been overtaken by the revised 7/13AF estimate that Takhli could accommodate additional tankers temporarily without deploying the Takhli F–105s to Korat since the two 5AF F–105 squadrons had already been cleared for their deployment to Korat, while Takhli could now accommodate the KC–135s as cleared. MACTHAI recommended completing the deployment of the 13th and 34th TFS to Korat as soon as PAC would have directed this.

In its 05/20:30Z June message to MACTHAI and PACAF, "Temporary Deployment KC–135 and Air Force Deployments", PAC referred to its 01/21:27Z June message, which questioned if the temporary deployment of additional KC–135 aircraft to Takhli also covered the proposed deployment of certain USAF personnel to Korat in connection with the ultimate location at that base of the 13th and 34th TFS. Reference was also made to MACTHAI's 02/12:30 June message, which responded to PAC's 01/21:27 June message, recommending the completion of the deployment of the two TFSs on grounds that 15 KC–135 aircraft could be accommodated at Takhli without the redeployment of tactical aircraft from Takhli to Korat. PAC said that note was taken of information that was received from MACTHAI and 7/13AF, which indicated that the crowded conditions at Takhli would exist temporarily if 15 KC–135 aircraft were to deploy without downloading tactical aircraft to Korat. PAC stated that a primary consideration in the temporary deployment of tankers to Takhli had been and continued to be the reaction of the Thai Government. While the crowded conditions at Takhli might be temporarily acceptable to U.S. forces, it might not be to the Thai. It was remarked that the completion of the two squadrons to Korat might technically have country clearance and might be desirable to U.S. forces but it might also be objectionable to the Thai given the changed circumstances. As a matter of record, it was stated that the five KC–135s temporarily deployed to Takhli would be returned to Kadena as soon as the runway repairs were completed. The temporary delay in the deployment of the two new F–105 squadrons to Korat was authorized to permit downloading of Takhli to make the KC–135 deployment palatable to the Thai and to make the required space available. The authorization of the deployment of personnel and F–105s would be considered upon assurances that the situation at Takhli was in all respects acceptable to the RTG, operationally feasible and that the Thai Government would concur in the completion of the two F–105 squadron deployments to Korat. PACAF was requested to comment concerning the conditions at Takhli which resulted from the KC–135 deployments.

In an 11/22:01Z June reaction to PACAF, "Temporary Deployment KC–135s and Air Force Deployments", which referred to MACTHAI's 02/12:30Z June message, PAC reacted to a message of 09/11:30Z June, which stated that MACTHAI had said that

1) Temporary bed-down of KC–135s at Takhli was operationally feasible.
2) The completion of the two delayed squadrons to Korat as well as the conditions at Takhli had the concurrence of the RTG.

As a result, PAC authorized PACAF to complete the deployment of the 13th and 34th TFS to Korat, and to keep MACTHAI and the Embassy in Bangkok advised. PACAF then informed 5AF and a number of "Info" addressees that PAC had authorized the completion of the deployment of the 13th and 34th TFS to Korat.

Fifth Air Force was subsequently informed in a message, "Deployment of two TFSs to Korat" that PAC had authorized the deployment completion of the 13th and 34th TFS to Korat, Thailand. It was authorized to resume the planned deployment as soon as possible. The info addressees had to be informed of the movement schedules and closure dates.

On June 11, a number of "new" aircrews were sent TDY from Korat to Takhli to await further developments. Some of them flew combat missions. They were recalled on the 16th and returned to Korat.

In its 12/10:30Z June message, "5AF OPORD 520-66, Deployment of two TFS to Korat" to 313AD, 41AD, et al, which referenced one PACAF and four 5AF messages, the 5AF Command Center directed both Air Divisions to initiate action upon receipt of this OPORD to ensure an orderly move of aircraft and equipment to Korat. "520-66" included, for example, the following subjects. The "mission" was to deploy the 13th and 34th TFS with 18 F–105Ds on June 14 in accordance with instructions as contained in the OPORD. Spare aircraft would ensure that 18 aircraft arrive at Korat (the best aircraft in both Wings were selected and all subsystems were thoroughly checked). Both Air Divisions were directed to prepare and execute the deployment of personnel, equipment, and aircraft to Korat and to coordinate the deployment with 5, 7, and 13AF, and 315AD for airlift. As to "Operations", 313AD was informed that by 5AF OPORD 141-65, the primary route for the 13th TFS was to be the BLUE MOOD routing to SEA, utilizing inflight refueling. No alternate refueling route was recommended unless coordinated between the tactical and refueling commanders. The configuration (for both squadrons) would be two 450-gallon, one 650-gallon, and the bomb bay fuel tanks. The routing for both units without inflight refueling was GOLDEN WARRIOR/BLUE MOOD through Clark to Korat. In the latter case, an EST was to be deployed to Clark to provide the necessary support not in place. 13AF was requested to assist in the turnaround and necessary support in the case of no-stick recoveries at Clark during air refueling with minimum support for this situation to be provided by 313AD as required.

41AD was informed that the primary deployment route for the 34th would be the GOLDEN WARRIOR/BLUE MOOD routing to SEA utilizing inflight refueling from Kadena to the final destination per 5AF OPORD 141-65. The departure from Yokota had to be scheduled at such a time to ensure that the 13th TFS had departed Kadena before the arrival there of the 34th TFS. Direct coordination between the two wings was authorized. 313AD was requested to provide assistance in the turnaround of the F–105Ds and the necessary support as required by 41AD. Both Air Divisions were to prepare deployment plans that would ensure, as soon as possible, that personnel, aircraft, and equipment would be in place at Korat not later than June 14 (13th TFS) and June 15 (34th TFS). The launch of the first flight of the 13th TFS from Kadena was planned for 13/23:00Z June and of the 34th TFS from Yokota on 14/23:00Z June. In case of a weather/tanker delay, each squadron could be slipped for 24 hours. The deployments from Kadena would be accomplished in three flights of six aircraft, plus two spares. Weather support was to be provided per OPlan 651 of the 1st Weather Wing.

A second "5AF OPORD 520-66, Deployment of two TFS to Korat" message was sent the same day at 11:14Z, informing the addressees of the deployment schedule. The departure date of the 13th TFS with 18 primary and two spares was scheduled to depart Kadena on June 14. Twenty-one C–130s would be involved in the airlift of personnel and equipment, six C–130s each on June 13, 14, and 15, and three on the 16th. The departure of the 34th TFS with 20 F–105Ds from Yokota would be on June 14 and from Kadena on the 15th.

In his June 17 message, "Deployments" DOPP informed 5AF/VC that all aircraft of the 13th/34th TFS were in place at Korat on June 15. The last C–130 load of equipment departed Kadena on 17/06:45L June.

The total personnel requirement was 1,453, of which 77 officers and 1,376 airmen. For Kadena, the requirement was 43 and 693 respectively (736). The numbers for Yokota were 34 and 683 (717). Kadena provided 343 personnel, 39 officers and 304 airmen. Yokota's numbers were 350, 34, and 316 respectively. Of the total number required, the two bases provided 73 officers and 620 airmen (693). According to 5AF, 1,385 officers and airmen were transferred to Korat, with the remainder coming from PACAF and CONUS resources.

There was one more SPOTLIGHT movement, 108, which involved the move to the U.S. of 87 Kadena and 96 Yokota families. Thirteen families of Yokota-deployed personnel remained in Japan. These were Japanese National wives of Air Force sponsors.

13th TFS

The introduction in the January 1 - June 30, 1966 history of the 18th TFW stated, among others, that one of the most significant occurrences during the reporting period was the activation of the 13th Tactical Fighter Squadron and its subsequent move to Southeast Asia. Although this deployment was a Permanent Change of Station (PCS), the esprit de corps of the entire Wing was revealed by the substantial number of volunteers desiring to be part of the new Squadron. Another major occurrence was the shift to the "Squadron Concept", making each TFS self-sufficient and self-supporting. This would enable a TFS to deploy in mini-

The 13th TFS after the F–105F WILD WEASEL Detachment had joined the Squadron as its fifth flight. Dick Baughn is fifth from the left on the first row. ***(Dick Baughn)***

mum time and with minimum effort. As a result, PACAF Special Order (SO) G-159 of May 18 discontinued the 18th Organizational Maintenance Squadron (OMS) effective June 8, with its personnel going to the Squadrons. In addition, the 418th Munitions Maintenance Squadron (MMS) relinquished the function of munitions loading on the assigned Wing aircraft. For the squadrons to accomplish the new responsibility, the 418th transferred one officer and 45 airmen to each of the three fighter units. A similar process took place at Yokota, where the 441st OMS was discontinued and the 441st MMS lost personnel to the three fighter units.

SPOTLIGHT 68 was the movement of personnel and equipment from Kadena to the new F–105 unit at Korat, the 13th TFS. SPOTLIGHT 68 identified the total aircraft complement and personnel which was to deploy on a PCS basis to the 388th TFW at Korat. In January 1966, the 18th TFW at Kadena was alerted to send a squadron With Personnel and Equipment (WPE) to Korat. The initial deployment date was set for May 20. As its squadrons were set up as deployable self-sustaining packages, the least confusion would be caused by simply renaming one the 13th TFS and restocking the old designation at leisure. This was accomplished and the 44th was the candidate. Ninety percent of the personnel was obtained from the 44th TFS and the other ten percent, through volunteers from the other two squadrons, the 12th and 67th TFS. Eight pilots of the 12th TFS for instance joined the 13th TFS. To equip the new squadron with 18 F–105Ds, the Wing organization was reduced from 72 to 54 F–105D/Fs. The 13th TFS received eight aircraft from the 44th and five each from the 12th and 67th TFS. Because of SPOTLIGHT, the number of flights in the 12th and 67th TFS was decreased from four to three. The first time these 18 tail numbers were mentioned in the Wing's Air Vehicle Assignment Directive was #66-6 of June 1, 1966.

The 13th TFS was constituted by order of the Secretary of the Air Force on May 2, after having been activated by Department of the Air Force letter 580n of May 2 and assigned to PACAF. In a 10/02:28Z May message, "OPORD 514-66, Activation of 13TFS", to 5AF et al, PACAF issued the order to activate the 13th TFS at Korat during the last week of May. The 18th TFW at Kadena was directed to deploy the Squadron WPE, With Personnel and Equipment, to Korat to bring the 13th TFS to UE strength. The formal Special Order (SO) to organize the 13th TFS effective May 15, SO G-150, was issued on May 10. At the same time, the Squadron was reassigned from PACAF to the 18th TFW and attached to the 388th TFW for operational control, and administrative, and logistic support. Personnel had to be furnished from PACAF resources. That the 13th TFS (and the 34th TFS) was not assigned to the 388th TFW, but just attached was an unorthodox arrangement which was made by the recommendations of the U.S. Ambassador to Japan to avoid "… the apparent movement of units out of Japan… " This was the reason for keeping the 45th TRS and 612th TFS designators at Misawa, but to deploy their personnel and equipment to South Vietnam as respectively Det 1, 45th TRS (as SPOTLIGHT 80 to Tan Son Nhut) and Det 1, 612th TFS (as SPOTLIGHT 67 to Phan Rang). Departure was set for May 26. Lieutenant Colonel Dick Baughn became the first Commander of the new unit.

As stated earlier, a staying order was dispatched through Fastel 142 on 25/16:45L May, which delayed the departure for thirty days. There were even rumors at Kadena that the move would not be made at all. With the lack of further information, many personnel canceled pro-

.The “illegal” emblem of the 13th Tactical Fighter Squadron. *(via André Wilderdijk)*

ceedings to return their dependents to the U.S. As a result, when the order was received to deploy with a week’s advance notice, many dependents were left to arrange their moves. While the Thunderchiefs were “stuck” at Kadena, they all went through Time Compliance Technical Order (TCTO) 1F–105–953. In a 29/05:07Z May message, “34/13 TFS Deployments” to PACAF, 5AF requested permission to return the 13th TFS personnel that had already deployed to Korat. In addition to 41 personnel, four C–130 loads of Squadron equipment were in place when Fastel 142 was received. The request was denied by PACAF.

On June 12, the Squadron was notified to be in place at Korat on the 14th. The aircraft departed Kadena in flights of six, six, and eight, with the launch of the first flight at 14/08:00L June, followed by the other flights at 30-minute intervals. With aerial refueling, the flying time was 3+30 non-stop. The aircraft closed at Korat on 14/06:34Z. A C–54 transport was on standby at Kadena to transport an EST to Clark if required. A total of 26 C–130 and one C–54 aircraft airlifted 443,598 pounds of cargo and 372 personnel.

The first combat missions were flown on June 18. The Squadron participated in the June 29 and 30 POL strikes. For its participation, the 13th was awarded the Air Force Outstanding Unit Award (AFOUA) with Combat “V”.

In the meantime, on May 31, nine officers and two F–105F Wild Weasel aircraft had arrived at Korat with the aircraft undergoing acceptance checks. Initially, personnel and aircraft were known as Detachment 1, 388th TFW. The number of Wild Weasel Fs had increased to five on June 3. Wild Weasel operations were initiated that same day. On June 14, Wild Weasel personnel and aircraft were assigned to the 13th TFS as its fifth flight.

In the June 18, 1966-February 25, 1967 period, the Squadron flew 3,672 SEA combat sorties. Forty-four of its crewmembers completed 100 “counters”. Before PCS-ing to Korat, several pilots had already flown counters while deploying TDY to Korat before joining their new squadron.

As mentioned before, Lieutenant Colonel Dick Baughn became the first commander of the 13th TFS. His combat career started at RAF Honington in England, where he arrived on October 27, 1944. He was assigned to the 383rd Fighter Squadron of the 364th Fighter Group, flying P-51Ds. The first combat sortie was flown on November 6. While assigned to Headquarters TAC at Langley (VA) as the F–105 program project officer, Dick was checked out in the F–105 at Nellis (NV). He flew his first Thud sortie on February 28, 1961. In September 1964, Baughn arrived at Kadena and was assigned to all three F–105 squadrons before joining the 13th TFS. After arriving at Korat on June 14, 1966, the first combat sortie was flown on the 18th.

Colonel Baughn appointed Major Ronald Johnson as his Operations Officer and Major Hansel Turley as the Assistant Ops Officer. The pilots were divided into four flights, Red, White, Blue, and Green. Dick Baughn about the patch,

We had to design our squadron patch, as the 13th was a brand new squadron. We had no guidance from above. I selected three talented pilots, Capts Jim Goode and Boris Baird, and 1st Lieutenant Roger Hegstrom, who all came over from the 67th TFS, and gave them general guidance. They came up with the design, I approved it and sent it up through the channels for approval. It was finally, after a year or more, and long after I had left the squadron, approved without a change.

The official description of the emblem was that it was composed of a spitting black cat, superimposed on the red numerical 13, and a yellow shield. The emblem represented the tenacity of a fighter squadron. Dick Baughn’s unofficial explanation was as follows.

The yellow signified the fighting will of Johnson and McNamara, the black panther was really a black cat, and the red 13 signified our blood. That may sound childish now, but after you watch your best buddies being shot down for nothing (“strike on a suspected 50 barrels of fuel in some wooded area)” you would understand. “Sarcastic” is putting it mildly.

Meanwhile, Sam Shearin, historian for DAF Heraldry at the Air Force Historical Research Agency, Maxwell AFB (AL) shed the following light on the subject:

According to AFHRA official records, the current 13th Fighter Squadron (previously known as the 13th Tactical Fighter Squadron) emblems are:

The historical CSAF–approved emblem was originally approved on August 15, 1985, when the unit was known as the 13th Tactical Fighter Squadron.

The AFHRA has no record of a previously approved emblem.

The unit might have had an “unofficial” design that was never officially approved.

The present organizational emblem was approved on August 16, 2007.

The emblem of the 34th TFS. Unlike the 13th TFS, the 34th TFS had a lineage and history. Upon organization, the Squadron was entitled to any honors and approved emblem belonging to the unit, which was inactivated and replaced by the 308th TFS on March 15, 1959. [Via André Wilderdijk]

Col Baughn continued as follows,

The entire 44th TFS personnel and aircraft were transferred into the 13th before we left Kadena. A few months earlier we had switched back to Squadron maintenance, so many of those folks came with us. There were some personnel changes due to rotational dates, but not too many. Most people knew they would eventually have to go, so they wanted to go with personnel they knew. Most if not all were volunteers. When we arrived at Korat we lost our maintenance people, including the crew chiefs, and reverted to "Communist" maintenance. The inefficiencies of that system were well known with the loss of personalized squadron maintenance, where maintenance personnel take tremendous pride in THEIR aircraft.

According to Baughn, the 44th was selected, as the Squadron had the highest combat efficiency rating in the 18th TFW at that time. The Wing was tasked to select a squadron for the assignment. It had just completed a concentrated training program and held a "Turkey Shoot" where the three squadrons competed in bombing, strafing, etcetera. The 44th won every event, so it was selected for the move. Dick Baugh again,

I was also interviewed by the 5th Air Force Commander, Lt Gen Maurice Preston. Most of us were not happy about the re-designation from the 44th to the 13th, but my feelings gradually improved. We had all wondered why the change was made. We were all very proud of the 44th and besides our helmets, flight suits, etcetera all had to be changed. As to the new designation we had no input. I think we had a 2-month warning time. When we got to Korat, we made a three-foot plaque with pilot's wings and with the Edsel grill in the center instead of the shield. We hung it in the Officers Club and took it down when we had VIPs. Many of the pilots of the 44th TFS had already flown 30 to 50 combat sorties during their earlier TDYs. Those who were close to rotation back to ConUS were given the opportunity to do so. Some did and some volunteered to remain with the 13th. We picked up pilots from both the 12th and 67th, They were all volunteers. I was due to rotate and already had an assignment to Nellis. This assignment was held for me until I had finished my combat tour.

The Squadron held a "helluva" going away party before the families and the 18th were left. The families returned to the U.S. within a few weeks after the PCS to Korat. Before the departure to Korat, Colonel Ritchie, the 388th TFW Commander, notified Lieutenant Colonel Baughn that the F–100F and F–105F WILD WEASEL operations would be assigned to the 13th TFS. Colonel Baughn in this respect,

Lt Col Garry Willard, the WILD WEASEL commander at Korat, stopped by to brief me at Kadena when he finished his tour. Ritchie and Willard both knew me and I'm certain they discussed me taking the Weasels. We had four fighter flights and two Wild Weasel flights. I was completely in favor of their "damned important" mission. I was indeed proud to have the Weasels assigned to my squadron. I flew about half of my missions with the Weasels. We always had two to three F–105Ds in each WW flight. Every squadron in the 388th provided pilots for the WW flights. Everything was ready when we arrived at Korat. Col Ritchie (I had worked for him in England and we knew each other quite well) had pushed hard and had new living and working facilities for everyone. We had so many people in the Squadron that some referred to the 13th as the 13th Fighter Group. Because of the size of the 13th, we had a larger ops building.

On October 6, Dick flew his 100th counter. His total F–105 flight time was 597 hours. His last Air Force assignment was as Deputy Defense Attaché in Saigon.

One of the pilots of the 44th who joined the 13th TFS was Captain Tom Lockhart. As he remembered,

In a big pilot meeting, we were briefed about Spotlight by the Wing commander, Col Bob Cardenas. When he asked for volunteers, Lt Col Dick Baughn said he had 22 volunteers and that the 44th was willing to go. This was the first time we 44th pilots heard about it. Col Cardenas then said the 44th was to deploy. The dependents would be sent back to the U.S. After the briefing, Baughn talked to us and explained why he decided to volunteer as a squadron. One reason was that everybody stayed together and did not have to get accustomed to other pilots, flight leads, etcetera. Baughn was also certain that everybody would be better off this way. Pilots who did not want to go, would not be forced to. Ultimately, only two pilots did not want to PCS to Korat for various reasons. We got three people from the 67th.

Tom said this resulted in fewer losses than the 34th TFS as they were volunteers.

The 44th, as the 13th TFS, was able to take along the best Ds in the Wing. The Squadron instituted a monthly four-

Before PACAF dispatched Fastel 142 of 25/08:45Z May, directing a 30-day delay in the movement of the two F–105 squadrons to Thailand, 23 C–130s were used to airlift personnel and equipment for the 34th TFS to Korat. The aircraft were launched on May 21 - 25 and airlifted 347 support personnel and 375,000 pounds of equipment to Korat. 5AF requested PACAF for their return but PACAF did not go along. The photo shows C–130A 60542 of the 315th Air Division unloading equipment at Korat. ***(Ed Skowron)***

day Rest and Recuperation (R&R). The first patch was not approved. It was an Edsel grill with the four wings and the "13". A new emblem was then designed, but had not been approved when the Squadron deployed to Korat.

Tom Lockhart flew his 100th mission on October 2. On the same mission, Turk Turley and Dick Flietz also completed their 100th counter.

34th TFS

PACAF also directed the 6441st TFW in January 1966 to organize, equip, and activate a tactical fighter squadron from within Wing resources and send it PCS to the 388th TFW at Korat. The movement of personnel and equipment from Yokota to the new F–105 unit at Korat, the 34th TFS, was called SPOTLIGHT 74. The deployment of the new squadron was initially set for May 20. As a result, Colonel A.K. McDonald, the Wing's Vice Commander, started daily morning briefings to keep all concerned aware of the progress. In addition, a "Project Spotlight Movement Control Center" was established in the 41st Air Division. All data regarding the movement of the 34th was kept in an up-to-the-minute read file. The status boards regarding training, loading, and movement, the briefings, and the read file helped pinpoint problem areas. Wing maintenance was alerted on March 28 for a possible move. After receiving further guidance in early April, considerable time and effort were expended during April and early May on planning for the move if it would materialize. Personnel and equipment were tentatively selected and placed in a high state of readiness. Aircraft were tentatively selected by tail number and given the highest priority for completion of TCTOs. As at Kadena, the Wing organization was reduced from 72 to 54 F–105s, with the residual 18 aircraft joining the 34th TFS. The number of personnel to PCS was 350, of which 34 officers and 316 airmen. The 36th TFS supplied about 100 personnel, including eight pilots.

The initial notification message to move to Korat was received on May 6 from PACAF. To discuss the type and quantity of the equipment to be moved to prevent an excess of support equipment, a conference was held at Korat on May 9 with representatives of the 6441st, 18th, and 388th TFW. The equipment discussion was completed satisfactorily. In its 10/01:38Z May message, PACAF sent the first official warning order. Personnel and equipment were to be in place at Korat on May 27. The Wing's Logistics Plans requested 315AD on May 11 airlift to deploy personnel and equipment to Korat. The airlift schedule was received on May 17. It showed the departure times in the May 21-25 period of 24 C–124s and C–130s that would airlift 587 passengers and 371 tons of equipment to Korat.

PACAF 11/00:06Z May message, "OPORD 514-66, Activation of 34TFS" to 5AF et al, issued the order to activate the 34th TFS at Korat during the last week of May. The order directed the 6441st TFW at Yokota to deploy the Squadron WPE to Korat and to bring the 34th TFS to UE strength. Twenty F–105Ds were to be deployed on May 25 including spares to ensure that 18 aircraft would arrive at Korat. The new squadron obtained its personnel and equipment primarily from the 36th TFS. This did not mean, however, that the 36th TFS, or the 44th TFS at Kadena, were inactivated. The constitution, activation, organization, assignment, and attachment of the 34th TFS followed the same pattern as the 13th TFS went through. In this case, the Squadron was assigned to the 41st Air Division. Upon organization, the 34th TFS was entitled to any honors and approved emblem belonging to the unit, which was inactivated and replaced by the 308th TFS on March 15, 1959. At that time, the Squadron was assigned to the 413th TFW at George AFB, California, and flying F–100D/Fs. Historical data, including information about any honors and approved emblem, would be forwarded automatically to CINCPACAF by the USAF Historical Division, Air University at Maxwell AFB, Alabama. Any flag or streamers authorized might be requisitioned in accordance with existing directives. The Commander of the 36th TFS, Lieutenant Commander Howard Hendricks, transferred to the 34th TFS. Five flights were established, India, Juliet, Kilo, Lima, and Metro.

The movement directive for the 6441st (and 18th) TFW was received by 5AF on May 13 and an execution order and additional planning guidance were dispatched

F-105D 24352 was one of the aircraft deployed to Korat to become part of the 34th TFS. According to tradition, "352" was the last uncamouflaged Thunderchief in Southeast Asia. It was assigned to B flight. On January 21, 1967, after Captain Bill Wyatt's F-105D (Chisel 03), 81156, was hit by 85mm AAA, he collided with Chisel 04, 24352. Wyatt was able to reach "feet wet" and was recovered by a Navy SAR UH-2B. Chisel 04, accompanied by Chisel 01 and 02, recovered at Da Nang. It was found that "352" had a hole about three feet wide on the right side of the forward section of the fuselage. It took 17 work days and 250 man-hours to get the airplane safe for a one-time flight to Air Asia in Taiwan for further repair. [Jerry Arruda]

to the unit. Frag Order #1 to 5AF OPORD 514-66 was published by 41AD on May 17 with a change to #1 on May 20. Reference was made to 41AD OPORD 514-66, 41AD OPlan 404-66, and 41AD Mobility Plan 400-1-66. Colonel Hendricks was designated as the Task Force Commander. Task organizations were the 6441st TFW and 441st CSG. Their mission was to deploy personnel, aircraft, and equipment that were selected as resources for the 34th TFS from Yokota to Korat. The 6441st TFW/DCO was to establish a Movement Control Center in the Command Center of the 41AD to monitor the entire deployment. His colleague, the 6441st TFW/DCM (Deputy Commander for Maintenance) was to prepare 20 F–105Ds, including two spares, to meet the deployment schedule. The Commander of the 441st CSG was to ensure that all selected personnel to deploy would be processed for their PCS in accordance with the current directives. He was also to assign responsibilities for the move, including a command control team to be in place at Kadena to control the launch on May 26 from Kadena to Korat. Other organizations involved in the move were 313AD at Kadena (turnaround support and facilities), 315AD at Tachikawa (airlift), 4252nd SW at Kadena (aerial refueling), and the 405th FW (Clark) turnaround support for any F–105s staging through Clark. An EST was to depart Yokota on 15/07:00L May and to remain at Clark until June 2 in the event the alternate deployment route was utilized. The 405th Fighter Wing (FW) was to support the turnaround for F–105s transiting Clark. The configuration of the F–105Ds and the routes from Kadena were the same as for the 13th TFS with one exception (see later). Departure for Kadena was set for May 25 and Korat on the 26th. Departure could be slipped 24 hours in the event of a weather delay. The final launch decision from Yokota would be made by the 6441st TFW/CC. The Squadron was to deploy in five flights of four with Yule 01-04 to depart Yokota on 25/0800L May (24/23:00Z) with the next four flights leaving at 30-minute intervals. The arrival of Yule 01-04 at Kadena was scheduled for 25/10:01L May. Departure from Kadena would be made in three flights of six F–105Ds with Yule 01-06 to depart on 26/08:00L and arrive at Korat at 11:30L. Aerial refueling would take place one hour after departure from Kadena. The next two flights would leave at 45-minute intervals. The Task Force Commander was to coordinate with 6441st TFW/DCO concerning the disposition of spare aircraft after 18 aircraft were in place and OR at Korat.

As a result, the required personnel and equipment were identified and placed in a state of readiness. The 35th and 80th TFS "stood down", while the 36th (all 34th aircrews were assigned, on paper, to the 36th) took most of the flying hours, sorties, etcetera. Aerial Combat Tactics (ACT) training was stressed. The aircraft were cleaned and "peaked". The airlift for dependents remained unconfirmed until May 23, when it was promised by the Military Airlift Command for May 31. Sponsors had requested their dependents be moved before their own PCS (the last F–105s were due to leave at 25/10:00L May).

In the May 16-20 period, the Inspector-General of 5AF conducted a pre-movement inspection at Yokota of the 36th TFS, 41AD. The inspection took place by a team of 11 members, with Lieutenant Colonel Robert Mize as Team Chief. In his report of May 20, Mize reported that the instructions in the initial PACAF notification message, PACAF OPORD 514-66, the 5AF warning and execution orders were adequate. However, the very short notice and the nearly simultaneous receipt of the warning and execution orders denied the 41AD and the 36th TFS a normal period to prepare for a PCS movement. The problems of preparation were further compounded by the fact that this was not a PCS of an existing organization. Rather, the movement required the composition of a new squadron from 41AD resources. Nevertheless, this situation did not cause unsurmountable

F–105Ds 24288 and 24326 of the 469th TFS are being refueled in August 1966 by KC–135A 10312. "288" was one of the original 34th TFS birds. The Thuds are configured with a 650-gallon fuselage tank and two M-118 3,000-pound bombs. Forty seconds after starting his takeoff roll on November 10, 1966, Major Dain Milliman's F–105D 24288, Elmo 03, experienced an afterburner failure, was streaming sparks, fire, and smoke, slid through the BAK barrier, snagged the MA-1 barrier, proceeded off the end of the overrun, across a highway, came to rest about 500 feet beyond it, and started to break up. A crew of an HH–43B Huskie made several attempts to suppress the fire but withdrew from the scene due to exploding ordnance, four CBU-24/Bs. The fire burned itself out. Major Milliman was killed. *(USAF)*

problems. There was not enough time to bring the Mobile Spares Kit (MSK) up to the latest configuration and port calls were not obtainable for all dependents requesting them concurrently with their sponsors' departure. The Team's inspection summary stated that the 36th TFS was satisfactorily prepared for the PCS movement and that the overall capability of the squadron to perform its mission was satisfactory. The pilots, who were all volunteers and who had flown an average of 30 SEA combat sorties, had completed all required flying training and were all combat-ready. Eighty percent of the airmen were volunteers as well. The aircraft which had been selected were in a very satisfactory condition and the scheduled maintenance actions should place them in the best possible condition and fully combat-ready. All aircraft were configured with Radar Homing and Warning (RHAW) equipment and a depot team was accomplishing other depot-level TCTO compliance as rapidly as possible. However, due to the short time interval between the notification and the scheduled date of the deployment, approximately 30 percent of the aircraft would not have all TOs completed but this would not affect the deployment. The Aerospace Ground Equipment (AGE) was in excellent condition.

The Personnel Division of the 441st Combat Support Group (CSG) at Yokota spent long hours devising a system of reassignment and processing of the personnel to accompany the 34th TFS to Korat, while at the same time setting up procedures to send more than 500 dependents back to the United States. Through the use of a single processing line with representatives of Finance, Transportation, Medical, Personnel Services for visas, Housing, and other units that were necessary for the processing, the time for the accomplishment was held to a minimum. Through cooperation with MAC in assigning accelerated airlift, most of the dependents were able to be accompanied to the departure terminal by their sponsors. However, some families had been forced to leave without notice, many after having arrived in Japan only a few months previous.

Colonel McDonald had OK'd the mounting of AIM-9B pylon adapters, without missiles, on each departing F–105D. This precluded the necessity for one entire C–130 load of the 25 loads that were requested. Airlift was critical and in short supply. The support aircraft, further reduced to 23, were launched on May 21-25 and airlifted 347 support personnel and 375,000 pounds of equipment to Korat. Some of the C–130s did not take off in time due to various reasons but in no instance did this cause any delay. All Wing personnel were prompt for their show times and all loads were palletized and waiting for the C–130s. On May 4, a general pre-deployment briefing was held in the briefing room of the 36th TFS. The individual flight briefings were to be held two hours before the scheduled flight departure time. In his May 25 message, 5AF/DOPP (Plans and Programs) informed 5AF/VC, Major General Fred Ascani, that the 18 F–105Ds of the 6441st TFW were ready for launch from Yokota to Kadena as scheduled.

On May 25, 5AF OPORD 514-66, Fragmentary Order #1, deployed elements of the 36th TFS from Yokota to Korat to form the 34th TFS. As a result, a large party of people and equipment departed Japan, while 20 F–105Ds, in five flights of four, were launched and recovered at Kadena as follows.

Call Sign Yule	Tail Number	Pilot	Departure Time	Arrival Time/ Status
01	24331*	Hendricks	0800L	0955L/
* changed to 24361				Doppler
02	24288	Nierste		OR
03	24366	Miholick		OR
04	24303	Hauth		ground blower inoperative
11	24306	Whatley	0830L	1025L/OR
12	24318	Jones		OR
13	24308	Reed		autopilot
14	24358	Lavok		OR
21	24370	Blank	0901L	1058L/OR
22	24380	Curtis		OR
23	24364	Hamby		OR
24	24277	Kelly		OR
31	10132*	Stressing*	0930L	1134L/
* changed to 24270; pilot, Rutherford				autopilot
32	24312	Duil (?)		OR
33	24270**	Rutherford**		CIN
34	24378***	Watkins***		fire control
** changed to 24378; pilot, Watkins.				
*** changed to 24356; pilot, Sullivan.				
41	24352	Hayes	1000L	1200L/ fire control
42	24356*	Sullivan*		OR
* changed to 10132; pilot, Stressing				
43	24379	Olman		fuel leak
44	24354	Reichart		OR

Jerry Arruda was the crew chief for F–105D 24352 and nicknamed it appropriately "Thunderchief". The name would not be on the aircraft for a long time as on May 5, 1967, it was probably hit by an SA–2, while Lieutenant Colonel Gordon Larson, who was attached to the 469th TFS for flying, was RESCAP-ing for the #04 in his flight, Lieutenant Colonel Jim Hughes, commander of the 469th TFS. His F–105 was hit by probable 85mm AAA. Hughes was captured and released in 1973.

While the pilots at Kadena were awaiting their launch order for the next day to their final destination Korat, 5AF, after receipt of PACAF's Fastel 142, in its 26/01:59Z May message to the 34th TFS rescinded OPORD 514-66 "Deployment of 34th TFS" and instructed the Squadron to redeploy to Yokota. As a consequence, the aircraft were flown back to Yokota with 19 returning on the 26th and the final Thud one day later. In the meantime, household goods had been packed and were sent to the U.S. along with the cars. Wives and dependents had booked flights.

According to the Appendices Volume of the history of 5AF for the January 1-June 30, 1966 period, the runway at Kadena had been temporarily closed in May, thus necessitating the temporary movement of SAC's KC–135s from Kadena to Takhli. To accommodate the KC–135s at Takhli, two F–105 squadrons were shifted to Korat. When the personnel arrived in May, there was no room to support the incoming people and aircraft. "Thus, the delay."

DOPP informed 5AF/VC on May 27 about the return of the 20 aircraft and that PACAF had queried 5AF earlier on the extent of the 34th TFS movement. 5AF/DOPP told PACAF that the move was 100% percent complete except for the F–105Ds, which were at Kadena. All except one returned to Yokota the day before with the last aircraft to return this morning. Airlift was requested on May 26 to return the personnel of the EST from Clark to Yokota and the return of the 13th TFS personnel from Korat to Kadena. Both Yokota and Kadena were then advised that the deploying squadrons were directed to conduct continuation training, emphasizing conventional delivery to ensure that aircrews and support personnel were kept at peak readiness. To accomplish these requirements, airlift requirements were requested to return the personnel and equipment.

While awaiting further developments, six aircrews of the 34th TFS were sent to Takhli around June 10 to partially satisfy a PACAF levy on 5AF units to provide pilots on temporary duty to fill shortages in the F–105 squadrons of the 355th TFW. This meant that when the Squadron deployed to Kadena on the 14th, Wing pilots had to fill in. After their arrival at Korat, they returned to Yokota. One of the six TDY pilots was 1st Lieutenant Phillip Kelly. On the second of the two combat sorties he flew with the 333rd TFS, on June 15, he was shot down and rescued. He flew in F–105D 24377 as #02 in Packard flight on an armed reconnaissance mission. After finding a ferry boat at the mouth of a river 30 miles north of Dong Hoi, Kelly was hit by AAA during his napalm drop. He flew his aircraft 30 miles to the west where he had to eject. He was picked up in approximately one hour with no injuries. On the 16th, the six Squadron pilots who were TDY to Takhli were recalled and arrived at Korat.

In its June 13 message "Frag Order #2 to 5AF OPORD 514-66" to 5 and 7AF, et al, the 6441st TFW referred to 5AF OPORD 514-66, 41AD OPlan 406-656, and to the 41AD Mobility Plan. Twenty F–105s would deploy from Yokota to Kadena on June 14.

At 02:30Z on June 13, the 6441st TFW sent its message, "5AF OPORD 514-66, 34th TFS Deployment" to 313AD, 18th TFW, 4252nd SW, 388th TFW et al, informing them of the following. Twenty F–105Ds would be staged through Kadena on June 14 en route to Korat, and three GOLDEN WARRIOR attrition F–105Ds to Takhli. The flying time would be two hours. The departure from Yokota had to be scheduled at such a time to ensure that the 13th TFS had departed Kadena before the arrival there of the 34th TFS. Per 5AF OPORD 141-64, the operational control of the aircraft was to pass from 41AD to 313AD upon landing at Kadena. Deployment would be in five flights of four aircraft (Form 11-14, 21-24, 31-34, 41-44, 51-54) and one flight of three aircraft (Form 61-63). The launch from Yokota was scheduled at 15-minute intervals, with the first flight to depart on 14/02:00Z June (14/11:00L) and the final flight at 03:15Z. The time en route for each flight would be two plus zero zero. 313AD was requested to provide turnaround support, billets, weather briefing, transportation, and navigational aids as necessary. The 4252nd Strategic Wing at Kadena was requested to provide air refueling on June 15 from Kadena to Korat. Launch from Kadena of the first of two flights of six aircraft (Form 11-16) would be on 14/23:00Z with a 15/00:01Z air refueling. The second six aircraft (Form 21-26) would depart 30 minutes later. The aircraft without air refueling would proceed directly to Clark, turn around, and then continue to Korat. The deployment commander was to determine the estimated departure (Kadena and Clark) and arrival (Clark) times. According to the Appendices Volume of the history of 5AF for the January 1-June 30, 1966 period, the flight schedule to Kadena was not changed. However, the Kadena-Korat schedule was, insomuch, that departure was in five flights of four aircraft and one of three with 30-minute intervals, directly to Korat with air refueling. Departure of the first flight was at 15/08:00L June. The last of the 20 F–105Ds closed at Korat on 15/03:47Z June (14/11:47L) while the three GOLDEN WARRIOR aircraft closed at Takhli.

The only FY61 Thud that originally joined the 34th TFS was 61-0132. On August 23, 1967, 1st Lieutenant Dave Waldrop of the 34th TFS claimed two MiG–17s while flying "132", nicknamed "Hanoi Special", as Crossbow 03. Dave, on his 53rd combat sortie, used two bursts of 20mm fire to down the MiGs. After the 388th TFW's Enemy Aircraft Claims Board reviewed and validated both of Waldrop's claims, two MiG–17 kill markings were painted on the fuselage under the cockpit. However, 7/13AF Special Order 2188/67 of December 7, 1967, confirmed only one of the two kills. The 7AF Enemy Aircraft Claims Evaluation Board "denied the first of Waldrop's claims based on the claims and evidence that were available at that time." The North Vietnamese confirmed the loss of one MiG–17 and its pilot. USAF lost one F–105D, one F–4C, and three F–4Ds, of which two were probably by MiG–21 pilots. The aircraft was lost on May 14, 1968, when Major Seymour Bass of the 34th TFS, as Hayfire 02, collided 90 nm northeast of Korat with his lead, Hayfire 01, who was able to recover at Korat. Major Bass was killed. *(USAF)*

In its 15/05:15Z June message to 5AF, 41AD referred to 5AF OPORD 514-66 and 41AD Frag Orders #1 and 2 to the OPORD. The Air Division stated that personnel and aircraft were in position at Korat as of 15/04:15Z June as scheduled. The Commander of the 34th TFS, Lieutenant Commander Howard Hendricks, reported that the Squadron was established and ready for action. Barring further requirements from higher headquarters, 41AD considered SPOTLIGHT 74 as completed.

As was the case with the 13th TFS, the first combat missions were flown by the 34th on June 18. The 34th lost its first pilot when on June 21, 1st Lieutenant John Sullivan's F–105D was hit by 85mm AAA on a mission three miles south-southeast of Kep Airfield. No chute or beeper was observed. Because of the location, no SAR was possible. His remains were returned to the U.S. on September 13, 1990. The Squadron also participated on June 29 in strikes against the Hanoi Petroleum Products Storage Complex (JCS 49) and the Duc Giang petroleum storage tanks complex (JCS 50). The missions were flown by both F–105 wings. The 388th TFW supplied two flights of F–105Ds and two WILD WEASEL flights with F–105D/Fs. The 355th TFW supplied four flights of F–105Ds.

Major Fred Tracy of the 421st TFS claimed the first MiG with an F–105. Captain Murphy Jones of the 333rd TFS was downed and captured. On the 30th, 24 F–105Ds of both Wings, plus support aircraft struck POL storage areas at Nguyen Khe (JCS 51) and the Viet Tri POL storage area (JCS 51.14). Captain Robin Nierste was lost. For its participation, the 34th was awarded the Air Force Outstanding Unit Award (AFOUA) with Combat "V".

In the June 18, 1966-February 25, 1967 period, the Squadron flew 3,727 SEA combat sorties. Thirty of its crewmembers completed 100 counters. Before PCS-ing to Korat, several pilots had already flown counters while deploying TDY to Takhli and Korat. An example was Captain Bob Pielin, Metro flight commander, who joined the 34th with already 87 counters. On July 9, he became the first Squadron pilot to reach the magic 100 number.

Original 34th TFS F–105D 24361 made it through the Air War and was transferred to the 127th Tactical Fighter Training Squadron (TFTS) of the Kansas Air National Guard (ANG) at McConnell AFB, Kansas for use in the F–105 flight training program. The October 2, 1971 photo shows "361" in 127th TFTS markings. The "RE" tail code (44th TFS) is still vaguely visible. While with the 44th, its nickname was "Yankee Peddler". After serving with the 127th, the aircraft was transferred on January 11, 1980, to the 465th TFS at Tinker and from there on October 1 to the 466th TFS at Hill AFB, UT. By then, the aircraft clocks showed a total of 5,847 flying hours. When the 466th converted to F–16A/Bs, 361 was flown in early February 1984 to the Defense Construction Support Center in Columbus (OH). In July 2002, it was trucked on flatbed trailers to the American Airpower Museum on Long Island (NY) where it is still on static display. *(Clyde Gerdes)*

In its 14/11:20Z October 66 message, "Base Loading at Jet-Capable Airfields, Thailand", MACTHAI informed PAC about the current and planned aircraft bed-down on existing jet-capable airfields and those under construction in Thailand. As to aircraft assigned to the RTAF Flying School, MACTHAI provided the following numbers: eight T–37, five C–47, 37 T–6, and 17 Chipmunk aircraft (in addition, the Thai Army had six O–1 and one U–6A stationed at Korat). The message also stated that the Flying School would still be at Korat in FY68 with 12 A–37s, eight C–47s, and 32 T–6s, but without any aircraft in FY69, when the School was programmed to move to Kamphaeng Saen in Nakhon Pathom Province, approximately 100 kilometers from Bangkok. The Thailand Military Construction Program as of January 11, 1967, showed that for the move of the School, $M11.2 was available in FY66 as supplemental funds and an additional $M9.8 in FY69. Construction included a 150' x 9,000' runway, operational apron, and taxiway, all three to be completed in October 1967. ■

Acknowledgments
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THE SA–2 AND U–2: A POSTSCRIPT

John A. Schell
Joseph J. Matis &
Pranay Bhardwaj

SA–2 and U–2. (mil.ru)
(All illustrations courtesy of the author.)

The May 1st, 1960, shootdown of Francis Gary Powers in a U–2C over the Soviet Union was a milestone in Cold War history. Incomplete and misleading public information masks the reality of "the U–2 incident" to this day. The Soviet Air Defense Forces immediately classified all records and placed them in Ministry of Defense (MOD) archives. "The U–2 and SA–2: Secrets Revealed"[1] summarized how the Soviets shot down Powers and why they hid this information in their archives. "The SA–2 and U–2: The Rest of the Story"[2], described actions by four SA–2 batteries against the U–2 and the attempts by four Soviet interceptors to bring down the U–2. And how the shootdown became an air battle in the skies over Sverdlovsk.

Research recently led me to the exact location where Gary Powers landed. This helped refine the U–2 final legs and warhead detonation point. Pranay Bhardwaj[3] estimated the forces that pushed the U–2 onto a new heading. Joe Matis[4] estimated how the U–2 fell to earth in a spin and broke apart coming down. His analysis includes Power push out and landing. "The SA–2 and U–2: A Postscript" is my third paper after over four years of research. At the end I provide a final summary.

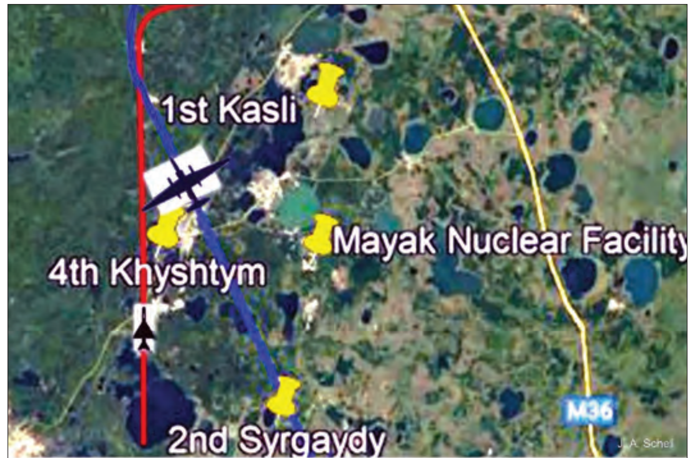
Operation Grand Slam

On May 1, 1960, Francis Gary Powers flew what was to become the 24th and final U–2 overflight of the Soviet Union. The route from Peshawar, Pakistan to Bodo Norway was 3300 nm and was planned for a maximum time of over 9 hours. At 410 kts cruise air speed, the groundspeed would be 400 kts plus or minus, depending on the winds aloft. To accommodate the long route, Powers' U–2 required adding wing fuel pods, each of which carried 115 gallons of fuel. Grand Slam was both the first end to end overflight and the first time that Soviet Air Defense Forces shot an SA–2 missile at a U–2. In 1960, the U–2 but had no threat warning receivers for missiles and air interceptors. Warning receivers would come in later years.[5]

The flight required imaging the ICBM test range at Tyuratam, the plutonium enrichment facility at Mayak, suspected ICBM factories near Sverdlovsk and Kirov, the ICBM operational site at Plesetsk, and submarines at Murmansk. CIA planners

Author's Note: The author wishes to gratefully ackowledge the assistance of Joseph J. Matis and Pranay Bhardwaj. The author's previous two articles on the subject are found in *Air Power History,* Vol. 68, No. 2, Summer 2021, pp. 33-42, and *Journal of the Air Force Historical Foundation*, Vol. 70, No. 2, Summer 2023, pp. 37-46.

Operation Grand Slam flight route.



Imaging Mayak

avoided routing the U–2 over known SAM sites.[6] As the U–2 approached Chelyabinsk, the autopilot malfunctioned. While normally a cause to abort, Powers chose to continue. He was more than 1,300 nm inside the USSR with clear weather ahead. From this point on, he used ADF reception from commercial radio stations for general location as he made visual updates and recorded manual course corrections.

Imaging Mayak

Proceeding past Chelyabinsk, the U–2 imaged the Mayak nuclear fuel facility and passed over three SA–2 sites escaping all three. The crews at Syrgaydy and Kasli were away for training thus leaving these sites unmanned. The U–2 then passed the site at Khyshtym whose radar transmitter suddenly malfunctioned, preventing a launch.[7]

Earlier, two unarmed Su–9 prototypes were sent aloft to conduct an airborne search. The mission was to climb in afterburner and ram the U–2. Yet to be armed prototypes, this was a suicide mission. Although aided by ground radar vectoring, the Su–9s could not locate the U–2. The lead Su–9 ran low on fuel and landed on an unpaved airfield. Command authorities ordered the second Su–9 out of afterburner to save fuel and return to Koltsovo airfield. After reducing the throttle, the Su–9 descended and passed about 6 km below the U–2. Pilots Mentyukov and Powers did not see each other as they passed. Command authorities then ordered Mentyukov to fly his Su–9 wide to the right as Powers continued to fly his U–2 northward. He unknowingly flew over three SA–2 sites and avoided two Su–9s. He now made a planned slight right turn onto a short leg toward the city of Sverdlovsk.[8]

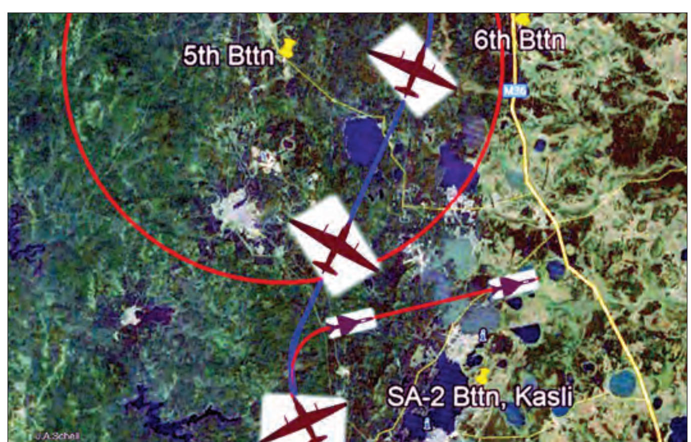
John Schell graduated with an MSEE in April 1970 from Penn State University and a reserve commission in the USAF. He was initially assigned as a radar research engineer at the Air Force Avionics Lab, at WPAFB, Oh. In 1976, he was selected as the Air Force lead radar engineer for the SR–71/U–2. This resulted in the ASARS-1 and ASARS-2 imaging radar prototypes for the SR–71 and U–2R. John also served as the Chief Avionics Engineer for both aircraft. He now volunteers at the National Museum of the USAF where he is a docent. John is a Cold War historian who has authored multiple papers and presentations on the U–2 and SR–71.

Between the 5th and 6th SA–2 Battalions

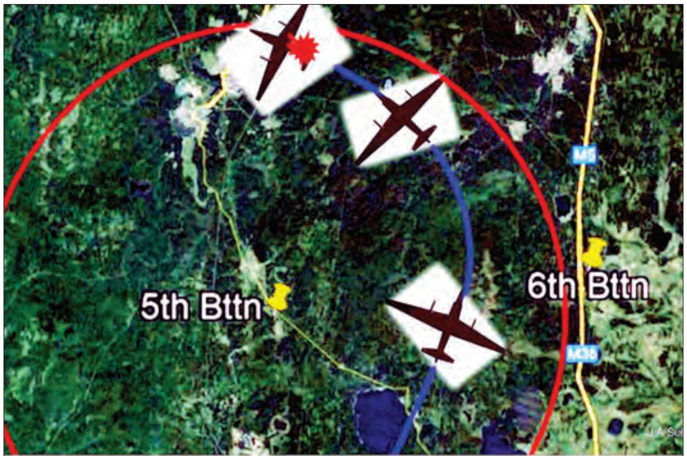
The U–2 entered the kill zones of the 5th and 6th SA–2 Battalions, flying a short leg about midway between them. The 6th suddenly had a transmitter failure, making it inoperable.[9]

Lt Col I. I. Novikov watching in the command van of the 5th battalion, noted that radar coordinates passed from Brigade HQ did not match those from his own acquisition radar. (Note: Brigade had relayed its radar by HF radio which introduced a time delay and a small range shift) And Novikov's IFF detected two targets. Which was the U–2 and which was the Su–9? (Note: Ground crews had not updated the Su–9 transponder with the new code for May.[10]) HQ ordered Lt Col Novikov to fire, but he delayed, trying to resolve the coordinate offset and target ambiguity. HQ then ordered the Su–9 to fly further east, to increase its separation from the U–2, followed by the command to "fire at the target coming directly toward you."[11]

As Novikov struggles, Koltsovo airfield launched two MiG–19s to replace the two Su–9's. The MiGs had guns. Unaware that the U–2 was just to the south, they headed to the north and then west to search. Powers flew north-



U-2 Enters Kill Zone of 5th Battalion



SA-2 Warhead Detonates

ward past the 5th Battalion. He then began a 90-degree left turn onto his next leg toward Kirov. The new leg would take him past the southwestern edge of Sverdlovsk.[12]

The Final Turn

As the U–2 turned, Novikov resolved the two issues and commanded "fire two rockets." After a delay due to launch operator error, the first missile was fired at 0846. The second missile failed to launch.

Completing the turn, Gary Powers had no indication a missile was now heading toward him. Novikov gave the warhead arming command and, a few seconds later, at about 0847, the warhead detonated as the U–2 was about to leave the kill zone. 5th Bttn radar operators saw a loss of track in all three-axis. And outside observers saw a white cloud form in the distance against a clear blue sky.[13]

The 136 Kg warhead detonated at the five o'clock position, below the U–2 center of gravity (CG). The blast force pushed on the rear fuselage, starting a clockwise turn. This combined with the pitting force of the explosion itself, rapidly turned the U–2 from a northwesterly heading of 292 to a northeasterly heading of 61 degrees. The blast immediately tore off the right rear stabilizer and the tail section a few seconds later.[14] Powers had no pitch or rudder control. Warhead fragments had damaged the right wing causing a roll to the right. The fragments tore open the right-wing fuel pod igniting the remaining fuel, causing the intense orange glow that Powers saw from the cockpit. The damaged wing lowered, and the U–2 lost speed. With a loss of airspeed, the U–2 nosed downward into a stall and subsequent oscillations. Violent secondary stalls resulted in inversion into an unrecoverable spin. Powers did not have his seat belt or shoulder harness tightened, and the turbulence flings him far forward in the cockpit, upside down. He was no longer a pilot but a passenger in an uncontrolled aircraft.

The 2nd SA–2 Battalion Fires

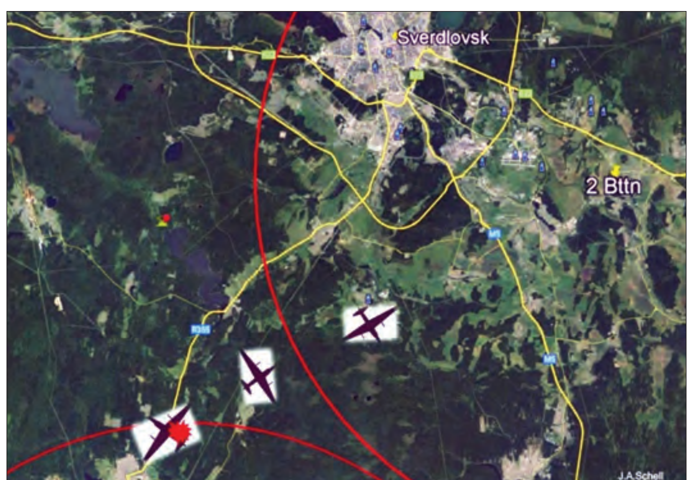
The spinning U–2 crossed into the kill zone of the 2nd Bttn commanded by Maj M. Voronov. It was immediately tracked by radar. Voronov fired an SA–2 almost immediately, but the missile quickly lost its guidance when the debris from the U–2 and initial detonation masked the radar signal. Voronov's missile flew past and above the falling U–2. About a minute after launch, it self-detonated. The white puffs it made in the sky were visible by observers at Sverdlovsk and the 5th Bttn. Unlike Lt Col Novikov, Maj Voronov was never able to confirm warhead arming or report a kill from his missile. When he stepped outside his command van, he saw Powers parachuting to earth.[15]

Analysis of the Fall[16]

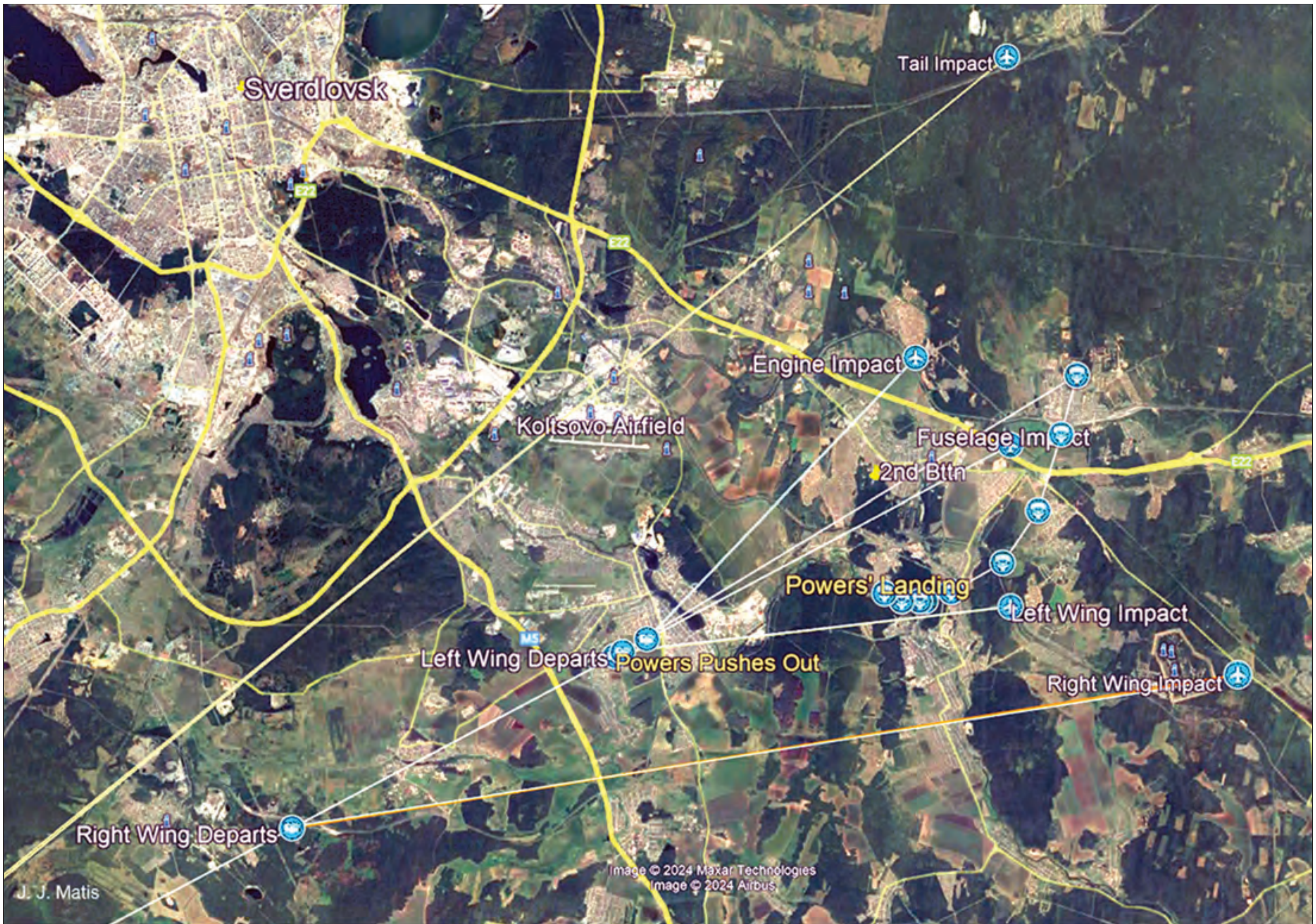
The spin allowed the U–2 to accelerate with gravity pulling it toward the ground at the rate of 9.8 meters per second per second (9.8m/s/s) until the remaining hulk reached terminal velocity. As it approached 43,000 feet, the damaged right wing departed the aircraft at a point approximately five feet from where the wing met the fuselage. This area received considerable damage from the blast and failed before the wing to fuselage juncture. Separation occurred at 56°38'04" N latitude, and 060°38'58" E longitude. This increased the stress loads on the remaining aircraft (and on Powers) making it difficult for him to "push out" of the aircraft.

Powers pushed out at 28,000 ft, 56°40'57" N, 060°48'45" E. The left wing departed the fuselage about one second later at 56°41'01" N, 060°48'59" E. He fell with a lower terminal velocity and momentum than the U–2, thus taking more time. Powers continued free fall until he reached 18,000 feet above mean sea level (56°45'37" N, 61°02'46" E) where his parachute automatically opened slowing his descent to approximately 800 feet per minute. While U–2 components continued moving forward from their momentum, Powers was now under canopy and subject to the winds of that day. We used Soviet radiosonde data taken on May 1st a few miles away. From that, we know after the parachute opened, the variation in wind speed and direction resulted in his travel back to the south-east.

Powers floated under parachute canopy; the wings began slowing from their initial ground speed of 400 knots to less than 100 knots while descending at a terminal velocity of less than 200fps. Once the left wing departed, the



U-2 Spins into Kill Zone of 2nd Battalion



The Fall and Break Up

spin rotation increased. This increase in speed and change in the center of gravity finally broke the already damaged engine mounts and the centripetal forces thrust the engine away from the fuselage. All aircraft components apart from the aft fuselage hit the ground in an area within a 4.5-mile radius of the debris field center with the fuselage finally resting at 56°44'27" N, 61°00'45" E approximately 26 nautical miles from warhead detonation at 56°32'03"N, 60°18'45"E. Since the aft fuselage departed long before the rest of the aircraft broke apart, it fell in a different location approximately nine miles from the debris field center created by the other components landing at 56°50'55"N, 61°00'40"E. On the other hand, Powers slowly descended and was subject to the surface winds which happened to push him in a direction that led toward the debris field created by the aircraft parts. It would be another 19 minutes until he landed by parachute, well after all the U–2 pieces had fallen. The next day, the Soviet Air Defense investigation team reported where the U–2 parts were found.

Tools Used to Analyze the Fall[17]

While the above explains what Powers and the U–2 experienced after warhead detonation, it does not establish plausibility. Nominally, that requires an aerodynamicist, a supercomputer, and validated U–2 modeling and simulation software. The team did not have access to these resources. Instead, we used Microsoft Excel, Soviet radiosonde data[18], reports on where U–2 parts landed[19], reports on where Powers landed[20], U–2 flight manual ((AFC)-1-1), and Google Earth Pro to "simulate" the effects of the blast and subsequent fall of Powers.

The team used the aircraft flight manual to determine the approximate size and weight of each component, then substituted these values into the online calculators to determine mass and cross-sectional area. They then entered these results into the online terminal velocity calculator to obtain each component's terminal velocity. Using this value, they either accelerated or decelerated the component until it reached the new terminal velocity. At that point, the spreadsheet continued processing at the given fall rate.

To account for Powers performing a bailout, the team used transcripts from Powers' debriefing[21] to determine the approximate altitude at which he pushed free of the stricken U–2. Powers indicated that he saw the altimeter passing through 34,000 feet as he departed. However, using information from the flight manual, this value is not accurate. The U–2 was in freezing conditions that would have obstructed or partially obstructed the altimeters pitot-static system. Additionally, when flying at altitudes above FL180 (aviators flying at altitudes above 18,000 feet

Mean Sea Level [MSL]) adjust the altimeter's barometric pressure to 29.92 inches of mercury regardless of the region's actual barometric pressure. This too will produce a slight inaccuracy in the altimeter's reading. When adjusting for these slight inaccuracies, the spreadsheet estimates that Powers pushed out just under 29,000 feet MSL.

The spreadsheet allows for Powers to freefall until automated parachute deployment occurs. According to the flight manual this occurs at 14,000 feet. However, that barometer used for parachute deployment can also suffer from inaccuracies, so the spreadsheet conducts multiple scenarios that show various conditions with the chute opening occurring anywhere from 18,000 feet MSL to 14,000 feet MSL. In all instances, the freefall coupled with time under canopy resulted in Powers landing in the same area as described in the section "Powers Lands."

The team used radiosonde data showing wind direction and speed at different altitudes to adjust for the effects of wind on Powers' descent in a parachute. It assumes that Powers did not have steering control of the chute and simply descended with the fall changing direction according to the wind effects on the parachute. Under canopy, Powers descended in a "J-shaped" descent until landing.

We used on-line calculators to provide the latitude and longitude of component separation locations and landing coordinates. We used Google Earth Pro to provide the actual altitude above mean sea level for each landing location. Together, this data validates the plausibility of location of the warhead detonation. With an initial forward momentum of 400KAS, the blast effect of the 130 kilogram fragmentation warhead, and the extremely thin atmosphere at 70,000 feet, the aircraft fuselage would rotate and spin at a high-speed traveling ENE (the blast effect would change the direction of travel by nearly 130 degrees because of where the blast occurred). It would take approximately 172 seconds to reach a location twenty-six nautical ground track miles from the blast while falling ~70,000.

The RH wing departed 83 seconds into the fall which increased the fuselage's terminal velocity until the LH wing departed almost immediately by the engine departing the fuselage (124 and 127 seconds into the fall respectively). Immediately after departure at 56°38'04" N latitude and 060°38'58" E longitude, the right wing began slowing until it reached its new terminal velocity. During this time, the forward momentum slowed because the wing presented a much larger surface area to the denser air below 33,000 feet thus acting as a large drag producing device. Since we used average speeds over time, the graph does not illustrate a declining momentum rate; rather, we used the average rate over time to show how the wing ended at the specific recovery latitude and longitude of 56°40'37" N, 61°07'39" E. The left wing separated from the fuselage at 56°41'01"N latitude, 60°48'59"E longitude while landing at 56°41'46"N latitude, 61°00'45"E longitude.

Estimated Landing of Gary Powers

While the calculations for all aircraft components were relatively simple; determinations of the distance travelled from point of component departure to ground impact, determining Powers fall requires a more complex solution. Powers was essentially another "aircraft component" travelling as part of the fuselage, this all changes once he pushes out of the aircraft at ~29,000 feet which would occur 123 seconds into the descent. As the aircraft slowly rolled to the right, Powers pushed out of the aircraft but would immediately start to slow to a new terminal velocity of ~177 fps as determined by using the Terminal Velocity Calculator on the Giga calculator website (https://www.gigacalculator.com/calculators/terminal-velocity-calculator.php).

Powers would free fall for ~54 seconds while falling from ~29,000 feet to ~18,000 feet where the barometric release would deploy Powers' parachute. Free fall started at 56°40'57" N latitude, 060°48'45" E longitude and ended when the chute opened at 56°45'37" N latitude, 61°02'46" E longitude. At this point, Powers would slow to eight hundred feet per minute (fpm) – quite slower than the 177fps that he fell during freefall. While under canopy, Powers' track across the ground would follow the flow of the wind that shifted at various altitudes as shown in the radiosonde report.[20]

Powers Lands

After pushout, Powers reached the ground in 24.5 minutes. This factors in the effect of variable winds. He landed in an area close to the Iset River at 56° 41 58 N, 060° 57 03 E, at the edge of the village of Povarnya. This was cited in a Russian news article and confirmed by Andrey Guselnikov, a local Russian.[21]

The village, the lake, the river, and power line were what Powers saw when landing by parachute. As he landed Powers was drifting left toward a lake (now a dry lakebed) and right towards woods.

He landed near a power line next to the Iset river. Locals immediately picked him up by private auto and transported him to a collective farm HQ and eventually to Sverdlovsk where the KGB took him into custody. From there, Gary Powers was flown to Moscow for a highly public trial.

Event	Time from Detonation	Coordinates
5th Bttn SA-2 Detonation	0 Sec	56°32'3.14"N, 60°18'45.75"E
Tail Section Departs	2 Sec	56°32'12.00"N, 60°19'15.00"E
Right Wing Departs	83 Sec	56°38'4.00"N, 60°38'58.00"E
2nd Bttn Fires SA-2	120 Sec	56°43'48.23"N, 60°56'33.10"E
Powers Pushes Out	123 Sec	56°40'57.00"N, 60°48'45.00"E
Left Wing Departs	124 Sec	56°41'1.00"N, 60°48'59.00"E
Engine Departs	128 Sec	56°41'14.00"N, 60°49'43.00"E
Engine Impact	172 Sec	56°45'54.84"N, 60°57'52.66"E
SA-2 Self-Destructs	180 Sec	56°36'8.01"N, 60°31'0.52"E
Fuselage Impact	182 Sec	56°44'27.29"N, 61°0'45.25"E
Left Wing Impact	283 Sec	56°69'61.88"N, 61°01'25.22"E
Tail Section Impact	330 Sec	56°50'55.72"N, 61°0'40.40"E
Right Wing Impact	330 Sec	56°40'37.46"N, 61°7'39.10"E
Powers Lands	1359 Sec	56°41'59.68"N, 60°56'55.71"E

Timeline of Events

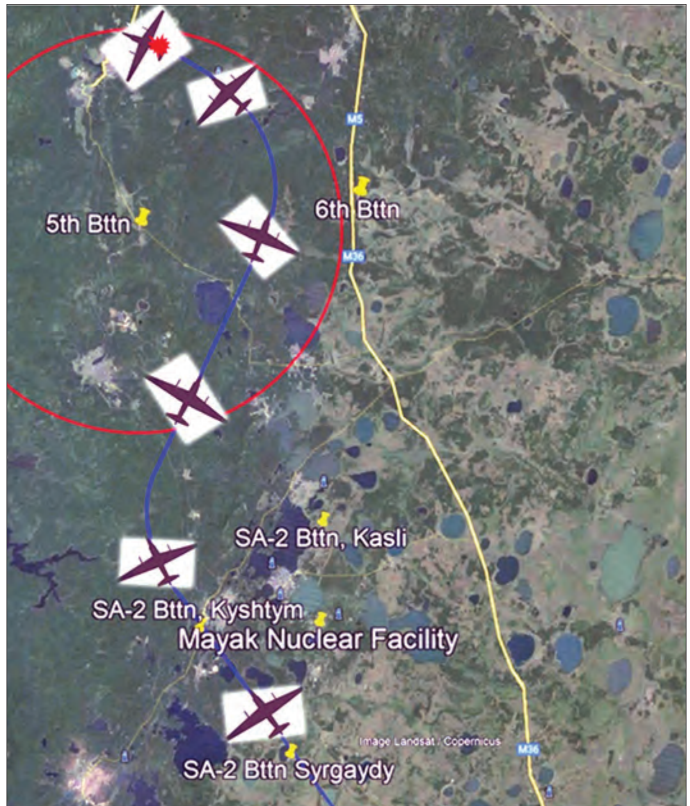
Timeline of Events

It is instructive to examine how events occurred after warhead detonation. Immediately after the SA–2 detonation, the right stabilizer and right wing fuel pod departed the U–2 and have never been found. The blast weakened the four connections holding the entire tail section aft of the cockpit. That section broke off two seconds after detonation. Forty seconds later, as the aircraft rolled right, Powers was able to free himself and push downward free of the U–2 a second or so before the left wing departed. This created the circumstances that allowed the already weakened engine mount to break free releasing the engine from the fuselage where it impacted the ground just 35 seconds later. While most aircraft parts reached the ground in under six minutes, Powers continued to fall for another 19 minutes as his parachute slowed his fall and the winds carried him to where he landed close to the left wing in the heart of the debris field created by the aircraft components. Powers reported what looked like a wing fluttering down nearby as he descended under parachute.

U–2 Final Legs

The Soviet Air Defense investigation report stated that the warhead struck the U–2 from behind, but "the target was beyond the kill zone." (Note: The Air Defense Forces had not updated their database. The new Desna 13D missile had an increased maximum range, resulting in extension of the kill zone from 28 km to 32 km ground radius.[22]) The U–2 was shot down just inside the new kill zone. Col (Ret) Mikhail Khodarenok, a Soviet engineer who held several anti-aircraft assignments, recently observed; "only the 5th Bttn could have hit the U–2 from behind and from below."[23]

Based on the recent Russian papers, Gary Powers recollections and his CIA debriefing,[24] the final turn began about 34nm SSE of Sverdlovsk. It took about two minutes to complete the turn, which ended at about 22 nm SSE of the city. Detonation occurred about 21 nm SSW of



U-2 Final Legs

Sverdlovsk at 0847. Detonation occurred as the U–2 was about to fly northwest to Kirov, taking about 50 minutes to fly 330 nm. With factories to build ICBMs it would surely have a concentration of SA–2 sites awaiting.

Another Six Missiles Are Fired

To the north of where Powers was shot down is the SA–2 site at Monettny. Maj Sheludko commanded the 1st Bttn at Monettny, and his radar showed an approaching unidentified airplane at 9km altitude entering the southern edge of his kill zone. He had not received the shootdown reports from the 5th or 2nd Battalions. After conferring with his Brigade, Sheludko fired three missiles at what he thought was the U–2, now flying at low altitude. But it was not the U–2. It was the Su–9, as it returned to land at Koltsovo airfield. The Su–9 pilot, Capt Mentyukov, sees the clouds of dust as the missiles were fired. He immediately flew below 3km altitude, too low for the radar to track. Without radar guidance, all three missiles flew above and beyond the Su–9 and self-detonated.

To the west, the 4th SA–2 Bttn at Reshety was also scanning the skies for the U–2. Commander Maj Shugayev, its Commander detected two incoming airplanes from the southwest, one followed by another at low altitude. Neither responded to the IFF interrogator. Sergei Khrushchev (son of Nikita Khrushchev) later explained[25] the MiG forgot to set the IFF transponder to the new code for May, so they looked like a hostile aircraft or target. Battalion HQ had received the 5th Bttn (Novikov) report, but disregarded it, because it was suspected to be outside the kill zone. The 2nd

Additional Six Missiles Fired

Bttn (Voronov) had not sent their report. Air Defense Forces presumed that the U–2 was still flying when, in fact, all parts of the U–2 had hit ground over 30 minutes earlier!

Gen Solodovnikov, the senior officer for missiles at HQ, took the call from Maj Shugayev and snapped "none of our planes are in the air!"[26] He gave Shugayev permission to fire. One floor down at HQ, the senior officer for air interceptors knew that two MiG–19s were currently in the air. But there was no communication between the air interceptor and the missile staff.

Indeed, two MiG–19s were returning to land at Koltsovo airfield. Shugayev commanded "fire three missiles." Two missed and self-detonated. The third detonated near the trailing MiG–19, which fell near a small village,

0740 - First Su-9 departs Koltsovo airfield

0810 - Second Su-9 departs Koltsovo

0836 - U-2 images Mayak nuclear facility

0839 - Su-9 passes under U-2

0841- U-2 enters kill zone of 5th Bttn from South

0843 -Two MiG 19's depart Koltsovo to search

0844 - U-2 begins final turn

0846 - 5th Bttn launches SA-2

0847 - Warhead detonates under U-2

0848 - SA-2 launched by 2nd Bttn

0848 - Powers pushes out of U-2

0849 – 2nd Bttn SA-2 self-detonates

0850 – U-2 fuselage hits the ground

0855 -Three SA-2 launched by 1st Bttn at Su-9

0856 - All three self-detonate, missing the landing Su-9

0910 - Powers lands by parachute

0922 - 4th Bttn launches three missiles at two MiG-19

0923- SA-2 detonates near one MiG, shooting down 1 Lt Safronov

The Complete Chain of Events

Degtyarsk, where a workers day parade was underway. Onlookers saw the plane fall and rushed out into a nearby field. They found a dead pilot in a parachute. It was Soviet 1st Lt Sergei Safronov.

Summary

At over 9 hours, Grand Slam was the longest and the only one-way U–2 overflight of the Soviet Union. It was a very risky mission justified by the intelligence value to the CIA as the Soviets had just activated new missile battalions around the city of Sverdlovsk and implemented the latest SA–2, the Desna 13D, which had a longer range extending its kill zone another 4 km to 32 km ground radius from launch.

It was the SA–2 concentration around Sverdlovsk where Powers ran into trouble. He was initially lucky. Two SA–2 battalions were gone for training and the one battalion still staffed had a hardware failure allowing Powers to fly over those three SA–2 sites. Finally, he approached the 5th Battalion which used its radar to track the U–2 and guide the missile to an intercept. Because of launch delays the intercept occurred as the U–2 was about to leave the kill zone. This fact became problematic in reporting and confirming the kill. Lack of training and operational procedures led the Soviets to believe an SA–2 could only intercept an approaching target. Since the U–2 was departing, command authorities did not believe the report and continued the hunt for the U–2. This led to more missiles fired at what they thought was the U–2. However, they were Soviet interceptors returning to land. They shot one of their MiG–19, killing 1st Lt Sergei Safronov. The tally: four SA–2 sites engaged, four interceptor aircraft engaged, eight SA–2 launched, one dead Soviet pilot and one incredibly lucky American pilot alive.

Gary Powers luck continued. The warhead detonated to the rear and under the fuselage which prevented shrapnel from entering the cockpit. Although Powers was able to level the wings, rapid undulations in airspeed caused the U–2 to invert in a clockwise flat spin. From the spin, Powers had no control of the U–2, and his sole objective was to push out and use his parachute to land.

Timing was critical. If he had remained in the cockpit when the U–2 broke up, he would have crashed with the fuselage. From the analysis we have a good idea of the times. The damaged right wing separated early, 83 sec after detonation. The next series of events was most critical. The 2nd Bttn fires an SA–2 at 120 sec, but the debris from the detonation and right-wing mask missile guidance. Unguided it flies above and past the U–2. At 123 sec Powers pushes out and free falls until his parachute opens. If he had delayed a few more seconds, the engine would have separated, the spin rate of the fuselage would have dramatically increased. and Powers may not have been able to push out.

Under parachute, the variable winds blew Powers back and forth. As he came to land three dangers awaited: a lake on his left, woods on his right, and a power line ahead. He was able to miss the lake and the woods and landed by a river (the Iset) near the power line. Luck was with him for the final time.

Grand Slam was a risky mission. Prolonged exposure to early warning, acquisition, and tracking radars posed risks. There were no warning receivers for such radars on the U–2 with the new SA–2 sites around Sverdlovsk, increasing the risk.

The lack of crew training, operations procedures, equipment reliability, and staff coordination led to delays and errors. These directly contributed to the added launches and the death of the MiG–19 pilot.

There was great confusion at the district HQ of the Air Defense Forces in Sverdlovsk, resulting in inability to report timely and accurate information to Moscow HQ. This resulted in Premier Khrushchev receiving a verbal report from Air Marshall Biryuzov that was incorrect. Biryuzov reported that an SA–2 from the 2nd battalion fired eastward had brought down the U–2. During the subsequent investigation it became obvious that this report was highly incorrect. Therefore, investigators from the Air Defense Forces classified and hid all shootdown records in the military archives. They also swore all participants to secrecy. They even destroyed the spent missile casings by taking them to a pipe plant and melting them down. Such evidence would reveal the direction of fire and how many missiles the battalions fired. Social media today still states that the SA–2 fired by Maj Mikhail Voronov's 2nd Battalion shot down Powers. And there are even rumors that Powers landed the U–2. It was not until 2006 when Col (Ret) Boris Samoilov opened the archives and declassified the records did the truth come out. He published two papers in 2012 using data from the records. Col Samoilov was both a participant in shoot down and a radar engineer.

Using his material as a base, I have researched the shootdown for over four years. During that time, I have published two papers. However, the exact location of where Powers parachuted down and how the U–2 broke apart has eluded me until recently. In January 2024, I discovered an article which described the general landing area. I estimated the specific location and had it confirmed by a local Russian, Andrey Guselikov. Pranay Bhardwaj and Joe Matis recently updated their analysis. This is the final of three papers on the SA–2 and U–2. *The Journal of the Air Force Historical Foundation* has published all of them. ■

NOTES

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2. John A. Schell, *The SA–2 and U–2; The Rest of the Story,* Journal of the Air Force Historical Foundation, Summer 2023, pp 31-40.'
3. Pranay Bardwaj is an electrical engineer working in the PCB manufacturing industry in Southern Ohio. He graduated from the University of Cincinnati in 2019. He is enthusiastic about aviation, defense, and weapon systems and would eventually like to work in the U.S. defense industry. Pranay currently volunteers at the National Museum of the United States Air Force in Ohio. https://drive.google.com/drive/folders/124iWFy0r2Hbr1ZEXOA4P0Gm23fLk5PBC?usp=sharing
4. Joseph J. Matis, served in the United States Air Force from 1970 to 1991, working as an Aircraft Crew Chief on F-106 and F-4 aircraft and retiring as a Senior Master Sergeant. After his military service, he transitioned to the private sector before returning to public service as a defense contractor and later a Federal Civil Service program manager, where he led the successful development of the Air Force's first cloud-based business system. Joe holds a BS in Business Information Systems, a master's degree in military Operational Art and Science, along with a master's certificate in Information Systems Architecture. In retirement, he assists the National Museum of the U.S Joe. Air Force in various capacities and volunteers at the Carillon Historical Park in Dayton, Ohio, sharing his knowledge of aviation and technology. https://drive.google.com/drive/folders/124iWFy0r2Hbr1ZEXOA4P0Gm23fLk5PBC?usp=sharing
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A Question of Vulnerability

David K. Stumpf

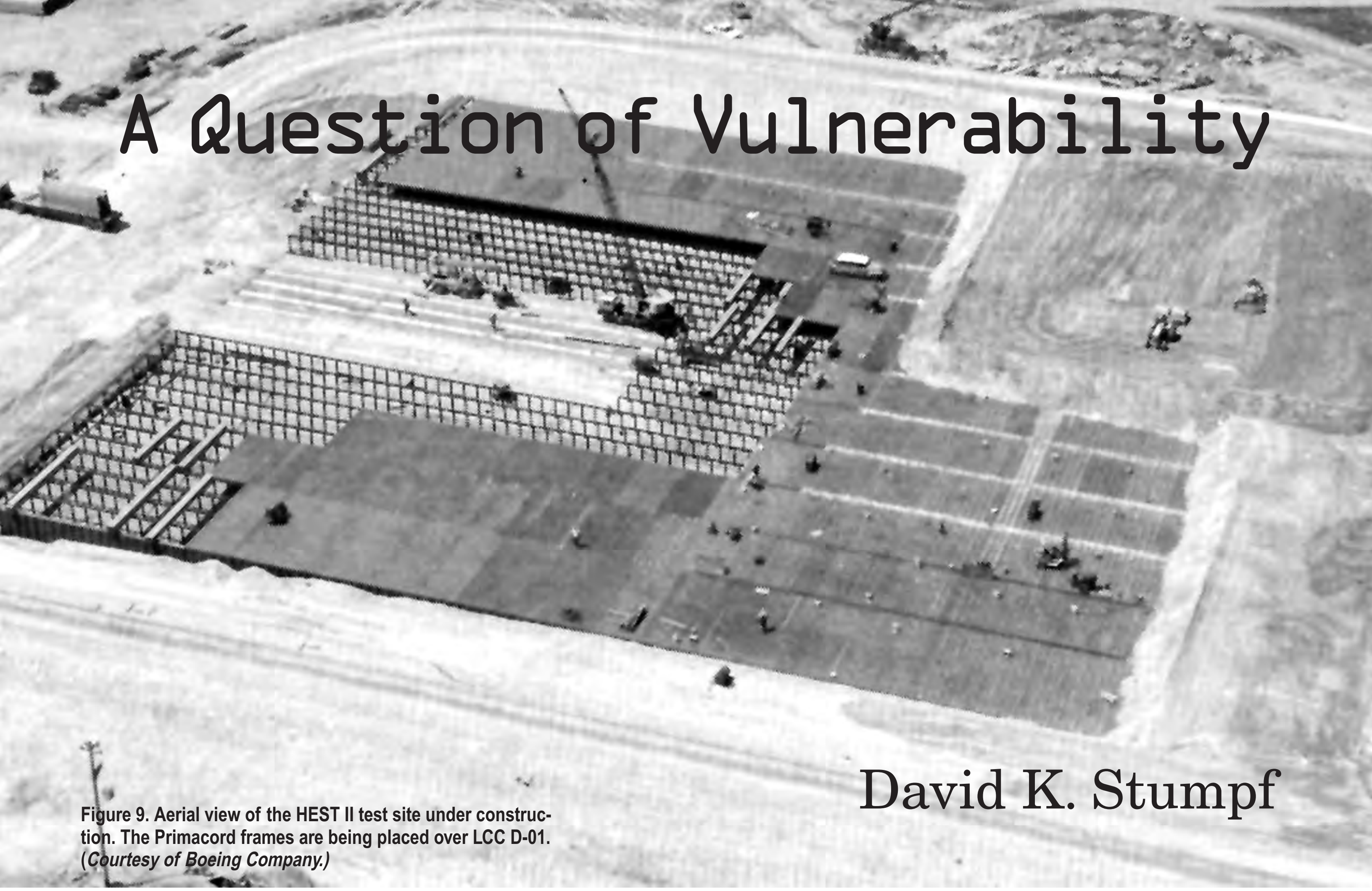

Figure 9. Aerial view of the HEST II test site under construction. The Primacord frames are being placed over LCC D-01. (*Courtesy of Boeing Company.)*

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]

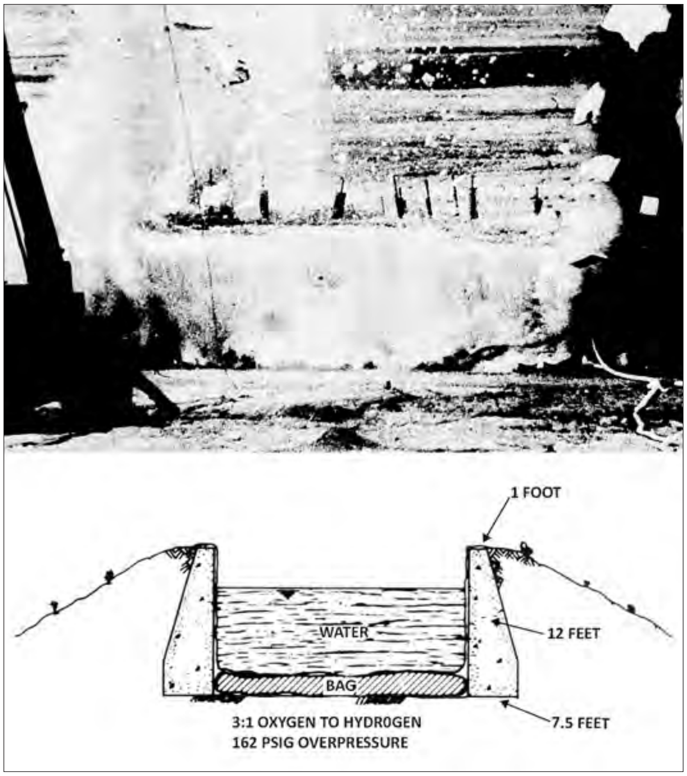

Figure 1. HEST Phase I Primacord Experiment, August 1964. Upper: Primacord with water overburden explosion; Lower: Design of the test bed. ***(Unless otherwise noted, photo credit is the United States Air Force.)***

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

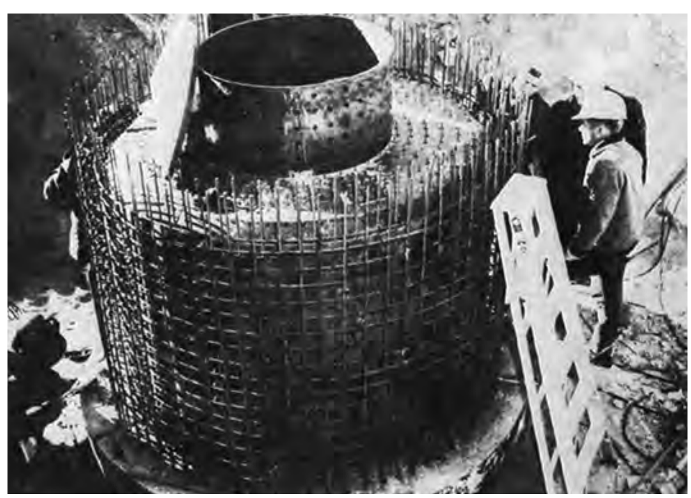

Figure 2. One-fourth scale model of a Minuteman launch facility used in the HEST Phase II experiment.

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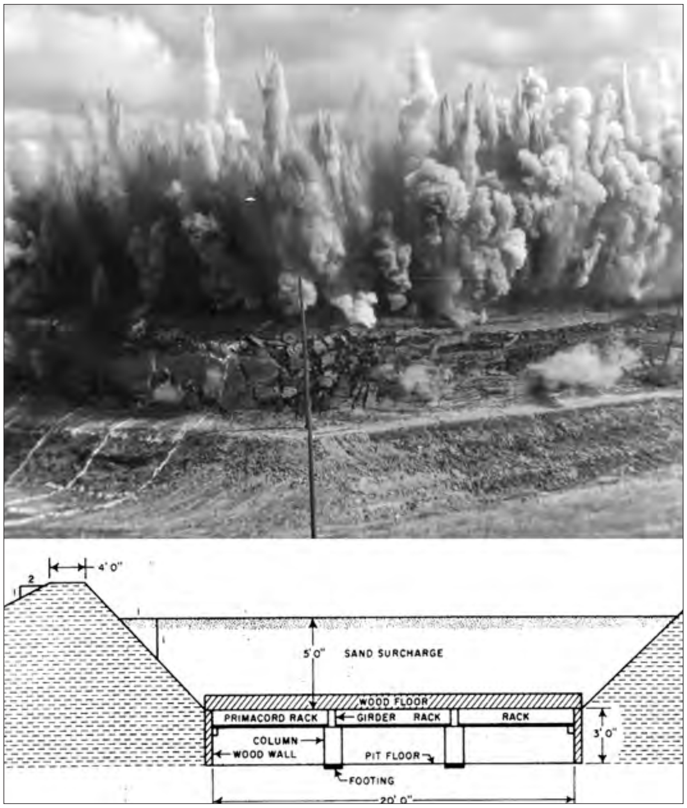


Figure 3. HEST Phase II. Upper: Seconds after detonation on December 15, 1964. This was the first large HEST structure test, 151 x 97 feet. Lower: Test bed details.

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

Figure 5. Minuteman IA Launch Facility.

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.

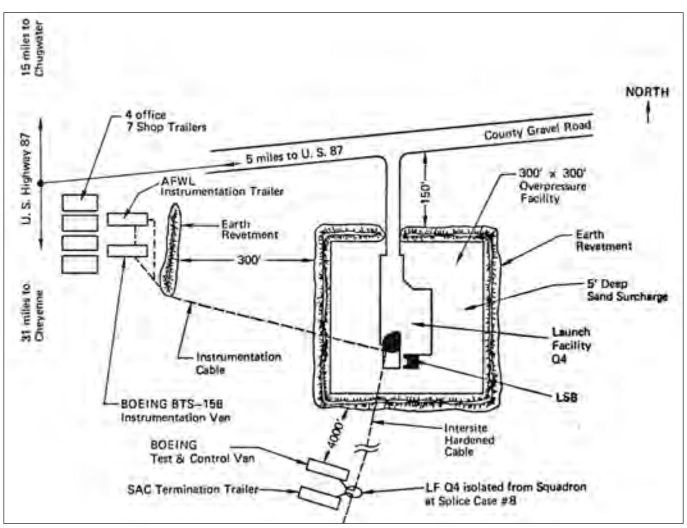


Figure 4. Layout of the QH-1 (HEST I) test facility at LF Q-04, 90th Strategic Missile Wing, F. E. Warren AFB. *(Courtesy of Boeing Company.)*

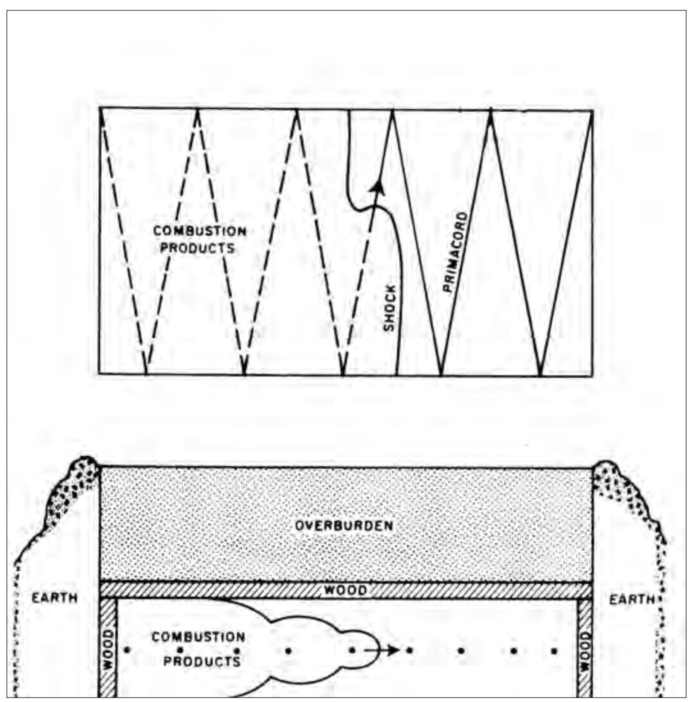


Figure 6. HEST-I. Upper: The Primacord had to be laid at a specific angle, 8.6 degrees, to achieve the wavefront needed for the experiment. Lower: propagation of the combustion gases took place in the air gap. This illustration does not show the movement of the overburden.

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

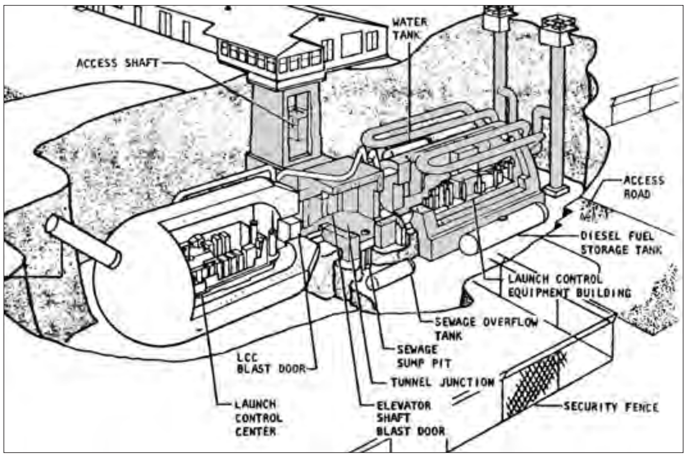


Figure 8. Typical 90 SMW Launch Control Facility. All the aboveground structures had to be dismantled. The structures highlighted with gray indicate what needed to be repaired after the test.

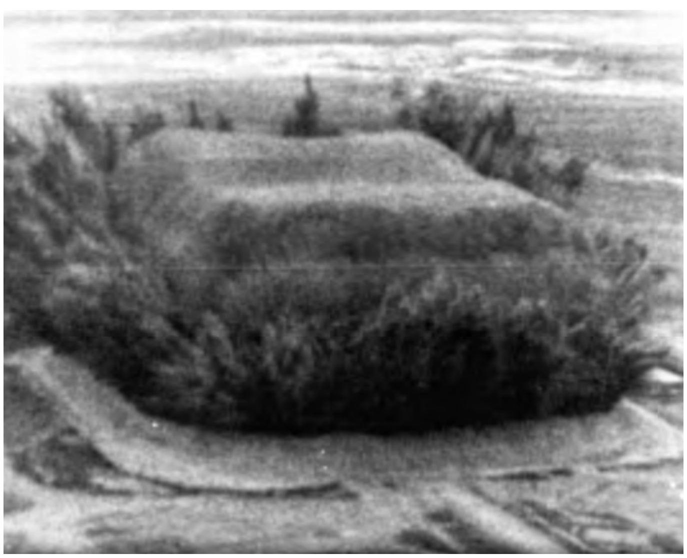


Figure 11. HEST II shortly after detonation. The overburden could be lifted as high as 180 feet depending on the amount of Primacord used. One complication was the need to remove all the overburden from the surface to investigate the damage, if any, to the test structures. *(Courtesy of Boeing Company.)*

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.)*

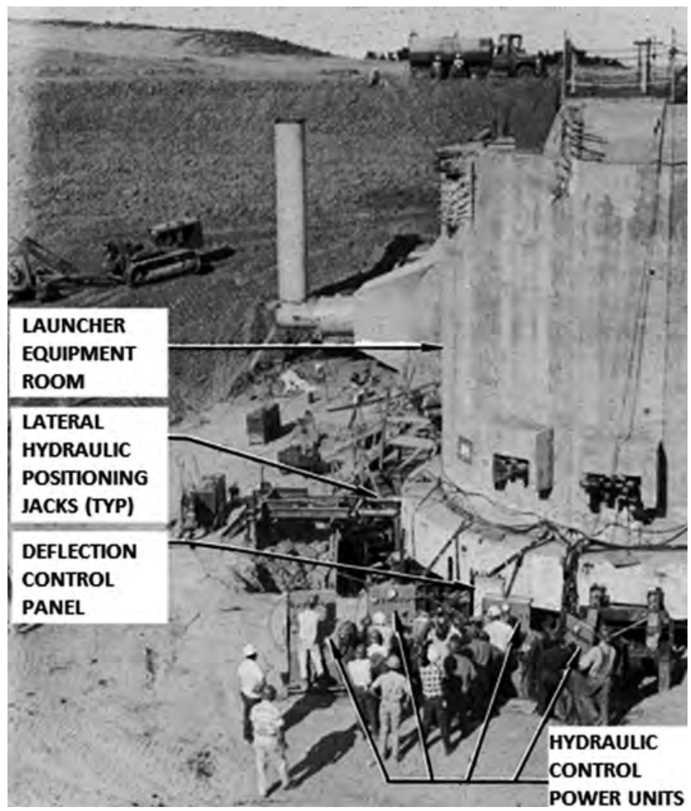


Figure 12. During construction at Grand Forks AFB two of the launcher equipment rooms settled beyond specifications. The structures were excavated and repositioned using massive hydraulic jacks. A similar technique was used to repair LF-28. *(Courtesy of Boeing Company.)*

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-

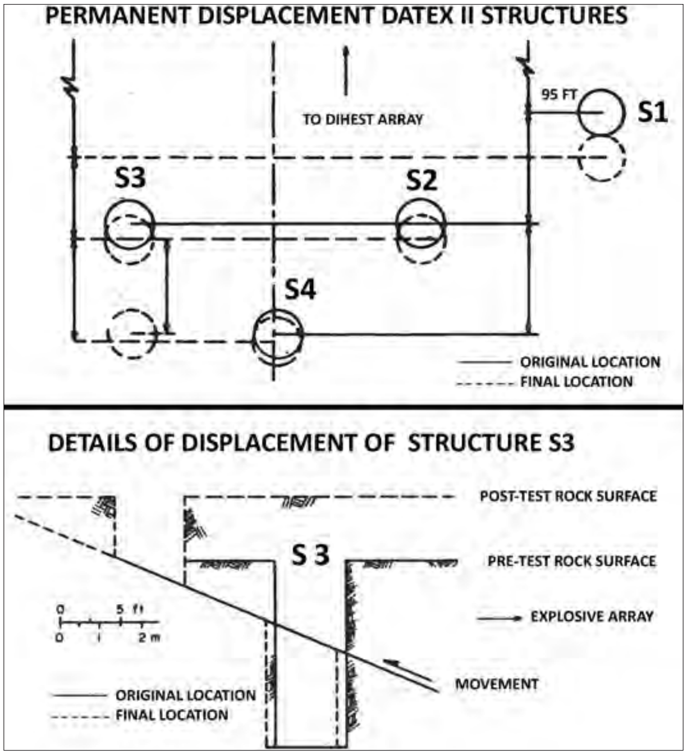


Figure 14. DATEX II. Upper: Plan view showing displacement of the four test structures. Structure S4, within 20 feet of Structures S2 and S3, was only slightly damaged. Lower: elevation view of the displacement for S3.

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×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

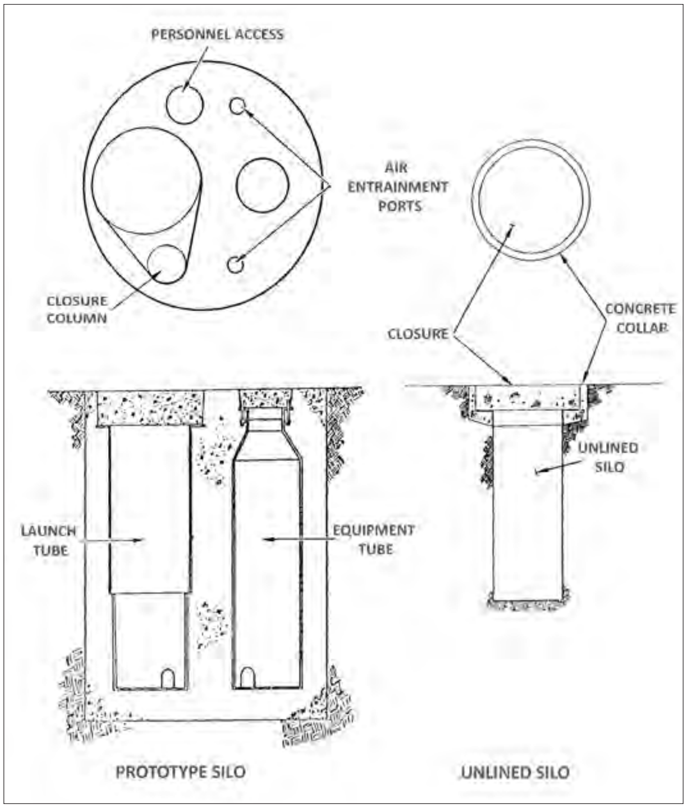
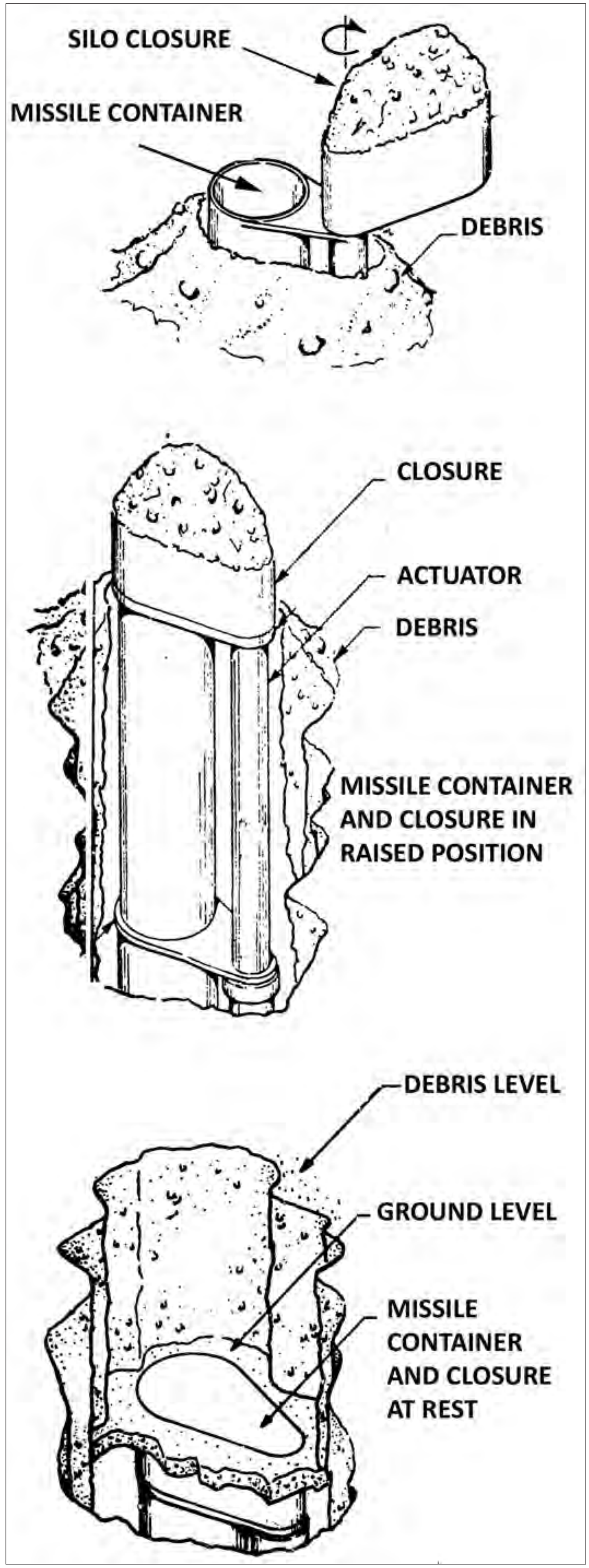


Figure 18 (Above). Side view of an early conceptual design of a HRS configuration. Note that the closure door is flush to the ground plane and there does not appear to be any consideration for debris capture. Minimum thickness of exterior walls of the prototype silo, S01, was 4 feet.

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]

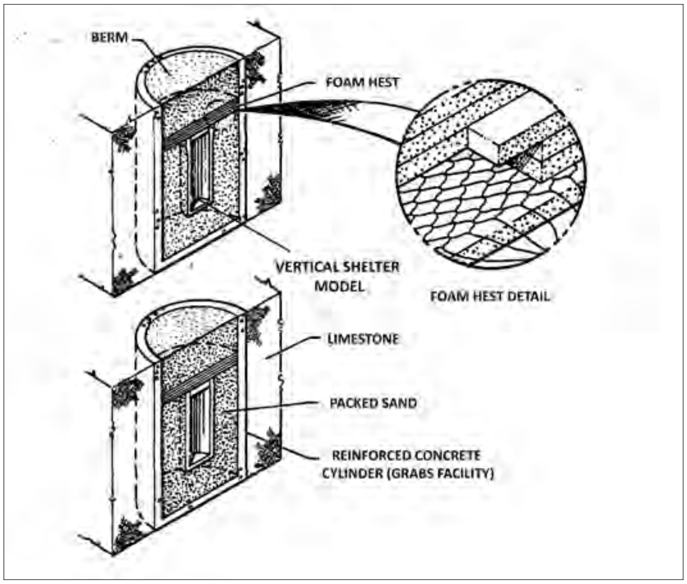


Figure 20. GRABS On Vertical Shelter (GOVS) program evaluated the response of vertical shelter models to vertical airblast and airblast-induced surface-blast loadings.

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]

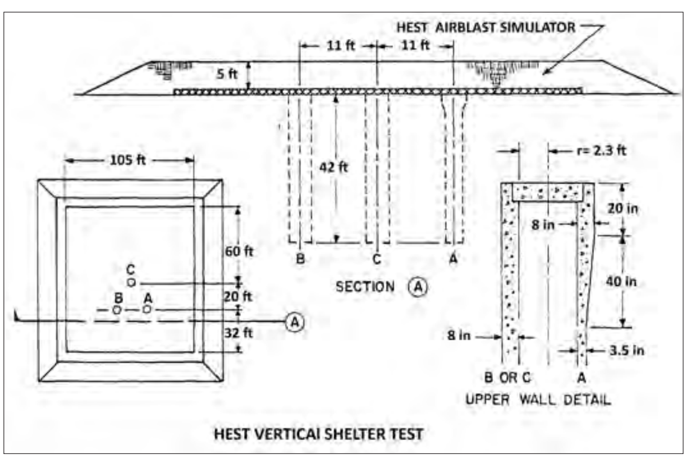


Figure 21. Phase III Vertical Shelter Test (HEST) 1/3 Scale. Three similar models were tested, two designed to respond without significant damage (B and C) and one (A) designed to have major longitudinal compression damage in the launch tube wall. The test was extremely successful and proved not only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

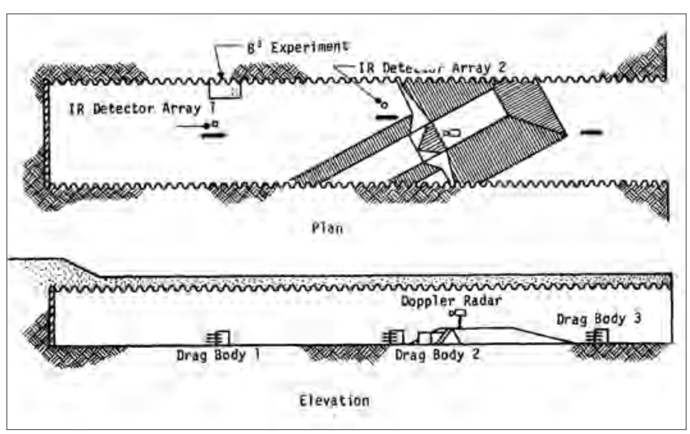


Figure 22. DABS Phase II S3 Event Test Layout.

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

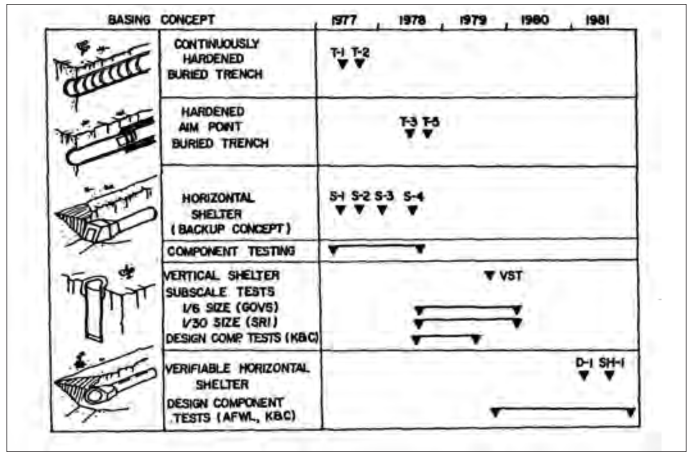


Figure 23. Basing Concept and Test Chronology.

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. ■

NOTES

1. A National Intelligence Estimate, 11-8-65, Foreign Relations of the United States, 1964-1968, Volume X, National Security Policy, Document 97, 1. In late 1950s and early 1960s the relative inaccuracy and limited number of Soviet ICBMs would have necessitated the air-burst mode of attack rather than surface burst. That changed completely with the deployment of the SS-9 beginning in 1966.

2. D'Arcy, G. P., Auld, H. E. and Leigh, G. E., "Simulation of Air-Blast-Induced Ground Motion, Phase I, April 1965," AFWL-65-11, 1-3. Defense Technical Information Center (DTIC), AD614990.

3. D'Arcy, 12-32.

4. *Ibid.*, 28-29.

5. Auld, H. E., D'Arcy, G. P. and Leigh, G. E., "Simulation of Air Blast Induced Ground Motions, Phase II, April 1965," Volume I, AFWL-65-26, 3-5, 34, 53, 146. DTIC AD0613674. 118,000 feet of 175-grain Primacord was used.

6. Wampler, H. W., Leigh, G. G., Furbee, M. E., and Seusy, F. E., "A Status and Capability Report on Nuclear Air Blast Simulation Using HEST," *Proceedings of the Nuclear Blast and Shock Simulation Symposium*, 28-30 November 1978, Volume I, (Defense Nu-

clear Agency, Washington, DC, December 1978), 32, DTIC, ADA073766*; Designing Facilities to Resist Nuclear Weapons Effects: Hardness Verification,* TM 5-858-6, (Headquarters, Department of the Army, August 1984, Appendix B, 5; Bratton, J. L., Simulation of Air Blast Induced Ground Motion Using HEST, *Proceedings of the Conference on Military Applications of Blast Simulators, 1967*, Suffield Experimental Station, Canada, 189.
7. Nalty, B. C., *USAF Ballistic Missile Programs 1964-1966*, (USAF Historical Division Liaison Office, March 1967), 28. Declassified Documents Reference System, CK2349654796.
8. By June 1969, 90 percent of the Minuteman launch facilities were updated to the design requirement of 300 psi. SAMSO then proposed Plan 2 with three options for further increasing the hardness of Minuteman launch facilities. Several of the proposed features became part of the Force Modernization Program. *Strategic Air Command History, Fiscal Year 1970, Historical Study Number 117, Volume II, Narrative*, (Office of the Historian, Headquarters Strategic Air Command, Offutt Air Force Base, 20 April 1971), 236.
9. Nalty, 29-30; *Department of Defense Appropriations for 1970, Hearings Before a Subcommittee on Appropriations, House of Representatives, 91st Congress*, 753.
10. Nalty, 30; *Minuteman Historical Summary 1966-1967*, (Boeing Aircraft Corporation, 1974), Boeing Archives D2-26485-4, Sheet X-3 to Sheet X-12.
11. *Minuteman Historical Summary 1966-1967*, Sheet X-18, Sheet X-30.
12. Nalty, B. C., *USAF Ballistic Missile Programs 1967-1968,* 31-32; *Minuteman Historical Summary 1966-1967*, Sheet XI.
13. Nalty, 31-32; *Minuteman Historical Summary 1966-1967*, Sheets X-39 and X-40; *Minuteman Service News*, January-February 1968, Issue 36, 10.
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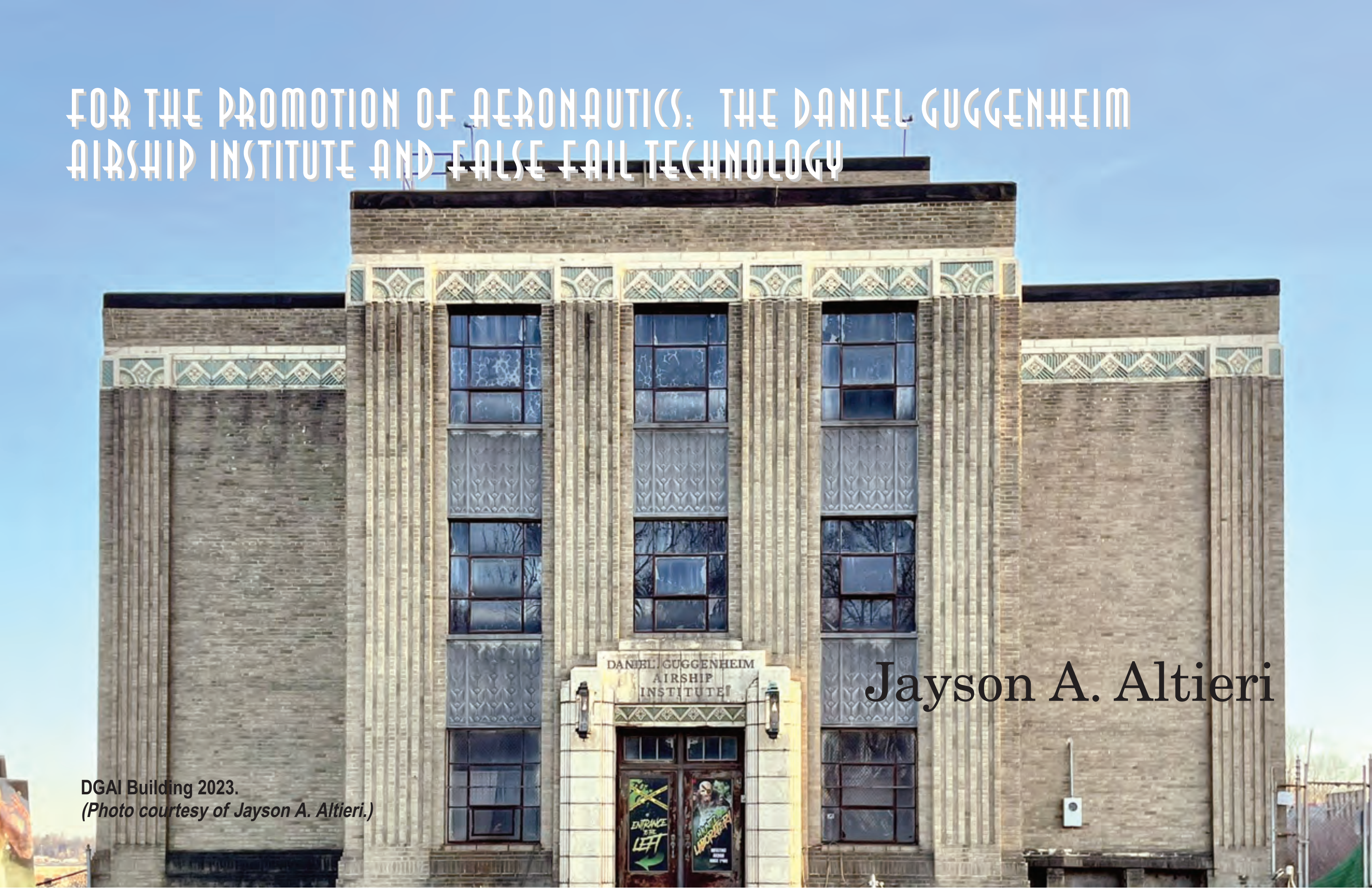
For the Promotion of Aeronautics: The Daniel Guggenheim Airship Institute and False Fail Technology

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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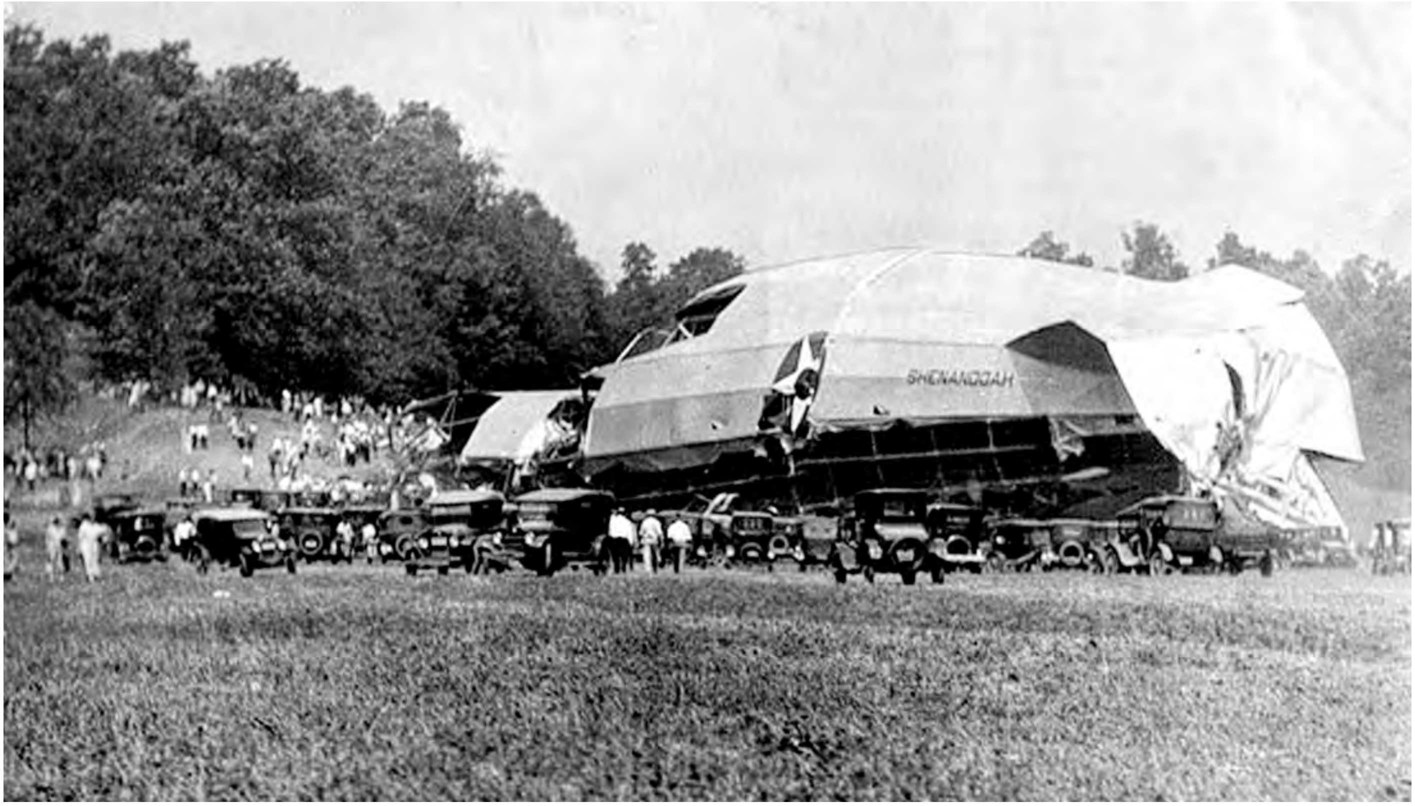
The Daniel Guggenheim Fund for the Promotion of Aeronautics was formally established on June 16, 1926. Its major objectives were aeronautical education, aeronautical research, the development of commercial aircraft and aircraft equipment, and the application of aircraft to a variety of economic and social 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.)***

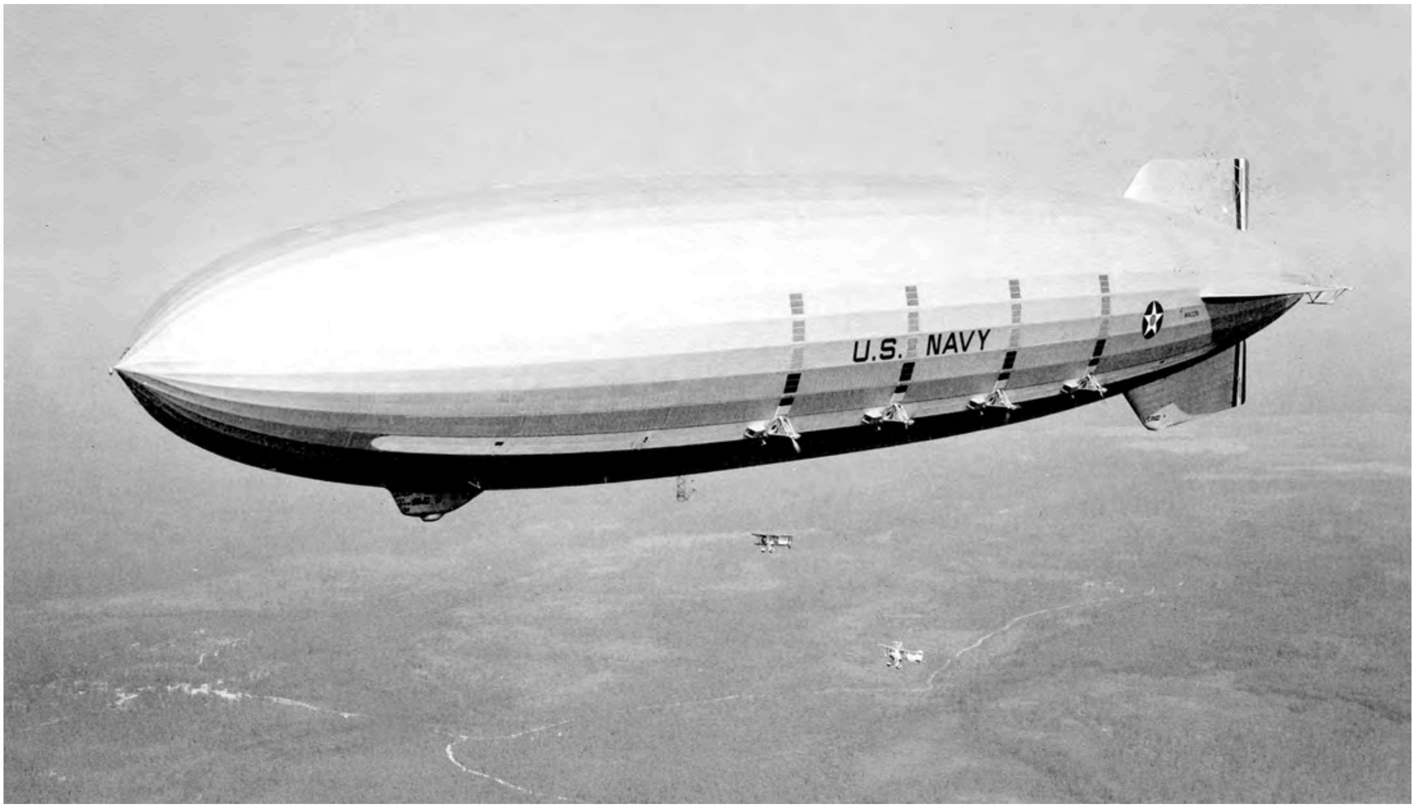
try and be of interest to post-graduate engineering students.[15] As early as October 28, 1926, Dr. Zook began the formal process of requesting funds in the amount of $250,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics for construction of the Institute.[16]

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.

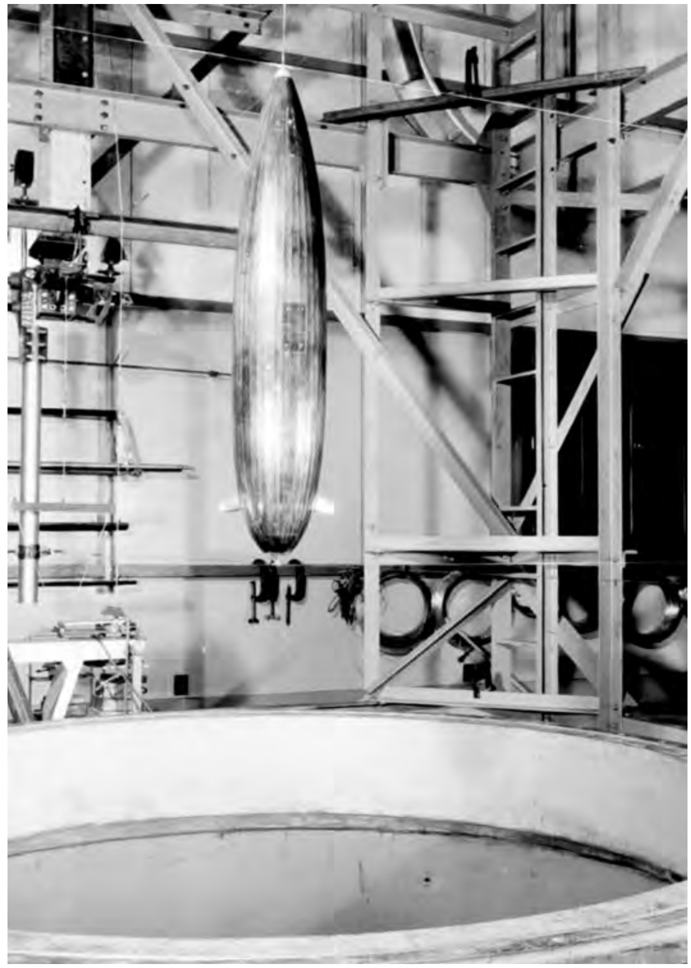
Goodyear-Zeppelin Bow Elevators

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]



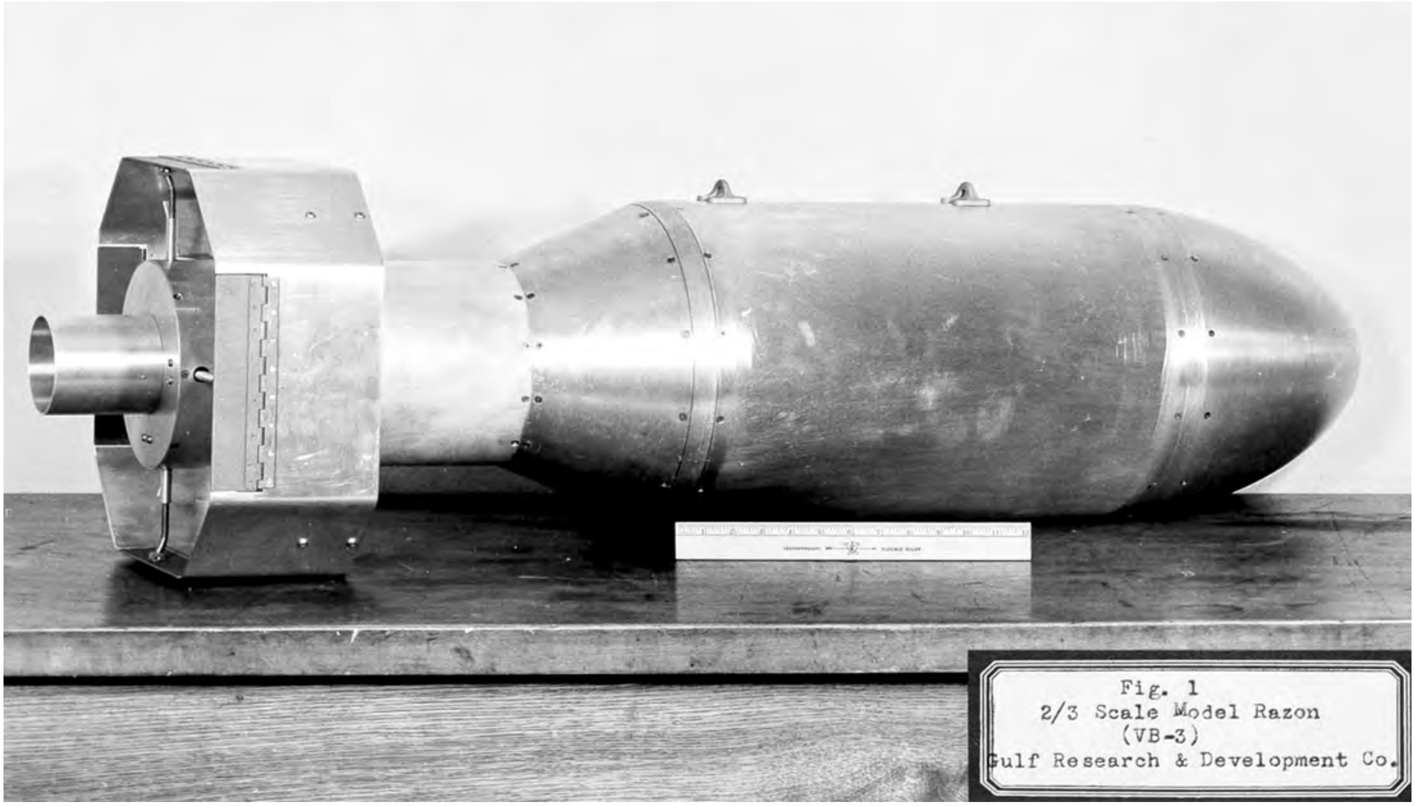
DGAI Airship Bow Fin Test. *(Photo courtesy of University of Akron.)*

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.

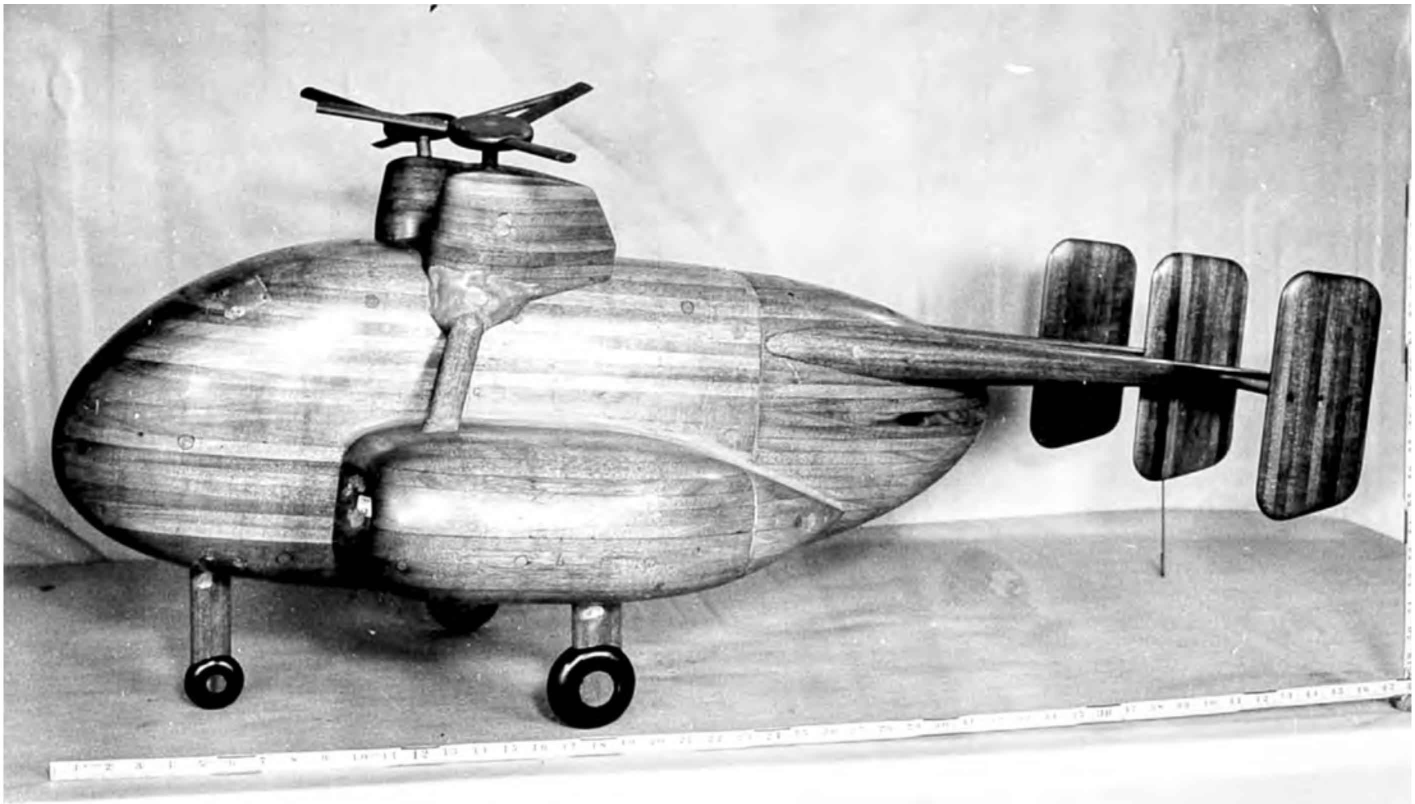
Bow elevators were not adopted by the Goodyear-Zeppelin Corporation in their rigid *ZRCV* (*CV* was the U.S. Navy abbreviation for aircraft carriers) design or the series of U.S. Navy non-rigid airships built during the Second World and Cold Wars.[38] None-the-less, forward mounted combined bow elevators 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).

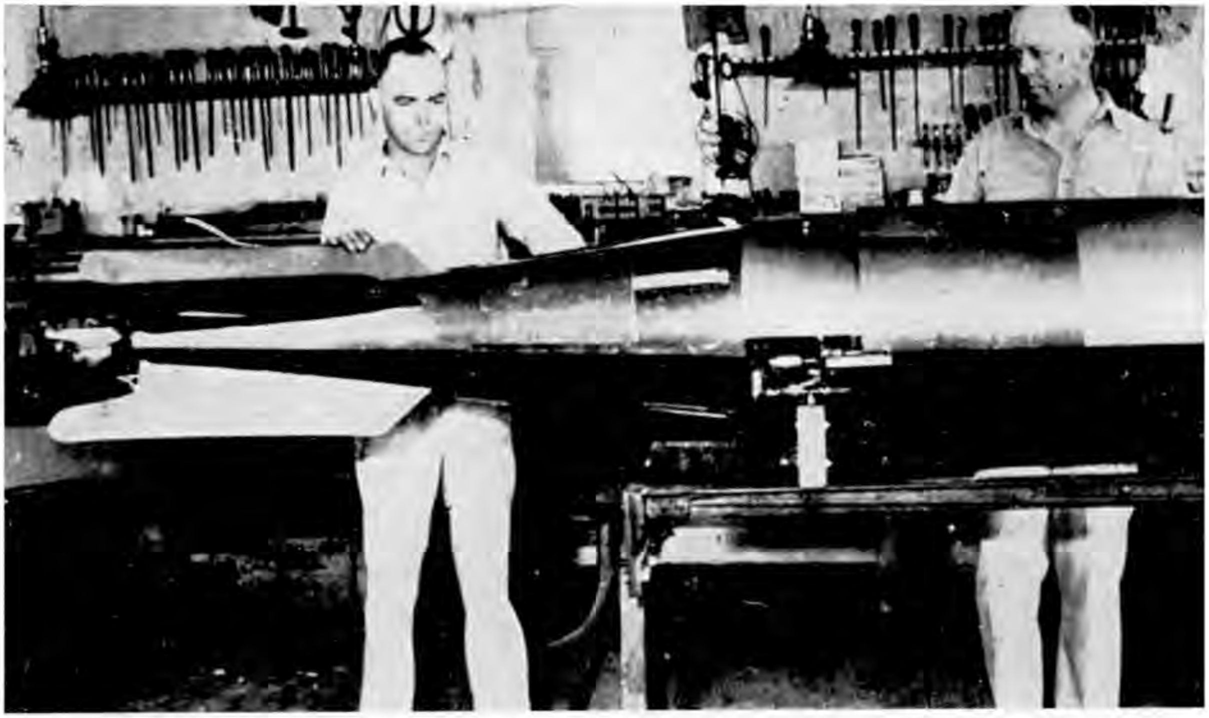
In conclusion, I suggest that we let Akron University dispose of this facility as they may wish.

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).
67. Robert S. Ross and Robert R. Ruggles, *Wind Tunnel Tests on XR-10 Helicopter Model, Vol. 1*. (Akron, OH: The Daniel Guggenheim Airship Institute, March 1945), II.
68. Robert S. Ross and Robert R. Ruggles, *Wind Tunnel Tests on XR-10 Helicopter Model, Vol.* 1, 1.
69. *Ibid*.
70. "Heaviest Copter Checks Out," *Popular Science Monthly*, September 1947. ttps://books.google.com/books?id=miQDAAAAMBAJ&dq=popular+science+1947+"piped+through+the+rockies"&pg=PA93#v=onepage&q=popular%20science%201947%20"piped%20through%20the%20rockies"&f=false (accessed March 30, 2024), 93.
71. Osaruguexyzz, *prod*. "The Forgotten Marvel: Unearthing the Kellett XR-10's Legacy," *Don't Delete History*, 2023. https://www.bing.com/videos/riverview/relatedvideo?q=Kellett+HXR-10+Crash&mid=5D93BDEB6176A55208995D93BDEB617 6A5520899&FORM=VIRE (accessed March 30, 2024).
72. J.A. Gasslein letter to Secretary, Caterpillar Club, New York, NY, October 7, 1949. "1949 Kellett XH-10; XH-10 Helicopter Historical Documents and Photos," *WorthPoint*, 2024. https://www.worthpoint.com/worthopedia/1949-kellett-xh-10-xr-10-helicopter-3774913130 (accessed April 18, 2024).
73. The Kellett Autogiro Company would produce two additional rotorcraft designs (a single pilot helicopter and a twin-engine convertiplane) and renamed the Kellett Aircraft Corporation in 1970 and later the Kellett Corporation. The company filed for bankruptcy in 1987, with some of the firms' parts and equipment being sold to Piasecki Aircraft Corporation. "Kellett," *Aerofiles*, 2008. http://www.aerofiles.com/_kellett.html (accessed March 30, 2024).
74. "History of Innovation Timeline," *Kaman*, 2024. https://kaman.com/about/ (accessed March 30, 2024).
75. U.S. Army parachutes were also tested during this same period using the Vertical Wing Tunnel. R. D. Landon letter to Curtis C. Myers, Akron, OH, January 10, 1949, The University of Akron Archival Services, Akron, OH.
76. Other examples of False Fail technologies include the US Government's attempts in the early 2000s to phase out incandescent light bulbs with more expensive and environmentally hazardous LED lights and the current attempts by the State of California in the 2020s to replace the more economically and environmentally friendly internal combustion automobile with more expensive, unreliable, and less safe electric vehicles. "65. The Attempt to Phase Out Incandescent Light Bulbs," *The 84 Biggest Flops, Fails, and Dead Dreams of Decade in Tech*, December 20, 2019. https://www.theverge.com/2019/12/20/21029499/decade-fails-flops-tech-science-culture-apple-google-data-kickstarter-2010-2019 (accessed March 30, 2024); Steve Forbes, "The Expensive and Harmful Truth About Electric Vehicles," *Forbes*, 2023. https://www.forbes.com/sites/steveforbes/2023/01/06/the-expensive-and-harmful-truth-about-electric-vehicles/?sh=565100d547c5 (accessed March 20, 2024).
77. "Inventory of the Daniel Guggenheim Airship Institute Records, 1926 – 1952, Record Group Number: 22/8," *Daniel Guggenheim Airship Institute Records*, 4.
78. Jerome C. Hunsaker letter to P. W. Litchfield, Cambridge, MA, January 10, 1949, The University of Akron Archival Services, Akron, OH.
79. "List of Daniel Guggenheim Staff," *Daniel Guggenheim Airship Institute*, Akron, OH, n.d. The University of Akron Archival Services, Akron, OH.



Yesterday's Dream . . . Today's Reality

A Biographical Sketch of the American Rocket Pioneer, Dr. Robert H. Goddard

By DR. EUGENE M. EMME
Historian
National Aeronautics and Space Administration.

In these days of rapid rocket and guided missile development, it is easy to overlook the great deal of pioneering that went into the development of the rocket art, and particularly the degree to which rocket development had been carried in this country before the second World War.

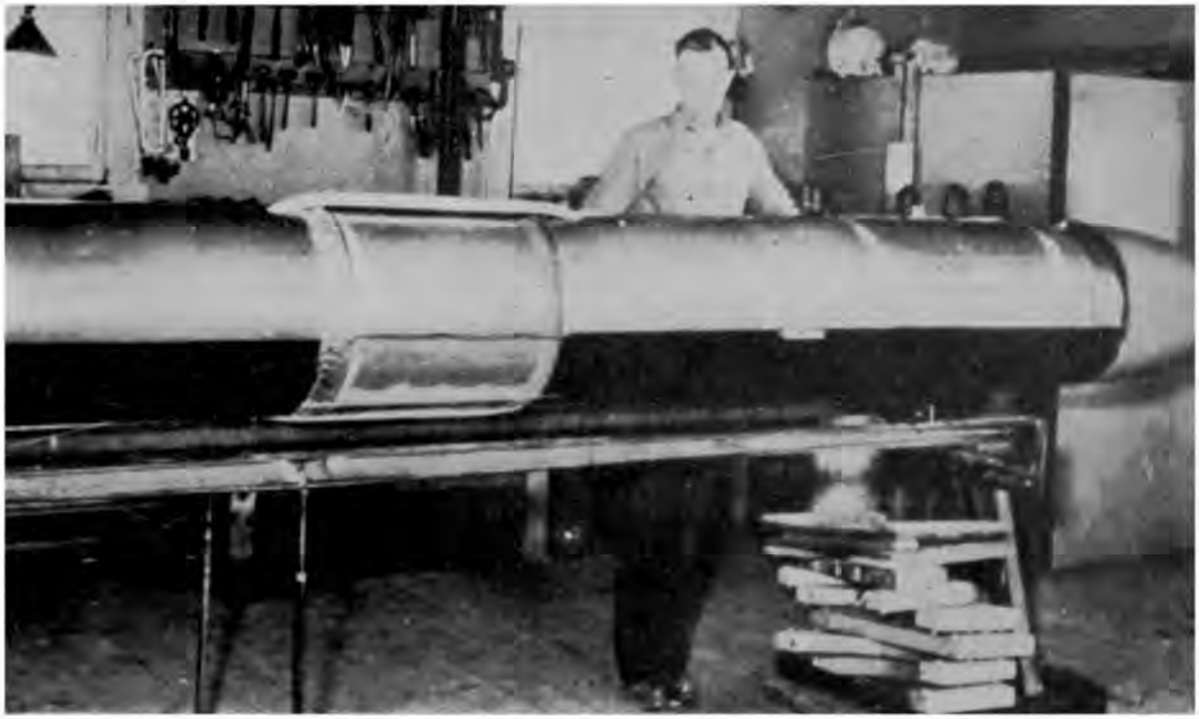
The accompanying photograph of one of Dr. Robert H. Goddard's pioneering liquid-fuel rockets was made in the spring of 1941, and shows the degree to which development had been carried by him at that time. The picture was presented to Harry F. Guggenheim by Dr. Goddard on December 28, 1944, a few months after the V-2 rockets began falling on London. Dr. Goddard inscribed on its back these words:

"Rocket produced in New Mexico in the spring of 1941, under the Daniel and Florence Guggenheim Foundation.

"It is practically identical with the German V-2 rocket."

This 1941 rocket had the following features in common with the later German V-2's, among others: (1) a similar arrangement of propellant tanks (2) a general similarity of shape and placement of major parts (3) liquid oxygen and alcohol as propellants (4) gyro-stabilization and gyro-control (5) steering by means of fins placed in the motor jet, plus steering by means of movable vanes in the airstream (6) pumps to drive the propellants into the motor.

Dr. Goddard's gyro-controlled rockets weighed from 58 to 85 pounds at starting, and were 10 to 15 feet in length. A large number of successful shots were made with them, some reaching altitudes of more than 7,500 feet.



"It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow."
—DR. ROBERT H. GODDARD (1882-1945)

I

THE FATHER of modern rocket propulsion is the American, Dr. Robert Hutchings Goddard. Along with Ziolkovsky of Russia, Oberth of Germany, and others, Goddard early envisioned the exploration of space.

A physicist of great insight, Goddard also had a unique genius for invention. He not only realized the potentialities of space flight but also constructed, static tested, and launched rockets to confirm his propulsion theories and engineering solutions. This rare talent in both creative science and inventive engineering places Goddard high among the rocket pioneers. While his scientific papers were copiously studied, however, his speculations and experiments were ridiculed, and his genius was largely unappreciated in his own day. Little wonder that this modest man once called "the moon-rocket man" and "Moony" has only recently been fully recognized.

By 1926, Goddard had constructed and tested successfully the first rocket using liquid fuel. Indeed, the flight of Goddard's rocket on March 16, 1926, at Auburn, Massachusetts, was a feat as epochal in history as that of the Wright brothers at Kitty Hawk. Yet, it was but one of Goddard's "firsts" in the now booming significance of rocket propulsion in military missilery and the scientific exploration of space.

As primitive in its day as the achievement of the Wright brothers, Goddard's rocket success made little impression upon responsible government officials. Modest grants from the Smithsonian Institution, and later grants from the Daniel and Florence Guggenheim Foundation as well as a protracted leave of absence from Clark University (where he was Head of the Physics Department) — these largely enabled Goddard to sustain a lifetime of devoted research, development and flight testing.

Eighteen years after Goddard's successful demonstration at Auburn, his basic concepts and many of his technical designs came to world-wide notice in the German V-2 ballistic missile. The advent

Dr. Robert H. Goddard standing beside the world's first liquid fuel rocket. This liquid oxygen-gasoline rocket was successfully fired on March 16, 1926, at Auburn, Massachusetts, what is now called the "Kitty Hawk of Rocketry."

of intercontinental missiles, earth satellites and spacecraft was not only based upon that to which Robert H. Goddard devoted his creative talents, but also opened up a new era in the accelerating impact of science and technology upon the affairs of mankind.

II

Robert H. Goddard's notebooks date back to 1898. Begun when he was sixteen years of age, they contain his speculation about the use of rockets for exploring the atmosphere and beyond. In December 1901, Goddard wrote a short article on space navigation. It was submitted to the *Popular Science Monthly* and was rejected.

Six years later his thoughts were expressed by both deed and word. He reportedly obtained some public notice in 1907 from a cloud of smoke eminating from a powder rocket fired in the basement of the physics building at Worcester Polytechnic Institute. School officials took lively interest in this work of student Goddard, but they did not expel him. That same year Goddard prepared an article suggesting that radioactive materials might provide a means of propulsion sufficient to navigate into interplanetary space. He submitted it to the editor of *Popular Astronomy* for publication. It was rejected with the comment: "You have written well and clear but not helpfully to science as I see it."

Based upon continuing research and study, Goddard received two U. S. patents in 1914. One was for a rocket using liquid and solid fuels, the other for a multistage rocket for reaching high altitudes. He began actual experimentation as an honorary fellow in physics and instructor at Clark University. At his own expense, he made systematic studies of propulsion. He proved both mathematically and in the laboratory that rocket propulsion will function in a vacuum. Reaching the limit of his personal financial resources by 1916, Goddard wrote a lengthy technical paper on his work to date and on the potentialities of rockets in order to gain financial support. This was his classic paper that resulted in a $5000 grant from the Smithsonian Institution in 1917, through the efforts of Dr. Charles D. Walcott, its Secretary, and Dr. Charles C. Abbot, his successor as Secretary. Dr. Walcott was also very instrumental in the early days of the National Advisory Committee for Aeronautics (NACA).

Goddard's 1916 essay requesting funds so that he could continue his research was later published along with his subsequent experimentation in the *Smithsonian Miscellaneous Collection for 1919*. It was entitled "A Method of Reaching Extreme Altitudes." Like all Smithsonian publications, it was available to the rest of the scientific world. Upon request, Goddard sent an autographed copy to Hermann Oberth of Germany in 1922 and received a warm letter of thanks from the early German pioneer of rocketry.

Towards the end of his report Goddard discussed the possibility of a rocket reaching the moon and exploding a load of flash powder there to mark its arrival. His scientific report was largely a dry explanation of how he had used the $5000 grant in his experimental testing of earlier mathematical theories of rocket propulsion in the search for methods of raising weather data-recording instruments higher than sounding balloons. A representative of the press in Washington, however, made of Goddard's report the first genuine proposal for interplanetary travel. Goddard's scientific thought about a rocket flight to the moon was quickly generated into a heated journalistic controversy concerning the feasibility of such a thing. Much "moon-rocket man" ridicule came Goddard's way. His attempts to minimize the sensational only fanned the flames. He thus reached reservations in 1920 about the virtues of the general accuracy of the popular press, a viewpoint he apparently held for the rest of his life. Several score of the 1750 copies of the 1919 Smithsonian report reached Europe, according to Willy Ley.

Goddard's work with the U. S. Signal Corps during World War I should also be recalled. Until 1917, Goddard had done most of his laboratory research on breechblock and feeding mechanisms for dry-fuel rockets. One of these rockets blew up in the Magnetic Laboratory of Worcester Polytechnic Institute on July 9, 1917, much to the notice of the surrounding neighborhood. Between 1914 and 1917, Goddard was granted seventy patents on rockets and rocket apparatus. In correspondence with General H. H. C. Dunwoody, he offered to investigate possible military applications of his rocket.

In January 1918, Goddard received U. S. Signal Corps financial support. He worked on two projects: (1) a rocket for long-range bombardment propelled by a solid-fuel rocket motor charged intermittently like a repeating-rifle; and (2) the progenitor of the famed "bazooka" rocket mortar of World War II fame.

The bazooka-type rocket was demonstrated at the Aberdeen Proving Ground in early November 1918. The launching platform consisted of two frail music racks to demonstrate the absence of recoil in rocket firing. This test was highly successful both as to trajectory and target impact. U. S. Army Air Service representatives strongly recommended its development for future combat employment. But the Armistice put an end to the war as well as to the active interest of the U. S. Army in rocket experiments until World War II. Things were different in Germany and Russia before World War II, but that is another chapter in the history of rocket propulsion.

III

Goddard's great engineering achievements resulted from his work in the 1920's and the 1930's. On November 1, 1923, he static tested a rocket motor using liquid oxygen and gasoline fuel, both supplied by pumps on the rocket. By December 1925, this motor was operated independently of the testing frame. And on March 16, 1926, this rocket flew 184 feet in 2.5 seconds, the world's first liquid fuel rocket flight. This was a historic event.

His last rocket flight at Auburn, on July 17, 1929, was witnessed by observers who thought it a flaming airplane and called out ambulances. The roaring rocket was heard all over town by most citizens. The wire services quickly spread the word that Professor Goddard's moon rocket had exploded violently. The Massachusetts Fire Marshall prohibited future rocket launchings within the boundaries of the State of Massachusetts. Even the Smithsonian quickly commented that "no such project as going to the moon is contemplated." Significant to note, this highly publicized flight carried an instrumented payload, an aneroid barometer, thermometer, and a camera triggered to operate when the parachute opened. They were successfully recovered. This was another historic first. In spite of the unwarranted publicity given this flight, it was thus that Goddard's work attracted the attention of Charles A. Lindbergh. Lindbergh personally visited Goddard and, recognizing the scientific significance of his work, enlisted the support of Harry F. Guggenheim and his father, Daniel Guggenheim.

The Smithsonian had, by this time, supported Goddard with $11,000. Between 1929 and 1941, Daniel Guggenheim and later the Daniel and Florence Guggenheim Foundation provided Goddard with over $150,000. This money supported his development of large gyro-controlled pump-operated, liquid-fuel rocket experiments in New Mexico. Progress on his work was described in "Liquid Propellant Rocket Development," published by the Smithsonian in 1936. This modest financial aid supported the pioneering efforts of Goddard which ultimately created a multibillion dollar industry and brought forth the enormous potentialities of long-range missiles, earth satellites, and space flight.

Goddard's work largely anticipated in technical detail the later German V-2 missiles, including gyroscopic control, steering by means of vanes in the jet stream of the motor, gimbal-steering, power-driven fuel pumps and other devices. Wernher von Braun, now Director of the National Aeronautics and Space Administration Marshall Space Flight Center, has said that when he had the opportunity in 1950 to study the Goddard patents he was "virtually overwhelmed by the thoroughness of his work and found that many design solutions in the V-2 rocket were covered by Goddard patents."

But Goddard, however, sought no publicity and did not widely make known details of his work. He called his rockets "Nell" after the girl "who ain't been done right by." When asked by then Lt. Homer Boushey of the Army Air Corps in 1940 why he did not publicize his work, Goddard stated that his earlier publications had been translated and reproduced in Europe virtually verbatim, often without mention of Goddard or their source.

During the late 1930's, Goddard unsuccessfully tried to interest the War Department in the military utility of his rockets. Dr. Theodore von Kármán's group at the California Institute of Technology and the Army Air Corps showed some interest in Goddard's work but nothing tangible resulted. In 1941, the Navy became interested in jet-assisted take-off and rocket bombs, and finally enlisted his services. One of his young assistants from Clark University in 1918, Dr. Clarence N. Hickman, also provided continuity on the development of the World War II bazooka. Goddard worked on rocket projects at the Naval Experiment Station at Annapolis from 1941 until his death, following a throat operation, on August 10, 1945. His work at Annapolis remains obscure.

IV

Praise of Goddard's basic work is in vogue today.

In hindsight, Dr. Robert H. Goddard was one of the first scientists who realized the potentialities of space flight and missiles. But he also brought them to a practical state of development. This rare creative and practical talent was, as Mrs. Goddard points out, combined with his dogged persistence and methodical scientific dedication. More than 200 patents on rockets and rocket apparatus have been issued to Robert H. Goddard, many since his death.

The labors of this scholarly modest man were appreciated by experts but went largely unrecognized until the recent dawn of what is now called the "space age." High honors and wide acclaim, belated but richly deserved, now come to the name of Robert H. Goddard. On September 16, 1959, the 86th Congress authorized the issuance of a gold medal in his honor. Goddard dinners and awards are annual events of the American Rocket Society, the National Rocket

Club, and the Air Force Academy. On June 28, 1960, the Smithsonian bestowed on Goddard its highest award, The Langley Medal. And, on July 13, 1960, the American Rocket Society erected a fitting memorial on the site of the world's first liquid-fuel rocket flight of 1926 at Auburn, Massachusetts.

NASA's new Goddard Space Flight Center, with its important responsibilities, is a living and working tribute to his historic contributions in the exploration and investigation of space. Once his biography, notebooks, and papers are fully available, Robert H. Goddard's trail-blazing role in the theory and application of rocket propulsion will be even more greatly appreciated.*

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* As this article went to press, settlement of patent claims of the estate of the late Dr. Robert H. Goddard, pending since 1951, was culminated on June 29, 1960. Past infringement and paid-up license for all future use by the government of all Goddard inventions and patents will be exchanged for payment to the Guggenheim Foundation and Mrs. Goddard of $1,000,000 ($765,000 by the Air Force, $125,000 by the Army, $100,000 by NASA, and $10,000 by the Navy).

BIOGRAPHICAL NOTES

No full-fledged biography of Dr. Goddard is available. His notebooks, correspondence, and papers are being edited by Mrs. Goddard with the assistance of the Smithsonian Institution and the Daniel and Florence Guggenheim Foundation. Mr. Milton Lehman of Garrett Park, Maryland, is completing a definitive biography. He was helpful in the preparation of this sketch while Mrs. Goddard generously made corrective suggestions. A select bibliography was included to guide the stimulated reader until Mr. Lehman's biography appears and Dr. Goddard's papers are placed in the Library of Congress.

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ASTRONAUTICS, PAST AND FUTURE

By J. R. Dempsey
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Astronautics surely must be the only field of human endeavor that has done so much—that has claimed the efforts of so many thousands of people, the attention of parliaments and geopoliticians, and a good share of the wealth of major nations—all so rapidly that a proper definition of the word itself is still lacking in many dictionaries.

Briefly, astronautics begins with nuclear physics and the resultant atomic bomb. The bomb, in turn, revolutionized the concepts of warfare, especially with respect to delivery vehicles for this startlingly new kind of weapon. Once developed and made reliable, one of the most desirable vehicles proved to be an intercontinental ballistic missile. The ruling function of such missiles was travel through space.

Thus *astro*nautics came into being as a means to an end—not as an end to itself—and in this way was quite different from *aero*nautics, the field from which it sprang. Aeronautics was born as the result of man's deliberate, long-standing determination to learn how to fly.

This was not true of astronautics. With the development of the ICBM, here—suddenly and unexpectedly—was a machine which could break out of the shell of earth's atmosphere. It wasn't very long until the ballistic missile was adapted to carry man himself into space. Here was something entirely new in human experience.

For well over a million and a half years, there have been manlike beings on this planet. During all of these generations, man, for all his cunning and ingenuity, has been confined within the thin membrane of earth's atmosphere. And only now, in this time, he has broken out!

Man's venture into space is a most remarkable achievement but yet, looking back, many may wonder why those journeys beyond the atmosphere had not taken place sooner. The high art of rocketry and the use of hydrocarbon fuels were known to the ancient Chinese. Those definitive discoveries, the laws of Johannes Kepler and Isaac Newton, were laid down in the 17th century. Yet, as recently as the 1930s, undergraduate engineers were taught that rockets could never be devised to carry even minimally useful payloads.

Fortunately, not everyone believed that—certainly not the Russian theorist, Konstantin Tsiolkovskii, or Dr. Robert Goddard, the American rocket experimenter, and particularly not the Germans, who developed the V-2 rockets in World War II.

Yet, astronautics might have remained dormant, had it not been for the parallel development of the atomic bomb. The requirement for a vehicle that could deliver the bomb created renewed interest in carrying on where the V-2s left off. The pressure creating the surge of technology came, not from technology itself, but from geopolitics. This appears to be almost a classical pattern.

History proves that, sooner or later, civilization makes use of new discoveries about the laws of nature. But the *when* of their application depends, not upon technology, but upon forces outside technology. These forces are the tides and currents of human affairs which resolve into national cultural trends and international politics. They are the "forcing functions" which mainly set the pace of technological applications.

It was just such a forcing function which set in motion the revolution of technical application in the field of astronautics. It is a revolution in which engineers have played a role that has yet to be fully understood and acknowledged. What was involved in this revolution was completely new in the long history of engineering.

Earlier in history, there were some fairly substantial leaps in the arts of application of a single science, or small groups of sciences—and even more challenging—the interrelationship of these technologies in completely new patterns. The scope of each of these challenging problems—the Pyramids, the Great Wall of China, the Panama Canal—was enormous for the technology of the times in which each was accomplished, and this element was not lacking in the ballistic missile program.

The engineers who tackled the ICBM problem had to (1) design a machine of very high mechanical density for which then-existing technology provided only a thin historical background, and which involved new and complex interrelationships of all the physical sciences; (2) simultaneously invent means of testing and measuring performance of a vehicle that disappeared from sight after the first few seconds of flight, was unmanned, and not recoverable; (3) decide which parts of the total system should be airborne and which should be situated on the ground; (4) design and install operational bases at the same time the R&D flights of the missile were still going on, meanwhile introducing necessary changes into the missile and its ground systems; (5) accurately predict what the incidence of spares requirements would be under operational conditions, and have the spares ready when the first missiles were installed at the operational bases; (6) devise a training program to prepare troops for manning the missiles the moment they were delivered to operational sites; (7) produce maintenance manuals that would also be ready the moment the operational birds were delivered.

And all this was done under a punishing time schedule dictated by urgent national need.

What has been achieved in these few short years is so broad in scope, so far-reaching in its effects, that it is difficult to make up an appropriate summary of those monumental accomplishments. It is even more difficult to measure the *effects* which these achievements will have in the course of history. But even now, at this dawning of a new field of technology and human adventure, one thing is certain—man will never again be content to confine himself within earth's atmospheric shell.

To look beyond this turning point and foresee astronautical events of the years ahead, requires an examination of the two principal forces involved—probable advances in technology, and possible forcing functions which will affect the pace of technological advance.

Future technical advances fall into two main categories—further applications of the basic sciences, and applications of new discoveries in science. Some of the areas in which progress will likely be made include:

Power Sources and Propulsion Systems

Scientists are already well into the business of using a wider variety of chemical elements for rocket propulsion—hydrogen, boron, beryllium, lithium, magnesium, fluorine, and a number of related mixtures and compounds.

Nuclear energy will undoubtedly be harnessed as a source of fuel. Solar energy is already being used, although on a much more limited scale than will be possible in the future. Experimental ion engines are running in the laboratories.

Further developments in each of these categories require substantial engineering effort. The rate at which this effort will be applied depends mainly on the forcing functions outside technology itself. Progress in the further exploitation of nuclear energy is very likely, since a strong economic forcing function is at work. This is the tantalizing prospect of handily applying nuclear energy to a tremendous variety of the world's everyday work. Such widespread effort by both organizations and individuals around the world, spurred on by the potential economic rewards, will undoubtedly produce accelerating results in application of nuclear energy. And this progress, while its objective is mainly to capture lucrative terrestrial markets, will provide power systems for astronautical applications.

Material

Today's constructional steels have strengths in the range of 100,000 to 300,000 pounds per square inch. Crystal theory, as well as experiments conducted on very small whiskers of high-purity perfect crystals of metals, indicates that strengths in the range of elastic modulus values may be achieved—strengths up to millions of pounds per square inch. Such metals could undoubtedly have a lasting effect on the design and performance of power plants, vehicle structures, and weaponry.

Scientists are already on the threshhold of unique new developments in composite materials. For example, the cellular structure of wood, and the various materials found naturally in wood, confer many favorable properties on this material. While wood is one of the oldest structural materials used by man, it is also used as a load-bearing structure in the Polaris missile, competing successfully with such lightweight metals as titanium and beryllium.

New composite materials incorporating ultrahigh-strength fibers or filaments of such substances as boron, alumina, and tungsten embedded in a matrix of plastic, metal, or ceramic, promise new generations of high-strength and high-temperature materials.

New materials are also being created by chemical and mechanical means in addition to conventional metallurgical alloying. Suspensions and emulsions of one or more metals in another have already yielded such improved materials.

Information Management In Product Design

Early astronautical developments drew upon the entire spectrum of the physical sciences. With the advent of man in space machines, the spectrum expanded to include the life sciences as well. Thus, the engineer faced another jump in the range of considerations which he had to apply to systems and detail design of astronautical vehicles.

The engineer traditionally asks two questions when he approaches a new design problem. How can it work? How can it *not* work? To ensure 100 percent reliability, the engineer should be able to think of all possible ways in which his device cannot work, and then test to prove he has avoided them all. Then he has to place his device in its proposed operating environment, conceive of all the additional ways it cannot work, and test them out. This latter cycle is a challenge with present aeronautical machines. In the future, it will be even more difficult.

One of the problems is in the very nature of the human animal. Man finds it quite difficult to imagine a situation which he has never personally experienced. Thus engineers are limited in thinking of ways in which a device can not work—particularly now that the technical spectrum is broadened beyond previous experience. Computers will continue to be of great value in this area, as they have been in the past. Yet, does man really use these machines wisely to augment his intelligence?

A trainer at Sea World, an undersea showgrounds in San Diego that features a troop of performing dolphins, once remarked that the limitation on teaching dolphins new tricks is a *man*-limitation. The dolphins learned quite easily most tricks which humans had been able to think up for them.

Much the same situation holds true for computers, in a somewhat different way. While computers have no latent intelligence, they do have a latent potential for performing feats now unheard of—if humans could only figure out what to teach them to do. Since this is apparently some sort of man-limitation, one approach to improvement may lie in a better association with the behavioral scientists, to see if there are better ways in which individuals and groups can perform design functions.

Management of Operation Information

The increasing complexity of relationships between the sciences is having a severe effect, not only on the information required for product design, but also upon the information needed to link these activities together into organizations that can operate effectively.

New understandings of organizational behavior, new points of view are needed, which will let man use computers and other machines much more helpfully than

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they are now. People must be used more constructively and more effectively as human beings, cohesively working together. It is in this area of organizational management where the greatest single opportunity lies to expedite progress in astronautics.

In many areas, it is not technology that is holding man back, it is in the ability to manage technology. Technology can only be managed through people, and to get things done, organizations of people are needed. The true management of technology, then, is the management of organizations. Unusually bright careers await those men who have the ability to "walk amongst the disciplines"—and their fellow human beings, to become the dynamic force—operating management—that really make things move.

Genetics

The current revolution in microbiology may have as lasting an effect as the revolution in physics that took place earlier in this century. Certain new findings have already approached the point of speculation on the possibility of affecting human characteristics through "tailoring" chromosomes. This factor may seem to be totally unrelated to the field of astronautics. Yet, astronautics is a by-product of progress in basic science which was not directly related to astronautics itself. If this can happen once, it surely could happen again. But what possibly could be the connection between genetics and astronautics?

In the area of astronautics which lies not far ahead, men will be landing on the planets. So far as is known, the climates on the surfaces of these celestial bodies are starkly inhospitable to man. It will be necessary, then, to send hundreds of pounds of precious weight, along with the men, to sustain their lives in those hostile environments.

Should this problem still exist during a period of time when geneticists had developed a means of modifying human metabolism, or other basic human characteristics, it does not seem too unlikely that there might be some thought of solving this class of astronautical problem with biological techniques.

The Laboratory of Space

In the sweep of universal events, the time which has elapsed since man broke out of earth's atmosphere amounts to scarcely a microsecond. Yet already there has been a taste of the vast feast of knowledge that may be returned from space. There are, for example, the moon pictures of Ranger, a repast to delight the intellects of astronomers for years to come.

The astrophysicists are impatiently awaiting the time when they, too, can gather more extensive firsthand samples of the phenomena of space. So, also, are the men of all the sciences. No one knows what they will find—but find things they will. And the small peek into the laboratory of space would seem to indicate that there is far more to learn there than man has yet dreamed of.

The Forcing Functions: Applications of Astronautics

The latent potential of science and technology is usually realized due to pressures of sociological, economic, or political events—the forcing functions. If science fiction can be described as "real behavior in fantastic surroundings," scientific reality in astronautics might be described as "fantastic behavior in real surroundings." How is it possible, then, to make a meaningful forecast of the fantastic forcing events which lie in the future? Perhaps by noting that the principal work of astronautics focuses on vehicles—and vehicles become a part of transportation systems. It might be well to view the future of astronautics in that light.

History shows a repetitive pattern in the development of transportation systems. They begin as technological feats, or even stunts, and sometimes they go no farther than that. For example, General Dynamics developed the "Pogo Stick" fighter airplane that sat on its tail, took off vertically, then transitioned to horizontal flight. In the 1950s, it was an interesting technological feat, but that was all. It had no utility. Yet, if this plane had been developed in the 1930s, it might have made an admirable convoy escort in World War II, based on the deck of conventional ocean-going freighters. In contrast, the airplane of Wilbur and Orville Wright was regarded as a stunt by many people of that day, but time has proven them wrong.

The introduction of the railway shows how difficult it often is for people to accept a new technological development and to realize its worth. Men cling to what is traditional, sometimes even with fanaticism. A member of the British parliament stated a proposal to build a railroad in England was "absolute madness . . . Carriages rushing along at ten miles an hour, drawn by the devil in the shape of a locomotive . . . Beelzebub himself at the controls, and behind him, his assistant fanning the fire . . . What a crazy scheme"[1]

In the first phase of utility, a new transportation system is used for gathering or transporting information. Aircraft were first widely used for reconnaissance, in the military field, and for transportation of mail, in the commercial field.

Next, an evolving transportation system is used to carry people or precious goods. Finally, a transportation system is adapted to carrying bulk cargo.

Will present space machines lead, in time, to a practical transportation system? With respect to rocket transportation costs, it is clear that a Sunday joyride in a rocket would be a very expensive trip. The propulsion efficiency of the aircraft and rocket are quite comparable, except that the rocket must carry both oxidizer and fuel. The specific fuel consumption of a turbojet engine is of the order of 3,600 pounds thrust per pounds fuel per second. For each pound of jet propellant used, approximately two pounds of oxygen and eight pounds of nitrogen pass through the propellant system, and could be considered as propellants. This would give a specific fuel consumption of about 300 seconds, which corresponds to a liquid oxygen/rocket propellant rocket engine.

To attain range, then, the airplane has the advantage of a higher "apparent" propulsive efficiency, as well as the advantage accruing from using air to support its weight, at a nominal cost in drag or power—for a nominal L/D of 10, then 10 percent of the weight of the airplane is drag, and must be overcome by the propulsive force.

If both the airplane and the rocket were to attain the same range, say, ICBM range at 5,500 nautical miles, then the airplane advantage becomes apparent in the mass ratio required—the percent of fuel required to the inert weight. The fuel weight was nearly all of the initial weight for the rockets.

This is a paradox, because for the automobile, ship,

[1]Heinz Gartmann, *Science As History*. (London, England: Hodder and Stoughton, 1960)

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and jet transport, the cost of the fuel consumed is 25 percent or more of the total cost of operating the system. For the rockets, which use 3 to 20 times as much propellant—including the more expensive oxidizer—the cost of the propellant is about 0.2 percent of the cost of operating the system. The paradox is explainable because all of the rocket is expendable since there is only one use. For the other systems, fuel is the primary expendable.

From other examples, and from detailed studies, space scientists have so far been unable to discover any law of nature, or physical law, which implies that rocket vehicles are inherently greatly different in operation than other transportation systems.

How does the historical repetitive pattern in the development of transportation systems apply to astronautics in the four principal categories of application—military, economic, national prestige (including exploration), and research?

Military Applications of Astronautics

Military astronautics is already in the information phase of development. Unmanned space vehicles are used to acquire information on weather, and as an aid to navigation on the earth's surface. There is speculation that unmanned satellites could be used for military reconnaissance by major nations. Satellites have already demonstrated their utility for international communication in the commercial field, and presumably the same application is available for military purposes.

Next comes the phase in which people are transported. An orbiting laboratory will be developed in which military man will begin an organized inquiry into the new environment of space.

Another recurrent speculation concerns transportation of troops by ballistic carrier, from the United States to any point on the globe, in less than an hour. This concept requires the solution to some staggering technical problems, but they are within the state of the art—*if*. The "if" involves the funds that would be required, in the face of all the other demands for development monies in the military budget. The course that presently is charted is a sound one—put up a manned military laboratory, and with the data thus collected, form a basis for further planning.

Economic Applications of Astronautics

As every stockbroker knows, the American public has great faith that the information phase of commercial astronautics will be highly successful. The price of shares in the new Comsat Corporation skyrocketed when they came onto the market in 1964.

International voice and picture transmissions by satellite have been going on since July 1962. The weather satellites are serving the economic interests of the country, as well as the military. The hurricane season, for instance, is not the nagging mystery it once was, for every feint and surge of those storms is promptly reported and charted by the ever-watchful satellites. This is already yielding economic benefits which are very real, although difficult to appraise.

Other information-transportation applications can be visualized, such as transportation of documents by ballistic carrier, between principal cities of the world. In fact, the French have been conducting such experiments. There is also a U. S. trend in this direction. Many banks are moving out-of-town cancelled checks by airplane, even by chartered airplane. This reduces the "float" between the time a check is written and when the accounts concerned are adjusted to reflect the transaction.

The sums of money involved are huge, and the minute-by-minute interest on that money far surpasses the cost of transporting the information contained on the checks.

As international commerce grows, so do the sums of money involved, and the resulting flow of fiscal documents. It is very possible that national and international ballistic transport of fiscal documents carrying information which cannot be carried electronically will come about. But sadly for some, when that day comes, most of the fun will have been taken from the practice of check kiting.

Once such systems are in operation, it is logical that the next step will be similar ballistic transport of precious goods—goods that are precious, not necessarily because of their inherent value, but because of their perishability or because of the fiscal leverage involved in the possession of the goods.

A current example is air transport of women's dresses. The manufacturer, jobber, and retailer can absorb the higher cost of air transport because of the perishability of style, and the merchandising advantage to the retailer in having a new fashion on his racks a day or two ahead of his competitors.

This is a type of utility for the airplane that was probably beyond the vision of many of the early aircraft builders. Yet it has come about, and a similar pattern may develop in the economic use of astronautics. And when recoverable boosters and new generations of propulsion systems become available, the ballistic transport of people, or of bulk cargo, may also become a reality.

In the total economic scope of forcing functions, it is impossible to ignore international affairs, and the stresses and strains in relationships between nations that stem from the continuing struggle over the world's wealth. The field of astronautics took its place in current affairs because of just such a forcing function.

The existence of the earliest astronautical machines—intercontinental ballistic missiles—created a standoff in big "hot" wars which, in turn, has brought into being the "cold" war. And cold wars are fought with new strategies and weapons, not the least of which are technological achievements in the field of astronautics.

Applications of Astronautics For National Prestige and Exploration

In an earlier day, national prestige was achieved by such things as a favorable balance of trade, winning the international seaplane races, World Fairs, and cruises of naval fleets to "show the flag" in world ports. In this time of cold war, more sophisticated events are required—such as putting man into space.

The suspenseful, edge-of-the-chair involvement of most Americans with the space flights of U. S. astronauts, is a recent memory. And space travelers are the heroes of the times. Astronaut John Glenn, for example, back from space, addressed a joint session of Congress and received a favorite son's tumultuous welcome riding through the jam-packed streets of New York.

Gemini astronautics are expanding the free world's space-flight envelope still farther, and not long after that, America will have new national heroes—Apollo astronauts

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who have stepped foot on the moon.

These explorations, aside from their great scientific value, offer tangible evidence of American vitality and purpose—especially since they are conducted openly—literally before the eyes of the world.

Applications of Astronautics in Research

It may be a mistake to discriminate between military and nonmilitary projects, for it is impossible to forecast just what applications will be found for the various space vehicles and space data of the future. Today's space vehicles are very impressive to look at, but they are as crude for accomplishing their mission as the early steamships, automobiles, and airplanes. The next phase in the evolution of rockets is to make them reliable and economical. This will be done in the same manner as for airplanes and earlier transportation systems—repetitive reuse with a consequent buildup in the body of knowledge in how to design, build, and maintain them.

In the process, as new situations are experienced for the first time, present points of view will undoubtedly change. And with these new points of view may come new ideas for applying rocket transportation systems which seem outrageous today. There is a very recent example of this in commercial airline traffic over the North Atlantic. The first 25 years of commercial transatlantic operations are a classic example of the evolution of a transportation system. From modest beginnings in 1939—slow-flying boats, small payloads, and irregular schedules—the transatlantic air bridge has grown into a giant jet stream of traffic which carried more than three million passengers between North America and Europe in 1964.

It seems evident, then, that there is logical reason for considering rockets as the basis of a tenable transportation system. This estimate is reinforced by the historical development of transportation systems on this planet.

The development of *intra*planetary transportation systems, between points on the surface of the earth—to sound a note of caution—has taken place in the presence of the obvious requirement to move things and people from place to place. This has presented a very visible economic forcing function which thus far is lacking in *inter*planetary transportation, where information collection and exploration are the only presently visible rewards.

This fundamental difference makes it even more important that space research and exploration be undertaken in a well organized fashion. Preparation of a cohesive national space plan presently engages some of the best brains in Government and industry. A prominent member of this society is Krafft Ehricke, General Dynamics/Convair, whose highly original opinions on interplanetary travel have profoundly influenced the thinking of the men around him.

The basic problem in preparing a long-range plan for exploration of the solar system is to make the plan sufficiently broad and imaginative to maintain a continuum of effect, but avoid preconception of details in carrying out the plan.

As yardsticks for solving this continuing series of dilemmas, the following proposals may be of value:

1. The three principal constraints on any given exploratory missions are: presence of a satisfactory launch window for departure from earth—either earth's surface or from earth-orbit; satisfactory window for return to earth; and availability of flight-proven hardware adequate to accomplish the planned mission. No specific mission should be planned in such a way that fulfillment of these three requisites is not possible.

2. The modular, or incremental development principal should apply to launch vehicles and flight articles. Basically, this means that a launch vehicle or flight ve-

The successful test-firing of this TITAN III-C on 18 June 1965 marked a momentous step forward in U. S. plans to develop a military capability in space.

The TITAN with a total of 2,400,000 pounds of thrust in four stages is the most powerful rocket yet developed by the United States. After further testing the Air Force hopes to use this rocket as a booster for its manned orbiting laboratory.

(USAF PHOTO)

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hicle should be expected to serve as an element of succeeding generations of vehicles, or as a reusable vehicle.

All these requirements and procedures should be viewed as meshing elements of a total interplanetary system. If this is done, some of the mistakes made in earlier development of transportation systems can be avoided.

3. Earth orbit can be the "proving grounds" for both vehicles and crews. With proper planning, useful experiments concerning earth and the near-earth environment can be conducted as a bonus of these training missions.

For the examination of other planets, a selection of missions—each attainable with "master plan" modular equipment—should be available. The selection should range from the relatively simple to the complex: instrumented flybys, unmanned orbital or "capture" missions, manned flybys, manned orbital laboratories, instrumented surface probes operated from manned orbital laboratories, manned landings, and manned colonies.

This progression permits collection of an incrementally greater volume of information with each step. The missions may be undertaken in progressive order. Steps in the progression can be skipped, or the progression can be terminated at any desired step. The determinants in making these choices are:

(a) The quantity and quality of the information acquired in each progressive step, which will determine which following step offers the best chance of a desired payoff.

(b) The amount of information already available from previous exploration—if a preliminary look at a given planet indicates conditions similar to those already discovered elsewhere, further examination of that planet may be deferred.

(c) National goals. For example, if interest at that time is to plant the flag on as many planets as possible, minimal "planet-hopping" missions may be desirable. On the other hand, if establishment of colonies is the goal, the full progression of steps will be more attractive.

Such a program can be, in effect, a sort of Lewis and Clark type of general survey of the solar system—setting out the major baselines for later exploration—meanwhile noting the areas offering greatest opportunity for later, more extensive exploration and development.

4. Examination of interplanetary space, and the phenomena occurring there, can be carried out as part of the planetary exploratory missions.

5. Data and experience acquired in this planned exploration of the solar system can form a basis for consideration of the possibility of exploration beyond our solar system.

The effect which forcing functions have upon the advance of technology is immense. But technology is not without its own effects on human affairs. Technology brought the atom bomb, and thus man acquired the most difficult practical problem he has ever had to deal with. But time may prove that the bomb's by-product—astronautics—is a more persistent question than the bomb itself. After all, the bomb poses such a gargantuan threat that man may be able to avoid destroying himself with it.

But space presents a mystery which will persist for generations. There will be many iterations of the question—what is to be done about the exploration of space? It really is not a new kind of question for Americans. The spirit of exploration runs strong in this nation founded by explorers. The Yankee Clipper, the coonskin cap, the pilot's silk scarf flying in the slipstream—all these lie close to the hearts of most Americans. And this characteristic is not going to suddenly die out.

Mankind as a whole will not abruptly cease its historical drive to expand its environment. Down through the centuries, men have poked and prodded to learn more about nature's laws. There have always been those who disputed the accepted facts, men who asked, "Is that *really* true?"

That's how man discovered that the world was not flat, that the earth is not the center of the universe, and that it is surprisingly easy to escape earth's atmosphere and come back again. The spirit of exploration will not diminish, merely because it is difficult for man to see clearly where technology can take him.

After all, this time is but a small moment in the grand march of historical events, and "the universe is full of magical things, patiently waiting for our wits to grow sharper."[2]

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[2]From *A Shadow Passes* by Eden Phillpotts.

NOTICE

Receipts for payment of Dues are no longer being issued, since your cancelled check is your receipt, and it eliminates needless cost.

'Father of Space Medicine'

Halley's comet launched his career

THE YEAR 1910 was a remarkable year in a cosmic sense, and it had a profound influence on the life of a 12 year old lad in Westfalia, Germany. Young Hubertus Strughold could hardly believe his eyes one February evening when he saw a comet in the western sky. The next day, the newspapers identified it as the Johannesburg Comet, or as it was later named, the Brooks Comet after its discoverer at the Observatory in Johannesburg, South Africa.

Dr. Hubertus Strughold

The Brooks Comet was visible for about one week and its tail grew to tremendous length. When the head of the comet was near the horizon, the tail extended to directly overhead. This celestial display was a prelude to the reappearance, three months later, of Halley's Comet after its 76 year trip through outer space.

There were reports in the press that the earth would pass through the tail of Halley's Comet, which contained toxic gases such as ammonia and cyanide. This caused much concern and even prompted a few people to suicide. All this made a lasting impression on young Hubertus and stimulated his already vital interest in space.

After completing the equivalent of American high school, he began his studies in medicine and natural sciences at the University of Muenster and later at the Universities of Goettingen, Munich and Würzburg. The first two lectures he attended were on anatomy and astronomy, and they were symbolic of the career he would pursue so diligently for years to come.

He received his PhD degree from the University of Muenster in 1922 and one year later he received his MD degree from the University of Würzburg. He served his residency in physiology, during which he concentrated on the mechanical sensors such as pressoreceptors in the skin of the lower part of the body which have to do with balance.

RESEARCHER TO THE END

This interest in pressoreceptors led to an interesting experiment later in which he injected novocaine in his posterior and flew in an airplane to see if he could stay oriented in flight without the aid of the sensors in his backside.

After achieving his MD, Strughold began to specialize immediately in aviation medicine. He even took a balloon flight to 4,500 meters altitude to collect data on the effects on his ability to perform simple tasks. Although the balloon ended up in a tree when it came down, young Dr. Strughold saved his data and two bottles of champagne he and the balloon pilot had taken along to help celebrate the success of their flight.

In 1927 he gave the first lecture ever given in aviation medicine at the University of Würzburg. In this lecture he pointed out, "In ten years, thousands of people will be flying the Atlantic and medicine must be ready to protect them against the hazards of altitude and unknown medical problems of air travel." Although many of his students smiled at the remark, the smiles disappeared quickly when just ten days later another young pioneer by the name of Charles Lindbergh made his historic flight across the Atlantic.

... an Aerospace Profile

By Thurman A. Glasgow

In early 1928, Strughold became so interested in flying he began to take flying lessons. It was during this period that he made the flight with his posterior deadened with novocaine. However, his flying training was interrupted short of achieving a pilot's license by an offer from the Rockefeller Foundation, to work with Dr. Carl Wiggers in Cleveland, Ohio, on the effects of hypoxia on the heart.

On arriving in Cleveland he found that Dr. Wiggers had been asked to help do some research on reviving the human heart after electrical shock. The relative newness of electricity was causing many people to be electrocuted since most people were unaware of its danger. This presented an immediate demand for research which was performed by Drs. Wiggers and Strughold in addition to hypoxia studies.

AVIATION MEDICINE HIS FORTE

In 1929 Dr. Strughold spent six months at the University of Chicago and while there, he held a seminar on Aviation Medicine. The Chicago newspapers carried stories about the seminar which were headlined "Aviation Medicine - New Field of Science." Toward the end of 1929 he returned to Würzburg, and did not visit the United States again until he attended a meeting of The Aeromedical Association (now The Aerospace Medical Association) in New York in 1937.

From 1935 to 1945 he was Director of the Aeromedical Research Institute in Berlin. Following World War II, he went to Heidelberg where he was offered a position as professor of Physiology at the University of Heidelberg.

It was here that he was visited by Colonel Harry G. Armstrong, commandant of the School of Aviation Medicine, and was offered a position with the School at Randolph Field, Texas. Colonel Armstrong later retired as Surgeon General of the U. S. Air Force. Dr. Strughold went to Randolph in August of 1947 and has been active in the Air Force's aerospace medical program ever since.

Thurman A. (Tim) Glasgow hails from San Marcos, Texas and attended Southwest Texas State University before entering the Air Force in December 1941. Tim became an Aviation Cadet in January of 1943 and was commissioned a 2nd Lt. in January 1944. He was a B-24 driver with the 15th Air Force in Italy and chalked up 48 combat missions. Some of the Air Force assignments he's held are: Assistant Director of Information, U. S. Air Force Academy; Chief, Public Information, Headquarters United Nations Command, Seoul, Korea; Director of Information, Headquarters Aerospace Medical Division, Brooks AFB, Texas and Chief, Public Information Division, Office of Information, Headquarters Air Force Systems Command, Andrews AFB, Maryland. Among Tim's many decorations are the Silver Star , Purple Heart, Air Medal with two Oak Leaf Clusters and several Commendation Medals. He retired from the Air Force in September 1968 after almost 27 years of service. He is a graduate of the Armed Forces Staff College, Armed Forces Information School and the Boston University Public Relations School for Information Officers. Currently he is Chief, Office of Information, Headquarters Aerospace Medical Division, Brooks AFB, Texas.

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In the fall of 1948 the School of Aviation Medicine held the first symposium on medical problems in space travel, and a few months later in January of 1949 the Department of Space Medicine was created with Dr. Strughold in charge of it. The department was the result of the realization that jet and rocket powered aircraft were taking man into regions so far above the earth that it was physiologically indistinguishable from space.

FATHER OF SPACE MEDICINE

The Air University conferred the title of Professor of Aviation Medicine on Dr. Strughold in 1951 and the title of Professor of Space Medicine in 1958. Because he is still the only man so honored, he is often referred to as the "Father of Space Medicine."

In 1953 Dr. Strughold submitted a project to the research council of the School of Aviation Medicine to build what was called at the time a sealed cabin. It was approved and about a year later the School had the Air Force's first sealed cabin for the study of artificial atmospheres and means of maintaining them within physiologically acceptable limits. The device was called a space cabin simulator.

The first experiments with man lasted eight hours and were later increased to 24 and then to 48 hours. It was not until 1958 that everyone concerned felt they were ready to expose man to a full eight days or the time calculated as enough to reach the moon and return. The experiment, with a young airman by the name of Farrell as the subject, attracted great interest across the nation. The Senate Majority Leader, Lyndon B. Johnson, was present to congratulate the School and Airman Farrell when he emerged from the cabin at the conclusion of his simulated moon trip. There had been considerable pressure from various sources to use a dog instead of a human for the first experiment. Knowing the value and power of public opinion as he does, Dr. Strughold has often remarked, "I doubt that Lyndon Johnson would have been there to shake hands with a dog, and his interest and presence gave impetus to the program that was needed in those early days."

During the next few years the Department of Space Medicine laid the groundwork for medical studies to support the man in space program which enabled this nation to proceed rapidly once the space program was officially approved. The first studies of many of the problems of environmental effects, weightlessness, and life support got their start in this department under the guidance of Dr. Strughold.

From 1957-1962 Dr. Strughold held the position of advisor for research to the commander of the School of Aviation Medicine at Randolph Air Force Base and later to the commander of the Aerospace Medical Center when it was formed at Brooks Air Force Base in 1961.

Dr. Hubertus Strughold and the Udet Flamengo aircraft in which he flew his experiment with his posterior anesthetized.

The Aerospace Medical Center was transferred to the Air Force Systems Command in 1962 and became the Aerospace Medical Division. Dr. Strughold became Chief Scientist of the new organization. He held this position until his retirement in September 1968.

QUENCHED MOUSE'S THIRST

In spite of the fact that he thinks, eats, and sleeps aerospace medicine, he has an unquenchable human interest in the world around him. This is characterized by an incident that happened at a very small gathering of his friends in a dinner club that Dr. Strughold frequents. He and his guests were seated on a sofa when one of the guests observed him take an ice cube from his drink and slide it under the sofa. The guest inquired as to why he was doing this when he saw him repeat it a few minutes later. Dr. Strughold explained in all seriousness that he had observed a mouse that lived under the sofa and that although the mouse could get food in the form of crumbs from the floor, there was no way for him to get water. When the ice cubes melted, they would provide him with a source of water.

The author of over 180 technical papers, Dr. Strughold has also authored a book titled "The Green and Red Planet: A Physiological Study of the Possibility of Life on Mars." He has also co-authored a textbook "Principles of Aviation Medicine" and has co-edited several books having to do with aerospace medicine and related subjects. Dr. Strughold is responsible for many of the terms accepted and used in aerospace medicine today. Such terms as bioastronautics, which concerns itself with the effects of space travel upon the astronauts; gravisphere, the area within which the gravitational field of a body is dominant; astrobiology, the study of the forms and phenomena of life on celestial bodies; to mention a few.

Although he has been retired for just over a year, he carries the title of Professor Emeritus and still lectures at the School of Aerospace Medicine. He is presently working on a book that is almost complete - "You and Your Body Clock" - which treats the effects of travel across time zones and in space on the body clock.

Dr. Strughold claims that the appearance of Halley's Comet in 1910 launched him on his career in aerospace medicine and he hopes to continue to contribute to his chosen field until it reappears in 1985.

Dr. Willy Ley, left, famous science writer visited Dr. Strughold at the School of Aviation Medicine in June 1957. The chamber in the background is the one in which Airman Farrell made his simulated eight day trip to the moon.

The Use of Meteorological Satellites in Southeast Asia Operations

by Henry W. Brandli

A typical northeast monsoon. In Southeast Asia during the northeast monsoon North Vietnam was mostly covered with low clouds. The weather pattern resembled a "wind sock" and the weather behaved as if clouds and moisture were sucked in off the South China Sea into the Panhandle of North Vietnam. The above DMSP visible imagery clearly shows the effects of the northeast monsoon on SEA.

DURING the height of the bombing mission by the United States Navy and Air Force throughout Southeast Asia, weather satellites were invaluable. In a CBS television interview in the late 1960s, Gen. William Momyer, Commander of the Air War, stated that meteorological satellite usage in Southeast Asia operations was among the most significant innovations of the Air War.

Sparse Southeast Asia (SEA) Weather Sources

The weather reporting network in Southeast Asia was sparse, at best. The U.S. was denied use of any weather reporting station the enemy had by their falsification of observations, not reporting at all, or coding the data. Other weather sources included debriefing by fighter/bomber pilots as well as special reconnaissance flights. But both of these methods were used with doubt because the observations were obtained under duress (enemy aircraft fire, ground fire, and SAMS—and sometimes all three). In addition, the seasonal monsoon weather pattern added to the meteorologist's forecasting problems.

The use of meteorological satellite imagery was the primary observational and short-term forecast tool to provide the environmental data needed to carry out a major part of the military effort, especially the Air War.

The need for a nearly cloud-free environment was never so much a premium as in the Air War in Vietnam. Precision bombing in the north necessitated Navy and Air Force fighter-bombers acquiring the target visually from an altitude of 15,000 feet. On their way to the northern targets from bases in Thailand, Air Force fighter-bombers required air-to-air refueling. Occasionally, a Navy aircraft also needed fuel from the KC-135s.

The tanker fleet flew tracks over Southeast Asia that also depended heavily on a cloud-free environment at the refueling altitude. Turbulence at the fuel flow altitude was important as well.

Gunship missions, strafing, napalming, and rescue missions also relied on good low-level weather. Modern air systems such as TV bombs, laser devices, and other sophisticated electronic weapons could be hampered by intervening weather.

During the Vietnam War, meteorological satellite use in Southeast Asia was vital to United States as well as ARVN operations, although little publicity was given this space-age product. The dissemination of the imagery naturally was restricted, although meteorological information derived from the photos was relayed throughout Southeast Asia for operational use via the telecommunications network.

Satellite Types

There were a variety of meteorological satellites used in Southeast Asia in the 1960s and the early 1970s. The U.S. Weather Bureau, now the National Weather Service and NASA satellites had Automatic Picture Transmission (APT) after December 1963 and could be utilized by anyone who had VHF-receiving equipment. These satellites were sun synchronous, taking photos at nearly the same local time each day. Data was available from 0700 to 0900 and from 1100 to 1300.

Weather satellite data used in early Southeast Asia operations were acquired at Ton Son Nhut Air Force Base, South Vietnam, and Udorn Air Force Base, Thailand. The United States Navy also had satellite readouts on board some of their aircraft carriers. (Recent evidence has indicated that the Chinese and possibly the North Vietnamese also were processing these daytime visual photos.) Sometimes intercepted surface observations reported bad weather when the satellite photos indicated just the opposite. A weather commander commented that this falsification of meteorological information was a violation of the "World Meteorological Organization Code." "What would you do if you were bombed on clear days only?" asked a young satellite meteorologist.

Map of North and South Vietnam. The location of the Thanh Hoa Bridge, a key target in North Vietnam is shown.

Defense Meteorological Satellite Program (DMSP)

In addition to NOAA and NIMBUS, encrypted Defense Meteorological Satellite Program (DMSP) imagery was available to Air Force and Navy meteorologists. The DMSP sun synchronous satellite at an altitude of 450 Nautical Miles (NM) produced day/night visual and infrared imagery at 0700, 1200, 1900, and 2400 local times.

Unfortunately, during much of the early Southeast Asia action, the Navy lagged the Air Force in satellite readout equipment installation and tracking, but this situation was remedied by 1970. The USS *Constellation* was the first carrier to have a shipboard DMSP readout.

The Navy Strikes the Thanh Hoa Bridge

The Thanh Hoa Bridge spans the Song Ma

Site VI, located on Ton Son Nhut AFB, Vietnam, acquired, processed, and relayed all satellite data from the Department of Defense, National Oceanic and Atmospheric (NOAA) as well as National Aeronautics and Space Administration (NASA) vehicles. The NOAA and NASA Automatic Picture Transmission (APT) "birds" were acquired by the TRK-1 mobile van. The Defense Meterological Satellite Program (DMSP) imagery as well as the APT data was microwaved to the Seventh AF Command Post and Military Assistance Command Vietnam (MACV) (before 1967). The imagery could be processed at Site VI in case of microwave failure. The WWV antenna was used for time checks.

River in North Vietnam and is located three miles north of the town of Thanh Hoa, the capitol of the Annam Province. This bridge was a replacement for the original French-built bridge which was destroyed by the Viet Minh in 1945.

The new bridge at Thanh Hoa was 550 feet long, 56 feet wide, and about 50 feet above the river. The bridge had two steel thru-truss spans which rested in the center of a massive reinforced concrete pier 16 feet in diameter and on concrete abutments at the ends. This giant bridge would prove to be one of the single, most challenging targets for U.S. air power.

On 17 June 1965, the United States Navy began a three-year effort to destroy this bridge. Primary attack aircraft used by the Navy against the Thanh Hoa Bridge included A-4 Sky Hawks, A-7 Corsair 2s, A-6 Intruders, F-4B Phantoms and, on occasion, A-3B Sky Warriors and F-8 Crusaders. These planes delivered vast amounts of ordnance on the bridge in an effort to deny its use by North Vietnamese trains and trucks. Using visual as well as radar bombing techniques, the Navy had succeeded in shaking only the steel girders. The approaches to the bridge, however, were battered to the point where according to one Navy official, "the general area looked like the valley of the moon."

The proximity of the Thanh Hoa Bridge to the Gulf, some 11 miles inland, together with the normal weather patterns over the northern part of North Vietnam, combined to provide very low, very poor weather over the target area much of the year. Low cloud ceilings and fog greatly hampered their operations against the bridge. Smoke from burning fields and a continual haze were additional hazards in trying to locate and destroy the bridge. In some seasons of the year, poor weather permitted only two to four visual attacks per month. This, of course, worked to the enemy's advantage inasmuch as he was able to carry out a great deal of repair work and thus keep his lines of communication open for a long period of time.

Meteorological satellite data was used to tell the target planners just when the weather would break. It was used very effectively in the latter part of the 1960s with improved day and night sensors. Night visual cameras on board the Department of Defense's satellite could pinpoint burning rice paddy fields and thus warn pilots ahead of time what the extent of smoke or haze coverage might be.

This nighttime visual capability of the DMSP also was greatly used in locating simultaneous thermal views of Southeast Asia that showed different cloud-top levels and breaks in clouds at nighttime.

Son Tay POW Raid

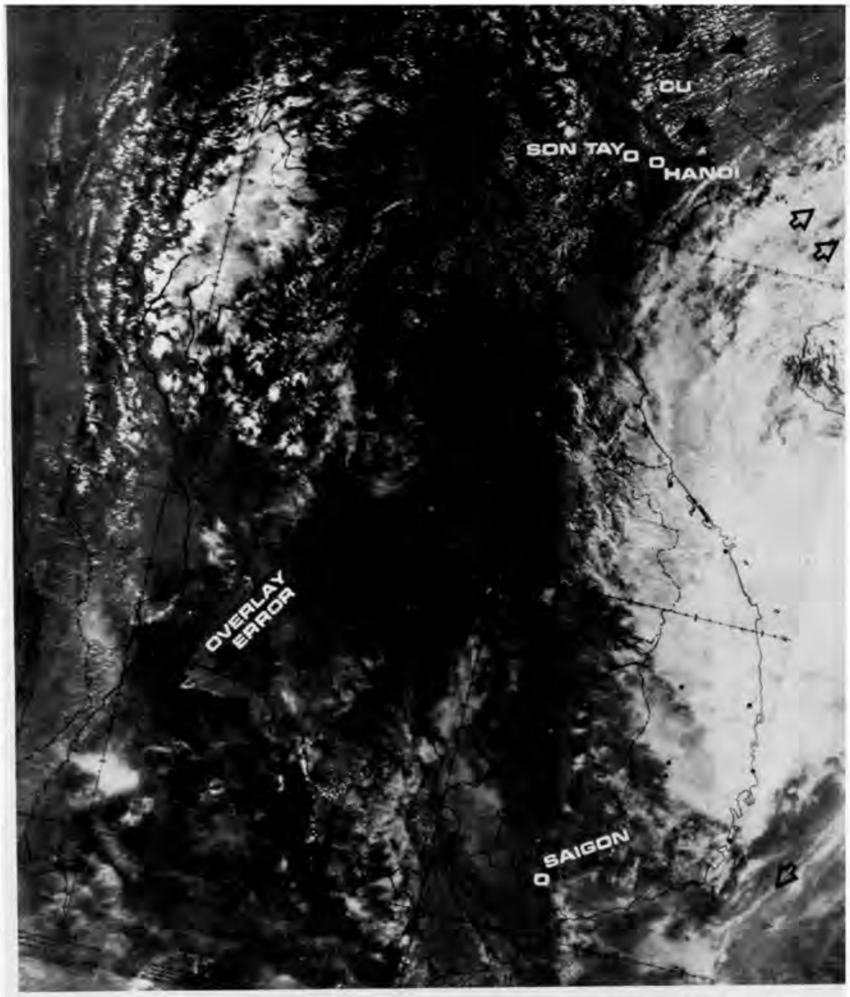
One of the most publicized operations in Southeast Asia was the attempt to rescue POWs from Son Tay in 1970. The most ideal weather situation occurred during that operation. When a typhoon or tropical storm approached the South China Sea from the east, the northeast low-level flow preceding the storm caused clearing weather in North Vietnam. During the Son Tay raid, this situation permitted a highly accurate three- to five-day forecast, based on the storm movement.

Satellite typhoon intelligence also was relayed to the Joint Typhoon Warning Center (JTWC) commanded by the U.S. Navy at Guam for incorporation into their data base. Site VI data was geographically gridded and analyzed. Typhoon eye description, location, and size were relayed to the JTWC. Guam acquired their own DMSP site in the early 1970s.

*The **Mayaguez** Incident*

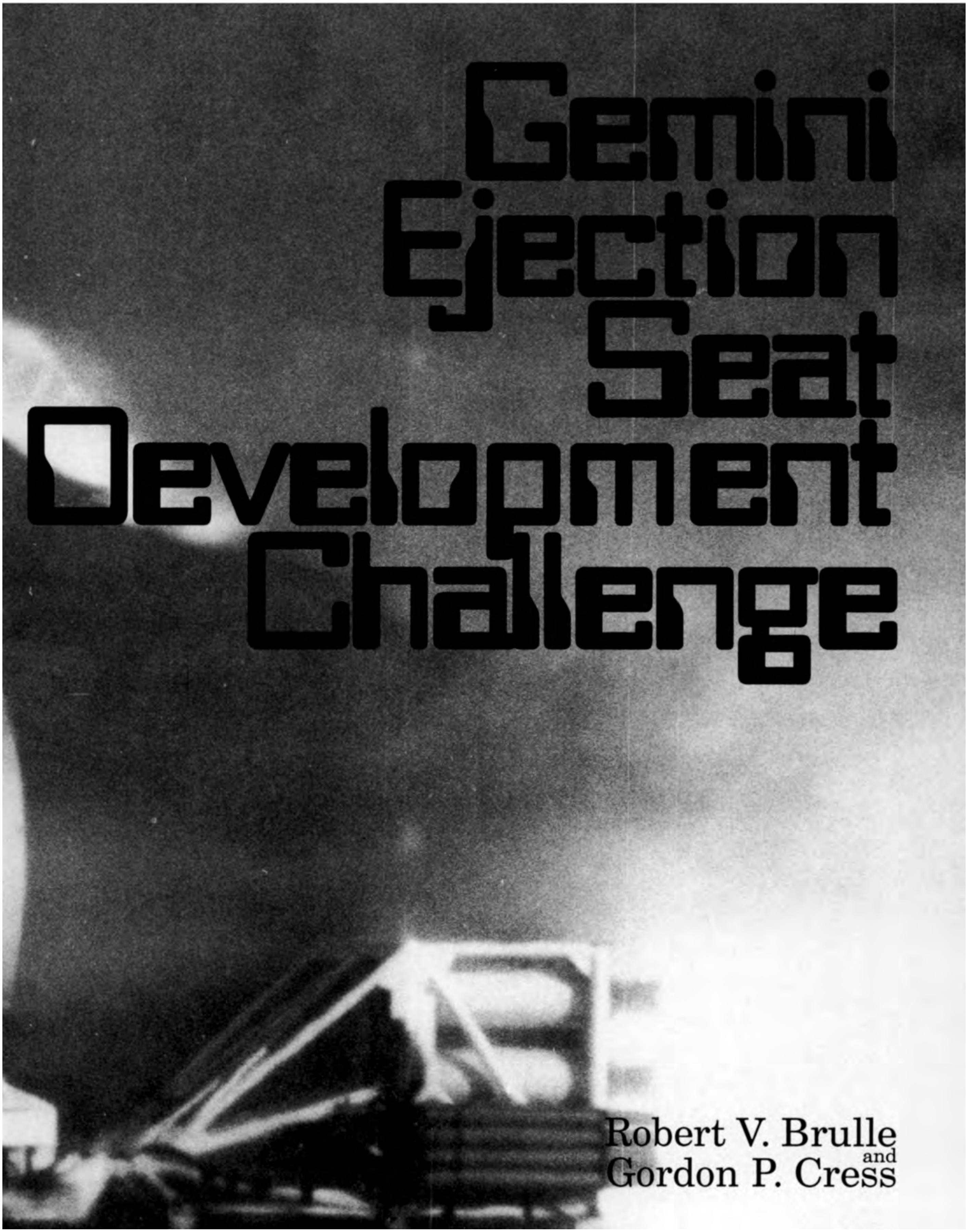
Well after the Vietnam war was concluded, weather satellites played another important use in Southeast Asia with the capture of the *Mayaguez* by the Cambodians in May 1975. President Ford was faced with a difficult decision because the *Mayaguez* was being kept off Kon Tang Island approximately 10°, 20 minutes north; 103°, 10 minutes east. (The only surface observations were from Thailand.) As always, the meteorological satellite was the most powerful weather observing tool. The DMSP site at Nakhon Phanom in Eastern Thailand played a very large and significant role in the weather support to the complex and sensitive Mayaguez recovery operations. As we all know, the Marines stormed the Island. Tactical Air refueling areas were moved on 14 May as the result of DMSP satellite photography. Also, decisions were made to recover some damaged helicopters on the Thai mainland rather than ditch in the sea. This was possible because there was no significant weather along the route as verified by the daily visual photographs.

In summary then, throughout the Vietnam conflict and even after the war, the weather satellite proved to be a valuable tool in supplying much needed weather information in an area that was nearly devoid of the conventional weather stations that we enjoy here in the United States. In future conflicts, weather satellite information will, once again, be a prime weather source wherever the conflict may be.



The above very high resolution DMSP photo shows the weather during the famous raid on the prisoners of war camp in Son Tay, North Vietnam. A typhoon in the South China Sea provides the most favorable weather in the Hanoi region because of the low level north "drying flow" produced. The forecasting and recognition of tropical storms using satellite data enables 2- to 3-day forecasting of good weather in the Red River Delta region of North Vietnam.

Henry W. Brandli is an Operational and Research Satellite Meteorologist. He holds M.S. degrees in both meteorology and aeronautics-astronautics. He is a retired lieutenant colonel from the USAF (1976) where he served as a satellite meteorologist. He is the author of over 50 technical articles, has co-authored the prestigious *Manual of Remote Sensing*, and has authored *Satellite Meteorology*, published by the Air Force. Brandli is considered one of the foremost authorities in the interpretation of environmental satellite data.



Gemini Ejection Seat Development Challenge

Robert V. Brulle
and
Gordon P. Cress

(Overleaf) Double seat ejection from the boilerplate spacecraft hurtling down the test track. *(Photo courtesy of Gordon Cress.)*

WE WERE CONCERNED ABOUT THEM AND DIDN'T WANT TO USE THEM EXCEPT AS A LAST RESORT

"We (the Gemini astronauts) were concerned about them and didn't want to use them except as a last resort." This quotation from Gemini astronaut Tom Stafford was in response to the question, how he felt about using the Gemini ejection seats to abort from a malfunctioning booster.[1] His answer exemplifies the sentiments of not only the astronauts, but also the designers and builders of that unique abort system. The rationale for that feeling will become apparent as this article is read.

The proposal to use the ejection seats as the astronaut escape system for the two-man Gemini spacecraft was greeted with incredulity and skepticism. It was unimaginable that an ejection seat could safely propel an astronaut 1,000 feet—the initial guess—away from an exploding booster. Ejection seats were, of course, common in the jet fighters of that era, but none had the capability of safe ejection at supersonic velocities or at a zero altitude and velocity. Unimagineable or not, the task was initiated with the admonishment to find a way to make it work. For the authors, as part of the team assembled to accomplish this dubious task, it was one of most challenging assignments undertaken in their engineering careers.[2]

Mercury, the first manned U.S. spacecraft, was built by McDonnell Aircraft in St. Louis, Missouri. It was a small one-man conical shaped vehicle that stood 9.5 feet high and had a 6-foot diameter base. With its 1,200-pound escape tower/motor system, it weighed 4,200 pounds. Two suborbital manned flights of 250 miles by astronauts Alan B. Shepard and Virgil I. Grissom during the summer of 1961 qualified all flight systems for orbital flight. Marine Lt. Col. John Glenn squeezed into a Mercury spacecraft he had named Friendship Seven, and accomplished the first U.S. orbital flight on February 20, 1962. This flight lifted the spirits of all Americans distressed by the Soviet Union's large space flight lead. The Soviets had already twice orbited cosmonauts in their heavy 10,000-pound Vostok spacecraft. They were also well along in their development of the two-man Voskhod spacecraft, which would beat Gemini into orbit by six months.

THE GEMINI SPACE-CRAFT, ONLY 20 PERCENT LARGER THAN MERCURY, WAS A TIGHT FIT FOR TWO PERSONS

The effort involved in designing and testing the Mercury spacecraft was unique and presented engineering problems never before explored. Of these, man-rating the booster and providing an escape system to assure crew survival under all possible mishaps were the most crucial. The critical challenge was getting the crew away from an exploding booster just at liftoff. The Atlas missile booster, used for orbital flight, burned a mixture of hydrocarbons (kerosene) as a fuel called RP-1 with liquid oxygen as the oxidizer. The resulting fireball and blast wave was spectacularly violent, as proved by several Atlas boosters that had malfunctioned during development and testing. Mercury crew survival provisions consisted of an escape rocket mounted on a tower above the spacecraft. The escape rocket had three canted nozzles that directed the rocket exhaust away from the spacecraft. In the event of a booster malfunction, the spacecraft would be explosively separated from the booster and the escape rocket ignited to tow the spacecraft a safe distance away. A normal parachute deployment, water landing, and recovery by the U.S. Navy would follow. During a normal flight, the escape tower was jettisoned a few minutes into the flight when the blast wave danger had passed.

The Mercury escape system was complicated by being completely automatic. This feature generated anxious moments several times during launch, when booster engine pressure spikes occurred that exceeded the threshold for triggering escape system initiation. Fortunately, they were of short duration, which prevented aborting from an otherwise normally operating booster.[3] The massive weight of the tower/rocket motor, coupled with a complicated automatic system, spurred the search for a lighter and simpler system to be used in the follow-up two-man spacecraft first called Mercury Mark II. It shortly acquired the apt name of Gemini after the zodiac constellation, the Twins. The main objectives of Project Gemini were to develop rendezvous techniques and docking procedures. Design effort on Gemini was initiated in the spring of 1961.[4]

The Gemini spacecraft, only 20 percent larger than Mercury, was a tight fit for two persons.[5] It was conically shaped like Mercury and stood 12.5 feet high with a base diameter of 7.5 feet. It had

During World War II Robert V. Brulle flew seventy combat missions as a P–47 pilot, 366th Fighter Group, 390th Fighter Squadron. He earned BS and MS degrees in aeronautical engineering and had various aviation and space assignments as a university professor, research engineer, and project engineer. He retired from active duty in 1957 and then from the USAF Reserve as a lieutenant colonel in 1968. From 1957 to 1983, Mr. Brulle worked for McDonnell Douglas in missile aerodynamics and on projects Mercury and Gemini. He spends his time writing about his aviation and space experiences. Several of his articles have been published in various publications including Air Power History.

Gordon P. Cress has been in the escape system field for more than thirty years and presently works for Lockheed Martin as team leader on the F–22 escape system. During his twenty-five years with Weber Aircraft, he participated in the design, development, test, and qualification of several major escape systems, and was a project test engineer on the Gemini Escape System. He published "The YF–22 Articulating Ejection Seat" in the Proceedings of the 1994 SAFE Association Symposium.

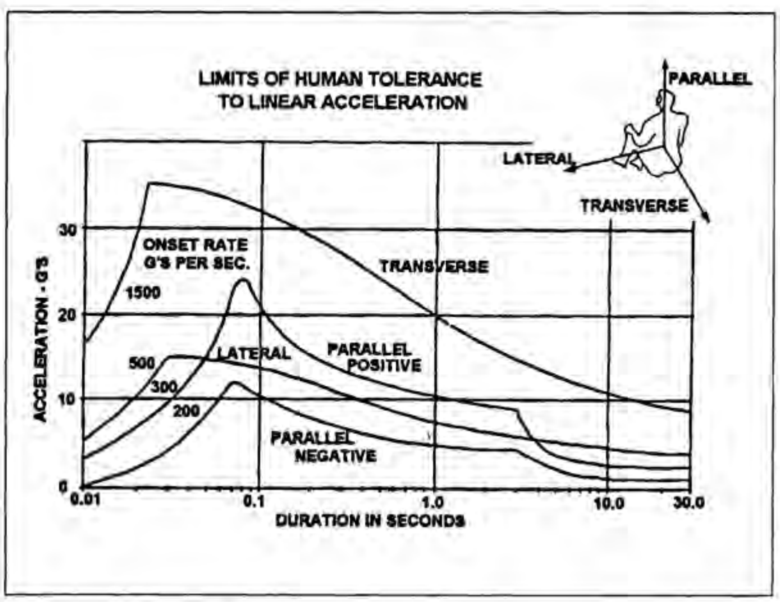
two conical sections called adapters attached to the base. One, the retro adapter, housed the retro rockets; the other, the equipment adapter, housed the extended orbit expendable supplies. Both adapters were jettisoned before reentry. Spacecraft launch weight was 8,400 pounds.

A modified Titan II rocket launched Gemini into orbit. The Titan II used a hypergolic (self-igniting) fuel of UDMH2, a blend of hydrazine and unsymmetrical dimethyl hydrazine, with nitrogen tetroxide as the oxidizer. The catastrophic mixing of the fuel and oxidizer caused a rapid burning (deflagration), instead of an explosion. This created a less severe blast wave and fireball than that encountered with the Atlas fuel of RP-1 and liquid oxygen. This supported the view that ejection seats were possible for crew escape, thus eliminating a weighty escape tower. Also proposed was the use of an inflatable controllable Ragallo wing, called a paraglider, for landing. It would deploy after reentry and allow the astronauts to land their spacecraft on retractable skids at an airport, rather than in the water. Ejection seats also provided a means of escape in event of a malfunctioning paraglider.[6] It should be noted that the paraglider was dropped from consideration midway in the program due to development problems, and a Mercury-type parachute with a water landing was substituted.[7]

WE WOULD DO OUR BEST TO PROVIDE A REASONABLE PROBABILITY OF CREW SURVIVAL ... BUT WE COULD NOT GUARANTEE SAFETY UNDER ALL CONDITIONS

This article describes the struggle to design, develop, and qualify the Gemini crew ejection seats. It was a challenge that taxed our engineering talents and greatly advanced the state-of-the-art in ejection seat design. Although the article is arranged in roughly chronological order of completion, the process was iterative, so all jobs were, more or less, worked on simultaneously. Crew safety was of paramount importance, but a realistic attitude pervaded both the corps of astronauts and the engineers: space flight was dangerous and casualties were bound to occur. Our philosophy was that we, as engineers, would do our best to provide a reasonable probability of crew survival in a catastrophic occurrence, but we could not guarantee safety under all conditions. This philosophy remains in effect today.

Figure 1.



Ejection Seat Criteria

The first challenge was to define the ejection seat criteria, that is, what the ejection seat had to do. We knew it had to propel the astronauts away from a malfunctioning booster, but how far and how fast, and to what flight altitude and velocity? Numerous studies were conducted to define those parameters and are narrated in this section.

Booster Debris Avoidance

Getting away from the booster debris caused by an in-flight malfunction was the first issue tackled, even as the debate raged between escape tower and ejection seat advocates. Tower advocates saw no solution to getting the ejection seats away from the debris pattern raining down from the point of malfunction. The debris pattern was postulated as an expanding cylindrical envelope lying in the plane of the trajectory, and was assumed to consist of debris of all sizes, shapes, and weights—all having different rates of fall. A postulated two-second time delay between booster malfunction and ejection exacerbated the problem since booster breakup would be above the ejected astronauts.

It was initially postulated to have the Gemini astronauts launched into orbit oriented the same way as in Mercury, i.e., with the astronauts sitting upside down in the trajectory plane. This meant that if they ejected during launch phase they would remain in the plane of the booster trajectory and be within the falling debris field.[8] The solution was a simple design change of turning Gemini 90 degrees on the booster so the astronauts would be inserted into orbit sitting sideways. The seat ejection would then be at nearly a right angle to the launch plane, hurtling the astronauts away from the debris plane. Thus, a simple design change eliminated the debris problem.[9]

Ejection Accelerations

Safe ejection accelerations were based on the human tolerance acceleration limits postulated by Dr. Mike Rickards, Weber Aircraft Co., and are shown in Figure 1.[10] This plot shows that the human body can withstand high accelerations, if their application time is short. It was understood that these limit accelerations were for human bodies restrained in perfectly contoured couches, and even then some injury was possible. The seat catapult and rocket motor thrust were tailored to follow very closely the parallel-positive (upward) acceleration limit of Figure 1. (A detailed discussion of the seat catapult and rocket motor is presented later.) Designing the seat to the human body limit accelerations was a design gamble, but was necessary to escape from an on-the-pad booster deflagration.

CALCULATIONS SHOWED THAT A BOOSTER MALFUNCTION ON THE LAUNCH PAD WOULD RESULT IN A FIREBALL 610 FEET IN DIAMETER

Deflagration Fireball

Getting away from a booster deflagration just at liftoff proved to be the design criteria for the ejection seat rocket motor. A deflagration fireball was established by extrapolating data of hypergolic propellent reactions tested by the Naval Ordnance Laboratory.[11] Calculations showed that a booster malfunction on the launch pad would result in a fireball 610 feet in diameter, which would have a radiant energy of 108 million BTUs, and last for 12 seconds.[12]

This design fireball led to the requirement that the seat rocket motor had to eject the astronaut to 400 feet from the booster at 3.5 seconds after ejection initiation. These figures were arrived at after many analyses and tests of astronaut reaction time, number and type of abort cues required, and iterations on types of failures that could occur. Parachute deployment would occur at 3.5 seconds, and being 400 feet from the fireball would prevent the deploying parachute from melting. This requirement led to the development of the largest rocket motor ever installed in an ejection seat.

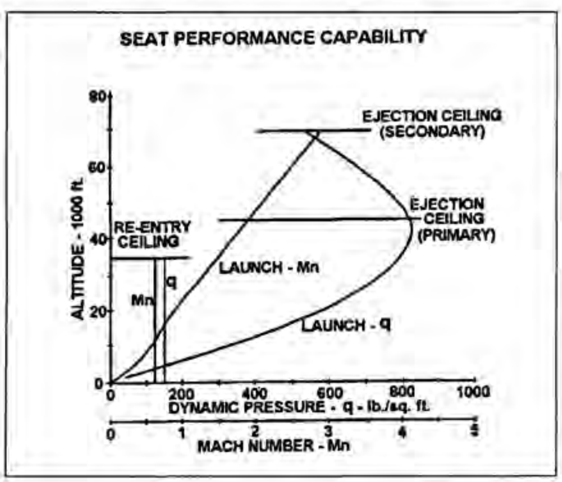
High Altitude Ejections

A FREE FALL FROM HIGH ALTITUDE IS AN EXTREMELY DANGEROUS UNDERTAKING

High altitude supersonic ejections require the astronaut to wear survival and life support equipment. The astronaut must be encased in a pressure suit that can withstand an aerodynamic heating pulse of about 660° F at a Mach 3 ejection. He must also be provided with oxygen and be thermally protected to survive a free fall of about five minutes through a subzero temperature of minus 70° (-70° F). Those requirements were levied on the pressure suit provider.

Ejections at high-altitude also require that the astronaut delay parachute deployment until he reaches a denser atmosphere, preferably below 15,000 feet. This is an absolute requirement as deploying a parachute at high altitude would, most likely, destroy the parachute and/or kill the astronaut from the opening shock. If he somehow survived the opening shock, he stood a good chance of freezing to death during the long, slow descent through the subzero temperatures.

Figure 2.



A free fall from high altitude is an extremely dangerous undertaking. In 1959, USAF Capt. Joseph W. Kittinger performed several high altitude jumps from a balloon ranging from 76,000 to 112,000 feet.[13] The greatest hazard Kittinger encountered, during the long free fall, was getting into a back-first flat spin. This flat spin is violent enough to render a person unconscious, as happened to Kittinger on one of his first jumps. Fortunately, while he was still unconscious, the automatic reserve parachute deployed correctly at 10,000 feet.

To prevent a flat spin, an astronaut must have a stabilization device that will keep him in an upright position so a flat spin cannot occur. Kittinger used a small stabilization parachute, but started his free fall from zero velocity. Some type of stabilization would have to be developed that could be safely deployed at Mach 3 and provide adequate stabilization throughout the long free fall. The stabilizer selected was the Goodyear Ballute. The design and testing of that device is covered later.

Mach Number and Dynamic Pressure

Mach number (Mn) and dynamic pressure (q) are both related to the flight velocity and are critical design parameters for computing ejection seat aerodynamic forces. Launch phase design values of Mn and q were determined by calculating the dispersion probability of the launch trajectory, and selecting the trajectories that provided the highest Mn and q envelopes. A tumbling spacecraft produced the highest Mn and q values for reentry. The selected design values are shown in Figure 2.

During launch the ejection seats were the primary mode of escape (abort) up to 45,000 feet. Above that to 70,000 feet, a ride-it-out abort mode was primary and ejection seats secondary. The ride-it-out abort mode implied that the astronauts would remain in the spacecraft in event of a malfunction. They would manually shut down the booster engines, if applicable, and remain attached to the booster until it was safe to separate the spacecraft and land normally. The spacecraft provided excellent protection from an inflight fireball, small debris, and the hostile environment. The ride-it-out abort mode was instituted late in the program for several reasons, but primarily because engineers had no confidence in the space suit to provide adequate astronaut protection during a high-altitude, high-Mach number ejection.[14]

Analyses and Design

Seat/Man Aerodynamics and Trajectories

Ejection seat trajectories of all possible abort conditions were required; these would, in turn, define many other design parameters. Aerodynamic forces and moments for use in trajectory calculations were obtained from a series of wind tunnel tests of the seat/man configuration. These spanned a range of Mach numbers from 0.5 to 3.5, and a complete range of angle of attack on all three axes. Additional limited angle of attack testing was conducted of the seat/man in proximity of the spacecraft and with a simulated seat rocket motor exhaust.[15] This was the first set of seat/man aerodynamic data ever collected over a complete range of tumbling attitudes and supersonic Mach numbers.

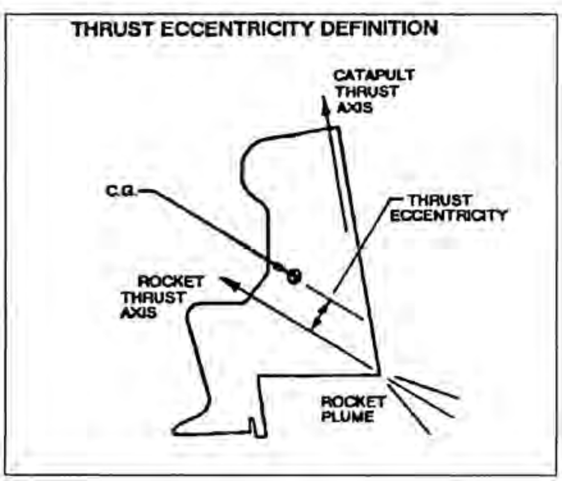
The ejection seat trajectory study utilized a six-degree-of-freedom computer program incorporating the full spectrum of aerodynamic data collected during the seat/man wind tunnel tests. Many variables had to be considered, such as initial ejection conditions of spacecraft altitude, velocity and rotational rates, seat/man weight, wind, variations in the seat rocket/catapult thrust, seat/man center of gravity (c.g.) location, and a host of others. The studies confirmed that getting away from the fireball was indeed the critical condition, and was most critical just at liftoff, denoted as an off-the-pad ejection.

ENGINEERS HAD NO CONFIDENCE IN THE SPACE SUIT TO PROVIDE ADEQUATE ASTRONAUT PROTECTION DURING A HIGH-ALTITUDE, HIGH-MACH NUMBER EJECTION

Ejection Rocket/Catapult

Seat ejection employed a rocket/catapult (RoCat), which was mounted in the back along the vertical centerline of the seat and consisted of two distinct parts, the catapult and the rocket section. The catapult forced the seat, restrained on the rails by three sets of rail sliders, upward and off the guide rails. As the seat left the rails, the rocket was ignited, propelling the seat away from the spacecraft.

Manufactured by Rocket Power, Inc., of Mesa, Arizona, the RoCat was the largest ejection seat rocket ever produced. The RoCat provided the attachment between the seat and the spacecraft, being mounted to the spacecraft at the bottom and providing the attachment to the seat structure at the top. The RoCat provided the required thrust to achieve a safe recovery trajectory, yet maintained accelerations that were within the limits of human tolerance shown in Figure 1. The initial catapult thrust created an onset rate of nearly 300 g's per second, based on a 15-percentile seat/man weight of 370 pounds, and peaked at 20 g's.

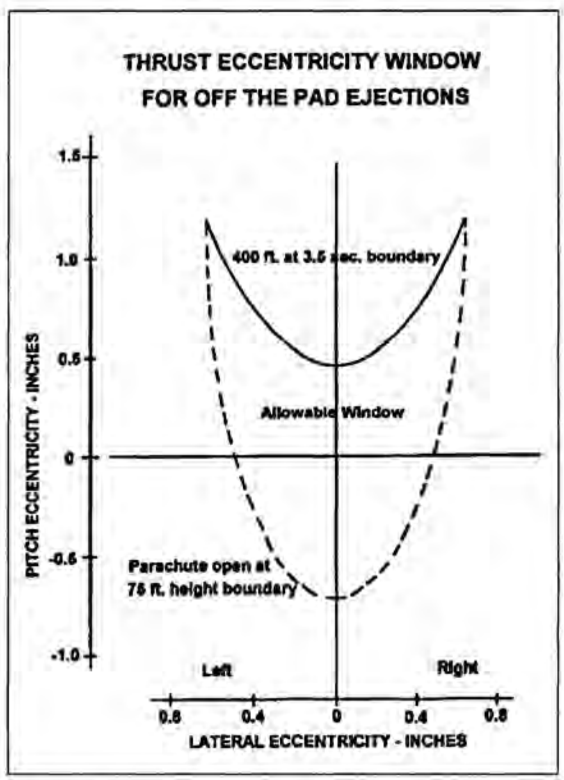


(Near right) Figure 3.

Eccentricity Window

Catapult thrust, the axis being well to the rear of the seat/man c.g., induced a forward tumbling motion to the seat/man as it left the rails. (See Figure 3.) The rocket thrust had to counteract that initial forward tumble, yet not induce an appreciable backward tumble before the rocket burned out. The relationship between the rocket thrust axis to seat/man c.g. (referred to as thrust eccentricity) was a very critical and sensitive parameter, and required a detailed engineering analysis to arrive at the allowable eccentricity window.

The allowable eccentricity window had a shield shape as shown in Figure 4. The area within the shield denotes the allowable eccentricity for safe off-the-pad ejections, defined in a pitch and lateral sense. Note that it allowed about 0.5 inch c.g. tolerance in both lateral and pitch eccentricities. The upper boundary was established by the requirement that the astronaut be 400 feet away from the Titan II booster at 3.5 seconds after ejection. That was when the parachute deployed, and a distance of 400 feet was needed to prevent the material from melting. The remaining boundary signified the points where the parachute was fully open and the astronaut was at a height of 75 feet and had decelerated to a velocity of 30 feet per second. The remaining 75 feet was allocated for decelerating to a safe 20 feet per second landing.



(Far right) Figure 4.

Since the RoCat thrust axis was fixed, the only way to adjust the eccentricity was to ballast each astronaut's ejection seat to the required c.g. posi-

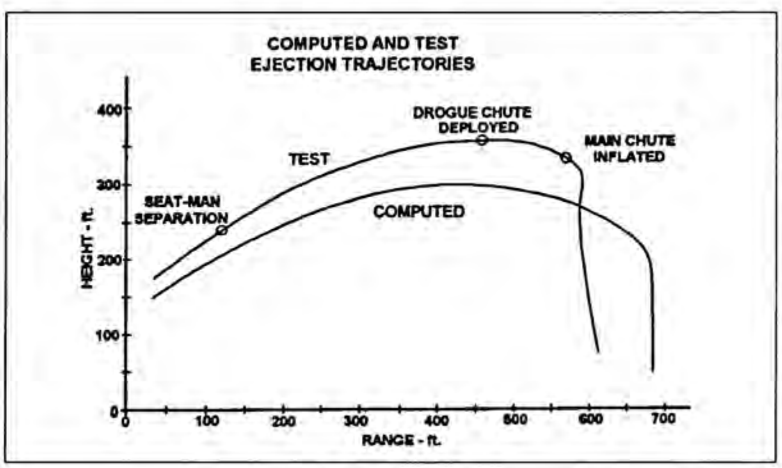
Measuring the vertical center of gravity of astronaut Wally Schirra at Weber Aircraft. *(Photo courtesy of Gordon Cress.)*

THE ASTRONAUT FREE FALL STABILIZATION DEVICE SELECTED WAS THE NOVEL GOODYEAR BALLUTE

tion. So critical was the ballasting that the c.g. change due to body and internal organ slump, caused by the ejection acceleration, had to be accounted for. It required that each astronaut have his own ballasted contour seat so the c.g. during ejection was within the acceptable window. A c.g. outside the window caused the seat to tumble, which reduced the ejection ground distance from the fireball.

Numerous simulated ejections defined the entire operating envelope. Also computed were predicted trajectories for all the ejection tests to allow a comparison between the predicted and test trajectories. Figure 5 presents such a comparison for an off-the-pad ejection. It should be noted that before we reached that level of comparison we experienced many heartbreaks and disappointments. Some of our trials and tribulations are discussed later in the Ejection Seat Tests section.

Figure 5.



Ballute

The astronaut free fall stabilization device selected was the novel Goodyear Ballute (contracted from balloon-parachute). It was essentially a drag balloon and had been under development by Goodyear for several years as a stabilization device for missile payloads.[16] Inflated, it is shaped like a top. The Gemini Ballute had a diameter of 48 inches and a length of 54 inches. It was nylon coated with aluminum for protection against the high heat pulse. After the ejection seat rocket motor burns out, the astronaut is separated from the seat, and if at a high altitude, the Ballute is deployed. Spring loaded inlets allow ram air to inflate the Ballute, stabilizing the astronaut during the long fall.

The Ballute system went through an extensive development and test program to get qualified. There were wind tunnel tests to measure the drag, stability, and deployment characteristics, and for structural qualification. Most of these tests were done in the 16 foot x 16 foot Supersonic Propulsion Wind Tunnel at the Arnold Engineering and Development Center, Tullahoma, Tennessee. There were free fall dummy drops from a C–130 aircraft at the Naval Parachute Facility at El Centro, California, and a long series of live jump tests from as high as 40,000 feet. Many problems arose that questioned the Ballute's suitability to perform its task, the most persistent being the deployment mechanism and its release. Nonstop test and retest, including live jumps, continued almost to the day of the first Gemini flight in March 1965 when it finally was qualified.

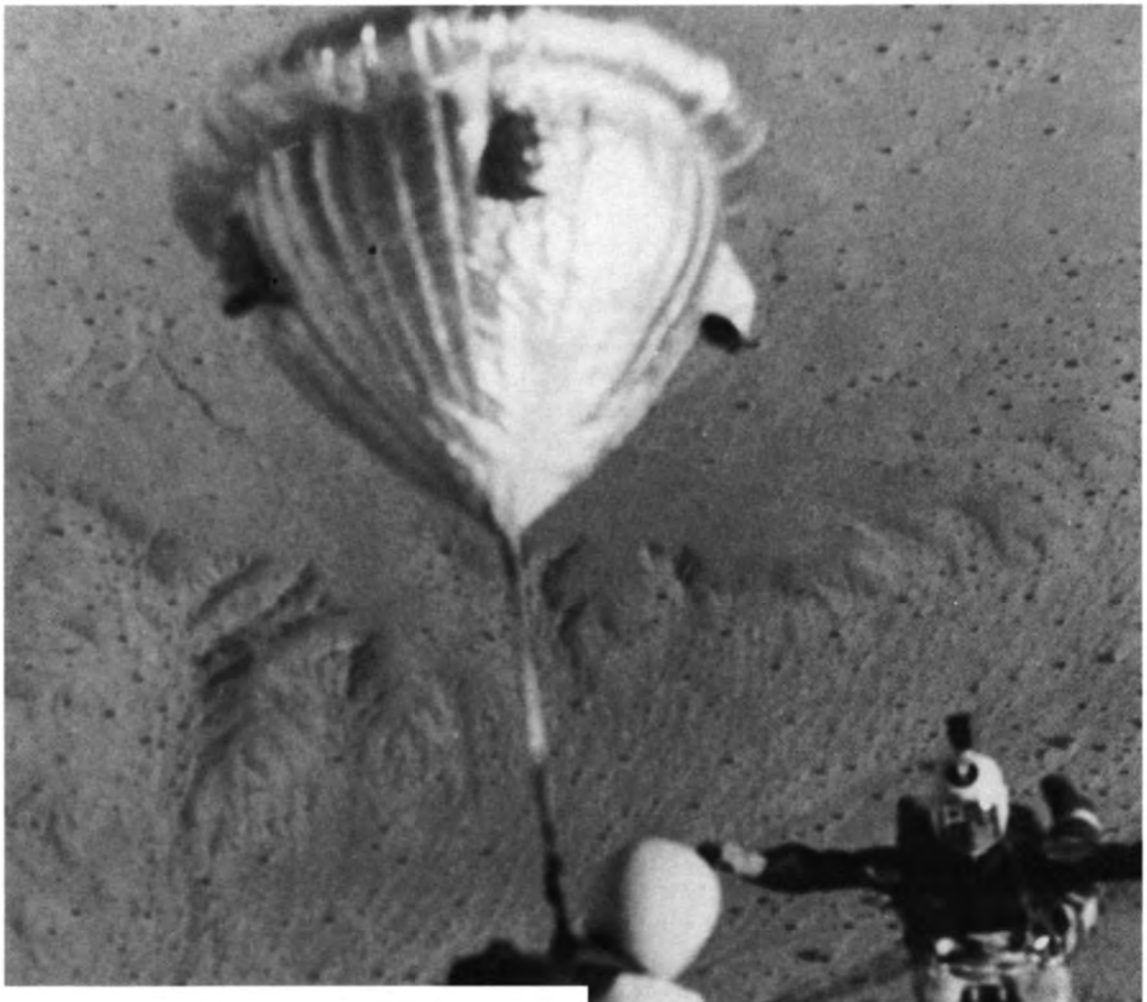
Ejection Seat Design

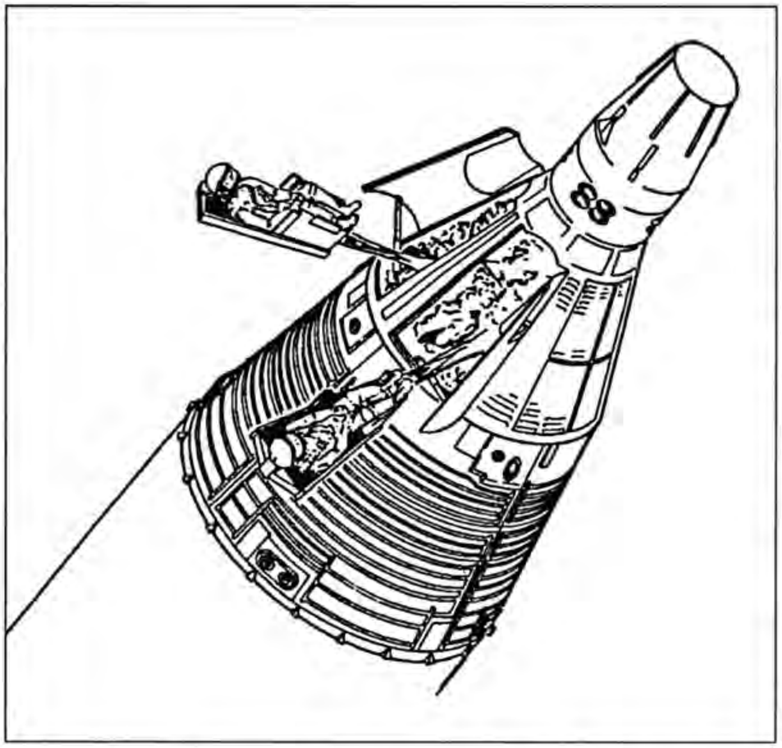
Weber Aircraft Company of Burbank, California, contracted with McDonnell Aircraft in St. Louis to design, develop, manufacture, and qualify the ejection seat escape system for the Gemini spacecraft. McDonnell Aircraft (MAC) and Weber negotiated an unusual contractual arrangement; Weber would function as a division of MAC for this purpose using MAC procedures and drawing format. A cost plus fixed fee contract guaranteed Weber would recover all costs associated with the program and receive a specified fee. This permitted Weber to go ahead with development and testing on an expedited basis without having to get formal MAC approval for every change in task.[17] Weber became a Gemini team member in April 1962, just after John Glenn's first Mercury orbital flight. By that time, preliminary calculations had determined that the ejection seat had to provide an astronaut recovery capability from off-the-pad to Mach 3 at 70,000 feet. It was indeed a daunting challenge even for state-of-the-art technology at that time.

The seat design commenced with the configuration definition, size and shape of the seat, and coordinated that with the Gemini spacecraft and the hatch system. This involved not only the seat, but also included the design and configuration of the spacecraft supporting rails, the interfaces for the pyrotechnic initiation systems, the life support systems and the ejection hatch actu-

(Right) Live jump testing at the Naval Parachute Facility at El Centro, California.

(Below) Gemini ballute checkout. *(Both photos courtesy Loral Defense Systems-Akron).*





Artist's rendition of in-flight ejection. *(Illustration courtesy of McDonnell Aircraft).*

ating systems. It was a difficult design task to meet the weight goals and yet provide the required structural adequacy to withstand ultimate crash loads, landing impact loads, and ejection loads. The seat structure was primarily aluminum with some titanium, steel, and nonmetallic components.

Two T-section rails in the spacecraft provided the support for the seat. Six sliders on the seat, three on each side, were the interfaces between the seat and spacecraft. Each astronaut sat on a hard-surface individually contoured seat, covered with a fire-resistant cloth. The seat bottom surface was the top of the emergency oxygen system for high-altitude ejection. The back surface was the forward face of the assembly called the backboard, which supported the Ballute, personnel parachute, and the survival kit. The survival kit was a hard pack with rigid sides that fit into the right-hand side of the backboard and nestled into the seat structure beside the center-mounted RoCat. The recovery parachute, a gun-deployed drogue chute configuration, was mounted on the left side of the backboard and nestled into the seat structure.

The seat egresses from the Gemini spacecraft through a finite hatch opening. To ensure the astronauts were maintained within the hatch opening envelope, several features were incorporated. Foot stirrups provided the support and retention means for the feet. The boot heels fit directly into the simple tube structure at the lower front of the seat. This ensured that the feet and legs were protected from striking the hatch sill. They also helped to maintain the leg mass position during the critical slump period, and prevent leg flail injuries during high dynamic pressure ejections. Also provided were arm guards on each armrest. These were manually rotated up from their stowage position during the potential ejection phases of launch and reentry. They prevented the elbows from moving out laterally during catapult phase and possibly striking the hatch sill. As with the arm guards, the center-pull escape system ejection control ("D" ring) was out and ready for use only during a potential ejection scenario. The rest of the time it was folded down and out of the way in its compartment and protected by a sliding cover.

A front view of the backboard. Parachute drogue gun is on right side of seat with the barrel canted outboard and ballute pack is on the opposite side. *(Photo courtesy of Gordon Cress).*

EACH ASTRONAUT SAT ON A HARD-SURFACE INDIVIDUALLY CONTOURED SEAT, COVERED WITH A FIRE-RESISTANT CLOTH

Seat Ejection

Seat ejection operation was very simple; just pull either seat ejection "D" ring to eject both seats automatically. The inertial reel automatically retracted the restraining straps, pulling the astronaut to the correct ejection posture, and the pyrotechnic sequencing system started by venting hot gas to the hatch actuators.[18] The hatch actuators unlocked the spacecraft hatches, then opened them. When the hatch actuator reached full stroke and the hatch was fully open, hot gas ignited the seat rocket catapult, moving the seat up the rails. As the seat progressed up the rails, a lanyard was pulled to start the emergency oxygen system flowing. Another lanyard activated the pyrotechnic time delay for seat/man separa-

EJECTION SEAT SEQUENCING

TIME (Sec.)	EVENT
0	Pull "D" ring
0.24	Hatch first full open
0.39	Ejection seat at end of track
0.72	Seat rocket burnout
1.46	Initiation of seat/man separation

A 3/4 front view of the seat with arm guards deployed. Wheels are from a ground handling cart. A temporary recovery chute rests below the seat. *(Photo courtesy of Gordon Cress).*

SEAT EJECTION OPERATION WAS VERY SIMPLE; JUST PULL EITHER SEAT EJECTION "D" RING TO EJECT BOTH SEATS AUTOMATICALLY

tion. Separation was achieved by a pyrotechnic plunger located on the front seat structure. A nylon strap ran from the plunger under the oxygen system and behind the occupant's backboard to its attachment in the headrest structure. When the separator plunger stroked, it activated a mechanical system that released the lap belt and backboard from the seat. It then pulled the strap taut, separating the astronaut and his equipment from the seat structure. Figure 6 presents the ejection seat time sequence of these events.

Above 7,500 feet, the Ballute is deployed for stabilizing the astronaut's free fall, and cut loose when descending through 7,500 feet. At 5,700 feet, the parachute deployment gun fired. After parachute deployment, the backboard and oxygen system are automatically discarded and the survival kit released and suspended below the astronaut with a line to his parachute harness.

Ejection Seat Tests

The seat test program spanned the entire spectrum, from individual parts through the subsystems, and finally the completely assembled ejection seat. The following section narrates the assembled seat program. It provides a glimpse of the trials and frustrations and the continued revisions required to develop the ejection seat. Recall that sophisticated computer simulations, which might today uncover such problems, were not available at that time; in fact, the main frame computer we used for calculations had less capability than today's small personal computer. We were also under a demanding pressure to get Gemini in orbit and to perfect space rendezvous so we could beat the Soviets to the moon. It may sound quixotic now, but we were enjoying every minute of the hectic work schedule. We felt patriotic and good about our work, and enthusiastic about meeting President Kennedy's challenge of putting a man on the moon in the decade of the 1960s.

Pad Ejection Tests

Completely assembled seat system development tests began in July 1962 with pad ejection tests conducted from the 150-foot tower at the Naval Weapons Center, China Lake, California. The first test of an off-the-pad abort condition could be termed a "learning experience." The extremely hot rocket exhaust gases destroyed the lower portion of the seat structure and the test dummy did not separate from the seat. This led to the incorporation of a nonmetallic flame bucket liner to protect the aluminum seat structure from the hot rocket exhaust, and a revision of the seat/man separation system. In the second test the seat/man separation worked correctly. Parachute deployment, however, was not achieved as the spring-loaded pilot chute drag was not adequate to deploy the tightly packed parachute. A gun-deployed parachute system was incorporated to achieve positive deployment of the canopy.

Those first tests also revealed the extreme sensitivity of the rocket thrust/c.g. eccentricity, necessitating a man/seat center of gravity fixture to accurately determine the c.g. Such a fixture was designed and developed and used at the test and launch sites to establish the c.g. location. Additionally, the change in c.g., caused by the body and organ slump in response to ejection accelerations, was large enough to consider it in the c.g. calculation.[19] The measurements and calculations allowed the c.g. to be placed at the optimum distance from the catapult centerline, and be within the thrust eccentricity window during ejection. This assured that the loads, accelerations, and onset rates would be within the human limits presented in Figure 1, and that the seat/man during rocket burn would be stable.

The test program progressed with the seats ejected from a fixed open door boilerplate spacecraft and then a functioning hatch boilerplate spacecraft. Fifteen off-the-pad ejection tests were completed.

An amusing incident occurred when astronauts Frank Borman and Jim Lovell witnessed a test. Of course, the odds of having a major system malfunction at a test are directly proportional to the importance of the observers. This axiom was again proven true. During this twin ejection test, the systems were initiated as programmed. The left-hand seat egressed the vehicle as designed and the test dummy was successfully recovered by

THE TEST DUMMY WAS COCKED TO ONE SIDE WITH ITS HELMET ALL CRUSHED AND CRACKED

YOU WOULDN'T BE INTERESTED IN TRADING SEATS, WOULD YOU?

THE ASTRONAUTS SHOWED GREAT FORTITUDE AND HELD UP EJECTING, SAVING THE MISSION

parachute down range. The right hand seat was another story.

Hot gases generated by pyrotechnic devices drove the hatch actuators. As the hot gases expanded they drove the piston upward, unlatching the hatch and opening it out of the way of the seat path. When the hatch was fully opened, the hot gas in the actuator was vented off to ignite the catapult. The seat then moved up the rails and out of the vehicle past the locked-open hatch. The right hand hatch actuator suffered a malfunction of the o-ring around the piston. This leak allowed the hot gases to escape prematurely and ignite the catapult before the hatch was completely open. The seat smashed into the partially open hatch, jammed the headrest and the dummy's helmet into the hatch structure, and then jammed itself on the seat rails. The rocket-catapult was then essentially in a locked-shut firing condition, which it could not withstand, and exploded, incinerating the inside of the boilerplate (a welded steel mock-up) spacecraft. Burned propellant permeated the whole area. The test dummy, in what was to be Lovell's seat, was cocked to one side with its helmet all crushed and cracked. After we looked at it for awhile, Lovell looked over at Borman and asked, "You wouldn't be interested in trading seats, would you?" Borman allowed as to how he was perfectly happy with where he was assigned and would stick with it. This incident resulted in a hatch actuator redesign and the use of redundant o-rings.

Dynamic Ejection Tests

Besides the pad ejection tests, six dynamic ejection tests were conducted on the Supersonic Naval Ordnance Research Test Track facility at China Lake. These used a boilerplate Gemini spacecraft, a welded steel mock-up aerodynamically similar to the actual spacecraft, mounted on the rocket-powered test sled. Functioning seats and hatches were installed to test and qualify the entire system at high dynamic pressures.

Again, the first sled test was a learning experience. This first test, conducted in November 1962, was just a dry run to gather aerodynamic data and verify the structural adequacy of the boilerplate spacecraft, sled, and pusher systems. It was decided to install two Gemini seats with test dummies in them to validate the operation and function of the telemetry systems, and record occupant accelerations and rotation rates in three axes. After all, it was just a dry run and what could possibly happen?

The test was programmed to achieve a maximum velocity of 1,000 feet per second. Twelve Genie (air-to-air missile) rocket motors, configured in four rows of three motors, drove the sled. The last phase of the sequenced ignition of the motors involved the top center motor. When the top center motor ignited, the pusher sled suffered a structural failure. When the structure failed, the Genie motor came loose and crashed headlong into the aft end of the boilerplate spacecraft. It easily penetrated the 1/2 inch steel simulated heat shield and went right into the spacecraft, where it completely incinerated everything inside. This test resulted in the redesign of the pusher sled and no further incidents of this type were encountered.

Dynamic sled tests finally got underway, with a refurbished boilerplate Gemini, in June 1963 with a dual ejection. The high dynamic pressure of these tests did uncovered some seat structural deficiencies that needed fixing. After a structural redesign and correcting several other system deficiencies, the sled ejection test program was successfully completed in December 1964 by test number 9.[20] It demonstrated the entire ejection sequence and confirmed the structural design under the most severe conditions for which the seat system was designed.

In-flight Tests

Seat ejection tests were completed with three ejections from the back seat of an F–106B aircraft. One was a static firing of the system to confirm the compatibility between the Gemini ejection seat and the F–106B. The other two tests, conducted in January and February 1965, were full systems tests of production configured units. One test verified seat ejection at 15,000 feet at Mach 0.72. The other ejected at 40,000 feet at Mach 1.7. These tests successfully proved the high dynamic pressure and high-altitude, high-Mach number operation of the complete seat ejection system under flight conditions.

Conclusions

The ejection seat escape system was one of three Gemini systems that caused the most trouble in getting qualified, the other two being the fuel cells for electric power generation and the maneuvering thrusters. All systems finally yielded to the persistent engineering analysis, design, and tests to clear the Gemini system for flight.

After two unmanned flights that qualified all flight systems, astronauts Virgil I. Grissom and John W. Young blasted off on March 23, 1965, completing three orbits and a precise landing in the primary recovery area. Eight more manned flights were completed. The ejection seats were never used. The closest they came to being used was on the Gemini 6 launch with astronauts Wally Schirra and Tom Stafford on board. The countdown had reached zero and the Titan II engines and mission clock had started. Suddenly, the engines cut off, leaving the Gemini spacecraft in a precarious position on top of a hot booster. Everyone was expecting the seats to come blasting out of the spacecraft, but the astronauts showed great fortitude and held up ejecting, saving the mission. The minor problem with the engine fuel system was corrected, and two days later the mission roared off the pad to perform the first rendezvous in space with the already orbiting Gemini 7 with Frank Borman and Jim Lovell on board.

The seats were qualified, meaning all the systems would work. But no one could guarantee that the astronauts would come through the ejection unscathed, primarily because ejection created accelerations that were at the absolute limits of human tolerance, escape could be near an unpredictable fireball and in a hostile environment, and there was always the possibility of the unknown. Ejection was a calculated risk that the astronauts were willing to live with, but would use only as a last resort. The authors, as principal team members in bringing the ejection seats to fruition, agree wholeheartedly with Tom Stafford's statement quoted at the beginning of this article, and are as gratified as the astronauts that they never had to be used.[21] ■

NOTES

1. Discussion with Tom Stafford at the Gemini reunion and memorial ground breaking in Titusville, Florida, July 1996.
2. The main proponent for using ejection seats was NASA's James A. Chamberlin, Chief, Engineering Division, Space Task Group. Jim Rose, Head of Mercury and Gemini Mission Planning, told us how he was tasked by Chamberlin to get an estimate of the fireball size of exploding Atlas and Titan missile boosters. Rose said he reviewed dozens of Air Force films and painstakingly measured the fireball size of the exploding boosters. This first quantitative fireball data was the basis for proposing ejection seats. (Conversation with Jim Rose at the Gemini memorial dedication, Titusville, Florida, July 1996.)
3. *Ibid.*
4. Among the many excellent books and articles published on Mercury and Gemini are Loyd S. Swenson, Jr., James M. Grimwood, and Charles C. Alexander, *This New Ocean: A History of Project Mercury*, NASA SP-4201, NTIS, 1966; Barton C. Hacker and James M. Grimwood, *On the Shoulders of Titans: A History of Project Gemini*, NASA SP-4203, GPO, 1977; and James M. Grimwood, Barton C. Hacker, and Peter J. Vorzimmer, *Project Gemini, Technology and Operations—A Chronology*, NASA SP-4002, NTIS, 1969.
5. The Gemini spacecraft was literally designed around astronaut Virgil (Gus) Grissom, the smallest astronaut, and to fit in the larger astronauts the seat and hatch had to be extensively modified. *On the Shoulders of Titans*, p. 220.
6. A land landing system was highly attractive because it eliminated the large Navy support needed to recover the astronauts from a water landing.
7. Although the Ragallo wing was not used, the development accomplished led to the now used very popular hang gliders.
8. The ejection seats were canted 12 degrees from the cockpit centerline (24 degrees between the two seats) and, therefore, would have had a negligible out-of-plane component when ejecting.
9. One of the authors, Bob Brulle, was instrumental in that design change, making his first contribution to the program success as related below.
I had just been assigned to Mercury Mark II program at McDonnell, and was acquainting myself with the various engineering analyses in progress. While talking to the engineer doing the debris escape analysis, I casually suggested that Gemini be turned 90 degrees on the booster. He explained that the overriding objection to that proposal was that the astronauts would experience a side load, quite critical for a human, and thus could not withstand the launch accelerations. I convinced management that side loads felt by the astronauts would be minimal since the launch trajectory was very nearly a zero gravity flight path, so the astronauts would experience only the transverse (forward) booster acceleration. When the astronauts heard of this change they were also wary, and I was delegated to convince them that no appreciable launch side loads would be felt. Most astronauts saw the correctness of the analysis, but I was not able to convince one. None of the astronauts who flew in Gemini ever complained of side loads. It's interesting to note that many people, including engineers and astronauts, did not grasp the concept of orbital mechanics at that embryonic space flight time period.
10. Plot was extracted from report, Michael A. Rickards, *Analysis of High Speed Encapsulated Seat Crew Escape System for Zero Speed and Zero Altitude Capability*, ASA-TDR-62-242.
11. Naval Ordnance Laboratory (NOL) Report 3058, *Blast and Shock Tables for Explosions in Air*.
12. For analysis on how those values were arrived at, see Martin Report 224, *Analysis of the Gemini Launch Vehicle Escape Environment*, Feb. 1964.
13. These jumps were performed as part of a USAF aeromedical study on the human factors inherent in high speed, high altitude ejections, and was called Project Excelsior. Kittinger's experiences were summarized in NASA Report SP-8, *Proceedings of 2nd Conference on Peaceful Uses of Outer Space*, May 8-12, 1962, Seattle, Wash., #19—Discussion of Project Excelsior, by Joseph W. Kittinger.
14. Internal McDonnell Memo on a telephone conversation titled, *Mode I Abort Revision*, dated May 28, 1964. The telecon was between W. J. Blatz, McDonnell Engineering Manager and D. L. Jacobs, NASA Gemini Project Office Abort Manager.
15. The results were published as *Aerodynamic Characteristics of the Gemini Ejection Seat-Man Configuration*, Aerodynamics Information Note No. 50, McDonnell Aircraft Corp., October 1963.
16. Ballutes are presently used as a retardation device for low-level bomb delivery.
17. As engineers, the authors were in constant touch and both sides were open and frank in discussing the numerous problems that arose. For the task at hand it was an excellent arrangement.
18. A pyrotechnic time delay device is essentially a powder train that takes a specified time to burn and then ignites the output charge. It is not unlike an old time dynamite fuse. A pyrotechnic time sequencing system is a series of pyrotechnic devices with built-in time delays that accomplishes a series of time related tasks.
19. A similar analysis determined the center of gravity change of the test anthropomorphic dummy slump characteristics under ejection accelerations.
20. Three of these tests did not involve ejections and were used to qualify the sled and spacecraft.
21. The authors thank the following people for their help and comments, without which we could not have completed this narrative: Ken Nail, Barbara Green and Elaine Liston, of the NASA, KSC Archives Library; Jim Rose, NASA head of Mercury and Gemini Mission Planning; Tom Stafford, astronaut; Sam Salem, Manager of Publications, Loral Defense Systems (Goodyear); Wilson McGough, Gemini Project Aerodynamicist and McDonnell engineer; John Yardley, McDonnell Gemini Program Manager; and Mike Rickards and other former Weber Aircraft personnel.

THE SPACE DICHOTOMY

by IVAN A. GETTING, President
AEROSPACE CORPORATION
TO
NATIONAL ROCKET CLUB
WASHINGTON, D. C.
September 18, 1962

As a text for my talk today, I use two sentences from a recent statement by Vice President Lyndon B. Johnson: "Some day we must come to the further assurance that every object has a peaceful purpose and will remain continuously peaceful. By peaceful purposes, I mean to help keep the peace as well as to increase our knowledge for living better in peace."

If we in the United States can come to understand this clearly stated fact of life, that *peaceful purposes* include *helping keep the peace,* we can eliminate from our national thinking a dangerous notion about our proper role in space. The idea is all too general that we are now engaging in two kinds of space activity—the first, peaceful and pure; the second, military and evil. Too many Americans today feel that we should be proud about only the former.

In thus assuming that there is a *space dichotomy*—that somehow our space activities can be split into good and evil parts—we create an artificial, false situation that hurts us both at home and around the world. Most serious of all, by painting ourselves into such a semantic corner, we gravely erode the respectability of a profession that justly has been honored and vital in the United States since the embattled farmers stood at the crude bridge in Concord in 1775 and fired the shot heard 'round the world in the defense of man's freedom and rights—the military profession now dedicated to keep the peace.

How did we get into such an unrealistic situation? And what do we do about it?

But first, let me note that throughout history, very often it has been the professional military man who in peacetime has braved the frontiers of the unknown and pushed them back.

In our American history, we can find many such instances. In 1804, it was a military mission—headed by Lewis and Clark and including 14 soldiers—that was assigned the task of exploring the vast territories acquired by the Louisiana Purchase. For months they journeyed toward the Pacific, across the plains and over the terrifying mountains where no white man had ever gone. They were, to repeat, military men but their's was a mission of peace.

Very early in the annals of flight, it was the military man, flying military aircraft, who did the pioneering. The first crossing of the Atlantic in 1919 was by Navy pilots in Navy planes. The first aerial circling of the globe in 1924 was by Army pilots in Army crafts. When the National Geographic Society in 1925 sent out an aerial expedition to explore the Arctic, the flying contingent was assigned from the Navy and was led by Admiral Richard E. Byrd. Military men on peaceful missions.

Even today, the exploration of the Antarctic by many nations continues to extend man's knowledge—an entirely peaceful effort being supported massively by military personnel and equipment.

And exploring the depths of the ocean is a clearly accepted mission of the Navy.

Not all pioneering activity by military men in times free from strife has been limited to exploration. Hardly a century ago, four naval vessels—two our's and two Britain's—were used in laying the first telegraphic cable across the Atlantic. No one batted an eye over this employment of naval strength for a peaceful purpose. Here certainly is a curious parallel with this summer's successful launching of the commercial communications venture—Telstar—into space by a booster developed by the Air Force to power an IRBM.

Historically, our armed services have been an agency reflecting our national posture. We think of ourselves as a peaceful nation, but one determined to defend its freedom. We expect to be more at peace than at war. And during peacetime, the chief role of our armed forces, is to preserve the peace and to present to the world at large our national image. Today hundreds of thousands of American men and women in the armed services represent us in Berlin, West Germany, France, England, Italy, Vietnam, Korea, Formosa. Our Navy visits hundreds of ports each year, and our Air Force girdles the globe in daily flights. Earlier this month, hundreds of tons of medicine and food were transported daily by the Air Force to the earthquake victims of Iran. These are the forces for "good"—not "evil." We must at all times foster the belief in all the peoples of the world that our armed forces are indeed ambassadors of the American people—that indeed they are American people working for peace.

I have gone into such detail about the peacetime activities performed by the military in the past—and even now—to emphasize that neither we nor other nations are concerned or dismayed by such goings on—except in space.

Why is it that in space matters alone this confusion exists—in the United States but certainly not in the USSR—this misunderstanding that there is a dichotomy, an artificial division between military activities on the one hand and all other activities for peaceful purposes on the other? Why do we associate exploration and science only with a civilian agency and deny these to the military? Why do we place an evil cast on military activities in space?

Perhaps we can find the answer by looking into history. Almost five years before the first successful flight by the Wright Brothers, the Hague Peace Conference solemnly promulgated a declaration that prohibited assignment of aircraft, present or projected, to combatant use in war. The discharge of projectiles or explosives from the air was banned, and by agreement the role of air vehicles was limited to reconnaissance and similarly passive employment.

In 1907, the Second Hague Conference was convened. The bomb dropping ban was reaffirmed, but by only 27 (mostly small nations but including the United States) of the 44 powers present. In almost direct, but inverse, proportion to the plausibility of the intervening demonstrations of the military potential of the airship and the airplane, the zeal of the Powers for the prohibition had diminished.

At the turn of the century, and for years thereafter, many men who should have known better persisted in thinking of the sky as a *thing* rather than as a *place* to do things with an airplane. And in the past four years or so, we have seen other men who persisted in considering space as a *thing*—a revolutionary new development somehow to be kept inviolate—rather than a *place* where, for the first time, we could do useful things with our satellites.

On March 26, 1958—more than five months after the first Russian Sputnik—then President Eisenhower made public a statement by his Science Advisory Committeee in which were listed four factors that gave "urgency and inevitability to advancement of space technology."

They were:

(1) The compelling urge of man to explore the unknown.

(2) The need to assure that full advantage is taken of the military potential of space.

(3) The effect on national prestige of accomplishment in space science and exploration.

(4) The opportunities for scientific observation and experimentation.

However, Mr. Eisenhower recommended that U. S. space activities be conducted under the direction of a civilian agency, "except for those projects primarily associated with military requirements" because "space exploration holds promise of adding importantly to to our knowledge of the earth, the solar system, and the universe, and because it is of great importance to have the fullest cooperation of the scientific community at home and abroad in moving forward in the field of space science and technology. Moreover, a civilian setting for the administration of space function will emphasize the concern of our Nation that outer space be devoted to peaceful and scientific purposes."

In 1907, the peoples of the world had sought to limit the extension of warfare to the newly invented capability of flying through air; in 1958, the United States, similarly motivated, unilaterally undertook a similar prohibition in space.

Are we being realistic in trying to save space for "peace"? Have we sold the idea to others? Or are we fooling principally ourselves? It would appear that a chief argument for preserving space for peaceful purposes is somehow connected with the sanctity of space. Unfortunately, space is already being trespassed—for ballistic missiles are space vehicles so launched as to intercept the earth at the targeting point. There is no substantial evidence from history that any power in time of national danger has denied itself the use of any medium when it considered the use of that medium to its arvantage. Today space has more potential for the free world than for the communist world—but in the exploitation of space we appear to be risking unilateral disarmament.

I might insert here the comment that somehow we have espoused space for peaceful purposes with the implication that the earth should be reserved for warlike purposes. Personally, I think we should consider everywhere—on earth as well as in space—as a proper and necessary locale to work for peace.

Although Vanguard was conceived as the U. S. contribution to the International Geophysical Year and was something aside from our military rocket programs, it was managed by the Naval Research Laboratory. Morever, the first U. S. satellite was boosted into orbit by a military rocket booster (as had been the Sputnik) and there was no uproar here or abroad. Nor were there outcries when the Air Force and Army launched other space experiments in 1958.

But beginning in the fall of 1958, though the Air Force continued to launch space experiments, this effort was increasingly as an agent of the new NASA, and very determined efforts were made to put a civilian space agency label on these shots. This de-emphasis of the Air Force conduct of—not merely participation in—U. S. space experiments resulted in very real damage to the morale and, in my opinion, the thoroughly proper, thoroughly legitimate mission of the military to help keep the peace.

If anything, there has been a steady, further erosion of military morale in the years since then, and I fear greatly that the inevitable consequence to the national welfare will be significant. If this damage to military morale and military effectiveness were the price that had to be paid to earn world-wide respect in a new era of international goodwill, perhaps the cost would be justified. But I have seen no evidence that the dawn of this new era of understanding has come.

That every element of U. S. military strength is focused squarely on the task of helping to keep the peace is a fact that somehow has become lost not only on the world at large but, I fear, on many of us in the United States.

There are many gains to be derived from the use of space. Some of these are peculiar to military use alone; but many have both military and other uses.

President Kennedy has said that to

insure peace and freedom in space, we must be first. Further, and I quote: "Freedom in space must be assured, preferably by mandate of the United Nations. The United States must have pre-eminence in security as an umbrella under which we can explore and develop space for the benefit of all mankind."

All Americans, I am sure, are both willing and eager to work toward that goal. To that end, it is essential that the military develop the necessary capability to perform in space and to keep that capability in a state of readiness. How better to obtain the necessary practice than to carry out missions in space that have both military and other uses?

Clear examples of such missions are the use of satellites as instrument-carrying platforms which cover the globe. They can be equipped to make continuing measurements on geophysical quantities useful in reporting and forecasting weather. Or they can be designed to provide greatly improved communications.

Within the United States, who has the most urgent need for such added capabilities?

Respecting weather, we already have quite good forecasting in the United States without satellites, but worldwide this is not so. The military has always been dependent on weather information. This is at least as true today as ever. Routing of naval ships and convoys at sea depends upon weather and sea state, the flying of MATS and SAC planes depends upon weather information; our ability to support limited wars is enhanced by worldwide weather knowledge. So I think it could be said that the military have a priority requirement for the worldwide weather information that can be provided by satellites.

In the case of overseas communications, the Department of Defense makes extensive use of privately owned common carrier facilities. But there are also many communications links that are owned and operated by the military. Commercial communications necessarily link populated areas of a developed type where the need for communications is sufficiently large to justify the capital investment. Military communications must meet strategic/tactical requirements. The reason that there are no direct commercial communications from the United States to South Africa by land line or submarine cable is that it is economically unattractive. From the military viewpoint, however, it is necessary to have continuous and reliable communications to South Africa, to Southeast Asia, and to the Congo.

Over and beyond the question of who has the prime requirement for such services of both military and civil value as can be provided by satellites is the fact that here are wonderful opportunities for the military to obtain priceless operational experience in space by performing useful, nonmilitary functions. To be prepared to meet military requirements in space at such time as they may appear, the Air Force has to be absolutely in the position of being able to make its satellite launchings at the necessary time and with the full expectation of reliability. This competence can be won only by practice—by repetitive launchings—by exercising capabilities.

Such military competence in space, in my opinion, is entirely consistent with our national goal, stated so ably only Wednesday of last week by our President:

". . . Space science like nuclear science and all technology has no conscience of its own. Whether it will become a force for good or evil depends on man, and only if the United States occupies a position of pre-eminence can we help decide whether this new ocean will be a sea of peace or a new terrifying theater of war.

"I do not say that we should or will go unprotected against hostile misuse of space any more than we go unprotected against the hostile use of land or sea. But I do say that space can be explored and mastered without feeding the fires of war, without repeating the mistakes that man has made in extending his writ around this globe of ours."

Looking across the ocean, I see the Russians progressing steadily with their space programs. When it suits their purposes, their space programs are shrilly proclaimed as being solely for peaceful purposes. They stroke the peace dove 'til it surely coos. But it is hard for us to forget how, with such talk, they persuaded us to enter into what has been called an honor moratorium on nuclear testing. We negotiated in good faith for a test-ban treaty while our nuclear technology suffered for lack of testing. And then, last year, the Soviets suddenly violated the moratorium—moving only when they had performed all necessary preparations in secret for a series of 50 nuclear tests.

We know, all the world knows, that we have no intention of exploiting space for reasons of aggression. But now the Russians are demonstrating to the world that their space exploits are straightforward demonstrations of raw military power, capable of being employed with terrible effect at any time the Kremlin whim may decree.

What do we do about all this? I have a few simple, straightforward suggestions that might help.

First, we in the United States need to reaffirm our traditional position—but with pride instead of seeming shame—that our presently great military strength is the most potent force in the world and that it is working 24 hours a day to help keep the peace. Once we understand this truth, we stand a reasonable chance the rest of the world will too.

Second, that if our strength is to be maintained we must have the military tools that are best suited to help keep the peace. And this means operational equipment—perfected by necessary exercise—that can be most effectively employed however and whenever and wherever necessary—in space, in the atmosphere, under the seas, or even underground.

Third, we need to give our military people a pat on the back now and then instead of constantly putting them on the defensive. We can expect, or at least hope, that the talented personnel—the military people on whose devoted service our security depends—will withstand the temptations to leave the service, *providing* that they have a chance to do their task of helping to keep the peace. But, at the very least, we've got to give them this chance.

Fourth, we need to restate the historic peacetime military role of sharing in exploring the frontiers . . . now in space . . . and that this sharing be on a basis of both cooperation and also some healthy competition. Let us clearly recognize that we are all Americans equally patriotic and all working for peace.

And fifth, we must recognize that many practical space missions have both military and civilian uses; that the exploitation of space for these missions necessarily involves both the development and continuing operation of these systems, and that as a consequence, each should be evaluated on the basis of how it can be realized most effectively from the standpoint of overall national benefit.

It will take our best efforts in an overall unified plan. But to assure success there must be no dichotomy in space any more than has been in any other worthwhile national undertaking.

We have the will, the skills, and the resources to lead the world in this greatest adventure of man—his projection into space.

US Air Power 1945-1990 Volume 2: Bombers 1945-1949 Part I: Policy, War Plans, Strategic Air Command and Manufacturers. By David Baker. Warwick UK: Helion, 2024. Photographs. Illustrations. Bibliography. Maps. Pp. 80. $29.95 paperback. ISBN: 978-1-804513-76-7

This book offers an in-depth exploration of the United States bomber force's evolution in the immediate aftermath of World War II. This volume is number 2 of 15, but now we learn each volume may be subdivided into separate "parts," each with its own book. Hence, there is no commitment as to just how many books will comprise the series; hence, no way to know how large a financial commitment may be required. This book delves into the transition from the USAAF to the independent USAF, the establishment of the Strategic Air Command, and the development of new aircraft capable of delivering atomic weapons deep into the USSR. The book is copiously illustrated with photographs from the period and color profiles specially commissioned to attract modelers. Both provide readers with a visual context.

Baker's extensive research is evident as he examines the evolving concept of war during this pivotal post-war period. He provides detailed analysis of selected policy decisions and war plans, and the roles played by major aircraft manufacturers as they transitioned from producing large numbers of wartime bombers to developing post-war designs incorporating innovative technologies for atomic warfare.

However, the decision to publish this extensive history in multiple volumes, each focusing on a specific period and aspect of US air power, has both advantages and drawbacks. On the positive side, this segmented approach allows for a dive into each period, enabling Baker to provide coverage of the technological advancements, strategic doctrines, and operational histories pertinent to each era. When the set is complete, readers interested in a particular period or aircraft type can select the volumes that align with their interests, making the series accessible to both casual enthusiasts and armchair scholars. Serious scholars may find that the bibliography is a poor substitute for the lack of citation and notation.

On the downside, spreading the information across numerous volumes can lead to a fragmented understanding of the overarching narrative of the development of US air power. Readers seeking a holistic view may find it challenging to piece together the continuous evolution of strategies and technologies over the entire 45-year span.

Furthermore, the piecemeal publication schedule means that readers must wait for subsequent volumes to be released to access information at later periods. This staggered availability will be frustrating for those eager to understand the full scope of US air power history from 1945 to 1990.

In conclusion, while this volume provides an engaging examination of a critical period in military aviation history, the decision to disseminate the information across multiple volumes has both benefits and limitations. Readers must weigh the advantage of in-depth, focused analyses against the potential drawbacks of a segmented and prolonged reading experience. Personally, I found the Dickensian serialization of this subject matter to be a poor publication choice.

Gary Connor, docent, National Packard Museum, Cortland OH

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East Africa Campaign 1940-41: The Battle for the Horn of Africa. By Pier Paolo Battistelli. Oxford UK: Osprey Publishing, 2024. Maps. Photographs. Index. Pp. 96. $25.00 paperback. ISBN: 978-1-4728-6071-2

This monograph recalls a lesser-known campaign conducted during the Second World War. Though in the Mediterranean Theater, it was fought along the periphery of better-known arenas of the conflict. In contrast to the well-known battlefields of Europe, this monograph's focus is on the battles fought in East Africa, a sideshow fought across the territories of Somalia, Eritrea, and Ethiopia, all within what is collectively known as the Horn of Africa.

It is also a point of consideration that the fighting in Africa was, in a greater context, the product of the Age of Imperialism; that is, fighting over colonial possessions. Italy, a very late player in the acquisition of colonies, had first conquered Eritrea and Italian Somaliland. In late 1935, went up against Ethiopia, one of the very last independent states in Africa. It won that war in 1936 (largely because the poorly equipped Ethiopians were no match against Italian artillery and airpower) and consolidated its colonies into Italian East Africa.

When the Second World War commenced, Italy—a member of the Axis Powers—successfully attacked the colony of British Somaliland, adding it to Italian-held territory. Thus, Italy's position at the entrance to the Red Sea made it a threat to Allied shipping to and from the vital Suez Canal. This was happening at a critical time for Great Britain. Italian forces had advanced in North Africa from Libya toward the canal, and Iraq had invited German forces to establish a base in that country. Greece, vital to the defense of the eastern Mediterranean, was soon to fall to German troops. Earlier in the same period, the British had been driven out of France and were fighting for survival during the Battle of Britain. From that perspective, the war in Africa became a necessary part of a strategy to first defeat the enemy on the edges of the conflict and begin the roll back of its main forces.

The British, holding back troops for a possible invasion of the home islands, used units from the British Indian Army and indigenous troops from its west-, south-, and east-African colonies. The Italians, totally cut off from re-supplies and reinforcing troops, quickly found themselves on the defensive. To make matters worse, their commanding general for all of East Africa was unimaginative and lacked a strategic vision. It was only a matter of time before Italian units were defeated piecemeal and captured. Thus, by May 1941 the British brought the war in East Africa to a successful conclusion thanks, in no small part, to far-better use of sea and air power and codebreaking.

The monograph is nicely augmented by easy-to-use maps that support the text. Photographs and illustrations as well add clarity to the descriptions of skirmishes and battles. This is a well-done addition to the Osprey series on war and interesting to read.

John Cirafici, Milford DE

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Visual Friendlies, Tally Target: How Close Air Support in the War on Terror Changed the Way America Made War, Volume 1: Invasions. By Ethan Brown. Barnsley UK: Casemate Publishers, 2024. Glossary. Notes. Bibliography. Index. Photographs. Pp. 254. $34.95. ISBN: 978-1-63624-422-8

Brown is an Air Force veteran who served 11 years as a special-warfare Tactical Air Control Party (TACP) specialist. He deployed to multiple warzones during the Global War on Terror (GWOT), working with conventional and Joint special operations teams. He is a Bronze Star recipient. Since leaving the service in 2020, he has worked as a policy analyst for a Washington think tank and has contributed to a variety of national security publications.

This book offers an in-depth exploration of the evolution and critical role of close air support (CAS) during the early years of the GWOT. Drawing from his tenure as a TACP specialist, Brown provides a detailed narrative that combines historical analysis with firsthand accounts that shed light on the complexities and significance of CAS in modern warfare. The book has three main parts, each focusing on a distinct phase of the early GWOT:

Retribution (Afghanistan: 2001–2003) delves into the initial US military response in Afghanistan, highlighting the challenges faced in a terrain historically resistant to foreign intervention. Brown discusses the integration of CAS in operations against terrorist networks, emphasizing the pivotal role of Forward Air Controllers (FAC) in directing precise airstrikes.

A New World War (Iraq: 2003) transitions to the invasion of Iraq. Brown examines the strategic shift and implementation of "shock and awe" tactics. He provides insights into the coordination between ground forces and air support, illustrating how CAS was instrumental in rapid advances and in confronting unexpected insurgencies.

Evolving the Machine (2004–2006) addresses the adaptation and refinement of CAS tactics in response to evolving combat scenarios. Brown explores the development of a global architecture for joint fires, the psychological resilience of FACs, and the technological advancements that enhanced the effectiveness of air-ground coordination.

While describing the integration of air and ground operations, Brown emphasizes the seamless collaboration between air assets and ground troops (facilitated by FACs) which was crucial in achieving tactical successes in both Afghanistan and Iraq. He covers technological advancements—highlighting the transition to digitally aided CAS—that improved precision and reduced collateral damage. Through personal anecdotes and interviews, Brown captures the experiences, challenges, and heroism of the individuals who served as the linchpins between air and ground operations.

While this is a comprehensive account that offers valuable insights into CAS's role in contemporary military operations, it was a difficult read. A non-TACP specialist will spend much time with the inadequate glossary trying to obtain full meaning of much of the narrative. "We would get CAS by contacting CJSOTF-N, we would then prioritize requests and submit those directly to the CAOC, who had allocated assets against the entire invasion force's prioritized requests" is tough to decipher. However, Brown's professional expertise makes this work an interesting read, especially for military professionals and historians interested in understanding the intricacies of modern combat dynamics.

Frank Willingham, NASM docent, Sterling VA

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Pearl: December 7, 1941. By Daniel Alan Butler. Haverstown PA: Casemate, 2024 (paperback reissue of 2020 book). Photographs. Maps. Bibliography. Appendices. Notes. Index. Pp. 354. $24.95 paperback. ISBN: 978-1-63624-452-5

This excellent volume offers a compelling and meticulously researched account of the events leading up to the attack on Pearl Harbor, as well as the attack itself. Butler's extensive research is evident throughout the book, providing readers with a comprehensive understanding of the complex political and military dynamics between the United States and Japan. His outstanding command of language and narrative skill transforms historical facts into a gripping story that is both informative and engaging. I rank him as one of the most skillful and effective authors that I have read this year.

In the initial chapters, Butler delves into the histories of both nations, tracing the evolution of their policies and actions that set them on a collision course. He explores centuries of Japanese and US history, briskly walking through impactful events to set the foundation for the confrontation between Japan and the United States. This thorough examination reveals how misunderstandings, underestimations, and conflicting ambitions led to an inevitable military conflict.

Butler's narrative is enriched by his ability to humanize historical figures, presenting emperors, presidents, diplomats, politicians, admirals, and generals as complex individuals whose decisions were influenced by a multitude of factors. He also highlights the experiences of ordinary sailors, soldiers, and airmen, providing a holistic view of the events that culminated in the attack on Pearl Harbor.

Employing both clear and evocative writing, Butler makes complex political and military strategies accessible to readers without sacrificing depth or accuracy. His vivid descriptions and attention to detail immerse readers in the historical context, allowing them to grasp the gravity of the decisions made by both nations. Butler's skillful storytelling ensures that the narrative remains engaging, even as it conveys a wealth of information.

This book must be praised for its clarity and comprehensive coverage of the events leading up to the attack. Butler provides a series of dramatic moments and hits all the key elements of the story, thus making it a valuable resource for anyone interested in this pivotal moment in history. Even armchair historians who believes they have mastered the subject will be rewarded with a more nuanced and comprehensive understanding of the subject.

I was fortunate to hear stories of Pearl Harbor from an uncle by marriage who survived the attack on the USS *Helena* on that Day of Infamy. He was expecting to complete his enlistment and muster out of the Navy during the week following the attack and ended up serving for the duration. He would talk about the attack and the aftermath, but never in detail. I think he would have approved of the story Butler tells.

This is a masterful work that combines rigorous research with exceptional writing. Butler's exploration of the historical context, policies, and actions that led to the attack on Pearl Harbor provides readers with a nuanced understanding of this significant event. His ability to present complex information in an engaging and accessible manner makes this book a highly recommended read for anyone interested in World War II history.

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Fearless: The Extraordinary Untold Story of New Zealand's Great War Airmen. By Adam Claasen. Auckland, New Zealand: Massey University Press, 2017. Maps. Tables. Illustrations. Photographs. Notes. Appendices. Bibliography. Index. Pp. 494. $50.00. ISBN: 978-0-9941407-8-4

The *AFHF Journal* doesn't normally review books that are more than a year or two old. However, this book is an exception. When it came to my attention, I realized that it would have received a rave review had it come in when published and should be brought to our readers' attention.

Dr. Claasen is a senior lecturer in history at Massey University in Auckland, New Zealand. His exceptional research and writing skills are evident in this book and in his latest work on fighter ace Keith Caldwell (reviewed in the Spring 2025 *Journal* issue). Both of these books tell the gripping story of New Zealand's participation in the first major air war.

During World War I, there was no Royal New Zealand Air Force. Prospective flyers became members of the Royal Flying Corps/Naval Air Service/Air Force (RFC/RNAS/RAF). Classen provides a wonderful synopsis of his country's rather tepid start to aviation in general, and military aviation in particular (it makes the slow US buildup look positively aggressive)! With only two flying schools (eventually) in the country, most New Zealanders ended up training in the UK and Egypt. The details of these training experiences are worth comparing to training in the Second World War and in modern times.

Throughout the book, Claasen makes liberal use of his subjects' diaries and letters and those of family members and loved ones. In their own words, they tell the story of this small country's war contributions (New Zealand's population during the war was only about 1.1 million). When studying the air war, most readers probably think of the *Dawn Patrol* type of combat on the western front. Many may not be familiar with aircraft use at Gallipoli and in Mesopotamia. New Zealanders were there, as they were on duty in France and in the defense of Britain.

Flying just about every type of British and French aircraft against almost all of the German and Austrian types fielded, nearly 850 men served in the air. And they flew just about every kind of mission: reconnaissance, air-to-air fighting, both day and night bombing, escort for bombers and recce aircraft, defense of England against Zeppelins and Gothas, and ground attack. New Zealanders were there for all of it, and 79 of them died fighting for the Commonwealth. Integrated into British squadrons, many rose to greatness. Nearly a dozen commanded squadrons. One commanded an air brigade. Fifteen were aces. Keith Caldwell (later an air commodore) led the field with 26 kills. Keith Park had 20 kills during the Great War and went on to lead 11 Group during the Battle of Britain. He retired as an air chief marshal. Arthur Coningham had 14 kills and became an air marshal and one of World War II's great tactical-air theorists and practitioners.

For readers interested in a great dissertation on what air warfare was like during the First World War, and how one small nation contributed to it, this is a superb, must-read book.

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

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Solomons Air War Volume 3. Guadalcanal: From the Brink, November-December 1942. By Michael Claringbould and Peter Ingman. Kent Town, Australia: Avonmore Books, 2024. Maps. Tables. Illustrations. Photographs. Appendices. Bibliography. Index. Pp. 184. $30.00 paperback. ISBN: 978-0-975-64233-7

Starting with *South Pacific Air War Volume 1* in 2017, Claringbould has authored, either alone or with other writers, more than 20 books on aerial combat and aircraft in the southwest Pacific during World War II. This book continues his chronicle of the air war day by day. Ingman, an aviation enthusiast, owns Avonmore Books.

Whenever possible, Claringbould correlates both sides' claims against actual results derived from Japanese and American documents. As has become well known in recent years, many pilots received credit for downing enemy aircraft when no corresponding loss is recorded in the enemy accounts.

The authors begin by reviewing Allied airpower at the start of November followed by a similar chapter on the Japanese. As the battle progresses, the respective air orders of battle are updated, thus reflecting losses and replacements.

Both sides used army and navy aircraft. Unlike the Allies, who treated fighting in New Guinea and the Solomon Islands as separate theaters of operation, the Japanese combined the two. They may have chosen to do so because of Rabaul's location on the island of New Britain, a base that served as their primary logistics hub in the region.

While proceeding day by day, the authors have allocated various time periods to specific themes. With the land battle for control of the American-held airfields grinding on and on, both sides faced logistical challenges. Furthermore, both reluctantly employed capital ships but relied on air power for controlling and denying the use of sea lanes.

Early November opened with the Japanese experiencing some success with what the Allies called the *Tokyo Express*. This effort, primarily using destroyers, reinforced and resupplied the troops on Guadalcanal.

From November 13 through Nov ember 16, the two sides engaged in a series of air and naval skirmishes. Over four chapters, the authors have carefully detailed the attempt by the Japanese to dispatch 11 transports to Guadalcanal. Allied aircraft prevailed, inflicting significant losses.

While fighter aviation and naval strike aircraft dominated the air campaign, both sides attempted to employ bombers with mixed results. The USAAF dispatched Boeing B–17s and Martin B–26s, with the B–17s primarily used to attack enemy airfields. Throughout the campaign, the Japanese relied on the Mitsubishi G4M, Allied code name *Betty*, to disrupt aerial operations from Henderson Field. Both sides also employed flying boats in various capacities. The Japanese effectively used pontoon-equipped fighters.

In early December, the Japanese again tried using destroyers and submarines to supply Guadalcanal. The high command then considered withdrawing its forces. In the meantime, the Japanese constructed an airfield at Munda on New Georgia. Only 200 miles from Henderson Field, the Allies repeatedly attacked it in the final days of 1942.

This book is highly recommended for anyone with an interest in the southwest Pacific in World War II.

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

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Yugoslavia and Greece, 1940-41: The Axis' Aerial Assault in the Balkans. By Basilio Di Martino and Pier Paolo Battistelli *and* **Sumatra 1944-45: The British Pacific Fleet's Oil Campaign in the Dutch East Indies.** By Angus Kostam. Both—Oxford UK: Osprey, 2024. Photographs. Illustrations. Bibliography. Index. Pp. 96. $25.00 paperback each. ISBN: 978-1-4728-5924-2 and 978-1-4728-6241-9 respectively

Both of these books delve into aerial campaigns that shaped their respective theaters in World War II. While Martino and Battistelli explore the German Luftwaffe's operations in the Balkans in 1941, Kostam provides an in-depth analysis of the Allied air offensive in the Pacific, focusing on Sumatra in 1944–1945. These books both serve as valuable resources for understanding airpower's role in two vastly different contexts, yet their stylistic approaches and substantive insights into aerial warfare diverge in unique ways.

Martino and Battistelli adopt a meticulously detailed narrative, underpinned by archival research and tactical analysis. Their writing has a scholarly tone, appealing to military historians and aviation enthusiasts alike. They interweave operational details with political and strategic contexts, creating a layered understanding of the Luftwaffe's operations in Yugoslavia and Greece. The book includes rich cartographic support, making it easy for readers to follow the campaigns as they progress.

In contrast, Kostam takes a more narrative-driven approach, focusing on personal accounts, squadron histories, and the broader strategic implications of the campaign. While grounded in research, the tone is more accessible, catering to a general audience. Kostam balances operational analysis with a vivid portrayal of the human experience of air warfare. His use of photographs, mission reports, and firsthand accounts brings the Sumatra campaign to life, but some readers may find the emphasis on storytelling detracts from granular operational details.

The two campaigns reveal both similarities and stark contrasts in the application of airpower during World War II. The Luftwaffe's campaigns in Yugoslavia and Greece were part of Germany's broader Blitzkrieg strategy, aimed at swiftly neutralizing resistance to secure the southern flank before the invasion of the USSR. Air superiority was a critical enabler for rapid ground advances, and the Luftwaffe's primary goal was to decimate enemy air forces and infrastructure early. Of course, Luftwaffe involvement was required only because Germany's Italian partners were unable to achieve tactical or strategic success.

In contrast, the Allied offensive over Sumatra in 1944–1945 was part of the broader strategy of isolating Japanese-held territories and crippling their supply chains. Airpower played a vital role in disrupting oil production in Sumatra, which was vital to Japan's war effort. This campaign emphasized strategic bombing over direct ground support.

In Yugoslavia and Greece, the Luftwaffe executed concentrated, high-intensity strikes that overwhelmed unprepared and poorly equipped local forces. The campaign highlighted the effectiveness of coordinated air-ground operations. However, terrain challenges in Greece and resilient partisan forces in Yugoslavia complicated German efforts, prolonging their campaigns beyond initial expectations.

The Sumatra campaign, by contrast, relied heavily on long-range B–29 bombers supported by carrier-based aircraft. The Allies faced significant logistical challenges in sustaining operations over long distances. Their success lay in precision strikes against key oil refineries (e.g., Palembang), which dealt a severe blow to Japan's industrial capabilities. However, the campaign's effectiveness was sometimes hampered by adverse weather and the difficulty of verifying bombing results.

The Luftwaffe's initial success in Yugoslavia and Greece was marked by the rapid destruction of enemy air forces and infrastructure. Yet, the campaign exposed Germany's vulnerability to prolonged operations in challenging environments and its inability to fully suppress resistance movements. The resultant diversion of resources delayed the launch of Operation *Barbarossa*, with long-term consequences for the Eastern Front.

In Sumatra, the Allies achieved their strategic objectives, severely disrupting Japanese oil supplies. The campaign demonstrated the evolving sophistication of Allied airpower, including navigation, bombing accuracy, and coordination. However, it also highlighted limitations, such as the high cost in aircraft and crews and the difficulty of maintaining momentum in a geographically isolated theater.

Both books illustrate the complexities of aerial warfare and its critical role in achieving strategic objectives during World War II. Martino and Battistelli's detailed examination of the Luftwaffe's Balkan campaigns offers a valuable case study in the strengths and limitations of airpower within a Blitzkrieg framework. Meanwhile, Kostam's account of the Sumatra campaign underscores the transformative power of strategic bombing in undermining an enemy's war economy.

Together, these books enrich our understanding of airpower's multifaceted impact during World War II, revealing not only its potential for decisive action, but also its inherent challenges and limitations. Score two more successes for Osprey.

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Focke-Wulf Fw 190: The A-G Series. By Martin Derry and Neil Robinson. Barnsley UK: Air World, 2023. Tables. Illustrations. Photographs. Appendices. Pp. 96. $34.95 paperback. ISBN: 978-1-39906-799-7

Derry and Robinson have both spent over three decades in the business of compiling, editing, and writing about aviation in both articles and books. They have contributed to Air World's FlightCraft series (of which this volume is one) before. Their subject this time is the radial-engine models of the Fw 190.

There is little question that the rugged Focke-Wulf aircraft was the best Luftwaffe piston-engine fighter of the Second World War. It entered service long after the ubiquitous Messerschmitt Bf 109 but was numerically inferior to the earlier fighter (some 20,000 built vs. over 34,000 Bf 109s). But it was a superb fighter that was constantly improved over the six years it flew to meet the ever-increasing capabilities of the Allies. Not only the Germans, but also the Hungarians and Turks flew it. France started reconstituting its post-war air force with Fw 190s rebuilt and modified indigenously.

Make no mistake: this is not a "Here I was at 30,000 ft" kind of book. It was written primarily with modelers in mind. The photographs and sideview illustrations are all excellent (I wish such material was around when I was active in the hobby). However, for the reader who wants to understand how Germany mastered the ability to take a basic airplane type and adapt it to many different needs, this book has much to offer.

The Fw 190, along with the Bf 109 and Junker's Ju 88 series, was not just an aircraft that went through progressive development with different model numbers representing major changes to the aircraft. All P–47Cs were basically the same. The P–47D incorporated major improvements, but all P–47Ds were, again, essentially similar. With the Fw 190, however, one has to carefully look at the full model designation: an Fw 190A-8/U1 and an Fw

190A-8/R8 have different armaments. Indeed, all P–47s were basically 8 x .50-cal machines. The Germans equipped the Fw 190 with various combinations of 7.92 and 13mm (basically .30 and .50 cal, respectively) guns and 20 or 30mm cannon. Through the use *Umr stbausätz* (factory conversion sets) and *Rüstsätz* (field sets), all sorts of combinations of armament, radios, engine-performance enhancement (nitrous oxide), and electrical systems were possible. I couldn't help but think that this must have driven the supply and maintenance troops nuts!

The point is that this is the main strength of this book—a detailed understanding of the wide variety of configurations of Fw 190s including the Mistel configurations, where a piloted Fw 190 served as drone director flying atop an explosive-laden, unmanned Ju 88 drone. Further, as the Luftwaffe phased out Ju 87 Stukas in favor of ground-attack Fw 190s, pilot conversion required Fw 190S 2-seat trainers.

With the long photo captions constituting a fair amount of the text, this book has plenty of information for readers other than modelers. It is an excellent overview of the radial-engine Fw 190s.

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

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Bravest of the Brave: The US Air Force Medal of Honor Recipients, Volume 1 1918-1943. By Joseph P. Bowman. Wolfe City TX: Del Hayes Press, 2025. Maps. Illustrations. Photographs. Notes. Appendices. Bibliography. Index. Pp. xv, 545. $59.99. ISBN: 978-1-73628761-3

Bowman is a retired USAF master sergeant who spent his career in the Security Police. Somewhere along the line, he must have discovered a love for awards and decorations and a flair for research. That is good, because he is quite excellent at ferreting out historical facts and putting them on paper. He wrote several books on individuals and their military decorations before compiling this first volume of a planned three on USAF (including the Air Service, Air Corps, and USAAF) Medal of Honor (MoH) recipients.

Sixty-two USAF airmen have been awarded the MoH for distinguishing themselves conspicuously by gallantry and intrepidity at the risk of their lives above and beyond the call of duty. Bowman covers the first 24 recipients in this first volume of the trilogy—from Eddie Rickenbacker in the First World War to Forrest Vosler in the Second. He has organized the books by date of the action for which the award was made. Most books on the MoH and its recipients are organized alphabetically. Bowman's system allows the reader to better understand the overall context in which the award was made. The four recipients from World War I are grouped together, so one gets a better sense of the award in context of that particular air war.

Each of the 24 recipient's stories is presented in a standardized format: a very short summary of the story is followed by a photo of the individual. What follows is the airman's life "Before the Medal," the "Medal of Honor Action, " and his "Life After the Medal" (unless the action resulted in the individual's death). Everybody is probably thinking this is the typical page or two biography. Absolutely not. What Bowman's decades of research give the reader is a monograph on each man that is generally way larger than a typical *AFHF Journal* article. We learn the details of the man—what made him tick and do what he did in combat. The reader also sees the vast diversity of these people: some rich, some poor; some outgoing, others nearly loners; highly educated to just-out-of-grade school; already famous to never-heard-of-again.

Let's talk research. Bowman's bibliography is huge: books, interviews, archival material, correspondence, newspaper articles, the internet, and more. His text is very well end-noted. If one wants to nit-pick some particular point, I'm certain that Bowman can readily go to the source. The two appendices list all of the awards and ratings the individual earned in his life and give actual citations for the major awards. The pictures are all germane and presented in hi-res. The publisher is to be commended for the layout work and presentation.

In short, this is the best of the many excellent MoH books I've seen. My only complaint is that more maps are needed given the level of detail in the stories. So, have an atlas handy. The next two volumes will, hopefully, be out about a year apart. I eagerly await them. For those interested in the best of the best of our Air Force, this book is more than worth the price and reading time.

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

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Pilots and Painted Ladies: 493rd Bomb Squadron and the Air War in the CBI. By Lawrence Drake. Havertown PA: Casemate, 2025. Photographs. Maps. Bibliography. Illustrations. Pp. 228. $34.95. ISBN: 978-1-63624-495-2

This book offers a compelling narrative that intertwines the operational history of the 493rd Bomb Squadron during World War II with the firsthand experiences of its members, highlighting the significant contributions of citizen soldiers in the American military tradition. Drake's father, Vernon, was a pilot with the 493rd and, as a talented artist, produced nose art that decorated some of the unit's B–24s. The book is organized chronologically, and much of the narrative consists of conversations Drake has fabricated using his father's papers and his knowledge of his father. This approach adds to the humanity of the story but also reduces its objectivity, thus reducing the book's value to serious historical researchers.

The 493rd Bomb Squadron, part of the 7th Bomb Group under the Tenth Air Force, played a pivotal role in the China-Burma-India (CBI) Theater. Stationed primarily in India at bases such as Pandaveswar and Tezpur, the squadron undertook critical missions that involved bombing strategic targets in Burma and transporting essential supplies over the treacherous Himalayan route known as "The Hump" into China. These operations were vital in disrupting Japanese supply lines and supporting Allied ground forces in the region. Drake meticulously reconstructs these missions, drawing from his father's detailed records to provide readers with an immersive experience of the squadron's endeavors.

A notable aspect of the 493rd's operations was their use of the AZON bomb, an early guided munition designed to improve bombing accuracy. The squadron's adoption of this technology exemplifies their innovative spirit and commitment to mission success, despite the challenges posed by the CBI Theater's harsh environment.

Central to the narrative is the portrayal of the citizen soldier, a cornerstone of America's military ethos. Vernon Drake epitomizes this ideal. His journey from civilian life to active duty in a distant theater underscores the profound sacrifices made by ordinary individuals during extraordinary times. Through personal anecdotes, letters, and photographs, Lawrence paints a vivid picture of his father's transformation and dedication.

The book also delves into a unique camaraderie among the squadron members. In their downtime, these airmen engaged in creating nose art—decorative paintings on their aircraft that often featured "painted ladies." This artistic expression served as a morale booster and a semblance of normalcy amidst the chaos of war. Drake juxtaposes these moments of creativity with the stark realities of combat, offering a balanced portrayal of life in the 493rd.

Pilots and Painted Ladies is more than a historical account: it is a tribute to the resilience and ingenuity of citizen soldiers who answered the call to serve. Drake's narrative ensures that the legacy of the 493rd Bomb Squadron and its contributions in the CBI Theater are preserved for future generations, shedding light on a lesser-known facet of World War II history. When children write about a parent's exploits, there is usually a mixture of pride and sadness. The resulting authenticity is always a solid read. I highly recommend this book.

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The Messerschmitt Bf 110 Story By: Jan Forsgren. Stroud UK: Fonthill Media, 2024. Photographs. Glossary. Appendix. Notes. Bibliography. Index. Pp. 160. $42.00. ISBN: 978-1-78155-916-1

In this book, Forsgren chronicles the Messerschmitt Bf 110, one of the most iconic aircraft of World War II. He offers a comprehensive exploration of the aircraft's development, operational history, and the broader evolution of the heavy-fighter concept in 1930-1945. This period marked a dramatic shift in air-combat tactics and technologies, making a fascinating story.

Forsgren meticulously details the aircraft's origins, tracing its lineage to the Luftwaffe push for a *Zerstörer* (destroyer) concept in the mid-1930s. Initially envisioned as a long-range, heavy fighter capable of escorting bombers and engaging enemy aircraft independently, the Bf 110 was a response to the Luftwaffe's doctrinal emphasis on offensive air superiority. Its twin-engine design, robust armament, and versatility made it a standout contender in early Luftwaffe plans.

The book captures the Bf 110's early successes in Poland, France, and the initial stages of the Battle of Britain. However, its vulnerabilities soon became apparent. Against more-agile, single-engine fighters (e.g., Spitfire and Hurricane), its lack of maneuverability and defensive blind spots were ruthlessly exposed. The Luftwaffe responded to these shortcomings. The Bf 110C and D models introduced modifications to enhance range and armament, but these were mostly stopgap measures. More significant redesigns came with the Bf 110E and G with improved engines and increased defensive firepower. However, by the time these were operational, the Bf 110 had been relegated to night-fighting and reconnaissance roles.

The book effectively treats the night-fighter era—the Bf 110's second life. Equipped with advanced radar systems and specialized armaments (e.g., upward-firing *Schräge Musik* cannons), the aircraft became a cornerstone of Germany's nocturnal defense against Allied bombing raids. This period underscores the adaptability of the heavy-fighter concept, even as it highlights the limitations imposed by the rapid pace of wartime innovation.

A strength of the book is its contextual analysis of the heavy fighter's place within broader air-power developments from 1930 to 1945. While the Bf 110's operational history is central, Forsgren compares it to its contemporaries: British Beaufighter, P–38 Lightning, and the Kawasaki Ki–45. These comparisons illuminate the shared challenges and divergent solutions faced by designers worldwide, offering readers a nuanced understanding of why the heavy fighter struggled to fulfill its original promise.

Adequately illustrated with archival photographs, the book is visually engaging. It is a useful resource for aviation enthusiasts and historians, not only for its insights into the Bf 110, but also for its broader commentary on the evolution of military aviation during one of history's most transformative eras. But Forsgren leaves a lot of ground unplowed. For example, many P–38 pilots lauded the advantage of locating machine guns and cannons in the nose. Forsgren makes no mention of whether Bf 110 pilots felt the same. There is also little mention of the standard Revi gunsight or how it was modified to accommodate *Schräge Musik* or WG21 rockets.

Forsgren's work is oddly formatted. The 160 pages are divided into 32 chapters. Some chapters are a single page, some are four or five pages. The chapter on the Bf 110's use in North Africa is a whopping four pages long while its use on the Eastern Front from 1941 to 1945 also takes all of four pages. Some chapters make significant use of aircrew anecdotes while others are little more than laundry lists of missions, weapons, and avionics. This format makes for a very quick, if unsatisfying, read. But, despite this, the book paints a balanced portrait of the Bf 110 as a product of its time—innovative, adaptable, and flawed. It offers invaluable lessons on the interplay between technology, strategy, and the unforgiving realities of combat. I recommend it.

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A Sword for Peace and Liberty Volume 1: Force de Frappe—The French Nuclear Strike Force and the First Cold War 1945-1990. By Philippe Wodka-Gallien. Warwick UK: Helion, 2023. Photographs. Maps. Illustrations. Bibliography. Pp. 86. $29.95 paperback. ISBN: 978-1-80451213-5

Whenever nuclear-capable nations are discussed, France seems to garner little attention. Considering it possesses a triad of nuclear-capable delivery systems, doctrine, and military strategies for the use of nuclear devices, its ability to operate below the radar seems odd. Wodka-Gallien's book offers an in-depth exploration of France's nuclear strategy, emphasizing its evolution through the Cold War era to the present day. It outlines the development of France's nuclear doctrine, emphasizing its core principle: "deterrence of the strong by the weak"—the idea that even a smaller nation can deter a much larger adversary if it possesses nuclear weapons.

One of the most compelling aspects of this work is its detailed historical context—how France sought to build its own independent nuclear deterrent, under the leadership of Charles de Gaulle. His vision for France was clear: the country needed to assert its strategic autonomy rather than rely on the US and NATO's nuclear umbrella. Thus, France embarked on developing the Force de Frappe, its nuclear strike force, to ensure it could independently defend its sovereignty in a world dominated by the Cold War superpowers. Considering the French program exists only because of US and UK assistance, Wodka-Gallien makes clear that both countries would fall into the category of strong countries to be deterred.

The book thoroughly details France's nuclear triad: submarine-launched ballistic missiles (SLBMs), air-launched nuclear weapons, and land-based missiles. This ensures that France has a second-strike capability (it could retaliate if attacked), the cornerstone of its deterrence strategy. While France's nuclear arsenal is smaller than those of the US or Russia, it is precisely calibrated to deliver enough devastating power to deter aggression, thereby realizing the concept of deterrence of the strong by the weak. Not explored is the fact that France's nuclear arsenal is stronger than that of many nuclear nations and significantly stronger than non-nuclear states.

A particularly noteworthy feature is the extensive use of photographs of extremely sensitive subjects. These images are of exceptional quality and are curated with great care, enhancing the narrative significantly. They are not only visually striking, but also complement the text by offering historical documentation of France's nuclear development. Rare images of key moments in French nuclear testing, political milestones, and technological advancements of the French military-industrial complex are included. These photographs bring the evolution of France's nuclear strategy to life.

The nuclear strategy analysis reveals how France has adapted to the changing global order while remaining consistent in its deterrence commitment. While France has reduced its nuclear arsenal over the years, the essence of its strategy has remained steadfast: maintaining the ability to inflict unacceptable damage in retaliation for any nuclear aggression.

The book also touches on France's role in nuclear diplomacy, particularly its opposition to nuclear proliferation and its participation in nonproliferation treaties. Nevertheless, France has always been careful to preserve the credibility of its own deterrent, balancing its commitment to global nonproliferation with the need to safeguard its national security. The book's one glaring omission is lack of discussion of the fact that by possessing nuclear weapons, France has a de facto capability for a nuclear first strike. Periodically, all nuclear armed nations are drawn into debates designed to draw out a policy statement that promises to forego any first-strike actions. France's position on this touchy subject is not presented.

The book is a valuable resource for understanding France's unique nuclear strategy. Its extensive use of high-quality, well-curated photographs enhances the reader's experience. At times, the narrative bogs down. Word choice and grammar make clear that the book is probably a machine translation from French. Despite that, Wodka-Gallien successfully captures the essence of "deterrence of the strong by the weak," making this book a must-read for those interested in nuclear strategy, international security, and military history.

Gary Connor, docent, National Packard Museum, Cortland OH

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Hitler's Miracle Weapons Volume 1: Secret Nuclear Weapons of the Third Reich and Their Carrier Systems *and* **Volume 2: The Secret History of the Rockets and Flying Craft of the Third Reich from the V-1 to the A-9 Unconventional Short- and Medium-Ranged Weapons.** By Friedrich Georg. Warwick UK: Helion, 2003 (these reprints 2024). Photographs. Bibliography. Maps. Notes. Pp. 127 and 118. $39.95 each, paperback. ISBN: 978-1-80451726-0 and 978-1-80451727-7

Within current literature, there exists a niche genre referred to as "alternative history." In these volumes, Georg poses "what if" scenarios to the reader. For example, "What if the confederacy won the American Civil War?" Or "What if Japan invaded the Hawaiian Islands following the attack on Pearl Harbor?" These types of subjects walk a fine line between fiction and non-fiction, science fiction and fantasy, and speculative military history and pseudo history. Georg's volumes ask the reader to believe that not only did Hitler's Reich avoid defeat, but also that the Reich survived and thrived to the point where they could develop and field a panoply of nuclear weapons and the systems needed to deliver them against the Allies. Some readers may recognize this concept as being like the charter of a web-based modeling group called "Luft46." These books are reissues of the original volumes published in German in 1988 and in English in 2003. There is no summary of changes made in the latest releases.

To craft his content, Georg carefully picks and chooses information that demonstrates the Reich possessed the various technologies to develop, test, and field in measurable numbers the weapons and systems so colorfully depicted in his books. He assembles these partial and half-truths into arguments that "prove" his thesis. Georg and his Helion editors ask the reader to ignore the realities of World War II in the mid-1940s.

The Reich's *Uranprojekt*, begun in 1939 by Heisenberg and von Weizsäcker, was charged with exploring nuclear fission and reactor technology. Virtually all historians and analysts agree that this effort was doomed to fail due to many factors: organizational fragmentation, decentralization, and lack of coordination; resource limitations; lack of prioritization and funding; and lack of engineering scale. The Reich's nuclear program was doomed from inception, even before the Allies' relentless attacks on the German military-industrial complex. The Reich was doomed and its nuclear program stillborn—despite Georg's fantasy.

Georg asks the reader to selectively suspend all knowledge of mid-twentieth century political, military, and scientific affairs and focus on the pretty drawings and blurry pictures of models to prove these weapons were on the cusp of reality and could have or would have changed the outcome of the war. Historians who address this issue are in general agreement that if the Reich possessed nuclear weapons, they would have used them. Hence, the world is better for a nuclear-armed Third Reich existing only in Georg's fantasy world.

I am not sure what Helion's editors were thinking when they elected to reissue this revisionist pseudohistory. Obviously, they believed it would sell. But, given the cost of these books, I would recommend other options: the 2018 film, *The Catcher Was A Spy*, is entertaining. Philip Ball's *Serving the Reich* is also enjoyable. And for someone intrigued by alternative history, Tsouras' *Third Reich Victorious* is another solid recreational read.

Gary Connor/Docent, National Packard Museum, Cortland, Ohio

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The V1 Flying Bomb Campaign 1944-1945: The Doodlebug Summer and After. By Jan Gore. Barnsley UK: Pen and Sword Books, 2024. Photographs. Diagrams. Maps. Bibliography, Index. Pp. 199. $34.95. ISBN: 978-1-39906-581-8

Jan Gore is a researcher, writer, lecturer, and former government librarian who has also lectured in French at Kingston University. He has two publications to his credit: *Send More Shrouds: The V1 Attack on the Guards' Chapel 1944* and *The Terror Raids of 1942: The Baedeker Blitz*.

Giulio Douhet stands out among military theorists regarding how airpower would change modern warfare. Douhet introduced the concept of "total war," with no distinction between soldier and civilian. In total war, bombing the population, he theorized, would cause the citizens to petition their leader to end the war, bringing about peace. Terror bombing, for which the V–1 and V–2 were intended, failed to cause England's capitulation and, hence, generally disproved Douhet's theory.

Gore's book is divided into twelve chapters. Throughout, he moves back and forth from the technical and strategic development of the V–1 to how the weapon affected the population of London and other cities. Gore includes many primary sources and biographical information on specific incidents and how the population responded. At times, so much primary (and secondary) source information is overwhelming, and the reader may get somewhat lost in the direction Gore is taking. This being said, he skillfully worked into each chapter in-depth details on the V–1 itself. Also covered are its launching sites, Allied efforts to neutralize these sites, and the German commanders who oversaw implementation of the V–1.

While the writing style is unique, Gore fails to include any discussion of the history of terror bombing. He may have better served the overall concept being discussed by including other examples of how terror bombing failed in World War II, such as the RAF's indiscriminate night bombing of Germany and the USAAF firebombing of Japan. The V–1 and V–2, while truly terrorizing, did not force the capitulation of England, just as the German and Japanese populations hardened their resolve during the above-mentioned bombings. The only time that terror bombing forced the capitulation of an enemy during the Second World War was by the use of atomic bombs.

Gore's book is well-written and has a unique writing and layout style. Gore describes the effects of the V–1 (and V–2) on the population of England in vivid detail. The descriptions are very personal and bring out the horrors of war as seen in the streets and neighborhoods of cities in England.

I highly recommend this book. It tells a fascinating story of bravery and population resolve in the face of persistent death and destruction. Gore's book should be a welcome addition to any military history enthusiast's library.

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

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Babe and Avonelle in Their Own Words. By Frank Hawke. Independently Published, 2024. Photographs. Pp. 447. $22.28 paperback. ISBN: 979-8-87129451-2

This is a heartfelt narrative drawn from the oral histories of his parents, Lt Col Francis "Babe" Hawke and Irene Avonelle Johnson. By focusing on their experiences during World War II, Hawke offers readers an intimate glimpse into the challenges of life on the home front. This memoir uniquely blends personal history with the broader context of a nation at war, capturing the emotional and practical struggles that millions of Americans faced, particularly around subjects such as rationing, communication, and dealing with casualties.

One of the book's standout aspects is its detailed portrayal of rationing, a constant reality for those on the home front. Avonelle recounts the day-to-day difficulties of managing household supplies using government-issued ration books—making creative substitutions in recipes due to shortages of sugar, butter, and meat. As with many women of her time, she learned to stretch what little was available, making meals that were nourishing yet modest. Her anecdotes reveal both the frustration and ingenuity of civilians as they supported the war effort. She recalls, for example, learning how to can vegetables and fruit, preserving the summer's bounty to feed her family through the winter months. Self-reliance not only sustained the family but also symbolized the larger sacrifices and adjustments made by all Americans during the war.

Communication with service members abroad is another poignant theme. V-Mail (Victory Mail) was a popular method of communication that allowed families and soldiers to stay connected via microfilmed letters which were printed out upon arrival. Avonelle's descriptions of eagerly awaiting letters from her husband highlight the emotional strain of long-distance communication in a time of war. She recounts the joy of receiving these letters, even though they often arrived weeks or months after being written. V-Mail was important in maintaining morale, not just for soldiers but for their families as well. Despite delays and censorship, they provided a critical emotional lifeline.

Casualty notification was a dreaded reality for families during the war. Avonelle shares her fears whenever a Western Union messenger or military officer appeared at someone's door. The anxiety of potentially receiving unwelcome news was ever-present, and the community was deeply affected whenever a local soldier was reported missing, wounded, or killed in action. Her account of comforting a neighbor who had just received such a telegram is particularly moving, illustrating the emotional toll that the war took on those who remained at home.

Hawke's book offers a deeply personal perspective on the home front, blending historical facts with intimate anecdotes that bring the era to life. Through his parent's stories, the reader gains a deeper understanding of the everyday struggles and emotional burdens that American families endured while their loved ones were fighting abroad. To be sure, the book contains a lot of personal stories and memories. Avonelle talks about society's view on women smoking. She talks about meals she cooked, and how a military spouse "lived" in the mid-20th century. This book is not only a tribute to the Hawke family, but also to the millions of ordinary Americans who quietly contributed to the war effort from their homes. While America's wars of the past three decades have not required rationing or sporadic communications, in many ways America's warriors and their families have been forced to cope with many of the same challenges.

The oral histories are available on YouTube at Lt. Col. Francis E. "Babe" Hawke Military History and Avonelle Hawke Oral History

Gary Connor, docent, National Packard Museum, Cortland OH

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Call Sign "Muff": The Life of a Radioactive U–2 Pilot. By Lt Col Donald Heckert, USAF (Ret). LuLu.com, 2024. Maps. Tables. Diagrams. Illustrations. Photographs. Appendices. Index. Pp. 324. $30.98 paperback. ISBN: 978-1-304-34102-0

This book takes readers on a journey through the fascinating and suspenseful covert world of aerial espionage, revealing missions that few know about. It recounts operations in some of the most sensitive regions around the globe.

Heckert is a command pilot with over 7000 flight hours across 30 different aircraft types. He flew the U–2/TR–1 operationally for 11 years. The U–2, also known as the Dragon Lady, was designed by Kelly Johnson and originally operated by the CIA. It's the most famous spy plane in history, capable of flying at unprecedented altitudes while carrying cutting-edge sensors, all under a cloak of extreme secrecy.

Throughout the Cold War, the U–2 Dragon Lady was regarded as a "national asset" and was tightly controlled. Pilots such as Heckert wore full pressure suits (like space suits) to endure the physiological dangers of flying at such high altitudes. At those heights, human bodies would experience catastrophic conditions—blood boiling, tissues expanding—due to Boyle's Law and Armstrong's Line. Additionally, exposure to radiation from nuclear explosions added another layer of peril to their missions. In the book, Heckert recounts numerous unique and dangerous experiences, including being the first pilot to fly into the radioactive debris cloud of China's largest atmospheric nuclear test.

In 1975, near Cambodia, the Khmer Rouge seized the US merchant vessel SS *Mayaguez* and imprisoned its crew. Heckert piloted a U–2, located the *Mayaguez*, and confirmed that the ship was "dead in the water." Heckert remained on station, maintained a full view of the *Mayaguez* through his view-sight, and relayed vital intelligence to US and allied forces as well as the National Command Authorities in Washington DC. U–2s flew at high altitude for a total of 27 hours over the tense three-day period. This dramatic episode is one of the many highlights that readers will find gripping.

While stationed in Alaska, Heckert commanded the nation's largest nuclear detection operation, describing the unique challenges of operating in the "last frontier." Later, as the program director for the U–2, TR–1, and SR–71 at Wright-Patterson AFB, Heckert managed the development and production of these highly classified aircraft. He defended "Black World" budgets before Congress, collaborated closely with Ben Rich of Lockheed's Skunk Works, and carried out duties at the infamous Area 51.

After retiring from the Air Force, Heckert pursued a career in Alaskan aviation, serving as a pilot, instructor, safety officer, and director of operations for three Alaskan airlines. He is also a certified FAA Airframe and Powerplant mechanic with inspection authorization, holds a US Navy certification as a radiation protection officer, and has a paratrooper rating from the US Army. Heckert is also combat-rated for nuclear delivery missions. One of his most harrowing experiences includes surviving for four days after a wintertime aircraft crash north of the Arctic Circle.

In summary, this book is a fascinating collection of reports and personal anecdotes that offer a unique glimpse into Muff Heckert's extraordinary life and career.

Colonel Charles P. "Chuck" Wilson, USAF (Ret), U–2 pilot/squadron commander and NASM docent

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Last War of the Superfortresses: MiG–15 versus B–29 in the Korean War 1950-53. By Leonid Krylov and Yuriy Tepsurkaev. Warwick UK: Helion, 2016, 2024. Maps. Tables. Illustrations. Photographs. Notes. Appendices. Bibliography. Pp. 92. $29.95 paperback. ISBN: 978-1-80451-624-9

I've read a number of books about the Boeing B–29 and its Pacific campaign in World War II, but the B–29 was also used heavily in the Korean conflict, and there's much less to read about that. The typical story, usually in scant detail, says that they were used in daylight bombing of strategic and tactical targets, were severely outclassed by the new MiG jet fighters, and the USAF shifted them to night bombing as a last resort.

In this book, the two Russian authors provide considerably more detail. They extensively researched every engagement between the MiGs and B–29s using records from the Central Archive of the Russian Ministry of Defense, written accounts of individual Soviet pilots, and US published sources. That's right: they researched *every* engagement and described them here!

The result is a very detailed accounting of every air battle—in a level of detail I found challenging to follow. Victories and losses are presented in accounts from both sides; and, probably unsurprisingly, they seldom agree. I should have kept a notepad available to tabulate what units were engaged (and from which side), what the many acronyms mean, and where the action took place. I got lost more than once.

I liked learning what I did from the book, which describes the evolution of Soviet and US strategies as the war slogged on. But I had to look hard for those messages because of the incredible detail of the account of every engagement. As the story went on, I literally found myself re-reading some paragraphs to make sure I knew who was the "enemy" and who was "us." Those terms got transposed several times. Most of the time, of course, the "enemy" was the Americans.

There's a table in Appendix III designed to help distill the detail, but one has to flip back to that table many, many times for the results of each engagement to truly sink in.

The book is richly illustrated with many photos of B–29s (all with their original captions from the National Archives), images of Soviet pilots, and 16 pages of color plates containing excellent artwork of MiG–15 and B–29 paint schemes. Unfortunately, I found the two maps of Korea less useful, because they don't show many of the locations mentioned. When they do, they're often not spelled the same way they are in the text. That's confusing.

The authors wrote the book in Russian. The English translation wasn't very well done; a lot of awkward phraseology required a lot of re-reading. I even found an archaic "olde-English" phrase that the authors certainly didn't use. It seemed far out of place for a book like this.

The last few sections of the text point out nicely how each side was both helped and handicapped by the technologies they had and didn't have. That was very helpful in understanding this period of awkward transition from propellers to jets.

Do I recommend this book? For those wanting a *very* detailed mission-by-mission accounting of the Korean B–29 campaign from both the Soviet and US points of view, then yes, I recommend it. But it's not an easy narrative, is awkwardly translated, and will definitely take effort to read.

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

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Realm of Ice and Sky: Triumph, Tragedy, and History's Greatest Arctic Rescue. By Buddy Levy. New York: St Martin's Press, 2024. Maps. Photographs. Notes. Bibliography. Index. Glossary. Pp. xiv, 368. $32.00. ISBN: 978-1-25028918-6

This book delves into the ambitious and perilous attempts to conquer the Arctic using airships in the early 20th century. This meticulously researched narrative brings to light the endeavors of explorers who sought to reach the North Pole by navigating the uncharted polar skies. Levy's storytelling captures the essence of human determination and the relentless pursuit of discovery in one of Earth's most formidable environments.

The early 1900s marked a period of intense fascination with polar exploration. Traditional methods, such as dog sleds and ships, had been employed with varying degrees of success. However, the advent of airships—lighter-than-air crafts capable of controlled flight—offered a novel approach to traversing the Arctic's icy expanses. European nations, particularly Norway and Italy, were at the forefront of integrating airship technology into their exploration strategies.

One of the era's most notable figures was Norwegian explorer Roald Amundsen. Already celebrated for his South Pole expedition, Amundsen turned his attention northward. In 1926, he, along with Italian engineer Umberto Nobile, embarked on a daring journey aboard the airship *Norge*. This expedition aimed to fly from Europe across the Arctic to North America, effectively crossing the North Pole. The mission was groundbreaking, marking the first verified flight over the North Pole and displaying the potential of airships in polar exploration.

Nobile led a 1928 expedition with the airship *Italia*. Tragically, it ended when the *Italia* crashed on the Arctic ice, leading to a complex and prolonged rescue operation. The incident underscored both the potential and the perils of using airships in such unforgiving terrain.

In the realm of commercial aviation, airships offered a glimpse into the future of passenger travel. The British airship R–34 made a historic transatlantic flight in July 1919, flying from the UK to the USA and back, demonstrating the potential for intercontinental airship travel. Similarly, Germany's *Graf Zeppelin* achieved numerous long-distance flights, including a circumnavigation of the globe in 1929. These feats captivated the public imagination and highlighted the possibilities of airship travel in meeting the challenges of arctic exploration.

Despite their promise, airships faced significant challenges. The infamous 1937 *Hindenburg* disaster, where the airship caught fire, marked a turning point in public perception. The loss of 36 lives starkly highlighted the vulnerabilities associated with hydrogen-filled airships. This tragedy, combined with advancements in heavier-than-air aircraft technology, led to the decline of airship prominence in both commercial and exploratory aviation.

Levy's writing style is both immersive and detailed, bringing the harsh realities of Arctic exploration to life. He masterfully blends historical facts with vivid storytelling, making complex technical aspects of airship travel accessible to the nonexpert. His casually engaging prose often reads like a Clive Cussler adventure novel rather than a purely historical account. The typical chapter is usually less than a dozen pages. When combined with Levy's narrative style, the book is a very quick read. His ability to weave together personal narratives, scientific advancements, and the broader geopolitical and socio-cultural context of the era keeps the reader invested. His deep research is evident, yet he avoids overwhelming the reader with excessive technical jargon, making this an entertaining, compelling, and informative read.

This book chronicles the daring exploits of polar explorers and serves as a testament to the era when airships were at the forefront of aviation technology. Levy sheds light on a fascinating chapter of history, illustrating how nations harnessed innovative airship technology in their quest to explore and understand the world's most remote frontiers. I highly recommend this book.

Gary Connor, docent, National Packard Museum, Cortland OH

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Cyclone Warriors: The Australian Defence Force and Cyclone Tracy December 1974–June 1975. By Tom Lewis. Kent Town, Australia: Avonmore Books, 2024. Maps. Tables. Illustrations. Photographs. Notes. Appendices. Bibliography. Index. Pp. 128. $42.95 paperback. ISBN: 978-0-9756423-1-3

When the publisher first sent me this book, I pretty much decided that the subject matter really didn't belong in an airpower journal. But, after thinking about it more, I realized that airpower isn't just involved in fighting. It's a force that can be used in peacekeeping, humanitarian assistance, and deterrence. This is a great story of humanitarian assistance.

Darwin is the capital city of Australia's Northern Territory. On Christmas Day, 1974, a small but powerful cyclone (hurricane, typhoon) hit the city with winds of over 130 mph. Having expanded greatly after World War II, the city was largely comprised of buildings (particularly housing) that weren't built to the most exacting of building codes. Communications with the rest of Australia were knocked out, 70% of the buildings (80% of the houses) had been destroyed, 66 people had died, and hundreds were injured. The small army unit in the city reestablished radio communications on the first day to inform the rest of the country that there had been a disaster.

My wife and I recently visited Darwin and repeatedly heard two major themes: the Japanese bombings of the city and local area in 1942, and Cyclone Tracy. Dr. Lewis is a well-known historian and retired naval officer who has lived in Darwin for many years. He has ably written about both of these major events in the city's history. This latest work is an excellent overview of the role of all of Australia's military forces—Army, Navy, and Air Force—in rescuing and reconstructing Darwin. If not for the military assistance, the city would probably have been written off and abandoned.

The first assistance came from the Royal Australian Air Force (RAAF). Its role was primarily to bring food, medical supplies, tents, and other materiel in, and then fly injured and displaced people out. They also performed search missions for some of the boats that were in the harbor, conducted aerial surveys of the damage, and did aerial spraying to thwart insects and disease. The primary aircraft involved were C–130s, Caribous, and HS.748s. Another welcome participant was USAF C–141s.

With the arrival of the carrier HMAS *Melbourne*, six naval Wessex helicopters joined the air work. Hundreds of sailors contributed greatly to the initial cleanup and rebuilding efforts. The Army's role was largely on the ground with its large manpower and equipment contributions.

As *Melbourne's* XO stated, "the book of instructions on how to clean up a city had been blown away in the storm [and we] had to start with a clean sheet. It was an interesting exercise." That is the book's message. In an unprecedented natural disaster, airpower and the larger military establishment found ways to serve their country and its people in ways that didn't involve active war. It's an interesting story well told.

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

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The Heroes We Needed: The B–29ers Who Ended World War II and My Fight to Save the Forgotten Stories of the Greatest Generation. By Trevor McIntyre. Warwick UK: Helion, 2024. Photographs. Diagrams. Maps. Notes. Bibliography. Index. Pp. 384. $37.95. ISBN: 978-1-804511-65-7

McIntyre's book is a compelling tribute to the B–29 Superfortress aircrews who played a pivotal role in bringing down the Japanese Empire. It is structured to intertwine historical narratives with McIntyre's own personal journey, creating a passion project which offers readers both an educational and personal experience. That is not to say the book is not well researched or historically sound, but it is a personal literary offering—not an academically rigorous one.

The book is organized into sections that alternate between recounting wartime events and anecdotes, and detailing McIntyre's endeavors to preserve B–29 artifacts, personal stories, and oral histories. This dual narrative approach allows readers to gain a comprehensive understanding of the B–29's significance during the war and the challenges involved in preserving its legacy. The historical sections are detailed, providing insights into the strategic importance of the B–29 Superfortress and the missions undertaken by its crews. But the inclusion of notes cannot make up for the lack of citation.

Interspersed throughout are McIntyre's personal anecdotes from his quest to recover and restore B–29 artifacts. I believe the typical reader may be surprised by the sheer volume of aviation and personal artifacts and ephemera that exists and is available for purchase. McIntyre's personal acquisition stories may be entertaining to some readers, or an annoying diversion to others. The average reader will recognize his passion for artifact collection and accept how that desire strengthens his personal connections to the subject. These keep history alive by adding depth and color to the overall narrative.

I will be generous when saying McIntyre's claim that this is the single best book on B–29 operations during World War II is subjective hyperbole. His work is at its best when blending personal narrative with historical recounting, offering a human perspective on the B–29's role in the war. The inclusion of personal anecdotes and artifact preservation stories sets it apart from more traditional military histories. However, for readers seeking a purely academic or technical analysis of B–29 operations, other works with more rigorous citation and focused military analysis might be more satisfying.

The Heroes We Needed stands out for its heartfelt dedication to preserving the stories of B–29 airmen and the aircraft they flew. While it may not fulfill the criteria of an academic text due to its informal and emotional approach, its blend of personal memoir and historical narrative offers an engaging perspective on World War II aviation history. McIntyre's passion for the subject matter is evident throughout, making it an interesting read for those interested in the human stories behind the machinery of war.

Gary Connor, docent, National Packard Museum, Cortland OH

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RAF Hawkinge: The RAF's Wartime Frontline Airfield; From Dunkirk to the Battle of Britain and D-Day. By Anthony J Moor. Barnsley UK: Air World. 2024. Photographs. Maps. Bibliography. Index. Pp: 303. $52.95. ISBN: 978-1-39907-146-6

This book offers a comprehensive exploration of one of Britain's pivotal airfields. As the closest RAF station to Occupied Europe during World War II, Hawkinge played a crucial role in several key operations. But the landing field at Hawkinge provided pivotal support to British aviation from the earliest days of aviation to the current day.

Moor traces the airfield's evolution from its pre-World War I origins through its significant contributions in World War II. His detailed narrative provides readers with an understanding of the strategic importance of Hawkinge, highlighting its transformation from a training ground to a frontline defense hub. The book delves into the daily operations, challenges faced by personnel, and the airfield's adaptation to the rapidly changing demands of wartime aviation. Unfortunately, Moor's has a very Dickensian writing style. The narrative often becomes stilted and plodding, and the story is drowned in a sea of words. Sentences frequently cover 50-75 words and occasionally contain 10-15 commas with an attendant number of clauses. I frequently found myself taking notes to diagram sentences just to follow the author's thought process.

Given the problematic narrative, the outstanding collection of finely curated images is a standout feature of this book. These images serve not merely as supplementary material, but as integral components that frequently rescue the narrative. They offer visual context, bringing to life the stories of the pilots, ground crews, and aircraft that defined Hawkinge's wartime operations. The photographs provide readers with a tangible connection to the past, illustrating the airfield's infrastructure, the intensity of aerial battles, and the human element of war.

Moor's background as an aviation historian is evident in the depth of research and attention to detail throughout the book. His research is thorough and his stories engaging. He provides readers with a well-rounded perspective on the airfield's operational history and its broader impact on the war effort.

However, the book is not without its shortcomings beyond the grammatically challenging structure. Some readers may find the extensive technical details overwhelming, particularly those who are not well-versed in military-aviation terminology. Additionally, while the photographs are a significant strength, there are instances where more detailed captions or contextual explanations would have enhanced their value.

Despite these critiques, *RAF Hawkinge* stands as a valuable resource for aviation enthusiasts and historians. Moor's ability to weave together factual data with compelling narratives makes the book an engaging, if challenging, read. The inclusion of firsthand accounts and personal stories adds a human dimension to the historical events, allowing readers to connect with the experiences of those who served at Hawkinge. Interestingly, Hawkinge continues to serve the community by hosting the Kent Battle of Britain Museum.

This book offers an in-depth and visually captivating account of a key RAF airfield's role during World War II. The name of RAF Hawkinge may not be as well-known as RAF Duxford or Cranwell, but the base's contributions are without equal. The detailed research and solid use of photographs make this book a commendable addition to the literature on Britain's wartime history. The cost is a bit pricey, but I recommend this book.

Gary Connor, docent, National Packard Museum, Cortland OH

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Mers el-Kébir 1940: Operation *Catapult*. By: Ryan K Noppen. Oxford UK: Osprey, 2025. Photographs. Drawings. Charts. Maps. Bibliography. Index. Pp. 96. $25.00 paperback. ISBN: 978-1-47285-970-9

Ryan K. Noppen's latest book explores a tragic episode during World War II when former allies Britain and France found themselves in armed conflict. The book meticulously examines the political and military events leading up to the British attack on the French fleet at Mers el-Kébir, Algeria, the ensuing hostilities, and the subsequent effects on Anglo-French relations.

In June 1940, following France's armistice with Germany, the British government faced a dire strategic dilemma: the potential of the formidable French fleet falling into Axis hands. Despite assurances from Admiral Darlan that the fleet would remain under French control, Prime Minister Churchill and his War Cabinet deemed the risk unacceptable. This led to Operation *Catapult*, aiming to neutralize the potential French naval threat.

On July 3, 1940, Vice-Admiral Somerville, commanding the British Force H, delivered an ultimatum to the French fleet moored at Mers el-Kébir. The options Somerville offered were stark: join the British, sail to a neutral port, demilitarize, or face destruction. When negotiations failed, the British opened fire from both the air and sea, resulting in the sinking of the battleship *Bretagne* and the loss of approximately 1300 French sailors.

Noppen provides a detailed analysis of the rapid deterioration in Anglo-French relations, highlighting the complexities and miscommunications that led to such a drastic outcome. He explores the British perspective, emphasizing their determination to continue the fight against the Axis powers and prevent any augmentation of enemy naval strength. Conversely, the French viewed the attack as a betrayal, leading to severed diplomatic ties and retaliatory bombing. Noppen's analysis of this complex, but deteriorating, relationship is detailed and nuanced. He notes that the appeasement policies of the Baldwin and Chamberlain governments created an atmosphere of distrust, with many senior French military and political leaders believing the British were willing to fight Germany to the last drop of French blood.

The aftermath of Mers el-Kébir left deep scars. The attack was condemned in France as an assault on a neutral nation, with many feeling their honor had been affronted. Marshal Pétain's Vichy government severed diplomatic relations with the UK on July 8, 1940, and French aircraft retaliated by bombing Gibraltar. These events strained the relationship between the two nations, with the French populace harboring resentment over what they perceived as a betrayal by a former ally.

However, as the war progressed, the dynamics shifted. The rise of the Free French Forces under General de Gaulle, who was recognized by the British as the leader of these forces on June 28, 1940, played a pivotal role in mending ties. Shared objectives and the overarching goal of defeating the Axis powers facilitated gradual reconciliation. Collaborative efforts in subsequent military operations further cemented this renewed alliance, culminating in joint endeavors during the liberation of occupied Europe.

Noppen's narrative is enriched with detailed maps, photographs, and artwork, bringing to life the forces involved and providing readers with a comprehensive understanding of this complex episode. The book serves as a poignant reminder of the challenges alliances face in wartime and the enduring spirit of reconciliation that can emerge from even the darkest chapters of history. This book is another Osprey winner.

Gary Connor, docent, National Packard Museum, Cortland OH

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Night Fighter Aces of the Luftwaffe 1940-43. By Neil Page and Jean-Louis Roba. Havertown PA: Casemate Publishers, 2024. Map. Tables. Illustrations. Photographs. Bibliography. Index. Pp. 252. $28.95 paperback. ISBN: 978-1-63624-490-7

Page has applied his German-language skills to good use with his third effort for Casemate's new series, Casemate Illustrated. Previously he wrote *Day Aces of the Luftwaffe 1939-1942* and *Day Aces of the Luftwaffe 1943-1945*. He has also translated the histories of several German fighter units. Roba, a World War II history enthusiast, contributed to Casemate's *Luftwaffe in Colour* series. As with Page, Roba wrote another book in the illustrated series: *The Luftwaffe in Africa 1941-1943*.

After an introduction, the authors review the beginning of Germany's night-fighter operations. Germany, as did its principal night-fighting foe, Great Britain, entered the war completely unprepared to fight in the dark. The British had discovered in the early months of the war that their bomber fleet lacked the capacity to sustain the losses inflicted by German day fighters. The Royal Air Force (RAF) switched to night attacks that initially failed to inflict much damage. They did, however, prompt a response by the Germans.

The next six chapters proceed in chronological order. The authors divide 1941 and 1942 in half. Because the book ends in mid-summer 1943, the final two chapters look at the first half of 1943 and July, when German tactics and technology improved.

In 1941, the Germans experienced the expected growing pains of pairing limited technical capabilities with an untested doctrine. The British faced similar challenges. Despite obvious limitations, German night fighters managed to inflict serious losses, partly because of a "home-court" advantage based on radar. In many ways, the two nations reversed roles from the summer of 1940 when they fought over southeast England.

Frustrated by the inability to accurately attack German targets, the RAF summoned Arthur Harris to lead Bomber Command in February 1942. Only in 1943, however, did Bomber Command launch sufficient forces that were capable of overwhelming the Germans. This became known as the Battle of the Ruhr.

While the authors overwhelmingly emphasize the German point of view, they interject British adjustments to provide context for the *Luftwaffe*'s response. Through the generous use of side bars, they profile several aces along with *Generalleutnant* Josef Kammhuber, who organized and directed night-fighter operations until his dismissal in late 1943. Other side bars look at aircraft development, including the Heinkel He 219. German pilots flew aircraft adapted from other uses (e.g., the Junkers Ju 88); but, with the He 219, the Germans finally had a dedicated night fighter.

Aside from photos of various aces, the authors have included dozens of pictures of assorted aircraft. Many photos came from private collections. Page has also included passages from some of the aces' memoirs that he translated from German.

This book is recommended as an introduction for those unfamiliar with the German response to Bomber Command's nighttime attacks. Specialists should find the photos of interest. The color illustrations may appeal to model builders.

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

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First Manned Rocket Launch: Natter, the Luftwaffe's Vertical Take-Off Interceptor Then and Now. By Jean Paul Pallud. Barnsley UK: After the Battle (Pen and Sword), 2024. Photographs. Charts. Pp. 168. $34.95. ISBN: 978-1-03610128-2

As Pallud points out in his introduction, the German search for "wonder weapons" at the end of World War II gave rise to some extraordinary leaps in technology, e.g., the Me 163 (the first rocket plane) and the V2 (the first rocket to reach space). But it also produced bizarre devices that gave little or no tactical or strategic advantage. The Bachem Ba 349 Natter (Snake) falls into the second category. Pallud and After the Battle have offered a lovely small book/photo album documenting the Natter program at the end of the war. The book is primarily photographs, of which many are in the "then-and-now" format that is the hallmark of "After the Battle" products.

Many of these photographs are unique. All are high-quality images, superbly curated and featuring comments and captions that are the heart of the book. The overall product is high-quality with excellent paper and printing and strong binding—all of which take a bit of the sting out of the high price.

My only disappointment is the lack of significant attention paid to the production and manufacture of the weapon system and its components. There are a few photos of factories and partially completed airframes. Pallud notes that components were built by prisoners and displaced persons. Assuming these people were not trained technicians, how were supervision, oversight, and quality control handled, not to mention acceptance testing? Since the Natter was a "one shot weapon," acceptance flight tests were out of the question. Similarly, Pallud mentions a radio-based target vectoring system that guided the Natter to an optimum firing location. I would have liked to learn more about that system as well.

I have read several commentators who opined that the way to judge the success or failure of Hitler's wonder weapons was to note which weapons and technologies were adopted by the victorious Allies for use by their armed forces. The Jumo axial-flow engines, guidance systems for surface-to-air and air-to-ground munitions, liquid fueled rocket engines, and swept-wing aircraft designs all found homes in the Allies' next generation weapon systems. There was, however, no great rush to develop an American "Snake" or a Russian "   ."

There are a handful of Natters in museums, but most of us must rely on excellent books such as Pallud's to remind us of this unique weapon system.

Gary Connor, docent, National Packard Museum, Cortland OH

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Beaufighters & Mosquito Operations in WWII: The Memoirs of a Radar Operator. By Zbyšek Nečas-Pemberton. Great Britain: Air World, 2024. Diagrams. Illustrations. Photographs. Index. Pp. 245. $42.95. ISBN: 978-1-52678-957-0

It is a rare occasion when I am introduced to a World War II aviator's experiences as approachable, unadorned, and informative as this memoir by Pemberton (a name he adopted after the war). As a young Czech émigré in England, he quickly learned English and joined the RAF as a night Radar Operator (RO) flying in Bristol Beaufighters and de Havilland Mosquitos during the second half of the war. He had a personal battle to contend with during his time in England. When he fled Czechoslovakia as an 18-year-old high school student in 1939 (just a month before the war broke out), he left behind his mother and her Jewish family members. Regrettably, he lost contact with them during the conflict. When he returned home after the war, he learned that no family members had survived the Nazi Holocaust. His anguished tale of leaving his family is woven throughout his autobiography. He returned to England when Communism became widespread in Czechoslovakia and lived there the remainder of his life.

Since his childhood, Pemberton had a love affair with airplanes, so it was easy to understand what his focus would be when he arrived in England. Although his desire to pilot a plane was never realized during the war, he excelled as a successful night RO. The RO was in constant contact with ground radar controllers who identified their targets and directed planes to the enemy aircraft. The RO then used his radar to virtually fly his airplane, commanding the pilot to interception coordinates as they approached the enemy target, always from behind.

Pemberton was credited with two German aircraft destroyed (one of which was the first Heinkel He 177 downed by the RAF in the West), one aircraft probably destroyed, two damaged, and one V–1 flying bomb destroyed. He is also credited with one enemy minesweeper set on fire off the Dutch coast. The palpable fear of all night fighters was friendly fire, and Pemberton fell victim to anti-aircraft damage over London when his Beaufighter took a direct hit to its port wing. Both he and his pilot successfully bailed out.

At the time, it was not uncommon in the RAF to have foreign expatriates participate in their own squadrons under their national designations. Pemberton flew with the legendary Czech 68 Night Fighter Squadron, "one of the best nightfighters in the RAF." As a hobbyist, he designed the squadron's unique emblem which was personally approved in a field meeting with King George VI as he agreed that an exception would be made, where the motto, normally inscribed in Latin, would be in Czech: "Vždy Ppripraven"—"Always Ready."

Much of the appeal of this engaging memoir is the remarkable legacy of foreign nationals participating in the

RAF's battle against the Axis, and the achievements of the RAF night fighters in the Second World War. Simply put, this is an unvarnished account of a dedicated young man who fled his country ahead of the Nazi occupation, who would never see his family again, and who unselfishly fought the Germans to protect his adopted homeland. Retired Colonel Nečas-Pemberton was awarded the Medal for Heroism by the President of the Czech Republic in June 2017. He died nine months later at age 97.

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

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Bf 109E: Battle of Britain. By Andy Saunders. Oxford UK: Osprey. 2024. Photographs. Illustrations. Drawings. Index. Pp. 80. $23.00 paperback. ISBN: 978-1-47288240-2

Osprey has published six previous books on the Bf 109E *Emil* and its role in the Battle of Britain; I have several on my bookshelves. All present the same general information in Osprey's proven formula. Solid research. Check. A readable narrative with interesting anecdotes. Check. Well-curated images that directly support the narrative. Check. Lastly, eye-catching colorful artwork. Check. Saunder's contribution checks all the blocks to add to the lengthy list of Osprey's literary hors-d'oeuvres about this iconic Luftwaffe fighter.

Saunders does take an unexpected approach. The first four chapters talk about organizations, tactics, and general scene-setting before beginning a serious discussion of the titular aircraft. His discussion of technical matters is perfunctory and does not introduce any new information. The Bf 109E was well known to the RAF; their boffins had the chance to examine numerous examples captured in France. British pilots had the opportunity to fly the *Emil* and confirm post-combat reports.

The *Emil* benefited from an improved powerplant that provided a 30% boost in horsepower. Combined with the standard fuel-injection system and the *Emil*'s combat-effective envelope was significantly increased. An upgraded weapon suite improved its lethality within that envelope. On the downside, the heavier aircraft with no increase in fuel capacity meant it still suffered from a limited combat radius. Saunders rightly places the "blame" for that shortcoming at the feet of the RLM and Luftwaffe leadership. Failing to include the necessary piping and pumps to employ external fuel tanks in the *Emil* while on the production line, as well as failing to provide the tanks themselves, was unforgivable.

To his credit, Saunders does not stop there. I found his discussion of flotation devices (*Schimmweste*) interesting. When *Emil* pilots were asked to go toe-to-toe with Fighter Command while wrapped in bicycle inner tubes, some negative effect on morale should have been expected. It is not as though the English Channel was a surprise to anyone. On the positive side, the shape and construction of the primary fuel tank worked to the benefit of pilots. The *Emil* fuel tank was shaped like the pilot seat it supported; so, if the tank was perforated and caught fire, the flames would be blown behind and away from the pilot. This was the opposite of the Spitfire and Hurricane, where the tank was located on the firewall in front of the pilot. If it caught fire, the flames enveloped the pilot.

Saunders' summary is the strongest part of his book. He offers a bit of analytical data which says the claims-to-losses ratio of Spitfires and Hurricanes to Bf 109s and 110s ranged from 1.2:1 to 1.4:1. He explains that the idea that Hurricanes engaged bombers while Spitfires engaged fighters was pure myth, and an analysis of individual engagement reports shows the *Emil* was more than a match for Hurricanes and Spitfires up to the Mk.V models.

I am no longer surprised by Osprey's ability to produce their continuing stream of high-quality products. The company's internal corporate discipline and ability to employ writers and illustrators who stick to the proven formula should serve as an example to other publishing concerns.

Gary Connor, docent, National Packard Museum, Cortland OH

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Messerschmitt Me 309: Development and Politics *and* **Messerschmitt Me 328: Development and Politics.** Both by Dan Sharp. Horncastle UK: Tempest Books. 2024. Photographs. Drawings. Bibliography. Notes. Appendices. Index. Pp. 200 and 150. $70.00 and $60.00. ISBN: 978-1-91165896-2 and 978-1-91170420-1, respectively

Sharps' works provide a comprehensive look at two of Nazi Germany's more obscure and unsuccessful aircraft projects during World War II. Both books delve into the intricate details of the development processes and the technical, political, and economic factors that influenced their ultimate failures. While the two projects share several similarities, there are also key differences in the motivations behind their developments, technical challenges they faced, and political circumstances surrounding each project.

The Me 309 was to replace the aging and increasingly outclassed Bf 109. As a small, light, high-performance fighter aircraft, it was expected to offer superior speed, firepower, and range to keep up with the evolving demands of air combat. However, the project was plagued by technical difficulties (lack of a suitable engine/propeller, problems with its retractable nosewheel landing gear, and an overly complex retractable radiator that ignored the widely known and recognized benefits of the Meredith Effect), delays, and shifting priorities within the Luftwaffe. The result was cancellation before entering production.

On the other hand, the Me 328 was a radically different project with far more experimental roots. What began as a technology demonstration, it found legs as a cheap, mass-produced, parasite fighter that could be launched from bombers. It was eventually supported by fanatics as a manned bomb or missile. The aircraft represented a more-desperate attempt to turn the tide of the air war in Germany's favor. Unlike the Me 309's incremental improvements, the Me 328 was driven by more innovative—if impractical—ideas that reflected the increasingly desperate strategic situation for Germany in the later stages of the war.

One of the key themes in both books is the significant political interference that characterized weapon development in Nazi Germany. As Sharp meticulously documents, both projects were heavily influenced by Hitler's centralized control over the war economy and the competing ambitions of various arms manufacturers and political figures. Shifting priorities, bureaucratic inefficiencies, and infighting among officials of the Reich Air Ministry (RLM) stifled the development of both aircraft. Messerschmitt found itself in a precarious position, having to navigate the competing demands of military officials, rival aircraft companies, and the increasingly chaotic resource allocation process within Germany's war economy. Sharp portrays Willy Messerschmitt as an amoral, controlling manager who made decisions that benefitted his company and was not afraid to ignore military and political leaders whenever it suited him.

Ultimately, both projects fell victim to the same systemic problems: constant pressure from internal and external sources, lack of resources (especially after 1942), scarcity of materials, and the Luftwaffe's ever-changing strategic priorities.

The political and strategic context of the two projects also differed significantly. The Me 309 was conceived early in the war, when Germany still had the luxury of pursuing more methodical and incremental advances in fighter technology. Although the war situation was deteriorating, there was still hope that a new generation of fighters could give Germany a technological edge. However, by the time the Me 328 project gained momentum, Germany's strategic position had worsened significantly, and the Luftwaffe was scrambling to produce unconventional solutions to counter the growing dominance of the Allied air forces. It symbolized the collapse of rational strategic planning within the Nazi regime, as it sought increasingly far-fetched and untested solutions to solve its mounting problems.

Sharp offers readers two detailed case studies of failed aircraft projects that were products of a dysfunctional war economy and a politically unstable military apparatus. While both projects share common themes of political interference, economic inefficiency, and technical challenges, they also represent two quite different approaches to aircraft development.

During his forensic analysis, Sharp presents a comprehensive discussion of German aircraft engines from 1937-1945. He meticulously discusses the steps taken by manufacturers to incrementally improve the performance of their engines to give Luftwaffe fighters an advantage in speed, climb rate, range, and payload. Even when discussing highly technical subjects, his writing is clear and efficient.

Both books are presented in an oversized format and printed on high-quality paper which shows photographs and drawings with clarity. Sharp includes copies of German documents and drawings to support his case. Unfortunately, many of these drawings in *Me 328* are faint and unreadable. The drawings are important in making his case and supporting his research bona fides. Having such a considerable proportion being unreadable is a lapse in his editor's contribution. Responsibility for numerous typographical and spelling errors would fall into the same category.

Sharp's books provide invaluable insights into the complexities of Nazi Germany's arms-development process and the broader political and economic factors that led to the failure of these two projects. Both books are essential reading for anyone interested in the intersection of military technology, politics, and economics during World War II.

Gary Connor, docent, National Packard Museum, Cortland OH

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The Petlyakov Pe–2: Stalin's Successful Red Air Force Light Bomber. By Peter C. Smith. Barnsley UK: Air World, 2024. Photographs. Map. Diagrams. Tables. Appendices. Glossary. Notes. Pp. 436. $42.95. ISBN: 978-1-39902-133-3

Peter Smith is an Englishman who has worked as a book and magazine editor. Since 1968, he has been a full-time historian and author, best known for his 86 books on aviation, military, and naval topics.

This book is an all-encompassing study of the Russian Pe–2 fast dive bomber-light bomber known as the *Peshka*. This is Smith's second book on the same topic. His original book, *Petlyakov Pe–2 Peshka*, was published in 2003 and is available; but it is out of print.

Smith's current book is divided into 20 chapters and includes many photographs, diagrams, and tables to back up the text. There are six detailed appendices, one of which is a comprehensive glossary. Throughout the book, there is a heavy emphasis on, and explanation of, the technical aspects of this aircraft, from the original design through its many upgrades and modifications. Reading this book may be somewhat tricky without an understanding of, and interest in, engineering. The sheer detail Smith has gone through sometimes makes the text hard to follow.

The twin-engine *Peshka*, designed by master aircraft designer Vladimir Petlyakov, is well documented, starting with design and following along through manufacture and implementation. Armament production at the onset of *Barbarossa* was limited and under direct threat from the German advance. The movement of Russian factories away from the German threat far to the east was incredible, ultimately allowing massive production of the *Peshka* and its variants.

Using many photographs, tables, and diagrams, Smith takes the reader along the continuum of the entire war on the eastern front, describing the *Peshka's* dominance in the context of the bloody battles necessary to repel the German invasion. Originally planned as a fighter, the *Peshka* was converted to a dominant dive bomber, easily recognizable with its tell-tale large glass panel on the floor of the tapered nose.

Readers must be patient with this book and let the story unfold, as it is complicated. They should not be discouraged by the amount of technical information presented, as its use is critical for Smith to produce a complete account of this aircraft. That being said, this is not a book for the casual military aviation enthusiast; the reader must have at least a moderate knowledge of the war on the eastern front to place the *Peshka* in the proper context and appreciate its importance.

The Petlyakow Pe–2 is a must-read for the serious student of World War II's VVS (Russian Military Air Force). It provides a wealth of information and insights to enrich understanding of this crucial period—and this important aircraft—in military history.

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

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***Wilde Sau* Nightfighters**. By Martin Streetly. Oxford UK: Osprey, 2024. Photographs. Illustrations. Bibliography. Appendices. Index. Pp. 96. $25.00. ISBN: 978-1-47286197-9

I have been a fan of Streetly since I discovered his book, *The Aircraft of 100 Group: A Historical Guide for the Modeller*, back in 1984. I re-discovered it ten years ago, as my interest in the history of World War II electronic warfare (EW) aircraft began. His latest book is a welcome addition to my topical library. It provides detailed coverage of interest to both the modeler and historian. Streetly is an author of EW and Intelligence, Surveillance, and Reconnaissance (ISR) publications. His 40-year career includes professional writing and serving as an editor for a variety of Jane's directories, yearbooks, and references.

The *Wilde Sau* (Wild Sow or Wild Boar) was a new Luftwaffe fighter tactic in 1943 and 1944 to compensate for the strain caused by fighting on several fronts, the increased success of British bombing raids on Germany (largely due to the advantage chaff jamming provided over Luftwaffe ground-radar-controlled intercepts), and aircraft production issues. This strain was further exacerbated when a Junkers Ju 88 nightfighter pilot defected to Scotland. As the plane carried an example of the Lichtenstein air-intercept radar, the Allies were able to analyze it and develop jamming techniques.

Wilde Sau involved cross-training day-fighter pilots for night fighting using Bf 109 and Fw 190 single-engine day-fighters and, later, Me 262s. The fighters co-operated with searchlight crews to visually identify and attack enemy bombers illuminated by the searchlights. Later illumination tactics included flares dropped by aircraft above the bomber streams or searchlights to back-light cloud cover below the altitude of the bomber streams and silhouette the bombers. All the while, the *Wilde Sau* pilots had to remain above German flak-battery firing altitudes. Several of the fighters were outfitted with Neptune air-intercept radar to aid the hunt for bombers, but the displays often interfered with the pilots' night vision. A contemporaneous program called *Zahme Sau* (Tame Sau or Tame Boar) assembled groups of orbiting fighters at specific locations via audio and/or visual beacons and then released them to intercept confirmed enemy bomber streams. They were guided by a running broadcast commentary based on ground observation, wireless communication interception, and contact reports from friendly aircraft tracking the bomber streams.

After some initial successes, *Wilde Sau* proved itself to be no more than a stop-gap measure until counter-chaff techniques and equipment could be deployed. Though bomber losses rose, so did Luftwaffe losses—the results of poor serviceability/readiness rates among the *Wilde Sau* units (the aircraft were being used in both day and night combat) and the deteriorating weather conditions in late 1943/early 1944.

Streetly's work encompasses the precursors to *Wilde Sau* through the development, deployment, and end of the program. It provides detailed chapters on technology and tactics and select biographies of pilots in the program. I was especially drawn to the technology and tactics sections. The combat operations discussions were a bit dry, with no clear first-person accounts. The color plates were outstanding and the profiles and photographs of the Neptune-equipped Bf 109s and Fw 190s were especially interesting.

This book is recommended for anyone with an interest in the development of night aerial combat tactics and equipment.

Tim Hosek, USG (retired)

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Battle of Britain Spitfire Ace: The Life and Loss of One of the Few, Flight Lieutenant William Henry Nelson, DFC. By Peter J. Usher. Barnsley UK: Pen and Sword, 2024. Photographs. Notes. Bibliography. Index. Pp. 217. $49.95. ISBN: 978-1-03610-612-6

In his latest book, Peter Usher, a native of Canada whose writing focuses on the feats of World War II Canadian airmen of Jewish heritage, presents a well-researched biography of fellow Canadian and Battle of Britain Spitfire pilot Nelson. This is Air World's latest entry on Battle of Britain combatants, joining Dilip Sarkar's volume on Sailor Malan (2021) and David Duker's on Squadron Leader Victor Ekins (2023).

Born and raised in Canada, Nelson found opportunities limited in his native land because of, at least in part, his religion. Traveling to England, he enlisted in the Royal Air Force (RAF) in 1937, where his faith was not a factor. He was the first Jewish Canadian to be commissioned as an RAF officer. As a bomber pilot, he was decorated for missions over Norway and Germany during the RAF's early long-range strategic-bombing efforts. During these months he found time to marry and start a family. With the situation critical after the June 1940 fall of France, Nelson volunteered to re-train on fighters to meet England's desperate need for pilots. Soon he became Canada's lone Battle of Britain Spitfire ace. Twenty-three years old when shot down on November 1, 1940, he left a wife and two-month-old son.

Usher's account encompasses Nelson's birth and childhood in Canada through his World War II combat time in both bombers and fighters. The book highlights his dedication, leadership, and humility. One of the themes—reminiscent of Forrester's portrayal of R.S. Tuck (1956)—is that Nelson's Jewish faith was not a factor in his RAF experiences.

Usher shaped a well-rounded narrative drawn from primary sources such as interviews with Nelson's son and remaining relatives, RAF records, and secondary sources. The book includes photographs of people, places, and aircraft that Nelson flew. The inclusion of previously unpublished family photographs enhances the reader's connection to the subject.

Nelson's personal and combat experiences are neatly woven together, offering insights into his motivations, challenges, and achievements. The story of his widow's subsequent life and her journey to Canada to meet her husband's family, as well as the perspective offered by Nelson's son on the father he never knew, enables the reader to understand the significance of war's life-changing impact on families.

As one of the latest entries in the rapidly expanding Battle of Britain genre, *Spitfire Ace* stands out, comparing with classic biographies of such renowned figures as Bader (1954), Johnson (1956), and Deere (1959). The book is well-footnoted, with sources tied to specific facts and quotes. The bibliography is heavily annotated with remarks on original sources and how they were used. The index is thorough.

Usher's accounts of political conditions and military campaigns presume no knowledge of military affairs or World War II, making the book accessible to a wide audience. This volume is recommended reading for anyone interested in the Battle of Britain.

Steven Agoratus, Hamilton NJ

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The Air National Guard: The Early Years 1946-1965. By Kennard R. Wiggens, Jr. Stroud UK: Fonthill Media, 2024. Tables. Photographs. Appendices. Notes. Bibliography. Index. Pp. 159. $35.00 paperback. ISBN: 978-1-78155-932-1

This book is perplexing. As a retired Air National Guard (ANG) officer, I was eager to read what Wiggens describes as a "light" history of the formative years of the ANG. The book is that, and it's full of wonderful photographs and biographical material about the people who helped form the modern ANG. Plus, it's nowhere near as dry as the official histories I've read.

But I was also looking for a full understanding of the ANG's use in operations. It falls short there. While it capably describes the ANG's role in the Korean War (its most important mobilization during that timeframe), that's about it. The 1961 Berlin Crisis, for example, isn't mentioned once, even though 20,000+ Air Guardsmen and 28 flying units mobilized for that.

Wiggens admits that this started as a simple account of the 1956 Earl T. Ricks Memorial Trophy Race and then grew in two ways: back in time to the formation of the ANG, and forward in time as it lays out—in great detail—ANG air races and weapons competitions.

The first half of the book starts with the formation of the ANG—not the typical ANG folklore about the New York National Guard's pre-World War I 1st Aero Company—but, instead, with the post-World War II formation of the true *Air* National Guard. It began with war-surplus pilots flying war-surplus fighters and earned enough of a reputation to be entrusted with new jets. But it then got called up for the Korean Conflict with a poor USAF gameplan for using its capabilities. Wiggens' telling of the complex story of picking up the post-conflict pieces is good reading. What follows next are some entertaining chapters on publicity-generating ANG record flights, ANG flight demonstration teams, and a chapter describing the early ANG jet fighters.

The book then changes into a very detailed accounting of the Earl T. Ricks Memorial Trophy Race (which the ANG used to generate public interest and recruits). Then it goes into an exhaustive accounting of operational competitions (used to generate appreciation of ANG capabilities within the USAF). The last chapter, "The Air National Guard Punching Above its Weight," is an even more exhaustive, team-by-team "diary" of weapons competitions well into the 1970s, with tables and appendices that cover competitions into the mid-1990s—far later than the book's title suggests.

Appendix II lists 24 USAF competitions that ANG teams won, only two of which occurred in 1965 or before. Wiggen's enthusiasm for those competitions got away from what he said the book is about.

The book tells the ANG story in a readable way. But it didn't cover some important activations and gave no clue as to why the ANG wasn't better prepared for the Vietnam conflict (which, by 1965, was right around the corner). The second half of the book, about races and competitions, was too much; it could have been told far more succinctly and interestingly. The personalities highlighted throughout the book are interesting and memorable. And there are occasional sections where a good editor could have made a big difference in readability.

Do I recommend this book? If one is looking for a comprehensive understanding of how the ANG was used between 1946 and 1965, no. But, for how the ANG evolved from its humble beginnings, who the people were who made that happen, and how it generated recruits and respect, it's an interesting read.

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

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Hamburger Hill 1969: Operation *Apache Snow* in the A Shau Valley. By James H. Willbanks. Oxford UK: Osprey Publishing, 2024. Maps. Photographs. Index. Pp. 96. $25.00 paperback. ISBN: 978-1-4728-6153-5

This is an account of a tenaciously fought and costly battle in the strategically important A Shau Valley of South Vietnam. Only a short distance from Laos, the valley is where the North Vietnamese Army (NVA) had overrun a Special Forces camp in 1966, driving away American forces for two years. In 1968, Operation *Delaware*, in response to the enemy's audacious 1968 Tet Offensive, was launched to once and for all drive the enemy from this sanctuary that served as a vital conduit for supplies and troops coming down the Ho Chi Minh Trail in Laos.

I was a part of that operation and naively thought that our success there would lead to control of the valley. In the immediate sense, we were responding to the NVA's bold assault launched from the valley that overran and held the iconic coastal city of Hue for nearly a month. However, the enemy was soon to return to the A Shau and continue operations after we departed.

Just as the intent of Operation *Delaware* had been to deny the valley to the NVA and destroy his forces, so too were Operation *Apache Snow*'s goals in 1969. It was the second phase of an effort in early 1969 to destroy munitions stockpiles and base camps and crush enemy units. This time, elements of the 101st Airborne Division (Airmobile) with Marine units from the Third Division and ARVN battalions would be the driving force to dislodge and destroy the enemy's war-waging capability in the northern provinces of South Vietnam.

This monograph describes participating units and leaders on both sides. Interestingly, one of the finest regiments in the NVA would be assigned the task of defending Dong Ap Bia (Hamburger Hill) with the goal of inflicting heavy casualties on attacking American units. To assure their survivability in the face of massive airstrikes and artillery barrages, the mountain was honeycombed with tunnels and bunkers. Willbanks goes on to describe the ten-day effort to reach the top. 101st troops engaged in a slugfest as they struggled to advance up the mountain while faced with intense fire from machine guns, rocket grenades, claymores, and snipers. In the end the top was reached and, for the moment, belonged to US troops. Two weeks after the bloody battle for Hamburger Hill, the NVA was back on top with over 1000 soldiers. When the newly appointed commander of the troops who had fought to the top of the mountain and defeated the North Vietnamese was asked if he would do it all over again to drive the NVA off, he replied yes, despite the large number of casualties. One must wonder, in light of the futility in fighting for and then relinquishing terrain features, why the bravado?

The reader acquires a sense of the strategic and operational goals of the ground war in Vietnam and what that translates to at the tactical level. The "body count" mentality was finally discredited when the negative reaction back in the States became loud and clear. That is, the pain of large numbers of casualties did not defeat the North. However, when the dead and wounded were Americans, the tolerance level at home was much lower. Consequently, Hamburger Hill was a tactical victory but clearly not a strategic one, and that could summarize the nature of the entire war. This monograph makes the futility of the war that much clearer.

John Cirafici, Milford DE

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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

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

May 29-30, 2025
The **Society for History in the Federal Government** will hold its annual meeting in Washington, D.C.; this year's theme is "History as Dialogue." For further details, see the Society's website at Society for History in the Federal Government - 2025 Annual Meeting.

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).

July 9-13, 2025
The Women Pilots Organization, better known as **The Ninety-Nines**, will hold their 2025 International Conference in Burlington, Vermont. See their website at Join 99s | Conference (The Ninety-Nines, Inc.) for more details.

July 15-17, 2025
The **American Astronautical Society** will again offer its annual Glenn Space Technology Symposium meeting at Case Western Reserve University in Cleveland, Ohio. The theme of this year's meeting is "Increasing the Thrust of Space Sustainability." For more particulars, see the Society's website at Glenn Space Technology Symposium | American Astronautical Society.

August 21-23, 2025
The **Tailhook Association** will offer its annual gathering at the Grand Sierra Resort Hotel and Convention Center in Reno, Nevada. For more information, including registration, see the Association's website at Hook 25 | Tailhook Association | Grand Sierra Resort.

September 20-24, 2025
The **Air & Space Forces Association** will hold its national convention in National Harbor, Maryland to be immediately followed by its 2025 Air, Space & Cyber Conference at a location yet to be announced. For additional details as they become available, see the Association's website at Events Archive - Air & Space Forces Association.

September 24-27, 2025
The **Society of Experimental Test Pilots** will hold its 69th annual symposium and banquet at the Grand Californian Hotel in Anaheim, California. For registration and other information, see the Society's website at The Society of Experimental Test Pilots.

October 9-11, 2025
The **Society for the History of Technology** will present its annual meeting at the Belval Campus of the University of Luxembourg. The theme of this year's gathering is "Technologies of Migration – Migrating Technologies." For details, including registration information, see the Society's website at 2025 SHOT Annual Meeting Luxembourg – Society for the History of Technology (SHOT).

October 28-30, 2025
The **American Astronautical Society** will offer its 17th annual von Braun Space Exploration Symposium at the University of Alabama in Huntsville, Alabama. This year's theme is "Expanding Exploration:From Vision to Reality." See the Society's website at von Braun Space Exploration Symposium | American Astronautical Society for further details.

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) for details as they become available.

January 8-11, 2026
The **American Historical Association** will host its annual meeting at the Hilton Chicago in Chicago, Illinois. For more details, including a timeline for preparatory events, see the Association's website at Timeline - AHA.

March 26-29, 2026
The **Society for Military History** will hold its annual meeting in Arlington, Virginia. For more details as they become available, see the Society's website at Future SMH Annual Meetings | The Society for Military History.

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: On June 25th 1965, American Astronaut and Air Force Officer Edward H. White II became the first American to conduct a Spacewalk (also known as Extravehicular Activity [EVA]), when he stepped outside of his space capsule, Gemini IV. For over 20 minutes floated in space while tethered to the Gemini IV spacecraft. While the spacewalk was only scheduled for 10 minutes to ensure White was back in the Gemini capsule before the capsule entered darkness and a communications dead zone, White did his best to extend his spacewalk, which ultimately lasted 23 minutes. To maneuver, White used a Hand Held Self Maneuvering Unit. Flying in the Gemini IV with Ed White was fellow Air Force Officer, James McDivitt. McDivitt and White were part of the second Astronaut group. Together, White and McDevitt would spend just over four days in space. McDivitt. McDivitt would later go to Space aboard Apollo 9. Tragically, Gemini IV would be Ed White's only trip to space as he lost his life during the Apollo 1 fire.

To learn more about:

Project Gemini:
https://www.nasa.gov/gemini/
Gemini IV:
https://www.nasa.gov/mission/gemini-iv/
Edward White:
https://www.nasa.gov/former-astronaut-edward-h-white-ii/
Gemini Spacesuits:
https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/1860282/gemini-g4c-space-suit1966/

New History Mystery

by Dan Simonsen

This Issue's Quiz:

Question:This quarter we have a multipart question looking for the historic event and the Air Force officer who accomplished it. Of the 350+ astronauts, 84 have been Air Force members. Air Force members have gone into space as part of the Mercury, Gemini, Apollo, Space Shuttle, and International Space Station programs. This June marks the 60th Anniversary of a significant American first in space. The astronaut who accomplished this American first was an Air Force officer. Prior to becoming an astronaut, this person was stationed at Bitburg AB, Germany, where he had flown both the F–86 Sabre and F–100 Super Sabre. He would also earn a master's degree in Aeronautical Engineering and graduate from the USAF Test Pilot School. Name the historic American Space event that happened 60 years ago this June. Name the Air Force member, turned astronaut who accomplished the feat. Finally, name the space program it was part of. Hint it is one of the programs mentioned above.

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