SUMMER 2024 - Volume 71, Number 2
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Journal of the Air Force Historical Foundation

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Coming Up — Don't Miss It

AFHF FALL SYMPOSIUM, LITERARY AWARDS AND MUSEUMS CONFERENCE

NOVEMBER 4-7, 2024
Doubletree by Hilton Tucson — Reid Park and Pima Air and Space Museum
445 South Alvernon Way, Tucson, Arizona 85711-4198
520-881-4200

CALL FOR PANELS

The theme for the 2024 Air Force Historical Foundation Annual Symposium/Air & Space Museum Conference is "Technological Change in Air and in Space, 1920-2020."

The Foundation is seeking combined academic/museum panels of 2 or 3 people that cover topics related to USAF airpower and space history, its applications, and implications from the late during the past century. It is a very broad topic and should allow a wide variety of panel proposals. The Foundation hopes to provide a forum for Air and Space Museums across the country to make presentations describing artifact collections, scholarship, exhibits, and changes in the technology of museums as well.

At present, eighteen panel openings are planned and will be competitively filled by the Program Committee. Selection will be made based upon strength of proposal and variety of subject.

Panel Proposal forms and Registration can be found at the following link:
https://www.afhistory.org/events/ (Scroll to bottom)
Symposium Site:
https://www.afhistory.org/wp-content/uploads/2024/02/AFHF-FALL-SYMPOSIUM-4-7-NOV-2024.pdf

"The AFHF is on a roll!" — This past year we celebrated the initiation of an Official Podcast, a Newsletter (The Raider Chronicle), and have made the leap to a full-color Journal format. The Foundation has worked to establish its own research page with the Air University Library Archives. Included there are small collections of images and biographies, storage for the Super Sabre Society journal (The Intake), and the beginnings of 300,000 images that are being digitized from the Air Force Magazine photo archive collection. We are just months away from publishing the first in a series of reprints together with Air University Press. *A Few Great Captains*, first published in 1980, is a must read for any USAF or SF member. Here are a few links to our programs.
Research and links (including the Journal of the AFHF and Newsletter): **https://www.afhistory.org/research/**
Podcast Page: **https://www.afhistory.org/podcast/**

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Features

Book Reviews

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Departments

COVER: Cover art "Almost Quittin' Time" © by Rick Herter. See page 19.

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Journal of the Air Force Historical Foundation

The Journal of the
Air Force Historical Foundation
Summer 2024 Volume 71 Number 2

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Journal of the Air Force Historical Foundation (ISSN 1044-016X) is produced for Spring, Summer, Fall, and Winter by the Air Force Historical Foundation.

Prospective contributors should consult the **GUIDELINES FOR CONTRIBUTORS** at the back of this journal. Unsolicited manuscripts will be returned only on specific request. The Editor cannot accept responsibility for any damage to or loss of the manuscript. The Editor reserves the right to edit manuscripts and letters.

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Correspondence regarding missed issues or changes of address should be addressed to the **CIRCULATION OFFICE**:

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Periodicals postage paid at Mechanicsville, MD 20659 and additional mailing offices.

Postmaster: Please send change of address to the Circulation Office.

Book Review List (cont.)

From the Editor

We continue our new methodology by providing our second themed "Special Issue" for Summer. The theme of this issue is simply *Technology*. We have tried to make this 160-page issue a visual departure from the past, as we have included color on the inside. It contains the usual magazine articles although several are longer and more in-depth than our 64-page format allows. We hope you enjoy the various subjects and interesting illustrations.

Our opening photo essay has been graciously offered by aviation artist Rick Herter. Visually, it's the best way to open a special magazine. It's stunning! We hope you like it

Our next article is by return contributor Theo van Geffen, as he continues to explore the aircraft used in the first Gulf War, and how those systems found their way to Southwest Asia.

Our third article is a companion piece to the one before, as one of Theo's sources provided a memoir to help illustrate the experience of using the technology.

Our fourth article is by a long-time USAF historian, Ray Ortensie, with a story about how incidents in the 70's influenced the development of technology in the Air Force.

Our fifth article, by David Reade, is by far the longest ever published by us, and it tells the story of how DoD tried to use technology to make the weather in Vietnam work in favor of the U.S. and South Vietnam.

Our sixth article by David Stumpf, is a lengthy dive into the development of the Titan II ICBM.

Following that, Mark Clodfelter comments on the experience of the "Bloody Hundredth" in World War II as illustrated by the Apple+ TV Series, "Masters of the Air."

Phillip Meilinger follows with an excellent review essay on the publishing concerning the air war over Europe in World War II.

Our final article is by Robert Gates, and his story of the development of missiles in the post-World War II era.

The Leadership's Message can be found on page 4. It's worth the read. Don't miss Upcoming Events on page 158. And the issue closes with the Mystery. Enjoy!

Richard I. Wolf, Editor

Leadership's Message

Dear Readers,

I am honored and privileged to address you for the first time as the new Chair of the Air Force Historical Foundation.

From all of us at the AFHF, we want to thank Gen Mike Holmes for his service as our Chair for the last three years—his leadership with our Board President Jonna Doolittle Hoppes has put an energy and direction forward that will serve our organization well in perpetuity.

First and foremost, I wish to acknowledge the incredible legacy of our Air Force and the importance of preserving its rich history. Our foundation plays a pivotal role in ensuring that the sacrifices, triumphs, and innovations of the men and women who have served in the United States Air Force and the Space Force are remembered and celebrated for generations to come. With this responsibility in mind, I am excited to share a long-range, strategic focus for the future of the Air Force Historical Foundation.

Education: We will prioritize the expansion of educational initiatives aimed at inspiring the next generation of leaders and innovators in aerospace and defense. Through outreach programs, virtual exhibitions, and digital content with Air and Space Museums around the Country, we will seek to ignite curiosity and passion for aviation history among young people, ensuring that they carry forward the legacy of the Air Force and Space Force with pride and dedication. The AFHF will work to develop or partner with engaging educational programs targeting students at all levels, from elementary school to university. We will offer virtual workshops, curriculum resources, and hands-on activities to inspire a new generation of students to explore the history of aviation and aerospace.

Experiential: We will look to build immersive, interactive virtual exhibits that allow visitors to explore Air Force history from anywhere in the world. Utilize cutting-edge technology such as virtual reality (VR) or augmented reality (AR) to provide a unique and engaging experience.

Archive: Launch an extensive oral history project to consolidate the stories and experiences of Air Force veterans, from World War II to the present day. Create a digital archive of these interviews, making them accessible to researchers, historians, and the public. Invest in digitizing and cataloging the foundation's archival collections to make them easily searchable and accessible online. Explore innovative digital preservation techniques to ensure the long-term integrity of these historical documents and artifacts.

Collaboration: Foster collaborations with USAF/SF Wing History Offices, Air University, USAFA History Department, other academic institutions, museums, and other organizations to facilitate research and scholarship on our rich history. Create opportunities for researchers to access foundation resources and contribute to ongoing projects. Participate in community engagement events, such as historical reenactments, air shows, and public lectures, to bring together enthusiasts and foster a sense of camaraderie among those interested in our history.

Outreach: Expand our podcast/webinar series featuring interviews with historians, veterans, and experts discussing various aspects of aviation and space history. Make these episodes freely available to the public, reaching a broad audience and fostering interest in the subject matter. Engage the public in crowdsourced history projects , inviting individuals to contribute their own stories, photographs, and memorabilia (digital only) related to the Air Force and Space Force. Create online platforms where participants can share their experiences and collaborate with others. Develop a mobile app that provides self-guided tours of Air Force historical sites, museums, and memorials. Incorporate interactive maps, multimedia content, and augmented reality features to enhance the visitor experience.

AI: Explore the use of artificial intelligence (AI) and machine learning algorithms to analyze large datasets related to Air Force history. Use these tools to uncover patterns, trends, and insights that may not be apparent through traditional methods. By implementing these innovative ideas, the Air Force Historical Foundation can continue to serve as a leading institution for preserving, promoting, and celebrating the rich heritage of the United States Air Force and the ever-growing Space Force.

As we embark on this journey together, I invite every one of you to encourage friends and colleagues to become members of the AFHF, contribute financially through donations or sponsorships, and provide your ideas, expertise, and enthusiasm to our shared mission. Together, we will honor the past, inspire the future, and ensure that the legacy of the United States Air Force and Space Force continues to soar.

In the coming weeks and months, I look forward to working closely with each of you to turn these ideas into reality. Together, we can ensure that our shared legacy is preserved and celebrated for generations to come.

Maj. Gen. John L. Barry, USAF (Ret.)
Foundation Chair

Doolittle Award

On March 22, AFHF President Jonna Doolittle Hoppes presented the Foundation's highest award to the 432d Wing "Hunters" at Creech AFB. The wing staff and many of the on-location Airmen and operators, about 250 in all, attended the ceremony in hangar 1000. Other non-collocated units also joined by video conference. After a wonderful rendition of the National Anthem by Staff Sgt. Leah Bullock, Airman 1st Class Brylon Chung read several letters written by members of the 432d Wing explaining why they are so dedicated to their unit, their job, and their service. The emotional readings reflected exactly the strong elements of unit cohesion and "family" that both Ms. Doolittle and Lt Col Dik Daso (USAF, ret.), AFHF Executive Director, witnessed during their visit to Creech. Ms. Doolittle noted, "Gen Doolittle would have approved!"

(Pictured , left to right, are AFHF President and granddaughter of Gen Doolittle, Jonna Doolittle Hoppes, Nicholas R. Pederson, 432d Wing Commander, Dik Daso, AFHF Executive Director, and CMSgt Cory L. Shipp, 432d Wing Command Chief)

Job Announcement for Journal Editor

The Editor of the Journal of the Air Force Historical Foundation will be retiring at the end of 2025. To ensure that there is sufficient continuity to allow for an uneventful handover of all of the functions, the AFHF would like to proceed through the hiring process during 2024. The duties include editing manuscripts, selecting suitable articles, refereeing submissions, laying out the magazine pages, and producing the final product as a PDF for either printing or posting on the Web site. Candidates should have magazine experience in production as well as computer skills to allow the use of page layout software and photo editing progrtams. A degree in History is essential, and the possession of an advanced degree is desirable. Experience in USAF history would be very helpful. Interested parties should send expressions of interest or requests for the job description to the Executive Director at **xd@afhistory.org**.

Guidelines for Contributors—We seek quality articles—based on sound scholarship, perceptive analysis, and/or firsthand experience—which are well-written and attractively illustrated. If a manuscript is under consideration by another publication, the author should clearly indicate this at the time of submission. Manuscripts should be prepared according to the Chicago Manual of Style (University of Chicago Press). Use civilian dates (month, day, year) and either footnotes or endnotes may be used. Because submissions are evaluated anonymously, the author's name should appear only on the title page. Authors should provide on a separate page brief biographical details, to include institutional or professional affiliation and recent publications, for inclusion in the printed article. Pages, including those containing illustrations, diagrams or tables, should be numbered consecutively. Any figures and tables must be clearly produced ready for photographic reproduction. The source should be given below the table. Notes should be numbered consecutively through the article with a raised numeral corresponding to the list of notes placed at the end. Submissions may be submitted either by mail or via email. Email is generally the norm. While Microsoft Word is the most common, any word processor may be used. Do not "Track Changes." Photographic illustrations are greatly appreciated. There is no restriction on the file format used. There is no standard length for articles, but 4,500-5,500 words is a general guide. Manuscripts and editorial correspondence should be sent to Richard Wolf, Editor, c/o Air Power History, 70 Shannon Way, Upton, MA 01568, e-mail: airpowerhistory@yahoo.com.

Jacob "Jack" Neufeld
December 1940 - August 2023

Jacob "Jack" Neufeld, Editor Emeritus of *Air Power History*, passed away in August 2023. His passing marks the end of an era in U.S. Air Force history. Over the course of his long and distinguished career, Jack left his mark on three decades of Air Force historical research, writing, and publishing, from as early as 1970 through his two retirements, first from the Air Force history program in 2006 and second from editorship of this magazine in 2014. He will be sorely missed by the historical community and by all who knew him.

Jack was born in December 1940, in Buczacz, Poland, one of just three children from his town who survived World War II. Jack and his mother (Nettie) survived by hiding in the forest, people's homes, and anywhere they could find shelter, while his father (Nadje Dunajer) was a partisan who was killed a few days before the end of the war. Jack and his mother were rescued and spent time in displaced persons camps. They arrived in New York City in 1950.

Jack earned B.A. and M.A. degrees in Russian history at New York University. After his Masters degree, he was commissioned in the U.S. Army and served with the Corps of Engineers at Ft. Campbell, Kentucky, and Ft. Belvoir, Virginia, from 1964 to 1966. After his Army service, he joined the Air Force History program in 1967, serving initially at HQ Eighth Air Force (SAC), then located at Westover AFB, Massachusetts. While there, he completed all of the course work for a doctoral degree at the University of Massachusetts, Amherst in American studies.

In 1970, when the Eighth Air Force was reassigned to another location, Jack chose to transfer to the newly constituted Office of Air Force History, in Washington, D.C. He remained assigned to that office in its many iterations until retiring in 2006. After this retirement, he continued to edit *Air Power History* until 2014, completing twenty-one years of leadership.

A unifying force at the Office of Air Force History, Jack held many positions, including staff writer, branch chief, division chief, senior historian, and director. A gifted researcher, writer, and editor, Jack wrote or edited numerous scholarly works in military history and the history of technology, including *The Development of Ballistic Missiles in the United States Air Force, 1945–1960*. In all, he had more than a dozen works to his name and oversaw as Director more than one hundred publications. He was an adjunct professor of history at American Military University, Montgomery College, and the University of Maryland.

In addition to his expertise as a writer and historian, Jack proved to be an excellent manager, especially as Chief of the Center for Air Force History and as Director of the Air Force Historical Studies Office. When office manning diminished after the end of the Cold War, he was instrumental in preserving the Air Force History book publishing program. A consummate professional, Jack was a hard worker and was keenly aware of the individual needs of those working for him. Moreover, he protected and fought for his people. People trusted Jack and knew they could count on him to listen and to help resolve many issues.

Jack was an esteemed colleague to dozens of Air Force historians, mentoring and encouraging many people throughout their careers. He was renowned for his caring, his quick wit, and his humanity, while still holding the highest standards. He might be sympathetic to a deadline being missed, but he never accepted less than the best.

Jack and his beloved wife, Shari, celebrated their 58th wedding anniversary in April 2023. Survivors also include daughters Michelle (Jonathan) Goldberg and Jessica Goldstein, and son Neil; and grandchildren Jordan Goldberg, Andie and Logan Neufeld, and Jeremy, Kyra, and Ethan Goldstein.

The Aviation Art of Rick Herter

"A Christmas Mission"

Rick Herter is one of the rarest of humans. He can exist in a three-dimensional universe and translate that experience to canvas in a way that makes a viewer feel like they are in the middle of the action. We are featuring a selection of Rick's work to commemorate the 80th anniversary of the D-Day invasion, but also to highlight the Foundation's major theme: *Technological Change from 1920-2020* in the second half of the montage. Sometimes it is easier to see evolution than to explain it.

Our Executive Director was honored to have flown with Rick while a T–38 pilot at Randolph AFB. The mission was to photograph a T–38 4-ship formation as inspiration for a future piece. The result was a painting that documented the multiple roles of the venerable T–38 Talon. It is a gift to be able to create a work of art that both inspires and informs, and we thank Rick for allowing us to print his work in this format. These paintings help us to "Know the Past and Shape the Future."

After graduating from Spring Arbor University with a B.A. in art in 1984, Rick took his artistic skills and began working in the commercial art and illustration arena. Herter's interest in aviation was never far away. Rick's first commemorative air show poster won a national award and the following season, he was commissioned to create work for shows in Pittsburgh, Denver, and Cleveland. In 1987, Rick was invited to become a participating artist in the elite Air Force Art Program. The AFAP, under the office of the Secretary of the Air Force, was created in the 1950's using the talents of select artists to document Air Force activities and history worldwide.

In 1990, Rick was awarded the prestigious American Spirit Award by the Air Force Recruiting. Service, its highest form of civilian recognition. The artist's work has hung in numerous private and public collections worldwide, among them the Smithsonian Air and Space Museum, The U.S. Air Force Academy, and the Pentagon. His list of corporate clients reads like a who's who of the aerospace industry. Besides the U.S. Defense Department, his work has been commissioned for the armed forces of many countries. A unique historical project of Herter's was the recent completion of the world's largest indoor hand-painted mural. The mural, located at the AIR ZOO in Kalamazoo, Michigan, measures 32 feet high by 900 feet long and tells the story of flight. The mural is a Guinness Book candidate.

The full accounting of the artist's commercial work can be viewed at his web site **rickherterart.com**. We are including edited descriptions of the paintings at the end of this article, but the complete explanation for each image's creation is on the web site. All of the paintings published herein are copyright by the artist and may not be reproduced. We are grateful for his allowing us to show them.

"Teammates"

"All in a Day's Work"

Rick Herter

The artist's travels have taken him around the world from the Orient and Europe to nations in the Middle East. In the spring of 2003, the artist logged combat flight time by flying missions with Air Force units during Operation Iraqi Freedom. His flight experiences have included classic aircraft like the P–51 Mustang to modern day fighters including the F–14 Tomcat, F–15 Eagle and F–16 Fighting Falcon. Herter has flown on missions overseas in B–52's and soared over the Alps with the German Air Force in F–4 Phantoms. He has flown low-level in Army attack helicopters and accompanied the first combat units into Haiti for Operation Restore Democracy. Rick has flown on numerous combat training missions with Air Force and Naval Fighter units worldwide.

“Grand Canyon Lightning”

"Double over Berlin"

"The Color of Courage"

"Railroaded"

"Sweating Out The Mission"

"Horse of a Different Color"

The Evolution of Technology 1920-2020

Technological change can often be more easily understood through pictures. Imagine our past and envision our future as Rick's artwork takes you on a voyage from biplanes and bailing wire to the threshold of space--with aircrew or without. See one hundred years of progress and innovation through aviation art.

"I'd Rather Be Flying"

"Hurryin' Home Horses"

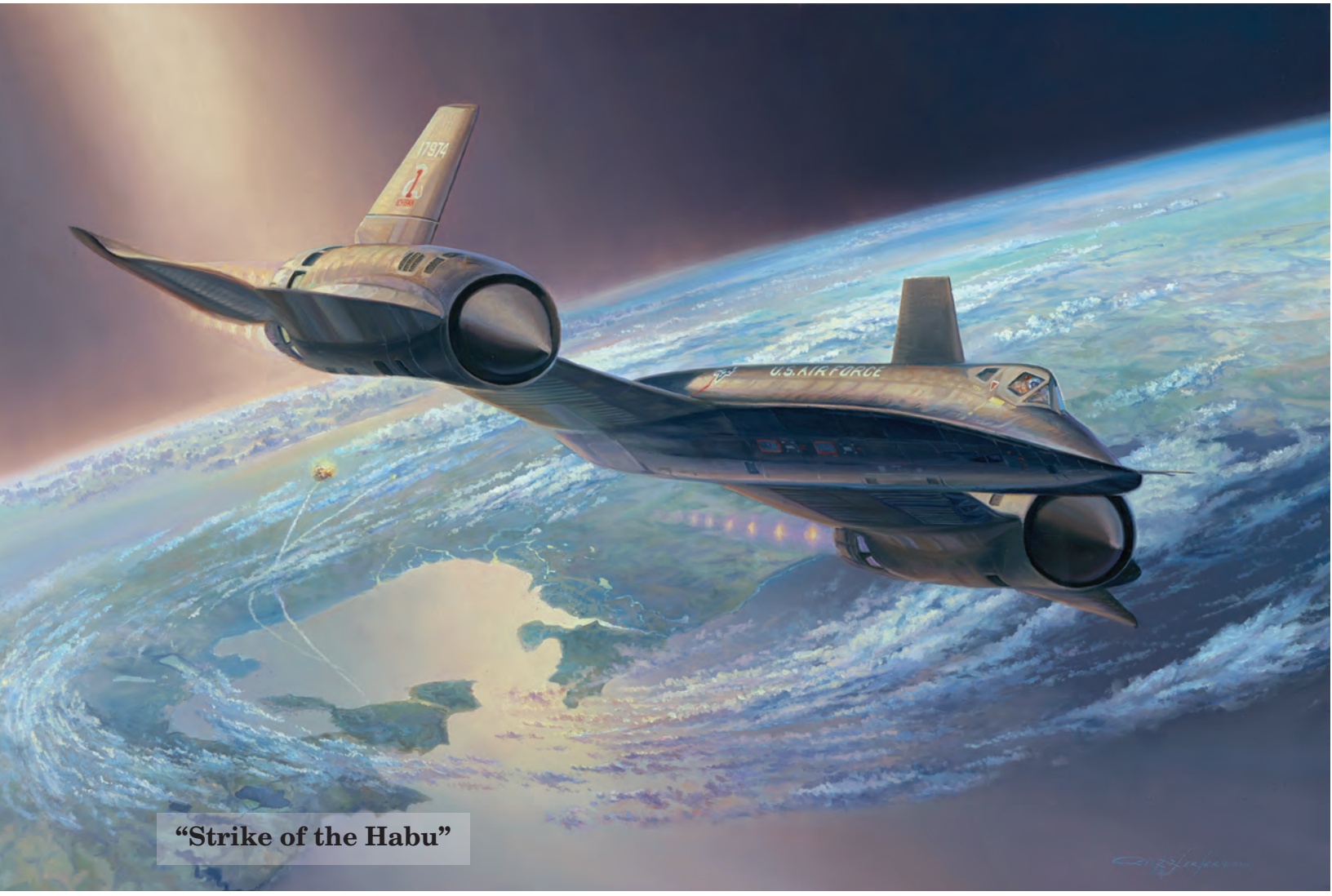
"Starting The Night Shift, Early"

"Fast Company"

“Iven Takes Ivan”

“Working The Field”

“Spirit Visitation”



“Strike of the Habu”

"Taking The Shot"

Cover Photo. Almost Quittin' Time In this painting, 78th Fighter Group P–51's are escorting home B–17 Flying Fortresses. The B–17s in Rick's painting are from the 303rd Bomb Group based at Molesworth, England. Though everyone has to remain vigilant, the crews are mindful that it is "almost quittin' time" for the day…and hopefully soon for the air war.

A Christmas Mission The weather has cancelled flying and the ground crews who are normally busy maintaining B–17's have a little extra time on their hands. As their fellow airmen play a game of cards and chat about Christmas past, two enterprising mechanics sneak off on a special mission. As the last light of day begins to cast long shadows over the icy landscape our friends return with some Christmas Cheer. Soon this simple symbol of the holiday will be raised in the tent and each and every man will be back "home"…even if it's only in his memories.

Teammates In this painting, a damaged, Consolidated B–24 Liberator is on a lonely journey back to its base. The damage to the airplane has slowed it down and as the rest of the formation pulled ahead and is now out of sight. All of a sudden a P–51 Mustang appears and pulls up in front of the wounded bird giving the crew something to ease their nerves. The escort fighters were called "little friends" by the bomber crews and although the missions of the airplanes were very different, they were Teammates!

All in a Day's Work This painting features a pair of Lockheed P–38 Lightnings of the 475th Fighter Group. In the foreground lays a downed Japanese Zero and, in the background, a partially sunken enemy ship.

Grand Canyon Lightning Two Lockheed P–38 Lightnings outrun a summer thunderstorm as they fly below the weather and over the majestic landscape of the Grand Canyon. The painting depicts these "Lightnings" on a ferry flight from Burbank, CA. to the U.S. East Coast to then be shipped by sea to fight against Nazi Germany. The lead airplane in the painting is P–38-L serial number 44-24630 and would serve with the 367th Fighter Group in France in 1944.

Double Over Berlin On October 15, 1943, Don Strait of the 356th Fighter Group flew his first mission over northern France. By the end of his first combat tour, Strait achieved two aerial victories over German Bf 109s. Returning in September 1944 for his second combat tour, he joined his squadron in the transition to the P–51D Mustang. Through the end of the war in Europe, now Major Strait achieved a total of 13.5 aerial victories while flying 122 combat missions over his two tours. In this painting Major Donald Strait achieves his 5th and 6th victories near Berlin in December of 1944.

The Color of Courage Known by the bright red tails their airplanes were painted in, the Tuskegee Airmen achieved such notable success in the skies over Italy and Europe that bomber squadrons commanded by white officers would often request that the unit specifically be used to escort them through the dangerous skies above Germany. In this painting, one of the Tuskegee Airmen flying his red-tailed Mustang, gives chase fast and low, in pursuit of a German Focke-Wulf 190. The Red Tails destroyed close to 300 enemy aircraft .

Railroaded A 4th Fighter Group P–51 Mustang flown by Major Gerald Montgomery pulls up after strafing a German locomotive in the Rhine valley. In this painting Monty is flying the aircraft he finished the war with. This particular print was countersigned by one of World War II's greatest fighter aces and combat leaders, Col. Don Blakeslee. Also signing the print was the war's greatest nose artist, SSgt. Don Allen.

Sweating Out the Mission Somewhere in England, an American crew chief impatiently watches his P–51 Mustang

to return from its first mission of the day. In this painting we see a crew chief anxiously waiting alongside several drop tanks as he watches his pilot and aircraft on final approach. He wonders how the aircraft performed for his friend and his thoughts turning toward the hours of work ahead.

Horse of a Different Color In this painting, a Curtis JN–4 Jenny has made a surprise landing in a pasture within the Teton Valley of Wyoming. Running low on gas, flying over rugged territory, the pilot decided to set down and seek replenishment from a local shopkeeper. As this unusual event is taking place some of the locals happen upon the scene. You can only imagine what the cowboy and his herd must be thinking: "Well, tarnation, look at that! Now that's what I call, "A Horse of a Different Color!"

I'd Rather be Flying Who hasn't daydreamed of escaping to a peaceful airstrip, climbing aboard a classic airplane and leaving your cares behind as you fly upward into a sun washed sky? This painting focuses on that daydream with the classic Boeing PT–17 Stearman as the star of the composition. The original painting from which this print was created measured 8 feet in length and was commissioned by a Stearman owner. This piece also features a Piper J–5 Cub Cruiser and a Curtiss Wright Travel Air 4000.

Hurryin' Home Horses Two P–51 Mustangs from the 357th Fighter Group, are beating up the English countryside as they head for the barn after a mission deep into Europe The lead aircraft 'Hurry Home Honey' was flown by 364th squadron commander Major Richard 'Pete' Peterson. Maj. Peterson would finish the war with 15.5 aerial victories and considered on of the the great combat leaders of the war. This painting was signed by Pete along with his fellow pilots from the group.

Starting the Night Shift, Early Air Combat in the Pacific wasn't just a daylight operation. Late in the war Northrop P–61 Black Widows of the 548th Night Fighter Squadron operated from bases on both Iwo Jima and later from Ie Shima, Okinawa. The squadron consisted of only 280 men flying and maintaining one of the most complex combat aircraft in the Army Air Corps inventory. When the squadron arrived on Iwo the men lived in foxholes, between Marine Howitzers and the enemy. In my painting a P–61 from the 548th begins a mission in the early evening prior to sunset. The P-61 was used on night intercept missions, attacking enemy troop concentrations and escorting B–29's on their night bombing raids over Japan. Most all of those missions were flown in the inky black darkness of night over vast stretches of water. The courage and skills of the P–61 crews flying such mission's was perhaps the most challenging of any of their brethren.

Fast Company Perhaps one of the most iconic of all American sports cars is the 1963 Chevrolet split window Corvette. From that same era of the early 1960's and on the cutting edge of jet aviation, was the Convair F–102 Delta Dagger. In this painting two American icons are juxtaposed to one another. The F–102 is in the markings of the 125th Fighter Interceptor Group of the Florida Air National Guard.

Iven Takes Ivan This painting captures aerial combat near the Yalu River on April 1st of 1952. United States Air Force Capt. Iven C. Kincheloe has just shot the tail of a North Korean MiG–15 thought to have been flown by a Russian Air Force pilot. Before his tour of 101 combat missions in the F–86 ended, Capt. Kincheloe would score his 5th victory becoming an Ace. After returning from Korea, Kincheloe went from Ace to Space! The fighter pilot became a USAF test pilot and went on to set speed and altitude records in the X–2 and was called "America's First Spaceman."

Working the Field It's getting late in the day on a crisp, autumn day. A farmer is harvesting his soybeans and deer season is right around the corner. Descending into all of the activity is a Boeing KC–135 on short final with her crew setting up the jet for a "touch and go."The first KC–135's to enter service were delivered to Castle Air Force Base in June of 1957 and eventually over 800 KC–135A's were produced with the final airplane delivered to the Air Force in 1965.

Spirit Visitation On the night of January 18, 2017, B–2 Spirit Stealth Bombers and their aircrews launched from Whiteman AFB, MO. Over the next 35 hours, the aircraft and their crews would make USAF history by flying one of the longest combat missions ever. This mission proved, once again, that no enemy anywhere in the world is safe from the B–2 and the warriors that fly and support their operation. This print depicts the 509th Bomb Wing and Operation Odyssey Lightning. The 509th Bomb Wing is the only unit in the world to fly the B–2 Spirit Stealth Bomber.

Strike of the Habu The SR–71 Blackbird is one of the most iconic airplanes of the 20th century. Build by Lockheed in the early 1960s, the mysterious reconnaissance aircraft flew higher and faster than any manned aircraft before or since. In this painting the landscape below is the Russian Naval base at Petropavlovsk on the Kamchatka peninsula. This area was a regular target for SR–71's based at Kadena air base on Okinawa. Along with ballistic missile submarines, a major MiG base and ground base ballistic missile test sites were in this area and made for a treasure trove of photographic and ELINT intelligence gathered on Blackbird missions.

Taking the Shot Depicts an MQ–1 Predator as it fires a Hellfire missile at a distant target. This painting was commissioned by one of my Corporate clients and given to a highly decorated, female, USAF pilot. The painting depicts a night mission near Kandahar, Afghanistan in which USAF Pilot, Major Tammy Bartlette, and her sensor operator SSgt. Garrett McClure discovered two Taliban terrorists as they were in the process of planting a roadside bomb for an oncoming American convoy. After observing the enemy and confirming that they were armed and planting a bomb the crew recieved permission to engage. Major Bartlette fired from approximately 15,000 feet and 3 miles away. The mission was a success and both terrorists were neutralized. I love telling the stories of actual events. Having an opportunity to work with individuals and crews. Hearing their first hand stories is critical in the accurate recording of history.

Be sure to read the full story of each painting at:
https://rickherterart.com/

Joint Task Force Proven Force and the Gulf War (Part 6)

An Air Force HC–130P Combat Shadow of the 67th Special Operations Squadron is framed in the cockpit of a Navy CH–53E Super Stallion of Helicopter Combat Support Squadron (HC) 4, while preparing to conduct an in-flight refueling during an Operation PROVIDE COMFORT (OPC) mission. The four HC–130N/Ps were part of the first group of aircraft to be deployed to Incirlik after the initiation of OPC. *[USN, PH3 Klein]*

Theo van Geffen

After the liberation of Kuwait City on February 27, 1991, President Bush ordered the suspension of offensive military operations as of midnight eastern time. As a result, on 28/0800L February, a Coalition-declared ceasefire went into effect. The next month, the redeployment of 545,000 U.S. troops was initiated. However, as part of USAF's residual assets in the Gulf Region during the ceasefire period, F–4G Wild Weasels would continue to provide SEAD (Suppression of Enemy Air Defenses) capability in case hostilities would begin again. Some three weeks after redeploying to Spangdahlem, part of the 23rd TFS returned to Incirlik with F–4Gs.

Earlier we looked at the development of EC–130E, EF–111A and F–4G Advanced Wild Weasel aircraft, and at Joint Task Force PROVEN FORCE (JTF-PF), B–52G, EC–130E, EF–111A and F–4G combat operations. In this 6th and final part the focus is F–4G post-war (combat) operations.

Post-Desert Storm, Turkey

1991

After Iraqi acceptance of the cease-fire terms on March 3, USCENTAF (United States Central Command Air Forces) on the 9th verbally approved JTF-PF's plan to redeploy personnel, aircraft and equipment. Return of U.S. forces from the Gulf Region and Turkey was called DESERT FAREWELL, popularly called DESERT CALM. For instance, aircraft of Tactical Fighter Wing Provisional, 35 (TFWP 35) flew 525 sorties with 1,057 flying hours from Shaikh Isa, of which 304 and 632 respectively by the two F–4G squadrons (561st and 81st TFS) and 221 and 425 respectively by the two RF–4C units (12th and 192nd TRS).

Aircraft being redeployed on the 9th from Incirlik (nicknamed the Lik) were 22 F–111Es of the 20th TFW (Tactical Fighter Wing) and five EF–111As of the 42nd ECS (Electronic Combat Squadron). On March 15, the first 23rd TFS contingent returned to Spangdahlem (nicknamed Spang). Five days later, the JTF-PF headquarters element redeployed to Ramstein, but Composite Wing Provisional, 7440 (CWP 7440) remained at Incirlik with a residual force until the official conclusion of the Gulf War ceasefire (it was announced by the United Nations on April 11). This meant continuation of defensive Combat Air Patrols (CAPs), reconnaissance, E-3 AWACS (Airborne Warning and Control System) and Scud response sorties.

Iraqi response to the rebellion of Kurds in northern Iraq, with the goal to establish an autonomous Kurdistan Region,

(Above) Army Sgt Frederick McMullen prepares for the start of his UH–60 Black Hawk helicopter before flying a mission in support of Operation PROVIDE COMFORT to protect and supply Kurdish refugees. *[USAF, SrA Gudrun Cook]*

(Below) USAFE fighter forces returned to Incirlik Air Base in Turkey after President George Bush ordered U.S. European Command (USEUCOM) to assist the Kurds and other refugees in the mountains of northern Iraq, to begin on April 6. F–4Gs of the 52nd TFW were also involved. The 'hero shot' shows one of the aircrews, Captains Bruce 'Spike' Benyshek and Larry 'LA Bud' Allen (EWO). *[via Bruce Benyshek]*

resulted in an estimated 1.5 million refugees. On March 3, General Norman Schwarzkopf, commander of U.S. Central Command (CENTCOM), warned the Iraqis that Coalition aircraft would down any aircraft flying over the country, violating the ceasefire. The Iraqis did anyway and pilots of two Bitburg 53rd TFS F–15C Eagles, Captains John Doneski and Thomas Dietz, each downed a SU–22 Fitter in northern Iraq, on March 20 and 22 respectively.

As a result of Iraq's repression of its civilian population, the United Nations Security Council on April 5 passed Resolution (UNSCR) 688, which, among others, condemned Iraqi repression, demanded an immediate end to it, and insisted that Iraq would allow immediate access

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One of the Coalition partners in Operation PROVIDE COMFORT (and later in NORTHERN WATCH) was the UK, nicknaming their part Operation WARDEN. Provided were, among others, VC–10 tankers and Jaguar fighter/reconnaissance aircraft. The photo shows three Sepecat Jaguar GR.Mk 1As of RAF's No. 54 Squadron. *[USAF, TSgt Anna Hayman]*

by international humanitarian organizations to those in need of assistance in all parts of the country. Later that day, President George Bush ordered U.S. European Command (USEUCOM) to assist the Kurds and other refugees in the mountains of northern Iraq, to begin the next day. This resulted in a chain of reactions. On the 6th, only some six weeks after the Coalition-declared ceasefire, Operation PROVIDE COMFORT was initiated. USEUCOM assigned Major General James Jamerson, the former commander of JTF-PF, as its commander and directed him to deploy to Incirlik immediately, where he arrived by C–20 Gulfstream early on Sunday, April 7. With no prior planning JTF-PC was underway. Earlier, on the 6th, Colonel Bryan Hooten, commander of the 39th Special Operations Wing (SOW) at Rhein Main (Germany) had been alerted for immediate deployment to Turkey. He was directed to load three of his COMBAT TALON MC–130Es (7th SOS) and deploy them to Turkey as soon as possible to airdrop relief supplies to refugees, to be followed by three additional MC–130Es, four COMBAT SHADOW HC–130N/Ps (67th SOS) and six PAVE LOW MH–53Js (21st SOS). The three MC–130Es arrived on April 6 with two aircraft accomplishing the first airdrops the next day, totaling 27 tons, with coordinated fighter protection, supplied by aircraft of CWP 7440. 'Slick' C–130s followed. On the 9th, the mission was expanded to sustain the entire refugee population for 30 days. On arrival in Turkey, the 39th initially became part of JTF EXPRESS CARE in Silopi (Turkey), which was renamed on April 17 as JTF ALPHA. The 10th Special Forces Group and British marines were also part of JTF ALPHA. Its counterpart JTF BRAVO was established on April 18 near Zakho, northern Iraq. Its mission included, for example, the establishment of a 30-kilometer Iraqi security zone and construction of humanitarian service support bases. It was augmented by the 24th Marine Expeditionary Unit (MEU), which arrived on April 15 with 16 helicopters and also supported JTF ALPHA. Initial Naval involvement comprised USS Theodore Roosevelt's Carrier Battle Group.

During the first twenty days, C–5 Galaxy and C–141 Starlifter aircraft flew 75 missions from CONUS and Europe to Turkey. C–5s also transported allied troops from Italy to eastern Turkey, from where they moved overland to Zakho.

Another Coalition partner in PROVIDE COMFORT (and later also in NORTHERN WATCH) was France, which supplied, for example C–135FRs and Sepecat Jaguar As. The photo shows a C–135FR in company of a Jaguar A. The shadow of a second Jaguar A is superimposed on the tanker with the photo probably made by its pilot. *[via Bruce Benyshek]*

7440's Mission was to provide air security for air drops and combat air support for any ground forces committed in the future. To bolster the Wing, the 20th (42nd ECS, EF–111A), 36th (525th TFS, F–15C), 52nd, 81st (92nd TFS, A–10A) and 86th TFW (F–16C), plus the 66th ECW (Electronic Combat Wing, 43rd ECS, EC–130H) were directed to deploy additional aircraft to Incirlik. For instance, the 52nd TFW began deploying personnel and six F–4G WILD WEASEL aircraft of the 23rd TFS to Incirlik, also on April 6. After arrival on the 7th of personnel and cargo aircraft of Coalition partners United Kingdom and France, General Jamerson renamed his organization Combined Task Force Provide Comfort (CTF–PC) on April 9. Jamerson remained commander until April 17, when he was replaced by Army Lieutenant General John Shalikashvili, becoming the latter's deputy commander for air. That day, ground forces were added to protect the refugees, for whom temporary camps were built. To allow the Kurds to return to their homes, a safe zone was established, using air and ground forces.

At the same time, a No-Fly Zone (NFZ) was established north of 36° N, covering some 19,000 square miles, to be enforced by U.S., UK and French aircraft, specifically banning all Iraqi air activity. Although the NFZ technically was in CENTCOM's zone, EUCOM was allowed by CENTCOM to patrol northern Iraq. PROVIDE COMFORT's northern NFZ set the stage as model for NFZs elsewhere, notably Operations SOUTHERN WATCH in southern Iraq and DENY FLIGHT in Bosnia.

Delivery of humanitarian relief goods was the responsibility of a six-nation airlift operation, which also involved

An F –4G Phantom of the 81st FS at Incirlik about to taxi out for the next PROVIDE COMFORT mission. *[Bruce Benyshek]*

The 23rd FS still teamed up with F–4Gs in PROVIDE COMFORT, but this time the Phantoms were not theirs like in PROVEN FORCE, but of their colleagues in the 81st FS. Four 23rd pilots by one of their F–16Cs, from left to right, Cal Tinkey, Mark Kirchhoefer, Mark Altobelli, and Brad Cushman. *[Karl Dittmer]*

countries such as Canada, Germany and Italy. On May 7, in two separate incidents ten minutes apart, pilots of an A–10A and F–16C reported coming under AAA fire over northern Iraq.

CTF–PC withdrew from northern Iraq on July 15, with a residual force remaining in Turkey to deter Iraqi reprisals against the Kurds. By that time, 23,000 Coalition personnel, of which 12,300 U.S. personnel, had been involved in CTF–PC. USAF transport aircraft had transported more than 7,000 tons of relief supplies. Nine days later, July 24, PROVIDE COMFORT ended. U.S. and coalition fighter aircraft provided air cover for such aircraft as USAF C–130s, Italian G-222s, British Hercules C.Mk 1/3s and French C–160 Transalls. Coalition forces flew 700 fixed-wing sorties, including 500 by U.S. aircraft.

On the same day, Operation PROVIDE COMFORT II (OPC II) was initiated. It included 5,000 personnel of six Coalition nations, 70 helicopters, 26 Incirlik-based aircraft and a Carrier Air Wing. Air Force Reserve (AFRes) units supported the Operation with HC–130 rescue, C–130 transport and MH–60G special ops aircraft.

Operation WARDEN was the British contribution to PROVIDE COMFORT. On September 3, Jaguar GR.Mk 1As of No. 54 Squadron (RAF Coltishall) initiated patrol of the airspace over northern Iraq, supported by VC–10 K.Mk 2/3 tankers of No. 101 Squadron (RAF Brize Norton).

On October 1, the 52nd TFW not only was re-designated 52nd Fighter Wing (and the squadrons, Fighter Squadrons), but its overall aircraft authorization decreased from 72 to 60, to include one squadron with 24 F–4Gs (81st FS) and two squadrons with 18 Block 30 F–16C/Ds each (23rd and 480th, the latter unit transferring six F–16C/Ds to the 23rd). This resulted in a swap-out of personnel, F–4G and F–16C/D aircraft, and equipment. Non-authorized F–4Gs and F–16C/Ds, except for a small number of BAI (Backup Aircraft Inventory) aircraft, were transferred to other units. At Incirlik, the F–4Gs of whoever provided them were then teamed up with F–16s from various USAFE Viper squadrons. Also, ANG and AFRes F–16 squadrons would be deployed to Incirlik for 60 days for this reason.

1992

On January 1, 1992, the 52nd FW had personnel and eight of its F–4Gs deployed to Southwest Asia, four aircraft at the Lik and four at King Abdul Aziz AB at Dhahran (Saudi Arabia, SA). According to the publication 'United States Air Forces in Europe, Historical Highlights, 1942-1992', the Wing maintained personnel and eight F–4Gs in Southwest Asia up to August 27, 1992 as part of CENTCOM's Operation DESERT CALM residual force to help enforce Iraqi compliance with the ceasefire conditions (see later).

During the winter of 1991-92, USAF transport aircraft, supplemented with Coalition and commercial aircraft, transported 119 tons of food and water and more than 4,000 bundles of clothing to the Iraqi Kurds.

After the A–10A's Combat Air Support (CAS) capability of the 81st FW (RAF Bentwaters) was no longer necessary in the course of the year and with the impending inactivation of the Wing, aircraft and personnel were redeployed and replaced by Precision-Guided Missile (PGM)-capable F–111Fs of the 48th FW (RAF Lakenheath), giving CWP 7440 a deep-strike capability. The 48th was converting to F–15E Strike Eagles with the first one arriving on February 21. While deployed to Incirlik, Aardvark pilots of the 48th, which included those of the 492nd FS, flew 1,185 sorties.

In 1992, the 52nd FW continued to support OPC II with all three squadrons participating. It looks like the F–16C squadrons deployed for 45 days at a time, joining the already present F–4Gs of the 81st.

1993

In the second half of January the Iraqis kept aircrews of Coalition aircraft quite busy while they flew their missions over northern Iraq preventing them from violating the NFZ. In two separate incidents on January 15 a pair of F–111Fs were fired at by Iraqi AAA, resulting in no hits

F–4G 90263 of the 81st FS taxiing at Incirlik. It is adorned with a shark mouth. Design and stencil was done during the Squadron's final deployment to the Lik in 1993 by Bruce Benyshek. He painted the first jet. According to him, six to seven F–4Gs had it at Incirlik. A violation of Air Force rules, but the Squadron Commander did it for the troops and esprit de corps. ***[Matt Ellis via Bruce Benyshek]***

Aircraft supporting PROVIDE COMFORT also included EF–111A Ravens. A crewmember of an EF–111A is pre-flighting his aircraft in a shelter at RAF Upper Heyford before deploying to Incirlik in September 1991. ***[USAF, SSgt Cynthia Alderson]***

and no retaliation. Also, the 81st FS deployed personnel and five F–4Gs to Incirlik, joining their Wing colleagues there of the 23rd FS with their F–16Cs. Two days later, Iraqi AAA fired at two F–16C Fighting Falcons. As on the 15th, there were no hits and no retaliation. On January 17, Captain Craig Stevenson of the 23rd FS scored the second F–16 kill with a single AIM-120 AMRAAM, while flying F–16C 86-0262. The Iraqi aircraft involved was a MiG-23 Flogger, whose pilot violated the northern NFZ. Stevenson's flight lead was Lt Col Steven Heil, the Assistant Director of Operations (ADO) of the 81st, who flew an F–4G and gave him the OK to press the attack. Also on the 17th, the aircrew of one of a flight of two F–4Gs struck an air defense site. F–4G aircrews came into action again the next day, when they struck SAM sites in northern Iraq, again with AGM-88s. Pilots of F–16Cs dropped CBUs on Bashiqah Airfield after being shot at by AAA. On the 19th, a 81st FS F–4G aircrew fired a HARM at a SAM radar site east of Mosul, after it 'locked on' their aircraft. About three hours later, pilots of two F–16Cs dropped CBUs on an AAA site after being fired at. A missile battery was struck on January 21 by aircrews of an F–4G and F–16C, who escorted a French Mirage F1CR recce aircraft when the Iraqi search radar began tracking the aircraft.

While personnel and aircraft were deployed at Incirlik, the 81st received its first (Block 30) F–16C on February 18 from the 56th FW at MacDill (FL), initiating its re-conversion from F–4Gs to F–16C/Ds.

On April 9, three F–16Cs, accompanied by an F–4G, were fired on by Iraqi AAA near the Saddam Dam in northern Iraq. The F–16 pilots expended their CBUs. Nine days later, a flight of one F–4G and one F–16C, flying north of 36° N, were illuminated by an Iraqi tracking radar site, which was situated south of the parallel. The crew of the Phantom fired an AGM-88 at the site and destroyed it.

To continue its SEAD mission after the phase-out of its Phantoms, conversion of the 52nd FW from Block 30 F–16Cs and F–4Gs to WW F–16CJ Block 50D aircraft was initiated on June 25, 1993, when the 480th FS received the first five of its complement of Fighting Falcons. It was expected the Wing would possess two Block 50D F–16C squadrons by early 1994 (squadrons would also receive a couple of Block 50 F–16Ds). A little over a month later, the 480th transferred the first of its 20 Block 30 F–16C/Ds to the 178th FG of the Ohio ANG at Springfield. Block 50D

The caption states that a USAF F–16 is refueled inflight over southern Turkey prior to a PROVIDE COMFORT mission over northern Iraq as the pilot of another F–16 awaits his turn. A closer look at the photo reveals the aircraft are F–16Cs of an Air Combat Command unit. ***[SrA Gudrun Cook]***

(and 52D) F–16CJs were configured with the HARM ALIC, Avionics/Launcher Interface Computer, which furnished the aircraft an additional mission, the full autonomous HARM employment capability. In this respect, the AN/ASQ-213 HTS, HARM Targeting System, was developed by Texas Instruments, which received a contract in 1991. The pod, externally mounted on either the left or right engine inlet hard-point of the F–16, provides substantial all-weather situational awareness to pilots on the types and locations of surface-to-air defense radars, as well as passing ranging solutions to the missile when launched. As first Block 50/52 F–16CJ Squadron, the 480th FS achieved IOC (Initial Operational Capability) in January 1994. On the 15th, it deployed personnel and F–16CJs to Incirlik to support OPC II. The original HTS pod was upgraded in 1996 with software Release 5 (R5). R6 was fielded in May 2000 and R7 in September 2006, employing a new digital receiver and GPS hardware capability, along with using Link-16 connectivity between aircraft.

In September, personnel and F–4Gs of the 81st FS returned from Incirlik to Spang for the last time. They were replaced by personnel and six F–4Gs of the 561st FS, which deployed from Nellis for their first and only, but extended deployment to Incirlik. It was also the Squadron's first deployment since its reactivation on February 1, 1993. A

RAF VC–10 K.Mk 2/3s operated from Incirlik in Operation Warden. The September 1993 picture shows VC–10 ZA-142 'C' of No. 101 Squadron in company of F–4G 97232 of the 561st FS. The aircraft joined up for a picture as an F–4G cannot be refueled by a VC–10. ***[Bruce Benyshek]***

swap-out of 561st personnel took place on December 27. The majority of Spang's F–4Gs and aircrews were transferred to the 561st FS, with the final four aircraft leaving for Nellis on February 18, 1994, ending more than 27 years of Phantom II ops at Spang. The 561st FS was reactivated at Nellis and assigned to the 57th Operations Group through Air Combat Command (ACC) Special Order (SO) GB–37 of January 27, 1993 as a second F–4G unit to support both PC and OSW. Idaho ANG's 124th FW was also responsible for F–4G training, while the 422nd TES with its two CB–coded F–4Gs at Nellis was responsible for test and evaluation of new equipment and development of tactics with maintenance being accomplished by the 561st. The total PAA (Primary Aircraft Authorized) on September 30, 1994 was 50, with 26 at Nellis and 24 at Boise.

The first 48th FW F–15E Strike Eagles to serve with OPC II arrived at Incirlik on August 2. It initiated a hectic pace of deployments that would, for nearly six years, keep at least one squadron constantly deployed. The deployment involved six aircraft, personnel and equipment of the 492nd FS. Seventeen days later, the crews of two mixed pairs of F–4Gs and F–16Cs reported possible SA-3 launches west of Mosul. Response was by the F–16C pilots with CBUs. Three hours later, 492nd aircrews of two F–15Es dropped four Laser-Guided Bombs (LGBs) on the site.

On October 1, USAFE re-designated the 39th Tactical Group at Incirlik as the 39th Wing. The mission of the Wing was to provide operational and logistical support for all U.S. forces in Turkey and to operate a Quick Reaction Alert Force for Supreme Allied Command Europe. As of October 15, 1971, the Wing was assigned to TUSLOG, The United States Logistics Group, until its reassignment to 16th Air Force on July 17, 1992. Attachment (since January 16, 1991) to CWP 7440 remained unchanged until November 30, 1995, when the Operations Group Provisional, 7440 was assigned to CWP 7440 as an element.

1994

A CTF–PC February 14 message to USAFE contained the Concept of Operations during the pending runway closure at Incirlik, which was a planned 6-9 month effort. The 39th Wing plan called for fighters to operate on the parallel, E-3 AWACS aircraft out of Adana and KC–135s out of Ankara.

In March, Lieutenant Colonel Jim 'Uke' Uken, Ops Officer of the 561st FS, took over the Detachment at Incirlik with a swap-over of personnel only. According to Jim deployments were made as 'packages'. When aircraft were rotated, a transport, usually an C–141, would accompany the jets with onboard a maintenance EST, Enroute Support Team, spare engines and 'all kinds of stuff' that might be needed to fix any maintenance problems. "We had the oldest aircraft on the ramp, but we were famous for our Fully Mission Capable (FMC) rate and never fell below the USAF standard. Ever!". He returned to Nellis in June. At that time, the 23rd FS with its F–16Cs were also deployed to Incirlik, still with its Block 30 F–16s. Uke, as to the standard OPC II mission,

While deployed with the 561st to Incirlik in June 1994, Bruce Benyshek completed his 2,000 F–4 Phantom flying hour. Result was the traditional water hose down. *[via Bruce Benyshek]*

It was flown with two F–4Gs and two to four F–16s. The Phantoms were configured with three fuel tanks, two AGM-88 HARMs, two AIM-7 Sparrows, an ALQ-184 and ALE-40 chaff and flare dispensers. When F–16s launched as a four-ship, they would split into pairs to enter east and west CAPs on border crossing. When there were only two F–16s, they became wingmen. As usual, we were out in front doing our own thing first. We had support from USAFE tankers, but they came in from a different base as they were no longer stationed at Incirlik as in the war. The refueling track was well east of Incirlik and not too far from where you could turn directly south into northern Iraq after refueling. If an F–4G had a problem requiring RTB, Return to Base, an F–16 would escort him home and we would revert to one F–4G and three F–16s operations. The two 'pushes' a day, and us flying six sorties a day, left us only two sorties a day to do local training like air-to-air currency, etcetera. We probably did some two versus two against the others in that case.

On April 14, two U.S. Army UH-60 Black Hawk helicopters and their crews (159th Aviation Regiment, 6th Battalion, Giebelstadt, Germany), assigned to Operation PROVIDE COMFORT II, were transporting U.S., United Kingdom, French, and Turkish military officers and diplomats of the MCC (Military Coordination Center) and Kurdish representatives to a meeting south of the security zone. Two 53rd FS (52nd FW, Spangdahlem) pilots of F–15C Eagles mistakenly identified the two helicopters as Iraqi Mi-24 Hind helicopters and shot them down, killing all 26 people on board the UH-60s. Improper coordination of Army helicopter activities with USAF operations, poor coordination aboard the 963rd Airborne Warning and Control Squadron (552nd ACW, Tinker) E-3, and poor recognition skills displayed by the Eagle pilots were examples that contributed to the tragic accident.

Not so long after the Black Hawk losses, Jim Uken was on a PC II mission with two F–16 elements, which were there as much for air-to-air as being Wild Weasel support. The F–4Gs were centered between the two F–16 elements. Jim stated,

An 'intruder' was called out by NATO AWACS as coming in high and fast heading to the no-fly line. This obviously spurred interest among the Viper crews with their see all radars and it soon became apparent the vector was to the northwest. With our 30+-year old radar I gained a contact, at some distance, and quickly assessed they were at approximately 65,000 feet and not fast. My immediate thought was it looked like a U–2. I warned the F–16s to not shoot until we had AWACs approval, etcetera. In the interim, the Viper pilots started losing their radar contact as the thought of moving their search pattern to higher altitudes didn't occur to them while their 'fangs hanging out'. The intruder 'punched' the line, went about 20-30 nautical miles northwest to Saddam Lake and did a 180 turning south. At mission debrief I relayed the events to Intel, etcetera, and it became a discussion point that PC II and OSW were not keeping each other informed. It was a U–2 on the OSW Air Tasking Order.

On November 27, the 190th FS deployed for the first time to Incirlik, relieving the 561st FS, which returned to Nellis with personnel and six F–4Gs on December 12. During its extended tenure at Incirlik, July 30, 1993-December 9, 1994, the 561st was concurrently at Dhahran for the October 30, 1993-January 4, 1994 and July 15-October 5, 1994 periods. Colonel Uken in this respect,

We set up three-month rotations as the standard. After returning home, it would normally take six months before somebody would deploy again. To keep track, I kept a 'good deal / bad deal' book. With rare exception, you did not go to Incirlik unless you'd been at Dhahran first. Given deployed and home station reality, e.g., accomplishing deployment training and playing in every Red / Green Flag at Nellis, we never 'maxed out'. In addition to the 24 F–4Gs we had 'on our books', we also had five spares, which never happens unless there is a reason. Normally, a squadron has to absorb major phase inspections and depot level maintenance with the number of aircraft it has. In our case, the spares allowed us to do so without losing any of our basic 24 aircraft. We also had two F–4Gs which were being used for BDR (Battle Damage Repair) and WLT (Weapons Load Trainer). So, we

An F–4G of the 561st FS streaks past the Erbil Observatory in the eastern part of the northern NFZ during a PROVIDE COMFORT II mission. It looks like it's not undamaged anymore. *[Bruce Benyshek]*

had six F–4Gs with eight aircrews at both Incirlik and Dhahran. If we had to bring jets home for major phase or depot level maintenance, two of the incoming crews would arrive a day or two early and the jets flown back by two crews going home. There was frequent airlift from Ramstein to both locations, so replacement aircrews and maintenance personnel arrived through Ramstein.

The 190th started three, thirty-day rotations to The Lik. The unit returned to Boise on March 15, 1995.

France's contribution at Incirlik in the 1993-94 period included four Mirage F1CR recce aircraft, four Jaguar As and one C–135FR. For 1995 this was five Jaguar As and one KC–135FR. Aircraft in Operation Warden in the 1993-4 period included eight Tornado GR.Mk 1s and two VC–10 K.Mk 2/3 tankers. For 1995, the number of Tornados was decreased by two, but the number of tankers did not change.

1995

The 190th returned to Incirlik on September 15 for its second and OPC II's final F–4G deployment. Eleven days later, an F–4G aircrew flew OPC II's 50,000th combat sortie, an accomplishment nearly five years in the making. As the CTF's Chief of Staff, Army Colonel Tom MacHamer, stated,

This is a Coalition accomplishment. It's not an American achievement, but true teamwork effort between the four Coalition partners. The presence and resolve of the Coalition proves the dedicated professionalism of all the people who have passed through Incirlik in the four plus years of Provide Comfort.

With regard to the scheduled departure of the F–4G from USAF's inventory in 1995, Major Mike Bell, the 190th FS Det commander, stated the unit had worked with F–4 Phantoms for 20 years, initially with the recce version, RF–4C, since 1975, and then with the F–4G, since 1991, and it would be a sad day when they were gone.

To celebrate the F–4G's departure from Incirlik, CWP 7440 organized a 'Pharewell Dinner' and an open house, including an F–4G four-ship flyby on December 3-4. Redeployment was initiated on the 12th. IDANG spent almost two years in the Gulf area, longer than any other ANG flying unit. More than 1,000 combat sorties were flown during two deployments each to Incirlik and Dhahran. HARMs were expended in four separate combat missions from the latter. Two aircrew members became the first, and possibly the only, ANG officers to fly 100 or more combat sorties over Iraq. F–4G operations at Boise were ended on April 18, 1996 with the final four aircraft departing Gowen Field, ID for AMARC two days later.

Epilogue

From the inception of PROVIDE COMFORT through 1995, 19 nations contributed. The cost to the U.S. of humanitarian aid alone was $M 150.2. A total of 153,389 hours were flown by USAF aircraft, directly supporting the Operation for a cost of $M 544.4. Through October 31, 1995 Coalition sorties numbered more than 50,000. Ultimately, the U.S. would fly over 62,000 sorties, including 42,000 fixed-wing and 20,000 rotary-wing, before OPC II ended on December 31, 1996 and was replaced by Operation NORTHERN WATCH.

Training at Shaikh Isa got a boost when it was possible to coordinate missions with units of Carrier Air Wing (CVW) 9 onboard the USS Nimitz (CVN 68) after it replaced the USS Ranger (CVA 61) in the Arabian Gulf. The photo shows a formation with a Strike Fighter Squadron (VFA) 147 F/A–18C Hornet, an Electronic Attack Squadron (VAQ) 138 EA–6B Prowler, and two 81st TFS F–4G Phantoms. *[via Bruce Benyshek]*

Units deploying to Turkey were primarily USAFE units and usually did so with 4-8 aircraft. As major maintenance and inspections could not be accomplished at Incirlik, aircraft concerned were flown to home base and replaced by 'fresh' ones. Although, for instance, ANG and AFRes units stepped in, USAFE units had to deploy virtually every year, impacting training and scheduled maintenance. But it could even be worse, as elements of the 81st (T)FS not only deployed continuously to Shaikh Isa/Dhahran in the March 1991-May 1993 period, but also to the Lik in the 1991-September 1993 period.

F–4G post-DESERT STORM deployments to Incirlik

(source, ACC/HO)

PERIOD	UNIT/NUMBER
Apr 6-14, 1991	81TFS/6
Mar-Sep 1993	81FS/4-6-5
Sep 1993-Dec 9, 1994	561FS/6
Dec 10, 1994-Mar 15, 1995	190FS/6
Sep 15-Dec 12, 1995	190FS/6

Post-DESERT STORM, Bahrain

1991

When the remaining 13 F–4Gs of the 561st TFS departed Shaikh Isa on March 23, 1991, the Squadron left behind personnel and 24 F–4Gs of the 81st TFS. As Tactical Fighter Wing Provisional, 35 (TFWP 35) still existed, OPCON (Operational Control) remained with that Wing, which was headed by Colonel Neil Patton, the DO (Deputy

for Operations) of the 35th TFW, who did not return to George. Redeployment of the 81st was initiated on April 5, when personnel with eight aircraft returned to Spang. Left behind at Shaikh Isa then were the 16 aircrews and some 100 maintenance/support personnel, a mix of those who remained and volunteers after the war, plus 16 F–4Gs, 'the Shaikh Isa 16'. The next rotations were scheduled and non-voluntary for the most part, but routine deployments for all personnel. Lieutenant Colonel Pete O'Day became the first 81st TFS Detachment commander.

On May 10, another eight Phantoms with personnel returned to home base. When Colonel O'Day returned to Spangdahlem in late May, his job was taken by Major Bart Quinn. He was a 1975 ROTC graduate and, except for a spell flying CT–133s while on exchange to the Royal Canadian Air Force, flew all four Air Force versions of the F–4 Phantom, of which the last 11 years the F–4G. On December 26, 1990, as an Assistant Ops Officer in the 480th TFS, he led a six-ship from Spang to Shaikh Isa, where all 480th personnel was reassigned to the 81st TFS, including scarves and patches.

After the departure of personnel and aircraft, those remaining of the 81st Det had Shaikh Isa for themselves except for the Bahraini Air Force units. For instance, rooms usually had one officer to a room. After the Gulf War, mostly training missions were flown, but no tankers were available, although in-flight refueling was accomplished for currency. There were no real radars to work against, other than the own air traffic control radar. Missions were in the 1.2 to 1.9-hour range. Aircraft were not configured with AGM-88 HARMs and/or AIM-7 Sparrows, which saved fuel. Day-to-day flying post-fighting was making up various scenarios. One involved defense suppression (weaseling), using APR-47's 'phantom ranging'. The computer in the F–4G's AN/APR-47 included a program that could generate its own Electronic Order of Battle (EOB). It could generate SAM symbols on the system's screen that the crew could use for training purposes. The EWO could input latitude and longitude coordinates to tell the computer where to center the simulated SAMs. Another scenario involved some of the other F–4Gs acting as interceptors, so 'turn and burn' could be done doing a little dogfighting. Although there were rails on the F–4Gs, no missiles were carried. No BFM (Basic Fighter Maneuvers) was flown, as this would require downloading the wing tanks while BFM was only flown with a centerline tank. It would take too much work to reinstall the wing tanks in case of an emergency. Major Jim Healy, EWO in the 81st TFS at Shaikh Isa, described the intercept scenario as follows,

Usually, two or four aircraft split up and flew to opposite ends of the airspace to get 20 or so miles of separation, and then turned toward each other. One airplane was designated as 'fighter', doing the intercept and the other as the 'target', being intercepted. The crew of the fighter tried to find the target on their radar and conduct an intercept, ideally resulting in a 'stern conversion', where the fighter ended up in a position behind the target. Then the target/fighter roles would be reversed for the next intercept. Often we'd brief that at the point in the intercept the target saw the fighter, the target would begin to maneuver and a 'dogfight' would ensue.

'Shaikh Isa Shacks Moving Day'. The trailers that were used by the 81st TFS as Ops buildings were loaded on flatbeds/eighteen wheelers for transportation to their new home, King Abdul Aziz AB at Dhahran. The Squadron even brought its duty desk along and used it there for life support, helmets, etcetera. *[Bart Quinn]*

In general, forces flying in Saudi Arabia, including Shaikh Isa's F–4Gs, were very restricted on what they could do and where they could fly.

USS Nimitz, CVN 68, departed home port Bremerton on February 25, 1991 to deploy to WestPac, relieving USS Ranger, CVA 61, on April 18. Onboard was Carrier Air Wing (CVW) 9, with, among others, two squadrons with F–14B Tomcats and two with F/A-18C(N) Hornets. ATO (Air Tasking Order) tasking included maintaining a six-hour alert strike package, while the Wing's Carrier Airborne Early Warning Squadron (VAW) 112 with its E-2C Plus Hawkeyes, making the aircraft's maiden deployment, maintained an AEW barrier in the North Arabian Gulf. After being relieved by USS Abraham Lincoln (CVN 72), she returned to Bremerton on August 24, 1991. Major Healy stated the following,

They and the 81st TFS took advantage of our mutual proximity to do some training, inter-service cooperation, that was normally not available and to break up the routine of 'peacetime' ops at Shaikh Isa. It was also good both would become familiar with each other in case we would have had to restart combat ops. They appreciated the fact they could get ashore and off the ship for a couple of days either at our base or at the U.S. Navy base in Manama, Bahrain. And most of us had never been on a carrier.

Major Quinn in this respect,

We developed a great working relationship with the Bahrainis and the aircraft assigned to the Nimitz. We flew composite training exercises down in southern Saudi Arabia, 'the Empty Quarter', an area of nothing than desert. Of

course the Saudis were aware of this. It was package training like we would actually employ if required. Navy aircraft would fly out of Shaikh Isa with us or launch from the carrier and we would meet like in the war at a rendezvous point, form up and go in. Bahraini F–16s generally flew fighter cover and F–14 Tomcats would be Red Air or reserve, pending on training requirements. The Ops Order we followed was developed by our Ops Officer and EWO Major Tom Moe, who did a great job organizing all this.

Major Healy was deployed in late March from Shaikh Isa to CENTAF's TACC, Tactical Air Control Center, in the basement of the Royal Saudi AF headquarters building in Riyadh to coordinate Weasel operations and tasking when necessary, doing all phases or parts of a renewed air campaign. Joe drove back and forth to Shaikh Isa a couple of times to keep current, taking him 2-2½ hours each way. According to Jim 'the scenery was desolate and boring with hours of nothing but sand'. The second time to do so was May 2, driving from TACC to Shaikh Isa around noon. Joe in this regard,

After I had been in about an hour, I was suddenly tasked to provide a tentative plan to provide F–4G escort for a U–2 mission over Iraq. I put a plan together after getting the basic facts, like targets, TOT, threat, SAM EOB, and tanker tracks. I then called the Squadron to give them a heads-up and left for Bahrain. I got there later in the afternoon and briefed Bart Quinn on the plan and said I'd wanted to take part if it came off. My training flight on the fourth was cancelled because of a horrendous dust storm. The word was the U–2 mission was on hold. Then on Sunday, the mission was on for the next day. I did fly and it was probably a unique instance when someone on a staff planned a combat operation and then flew in it!

Joe teamed up with his Desert Storm pilot, Captain Jim Hartle. They flew as Pearl 02 on Colonel Patton's wing. Aerial refueling was accomplished over Saudi Arabia. The flight was directly over Al Taqaddum, just south of the center of Baghdad and right over Salman Pak, which was Jim's and Joe's target on the first night of Desert Storm. No signals came up. Flying time was 4.1 hours.

Before flying their F–4G Phantom from Shaikh Isa to their new home in Dhahran, Bart Quinn, the 81st TFS Detachment commander, was interviewed by Bahraini TV. Getting into their jet in the background are Bruce Benyshek and his EWO Jim Parker. ***[via Bart Quinn]***

Bart Quin with regard to the U–2 escort mission,

On May 6, we flew in a large mission in support of a U–2. It was in response to some opposition / threats to U–2 flights over Iraq, i.e., SAM activity. It was flown on May 6, but was called Cinco de Mayo Raid according to Zulu time. Fourteen of the 16 F–4Gs at Shaikh Isa participated. The aircraft were configured with two AGM-88 HARMs, two AIM-7Fs, an ALQ-131 ECM pod and three fuel tanks. Six aircraft, led by me, were planned in western Iraq and another eight, led by Colonel Patton, in Central Iraq, including Baghdad. We had tanker support on the way in, but none on our return trip. The only opposition seen was AAA fire along a road out west, which appeared to be large caliber guns. We could see smoke coming from the barrels. Accordingly, we moved away to deny them any barrage or lucky hits. Not a single Iraqi radar came on the air. The mission was a success with all aircraft returning without incident. No ordnance was expended.

Bruce 'Spike' Benyshek, an F–4G pilot, added the following,

Notification and planning were a couple of days prior to the mission. The most important information for us would be where the U–2 would be and when, so that we could evaluate threats and which ones to shoot. Wasting a HARM on a SAM that could not hit the U–2 would be defeating half of one's weapons load. There was a mass-brief, then each flight individually. My EWO was First Lieutenant Jim Parker. The flights of two were staggered to cover the U–2's TOT, Time-over-Target, which was quite long. The flights apart gave one hour thirty minutes. One or two flights might have gone to the tanker, and come back north one more time.

On the evening of May 21, the 81st had a party with all personnel, the Navy crews and their maintainers. Of the remaining eight WILD WEASEL aircraft, four were returned on June 27, soon after the Det's move to Dhahran. The final four F–4Gs were still at Dhahran as of December. TFWP 35 and Combat Support Group Provisional, 35 (CSGP 35) were inactivated effective August 2, 1991 through TAC Special Order (SO) GB–78 of the same date. In the meantime, TAC SO GB–37 of March 13, 1991 had designated and activated TFWP 4404 at Prince Sultan AB, Al Kharj (SA) and assigned it to USCENTAF for the purpose of command and control, administration and the exercise of Special Courts-Martial convening authority (UCMJ), all effective March 13. In addition, CSGP 4404 was designated, activated and assigned to TFWP 4404, also effective March 13. The new Wing replaced TFWP 4, assuming its mission, personnel and equipment, which, together with CSGP 4, was inactivated effective March 13 through SO GB–37. Assets assigned to TFWP 4404's subordinate units were F–15C (53rd TFS) and F–15E (335th TFS), ANG F–16As (138th and 157th TFS) and ANG C–

When the remaining 13 F–4Gs of the 561st TFS departed Shaikh Isa on March 23, 1991, the Squadron left behind personnel and 24 F–4Gs of the 81st TFS. As Tactical Fighter Wing Provisional, 35 (TFWP 35) still existed, OPCON (Operational Control) remained with that Wing. On the 23rd, Colonel Neil Patton assumed command of the Wing. He was the DO (Deputy for Operations) of the 35th TFW and did not return to George. On June 18, Col Patton and Major Joe Healy flew the last F–4G, 97202, out of Shaikh Isa. It must have been his final F–4G sortie, as after landing at Dhahran he received the traditional hose-down, which should not have been too bad because of the temperature. The photo shows Major Bart Quinn presenting Colonel Patton with a 81st TFS plaque. Others in the picture are Bruce Benyshek and Jim Elwell. *[via Bruce Benyshek]*

130H (166th TAG) aircraft, while plans were in place to also include F–4Gs, EF–111As and A–10As. EF–111A maintenance personnel visited Al Kharj on March 27 to check out base facilities, while two F–4Gs arrived at Al Kharj in the final week of March for the same purpose. Personnel and EF–111A aircraft of the 42nd ECS supposedly arrived at Al Kharj on April 11. Although eventually a move of personnel and F–4G aircraft from Shaikh Isa took place, the destination was not Al Kharj (see later). In the first week of April, the government of Saudi Arabia approved a block of airspace for training sorties by Wing aircraft. Also, F–15C aircrews of the 53rd TFS started flying exclusively at night. On April 18, the mission was taken over by the 335th TFS. Five days earlier, the Wing was informed by CENTAF that its aircraft were not to fly north of 36° N. CAP missions up to 36° N were continued to be flown to protect redeploying U.S. ground forces.

Aircrews of Navy F–14 Tomcats and F/A-18 Hornets arrived at Al Kharj on the 29th to discuss how they could conduct CAP in conjunction with USAF aircraft.

The May 7 redeployment plan put in motion, changed the nature of CAP sorties: it was no longer flown north of the DMZ, Demilitarized Zone, in Iraq, while CAP sorties over Kuwait and Saudi Arabia were flown to protect allied forces from a potential air threat. As of May 10, the alert commitment for F–15E aircrews of the 335th TFS was ended. On May 29, the Wing added the A–10A to its inventory when the 91st TFS arrived at Dhahran from RAF Bentwaters. The first sorties were local orientation sorties. Redeployment was on September 13.

On June 15, the Wing initiated its move to King Abdul Aziz AB at Dhahran. Four days earlier it was announced that the 22nd TFS (F–15Cs) would remain at Al Kharj until its redeployment to Bitburg (Germany). Personnel and four F–4Gs of the 81st joined the Wing from Shaikh Isa after Colonel Patton had been directed by CENTCOM to move Spang's Det to Dhahran. He arranged money for the contractors to move its buildings.

Maintenance was part of the detachment. All routine maintenance could be accomplished locally, however, major work/inspections required the aircraft to be swapped out with jets from Spang. Maintenance personnel made a couple of Dhahran site visits to check out base facilities and prepare for the coming move, resulting in setting up operations there very easily. The Det never stood down with ops ending at Shaikh Isa and jets being ready after arrival at Dhahran. Bart Quinn,

At Shaikh Isa the Det had a couple of Crown Victoria vehicles. The 4404th guys were aware of them. They would brief us how they would take them when they got to Dhahran. However, Colonel Patton threatened non-judicial Article 15 punishment for ANYONE who gave up a vehicle! Lol! Most of the CVs remained with the Det and it was always fun to drive to our jets in a convoy of four Crown Vics!

Bart led a flight of two F–4Gs out of Shaikh Isa with two Bahraini F–16s on his wing. Bart's wingman was Bruce 'Spike' Benyshek. The flight could have been 15 minutes, but a ceremonial flyby was made over the harbor in fingertip formation and close aboard to Hotel Diplomat with a bunch of VIPs out on the balcony on the top floor. With the wait for the final appointed time, flying time was some 45 minutes. In the meantime, the infrastructure at Shaikh Isa had been dismantled. Bart in this respect,

The ops buildings were loaded on flatbeds / eighteen wheelers. To drive them over the causeway, where they barely fit, the air in the tires had to be let out. The Saudi border guards were losing their minds. But we got them to Dhahran, otherwise our maintenance, intel and ops would not have had any space to work. We even brought the duty desk with us and used it for life support, helmets, etcetera.

One of the pilots making the move to Dhahran was Spike Benyshek. He was stationed at Spangdahlem from May 1988 to April 1994 and then continued to fly the F–4G at Nellis with the 561st FS until the Squadron was shut down in April 1996. Initially, he had three-year orders in 1988, but after the war he was asked if he would like to stay longer. "Hell, yes" he reacted. He loved his 81st (T)FS assignment, the best Squadron he was ever in. And he loved Europe, in fact still does. Bruce was single and volunteered to do a lot of rotations from 1992-1995, helping the married guys out. Spike in this regard,

It typically went like this, three months in Dhahran, come home to Spang for a month, deploy to Incirlik for a month, back home for one month, back to Dhahran for three months, etcetera. That's how I got 238 sorties, of which 31 [were] DESERT STORM sorties and 207 NFZ sorties. In the former we expended 11 HARMs and two Shrikes, in the latter, no missiles.

Two F–4Gs of the 81st FS in the de-arming area at Dhahran. The aircraft still have their chutes trailing. On the right, two F–15 Eagles of the Royal Saudi AF. F–4G 97210 was one of the F–4Gs which were reassigned to the 561st FS when the Phantoms departed Spang. *[Bruce Benyshek]*

Around June 10, another Nimitz detachment visited Shaikh Isa and Joe Healy visited the carrier for some 5½ hours, getting a tour of the ship and watching launches and recoveries of several aircraft.

Joe was Colonel Patton's back seater when on June 18 they flew the last F–4G Phantom, 97202, out of Saikh Isa. After takeoff they meandered around eastern Saudi Arabia at relatively low altitude, until enough fuel was burned down and the aircraft was at landing weight. This meant, with the scheduled return to Spang on the 27th, he, and others, would be at Dhahran only for nine days. Most of the redeploying personnel were not happy about this.

According to Major Quinn, his Det was the second unit to arrive at Dhahran with the EF–111As being first. For a short period, the F–4G and EF–111A detachments were the only ones there.

Post-DESERT STORM, Saudi Arabia

1991

Operations at Dhahran were different from Shaikh Isa. Initially, the Det had a squadron space in a RSAF, Royal Saudi Air Force, building. However, there was not much interaction with them. The F–4Gs were almost two miles away and it took a while to get to them after the briefing. Later on, a new building was built closer to the jets, called 'Tad-Town'. Every deployed U.S. squadron was in it. As commander of TFWP 4404, Brigadier General Tad Oelstrom directed its construction. No routine type training was accomplished any longer, but all Det's missions supported ongoing coalition operations such as air defense CAPs over Kuwait. All missions came down on the CENTAF–issued Theater ATOs and in general had tanker support fragged. However, SOUTHERN WATCH changed this all. Flying was still accomplished off the ATO, but now it was over all of southern Iraq. The rest was very much

F–4G 97558 of the 81st FS is being refueled by a KC–135R Stratotanker near the Iraqi border while on a SOUTHERN WATCH mission. It was another F–4G reassigned to the 561st FS. [Bruce Benyshek]

The 429th Electronic Combat Squadron (ECS) of the 27th Fighter Wing at Cannon (NM) was the sole EF–111A Raven operator in 1993-1998. Hence it had the responsibility to deploy detachments to both Incirlik and Dhahran. The photo shows EF–111A 60033 on a mission over Saudi Arabia. The Squadron's call sign in the AOR was 'Elvis'. *[Bruce Benyshek]*

in-house. The Wing at Spang remained responsible for the Det, including personnel, aircraft, etcetera.

Not only operations at Dhahran differed from Shaikh Isa, but also the living conditions. As to his new living conditions, Bruce stated,

The stay at Shaikh Isa was not bad. Basically, Bahrain was much more westernized and normal place to be. We'd fly a training sortie in the morning over Saudi Arabia, had lunch and dinner and maybe go downtown to Manama, which was a nice city. In June 1991, the powers that be decided to relocate us to Dhahran, only 30 miles away, but a different world. We lived in Khobar Towers, four or more aircrews in a suite setup, which was OK, but it was a closed compound inside the city. Saudi Arabia was a much more strict and controlled country. We didn't really like it there (Bruce used a less diplomatic term, but this author preferred to use a more diplomatic 'didn't like it there').

On June 20, the 49th TFW sent personnel and F–15A Eagles of the 9th TFS to Dhahran for the Wing's first of two F–15A deployments. The 9th flew some 850 sorties and was relieved by the 7th TFS, which returned to Holloman on December 12 with some 650 sorties flown.

July 1 saw a total swap of 81st Det personnel with four of the F–4Gs remaining at Dhahran. The other four Phantoms were flown back to Spang at 1300L on June 27 with the support of a KC–10A Extender. Joe about the redeployment,

Today was incredibly hot. After engine start, the wind was behind us and blew the engine exhaust and the 105°F desert air over us in the cockpit. I don't think I've ever been that hot. We were refueled 2-3 times. The flight took us up the Red Sea, across Egypt south to north, then turning north, once west of Sicily, going feet dry at the French coast, then into Germany.

Bart Quinn, Bruce Benyshek and other personnel followed on July 1 by commercial charter plane. Bart then became the Wing's Chief of Wing Stan/Eval. Lieutenant Colonel Byron Beale took over the Detachment. While Dets remained deployed longer, personnel rotations in general lasted 45 days.

TAC SO GB–78 of August 2 inactivated TFWP 4404 and CSGP 4404 effective the same date, activated Wing Provisional (WP) 4404, assigned it to CENTAF Forward, activated four Provisional Groups, including Operations Group Provisional (OGP) and Logistics Group Provisional (LGP) 4404, and assigned them to WP 4404. In addition, GB–78 moved USCENTAF Forward from Riyadh to Dhahran.

To bolster the 81st TFS Det, the 35th TFW deployed personnel and four F–4Gs to Dhahran in late June as part of the ongoing U.S. presence in the Gulf Region. Bruce in this respect,

I think they deployed because we needed to give 81st personnel a break, as some had only been home for three months. We flew joint operations in contrary to missions flown in the Gulf War, so a Spang pilot might fly with a George EWO, etcetera. However, the big difference between TAC and USAFE was respectively, 'You will not do anything unless I approve it' and 'Don't do anything stupid or prohibited', which was refreshingly trusting. I loved USAFE. George personnel and aircraft joined our Det, which led to the unofficial 'activation' of the 3552nd VSF, 35 and 52 for the parent wings we were assigned to. We told the Wing commander 'VSF' stood for 'Vast Saudi Frontier' or 'Vicious Sand Fighter'. But it really meant 'Very Severely F..d'. The Wing commander supposedly bought it and I designed a patch.

Of the eight F–4Gs which were flown to Dhahran, four redeployed to Spang on June 27. To bolster the 81st TFS Det, the 35th TFW deployed personnel and four F–4Gs to Dhahran in late June as part of the ongoing U.S. presence in the Gulf Region. The result was the 'activation' of the 3552nd VSF, the 'Desert Weasels'. It was designed by Bruce Benyshek. *[via Eric Bosch]*

Yet, '3552nd VSF' was used for tasking purposes on the ATO produced in Riyadh. A George personnel rotation took place August 11-17.

On August 11, higher headquarters cancelled six F–4G and two EF–111A sorties. Ten days later, F–4G 97550 of the 561st TFS, on a training mission, crashed about 63 miles southeast of Dhahran in the Saudi desert. The crew ejected successfully and was recovered. The 52nd was tasked to send a replacement aircraft. Between September 22-28, F–4G and unit aircrew movements took place.

1992

In April, the 3552nd VFS was 'inactivated', when George's personnel and F–4G aircraft redeployed, meaning the end of the involvement of the 35th (T)FW in the Gulf Region, which had started in August 1990 and leaving the 81st at Dhahran. Effective June 30, both 35th FW F–4G squadrons, the 561st and 562nd FS, were inactivated through SO GB–97 of July 15. This meant that between Incirlik and Dhahran there was never a time when 81st (T)FS personnel and F–4Gs were not dual-deployed to both bases until May 1993, when Idaho ANG's 190th FS took over at Dhahran. Added to this was the fact 81st FS aircrews were sent to Nellis, to get the 561st FS operational, which was reactivated on February 1, 1993. Jim Uken in this respect,

There was about a six-month period where every two weeks a new F–4G pilot and EWO would go to Dhahran for three months, then deploy to Incirlik for another three months, followed by two-four weeks at Spang, before starting all over again.

On June 1, TAC was inactivated and replaced by ACC, Air Combat Command, which was activated the same day. This meant units assigned to TAC were inactivated, reactivated and assigned to ACC, also effective June 1. For WP 4404 and its four Groups this resulted in two different SOs: TAC's SO GB–1 of June 10 inactivated the Wing and ACC's SO GB–68 of June 8 activated the 4404th. The Special Order also activated and assigned an additional six Groups to the Wing, including OGP 49 at Khamis Mushayt (SA) with F–117As and OGP 4401 at Rhiyad (SA) with U–2s (Reconnaissance Squadron Provisional, 4401) and KC–135 tankers (Air Refueling Squadron Provisional, 4401).

As the U.S. and UK deemed that Iraq's president Saddam Hussein was not complying with UNSCR 688 of April 5, President Bush, on August 26, announced Operation SOUTHERN WATCH (OSW) to ensure Iraqi compliance.

OSW involved the establishment of a No-Fly Zone (NFZ) in Iraq south of 32° N. The zone, called 'The Box', would be enforced by Coalition forces from the U.S., UK, Saudi Arabia (SA), France (and later) Kuwait. As a result, the 52nd FW deployed an additional four F–4Gs to King Abdul Aziz AB on August 27, bringing the total there to eight. The first operational sorties were flown on the 27th, less than 24 hours after President Bush's announcement. AFRes contribution included deployment of HC–130 and

When the 561st FS Det at Dhahran redeployed to Nellis in early October 1994, it was replaced for the first time by a F–16CJ Wild Weasel Detachment of personnel and six F–16CJs of the 79th FS of Shaw's 20th Fighter Wing. The photo shows an F–16CJ, configured with AIM-9s, AIM-120s and AGM-88s, being refueled by a KC–10A Extender near the Iraqi border. *[USAF, A1C Greg Davis]*

HH–60G rescue aircraft. The British contribution was called Operation Jural and involved Tornado F.Mk 3 interceptors stationed in Saudi Arabia and Tornado GR.Mk 1s, which operated out of Kuwait. France's contribution included Mirage 2000, Mirage F1CR and C–135FR aircraft. Bruce Benyshek was one of the pilots augmenting the 81st FS Det. On August 27, he was the F–4G SEAD commander for a mission where eight F–16s dropped leaflets from a cluster-bomb type clamshell container along the Tigris and Euphrates, warning the Iraqis to not fly anything in the NFZ. There was pre- and post-mission aerial refueling. Support was by F–15Cs and EF–111Es. According to Bruce, the Iraqis did not even turn on a radar. In OSW, SEAD missions were always flown as F–4G-F–4G.

In October, the 4404th conducted its first composite training exercise since the beginning of OSW, SANDSTORM. Participants included USAF fighters, aircraft from the carrier USS Ranger, and RAF Tornado GR.Mk1s.

Throughout the fall, Coalition aircraft flew an average of 100 sorties per day, at medium altitude to avoid shoulder-fired SAMs and AAA. When on December 27 an Iraqi MiG-25 Foxbat penetrated the southern NFZ, Lieutenant Colonel Gary North, the commander of the 33rd FS (20th FW, Shaw), shot it down with an AIM-120 while flying F–16D 90-0778 as 'Benji 41', after the Iraqi pilot ignored verbal warnings. It was USAF's first F–16 kill and one by an AIM-120.

Between November 10 and 16, the 52nd FW deployed two F–4Gs to Dhahran as part of a scheduled rotation. In December, Major Quinn returned to Dhahran for a 90-day TDY. As to the differences between his first, short, deployment in June 1991 and this one, Bart stated,

The biggest difference was that back then the war was over and it was really just post-war ops. The USAF was forming an Expeditionary Wing, but that would not be solidified for

months. Also, Dhahran was a big transportation port for flights in and out with troops and cargo.

Bart took part then in the limited punitive strikes ordered by President Bush (see '1993').

1993

By January, the Iraqis had moved additional SAM sites into both the southern and northern No-Fly Zones and openly challenged Coalition efforts to protect the Shiites in the south and Kurds in the north. In addition, they used their SAM radars to track Coalition aircraft while on routine patrol sorties, while Iraqi aircraft made incursions into the southern NFZ, supposedly trying to lure Coalition aircraft into concentrated SAM traps.

Although the U.S., UK, France and Russia on January 6, 1993 issued a joint ultimatum to Iraq, to expire at 28/2230Z January, demanding withdrawal of all SAMs south of the 32° N, missile sites were still operational on the 13th.

As Iraqi troops also made repeated forays across the new demarcation border with Kuwait, President Bush ordered limited punitive strikes against 32 SAM sites and air defense command centers. Strikes took place in the January 13-18 period. For instance, on the daylight mission of the 18th, 75 U.S., British and French aircraft re-struck three Interceptor Operations Centers (IOCs), which were also earlier targets on the April 16 night mission. The IOCs were destroyed. Bart Quinn in this respect,

On January 13, I led one of the two-ships of F–4Gs in support of F–117As bombing targets, including an SA-3 Goa site by Tallil Air Base, southwest of Nasiriya. My EWO was Major G. Tovrea and the other crew consisted of Captain John Goode and Lieutenant Colonel Mike York. Our aircraft were configured with three bags, an ALQ-131 ECM pod, two HARMs and two AIM-7s. The warning came that day for a same night launch. There was a mass brief with a time hack. The F–117As were from King Khalid AB near Khamis Mushait. Other aircraft that participated were EF–111As and F–15Cs. There was Bar Lock early warning radar and a Thin Skin height finder together on a hill to the north, which had been on and off. I wanted to hit them, but the ROE was no HARM shots until bombs hit and/or after TOT of 3:15 am. I had my thumb on the pickle button, but the darn F–117 bombs hit exactly at 3:15 am and the radars shut down simultaneously. The SA-3 site was destroyed and its missiles ignited from the heat of the explosions and went across the desert like bottle rockets. Flying time was some three hours.

To support USAF in meeting F–4G mission requirements in the Gulf Region, part of the 190th FS/124th FW of the Idaho ANG, which had converted from RF–4Cs to F–4Gs, on March 2 received tasking for a deployment to Southwest Asia. Its first deployment of (volunteer) personnel and six aircraft followed later that month. All deployments were supported by the Wing's 189th Wild Weasel FTU. It proved to be the first deployment of four almost

Personnel and the six F–4Gs of the 561st FS Det returned home from a 90-day deployment to Dhahran on October 5, 1994. Some twelve days later, the Squadron redeployed to Dhahran with personnel and ten F–4Gs to augment Coalition forces for Operation VIGILANT WARRIOR. One of the ten F–4Gs is being refueled by an KC–10A Extender over the Mediterranean. ***[USAF, A1C Brett Snow]***

back-to-back deployments to support both SOUTHERN WATCH and PROVIDE COMFORT. The 190th replaced the 81st, which returned to Spangdahlem on March 30 with personnel and its six F–4Gs, officially ending the Squadron's 31-month deployment to the Persian Gulf. Over a 938-day period, its aircrews flew 5,450 sorties, logging 13,850 flying hours.

The crew of one of the two 190th FG F–4Gs, Majors Larry Kaufmann and Eddie Payne in 90298, who on June 28 were escorting OSW aircraft over the southern no-fly zone, fired a HARM at an air defense radar after it illuminated the aircraft, and destroyed it. A radar site encountered a similar fate on July 24, after it illuminated two F–4Gs on a routine patrol. Five days later, aircrews of two Navy EA–6B Prowlers expanded AGM-88 HARMs at another Iraqi radar site.

After being relieved by personnel and six F–4Gs of the 561st FS, the last IDANG personnel and F–4G aircraft returned home on October 2.

1994

The IDANG returned to Dhahran on January 9 for its second OSW deployment, replacing the 561st FS. On June 6, Major Mike Williams, EWO with the 190th FS, flew his 100th combat sortie over Iraq. This deployment also lasted

An air-to-air overhead view shows three of the ten deploying F–4Gs in formation over Saudi Arabia. Note the travel pods on the inboards. ***[USAF, A1C Brett Snow]***

six months, departing mid-July and being relieved once again by the 561st on the 15th with personnel and six F–4Gs. Personnel and aircraft redeployed to Nellis, arriving on Friday October 7. This was when the very first Block 50/52 F–16CJ Wild Weasel aircraft (six) and personnel (Shaw's 79th FS) deployed on October 1 to Dhahran. For this deployment Fighter Squadron (FS) Provisional, 79 was activated by ACC and assigned to OGP 4404. At that time some 74 aircraft were in-theater, including 24 F–16Cs, nine F–15Cs, 29 fixed-wing support aircraft, including EF–111As, and 12 Coalition fighters.

For much of the year, the Iraqis seemed to accept the Coalition's daily patrols, since little activity warranted defensive protection and/or retaliation. However, when by the first week of October Iraq had moved elements of its Republican Guard to Kuwait's border, CENTCOM activated its Crisis Action Team (CAT) on October 7. As a result, President Clinton directed the sending of additional troops, aircraft and equipment On the same day, the USS George Washington Carrier Battle Group, including the carrier's CVW-7, began moving to the AOR (Area of Responsibility) from the Adriatic, while KC–135 tankers, U–2s and RC–135s were directed to move to the AOR. Two days later, lead elements of the 24th Infantry Division (Fort Stewart, GA) and two Patriot air defense missile batteries (Fort Polk, LA) initiated their move to Kuwait. On October 11, the U.S. initiated Operation VIGILANT WARRIOR. U.S. troop strength was increased to some 25,000 personnel and the number of aircraft temporarily increased with some 200 aircraft to over 270, including Langley F–15Cs (1st FW), Pope A–10As and F–16Cs (23rd Wing), Shaw twelve F–16CJs (78th FS) and Nellis ten F–4Gs (57th Wing). Some ten days after arriving at Nellis from Dhahran, the 561st FS was directed to redeploy to Dhahran with a detachment of personnel and ten F–4Gs. The route was Nellis-RAF Lakenheath (11.6 hours)-Dhahran (8.5 hours), arriving on the 17th. Personnel and the F–4Gs were back at Nellis by November 19. On October 22, the 4404th flew 165 sorties. For the month, 2,889 sorties were flown with 8,726 hours.

USAFE placed some units on alert for possible deployment and provided en route and aerial refueling support to deploying forces from CONUS. Surveillance over the no-fly zone was increased. As the Iraqi push south never developed, CINCENT in a November 5 message recommended redeployment of the VIGILANT WARRIOR forces, which was initiated on the 19th. On November 15, 1994, ACC's SO GB–26 activated, effective November 15, nine Provisional squadrons at Dhahran, of which five flew fighters, one EF–111As, one flew C–130Hs, one EC–130Hs and one EC–130E ABCCCs. All were assigned to OGP 4404. Among the activated fighter squadrons were Fighter Squadron Provisional, 79 (FSP 79) and FSP 561.

ACC SO GB–40 of December 23 activated two provisional and inactivated three provisional units, effective the SO's date. It seems GB–40 should have inactivated a fourth provisional unit, FSP 561, as ACC's Special Order GB–119 of September 18, 1995 amended GB–40: 'Change paragraph 2 to include the inactivation of Fighter Squadron Provisional, 561'.

1995

FSP 79 was inactivated effective January 27 by ACC GB–50 with the same date. In addition, FSP 78 was activated, replacing the 79th at Dhahran. After flying 1,150 sorties and 3,293 hours, personnel and its F–16CJ WW aircraft returned to Shaw. FSP 78 was inactivated, effective March 20, by ACC Special Order GB–71 of March 20.
When personnel and initially nine F–4Gs of the 561st FS redeployed to Dhahran on April 12 to replace FSP 78, it did so as 'Fighter Squadron, 561 (Detached)' as directed by GB–71, but effective April 7. The unit was assigned to OGP 4404 for the purpose of command and control, administrative support, and the exercise of UCMJ authority. This meant formally that up to GB–119's publication, there were two F–4G detachments at Dhahran, Fighter Squadron, 561 (Detached) and Fighter Squadron Provisional, 561.

According to the March publication 'Peace Operations' of the United States General Accounting Office, USAF had 33 F–4Gs assigned in June 1994, of which 19 were available for training and/or contingency deployment (others were used as test aircraft or undergoing maintenance) and 14 were deployed to peace operations. This latter and small number resulted in increased flying hours, plus additional wear on the aircraft. Were 561st FS aircraft undergoing major phase maintenance every 7-8 months one year earlier, this changed to every 4-6 months. Also, F–4G personnel approached or even exceeded Air Combat Command's recommended maximum number of TDY days in a year, 120. According to Squadron officials, this affected the morale of the personnel concerned.

Units assigned to OGP 4404 on December 31, 1995 included, among others, ECSP 41 (EC–130H), ECSP 429 (EF–111A), FSP 34 (F–16C), FSP 1336 (F–15E), and FS 561 (Detached) with (six) F–4Gs.

1996

USAF's final F–4G combat mission in the Gulf Region was flown on January 11 by aircrews of the 561st FS. Relieved on January 13 by personnel and 12 Block 50/52 F–

VIGILANT WARRIOR in October 1994 not only resulted in the deployment of additional fighter aircraft to the Gulf Region, but also made it necessary to deploy KC–10 and KC–135 tankers to refuel those fighters. The photo shows four KC–10A Extenders on the flight line at Moron AB in Spain. ***[USAF, A1C Brett Snow]***

16CJs of the 77th FS, redeployment to Nellis was initiated on the 15th.

On March 25, Squadron Commander, Lieutenant Colonel Jim Uken, and his EWO, Lieutenant Colonel Mark Bruggemeyer, in F–4G 97295, led USAF's last eight F–4Gs into retirement at Davis-Monthan (AZ). The Squadron was, once more, inactivated effective October 1 through ACC SO GB–109 of August 15.

Epilogue

In the August 1992-February 1995 period, Coalition aircraft flew 58,000 sorties in Operation Southern Watch, of which 38,000 over Iraq. Involved were over 100 U.S. and a smaller number of allied aircraft. U.S. aircraft came primarily from CONUS bases and came under operational control of CENTCOM. In the years 1992-1995 (DESERT CALM and OSW), USAF aircraft flew 269,859 hours at a cost of $B 1.94, including $M 105 for Operation VIGILANT WARRIOR. With regard to the limited training in OSW, focus was mostly on air-to-air. Surface attack suffered the most due to altitude limitations and other restrictions. Normally USAF personnel were deployed on a 90-day rotational basis with operational flying units deploying the necessary aircraft, personnel and equipment.

However, emergency deployments, like VIGILANT WARRIOR, and routine deployments, like PROVIDE COMFORT I/II/NORTHERN WATCH, SOUTHERN WATCH, and DENY FLIGHT in Bosnia, created several personnel and operational problems. As to the former, some USAF personnel faced multiple TDY assignments within a year. For instance, E-3 AWACS or RC–135 aircrews deployed as many as 200 or more days. This resulted in problems, such as in proficiency training, quality of life, and pilot retention. After assessing its overall Ops-Tempo, USAF took a number of measures, such as limiting the number of days personnel deployed and cutting back higher headquarters inspection visits, competitions and peacetime training exercises. From August 1992 through December 1996, ACC, activated 81 provisional wings, groups and squadrons at various times to meet the manpower and force structure requirements.

F–4G post-DESERT STORM deployments to Bahrain and Saudi Arabia (source, ACC/HO)

PERIOD	UNIT/NUMBER
Apr 1991	81TFS/16
May 5-Jul 21, 1991*	81TFS/16-8-6
Aug 24, 1991-Apr 1992	'3552 VSF'/8-9
Apr-Aug 1992	81FS/9-8
Aug 1992-Mar 1993	81FS/12
Mar-May 1993	81FS/6
May-Oct 3, 1993	190FS/6
Oct 3, 1993-Jan 9, 1994	561FS/6
Jan 9-Jul 14, 1994	190FS/6
Jul 15-Oct 5, 1994**	561FS/6
Oct 17-Nov 16, 1994***	561FS/10
Apr 12, 1995-Jan 15, 1996	561FS/9-6****

* moved to King Abdul Aziz AB, Dhahran mid-June.
** replaced by six F–16CJs of the 79th FS (20th FW, Shaw).
***in Operation VIGILANT WARRIOR.
**** reduced from nine to six on July 10, 1995.

■

Acknowledgements

Thanks to Sandor Kocsis, Victor Ballanco, Bruce Benyshek, Kevin Brown (NGAUS), Joe Healy, William Redmond, Jim Uken, George Walton, ACC/HO, ANG/HO, and Jim Musser (AFHRA).

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Memoir of First Night

Joe Healy with his pilot Jim Hartle after a DESERT STORM combat mission in late February 1991. They brought home at least one AGM-88 HARM. The ECM pod is an AN/ALQ-131. The F–4G was assigned to the 81st TFS, but its wing and squadron markings were removed. *[Via Joe Healy]*

Joe Healy

Major Joe Healy, F–4G EWO, arrived at Spangdahlem in August 1989 after a non-flying staff job at Eglin and getting re-current in the F–4G at George (CA). Sometime in mid-1990, he became airfield manager and was assigned to the 81st TFS for flying. Joe deployed to Shaikh Isa on December 26 with USAFE's second F–4G group. There he teamed up with Captain Jim Hartle and flew 36 Desert Storm combat sorties, expending a total of 11 AGM-88 HARMs. Joe always states Jim and he flew 37 combat sorties and around 130 hours, counting the sortie and flying hours in May 1991 while escorting a U–2. In late March, Joe exchanged Shaikh Isa for Riyadh as a Weasel fighter duty officer at CENTAF's Tactical Air Control Center (TACC). His quarters were good and he drove every day from Eskan Village to CENTAF in the basement of the Royal Saudi AF headquarters building in Riyadh. Joe drove back to Shaikh Isa a couple of times to keep current in the F–4G. In mid-1992 he returned to Eglin and retired in 1994.

After 15 years in the military, waiting and wondering what it would be like and how I would react and perform, I have experienced combat.

At 10 pm that evening of 16 January our squadron, the 81st TFS, assembled in the building known as 'The Church', because our squadron commander had once referred to it as 'The Church of What's Happin' Now' in one of his characteristic nervous ad-libs. That humorous note was forgotten now. I surveyed the room. The near total silence and straight, somber faces were striking. This was a *very* BIG deal and all present sensed we were each a small part of an immense and complex undertaking. I imagined this must have been how it was for the Airborne troopers immediately before they boarded for Normandy late on 5 June 1944.

Our mission was to support F–117 and F–111 strikers hitting the biological and chemical weapons storage and production facilities at Salman Pak, just south of Baghdad. The eight-ship F–4G Weasel package was to be led by Bart (Major Quinn). The squadron commander made sincere, encouraging remarks, standing before men who very well might not be alive eight or less hours hence, in accord with what he, correctly felt, was his necessary duty and responsibility on such a momentous occasion.

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* **Editor's Note:** Joe Healy, who authored this memoir, figured extensively in the preceding Part 6 of Theo van Geffen's narrative on Desert Storm. His story was sufficiently indicative of the events that transpired to merit a more complete treatment, which is contained here. These are the words of Joe Healy.

Shaikh Isa's flight line with Marine Corps F/A–18A Hornets and 561st TFS F–4Gs in the foreground and Marine Corps AV-8Bs in the background. Note the AGM-88s on the Hornets and Phantoms. ***[USAF, SSgt Mark Cormier]***

After the remarks we emptied out of 'The Church' and walked to the mission planning building a few yards away in the compound. Around eleven, our two flights of four met in one of the briefing rooms and Bart went over the details of the mission one more time. Then it was off to life support to suit up before heading to the jets.

We got our gear on and headed for the jets schlepping all kinds of extra, 'just in case' stuff, mandated and otherwise. I had large-scale maps I thought would help in an evasion situation, stuffed inside my flight jacket where I felt they would be secured by the harness and not fly away during an ejection.

By the time we stepped, the clock had advanced beyond midnight and it was now the first hour of 17 January, 1991. We got out of the crew van and into surrealistic environs. On this moonless night the flight line was painted in one of two colors, bright blue-white light or total blackness in the sharply defined shadows. That vision was accompanied by a sound track consisting of the combined roar of jet engines running up and dozens of un-muffled gasoline-powered generators providing power to the flood lights and the airplanes, reverberating off the metal revetment walls. We walked 30 yards or so to our plane. I was wired on adrenalin like I hadn't been since my first HALO, High Altitude-Low Opening, jump.

After doing pre-flight, we climbed the ladder (I couldn't help wondering if it was for the last time) and began the strapping-in ritual. After the crew chief had connected my shoulder straps he said, "Good luck and God bless you Sir. I'll be praying for you." I replied, "Thanks, Chief. I appreciate that."

Following engine start and pre-flight checks we rolled straight out of the revetment and made an immediate left turn onto the taxiway. There we were greeted by the sight of the seven ground personnel who'd spent the previous hours preparing our jet, lined up along the edge of the taxiway. They were standing in a perfectly spaced row, as if they'd done a 'dress-right-dress'. As we came abeam them they simultaneously came to attention and then snapped us the sharpest salutes I'd ever seen! We returned them and rolled on.

After quick check and arming, we followed our flight lead Durch (Captain Jim Durchi) and Sid (Major Crumley) onto the runway and went through the before takeoff checks. When Durch began to roll at 2334Z or 0234 local time, Jim asked his traditional question, "You ready?" I answered, "Yeah, let's do it!"

Now there were a few brief moments before he lit the burners and the familiar acceleration began; a few short seconds to myself before I'd have to say, "Off the peg…". I quickly blessed myself and silently recited, "Saint Michael, Archangel, defend us in battle, that we may not perish in the awful judgment" as I'd promised myself I would, years before in the Chapel at St. Michaels College in Winooski, VT. I added, "That goes for everybody in the coalition flying tonight. Protect us Lord". We lifted off. I tried to watch the ground behind us on both sides of the aircraft for signs of an SA-7 launch, my finger on the flare button.

We rejoined with lead and proceeded, coms out, to the tanker track. One of the little known aspects of the whole operation was the complexity of the refueling plan which had to go well before any airplanes crossed the border on their missions.

There were five, north-south oriented tanker tracks, side by side, over the middle of Saudi Arabia. The complicating factor was that each of the five tracks was three deep, three vertically separated refueling orbits stacked one above the other! Each of the fifteen tracks had a cell of three tankers orbiting in it.

The receivers, the flights of fighters, were assigned to refuel from a specific tanker in one of the 15 tracks. Hundreds of receivers had to enter the track, rendezvous, refuel, and depart. Arriving receivers entered their track from an altitude below it and departed by climbing above it. All of this was accomplished without communication *in the dark,* on a moonless night! The average daylight refueling in peacetime required a certain amount of radio coordination between tankers and their receivers. The fact that this incredibly complex, hazardous plan did not result in a single midair collision was truly miraculous.

But as with any intricate human endeavor, things rarely go perfectly. Bart led all eight planes successfully into our track, with the tankers about 30 or 40 miles ahead

A weapons specialist loads chaff and flares aboard an F–4G. The missile is an AGM-88 HARM. ***[USAF]***

Tactical Fighter Wing Provisional, 35 (TFWP 35) avionics specialists work on an F–4G radar in the South Loop area at Shaikh Isa. ***[USAF]***

of us, northbound. I was watching them on radar. When they reached the northern end of the track they would turn south toward us and we would swing in behind them. Each of our two flights had a specific tanker we were to refuel from. The flights would be within two or three miles proximity while getting our gas, flying in the same direction, after which we'd depart to the north together.

As I watched, I saw our tanker, the second of the three, begin his turn south prematurely while his leader and cell mate continued north! In a few minutes this could cause big problems. We would either have to turn south to rendezvous with our gas while Bart's flight continued flying north, thus separating us and leading to a big fuel and time consuming effort at getting back together, in the dark, in crowded airspace, or we could continue ahead to stay with Bart, finding a means of getting the necessary fuel from another tanker, without using the radios! I was confident that Sid saw what was happening and imagined he and Durch were trying to come up with a solution, but the urge to say something to him, to confirm it, was strong! When I first noticed the turn I had hoped the tanker pilot or his leader would recognize his mistake and he'd get back into formation. But as I watched, he continued it and established a southerly heading. As he got closer, we began a lead turn to the south and rolled out behind him. But now we were heading directly away from Bart's flight. I don't recall what we did to eventually get back together, but we did. We survived the five side-by-side, multi-layered orbits with the swarm of arriving and departing aircraft and headed north for hostile Iraqi airspace and whatever fate awaited us.

Even before the first fighters crossed into Iraqi skies, a special joint Air Force-Army helicopter task force attacked a key Iraqi EW radar site guarding their southern border, in order to blast a gap in the radar coverage and allow coalition attack flights to flood across into enemy airspace with little specific prior warning. Air Force Pave Low helicopters used their GPS navigation systems to guide Army Apache gunships to the radar sites where they unleashed rockets, cannon fire, and Hellfire missiles to destroy the facilities. I think it's somewhat ironic that the first SEAD action of the campaign was carried out by Army helicopters!

In another unconventional, dastardly, sneaky, Yankee move, unarmed drones, normally used for air-to-air target practice and weapons testing, were launched from Saudi Arabia ahead of the first wave of strikers. They flew to a number of targets around Baghdad and began circling around the area at the same time cruise missiles were slamming into those targets. The Iraqis, fooled into believing the drones were manned aircraft in the area and the cruise missile impacts were their bombs landing, obliged us by turning all their radars on, giving away their positions. They were rewarded with a hail of HARMs! Additionally, our airborne jets could see and avoid the threats, to some extent, by using their RWR systems. Yet another bonus of the drone effort was for our intelligence people who recorded and cataloged all the emitters.

The next thirty minutes would be epic to say the least, if indeed, there were thirty minutes left to be had. The last few miles of friendly Saudi territory slipped under our wings. Penetration of Iraqi airspace was denoted by the absolute absence of any light on the ground. Below us was a black, bottomless void. Appropriate. Light was lacking in more ways than one down there. We cruised along silently except for the usual flying noises. I had set the radar at level to help Jim keep track of lead on his scope in the front. I concentrated on the APR-47 knowing it would give us the first indication of any immediate threat to us. Periodically, AWACS transmitted "Miller, (Bart's flights' call sign) picture clear" on our frequency, meaning they saw no Iraqi fighters in our vicinity.

I thought this would have been the perfect time to have transmitted 'The Ride of the Valkyries' or 'Darth Vader's Theme' from Star Wars to the Iraqis over the radio.

Shortly after I momentarily speculated about how it was I had come to be at this particular point in space and time, the first physical confirmation that this whole thing was for real manifested itself. Off to the left I saw the first red tracer appear and float up against the black background. Then I knew for sure we were experiencing something new.

Shortly, the eight-ship heard an electrifying call from someone in our formation about a radar contact 40 miles ahead! I looked down and saw it on my scope while simultaneously reaching for the radar antenna controller with my right hand. I thought, "This ain't good!" The APX produced no return in any of four modes, telling me it wasn't friendly. It was a device that allowed us to interrogate the IFF, Identification Friend or Foe, transponders in other aircraft and it displayed a symbol on the radar screen in our aircraft. You could almost feel the pucker factor spiking in the formation.

I was incredulous. I couldn't believe one of these [Iraqis] had been lucky enough to get airborne, at night,

evade AWACS *and* the Eagle MIGCAP *and* position himself right in front of *us*! What were the odds?! And there was no indication on the 47 of a MiG or Mirage radar, anywhere! He'd *have* to have his radar on to make a head-on attack at night!! This just didn't add up. But, there was solid proof, right in front of me on the radar.

As calmly as I could I told Jim, "OK, switches air-to-air, CW (continuous wave missile guidance radar for the AIM-7 Sparrow) standby, tune up the missiles", meaning our Sparrows. "When I tell you to, turn the CW on." I intended to lock onto him to try to scare him off. From intelligence briefings we knew that their standard reaction to being locked onto was to do a 180 degree turn and run away. I hoped lighting up his radar warning gear with our CW missile guidance radar, would motivate him to do just that, while he was still out of range of our Sparrows… and we of *his* weapons! With a little luck, he might turn and run right into the arms of the F–15s! If he didn't turn north, then we'd shoot him in the face at maximum range, if someone in front of us didn't do it first.

Even a weakly executed attempt at an attack could throw a monkey wrench into our whole effort. If the formation got scrambled as people broke left or right to avoid a missile from this interceptor, getting back together in the dark, in time to make our TOTs, would be next to impossible. The fact my best friend was 10 miles closer to the bogey and more likely to be shot at than I was, concerned me too. As I looked at it, there seemed to be something suspicious about this contact. Dare I hope? Could it be…? "Wait a second, wait a second. Lemme see something", I said to Jim. I locked onto it and checked the Vc (velocity [of] closure, or the combined speed that our aircraft and whatever the radar was locked onto, such as another plane, chaff, etcetera were converging at) against our ground speed according to Arnie (our nickname for the ARN-101 INS, Inertial Navigation System, in the F–4). Both numbers were the same! The aspect angle said 90. That meant what I was locked onto wasn't moving; it was suspended in mid-air! I'd thought it had looked a little fuzzy around the edges!

I keyed the mike "Miller 01, ahh, Budweiser 02, Contact chaff." I paused and keyed the mike again "Contact is CHAFF!" I'd really wanted to just blurt out "BART, IT'S JUST CHAFF!", but my consummate professionalism overrode the urge. My message echoed through the flight as at least two other guys said "Contact is chaff!", "Contact is chaff!" I thought I noted a bit of relief in their voices. I know I felt it! My faith in AWACS and F–15s was restored. A minute or two after that I was again looking out into the pitch dark to the left when a bright red-pink light blazed up instantaneously in mid-air right next to us! Another jet in the formation, one of Bart's flight, had somehow drifted back parallel to us and decided to dispense an IR decoy flare! I imagined they must have thought they were being shot at by a ground based IR-guided SAM, which wasn't true. All it accomplished was to startle us and ruin our night vision. A few moments later they dispensed another! I keyed the mic again and said, "Knock it off with the flares!" and complained to Jim questioning why in the hell they were doing that! What they were really doing was attracting unwanted attention and giving our position away to gunners on the ground so that they could aim more accurately! "Good grief", I thought, "are people losing their nerve?" As tense as those moments were, more were in store.

Sgt Deborah Thompson, TFWP 35 intelligence specialist, provides F–4G aircrews with current intel. ***[USAF, SSgt Mark Cormier]***

The further north we progressed, the heavier the fire became. A few scenes are indelibly etched in my mind. At one point we were flying parallel to a major interstate-like north-south highway with light poles in the median. I was surprised that the lights were still on and had not been switched off. Cars were clearly visible with their headlights on, racing at high speed along the south-bound lanes! I could see them through a thin cloud deck not more than a few thousand feet below us. The cloud deck was a surprise too. The weather briefing had predicted clear skies. It was only days later that it dawned on me that what I saw was not cloud but smoke from burst AAA rounds! There had been so much that it had merged together into a continuous layer!

While I was watching the cars scream south I saw twin parallel streaks of lime green colored tracer passing just beneath us coming from our two o'clock. I looked twice to confirm the color to myself. Yep, green! That was the only green tracer I saw during the whole campaign. All the rest was bright red, the same color as automobile tail lights, but brighter. At the same time white flashes were popping around us, mostly at or slightly above our altitude.

I looked to the left, where most of the fire was and saw dozens of bright white lights moving against the dark sky. My impression was that most of them were far off, 10 miles or more. Some behaved like the first red AAA we'd seen. They floated up, winked out and then there would be a lot of flashbulb-like bursts in their place. Others streaked up and didn't go out. Those were SAMs flying off the ground. Knowing the rounds that would hit us were the ones that did not move fore or aft on the canopy, I tried to judge whether some were moving or not. I couldn't really tell so I put my finger over one or two of the more threatening looking ones, but that didn't work either and within a few seconds, I gave up the effort because there were just too many to keep track of!

It was early in this phase of the mission, as the ground fire was intensifying, that one of the EF–111s radioed that

he was "bugging out!", that is, leaving his jamming orbit and heading south. Was it that bad? Maybe he was being attacked by an Iraqi fighter. But I didn't think that was likely. They were not in the same heavy fire we were, yet they were running for it? I had the urge to key the mic and say, "Hold your ground! People are counting on you!", but didn't.

As the ground fire got heavier, it seemed inevitable that we were going to be hit. I had an irrational thought that, momentarily, a hole was going to open in the floor right between my feet and I'd be looking down through it at the highway and ground lights. Of course if a hole had been blown in the floor, it probably would've done some serious damage to me too!

I found myself thinking, "Well, so far so good. We haven't been hit yet." Then, "If we get hit one thing or the other will happen; either we'll be killed or not. If we're not, either we'll be knocked down right away, or be able to limp south a ways and punch. We might be able to evade and get rescued or we might be captured. Or we might ride the stricken jet all the way back across the Saudi border." This whole thought process seemed to go on for two or three minutes but was probably more on the order of 10 or twenty seconds, I don't know, but I finally ended it by telling myself, "Oh screw it! Do your job and deal with a hit *when* it happens", and then got back to work.

When I took another look out to the left, I saw a SAM fly past so close that I could see its long exhaust flame flickering through a halo of light at the rear of the missile! There was no indication of a radar associated with it on the 47 and it occurred to me that the Iraqi's were firing them off ballistically, unguided, literally 'a shot in the dark', just hoping for a lucky hit! I watched the missile fly up behind us as long as I could, hoping to see it detonate at the end of its time of flight, but I couldn't crane my head around far enough and turned back to the more pressing business at hand.

I glanced at the ALQ-131 jamming pod control and was astounded. It looked like a pinball machine! Most of the symbols in all three bands were flickering continuously indicating the pod was actively detecting and jamming threats across the radar spectrum.

An 561st TFS aircrew prepares for another mission, while 561st AMU personnel await to launch the F–4G. [*USAF]*

The aircrew of an F–4G of the 81st TFS pulls out of the arming area for their next mission. Note F-4G 90269, which is still in the 'European' camouflage scheme. *[Bruce Benyshek]*

It was about this point in the mission that I experienced a malfunction of the 47 I'd never seen before nor ever again after. I was looking at the scope when the concentric range rings and all the displayed emitter symbols essentially collapsed uniformly, in stages, into the center of the scope and vanished in a matter of a second or two! "What the f___ is that!!? Not NOW!! Of all times!! You gotta be shittin' me!!!" I thought. After a few agonizing seconds, the display suddenly popped into being again and everything was where it belonged. I felt momentary relief, but then the cycle repeated! It did the same thing intermittently for the rest of the mission. Everything would look OK for a while, then march into the middle! The only cure I could think of was to run a BIT (built in test)-7. A BIT-7 was akin to a partial reboot of the computer and often cleared problems, but there was no way I was going to take our super RWR offline here and now in this environment! I had no doubt that if I ran the short test that was precisely when we'd be locked onto and engaged by a SAM! So a BIT-7 was out. I did try the age old cure-all of hitting the scope hard, but that had no discernable effect.

As soon as Baghdad and our target area rose above the radar horizon the 47 really came alive. A whole menagerie of emitters popped onto the screen. There were more signals than I'd ever seen simultaneously in any Red Flag or Green Flag or in the simulator! By the time we got into the target area proper, the air was alive with invisible signals, and very visible SAMs, tracers, and exploding AAA!

Jim and I were tasked to cover a group of four, Soviet-built SA-8 Land Roll systems, suspected to be northeast of Salman Pak. As I watched, they showed up on the 47 as predicted, right where they were supposed to be, in a nice row, oriented east to west! During one of the 47's periods of quiescence, I designated the second SA-8 from the eastern end of the line and told Jim, "I've selected our victim." We were still out of range but I wanted the 47's brain to have plenty of time to work out an accurate position on it.

Now it was only a matter of waiting until we were in range. I continued to monitor the 47 for anything that might be targeting us and stole occasional glances outside

at the fireworks! Finally we were in range and based on the strikers TOT, it was time to shoot our first missile in actual combat! Jim selected the HARM on the left wing and I pushed the handoff button on the panel directly in front of me. A few moments later I was rewarded with a green 'RDY' light (the 'ready light' that illuminated on the APR-47 panel after the EWO handed off a threat to the AGM-88 HARM to go after, meaning the missile had all the data and was ready to be launched). Here we go! "Eye's!" I said to Jim so he could momentarily close his eyes to avoid being blinded by the flame of the rocket motor. About half a potato later I mashed my right thumb down on the pickle button on my stick. There was a heavy '*CHUNK*' feeling accompanied by a rushing roar and then the whole airplane shuddered side to side as the big missile streaked off towards the SA-8. As the time of flight counter for the HARM counted down to '0', the site went 'dotted', and I didn't hear any more audio from it, a pretty good indication that we'd killed it and, in all probability, the three radar operators and the driver sitting directly under the antennas.

I targeted another of the SA-8s with the second HARM. We had good information on it so I pressed the handoff button right away. But this time, instead of 'RDY', I saw the yellow 'FAIL' light illuminate! That meant the targeting information the 47 had about the SA-8 was not being handed off to the HARM. I pushed the handoff again. 'FAIL'. I pushed the pickle button hoping it might launch anyway, but it just hung there, inanimate, on its launch rail.

I ran through the checklist again in my head. Jim confirmed that the proper station was selected and the master arm was on. Demonstrating Einstein's definition of insanity, I went through the steps a third time and got the same non-result! This was maddeningly incongruent! Why were we able to launch the first missile successfully but not this one?! Now I was in a quandary. Again, I considered, and instantly rejected the idea of doing a BIT-7 in an attempt to clear *this* problem, but there were even more SAM radars on the air now, than before. No way was I going to knowingly blind us to them at this point!

F–4G Phantoms were deployed to Incirlik in Turkey, Shaikh Isa in Bahrain and Dhahran in Saudi Arabia in the August 17, 1990-January 15, 1996 period. Two aircraft were lost. On January 19, 1991 F–4G 97571, assigned to the 81st TFS, crashed in Saudi Arabia while on a night Wild Weasel mission. Its crew, Capts Tim Burke and Juan Galindez (EWO), ran out of fuel after their aircraft was hit by AAA. They ejected safely, were recovered and back in business two days later. The 561st TFS was directed to transfer one of its F–4Gs to the 81st. With 2,676 combat sorties flown, the loss rate per 1,000 sorties was 0.4. The second F–4G was lost on August 21, 1991, when F–4G 97550 of the 561st TFS, on a training mission, crashed about 63 miles southeast of Dhahran in the Saudi desert. The crew ejected successfully and was recovered. The 52nd was tasked to send a replacement aircraft. The photo shows what was left of '571' after it was trucked back from Saudi Arabia to Shaikh Isa. ***[Bruce Benyshek]***

F–4G 69-286 of the 81st TFS being refueled by a KC-135. The colored band on the vertical and the 52nd TFW emblem on the intake were removed. The aircraft is configured with two AGM-88 HARMs and an AN/ALQ-131 ECM pod. ***[Bruce Benyshek]***

By now we had reached our furthest northern point and had begun a gradual left turn back to a southerly heading. Baghdad was to our northwest and alive with signals just asking for a HARM! I designated a strong one coming out of the middle of the city. Maybe the 47 will like this one better, I thought. Handoff, 'FAIL'. In total, I probably tried to shoot that second missile five times, but it never would take flight.

I suspected the same problem that was causing the display to malfunction was causing this trouble too. My frustration level was off the charts. There we were, in the most target-rich environment a Weasel crew might have ever seen or see again, a veritable smorgasbord of emitters, with a missile on our jet, and the cursed thing refused to do its job! "Swine HARM!!"

While we were pointed west Jim told me to take a look to the right at Baghdad. What I saw was impressive to say the least! There was a solid, fairly narrow layer of smoke above the still lit city, everywhere this manmade cloud was sparkling, glowing, and churning within from bursting AAA, tracers, and SAMs. It was the perfect analogy for the intensity of cussing emanating earlier from my cockpit directed at the malfunctioning 47 and/or HARM, as I gave rein to my full repertoire of colorful language gleaned from paratroopers and fighter aviators over two decades. Alas, it made no impression at all on the inhuman computers. They defiantly refused to cooperate.

Our southbound return trip to the safety of the Saudi border was uneventful, with only a few cursory, ineffective amounts of AAA haphazardly tossed into the air, here and there. Looking east toward Kuwait in the pre-dawn gray during egress, I saw what I can only describe as a green vapor that seemed to cover a patch of the desert. I don't know what it was, but that's what I saw. It may have been fog lit from below by some green light source, but it covered an area that would've consisted of several square miles. We rendezvoused with our post-strike tankers. I was anxious

to take a nose count and see if all the planes and crews showed up. To my relief all eight jets were there and without any damage! After what we'd flown through, I was somewhat amazed by that fact. I at least expected we'd see a hole or two in a wing or tail!

Indeed, a year later Ken Hanson gave an interview to a reporter from 'Stars and Stripes' about the first night. In it he said, "The fire was so intense, I don't know how we made it through. It was a miracle". When I read that, my quiet prayer to Saint Michael immediately came to mind. I had never mentioned my short prayer to anyone, so Ken's comment was unbiased confirmation it was answered.

Because the formation got a little shuffled on the way out and the fact that one crew had jettisoned their wing tanks, Jim and I RTB'ed with Durch and Sid and two guys from Bart's flight. I was mildly relieved to see that Durch and Sid still had one of their HARMs too. I was anxious to ask Sid what had happened and if he'd experienced the same thing I had. Later we found out, there was a software failure that kept the missiles from launching.

A maintenance guy later tried to tell Jim that our recalcitrant missile's motor had actually fired but it had stayed on the launcher! An impossibility! I think we could not have helped but noticed the bright flame, noise, and horrendous extra thrust on the right wing! If the wing had withstood the stress, we would've blazed across the sky like a comet! What a ride that would've been!

A few minutes after leaving the tanker on the way back it was pretty quiet. To break the silence I made one of the more outrageous comments of my life. In a matter-of-fact tone I said to Jim, "Well … that wasn't so bad." He must've thought I'd completely lost it! There was no response. He was too polite to call me an idiot. I went cold mike and laughed out loud at my own cheekiness. It just goes to show, there are an infinite number of ways of relieving stress!

We were back on the ground just after first light. What a reception we got! All the ground support troops were gathered at the entrance to the revetment parking area. They had waited for our return after the end of their all-night shift. There was a blue Air Force bus pulled off on the dirt waiting to take them back to their quarters. As we taxied past they were all waving, cheering, saluting, giving us thumbs up and pumping their fists! We turned, stopped and were pushed back into our spot where Jim shut down the engines. I unstrapped, gathered up all my stuff, and climbed down the ladder to solid ground. The first thing I did was to shake Jim's hand and say, "Great job", wearing an enormous smile! There were more handshakes all around with the daytime ground crew and the other guys in the formation when we met up at maintenance de-brief. Excited descriptions of personal experiences and impressions went on for several hours after the official mission debrief. But they were tempered by the realization that we were going to do it again that evening, and again after that, and yet again… I wondered how many times we could do what we'd just done and get away unscathed. I imagined that, inevitably, someone would pay the fine levied by the law of averages. But who? Jim and I?

We went back to our quarters on the other side of the base and then to the chow hall. I stopped by Bart's building on the way and that's where Maj Gary 'Rat' Rattray took the picture of Bart and I immediately after mission with my camera. In the chow hall the TV was playing live reports from CNN reporters in Baghdad. It was something to listen to their impressions of events they had witnessed which we had just participated in.

At the same time we had been penetrating to the heart of Saddam's fiefdom, many other attacks had assaulted his forces of occupation in Kuwait. This effort would continue around the clock for weeks.

By unanimous agreement our second mission, a night sortie over Kuwait, was anticlimactic. Lead shot at one signal twice, with no apparent effect. In stark contrast to our baptism of fire earlier, this time we saw no AAA or SAMs at all! We did see a strike by B–52s, an impressive sight. Long strings of bombs detonated on the ground in a matter of a few seconds. The individual orange fireballs penetrated upward through a low lying layer of fog.

One interesting aspect of all the destruction we witnessed characteristic of air warfare is that it is like watching a silent movie! Our minds are so accustomed to hearing appropriate sounds when our eyes observe explosions that we, at least I, almost reflexively provided the missing appropriate sound track by making explosion exclamations like 'BAM!', 'Ka-BLAM!' or 'Ba-Boom'!

Whenever I see a History Channel documentary about Desert Storm I'm amused by videos of bombs hitting targets because they dub in explosion sounds that, of course, are impossible to have been recorded by non-existent microphones on an the airplane flying 400 mph, several miles away! But it seems too unrealistic to the viewing audience without them!

Our flight was walking back into the ops area after the second mission at about 10 pm. I noted to myself that time had flown. It had already been 24 hours since we'd had the mass briefing before the start of offensive operations and we'd already flown two combat missions. We were veterans.

A Shaikh Isa gaggle being refueled by a KC-135R tanker, one 561st TFS and three 81st TFS F–4Gs and a 12th TRS RF–4C. The photo was made by the RF–4C's wingman. ***[via Bruce Benyshek]***

F–4G 97212 returned from DESERT STORM with a sortie number in the sixties and five confirmed Iraqi radar kills. Bruce Benyshek and Larry Allen were the aircrews of its final DESERT STORM combat sortie. The HARM silhouettes were designed by Bruce. '212' eventually became the 52nd FW commander bird. From Spang it was assigned to the 561st FS at Nellis. ***[via Bruce Benyshek]***

Three newly arrived recce Phantoms, RF–4Cs, taxiing through the South Loop to their parking spots. The aircraft were assigned to the 152nd Tactical Reconnaissance Group of the Nevada Air National Guard and arrived from Al Dhafra, UAE. All USAF Phantoms were then located at Shaikh Isa. ***[USAF]***

After eating mid-night chow at the Marine Corp mess tent, I called my parents in Center Moriches (Long Island, NY) on the phone in the hall outside my room. My mother answered and I said, "Hi Mom! You'd never *believe* where I was this morning"! After reassurances that I was OK and being careful not to discuss anything classified, I said goodbye and went to sleep so as to be ready for the next one. And so ended my introduction to air combat and war. More followed.

At home, my parents had been watching the news reports since my brother Andy called them and told them the attacks had begun. They said that many reports, including a briefing by Marlin Fitzwater at the White House, had mentioned the Weasels and that we were 'famous'! Ha! I guess this is our 15 minutes in the spotlight. They said the newspaper also had an article about the Weasels and our role. They said one of the press briefings specifically said that, "We are/or were waiting for the Weasels to come out". This may have been a reference to our 8-ship. I guess people have been calling home all day asking about me. All the concern and support of the people at home really means a lot to us. We're very aware and appreciative of it.

Heard a true story of one 561st TFS crew who had a **dual** flameout during egress coming out of Baghdad and descended to 1700 feet before getting one of them restarted! He then restarted the other! Bart had one flameout on him because of exhaust from one of his HARMs! But his engine restarted immediately.

***

On June 27, it was time for Joe to redeploy to Spangdahlem, after some six months in the desert. On that day, he wrote the following while flying 155 nautical miles east of Sicily, westbound at 25,000 feet, while in company of three other F–4Gs and their KC-10 Extender tanker/transport aircraft. Joe described this as follows,

Finally the day we've been waiting for, for so long, came. We departed Dhahran at 1300L for Spangdahlem. The remainder of the people (Bart, Rat, Paul Gregory et al) should be coming home on a commercial charter airplane on Monday 1 July. Today was incredibly hot. After engine start the wind was behind us and blew the engine exhaust and the 105-degree Fahrenheit desert air over us in the cockpits. I don't think I've ever been that hot!

The stripes on the top of the Phantom tails had been yellow, the color of the 81st TFS. However, when we got to the airplanes, the maintenance guys from the 480th had painted red stripes on the tails, their squadron color, and had a sign that said "the 480th TFS LIVES!" (When aircrews, maintenance personnel and aircraft deployed to Shaikh Isa, they were all reassigned to the 81st TFS. TvG). I don't think it was such a horrible crime but Colonel Neil Patton was a bit irate. Oh well. Our Squadron commander, Lieutenant Colonel Randell Gelwix will be PO-ed when we roll into parking! That will be worth seeing!

As I was strapping in, I looked up at Colonel Patton standing on the ramp. He shrugged his shoulders and raised his arms in a 'Oh well…' gesture. I'm not sure what he meant. I went back to strapping in and the next thing I knew he (Colonel Patton) was standing on the intake with his hand outstretched saying "Have a good flight". I told him "Thanks very much for everything. I really appreciated it. Good luck." I had told him the day before how much I had appreciated his leadership. A few days prior to that when he and I flew the last jet out of Shaikh Isa and Bahrain, we were talking about the war, etcetera. I really liked the guy.

Well, I still don't really believe we're going home. We're past Sicily now.

The homecoming arrival was nice. We arrived overhead about 20-25 minutes early and instead of landing immediately after a 7½-hour flight, we were asked to **hold**! I was irate! But we eventually got down through the weather, making individual approaches. There were rain showers in the area. We taxied in with canopies up and lined up and shut down on ramp four, next to the tower. There was a crowd of about 150 people waiting even though it was cold, windy and rainy. ■

Seventies' Incidents Impacting Weapon System Acquisitions used in Desert Storm

Ray Ortensie

An F–15 from the 1st Tactical Fighter Wing, Langley AFB, Virginia, parked in a bunker in Southwest Asia during the beginnings of Operation DESERT SHIELD.

"To be prepared for war is one of the most effectual means of preserving peace. In jet-atomic warfare, there will be no room for gross errors of judgment. There will be no time, should hostilities start, to correct mistakes in the types of forces that we have provided, the manner in which they have been organized and trained, or the way we fight."

Lt Gen Laurence S. Kuter, November 24, 1955[1]

Just before dawn on August 2, 1990, Iraqi dictator Saddam Hussein deployed units of the Republic Guard Forces Command across the Kuwaiti border in a brutally swift assault that quickly seized Kuwait City, the country of Kuwait and by the second day of the invasion, had moved towards the Saudi Arabian border.[2] Saddam voiced "major grievances" before the invasion, alleging that Kuwaitis had stolen oil between the two countries, disregarding production limits set by the Organization of Petroleum Exporting Countries (OPEC) and thus driving down the price of oil as well as stating revolutionaries had overthrown the Kuwaiti government and requested his intervention.[3] On August 6, Saudi King Faud bin Abd al-Aziz met with a U.S. delegation that included Secretary of Defense Richard B. Cheney, Commander in Chief, U.S. Central Command (CENTCOM) U.S. Army General H. Norman Schwarzkopf, and Air Force Component Commander, CENTCOM, U.S. Air Force Lieutenant General Charles A. Horner in Jedda for the first time in Saudi history, where "the head of state agreed to accept the deployment of foreign troops into his country." Schwarzkopf appointed Horner as the CENTCOM forward commander with the responsibly of the beddown of forces that began flowing into the theater.[4] In addition to this partnership with the Saudis, President George H.W. Bush also molded the support of an international Coalition to "avoid a unilateral American intervention on behalf of the Saudis or any appearance that non-Arab countries from outside the Middle East were combining against a lone Islamic state." With this being said, the President built a diplomatic alliance which included many Arab countries that opposed Iraq's occupation of Kuwait, and on August 6 the United Nations Security Council imposed a trade embargo on Iraq.[5] Consequently, on the same day, President Bush directed U.S. military forces to deploy to the Persian Gulf with the McDonnell Douglas F–15C/D *Eagles* from the 1st Tactical Fighter Wing out of Langley AFB, Virginia, deploying within twenty-four hours to Saudi Arabia and forty-eight hours later flying defensive patrols over Saudi airspace, thus the beginnings of Operation DESERT SHIELD.[6]

Over the next five months, United States and Coalition forces deployed to the Persian Gulf to deter any further Iraqi aggression and "set the stage for offensive actions."[7] The buildup of Coalition forces began first with Saudi F–15Cs and Boeing E–3 *Sentry* Airborne Warning and Control Systems (AWACS) flying a 24-hour defense air patrol as coalition forces arrived. By the end of August, two fighter squadrons from the Royal Air Force were in place along with accompanying

F–15s from the 1st Tactical Fighter Wing, Langley AFB, Virginia, prepare to depart a base in Saudi Arabi to fly defense patrols over Saudi airspace during the beginnings of Operation Desert Shield.

tanker and maritime patrol aircraft, fifteen U.S. tactical fighter squadrons (U.S. Air Force and Marine Corps), three carrier battle groups, a B–52 squadron, four tactical airlift squadrons, seven Army and Marine Corps brigades with attack helicopters, and a Patriot air defense system. Due to a planned frontal assault and the likelihood of heavy Coalition losses, President Bush authorized additional ground and air forces to enhance Schwarzkopf's options. With this, the second phase saw an additional increase of 400 Air Force aircraft,[8] three carrier battle groups, and more than four Army and Marine divisions. By mid-January, the "Coalition forces included nearly 1,800 combat aircraft from 12 countries, a large naval force in the Persian Gulf and the Red Sea, and approximately 540,000 group troops from 31 countries. The total Coalition force numbered more than 660,000."[9] Just before the launching of combat operations on January 16, 1991, Air Force Chief of Staff General Merrill A. McPeak wrote to his former boss General Wilbur "Bill" Creech that they were about to "harvest the results of years of hard work and leadership" of Creech and a handful of other "great Airmen." He went on to state that, "We will do well. But we need to recognize that we are beholden to you, because you really built this magnificent Air Force we have today"[10] with General Horner echoing these same thoughts, stating that Creech had given the Air Force "the organization and training that made the success of our crusade possible."[11]

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During the early hours of January 17, over 160 tankers circled south of the Iraqi border following similar tracks they had used since August, escorted by F–15s and three E–3 AWACS peering into Iraq to keep tabs on their air forces. Gen McPeak, Chief of Staff of the U.S. Air Force, remarked later that what the Iraqis were seeing on their radar screens was nothing new that "we had been showing them since August." However, what the Iraqis did not see were the aircraft behind the tankers, the "stealth F–117s, the vanguard of the covert, stunning success air attack that would open" Operation DESERT STORM. At 0235, ten F–117s dropped from their tankers to innate targets within Iraq and four minutes after this, Sikorsky MH–53 *Pave Lows* and Boeing AH–64 *Apache* helicopters destroyed two electronic warfare sites in western Iraq, opening the corridor for McDonnell Douglas F–15E *Strike Eagles* to strike Scud sites.[12] By January 27, Coalition air forces achieved air supremacy, and a month later the war ended with a Coalition-declared cease-fire as the Iraqi army had been driven into a corner of southern Iraq.[13]

Predecessor units of Air Force Materiel Command (AFMC) played a major role in the Gulf War by designing, developing, testing, acquiring, and sustaining many of the frontline aircraft flown in the war – among them the F–15, General Dynamics F–16 *Fighting Falcon*, Fairchild Republic A–10 *Thunderbolt II*, and Lockheed F–117 *Nighthawk*[14] – along with developing and expanding the capabilities of other technologies and aircraft such as Low Altitude Navigation and Targeting Infrared System for Night (LANTIRN), the Westinghouse AN/APG-68 and Hughes Aircraft AN/APG-70 attack radar with advanced cockpit displays, digital flight control technologies, improved fuels and engines, precision-guided weapons, and Global Positioning System (GPS). Pilots later claimed the AN/APG-70 attack radar in the F–15E and the AN/APG-68 in the F–16 offered "phenomenal" range and resolution. In interviews, they proclaimed, "if it had metal in it, we could find it," and 'with the APG-70, you could tell from 30 miles away whether a MiG-sized target had weapons or fuel tanks on it."[15] As authors Eliot Cohen and Thomas Kearney point out, by 1991

General Merrill A. McPeak, USAF Chief of Staff.

some post-Vietnam aircraft that had been operational for years along with the newer systems that had less than a year of service "was the combination of U.S. capabilities and coalition, not all of which were based on advanced technologies, that made airpower so predominant" during Desert Storm. It was with these new weapons that the older weapon systems like the F–111, A–6, and B–52 performed well with precision-guided and unguided bombs.[16] Through intelligence gained from the 1967 Domodedovo Russian air show to lessons learned from the Yom Kippur War to changing weapon acquisition practices, the major weapon systems utilized in the defeat of Iraqi forces during Desert Storm took their shape over 50 years ago during the early parts of the 1970s as a result of reappraisals of the perceived Soviet threat in Europe.

Soviets Burst on Scene

In July 1967 at the Domodedovo Civil Airport south of Moscow, the Soviet Union unveiled at the Tushino Air Show twelve new and advanced military aircraft in its first large airshow in nearly six years, displaying variable-sweep, vertical and/or short take-off and landing (V/STOL) attack, and short takeoff and landing (STOL) aircraft. Soviet Union's intentions with the airshow were to demonstrate their increasing capabilities in tactical warfare and ability to keep on pace with the West with the unveiling five new aircraft and four already in the active inventory but with significant upgrades with half of the aircraft developed by veteran designer Artem Mikoyan and the other three by Pavel Sukhoi's design bureau – the aerodynamic prototype MiG-23 *Flogger*, the swing-wing variants of the Sukhoi Su-7 *Fitter-A* and the Mach 3-plus MiG-25 *Foxbat*.[17] These airframes reflected the Soviet Union's new stress on improving their air support for theater forces and their first major public showing of combat aircraft since 1961. According to the Central Intelligence Agency, this suggested "Soviet intention to improve all aspects of fighter aviation," a "massive" move, as Dr. Richard Hallion states, to "diversify the types" and "reshape its tactical and air superiority force" from their first generation of transonic and supersonic fighters.[18] General John P. McConnell, Air Force Chief of Staff, in August 1968 before the Senate Preparedness Subcommittee, stated that with the unveiling of the Mikoyan *Foxbat* and other Soviet fighters dictated that "we produce a fighter aircraft *optimized for the air-to-air role*…. To keep pace with the Soviet advances," the U.S. must modernized its fighter force the mid-seventies.[19] Roughly a year later, during his last congressional committee prior to retiring, General McConnell declared that there was "still the simple truth that if the other fellow has more and better weapons than you – and the will to use them – then you had better get busy or you are lost."[20] During Secretary of Defense Melvin R. Laird's message to the Joint Session of the Senate Armed Services and Appropriations Committee on February 20, 1970, he stated that the "most formidable technological threat confronting" the United States was the "already large and rapidly growing military-related R&D effort of the Soviet Union."[21] Laird continued that the Soviets continued to outspend the United States on research and development at a rate roughly ten to thirteen percent while the United States remained rather constant, but believed the U.S. remained at a technological lead over the Soviet Union due to its "greater past expenditures."[22]

Through the late 1960s up until the early 1970s, Soviet science and technology continued as a major objective of their national policy with the military establishment a major benefactor as budget allocation to the military remained essentially constant; the key was the allocated percentage stayed constant as the state budget continued to grow. The military threat from the Soviets facing the United States remained both quantitative – the number of Soviet combat aircraft (fighters) exceeding that of the United States; estimated intercontinental-range strike forces delivering more nuclear explosive power than the

Soviet MiG-25 Foxbat.

United States; and, the number of deployed Soviet ICBM's exceeding that of the United States – and qualitatively – systematic improvements in their missile, aerodynamic, space, and military electronics and special weapon system developments.[23] At one point, according to author Dick Hallion, the Soviets produced yearly, over 50,000 surface-to-air missiles (SAM) each year."[24] With these improvements, it was deduced that the Soviets were rapidly achieving a "strategic military balance" with the United States with the Foreign Technology Division at Wright-Patterson AFB reminding General Jack Merrell, Air Force Logistics Command commander, in prep material for speeches in 1971 of the Soviet's announced goal of "military-technological superiority." During General Merrell's speech to the Dayton Area Progress Council, he reminded those in attendance that the United States must "realize that requirements do not remain static" with the weapons of the day not being "optimum tomorrow in the face of the technological and military threat environment." He would respond publicly during both 1971 speeches on the rising Soviet threat that the United States Air Force "must be extremely versatile," that they must not "only possess enough aircraft and munitions for simultaneous deployment to various parts of the world, but also the kinds of aircraft suitable for diverse missions and the ordnance appropriate for striking a wide range of targets…. Weapons must be tailored for specific tasks and must be of differing magnitude for incremental applications."[25]

Along with aircraft revelation at the 1967 Tushino Air Show shocking the West, in 1968, at the height of the Vietnam War, the Soviets and Warsaw Pact forces invaded Czechoslovakia to put an end to the "Prague Spring," a perceived threat to the communist hold on the country. This sudden ease of invasion sent shocks waves into the West with the Soviets abruptly boosting its offensive character in Europe, keeping with "the philosophy of party leader Leonid Brezhnev" of a defense policy with three major goals: build military forces strong enough to defeat the combined strength of potential adversaries; dominate Eastern Europe with both permanent military presence and intervention; and encourage revolution and build communist states.[26]

Acquisition Reform

It was during the 1960s, specifically between 1964 to 1967, that defense spending increased by 5.4 percent annually and reached $236.6 billion (in 1982 dollars) by 1968. Nevertheless, as the deficit grew in the 1970s, defense spending declined by seventeen percent as a share of federal spending while non-defense spending hit record highs.[27] But this did not halt defense spending. During Secretary of Defense Robert McNamara's statement before the Senate Armed Services Committee in January 1968, he remarked that in the more "distant future" the Air Force would "most likely require a replacement" of the McDonnell-Douglas F–4 *Phantom II* along with discussions on the replacement of the Ling-Temco-Vought A–7 *Corsair II* with FY 1969 funds supporting the "preliminary work on the long lead-time subsystems" that the future aircraft would require.[28]

Rollout of the first production F-111A fighter in 1963 (63-9766).

During this same period, the Vietnam War persisted in Southeast Asia and demonstrated early to the fighter community the "unsuitability" of the Century series in air combat against the MiGs in weapons, tactics, and training. Vietnam, as author Dr. Hallion points out, demonstrated that the acquisition of the *Phantom* came just in time as it bore the brunt of air superiority but only had a kill ratio of 3.38 to 1 by the end of the war, mostly due to the unreliability of the AIM-7 radar-guided missile and not the aircraft. In the early 1960s, career Air Force fighter pilots, who cut their teeth during World War II and Korea, had differing opinions from then currently accepted ideas of long-range, low-level nuclear-armed penetrators or multisonic interceptors as well as how the acquisition community were becoming fixated on these airframes, which many felt were unsuitable for real-world air combat. Some engineers pushed the Tactical Fighter Experimental (TFX), which became the General Dynamics F–111 *Aardvark*, with its thrust-to-weight ratio of only .75 but nowhere near what the fighter community wanted or demanded.[29] Some within the fighter community claimed that aircraft were becoming "senile," a "condition in which a weapon [was] not obsolete…. But the threats it faced [were] so great that expensive countermeasures" were having to be taken.[30] Vietnam proved that jet aircraft were vulnerable to antiaircraft fire and surface-to-air missiles, increasing their dependency on electronic protection and suppression.[31] In 1965, Major General Arthur C. Agan, the Air Staff's Director of Plans (and future Commander of Aerospace Defense Command) gathered a team of fighter pilots to conduct a study to argue for a more "maneuverable, agile fighters carrying both missiles and guns" and staffed it to Chief of Staff General John McConnell entitled "Air Force Doctrine on Air Superiority," with General McConnell issuing it throughout the Air Force on May 3, 1965, in part stating: "For air-to-air combat we should seek advantages in such performance parameters as acceleration, climb, maximum speed, ceiling, maneuverability, sighting equipment, and armament ca-

Mr. David Packard, Under Secretary of Defense.

pability." With this endorsement for air superiority and the Air Staff Fighter Mafia[32] rejecting the *Aardvark*, a new generation of aircraft began to grow wings.[33]

Following Vietnam, Tactical Air Command (TAC) set out to address the loss ratio by making huge strides to conduct realistic training for its aircrews to defeat the "hordes of Soviet fighters" that were theorized the United States and coalition forces would face over Europe. The creation of Red Flag at Nellis AFB began by teaching fighter tactics to Tactical Air Command (TAC) personnel against Soviet tactics and then expanded to other commands and coalition forces. This training led to a correlation to greater readiness; however, even the most skilled and motivated pilot required a mission-capable aircraft. Through the mid-1970s, mission-capable rates, either fully or partially, improved to around 70 percent and approached 80 percent during the 1980s.[34]

It is also interesting to note that at the same time, testimony before a congressional committee in 1969 stated that roughly "90% of the major weapon systems that the Department of Defense procures end up costing at least twice as much as was originally estimated." Another analyst testified before the same committee that only two of eleven major weapons systems at the time "had electronic components that performed up to standard." This same year, the General Accounting Office discovered during a survey of thirty-eight current weapon systems that cost estimates were "already 50 percent higher than the original contract figures."[35] It is with this and a need for reform in weapons acquisition, changing perceptions of the military establishment, and views on the United States involvement in Vietnam, that incoming Secretary of Defense Melvin R. Laird received his marching orders to fix defense acquisition. Laird was determined to improve control of cost growth and set out to revise many of Secretary McNamara's programs as the prior years were noted as a period of "better management would solve problems" ultimately translating into "more management with an increase in rigidity, delay, and suppression of initiative."[36] McNamara's approach to acquisition originated from his background at the Ford Motor Company, believing that the "on-paper assessments" were an efficient substitute for costly prototypes; however, this was only the "front end" of the overall acquisition process and thus his Total Package Procurement Concept (TPP) came about. TPP was to provide, during the early period of the procurement cycle, "a competitive purchase of a undesigned system for virtually the entire life cycle of the system." It was under TPP that the contractor was to guarantee the performance of its theoretical design with the intention of absorbing the procurement risk all the while expected to deliver systems on time at the given cost but permitted considerable flexibility in making design tradeoffs.[37]

For his deputy, Laird brought in one of the most successful industrial managers to help with acquisition reform, David Packard, from Hewlett-Packard. Packard wasted little time by moving away from a tightly controlled military management style to a "system in which overall objectives were clearly stated and agreed upon" and giving individuals "the flexibility to work toward those goals in ways they determine best for their own areas of responsibility." Packard accepted the challenge to reverse McNamara's Total Package Procurement (TPP) approach, which combined both system development and production of the weapon system into one contract and create a system more responsive with "additional production-ready options for future decision makers." McNamara's TPP approach eliminated competition early in the acquisition process that restricted options while at the same time encumbered DoD with "an incredible amount of risk by committing production contracts to designs that only existed on paper."[38]

Share of the blame on acquisition programs under TPP fell on both the services and contractors due to contractors having little incentives because of the absence of competition for production contracts and the services allowing contract changes and not enforcing the fixed-price of the contracts for fear of further delays. Even more importantly, TPP failed to allow industry any opportunity for significant redesigns before production began.[39] Packard's challenge lay in unifying all the stakeholders within the military-industrial complex as well as shifting the focus of politicians and the defense industry from Vietnam back towards the Soviet threat. In May 1969, Packard took the first step in modifying the defense acquisition practices at the highest level by creating a new organization that advised him on the "status and readiness of each major system" and its readiness for the next phase in its life cycle. This new organization, the Defense Systems Acquisition Review Council (DSARC), advised Laird and Packard on major weapon systems progress at critical decision points. DSARC, formed in May 1969, created three progress milestones for acquisition programs that intended to "enhance" the acquisition process – program initiation decision, full-scale development decision, and production decision. Packard's logic for reforming the acquisition process was two-fold: es-

General James Ferguson, Commander, Air Force Systems Command .

tablish a decision point within the Office of the Secretary of Defense (OSD) to "ensure its integrity and increase the number of programs pushed into hardware development by fully utilizing advanced prototyping initiatives." With this, programs needed to establish various milestones within the development and test schedules with "step-by-step achievement" of the objectives to "guard against technical surprises and demonstrate program progress."[40]

One key to Secretary Packard's acquisition reform was prototyping. In the late 1960s, prototyping gained a new appeal as it addressed Packard's acquisition reforms with its "promise to reduce – even minimize – the technical risks in new programs" and believe it could help avoid time and cost as technical problems surfaced once the new system was in production. Many considered this a "new" concept in the late 1960s because it had fallen out of favor for nearly a decade as it had been deemed an unnecessary expense at the beginning of the 1960s with the theory that accomplishment of aircraft selection could be based upon paper analyses, brochure competition, and statistical evaluation with hardware demonstrations replacing prototyping.[41] However, some supported prototyping with a RAND Corporation study in February 1963 urging prototyping "particularly where large technological advances are being sought" and five years later in another study stating that it was "sensible to build and fly a prototype of an aircraft before finally deciding to produce it in quantity." Later in the year, President Lyndon B. Johnson's special assistant for science and technology, Dr. Donald F. Horning, pondered if "putting more emphasis on prototype development before deciding about production" would alleviate acquisition issues. As 1968 closed out, during a lecture in London, Mr. George Schairer, of the Boeing Company, stated "Paper competitions assume that people can get smart by studying. Prototype competitions add that very great increment of smartness which can be learning only by doing." General James Ferguson, Air Force Systems Command commander, supported Secretary Packard's push for prototype competitions as he wondered if prototypes had been more expensive "in the long run" with some industry officials and financial analyst believing that huge sums of money were utilized in building prototypes with no guaranteed return on investment but Ferguson believed that prototype competitions added a "degree of confidence" to the production decisions "as well as a predictable reduction of technological risks in acquisition programs." Ferguson advocated source selection as it could "be based on a hundred cubic feet of hardware rather than a hundred cubic feet of paperwork.[42] Packard felt that the long-term advantages of prototyping allowed more "flexibility and certainty" which gave contractors the ability to "build and test a real piece of hardware not only gave assurance the design would demonstrably perform, but also meant better estimation of follow-on costs." The old practice of cost estimating, he felt, was "wishful thinking" and "encouraged the ruse of parametric costing, combined with prototyping, to reduce overrun risk."[43]

By the end of the 1960s, prototyping re-entered, as it had been done during the 1930s and 1940s and called "Try-Before-Buy", into the acquisition lexicon as well as other parts of Secretary Packard's reform movement as new computers and manufacturing technologies helped enhance acquisition process but fiscal austerity and inflation in the 1970s undermined programs.[44] This fiscal austerity began in the late 1960s in Vietnam and saw no end in sight along with pending defense cuts on the horizon placed a daunting task for the U.S. military to shift focus away from Vietnam and back against peer competition with cost, schedule, and performance within the acquisition process becoming vital. It is with this in mind that Secretary Packard created his acquisition reform movement that "fostered, facilitated, and incentivized innovation within the fiscally austere, cost-conscience budget landscape."[45]

Secretary Packard's reforms looked to decentralization of program management by strengthening the system project offices by giving the system program directors (SPD) "full system configuration authority and by providing him the procedures which enhanced the control of the system's flow through the acquisition phase of its life cycle." One procedure that was made available and institutionalized with the SPDs was the Blue Line Reporting System, which gave SPDs of a weapon system "direct access to the Chief of Staff and Secretary of the Air Force." This allowed direct communication up or down for "rapid and direct system decision making." Program Assessment Reviews (PARs) and Command Assessment Reviews (CARs) provided opportunities for SPDs to delineate program progress and problems up the chain to ensure "close attention to cost tracking and control" of the individual weapon systems. In 1973, AFSC instituted the Field Assessment Review (FAR) to inform the Commander of a review of resources and activities within AFSC's test and evaluation organizations as well as a Management Assessment Review (MAR), similar to PARs/CARs, that looked at non-Par/Car programs.[46]

Secretary Packard's new acquisition processes met with some resistance to his focus on "cost as king" and his

efforts to streamline reporting channels between OSD and program offices within AFSC. In September 1970, General George S. Brown assumed command of AFSC and believed that the F–15 program office was locked "out of an awful lot of possible help" from AFSC. General Brown believed that program managers had "certain responsibilities" to the AFSC commander, and it was AFSC's responsibility to "deliver performance and operational capability…and getting the system within the schedule." In January 1971, Brown met with Secretary Packard demanding the authority, the resources, and minimum staff interference to "identify losers as soon as possible and divert the funds to likely winners" and stated that he would notify Packard "about it after we've done it" as well as ask if he ever needed help. Packard saw no issues with Brown's requests stating that if he saw something that was not going well, "cancel it" and to "periodically let me know how things are going." Packard's push to improve decision-making ability and away from McNamara's "tight grip" on the services by delegating authority down to the lower levels had ruffled senior leaders with General Brown not consenting to program managers risking schedule and performance requirements to attain cost goals.[47]

Yom Kippur War and Ramifications for the U.S. Air Force

Fourth in a series of major Arab-Israeli conflicts that followed the formation of the Israeli state, the Yom Kippur War followed two preceding conflicts – the War of Independence in 1948 and the Six-Day War of 1967 – that lead to clear Israeli victories. The Six-Day War was one-sided where the Israeli Air Force (IAF) commenced preemptive attacks that devastated their Egyptian counterpart in a single morning with Israeli combined armed forces sprinted to victory, taking substantial areas of Egyptian and Syrian territory as well as capturing the Jordanian West Bank and sole possession of Jerusalem.[48] The Yom Kippur War provided important lessons for future conflicts and "constituted a microcosm of the kinds of issues that might be involved in a high-technology war of movement in Europe."[49]

Following the Six-Day War, periodic fighting along the Suez Canal resulted in the building of the Bar-Lev defensive line during the late 1960s by the Israelis. This in turn triggered Egypt into launching attacks, known as the War of Attrition, lasting until August 1970 consisting of artillery exchanges, commando raids, and aerial battles. The IAF developed familiarity with modern air defense systems but faced losses despite the supply of American electronic countermeasure (ECM) equipment. Despite these losses, the Israeli military emerged from the War of Attrition with their military reputation unharmed. After the Six-Day War, the IDF received shipments of Douglas A–4 *Skyhawk* and McDonnell Douglas F–4 *Phantom II* jets from the United States as well as other weapons to modernize. To defend against these modernization efforts, both the Egyptians and Syrians employed an expanding number of Soviet-supplied SA-2, SA-3, SA-6, and SA-7 missile systems in the

Israeli Air Force during the Yom Kippur War. ***(Wikipedia Commons).***

Suez Canal region as well as received MiG-21 *Fishbeds* and MiG-25 *Foxbats*.[50]

The timing and extent of the attack by Egypt and Syria on the afternoon of October 6 – the holiest day on the Jewish calendar and during the Muslim holy month of Ramadan – caught Israel by surprise with the IAF scrambling to support embattled ground forces from the massed formations of Egyptian armor and infantry assaulting across the Suez Canal. Unbeknown to the Israelis was the extent the Soviets had equipped the Egyptian and Syrians with air defense equipment since the end of the War of Attrition that created an impenetrable SAM "umbrellas" that "shielded Arab forces from Israeli Air Force attacks on both fronts."[51] The Egyptian air defenses were the "most elaborate ever constructed" on a scale "not witnessed since" World War II with the equipment levels, troop proficiency, leadership, and logistical support significantly increased along with the incorporation of wide-ranging innovations since the Arabs' last defeat.[52] During the late 1960s through the early 1970s, the Soviets had greatly improved its battlefield defenses, which would be highlighted by the air defense systems implemented by the Arabian forces and the lack of the Israeli *Skyhawks* and *Phantoms* to detect SA-6s operated by the Egyptians, downing the majority of the 96 IAF aircraft lost during the war.[53]

Through Israeli determination and skill, Arab blunders, U.S. materiel support slowly turned the tide. As the Soviets continued to actively supply weapons to

Israeli Air Force during the Yom Kippur War. ***(Wikipedia Commons).***

The first MAC aircraft to land at Lod Airport, Israel, was C–5 (4061) assigned to the 60 MAW at Travis AFB, Calif. Operating in a "dark window" schedule, the C–5 landed at Lod at 2201Z hours on October 14, with 93.1 tons of military aid for the Israeli Defense Forces.

Egypt/Syria, U.S. Secretary of State Henry Kissinger decided that the United States could not afford Soviet aid to allow the Arabs to defeat Israel. Further, Kissinger held firm that the United States could not afford an adversarial win over a U.S. ally and by sending arms to Israel, the United States could ensure an Israeli victory, hand the Soviets a defeat, and provide some influence over a postwar settlement. On October 13, President Richard Nixon[54] ordered the resupply of Israeli forces. Known as Operation NICKEL GRASS, the airlift included large quantities of equipment and weapons along with the delivery of combat aircraft from frontline units to IAF squadrons. On October 24, the Soviets threatened to intervene in the fighting with the Central Intelligence Agency reporting that the Soviets had stopped airlifts to Egypt but preparations to switch from weapons to troops were beginning. In response, Nixon placed the U.S. military on alert, increasing its readiness for the deployment of conventional and nuclear forces. It was also during this period that President Nixon faced the Watergate Scandal, with some theorizing that he utilized the Soviet's response in the war to divert attention away from the scandal, but the danger was real and probably the closest the two superpowers ever came to nuclear war other than the 1962 Cuban Missile Crisis. The Soviets, however, never sent troops and U.S. forces were taken off alert. Now resupplied, the Israeli military forces countered successfully and took advantage of Egyptian and Syrian mistakes, advancing past the original positions on both fronts by the ceasefire declared on October 24.[55]

Despite IAF's accomplishments, it was their experiences and especially their struggles against the Soviet-supplied air defenses that drew the most analysis in the war's aftermath. The IAF lost roughly 100 aircraft in less than three weeks of fighting and struggled to make a presence on the ground battle. At the wars end, it seemed that the future of tactical air power was in doubt with some believing that the "missile [had] bent the aircraft's wing," however, from the U.S. Air Force's perspective, the Soviet missiles were "bending," or downing, American-supplied aircraft.[56] The IAF had repeatedly defeated the Arabs' attempts at establishing a credible air defense system and only weeks prior to hostilities baited and ambushed Syrian interceptors, downing 19 aircraft. The IAF was surprised by the effectiveness of the Arabs' proficiency in operating the Soviet-supplied air defense systems without advisers. The old electronic countermeasures were unable to jam the radar acquisition and tracking frequencies of the SAM-6 and flares were ineffective against the "optically-aimed, heat-seeking" missiles.[57] The IAF did not crack the air defense cover on the Egyptian front until Israeli tank units physically overran the SAM and AAA sites on the West Bank on the night of October 15-16 . Then the IAF was able, in coordination with ground forces, to defeat the air defense systems.[58] This worried defense analysts considering future NATO combat against Warsaw Pact forces. Hypothetical plans for war in Europe relied heavily on armor and aircraft that were vulnerable to new enemy weapons and now had to factor in high rates of attrition and materiel resupply with NATO forces needing to replace battle losses on an unanticipated scale; attrition and consumption rates along with the ability of a modern ground-based air defense contesting the control of the air now became key concerns to planners.[59]

During a speech to the Squadron Officers School at Maxwell AFB on November 28, 1973, retired Lieutenant General Ira C. Eaker stated that the Arab forces, equipped with the "latest Russian weapons, of the same quality with which Russian front-line divisions are equipped," confronted American-built aircraft with Soviet-made missiles had shown once again the criticality of air superiority in warfare. The IAF "struggled to impose itself over ground battles fought in SAM-defended zones" with Israeli ground forces suffering high losses.[60] Chaim Herzog, a career soldier and later president of Israel, stated that the "role of the plane in war has changed…. To a degree air power will not be as influential as it has been and will affect the battlefield less than it did."[61] The International Institute for Strategic Studies noted that the war showed "how effective an air-defense umbrella over ground troops can be, so the heavy Soviet air defenses in Europe clearly have to be reckoned with….There is no likely to be great emphasis placed in the West on the development and deployment of…missiles to suppress air defenses. Weapons which, because of their accuracy, increase the probability of a single-shot kill, thus reducing munitions expenditure and aircraft sortie rates (and hence vulnerability) will attract increased attention as a result of this war."[62] Technology now would be key in either winning or losing as Giora Ram, an Israeli *Skyhawk* squadron commander noted in October 1973: "[The outbreak of the war] witnessed one of the watersheds in the history of the air force: technological inferiority. Technological superiority had been one of the cornerstones of the Israeli Air Force, and in 1973 the air force had to make a great effort to close the technological gap created by a new type of [threat]…. We [had] entered the war at a technological disadvantage."[63]

Soviet-supplied SA-2 surface-to-air missiles deployed to Egypt during the Yom Kippur War.

Following the ceasefire on October 24, the U.S. Air Force participated in several joint and discrete military fact-finding activities. One of which was the United States Military Operational Survey Team (USMOST) directed by Secretary of Defense James R. Schlesinger to identify lessons learned. Admiral Thomas H. Moorer, Chairman of the Joint Chiefs of Staff, outlined the purpose of USMOST as "determining first-hand the operational lessons" from the conflict with lessons learned being "invaluable in our constant effort to maintain the best possible defense posture against potential enemies."[64] Specific to the Air Force, the team was to look at the IAF's coordination between air and ground forces during close air support and air defense missions, the employment of the AIM-7 *Sparrow* and AGM-65 *Maverick* missiles, SAM suppression and effectiveness of countermeasures with specific emphasis on the SA-3, SA-6 and SA-7 systems, electronic warfare, and lessons regarding command, control, and communication.[65] Another team, the U.S. Military Equipment Validation Team, Israel, or USMEVTI, arrived before USMOST to "determine weapons effectiveness data as available from tank/equipment carcasses and field visits" with the directions to work together with USMOST, transferring and supplementing information and avoiding duplication of efforts.[66] The U.S. Air Force also participated indirectly via political initiatives as a "chaperone" during a visit of the subcommittee of the House Armed Services Committee to the Middle East in November 1973. Major General Marion L. Boswell accompanied the congressmen on their visit to Israel as well as Egypt to "meet with National decision makers, discuss tactics and weapons with military leaders, and to observer first-hand the impact" of the war.[67]

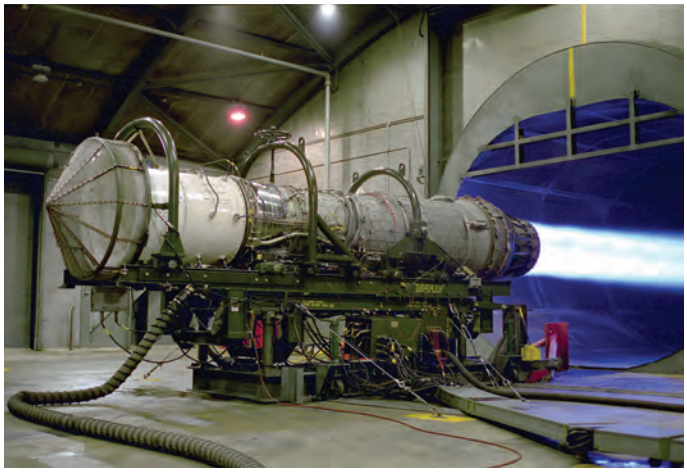
Along with these various visits to Israel, the Air Force also took various service initiatives as well. On October 30, 1973, John L. McLucas, Secretary of the Air Force, suggested that the Air Force Policy Council meet to discuss the lessons learned. It was agreed that analysis would be incomplete but McLucas was keen to safeguard "the planning and budgetary process promptly…in such areas as R&D, weapons acquisition, basing, training, deployment, employment, and intelligence."[68] At the same time, Lieutenant Colonel Charles A. Horner[69] in the Directorate of Operations, produced two key talking papers in November – "Mid East War Data Support of USAF Programs" and "Interdependence of Air and Ground Operations" – that interpreted the conflict and drew conclusions with long-term relevance.[70] It was the Yom Kippur War that led to the U.S. Air Force's efforts to innovate against the expanding IADs threat in the mid-1970s with the Pave Strike initiative with the purpose to preserve the capability of strike aircraft against the increasing and involving threats in Eastern Europe.[71]

It was obvious through analysis of the Yom Kippur War that the Air Force would need to assume high levels of materiel attrition and munitions employment in a modern conflict. Discussions on quantity played into discussions regarding the optimum high/low force balance proposed between new weapons systems and it became clear that not only would a capable aircraft be required but also numerous "quantities of consumable stock – an important observation as the U.S. military contracted in 'normal' post-war fashion after the end of its involvement in Vietnam."[72] The Yom Kippur War contributed to the adoption of an "offset strategy" by the U.S. during the 1970s.[73] This strategy pursued "leap-ahead technologies to offset Soviet superiority in Europe."[74] As the United States Air Forces in Europe (USAFE) Director of Intelligence in 1973, then Major General Wilbur L. Creech had access to the latest intelligence on the modern Soviet SAMs being used during the Yom Kippur War as well as the first-hand accounts from the IDF pilots against them. Creech believed that once the SAMs were degraded that operations could adjust and then utilize precision munitions, leading to air defense rollback, his central vision of air superiority.[75] In his 4 March 1974 report to Congress, Secretary of Defense James R. Schlesinger stated that the "tactical air forces [were] not only a great investment of national resources" but "also a most essential element in our national defense strategy." He would go on to state that the tactical air forces were depended on to "offset…possible numerical inferiorities in land forces as compared to potential adversaries."[76] However, during the early-to-mid-1970s, planners anticipated a conflict in Europe and worried about defending the West from a Soviet "blitz through the Fulda Gap," which according to author Dick Hallion, "distracted American and European nations from more likely conflicts in traditional hotspots."[77]

Packard's Processes Put into Action to Build a New Air Force – A Review of Select Programs

F–X Fighter-Experimental (McDonnell Douglas F–15 *Eagle*)

When secretaries Laird and Packard entered the Pentagon, they believed that the cost overruns on the F–X were caused by TPPs lack of program supervision once a contract was signed with Packard insisting on the establishment of a new "milestone" process to monitor developmental and production costs and "fly-before-you-buy" or



Pratt & Whitney F100 engine during testing.

Brigadier General Benjamin N. Bellis (far left), deputy for the F–15 program, discusses the F–15 model with (left to right) Secretary of the Air Force Robert Seamans; General James Ferguson, commander of Air Force Systems Command; and Lieutenant General James Steward, commander of Aeronautical Systems Command.

prototyping. Air Force Systems Command explained to Secretary Packard that it had considered a form of prototype fly off with the F–X but discovered it was too complicated and cost nearly $6,000,000; utilizing data from twenty-two different prototype programs from the past, it was determined impractical for the advanced F–X. Nevertheless, Packard insisted on prototyping for the engine and radar as well as for all future major programs.[78] A month before General Agan's memo, Air Force Systems Command began studies for a new tactical fighter, coming up with the "Preliminary F–X Concept Formulation Package" in September 1966 in which Major John Boyd rejected it in October.[79] It took the following June before a final concept was agreed upon and another year before a request for proposal (RFP) on the airplane, its pulse-doppler radar, and engines was issued. On September 30, 1968, eight manufacturers received the RFP with four responding and three narrowed down by December: McDonnell-Douglas, North American-Rockwell, and Fairchild. On December 23, 1969, the Air Force selected McDonnell Douglas the winner of the F–X and designated it the F–15 *Eagle,* and contracting the company for an initial twenty aircraft for developmental testing with DoD supplying Pratt & Whitney engines. Until the *Eagle* met the technical milestones, commitment to production would be deferred. The Air Force utilized a cost-plus-incentive-fee (CPIF) contract that covered design, development, test, and test support whereas a fixed-price-incentive-with-successive-targets (FPIS) contract covered the test aircraft, test support equipment, spare parts, and ground support equipment to support the test program along with the first production of the first 107 aircraft fell under the FPIS contract. Passing the critical design review in April 1971, the *Eagle* made its first flight on July 27, 1972.[80]

While the F–X airframe itself did not go into prototyping competition, two key components of the F–X would be the radar and engine. The Hughes AN/APG-63, pulse-Doppler radar, with a "look-down, shoot-down capability" that could track multiple targets at long or short range, won the competition for the radar but after a very competitive and close competition for the engine, the Pratt & Whiney F100 engine was chosen over the "lighter and structurally superior" General Electric 401 due to what was "considered higher risk." Due to the technological advancement and the critical linkage to the *Eagle's* performance, the contract Pratt & Whiney entered had several milestones the F100 had to meet with one being a satisfactory Military Qualification Test that included a 150-hour endurance test, as well as a clause within the contract stating that Pratt & Whiney had to correct, at their expense, "any subsequently discovered deficiency stemming from its design, workmanship, or material."[81] The goal was to get the F–X selection process completed and into production as quickly as possible but many within the Air Force blamed OSD for the forced delays, nevertheless, the careful review of the program as it moved along allowed the "technology of the F–15 to develop more fully."[82] Of note, by early 1973, wind-tunnel test hours reached nearly three times that of the entire F–4 program mainly due to the lessons learned from the F–111 experiences, looking intensively at potential engine-inlet compatibility issues. By the end of 1973, airframe fatigue tests equated to four lifetimes. The flight test program progressed at a faster pace than in previous jet aircraft development. Information from these tests resulted in timely design changes with fatigue test failures leading to wing spare modifications and flight tests leading to changes in the variable-geometry engine inlet ramp sensitivity, control stick force, and flight control system.[83]

Testing of the *Eagle* proceeded accordingly and met all its performance milestones on or ahead of schedule apart from engine qualifications. Plans were initially laid out with the first procurement of 30 funded in FY 1973, another 62 funded in FY 1974, and the FY 1975 budget included $183 million for R&D and $893 million for the third procurement of 72 with the remaining 565 scheduled in FY 1976 through 1980.[84] Program costs initially projected at $6 billion in September 1968 would climb to $7.3 billion by February 1970 with Secretary Laird pointing to "bad estimates at the initial planning stage" as well as very high

First flight of the F-15A prototype at Edwards AFB, California.

YF-16, winner of the Lightweight Fighter competition

inflation rates of the mid-1970s affecting perhaps the "largest single element of the F–15 program cost growth." Nevertheless, Laird pointed out in 1970 that the *Eagle* was proceeding on schedule with a projected allocation of $370 million in FY 1971.[85] However, the procurement rate did not work out this way and the initial acquisition was stretched out to nine years, adding two billion dollars.[86]

F–XX/LWF Lightweight Fighter
(General Dynamics F–16 *Fighting Falcon)*

Before the *Eagle* getting off the ground, Major Pierre Sprey stated that there were four criteria for an air-superiority fighter, in order of importance: "first, obtain the first sighting; second, outnumber the enemy in the air; third, outmaneuver the adversary to gain firing position; and, finally can achieve split second kills." Sprey and others believed the *Eagle* was "too large to achieve the first, third, and fourth" and became too expensive to purchase in the numbers that the second required. This debate generated other questions with the central question of "should American fighter design be driven by the eternally optimistic theory that sophisticated, that is, more complex, technology [would] negate the effects of being outnumbered," or evolve away from "combat-drive criteria" requirements and build greater numbers of "less complex aircraft."[87] A group of individuals within the Fighter Mafia began their descent away from what they felt was just "another big, fast sled" before the *Eagle's* first flight and began championing a lighter, single-engine, more agile, air superiority fighter at low-cost, to fit within the decreasing defense budget that they dubbed the F–XX, later known as the Lightweight Fighter (LWF). Majors John Boyd, Pierre Sprey, and Col Everest Riccioni pushed the F–XX as an alternative to the *Eagle* but found little sponsorship within the Pentagon as Secretary of Defense James R. Schlesinger, in his message to the House Armed Service Committee on March 4, 1974, stated that the *Eagle* was to be the first fighter "specifically designed to excel in air-to-air-combat." He would go on to state that it was armed with the newest air-to-air missile system and an improved close-in air-to-air missile system, making it "superior to any fighter the Soviet Union was likely to deploy in the next 10-15 years."[88] However, supporters of the F–XX found promise after the Aeronautical Systems Division study "Application of the Theory of Energy Maneuverability to Fighter Aircraft Design" that favored the F–XX as well as President Nixon's "Blue Ribbon Defense Panel"[89] report in June 1970 and Deputy Secretary of Defense David Packard establishment of "fly-before-buy" competitive prototyping process that leaned towards the

John Boyd, member of the Fighter Mafia.

Boeing's Lightweight Fighter Concept, later known as the YF-16.

F–XX. In February 1971, Secretary Laird agreed to the Simon Study[90] that examined the potential of utilizing the F–XX within Secretary Packard's prototyping program. At the same time, as Riccioni prepared to leave for his assignment to Korea, he received funding for a study on the F–XX and passed the money to both General Dynamics and Northrop to "design a 25,000-pound fighter whose performance would be superior to the F–4." The study soon leaked to other contractors who immediately offered unsolicited proposals for the F–XX to the Air Force; Boyd and Riccioni visited Boeing when the contractor failed to submit a proposal and heavily urged them to submit, which they did. Packard recalled later that it was "impossible to make sense of what the problem was" and brought together "pilots from Vietnam" for discussions on the F–XX proposal. It was with "fly-before-you-buy" prototyping that Boyd and Major John "Mike" Loh in September 1971 realized the opportunity to push the F–XX, eventually the Lightweight Fighter (LWF) Program, as a technology demonstration to evaluate two alternative designs, the YF–16 and YF–17.[91]

The Simon Study was the outline utilized to prepare the RFP for those to compete for the LWF contract where two companies would be selected and given 100 million dollars each to build a prototype for the fly off with each company given a wide latitude in their development of the new fighter; selected on April 13, 1972, General Dynamics and Northrop began efforts on their respective prototypes for the fly off with the YF–16 prototype rolling out of the General Dynamics Fort Worth facility on December 13, 1973. However, not everyone was on board with the LWF. As Chief of Staff of the Air Force, General George S. Brown was very cautious as Secretary of Defense James R. Schlesinger reflected years later: "He really tore the idea of the F–16 apart, preferring to stay with the F–15 [as] I was pushing for the development of the F–16."[92] On January 13, 1975, General Dynamics received an FPIF contract for the production of 15 engineering development YF–16 – 11 single-seat and 4 two-seat versions. In January 1978, it was announced that the YF–16, with the same Pratt and Whitney engine as the *Eagle*, won the fly-off with Robert Coram writing: "the YF–16 was the unanimous choice of pilots who flew both aircraft…[because] it could flick from one maneuver to another faster than any aircraft they ever flew…the most nimble little banking and yanking aircraft the world have ever seen." Packard remarked later in his memoir that the F–16 became the "best Air Force fighter plane"[93] with fighter pilot confirming that the F–16 was everything that he had been looking for, stating that it was "an F–4 writ small, not writ large like the F–15."[94]

A–X Close Air Support
(Fairchild A–10 *Thunderbolt II*)

Some might say the most significant acquisition move Secretary Packard made came in January 1970 when he ordered the Secretary of the Army and the Secretary of the Air Force to resolve the close air support (CAS) debate and develop a "unified DoD position" with an agreement between the two secretaries coming two months later to move forward on the A–X program. Secretary Packard recognized that it was more efficient that a compromise be reached through the two service secretaries rather than attempt to "strong-arm" the service chiefs. Dr. Robert Seamans, Secretary of the Air Force, remarked that both he and Stan Resor, Secretary of the Army, agreed that "a fixed-wing, close-support aircraft, the A–X was probably needed, and that the Air Force should be responsible for its development.[95] In April 1970, the approval for the A–X concept for prototype development with the final RFP issued in May to twelve companies with six responding and the Air Force selecting Northrop and Fairchild to build prototypes for the competitive fly-off by December; the A–X's primary weapon, the GAU-8 30mm Gatling gun, RPF released on November 16 and in June 1971 entering into a competitive prototype competition between General Electric and Philco-Ford Corporation. The A–X would be the first air-

The Northrop YA–9A prototype in flight at Edwards AFB, California, loaded with BDU-33s in 1973.

First flight of the Fairchild-Republic YA–10 at Edwards AFB, California in 1972.

Lockheed F-117 Nighthawk taking off at Tonopah Test Range, Nevada

craft, under Packard, to be built under his new "fly-before-you-buy" program. By the summer of 1972, the Northrop YA–9 and Fairchild YA–10 completed 284 flight test hours with the YA–10's first flight on May 10, and then twenty days later the YA–9 took its first flight. In January 1973, Secretary of Air Force, Dr. John McLucas, declared Fairchild the winner and contracted to reproduce ten test aircraft. In March, officials contracted General Electric to develop and deliver 32 TF–34 engines over the Avco Lycoming F102. On June 21, Secretary McLucas announced the award of a developmental contract of the GAU-8A to General Electric under a Fixed Price Incentive (Firm) contract for three preproduction systems.[96]

Despite this quick movement on a solution for CAS, in July 1973 the Senate Armed Services Committee cut the FY 1974 request for A–10 preproduction aircraft down to six as well as recommended a flyoff between the YA–10 and the LTV A–7D *Corsair*. Between April 15 and May 9. 1974, the YA–10 and A–7D conducted a joint comparative flight evaluation test at Fort Riley, Kansas, nicknamed Saber Compare, where the YA–10 was declared by OSD to be the more effective aircraft. The A–10s slower speed allowed it to keep the target in sight, stay closer to the target with its maneuverability, and allowed it to attack several times quickly. The following year, Deputy Secretary of Defense William P. Clements Jr authorized the Air Force to proceed with the initial production of 52 aircraft. On October 21, 1975, the first production A–10 flew from Fairchild's Farmingdale, Long Island plant.[97]

Stealth
(Lockheed F–117 *Nighthawk*)

Lessons learned from Vietnam and following the Yom Kippur War, low radar cross section (RCS) projects gained traction when survivability became a critical focus and individuals believed that to defeat an enemy's air defenses was to "minimize the radar and infrared signatures of an aircraft by careful attention to shaping, use of radar-absorbent materials, and use of 'cool' two-dimensional sheet-like exhausts."[98] Beginning in October, the Defense Department and various research agencies directed several studies in response to the challenges it perceived. In November 1973, the Science Advisory Board met with Tactical Air Command personnel at Langley AFB to discuss the topic of aircraft survivability.[99] A study completed during the summer of 1974 by the Defense Science Board took the results from the Yom Kippur War and extrapolated them onto a European scenario and concluded that "U.S. and NATO air forces would be decimated in a general war in as little as two weeks."[100] Following the study, Dr. Malcolm Currie, Director of Defense Research and Engineering, instructed the hunt for "radical new ideas" that would overcome the air defense problem.[101] With Air Force sponsorship, DARPA proposed a "high stealth aircraft" that represented "a silver bullet…that could blow a hole through [Soviet] defenses."[102] DARPA issued a Statement of Work for a "High Stealth Aircraft" study that emphasized "the… design of tactical aircraft possessing maximum stealth through the minimization of radar, IR, visual, and acoustic signatures."[103] The low RCS feasibility study went to five aerospace companies – Northrop, McDonnell Douglas, General Dynamics, Fairchild, and Grumman.[104] In April 1977, Lieutenant General Alton Slay, Deputy Chief of Staff for Research and Development at Headquarters USAF, chartered the SENIOR HIGH[105] program with the initial cadre studying the "technology's possible influence on deterrence." Ultimately, it was Lockheed that developed the concept air platform, "Have Blue," and in October 1978, the Air Force issued the Skunk Works a contract to build the F–117 itself with the first flight scheduled for July 1980, reaching Initial Operational Capability (IOC) quickly by December 1982. In December 1978, Lockheed received authorization to begin production at roughly the same time that program management transferred from Air Staff to the newly created Systems Program Office (SPO) for low

Second flight of the Rockwell B–1A Lancer.

observables with the Aeronautical Systems Division at Wright-Patterson.[106]

Rockwell B–1 *Lancer*

Application of Packard's acquisition processes was demonstrated with the Rockwell B–1 *Lancer* even though it was not anticipated to produce a sufficient volume of orders to warrant a full prototype competition. Packard believed in simplifying the RFP as the "important first step" as was practiced with the Lightweight Fighter, where the source-selection process was dramatically shorted with the establishment of the length of the proposal and changing the scoring system.[107] The RFP for the new strategic bomber was released in November 1969 and almost immediately felt the presence of Packard as the originally proposed RFP was believed to be "one of the largest paper monsters ever produced." Packard himself reviewed the document and removed significant amounts of what he felt were unnecessary wasteful requests. Packard adhered to paperwork, citing one project that crossed his desk as "paperwork accounting for 30% of the program's total cost." With the *Lancer* RFP, Packard wanted those involved to take a hard look at the precise detail within the RFP, expounding how the draft stated the "contractor would have had to go through this big exercise on how he was going to do all" of a particular item when he should be "allowed to direct his full attention to making a better airplane." Packard believed that "all the detailed paperwork that needs to be done" could be accomplished at the "appropriate time."[108] On June 5, 1970, Dr. Robert Seamans, Secretary of the Air Force, announced the selection of North American Rockwell and General Electric as winners of the airframe and propulsion contracts. Packard's "fly-before-you-buy" approach was taken with the cost-plus-incentive-fee (CPIF) contract signed for only the engineering development of the B–1 with Rockwell to provide five flight test aircraft, one static test airframe, and one fatigue test airframe (later reduced to just three) while General Electric was separately contracted to develop and build 40 "preliminary-flight-rated-test" engines (later reduced to just 27). During this time there was no avionics contract awarded and no authorizations on production. Eventually, avionics split into two packages with Boeing selected to integrate offensive avionics into the B–1 in April 1972 and Cutler-Hammer contracted in January 1974 for the defense avionics system.[109] Secretary Packard affirmed to Dr. Seamans that this authorization of the B–1 was for development only, and that a decision on "whether the B–1 will be authorized for production, when production might be authorized, or what level of production will be authorized" had not been made.[110] Approval for production would not come until the Reagan administration, followed through on a presidential campaign promise; however, Research, Development, Test, and Evaluation (RDT&E) had funding kept the flight test program ongoing and allowed continued maturity of component technologies until full-scale development and contract awarded of Lot 1 production in January 1982. Between the first flight of the B–1A in December 1974 to April 1981, the four prototypes "accumulated 1895.2 flight hours, more than 25,000 hours of wind tunnel testing, and the structural article had been subjected to fatigue testing designed to simulate three aircraft lifetimes" as well as included the dropping of roughly 60 B61 inert nuclear weapons and two missiles.[111]

Foreign Military Sales (FMS)

Both the Nixon Doctrine and Vietnamization, withdrawing U.S. forces and transferring the responsibilities to South Vietnam, involved shrinking United States worldwide commitments from a two-and-a-half posture to a new one-and-a-half posture, a strategy that relied heavily on foreign military sales (FMS) to U.S. allies. On April 14, 1970, Secretary Packard addressed a crowd in St. Louis concerning these impacts on defense spending, DoD workforce, and policies abroad, noting that for the first time in twenty years the shift in government spending away from defense spending and towards domestic programs. In August, when asked by the media if there could be even more cuts following the ramping down of Vietnam, Packard warned that the United States "must keep our military capability up, because the world is no less hostile just because we are withdrawing from Vietnam" and he warned that the world could be growing even "more hostile" due to the "growing danger in the Mideast" and the "heavy defense spending" by the Soviets.[112] During this same timeframe, the U.S. saw a shift in support to our allies with just nearly seven billion expended between 1966 to 1969 but a 40-percent increase between 1970 to 1973. During the Israeli-Arab wars from 1967 to 1973, the Soviets increased their aid to Egypt and Syria, including the establishment and operation of an air defense system in Egypt, and as the war unfolded between March 1969 to August 1970 along the Suez Canal, the U.S. felt obligated to increase their aid to Israel from $40-million-a-year for three years post the Six-Day War to $400-million-a-year after, nearly 28-percent of Israel's total defense spending.[113] However, this region

Egyptian F-16s.

Headquarters Air Force Systems Command, Andrews AFB, Maryland.

would be constantly changing and in 1979, the U.S. and Egypt signed a letter of offer and acceptance for the sale of 40 F–16A/B aircraft under the name of PEACE VECTOR to modernize the Egyptian Air Force and demonstrated the United States' willingness in providing Egypt with similar equipment provided to Israel, known as PEACE MARBLE. Similar foreign military sales took place in the mid-to-late 1970s.[114]

During President Nixon's 1972 State of the Union Address, he stressed his Realistic Program of Foreign Assistance, which included provisions for loans and grants-in-aid, foreign military sales (FMS), military technology licensing, and technology transfer to key allies. A few years prior, during Secretary Laird's message to Congress on the FY 1971 Defense Budget in February 1970, he noted that due to the Nixon Doctrine, the defense budget percent of the GNP would drop to 7 percent, down from 9.5 percent in FY 1968 with the passing comment that DoD was "looking for a new 'International Fighter' for NATO and its other allies," those individuals that, under the Nixon Doctrine, "would be taking more responsibility for their own defense." This pledge was reflected in the DoD FY 1973 Annual Report which Secretary Larid pointed out that for the "first time, planning for military assistance and credit sales took place." Secretary of Defense Elliot Richardson, in April 1973, pointed out to the House Armed Services Committee that "strong alliances of friendly nations, with each carrying its equitable share of the burden of the common defense" was essential to having "sufficiency of military strength." This would be displayed over the following years to various countries and of note in the Middle East where United States contractors found a willing market for military technology with U.S. suppliers pleased to support such countries like Saudi Arabia. Between 1973 and 1980, Saudi Arabia obtained roughly $34 billion in military hardware through FMS and transfers with the Saudi Air Force first modernized with Northrop F–5s and then, by the end of the decade, updating to the more advanced *Eagle*. An observer noted in 1977 that the Saudi military build-up was so rapid that "even if Saudi Arabia were to receive no more military equipment it would take six years for existing personnel to be able to use already bought technology." Some NATO defense chiefs selected the F–16 as their next standard "swing-role fighter" with the aircraft "saddled with NATO's traditional tactical fighter-bomber, ground-attack mission" as well.[115]

Movement of Weapon System Program Offices to Air Force Systems Command

Early in the F–X Program, June of 1969, General James Ferguson, commander of Air Force Systems Command, attended a discussion on F–15 program management that included Deputy Secretary of Defense David Packard, Secretary of the Air Force Robert C. Seamans, Under Secretary John L. McLucas, and Air Force Chief of Staff General John D. Ryan. Out of this meeting, various agreements were reached with AFSC assigned to "manage and perform the research, development, and procurement of systems and equipment to achieve those capabilities." Following the meeting, Ferguson took the opportunity to write General Ryan and bluntly stated that it was time to "take advantage of the current attitude in OSD to streamline Air Force procedures, establish responsibilities clearly, and set the example which will pre-empt any DDR&E attempts to continue their detailed direction of our programs." He further requested the following within the F–15 program – "the transfer of the F–15 Program Element Monitor (PEM) responsibility from Headquarters USAF to AFSC, qualified individuals to function in the F–15 PEM, and a general officer to cover the position as F–15 Program Director" – with General Ryan approving the request with an effective date of July 14, 1969. General Ferguson established the Office of the Assistant for F–15 at AFSC Headquarters, reporting directly to him,[116] and at the same time

US Air Force Chief of Staff, General John D. Ryan.

directed the Aeronautical Systems Division Commander at Wright-Patterson to continue their functional support of the F–15 System Program Office. This decentralization of the F–15 program impressed General Ryan, who in September stated his intentions to "reduce detailed system program management in the Air Force and to depend on AFSC to manage assigned programs in the Washington area." The Chief of Staff, pointed to the F–15 as an example of shifting elements of systems program management to AFSC and directed the transfer of the F–111, Minuteman, and Program 664 to AFSC on November 1, 1969; two months later, the C–5, A–7D, AGM-69, Program 777, Airborne Warning and Control System (AWACS), and others would be added to the list.[117]

Conclusion

The planes of the 1970s were designed to survive in threatening environments, drop tons of ordnance on enemy targets with strike aircraft accompanied by fighter planes, equipped with the newest radar, long-range television, and radiation sensors with the newest antiaircraft missiles to engage enemy aircraft at different ranges. Along with these, electronic-warfare aircraft, such as the E–3 *Sentry* or AWACS, were able to capture enemy communications and integrate the data and command the air battle.[118] It took Secretary Packard, to help with the rise of the fourth-generation airpower with the significant budget cuts that would come in the early 1970s, to change how DoD acquired systems and develop a long-term strategy that ultimately enabled DoD to "modernize its forces during a decade of considerable cost constraints." Packard's most significant contribution during this period was the reintroduction of prototyping and the "fly-before-you-buy" approach to defense acquisition that decreased risk and uncertainty. Elements of Packard's "fly-before-you-buy" approach were implemented at the subsystem level to mitigate risk in the B–1, F–15, F–16, A–10, and AWACS programs along with parts of the original DoD Instruction 5000 series, creating the Program Objective Memorandum (POM) and concepts of the Milestone Decision Authority (MDA), all which contributed to pieces of today's framework of modern acquisition systems with some calling Packard the "father of fourth-generation airpower." However, once leaving DoD, Packard addressed continued frustration with resistance to changes in the acquisition process with individuals objecting to extensive testing with some believing it would "delay" programs but Packard pointed out that testing "showed up things that needed to be fixed and it took time to fix them," thus delaying the "initial operating capability" of the weapon system. He believed that if this thinking was not able to be gotten rid of, there would "be no hope." Ultimately, Packard's reforms led to the launching various platforms—the F–16, F–15, A–10, AWACS, C–17, and the B–1—between 1969 and 1972 that provided the Reagan administration with "production-ready, combat-ready options to modernize the force in the 1980s" with defense aircraft production increasing 80-percent between 1980 and 1986 compared to only 6-percent from 1977 to 1980. Secretary Packard's reforms centered on weapon systems – airframes and propulsion systems – that saw significant use during Operation Desert Storm and still today.[119]

Conversely, predecessors of Air Force Materiel Command also contributed greatly in the years leading up to Desert Storm with systems such as the Low-Altitude Navigation Targeting Infrared for Night (LANTIRN), the Northrop Grumman E–8 Joint Surveillance Target Attack Radar System (JSTARS), and Navigation Satellite Timing and Ranging (NAVSTAR) global positioning system (GPS) to name just a few. In August 1990, LANTIRN was one of the first systems to deploy with the F–15E *Strike Eagle* and F–16 C/D *Viper* of the 4th Tactical Fighter Wing, 247th Tactical Fighter Wing, and the 388th Tactical Fighter Wing. In total, the system flew over 14,000 combat hours with the *Strike Eagles* flying exclusively at night with the LANTIRN system. Two years prior, delivery started with only twelve pods delivered by August 1990 with scheduled completion not projected until 1992 as well as its initial operational capability not reached at the time of deployment. The LANTIRN was directly inserted in combat in some airframes but there was no logistical system in place and no spares nor validated technical orders. Also, the system was still working through initial problems resulting in a support team deploying to the 4 TFW's location "to fill gaps in organic maintenance capability and logistical support."[120] The JSTARS, in January 1991, was still in development with an expected initial operational capability four or five

Boeing E-3 Sentry Airborne Warning and Control Systems (AWACS) and Northrop Grumman E-8 Joint Surveillance Target Attack Radar System (JSTARS) together on the tarmac.

years down the road with software in development and prototype hardware; however, due to a successful field demonstration in Europe during the Fall of 1990 to give Tactical Air Command users an opportunity to preview its capabilities and refine operational requirements, General Schwarzkopf decided to deploy it.[121] Finally, NAVSTAR had been an ongoing program for several years but suddenly found itself in the spotlight with the launching of Desert Storm due to the "featureless environment providing few navigation and location cues" with NAVSTAR providing "precise position, velocity, and time information" to aircrews.[122]

But it was the lessons learned from the Yom Kippur War that showed the cost-effectiveness of fighter-bomber aircraft could be questioned and that it could either prohibit an attacker with a limited quantity from conducting large-scale attacks or necessitate the employment of inexpensive, light-weight aircraft with reduced payloads. New, technologically advanced, air defense threat systems required increasingly sophisticated electronic counter-measure (ECM) equipment, greater use of drones for reconnaissance and electronic support missions, and the employment of stand-off-air-to-surface missiles.[123] It was these lessons from the 1970s that paid off for the U.S. Air Force in the 1990s in the quality and quantity of aircraft and materiel that contributed to the successful air campaign in the Persian Gulf with authors from the Gulf War Air Power Survey noting that the United States provided "all or almost all of the Coalition's command and control systems, electronic warfare aircraft, heavy bombers, cruise missiles, and stealth capabilities…. Some [capabilities] were based on quality [for example, stealth], others on a quantity so great that it brought a quality all of its own."[124]

In the 1992 Department of Defense Annual Budget Report shortly after the Gulf War, Secretary of Defense Dick Cheney stated that "capable and survivable tactical air forces with sustainable global reach would continue to be key to this nation's success in meeting future challenges."[125] It is this future challenge that has current leaders developing new approaches once again to defense acquisition, more notably the growing threat of a militaristic China, an aging workforce, and the growing opportunities of new digital technology.

It is this new digital technology that in 2022 General Duke Z. Richardson, Air Force Materiel Command commander, warned that leaders needed to "get on the bus, or you're going to get run over by the bus" when discussing the use of digital engineering and modeling to design, develop, and sustain new systems. Under Secretary of Defense for Acquisition and Sustainment William A. LaPlante added to this when speaking to industry when he told them that they "…should be moving – if you haven't already – your engineering departments into the digital world." LaPlante explained that the move to paperless designs was not about automating the process but that digital engineering gives the ability to "crunch designs overnight; tens of thousands of designs…digitally, so you can find design spaces you would never have found before" as well as it benefitted new engineers by enhancing and accelerating learning curves with new engineers to create "sophisticated designs, whereas 20 years ago, it might have [required] someone with 10 years of experience" to complete.[126]

Andrew Hunter, Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics, pointed out that the Operational Imperatives laid out by Air Force Secretary Frank Kendall demands "more efficient, and more effective acquisition than what has been possible in the past two decades." He went on at an Air Force Association event in September 2022 to state that this "demands a 'sense of urgency' and focus" because China's goal of becoming the world's top military superpower necessitates "transforming the acquisition system for the 21st century."[127] New acquisition systems have to deal with systems being developed that are software intensive, shying away from the past systems that were the foundations of the acquisition world. But General Richardson sees this as a benefit, not only in the acquisition of the system but also sustaining it, as it "will actually allow us to accelerate all along the life cycle" if the digital 'foundation' was built correctly.[128]

The Air Force has its "job jar" full as it begins to modernize its nuclear deterrence, fielding new weapon systems while finding new ways to sustain legacy systems, much like what was confronted leaders over 50 years ago. Leaders today are challenged with revolutionizing weapon acquisition/sustainment systems to keep pace and answer an economic power and technologically advancing China while encountering resource challenges. ■

NOTES

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3. Jamieson, *Lucrative Targets*, pp. 1-2.
4. Keaney & Cohen, *Summary Report*, p. 3; Jamieson, *Lucrative Targets*, p. 3.
5. Jamieson, *Lucrative Targets*, pp. 3-4.
6. *Ibid*, pp. 4-6.
7. Keaney & Cohen, *Summary Report*, p. 1.
8. For the purpose of this paper, total number of aircraft deployed to the Persian Gulf: 120 A–10s, 96 F–15Cs, 46 F–15Es, 168 F–16s, 36 F–117s, and 7 E–3As, Eliot A. Cohen, *Gulf War Air Power Survey, Volume V: A Statistical Compendium and Chronology*, (Washington: Government Printing Office, 1993), pp. 27-28.
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10. Gen Merrill A. McPeak, Air Force Chief of Staff, to Gen Wilbur L. Creech, letter, 16 January 1991, in Edgar F. Puryear Jr., *American Generalship: Character is Everything: The Art of Command,* (New York: Random House, 2000), p. 226.
11. Bill Creech, *The Five Pillars of TQM: How to Make Total Quality Management Work for You*, (New York: Dutton, 1994), 123 cited in Slife, *Creech Blue*, p. 1.
12. Jamieson, *Lucrative Targets*, p. 41; Keaney & Cohen, *Summary Report*, p. 13.
13. Keaney & Cohen, *Summary Report*, p. 24.
14. Total sorties flown: A–10s, 8084; F–15C, 5685 (Saudi Arabia, 2088); F–15E, 2172; F–16, 13,087 (Bahrain, 166); F–117, 1299; E–3, 379 (Saudi Arabia, 303), Cohen, *Statistical Compendium*, p. 316.
15. These radar systems were an outgrowth of the Forward Looking Advanced Multi-mode Radar Program overseen by Wright Laboratory's Avionics Directorate in the 1970s. R. Ray Ortensie, *FLASHBACK: Wright-Patterson's Support to Operation DESERT STORM*, (Wright-Patterson AFB: HQ AFMC History Office, January 2021), https://media.defense.gov/2021/Jan/22/ 2002569566/-1/-1/1/FB_WPAFB%20AND%20DESERT%20 STORM.PDF; Lt Col (USAF) Joanne S. Schoonover, *Accelerated Air Force Acquisition Processes: Lessons Learned from Desert Storm*, (Maxwell AFB: Air University Press, August 1994), pp. 3-4.
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24. Hallion, *Storm Over Iraq*, p. 68.
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26. Hallion, *Storm Over Iraq*, pp. 67-68.
27. David K. Henry and Richard P. Oliver, "The Defense Buildup, 1977-85: Effects on Production and Employment," *Monthly Labor Review*, August 1987, pp. 3-11; John T. Correll, "Sacrifice to the Deficit Monster," *Air & Space Forces Magazine*, 1 Dec 1987.
28. Robert S. McNamara, Secretary of Defense, "The Fiscal Years 1969-73 Defense Program and the 1969 Defense Budget," *Senate Armed Services Committee*, 22, January 1968, p. 134.
29. Hallion, *Storm Over Iraq*, pp. 27-28, 31, 37.
30. George and Meredith Friedman, *The Future of War: Power, Technology and American World Dominance in the Twenty-First Century*, (New York: St Martin's Griffin, 1996), p. 250.
31. Hallion, *Storm Over Iraq*, pp. 20-2.
32. The Fighter Mafia consisted of: Maj John Boyd, Chuck Myers, Pierre Sprey, Col Everest Riccioni, and Maj John "Mike" Loh. Riccioni, according to Dr. Michel, is credited with the group's designation and naming himself "the Godfather." These men were dedicated to ending the status quo on fighter development and spent from 1966 to 1972 transforming the Air Force's approach to air superiority. See Hallion, *Storm Over Iraq*, p. 38; Marshall L. Michel III, *The Revolt of the Majors: How the Air Force Changed After Vietnam*, Dissertation, Auburn University, 15 December 2006, p. 123.
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36. Michel, *Revolt of Majors*, pp. 120-1; Frederickson, *Laird-Packard Way*, pp. 28-9.

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38. Frederickson, *Laird-Packard Way*, p. 3; Michel, *Revolt of Majors*, pp. 121-2; Brown, *Defense Acquisition*, pp. 145-6.

39. Frederickson, *Laird-Packard Way*, pp. 33-4.

40. Fox, *Defense Acquisition Reform*, pp. 42-3, 47-9; Michel, *Revolt of Majors*, pp. 121, 125; Frederickson, *Laird-Packard Way*, pp. 2-3, 29; Brown, *Defense Acquisition*, p. 147; Air Force Systems Command History Office (AFSC/HO), *History of Air Force Systems Command (AFSC), 1 July 1969 – 30 June 1970, Volume I: Narrative*, (Information used is Unclassified), p. 11, hereafter sited as *FY 1970 History*; Foote, *Concurrency*, pp. 53-54.

41. Prototyping was not a new concept in the 1960s as the concept was called Pilot Models prior to World War II. Prototypes are/were utilized to reduce technical risks, validate designs or estimate costs, evaluate manufacturing processes, refine requirements, and/or explore operational concepts. Most prototypes were not the fully designed system and were only designed to various critical performance parameters. Brian Duddy, "What Are Prototypes? Very Useful, But Not Panaceas," *Defense Acquisition*, Vol. XLIX No. 2 (March-April 2020), pp. 26-27, https://www.dau.edu/library/defense-atl/DATLFiles/Mar-April_2020/DEFACQ%20Mar-Apr%202020.pdf.

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43. Michel, *Revolt of Majors*, p. 122; Brown, *Defense Acquisition*, 148; HQ AFSC/HO, *FY 1970 History*, pp. 4-5.

44. Brown, *Defense Acquisition*, pp. 141-2.

45. Frederickson, *Laird-Packard Way*, p. 38.

46. HQ AFSC/HO, *History of Air Force Systems Command, Fiscal Year 1971-1972, Volume I: Narrative*, Andrews AFB, pp. 117-18 [Information used is Unclassified]; HQ AFSC/HO, *History of Air Force Systems Command, Fiscal Year 1974, Volume I: Narrative*, Andrews AFB, pp. 8-9 [Information used is Unclassified]; Neufeld, *F-15 Eagle*, pp. 42-44.

47. Frederickson, *Laird-Packard Way*, pp. 71-72; Edgar F. Puryear Jr., *George S. Brown, General, US Air Force: Destined for Stars*, (Novato: Presidio, 1993), p. 190.

48. Joseph S. Doyle, Sq Leader, RAF, *The Yom Kippur War and the Shaping of the United States Air Force*, Dissertation, School of Advanced Air and Space Studies (SAASS), Drew Paper No. 31, (Maxwell AFB: February 2019), p. 1.

49. Hallion, *Storm Over Iraq*, p. 59.

50. Doyle, *Yom Kippur War*, p. 1; Robert S. Bolia, "Overreliance on Technology in Warfare: The Yom Kippur War as a Case Study," *Parameters*, Vol 34 No 2 (Summer 2004), p. 51.

51. At least nine Arab states, including four non-Middle Eastern nations (Libya, Sudan, Algeria, and Morocco) actively assisted the Egyptian-Syrian war efforts along with Iraq moving a squadron of Hawker *Hunter* jets to Egypt months prior to the attack. Doyle, *Yom Kippur War*, p. 2.; American-Israeli Cooperative Enterprise (AICE), "Background & Overview – Yom Kippur War," *Jewish Virtual Library*, www.jewishvirtuallibrary.org/background-and-overview-yom-kippur-war, Accessed 9 February 2023.

52. Lawrence Whetten and Michael Johnson, "Military Lessons of the Yom Kippur War," in *The World Today*, Vol. 30 No. 3 (March 1974), p. 101.

53. Adam R. Grissom, Caitlin Lee, and Karl P. Mueller, *Innovation in the United States Air Force: Evidence from Six Cases*, RR1207, (Santa Monica: RAND, 2016), p. 53.

54. For a discussion on US diplomatic discussion on the Arab-Israeli standoff prior to US support to Israel, see Office of Historian, Department of State's "The 1973 Arab-Israeli War," https://history.state.gov/milestones/1969-1976/arab-israeli-war-1973, Accessed 9 February 2023.

55. Doyle, *Yom Kippur War*, p. 2; AICE, *Yom Kippur War*.

56. Doyle, *Yom Kippur War*, pp. 6-7.

57. Whetten & Johnson, *Yom Kippur War*, p. 103; Bolia, *Overreliance*, pp. 52-53.

58. *Ibid*, pp. 103-4.

59. Doyle, *Yom Kippur War*, pp. 8-9.

60. Lt Gen (Ret) Ira C. Eaker, "Some Observation on the Latest Arab-Israel War," address, Squadron Officers School, Maxwell AFB, AL, 28 November 1973, cited in Doyle, *Yom Kippur War*, p. 9.

61. Chaim Herzog, *The War of Atonement: The Inside Story of the Yom Kippur War*, London: Greenhill Books, 2003, 261, cited in Doyle, *Yom Kippur War*, p. 9.

62. International Institute of Strategic Studies, "The Middle-East War," *Strategic Survey* 74 (April 1974), p. 55, cited in Doyle, *Yom Kippur War*, p. 10.

63. Meir Finkel, *On Flexibility: Recovery from Technological and Doctrinal Surprise on the Battlefield*, translated by Moshe Tiamin, Stanford: Stanford Security Studies, 2011, 1pp. 71-2, cited in Doyle, *Yom Kippur War*, p. 12.

64. Adm T.H. Moorer, Chairman, Joint Chiefs of Staff, to Secretary of Defense, memorandum, 30 October 1973, Enclosure B, cited in Doyle, *Yom Kippur War*, p. 17.

65. Adm T.H. Moorer, Chairman, Joint Chiefs of Staff, to Secretary of Defense, memorandum, 30 October 1973, Enclosure A, cited in Doyle, *Yom Kippur War*, p. 18.

66. Joint Chiefs of Staff, United States Military Equipment Validation Team (US-MEVTI), *Trip Report to Israeli Defense Forces, 28 October – 8 November 1973*, 1973, vii, cited in Doyle, *Yom Kippur War*, pp. 18-19.

67. House Armed Services Committee to Secretary of the Air Force, memorandum, 29 November 1973, p. 2, cited in Doyle, *Yom Kippur War*, p. 19.

68. John L McLucas, Secretary of the US Air Force to General George S. Brown, Chief of Staff US Air Force, memorandum, 30 October 1973, cited in Doyle, *Yom Kippur War*, pp. 19-20.

69. Retired as Commander in Chief, North American Aerospace Defense Command and US Space Command and Commander, Air Force Space Command, Peterson AFB, Colorado.

70. Lt Col C.A. Horner, Directorate of Operations, Air Staff Talking Papers, subjects: Mid East War Data Support of USAF Programs; Inter-dependence of Air and Ground Operations, 24 November 1974 cited in Doyle, *Yom Kippur War*, pp. 19-20.

71. Grissom, *Innovation*, p. 53.

72. Doyle, *Yom Kippur War*, pp. 26-27.

73. Robert R. Tomes, *US Defense Strategy from Vietnam to Operation Iraqi Freedom: Military Innovation and the New American Way of War, 1973-2003*, (Abington: Routledge, 2007), p. 58.

74. Tomes, *US Defense Strategy*, p. 65.

75. Slife, *Creech Blue*, p. xx.

76. Department of Defense, *Report of the Secretary of Defense James R Schlesinger to the Congress on the FY 1975 Defense Budget and FY 1975-1979 Defense Program*, March 4, 1974, Washington: US Government Printing Office, 1974, p. 112.

77. Hallion, *Storm Over Iraq*, pp. 69-70.

78. Michel, *Revolt of Majors*, p. 122; Neufeld, *F-15 Eagle*, pp. 55-64.

79. See Robert Coram's *Boyd: The Fighter Pilot Who Changed*

the Art of War (New York: Back Bay Books, 2002), for a discussion on Boyd's involvement on the designs of the F-15 *Eagle*, particularly chapters "Thirteen: I've Never Designed a Fighter Plane Before", "Fourteen: Bigger-Higher-Faster-Farther," and "Fifteen: Saving the F-15." See also, Aeronautical Systems Division History Office (ASD/HO), *History of the Aeronautical Systems Division (ASD), January 1967 – June 1968, Volume I: Narrative*, Wright-Patterson AFB, pp. 299-308; Neufeld, *F-15 Eagle*, pp. 18-20.

80. Hallion, *Storm Over Iraq*, p. 40; ASD/HO, *History of ASD, Jan 1967 – Jun 1968*, pp. 297-314; Neufeld, *F-15 Eagle*, pp. 55-61; Drews, *Great Engine War, pp.* 30-32.

81. Michel, *Revolt of Majors*, pp. 127-8; Neufeld, *F-15 Eagle*, pp. 32, 55-64; C.R. Anderegg, *Sierra Hotel: Flying Air Force Fighters in the Decade After Vietnam*, (Washington: Air Force History and Museums Program, 2001), p. 154; Maj Robert W. Lyons, *The Search for an Advanced Fighter: A History from the XF-108 to the Advanced Tactical Fighter*, Rpt. No. 86-1575, (Air Command and Staff College, Air University, April 1986), p. 23.

82. Michel, *Revolt of Majors*, p. 123; Foote, *Concurrency*, pp. 56-57.

83. Lee, *Strategy*, p. 131.

84. Schlesinger, *FY 1075 Report*, p. 150; Michel, *Revolt of Majors*, pp. 132-3.

85. Frederickson, *Laird-Packard Way*, p. 60; Michel, *Revolt of Majors*, pp. 126-7; Neufeld, *F-15 Eagle*, p. 48.

86. John T. Correll, "The Costly Alternative to Controlling Cost," *Air & Space Forces Magazine*, 1 June 1983; Lee, *Strategy*, p. 133.

87. Slife, *Creech Blue*, pp. 15-16.

88. Schlesinger, *FY 1975 Report*, p. 150; Michel, *Revolt of Majors*, p. 123; Neufeld, *F-15 Eagle*, pp. 64-66.

89. President Nixon announced on 30 June 1969 the appointment of a select committee of individuals from the private sector, headed by Mr. Gilbert W. Fitzhugh, chairman of the Metropolitan Life Insurance Company. They were to take a year to study the Defense Department, its organization, and operation and became known as the "Blue Ribbon Defense Panel." HQ AFSC/HO, *History of Air Force Systems Command, 1 July 1968 – 30 June 1969, Volume I: Narrative*, Andrews AFB (Information used is Unclassified), p. 28; Michel, *Revolt of Majors*, p. 129. See Department of Defense, *Report to the President and the Secretary of Defense on the Department of Defense by the Blue Ribbon Defense Panel*, 1 July 1970; Foote, *Concurrency*, pp. 54-56.

90. Named after its leader, Allan Simon, who worked in research and development in the Department of Defense.

91. The YF-17 ultimately became the Navy's F-18 and remarked by Packard in his memoir as the "best Navy fighter."

92. Puryear, *Brown*, p. 220; Michel, *Revolt of Majors*, pp. 133-4; ASD/HO, *History of Aeronautical Systems Division. July 1973 – June 1974, Volume I: Narrative*, Wright-Patterson AFB, p. 8.

93. Frederickson, *Laird-Packard Way*, p. 78; Michel, *Revolt*, pp. 137-8; History, ASD/HO, *History of Aeronautical Systems Division, July 1974 – June 1975, Volume I: Narrative*, Wright-Patterson AFB, p. 239.

94. Anderegg, *Sierra Hotel*, p. 176.

95. Frederickson, *Laird-Packard Way*, p. 64.

96. Frederickson, *Laird-Packard Way*, pp. 64-5; Michel, *Revolt of Majors*, p. 128; Anderegg, *Sierra Hotel*, pp. 166-68. For a complete history of the fielding of the A-X/A-10/GAU-8, see R. Ray Ortensie, Ed., *Birth of a Hog: The Beginnings of the A-10 Warthog*, Wright-Patterson AFB, 2021.

97. Anderegg, *Sierra Hotel*, p. 168. For a complete history of the fielding of the A-X/A-10/GAU-8, see Ortensie, *Birth of a Hog*.

98. Hallion, *Storm Over Iraq*, p. 62.

99. *History of Tactical Air Command, Fiscal Year 1974*, 125, cited in Doyle, *Yom Kippur War*, p. 47.

100. Paul G. Kaminski, "Low Observables: The Air Force and Stealth," in *Technology and the Air Force: A Retrospective Assessment*, eds. Jacob Neufeld, George Watson, Jr., and David Chenoweth, (Washington: Air Force History and Museums Program, 1997), 299-300, cited in Doyle, *Yom Kippur War*, p. 47.

101. Ian A. Maddock, "DARPA's Stealth Revolution," in *50 Years of Bridging the Gap*, DARAP, 2012, p. 152, cited in Doyle, *Yom Kippur War*, p. 47.

102. Kaminski, "Low Observables," p. 300, cited in Doyle, *Yom Kippur War*, p. 47.

103. Mailes, *Mythical Nighthawk*, p. 33.

104. Tomes, *Defense Strategy*, p. 79, cited in Doyle, *Yom Kippur War*, pp. 47-8.

105. Also referred to as SENIOR TREND in some sources. Memo, Ed Martin to Ben Rich, "Comments on XST, May 19th ARPA Review," 26 May 1976, https://www.archives.gov/files/declassification/iscap/pdf/2019-010-doc-1.pdf; Timeline, "XST Log, 26 March 1975 to 23 Dec 1977," ca. 1977, https://www.archives.gov/files/declassification/iscap/pdf/2019-010-doc-2-corrected-version.pdf.

106. Aronstein and Piccirillo, Have Blue and the F-117A: Evolution of the "Stealth Fighter", Reston: American Institute of Aeronautics and Astronautics, 1997, pp. 32-33, 154, cited in Doyle, Yom Kippur War, pp. 47-8; Mailes, *Mythical Nighthawk*, p. 50.

107. Brown, *Defense Acquisition*, pp. 148-9. For a look on the Lightweight Fighter Program, see David Aronstein & Albert Piccirillo, *The Lightweight Fighter Program: A Successful Approach to Fighter Technology Transition*, (Arlington: ANSER, 1995).

108. Frederickson, *Laird-Packard Way*, pp. 67-9.

109. Frederickson, *Laird-Packard Way*, pp. 60-1, 68.

110. Frederickson, *Laird-Packard Way*, p. 68.

111. Frederickson, *Laird-Packard Way*, pp. 68-69; Drewes, *Great Engine War*. p. 111.

112. Frederickson, *Laird-Packard Way*, pp. 44-45.

113. Frederickson, *Laird-Packard Way*, pp. 43-44; Neufeld, *F-15 Eagle*, p. 48.

114. Col. (USAF) David R. Olds, "A Case Study: PEACE VECTOR I (Sale of 40 F-16s to Egypt)," *Air Force Journal of Logistics*, Vol. IX. No. 4 (Fall 1985), pp. 21-24.

115. Hallion, *Storm Over Iraq*, p. 41-2; Frederickson, *Laird-Packard Way*, p. 78; Brown, *Defense Acquisition*, pp. 142-144; Michel, *Revolt of Majors*, pp. 126-7, 132-3; Elliot L. Richardson, "Fiscal Year 1974 Annual Defense Department Report," *House Armed Services Committee*, 10 April 1973, p. 20.

116. Brig Gen (designee) Benjamin Bellis was named the new director just three days earlier with the general officer position established from the vacancy opened by the cancellation of the Manned Orbital Laboratory (MOL) program in June. Bellis was the Air Force's most senior R&D manager, with service dating back to the Special Weapons Project at Sandia Base, New Mexico in 1947, and was the first general officer assigned to a Weapon Systems Program Office (WSPO) or Systems Program Office (SPO).

117. HQ AFMC/HO, *FY 1970 History*, pp. 12-14, 17; Neufeld, *F-15 Eagle*, pp. 38-44.

118. Friedman, *Future of War*, p. 250.

119. Production of aircraft and missile engines for defense increased by 14-percent between 1977 and 1980 compared with 69-percent increase from 1980 to 1985. Frederickson, *Laird-Packard Way*, 7, pp. 87-8; Brown, Defense Acquisition, pp. 155-6; Henry, *Defense Buildup*, pp. 3-11; Foote, *Concurrency*, pp. 58-60.

120. Schoonover, *Accelerated*, p. 27; Slife, *Creech Blue*, pp. 62-3.

121. Schoonover, *Accelerated*, pp. 29-30.

122. Schoonover, *Accelerated*, pp. 32-3.

123. Whetten & Johnson, *Military Lessons*, pp. 105.

124. Thomas A. Keaney and Eliot A. Cohen, *Revolution in Warfare? Air Power in the Persian Gulf*, Annapolis: Naval Institute Press, 1995, p. 153, cited in Doyle, *Yom Kippur War*, p. 53.

125. Dick Cheney, Secretary of Defense, *Annual Report to the President and the Congress*, Washington, Government Printing Office, February 1992, p. 84, cited in Doyle, *Yom Kippur War*, pp. 54-5.

126. John A. Tirpak, "Acquisition Reform Takes On a Sense of Urgency," *Air and Space Forces Monthly*, Vol. 105 No. 11 (November 2022), p. 39.

127. Tirpak, *Acquisition Reform*, p. 40.

128. Tirpak, *Acquisition Reform*, pp. 40-1.

Perception-vs-Reality: The True History of Weaponized Weather and Operation Popeye in Southeast Asia

David Reade

Image of an actual tropical cloud seeded with Silver iodide, during the US Navy's Operation GROMET II (the Philippines 1969) as part of drought relief efforts. *(Photo courtesy of Dr. Edwin X Berry.)*

In certain instances, perceived history, as presented in the public domain as factual history, were in reality often misconstrued, with elements which were incorrect or not historically accurate, with the perception of the story teetering on the edge of representing modern mythology. (*The public domain referred to here is that historical information contained within current and archival newspapers, magazines, books and internet webpages and other media.)*

One public domain historical story, that surrounds the Vietnam Conflict (1955 – 1975), is the military utilization of weather modification as a weapon of war, as conducted under classified U.S. military efforts known as Project & Operation Popeye (1966-72). Popeye comprised the use of various cloud seeding technologies (and techniques) to principally extend the rainy monsoon season in Southeast Asia (SEA), to "muddy-up" the Ho Chi Minh Trail system—that winds its way through areas of North Vietnam, Laos, Cambodia and South Vietnam—to tactically support U.S. interdiction efforts to counter infiltration of North Vietnamese combatants and supplies flowing into areas of South Vietnam. (The Ho Chi Minh Trail was a complex network of jungle roads, routes, trails and footpaths used to covertly travel from the north to the south of Vietnam. Many parts of the Ho Chi Minh Trail still exist today, with various sections of the route having been paved as components of the newer Ho Chi Minh Highway.) It was thought that utilization of the ever-growing technology of weather modification (during the 1960s -70s) might provide a viable means to support the further prosecution of the war.

Weather as a Weapon

Weather has always been of interest to the military and became of greater interest to them with the beginning of manned flight and subsequently more so with the era of Jet aviation. But as the Cold War era began and soon heated up, perceived threats from the Soviet Union had the U.S. military scrambling for new weapons. Weather control had been suggested as a potential new Cold War weapon which needed to be explored in greater detail. As a proposed new weapon, weather modification seemingly had the potential to release large amounts of energy to destroy an enemy force, deny his use of the battlefield, while causing costly economic hardships at home, or in some cases, improve the battlefield weather

* **Author's Note:** Recently, in the pages of this publication, the concept of perceived history -vs- the reality of history was presented. ("Historical Perception vs Reality: the Story of Joseph B. Duckworth's 1943 Hurricane Flights;" the *Journal of the Air Force Historical Foundation*, Vol.70, No.1; Spring 2023.)

North Vietnamese supply vehicles proceed along the Ho Chi Minh Trail.

Project Popeye WC–130A Hercules in 1968.

conditions (strategically) towards the advancement of one's own forces.

Proposed military applications for cloud seeding technology / weather control efforts comprised the release of violent weather against an enemy's territory, disrupt agricultural areas of a nation for strategic purposes (hindering a nation's commerce), influence weather (heavy rain or snow) to hinder an enemy's troop movements, rendering incapable the enemy's ability to logistically resupply itself or control weather precipitation as a means to deliver biological and or radiological agents.

Despite the perceived threat posed by Soviet climate change and cloud seeding experiments, it was the United States of America that has the distinction of being the first nation in the world to have implemented weather modification as a weapon in active conflicts.

The weather modification effort in question here, Popeye, came to fruition during the Vietnam Conflict, when clandestine cloud seeding aircraft flew over remote and steamy jungles of Southeast Asia to cause a near-steady state of monsoon rainfall in an effort to flood out key stretches of the infamous "Ho Chi Minh Trail" (HCMT) and stem the flow of logistical material transport and personnel along the trail network by Viet Cong guerrillas (VC) and North Vietnamese Army (NVA) units. U.S. Department of Defense (DoD) estimates in 1966 suggested between 58,000 and 90,000 NVA troops (at least 5 full regiments) infiltrated into South Vietnam via routes that makeup the Ho Chi Minh Trail system. At the time, U.S. intelligence reports further established that North Vietnamese forces were building drivable sections of road along the trail network from North Vietnam through to Laos and Cambodia. Thus, the interdiction of enemy movements along the trail was paramount and the implementation of cloud seeding / weather modification as a tactical weapon was employed.

David Reade is a retired international aerospace consultant, aviation journalist and once leading authority on maritime patrol and scientific research aircraft. As P-3 Publications, Reade continues to write authoritative historical articles associated with little known aspects of aviation history and a book on the unrealized history of hurricane hunting aircraft, since before WWII to present. It is in this area, backed up by considerable (deep) archival research, that has led Reade to reinterpret our understanding of the history of hurricane hunting, the aircraft utilized and the people involved, to correct the perceptions of history and present the unrealized reality of it. The article presented here, is but a small example of the overall history of Hurricane Hunting and the perceptions -vs- the reality of that history.

Project Popeye (1966)

As the Popeye story goes, on September 17, 1966, the secret weather modification project in SEA was initiated, as an experimental pilot program to test the feasibility of extending the rainy monsoon season in Southeast Asia. With the proposed goals to hamper or impede North Vietnamese traffic along the HCMT network, by muddying up the trail system, washout key intersections and way stations, while making new vehicle route sections impassable. This project, utilizing cloud seeding (weather modification) technology developed by military scientists, was to extend the regional monsoon season and increase normal rainfall to soften (muddy) up road surfaces, create landslides along the roadways, washout river crossing and generally maintained soften soil conditions beyond the normal rainy season. The overall goal of the experimental project (Project Popeye) was to test the theories of extend the existing monsoon season by 30 to 45 days to muddy up sections of the trail system and (if possible) increase the annual monsoon rainfall averages by upwards of 20-30 percent.

As presented in the public domain, Project Popeye (and its follow-on Operation Popeye) cloud seeding program was a project carried out by the DoD / U.S. Air Force and flown by specially modified USAF C–130 Hercules transport aircraft and Air Force tactical reconnaissance jets flown solely from the Royal Thai Air Force Base, Udorn, in Thailand.

Most of what is perceived in the public domain about this tactical rainmaking program in SEA is attributed to a

subsequent top secret (classified) DoD briefing on the subject provided to U.S. Senator Claiborne Pell (D. Rhode Island) and his subcommittee on Oceans and International Environment (a component of the Senate's Foreign Relations Committee) in March 1974, newspaper reporting at the time, as well as aviation based internet webpages and articles detailing the USAF Air Weather Service's 54th Weather Reconnaissance Squadron participation in the Popeye cloud seeding flights*.

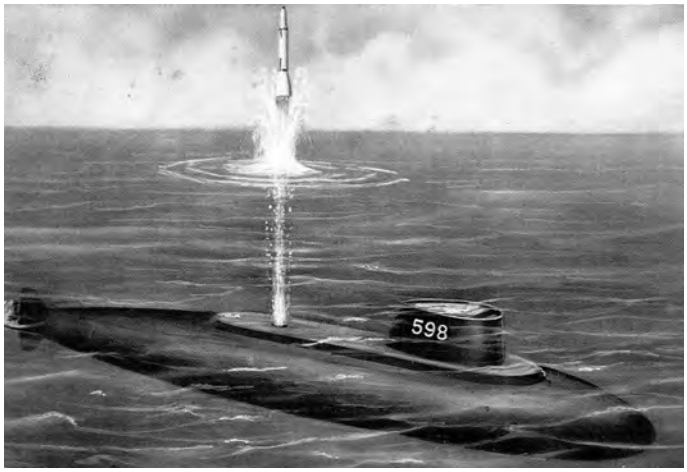
It's interesting to note; that a transcript of the March 1974 classified DoD briefing regarding rainmaking in SEA, provided to Senator Pell's committee, was arbitrary released to the public (approximately 8-weeks later) in May 1974 by Senator Pell into the congressional record as a declassifying disclosure effort to bring the program's specific information on the secret SEA rainmaking to the immediate attention of the American People.

Under public domain perceptions of Project [and Operation] Popeye histories, it has been suggested that Popeye was the first, or single, or only weaponized weather modification project conducted during the Vietnam Conflict, and more importantly during the decades of the 1960s-70s. And further, that Popeye was a weaponized weather modification program of the DoD and or the U.S. Air Force during this period.

The reality of weather modification history, and specifically that of weaponized weather, is much more comprehensive and equally convoluted than that presented by the public domain. The unrealized history of weaponized weather encompasses the fact that Popeye was just one in a long series of weaponized weather *"applications"* utilized in SEA and elsewhere in the greater extent of the Cold War. And that Popeye *(i.e. weaponized weather)* was actually conceived, pioneered and conducted by the U.S. Navy !

The Reality of Weaponized Weather

During the Cold War with the Soviet Union (1945-1991), there was a point within the U.S. Military establishment where both the U.S. Air Force and the U.S. Navy competed for the position of being the primary United States' strategic (nuclear) force. The USAF's Strategic Air Command (SAC) with its state-of-the-art Jet Bombers carrying the latest versions of nuclear bombs, versus the U.S. Navy with its brand-new fleet of nuclear ballistic submarines outfitted with the Navy's newly developed and sophisticated (nuclear tipped) Polaris Missiles.



Concept image of the Navy's nuclear-powered submarine fleet and their sub-launched "Polaris" missile system.

Unfortunately for the two services, the newly elected Kennedy Administration (1961) had essentially established a policy of co-existing with the Soviet Union, with diplomatic efforts made to relax strained relations between the two Superpowers - derailing any U.S. military concepts (or plans) towards a first-strike nuclear attack on the Soviet Union. Thus, relegating the U.S. strategic nuclear arsenal to that of a deterrent capability. They were basically being told that they were not going to be allowed to arbitrarily "Nuke" Russia.

The U.S. Navy in particular, having just spent hundreds of millions of dollars (billions in today's dollars) on its fleet of nuclear submarines with ballistic missiles (foregoing new modern Aircraft Carriers and other combatant ships until the 1970s) was not pleased. But in retrospect of this White House decision, the Navy continued to believe in an eventual confrontation with the Soviet Union. Presented with this situation, the Navy began exploring concepts for the development of a new, non-nuclear, super weapon that would have the (equivalent) power of an atomic blast to destroy the Soviets outright in any confrontation that might emerge.

Ultimately, through a series of coincidences and timing, the Navy settled on the potential of "weather" as a weapon and began to fund development of cloud-seeding technologies to create weapons of war.

As originally established in the online article; *"The Unrealized History of the Military's Utilization of Weather as a Weapon, the 'Real' Father of Weaponized Weather and the Secret Hurricane Modification Program Nobody Has Ever Heard Of"* by David Reade; P-3 Publications (January 2015), the basic story begins at The Naval Ordnance Test Station (NOTS; later the Naval Weapons Center or NWC), China Lake, California. Back in 1958-59, China Lake was asked to revise or redevelop a new survival smoke (signal) marker for Navy aircrews and jet pilots downed at sea. Although the existing Navy survival smoke markers worked well enough on land, it was difficult to see from a long distance during seaborne search and rescue missions. The

* There are other perceived public domain weather modification history references mentioning Popeye and the weaponized weather modification flights in SEA, that are subject to misconstrued (historical) information as well as biases beliefs and concepts associated with specific weather modification conspiracy theories at the core of contemporary fringe weather control conspiracies - like those regarding the current Chemtrail weather control conspiracy. In this specific case, misconstrued interpretations of weather modification history are presented within the public domain as "smoking-gun" evidence to justify their conspiracy theories.

Aerial photo of China Lake.

China Lake chemists and technicians eventually developed a smoke marker in 1960 that produced huge amounts of smoke, given its relatively small package. These smoke markers were made up of a pyrotechnic compound comprised of Silver iodide.

As established by renown atmospheric chemist Dr. Bernard Vonnegut, (pure) Silver iodide catalyzes supercooled water, within convective storms, to freeze into ice. A cloud seeding catalyst must not dissolve before the supercooled liquid has a chance to freeze. Silver iodide is relatively insoluble in water and has a particular structure similar to that of ice crystals. Thus, this chemical reaction / process induces clouds to produce rain or snow. Silver iodide was therefore the perfect chemical to be used for any cloud seeding project.

At China Lake, this Silver iodide (smoke) pyrotechnic compound was quickly recognized as being of potential interest to weathermen in weather modification projects and operations being conducted or contemplated within the United States. China Lake quickly became the center-of-excellence for the production of cloud seeding compounds, development of cloud seeding generators and different cloud seeding techniques for countless public civilian, joint civilian and military operations, and or just military cloud seeding projects and programs across the United States and the world.

It was in this capacity that China Lake additionally became the originator of a secret weather modification program for the Navy itself, that saw the development of weather as a weapon beginning in 1960-61. Supported by the Special Projects office of the U.S. Navy's Bureau of Weapons (i.e. Bureau of Naval Weapons), later by the meteorological section of the Office Of Naval Research (ONR) and later still the Navy Weather Research Facility, between 1960-1966, China Lake entered an experimental phase for the development of cloud seeding processes and procedures as well as the testing and implantation of strategic and tactical "applications" of weaponized weather – some covertly conducted using on-going public civilian or joint cloud seeding experiments as cover.

China Lake's development of weaponized weather began with the establishment of the "Atmospheric Control Experiment" (or ACE). ACE was a Research, Test, Development & Evaluation (RTD&E) program to develop the hardware, materials, procedures and techniques (and technologies) specifically needed to develop weather modification capabilities that could be used to establish tactical and strategic (as well as economic and political) applications of weaponized weather. ACE also comprised the development of associated scientific activities, such as atmospheric physics, cloud physics and weather research capabilities, at China Lake (and elsewhere), that would aid in the establishment of weather control programs.

It's seemingly apparent, that ACE was an over-arching program towards the development of weaponized weather projects and the "first" application of weaponized weather to be developed just happened to be the exploitation of hurricanes as a weapon starting in 1961.

Again, as introduced in *"The Unrealized History of the Military's Utilization of Weather as a Weapon, ...* See previous page*)*, China Lake secretly conducted experimental cloud seeding operations into Atlantic hurricanes between 1961-1966. The hurricane seeding flights were flown by various Navy aircraft (and USAF AWS Aircraft) within the open ocean areas of southwestern North Atlantic, the Western Caribbean Sea and the Gulf of Mexico, with little or no restrictions placed on the China Lake personnel involved in management of the experimental seeding flights. Unlike the subsequent public Project Stormfury* hurricane seeding operations of the U.S. Weather Bureau (jointly with the Navy), that conducted weather modification operations [to weaken hurricanes] out of Puerto Rico into a small, boxed seeding area approximately 100 miles (161 kms) x 150 miles (241 kms) – bound by rigid restrictions.

While Stormfury only seeded about three or four hurricanes in its 21-year existence, the Navy's (China Lake) secret hurricane program seeded dozens of hurricanes between 1961-66 alone. Under this secret effort, hurricanes were intensified and steered towards Cuba to wrought destruction on the island-nation from the power of these tropical giants.

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* Some public domain references suggest that Project Stormfury "was" itself a malevolent covert hurricane seeding program of the U.S. Government / U.S. Military conducted to weaponize hurricanes instead of the publicly stated goals of this hurricane research project to weaken the storms. The reality of the situation is that Stormfury was not exploiting hurricanes towards the development as weapons. However, the U.S. Weather Bureau jointly conducted Stormfury with the U.S. Navy (i.e. the Navy Weather Research Facility via ONR funding). The NWRF in turn subcontracted (if you will) their side of Stormfury to the weather modification experts at China Lake. The same group conducting covert hurricane seeding efforts to weaponize hurricanes. According to China lake archival records and published materials, it seems pretty evident that China Lake "utilized" their participation in Project Stormfury to provide cover for their secret hurricane seeding operation's funding and logistical activities. They also used Stormfury as a cover, additionally when countries such as Cuba and Mexico complained about perceived manipulation of hurricanes that struck their territories. (as presented in newspaper stories at the time.)

Project Stormfury aircraft.

Later, between 1966-75, a more operational phase of the Navy's weaponized hurricane modification effort took place (sponsored by the same folks that ran rainmaking operations in SEA) whereby the Navy (China Lake) created, intensified, and steered hurricanes towards Cuba to wreak havoc on the Cuban economy - in an overall effort to destabilize the island nation's agricultural industries, including sugar (cane), tobacco, coffee and bananas for export. This weaponized hurricane seeding operation was additionally offset by another covert cloud seeding/weaponized weather modification application, designed to strategically cause severe "droughts" in Cuba, again to destabilize their agricultural exports and cause a cascading economic collapse of the Cuban economy.

However, within the confines of this specific historical treatise; one of the most documented weaponized weather modification applications conducted by the Navy (China Lake) was its establishment of a tactical rainmaking operations in SEA, to support the ongoing U.S. military efforts to stem the flow of enemy infiltration into the south via the Ho Chi Minh Trail (i.e. the HCMT).

The Real Project Popeye (1966)

As presented in the public domain, Popeye was tasked to reduce the "trafficability" along the main logistical resupply and infiltration routes from the north to the south, by softening road surfaces, saturating the soil to encourage landslides and generally cause wide-spread flooding to wash out roads and river crossings along the HCMT. Project Popeye was the secret experimental phase of this weaponized weather modification program to test the feasibility of extending the rainy monsoon season in Southeast Asia.

It's interesting to note; that many of the public domain references for the Popeye story like to mention a side-story suggesting that the CIA had first utilized cloud seeding in SEA back in 1963 via its proprietary air service "Air America". As the story goes, Air America utilized a Beechcraft Model 18 Twin Beech, configured for Silver iodide cloud seeding, as part of a CIA cloud seeding scheme to hamper and suppress anti-Diem Government demonstrations by Buddhists Monks in the city of Hue and elsewhere in South Vietnam. However, according to Air America archival documents (kept at the University of Texas – Dallas, McDermott Library, Special Collections Dept, "CAT/Air America Collection") there is no actual evidence that this proposed cloud seeding event ever took place. Even if it had, it might have only warranted a footnote as the first "political" application of weather modification in military history. The reality is that the newspaper reporters, and or their sources for this story, confused this cloud seeding story with an actual Air America aircraft configured for a "herbicide spraying" effort conducted about the same timeframe (1963-64) in Laos – as part of the CIA's secret war in Laos between 1961-75*.

SACSA

There are a couple of different public domain versions of how Popeye was initiated and introduced into the Vietnam War. One public domain reference (interestingly generated from China Lake published materials – that is

* If one were hard pressed to present a potential "first" tactical application of weather modification as weapon in SEA, then you wouldn't have to look any further than the French Indochina (colonial) Government during the siege of Diem Bien Phu in 1954. With more than one hundred tons of supplies per day streaming into French Indochina (from southern China), supporting the communist Viet Minh insurgency and the siege of the French fortress at Diem Bien Phu, the French military turned to one of its chief meteorologists for help. Col. Robert Genty, suggested a cloud seeding concept to increase precipitation to hasten an early onset of seasonal monsoons and muddy up the Viet Minh's supply routes by which to stem the flow of supplies and support the ultimate breakup of the siege at Diem Bien Phu.

Genty eventually came up with and conducted a number of cloud seeding test flights with Silver Iodide, mixed with activated charcoal, dropped by parachutes into cumulus clouds from a modified French Air Force Sub-Quest SO-30P Bretagne cargo – transport aircraft, with significant results. The artificial rain making (test) project's first seeding flight created a torrential downpour as well as a hailstorm within minutes of the seeding operation over an area 25 miles (40 kms) across, near Diem Bien Phu, that lasted 2 hours. However, before this cloud seeding concept could be implemented operationally by Genty, the Communist insurgents overran Diem Bien Phu and forced the surrender of the French colonial forces. This action ultimately led to the complete withdrawal of French control over Indochina. It was later acknowledged, by General Giap commanding the Communist insurgents, that heavy rains associated with the normal monsoon season did severely disrupt his army's supply lines with several of the truck routes turned to quagmires, and supply trucks sunk up to their bumpers in deep mud.

Viet Minh trucks labor through the mud.

consistent with a subsequent declassified DoD briefing on the project) suggests that the DoD/U.S. Air Force approached China Lake to support Popeye. This reference further suggests that the approval chain for authorization came down from the President (Johnson), through the Secretary of Defense (McNamara), to Air Force Director, Defense Research and Engineering (Dr. Foster) down to China Lake. That Project Popeye was approved by McNamara on September 17, 1966. Unfortunately, this version of the Popeye story is not historically correct and further casts suspicions that China Lake (with the CIA) was deliberately trying to hide this weaponized weather project under the DoD and U.S. Air Force, presumably for them to take the blame if things went south.

Although a long and convoluted story, the reality of it is that China Lake actively marketed its weather modification capabilities to various potential DoD, CIA, and other U.S. National Security customers, that encompassed secure briefings including motion picture presentations of actual weather modification seeding operations. In July – August 1966, one of those potential customers contacted China Lake and Project Popeye was the end result.

The reality is that the public domain perceived "September 17, 1966" authorization for Project Popeye by Defense Secretary Robert McNamara, was "not" an authorization and further was "not" an authorization for Project Popeye. The September 17, 1966 so-called authorization (document) was a request from McNamara to the Naval Commander-in-Chief of the Pacific (C-in-C Pacific) and Military Assistance Command - Vietnam (MAC-V) to come up with an interdiction / anti-infiltration system, to stem the flow of North Vietnamese combatants and their resupply "Trafficability" from the north to the south along the Ho Chi Minh Trail; and have it operational by 1967*.

* The September 17, 1966 McNamara request document is actually the impetuous of a subsequent interdiction / anti-infiltration system developed to help stem the flow of North Vietnamese combatants and their resupply efforts through the HCMT network, that was op-tested in 1967 and fully operational by August 1968. This interdiction program was known as *Igloo White*.

The actual Popeye project was independently requested, tasked and authorized over a month before this McNamara request document, by a little known and little understood (covert) organization secreted within the Pentagon; known as the office of the SACSA!

Popeye (and other applications of weaponized weather in SEA) was ultimately sanctioned by the office of the "Special Assistant for Counter – insurgency and Special Activities or SACSA" (an office embedded within the Pentagon somewhat) positioned under the Joint Staff Services of the Joint Chief of Staff (JCS) that was responsible for covert operations in Southeast Asia and (later) elsewhere in the world. At that time, only a small minority of Washington insiders knew that the SACSA office was effectively a covert CIA control office secretly embedded within the DoD.

A word here about the CIA & SACSA: we now know that SACSA was essentially a covert "secret team" of the CIA, embedded within the Pentagon. Its mission was to influence military and political policies as well as to provide the logistical support (and authorization) for covert operations throughout Southeast Asia and later around the world. Confirmation of and descriptions of the SACSA office is provided by one of its participants, USAF Col. L. Fletcher Prouty and recently by declassified CIA archival [CREST] documents.

Prouty had worked in this CIA secret team office in the Pentagon even before it was reorganized and designated SACSA in 1961. (the SACSA office was established from a component section of a previous entity known as the Office of Special Operations – positioned under a support organization of the Secretary of Defense) Later in a book he wrote *"The Secret Team: The CIA and Its Allies in Control of the United States and the World"*, Prouty outlines the inner workings of the SACSA office, its basic location within the Pentagon (office / room #1E962) and that it was manned by U.S. Military personnel working for the CIA, as well as CIA personnel posing as U.S. Military officers. In a bizarre twist of perceptions, subsequent DoD / Joint Chiefs of Staff personnel believed that the SACSA office was a support office (function) of the DoD / Pentagon, while the DoD / Pentagon believed this office to be a support element of the Joint Chiefs of Staff's service staff. Although Prouty himself didn't actually disclose the "name" of his secret team office in the Pentagon, (until much later in other writings) as being the office of the SACSA, recently declassified CIA archival [CREST] documents have now revealed the background, makeup and personnel assigned to SACSA in the 1960's and 1970s. In these declassified CIA documents, Col. Fletcher Prouty is listed as a member of the SACSA office. Thus, verifying his book's details about the secret team's covert activities, as that of the SACSA office.

Some recent public domain references report the SACSA office was an openly (known) subordinate office of the DoD / Joint Chief's of Staff, thus covert operations were those of the DoD. The reality is, however, that at this time of the 1960s and 1970s, the U.S. Military (DoD) "had no" covert counter – insurgency and special activities opera-

tions. Only the CIA did. All the special forces, covert and to some concern, Clandestine operations that were conducted within Southeast Asia (1963-75) were CIA operations utilizing U.S. Military resources and personnel under the cover of U.S. DoD operations. The SACSA office independently planned, authorized and logistically coordinated U.S. Military support to CIA clandestine service operations in SEA. SACSA was the CIA.

SACSA's area of responsibility (AOR), originally comprising covert operations in Southeast Asia through its in-country control elements under MAC-V, was suddenly expanded from Southeast Asia to all areas of the world in July 1965. This coincides with the U.S. Government's expansion of covert activities against Cuba, previously conducted by other divisions of the CIA at Langley. Later, the forementioned secret geophysical warfare campaign (weaponized hurricanes [1966 -75] and the drought seeding project [1969-75] run by China Lake) employed against Cuba, were also sanctioned by SACSA. According to recently declassified CIA archival [CREST] documents, the expansion of the SACSA's AOR was approved to specifically provide the means for the CIA to step-up its covert actions and operations against Cuba. At this time of its expanding AOR, SACSA's clandestine position within the DoD - JCS / Pentagon was somewhat legitimized via the office being quietly re-located into the support staff of a (non-descript) DoD Assistant to the Secretary of Defense position (as cover) – while still retaining its completely covert special operations mission and independent authorization. According to an article published in the "Joint Forces Quarterly", The journal of the National Defense University, entitled "the Great Divide: Strategy and Covert Action in Vietnam" (Autumn / Winter 1999-2000) by Richard H. Shultz Jr., SACSA routinely bypassed all normal bureaucratic (chain-of-command) procedures to approve and maintain tight controls over covert activities to keep them secret from even the DoD / Pentagon and Joint Chiefs if necessary.

Kissinger

Some public domain references suggest that Secretary of State Henry Kissinger (along with the CIA) authorized and or ran the rainmaking operations in SEA. However, this is not specifically correct. Both Project Popeye and Operation Popeye were initiated long before Kissinger was ever appointed a Presidential National Security Advisor, to Nixon when he became president in January 1969. Again, SACSA, with its unique positioning within the Pentagon authorized and controlled the weaponized weather modification program, with the Navy (China Lake).

However, it can be said that Kissinger might have had knowledge of U.S. weaponized weather modification programs (in 1969) in his position of NSA Advisor and then more specifically with regards to those China Lake weaponized weather applications being conducted against Cuba. According to recently declassified CIA archival [CREST] documents, Kissinger (with Nixon's approval) was asked to be "read-into" all CIA covert operations, and particularly those specifically against Cuba. Kissinger subsequently ordered another round of escalations in covert operations against Cuba in 1969, that saw additional geophysical warfare applications levied against Cuba, by China Lake.

President Richard M. Nixon & National Security Advisor Henry Kissinger.

So to recap, it's seemingly unlikely that more than a handful of U.S. Government officials ever really knew about weaponized weather modification operations being conducted by the SACSA (via the Navy) in SEA, against Cuba and or elsewhere. President Johnson only came to know about the rainmaking program in SEA, specifically Operation Popeye, via a (Literally Eyes Only) internal memo from White House Special Assistant for National Security Affairs, Walt W. Rostow on April 29, 1967 – after the operational phase of Popeye was already in progress. (the memo was an excerpt from one of the weather modification program's weekly reports, April 14-20, 1967, that contained intelligence information regarding U.S. troop contacts with the enemy – that seemingly contradicted other intelligence reports present to the President.) There was an additional May 23, 1967 memo to Rostow - for Johnson – from Donald F. Hornig, Special Assistant to the President for Science and Technology. This memo related to potential areas where the weather modification activities in SEA might be exposed visually and how that might translate to the secret weather modification project underway in India.*

* Not generally known, is that at this time in 1967 the Johnson Administration was trying to expand U.S. influence to other nations susceptible to Communist interventions. In an effort to open doors, the Johnson Administration offered U.S. Science and Technology (transfers) to normalize relations with other countries. India was in the midst of a severe drought and sought help from the U.S. via drought relief cloud seeding. Because of tensions between India and its neighbor East Pakistan, India wanted to have the rainmaking operations carried out in secret. Thus, the subsequent rainmaking operations were conducted via the CIA – subcontracted to China Lake. President Johnson only became aware of the rainmaking operations in SEA via the rainmaking (drought relief) project in India.

An actual secret hurricane seeding aircraft in the war against Cuba, circa 1963.

Nixon didn't find out about Popeye operations (and potentially the other SEA applications) until late 1972, when he and Kissinger were briefed on the weather modification operations as they related to potential U.S. -USSR treaty negotiations and subsequent requested for government approval associated with the Congressional Environmental Modification (ENMOD) ban, via the Senate approved resolution SR–71.

It's interesting to note: that Nixon, through Kissinger, requested specific information from the DoD / JCS for weaponized weather operations data to support decisions on Soviet Treaty talks and actually received resistance. Nixon / Kissinger then asked for a "study" associated with "…Military aspects of Environmental [and] or Geophysical modification activities…and capabilities.…" According to a declassified Department of State copy of the so-called study - *Foreign Relations of the United States, 1969–1976, Volume E–14, Part 2, Documents on Arms Control and Proliferation, 1973–1976 , # 42. Paper Prepared in the Department of Defense Washington, April 19, 1974; A Study of the MIlitary Aspects of Environmental or Geophysical Modification Activity in Response to NSC Memorandum, (January 25, 1974)*. In the DoD Report, under the sub-heading Current Capabilities: the DoD again states " …[that] at present, no capability exists to alter the environment in a controlled (militarily useful) manner through oceanographic, terrestrial, or ionospheric modification techniques. Accordingly, this section addresses weather modification activities in fog, precipitation, severe storms, and inadvertent weather modification. The conclusion is that even in the cases of the most advanced knowledge in weather modification technology (fog and precipitation), the state-of-the-art is minimal …."

The study report goes on to suggest that current operational programs within the DoD encompasses "…only two DoD programs are operational, an Army warm fog dissipation using helicopters, and an Air Force cold fog dissipation using airborne dry ice and ground-based propane seeding …." (i.e. there is no mention of the Geophysical warfare campaign still being waged, at the time of this reports writing, against Cuba involving the intensification of Atlantic hurricanes steered towards the island nation, and a cloud seeding project to cause severe droughts in Cuba until early 1975). After reviewing this so-called Study, the Nixon administration issued National Security Decision Memoranda 165 (NSDM-165) that effectively decided to defer a decision on the matter of policy governing Military Aspects of Weather Modification as a weapon of war. NSDM-165 was signed by Kissinger.

Project Popeye Authorization

SO, the actual authorization in 1966 for Popeye flowed down from SACSA, through the Chief of Naval Operations (CNO; Adm. D.L. McDonald), to the C-in-C Pacific (Adm. R.L. Johnson), with dotted lines to National Security Advisers (W. Rostow) in the White House, on to MAC-V (Gen. W.C. Westmoreland), who provided all logistical support authorizations for the program in-country. The day-to-day functional control of Popeye's seeding flight operations and technical support to the cloud seeding missions, in country, was commanded by NOTS / NWC China Lake personnel. China Lake additionally provided all participating personnel training, supervisory and leadership direction for the project as well as managed all of the scientific analysis and design, manufacture (fabrication) and distribution of all seeding dispensers, canisters and seeding agents used in SEA*.

The Navy program lead for China Lake's secret geophysical warfare program, and the commander for weaponized weather applications in SEA was Mr. Pierre Saint-Amand. Despite what various public domain references suggest, Pierre Saint-Amand pioneered the development of military (tactical) weather modification, the weaponization of weather, at China Lake. In fact, he pioneered successful weather modification in general, with dozens of patents (shared and alone) and numerous technical papers that demonstrate the processes, techniques, equipment, and capabilities of cloud seeding that were used by the U.S. military and that are still being used by commercial cloud-seeding companies today.

Known as a geophysicist, Saint-Amand had a Ph.D in Geophysics and Geology and was widely known as an earthquake expert, when he joined NOTS China Lake in 1954. In 1960-61, Saint-Amand was assigned to the Astronautical Sciences Division of the NOTS's Research Department (later the Earth and Planetary Sciences Division of NWC) with the important task of developing the Navy's weather modification capabilities based initially upon NOTS-developed pyrotechnic silver iodide compounds as

* Different public domain references suggest that Popeye operations had no physical or analytical data that was captured during the program, to provide definitive metrics as to the successfulness of the weather modification effort - casting doubt as to the effectiveness of the program. Despite this perception, specific China Lake personnel were on hand in-country to collect, analyze and document parameters of the program. Although some public domain references report (in some cases quoted by senior military personnel) that the program had marginal effectiveness at best, the reality is somewhat different.

China Lake personnel running Popeye operations, in Da Nang (circa 1966-68); (Admiral) Pierre Saint-Amand is second from left. The U.S. Naval Officer next to him is Cdr. Frances R. "Knobby" Walsh Jr., China Lake's technical program officer for Popeye in-country at the time.

well as other cloud seeding solutions and materials. Subsequently promoted to head of the Earth and Planetary Sciences Division, Saint-Amand personally ran or oversaw all of China Lake's numerous weather modification projects, often managing projects on the ground himself in such places as India, the Philippines, Southeast Asia, the Western Pacific (Midway and Okinawa), the Azores, and throughout the United States. He personally led China Lake's technical contingents to Puerto Rico each year in support of Project Stormfury, conducted most of the prebrief / cloud seeding training of military flight crews conducting drought relief cloud seeding operations in the far Indian Ocean, Western Pacific and Eastern Atlantic oceans. He was the man that pioneered the weaponization of weather beginning in 1961, that encompassed those "rainmaking" applications in Southeast Asia (1966-72).

For those with a keen-eye and a nose for proper military etiquette, it is evident that Saint-Amand was a civil-service civilian and should not have been permitted to command these Popeye operations in SEA. And yet, he did! In reality, there was a U.S. Naval Officer (from China Lake) who was the actual program / project manager of Popeye and the other weather modification operations in-country. This officer was the Navy uniform lead on the ground and was the officer in operational control of these programs. However, this officer clearly deferred his lead elements of command and control of the weather modification programs over to his civilian boss at China Lake, Pierre Saint-Amand, during the duration of their time in Southeast Asia. In fact, sometime within the 1967-1969 timeframe, Saint-Amand picked up the moniker of "the Admiral" and was arbitrary address as Admiral in any of his dealings with various regional commanders over any logistical support issues or regards to authorizations in country.

Project Popeye, under Saint-Amand's direction, comprised the utilization of several in-country airborne assets from the U.S. Military, including various transport aircraft from the U.S. Air Force and jets from the U.S. Marine Corps to conduct flight operations to seed the clouds over Laos.

Although the public domain and internet suggests or infers that Project Popeye (1966) was based out of the Royal Thai Air Force Base at Udorn, Thailand, the reality is that the project was run out of Da Nang (South Vietnam) with support elements operating out of the RTAFB at "Ubon", Thailand and the Pleiku Air Base, in Vietnams' central highlands. (Ubon is approximately 300 miles [488 kms] northeast of Bangkok and specifically within 37 miles [60 kms] west of the southern Thai border with Laos.)

Under the experimental Project Popeye, the USAF provided two troop carrying (tactical airlift) C–130A transport aircraft, flown by individual transport flight crew elements of the 374th Airlift Wing (Okinawa) that were temporary

Pierre Saint-Amand (at left) in the Azores.

VMFA 115 F–4B Phantom Jet.

VMFA 115 F–4B Phantom Jets in roughly 1966.

assigned to the Air Weather Service's 54th Weather Reconnaissance Squadron (based in Guam), while the U.S. Marine Corp's VMFA-115 squadron (out of Da Nang) furnished three F–4B Phantom jets flown by select flight crew elements of this Squadron.

As established in the online article "*The VMFA-115 Rainmakers of SEA: Now You Can Know the Rest of the Story"* by David Reade; P-3 Publications 2006, the VMFA-115 "Rainmakers of SEA" were based at Da Nang Air Base. Between August and October 1966, three of VMFA-115's F–4B Phantom jets were selected for used as the primary seeding aircraft for Project Popeye. The F–4Bs were flown by a small select group of three pilots and three Radar Intercept Officers (RIOs) from the squadron. The flight crews would fly the "rainmaking" missions, seeding the clouds and then standby on station to assess the reaction of the clouds to the cloud seeding runs.

For the project, the F–4B were equipped with a modified version of an A-6 photoflash ejector, coupled with Silver iodide seeding flares, dubbed "Wimpy" by China Lake personnel during the project - in keeping with the Popeye cartoon theme. Developed by China Lake, the so-called Wimpy system comprised 40mm aluminum photoflash – type cartridges made up of pyrotechnic Silver iodide seeding material. The cartridge dispensers were incorporated into a specially designed aerodynamic launching / dispensing canister developed specifically by China Lake for high-speed jets. Each mission ran about 4.5 to 5 hours in duration.

Most of the project's seeding flights were flown in the early afternoon from Da Nang, conducted under the guise of the Air – to – Air "Hot Pad" flight operations, that were maintained at Da Nang. Hot Pad flights were conducted like a 5 – minute "ready alert" scramble, where manned and ready flight crews stood-by armed and ready aircraft – to quickly takeoff on seemingly non-scheduled combat flights. The Hot Pad area was far away from squadron's normal flightline activities, further down the Da Nang flight line. Again, only a very small number of the Squadron's personnel knew about the Popeye rainmaking flights. The Squadron's air–to-air Hot Pad duty flights, conducted for other commands, were not maintained (documented) in the Squadron's regular operations reports, furthered helping to hide the squadron's cloud seeding / rainmaking flights. In fact, the Project Popeye missions are not even mentioned in the Squadron's official history, despite Popeye's declassification since 1974.

Most of the Project Popeye's cloud seeding flights were conducted over the Annamite Mountain range and a wide area of the Se Khong River Valley *(watershed)* east of the Bolaven Plateau, in the panhandle region of Laos. The experiment's targets were cold cumulus clouds at altitudes between 14,000 *(4267m)* and 19,000 feet *(5791m)* that were seeded with Silver iodide smoke. One of the first experimental seeding flights saw seeded clouds drift over the border into South Vietnam and dump heavy rains over a wide area. A U.S. Special Forces A-camp, located in the heart of VC territory along the border, recorded approximately 9-inches of rain over a 4-hour period.

The areas of Laos seeded under the experimental Project Popeye (1966).

Pierre Saint-Amand (right) with one of the Project Popeye C-130As equipped with Grumpers in SEA ,circa 1966.

One of the two USAF C–130A transport Hercules that were utilized, flew as the command, reconnaissance and monitoring (control) aircraft during the seeding missions, and served as a back-up seeding aircraft when needed. The second Hercules aircraft, flown from Ubon, scouted for the clouds to be seeded and provided for a secondary (backup) seeding capability when required. This scout aircraft often served as a flight-test aircraft for the various seeding devices that were evaluated during this experimental rainmaking project*.

* In fact; there were an additional 23 cloud seeding flights flown (not recorded in Project Popeye records), by both the Air Force C–130A and the Marine F–4B, over open ocean areas off the South Vietnamese coast, east of Da Nang, ostensibly for cloud seeding practice and or cloud seeding equipment / systems tests. During Project Popeye upwards of six experimental pyrotechnic Silver iodide smoke generators and seeding devices were tested and evaluated during these cloud seeding experimental flights. Besides the small hand-fired (AN/M-8 Very Pistol) flare called "Sweetpea", the Hercules aircraft were (test) equipped with a specially modified rocket –motor version of the China Lake's ALECTO seeding device called "BLUTO" as well as a seeding smoke generator dubbed the "Grumper". (the Grumper comprised a Silver iodide smoke generator based upon a modified JATO rocket housing filled with pyrotechnic Silver iodide seeding compound) Several Grumpers were fitted to the standardized JATO rocket assist racks mounted on the starboard and portside air deflector doors of the project's C–130A Hercules – and utilized the aircraft's existing JATO rocket fire-control panel in the cockpit to ignite the seeding generators. Additionally, modified versions of China Lake's Cyclops II and a standardized ALECTO flare ejector system (dubbed "Olive Oyl & Goon Girl" keeping with the Popeye cartoon theme) were also tested during the experiment project. But the two units were deemed too hazardous for operations and not suitable for the experiment as they burned too hot and could cause jungle fires if they made it all the way to the ground. They were subsequently only used for aircrew practice (training) cloud seeding flights flown over open ocean areas off the coast of Vietnam.

Project Popeye C-130A with Grumpers, circa 1966.

Another specific element of Project Popeye, that is little-known within the public domain, is the project's utilization of two Douglas A–1E Skyraider ground-attack aircraft, from the USAF's 1st Air Commando Squadron, based in Pleiku. The Skyraiders provided low-level observation and (ground) precipitation assessment reconnaissance, during their normal tactical missions along the Ho Chi Minh trail network.

Unfortunately, the Skyraiders had trouble visualizing the accumulated rainfall produced by the cloud seeding flights from the air. The subsequent fix was to have F–105 Strike (attack) aircraft (likely from the 432nd Tactical Reconnaissance Wing out of Udorn), sent out to bomb sections of the Ho Chi Minh trail in the areas that were to be seeded —once radioed by one of the C–130A scout planes. The heavy general-purpose bombs (approximately 500 pounds) would create large bomb craters, that would fill up with rainwater from the cloud seeding flights. The Skyraiders could then fly over the sections of the trail and see how filled the bomb craters were.

For this situation, China Lake had actually bombed areas of their test ranges back in California and ran water into the craters. The China Lake technicians then took photos of the craters with water at different levels. Measuring the amount of water at the various levels, allowed them to create a visual (photo) index of water filled craters

Douglas A–1E Skyraider ground-attack aircraft, from the USAF's 1st Air Commando Squadron, based in Pleiku.

that corresponded to specific measurements. Armed with the crater photo indexes, the Skyraider pilots could give rough estimates of rainfall amounts from several hundred feet up*.

So as not to give away their cloud seeding missions, to the enemy or other U.S. Forces in-country, Project Popeye utilized a series of code-words and code-names, over the radios, to hide their operations, while coordinating their operational flights. The Air Force Hercules were codenamed Vulture 45, the Marine F–4Bs were Condole 100 & 101, while the A–1E Skyraiders used Hobo 1& 2 as call signs.

Under the experimental weather modification project, China Lake conducted 56 experimental cloud seeding flights, (33 flights flown by the Marine F–4Bs and 20 sorties flown by the Air Force C–130As) of which 48 of the mission sorties were deemed successful, equating to an 85.7% success rate of seeded clouds producing significant rainfall. (Under the project, the A–1Es flew 36 mission support sorties)

Project Popeye completed its experimental flight operations in early November 1966, with enough positive results that recommendations were forwarded back to Washington for the initiation of an operational phase of the tactical weather modification mission in Southeast Asia. Although Project Popeye had the in-country support of those knowledgeable regional commanders, including the U.S. Ambassador to Laos (William H. Sullivan), the Navy C-in-C Pacific and of course Navy headquarters, the project was not immediately approved.

A word about the successfulness of Project Popeye; In a U.S. State Department memo (sent by Deputy Under -Secretary of State [for Political Affairs] Foy D. Kohler, to Secretary of State Dean Rusk) it was stated that "…. the experiments were undeniably successful …… and in some cases too successful …." However, a read of "Project Popeye; Final Report" the technical sections of the report, with much supportive scientific analysis of collected metrics / data during the seeding flights, indicates "less" than the stellar results than those offered by Kohler to Dean. In fact, the Final Report clearly expresses that the results from the project were inconclusive and could not be proven "absolute" in any basis of statistical treatment, having fallen short of those results expected.

In other sections of the report, the results of Project Popeye were categorized as "…. that they were more than adequate ….. [that] artificial induced rainfall was [within] quantities to [achieve the results sought] at a relatively low cost. ….". Saint-Amand, who wrote a good portion of the report generally categorized the project as "can successfully produce tactically significant rainfall to extend the monsoons in Laos and Cambodia."

Secretary of Defense Robert S. McNamara

Again, with glowing recommendations of knowledgeable regional commanders and those from other political figures-in-the-know, including an urgent request from the DoD / JCS *(SACSA)* to start the next phase of Project Popeye before the onset of the southwest monsoon in early 1967, the operational phase of Popeye was not immediately approved. It was said that there were concerns about the program over at the U.S. State Department and with the Defense Secretary, Robert McNamara.

Despite what might be expected and established by the public domain, the reality of this situation is that its abundantly clear that McNamara had little or no knowledge of the rainmaking (weaponized weather modification) operations in SEA prior to early 1967, when the State Department and others brought the matter to his attention, according to declassified CIA archival [CREST] documents and those of the U.S. State Department archives. Just at the point SACSA was making preparations for the follow-on operational phase of Popeye, McNamara became aware of Project Popeye, and then subsequently Operation Popeye. Thus, it's evident (by his subsequent actions) that he had not previously approve the former rainmaking (experimental) program back in 1966 and was not aware of the follow-on operational program until after it was already in operation, disclosed to him in early 1967*. In fact, some Mc-

* This process was cumbersome and required many revolving parts to work in coordination. That meant "reading" more people into the highly classified project that was Popeye, which provided increased opportunity for accidental disclosure. Ultimately, under Operation Popeye, the Skyraider & bombing aircraft process eventually went away and another process to capture more accurate rainfall accumulations was devised – as we will see later in the pages ahead.

* Historical Note: according to declassified CIA archival [CREST] documents, archival documents of the U.S. State Department and information contained within different McNamara biographies and books, McNamara was despised by the War Hawks at the Pentagon (DoD & JCS) and CIA. It would be in keeping then, under normal procedures, for SACSA to exclude as much of the U.S. Government as possible from having visibility to their actions and operations. (According to a declassified CIA archival [CREST] document, the CIA adhered to a secrecy doctrine that was less about adversaries knowing about covert operations, than it was about the U.S. Government and the Public."….

Namara biographies suggest he only found out about Op Popeye during a visit to Saigon and that he immediately moved to shut it down.

However, the events of 21 February 1967, brought into stark clarity the need to interdict the HCMT. On this date, a counter-offensive strike by NVA agents and VC insurgents (infiltrated into South Vietnam via routes and trails that made up the Ho Chi Minh Trail system) during Tet celebrations in Saigon and the surrounding area, disrupted the normal celebrations. This attack specifically targeted U.S. and South Vietnamese command and control centers. The North Vietnamese further sought to incite an uprising among the South Vietnamese people to topple the U.S. - backed Saigon Government and cast out the Americans invaders. No action taken by the enemy so apply demonstrated the need to disrupt the infiltration routes along the Ho Chi Minh Trail system†.

In the days after this Tet attack, SACSA had all the authority it needed to green-light the operational phase of its tactical weather modification program in SEA, despite any reservations from officials within the Administration. With the gloves off now, Operation Popeye and the tactical use of weaponized weather was about to enter the war unchecked and ready to destroy the enemy.

It's interesting to note; that the press itself reenforced this scenario, reporting that once McNamara found out about of Operation Popeye, he ordered the U.S. Air Force to shut it down, in late 1967, as reported by Seymour Hersh *("McNamara Ordered to End Rainmaking in 1967 reported"; New York Times 4 July 1972).* In this article, Hersh speculates whether McNamara's orders were intentionally disobeyed, ignored or disregarded by the very military forces he was supposed to have directed. In retrospect, this incident demonstrates that McNamara, as Defense Secretary, had no knowledge of the Popeye, had not authorized it and when he learned about it, tried to shut it down. Unfortunately, asking the wrong branch of service to stop doing it. He apparently asked the "Air Force" to stop, while the U.S. Navy (via SACSA) continued the program unabated. This incident further speaks to the underlining polarization within the U.S. Government that surrounded the Vietnam War in the 1960s and 1970s.

Operation Popeye (1967-72)

The operational phase of the weaponized weather application program in Southeast Asia, "Operation Popeye", commenced in March 1967. (at China Lake, this program was seen as an extension of the first, i.e. "Phase II of Project Popeye", but as time progressed, they abandoned this mind-set and viewed "Operation" Popeye as a whole different stand-alone operation) The seeding flights were flown just before the onset of Southwest Monsoon season (between April and September) with an objective of increasing the normal amounts of rainfall during the monsoon season and then to extend the seasonal conditions further through October or about 30-45 more days. Special attention was paid to increasing rainfall to washout river crossings, saturating the soil to cause landslides and to make the trails and supply routes muddy and impassible.

14th TRS RF–4C at Udorn.

The perceived technical success of the pilot project supported the authorization for the operational phase of the tactical weather modification program in SEA, albeit with a few changes. Under this revised weather mod program, the primary seeding missions were now flown by specialized C–130 Hercules transport aircraft manned by flight crew elements of the USAF's 54th Weather Reconnaissance Squadron (WRS), forward deployed to RTAFB Udorn, Thailand. The Herks were supported by photo-reconnaissance RF–4C Phantom jets from the USAF's 14th Tactical Reconnaissance Squadron (of the 432nd Tactical Reconnaissance Wing) also based at the Udorn. Udorn had been the home base airfield for the CIA's Air America since 1955 and was still something of a classified air base throughout the 1960s. Operations here were limited with many flight operations being conducted here given the tight confines for ramp space and personnel accommodations.

The secrecy of covert operations also reduces the possibility of effective monitoring within the U.S. Government [itself] ….") It was because of this adversarial relationship between the Secretary of Defense and his Defense Department (and a perceived stress-induced mental breakdown) that President Johnson asked McNamara to resign. He left his position as Secretary of Defense on 29 February 1968. In retrospect, it's abundantly clear that McNamara was not involved in approving or controlling Popeye operations in SEA and only became aware of these weaponized weather modification operations late in his tenure.

† The mention here of insurgent attacks in February 1967 during Tet celebrations in the south, sounds a lot like "the Tet Offensive" captured by the U.S. press and displayed on U.S. National Televisions in March 1968. Seemingly not well understood in the public domain is that the Tet Offensive of 1968 was just one of a number of insurgent attacks launched against U.S. and South Vietnamese commands during annual Tet celebrations (Tết Nguyên Đán, that celebrates the arrival of spring) during the Vietnam war. Although the March 1968 Tet Offensive is the most widely known, there were others, like that which occurred on 21 February 1967.

14th TRS RF–4C from Udorn.

54th WRS WC–130E.

The USAF 14th TRS committed a revolving two-jet detachment to fly project missions. The RF–4C Phantom jets were equipped with several wing and fuselage mounted Silver iodide flare dispensers (52 flares per unit) fitted on each aircraft. These RF–4Cs, when tasked, seeded clouds at 19,000 feet (5791m) as secondary seeding aircraft. The RF–4C additionally conducted routine photo-reconnaissance missions in conjunction with the seeding missions*

It's interesting to note; that according to the Project Popeye, Final Report, Saint-Amand had a whole different vision of how "Operation" Popeye should have been carried out – aircraft wise. In his mind, Popeye should have been an "all Navy show" with the utilization of U.S. Navy Carrier Attack aircraft provided by 7th Fleet Aircraft Carriers off the Vietnamese coast. In this scenario Navy Carrier A–6A Intruders and A–4B (C or E) Phantom jet attack aircraft would be assigned to the seeding missions. With Carrier F–8E (RF–8A) Crusader and or A–3B (RA–3B) Skywarriors providing the aerial scout and reconnaissance tasks, while E–2A Hawkeye surveillance planes, provided the cloud seeding (director) control aircraft duties. But for reasons unknown, Operation Popeye's aircraft utilization tracked more like Project Popeye, encompassing aircraft already "in-country" instead.

Under Operation Popeye, the 54th WRS initially flew three of their WC–130E Hercules weather reconnaissance aircraft in the primary seeding role for most of the first season in 1967. Although most public domain references suggest that the 54th flew specially modified WC–130A aircraft in 1967, this is not specifically correct. In the rush to put the operational phase of weaponized weather modification into action, the three C–130A transport Herks acquired by program as seeding aircraft, had been required by the AWS to be converted to the "W" (i.e. Weather Bird) weather reconnaissance configuration first (by the USAF 's Warner Robins Air Materiel Area or "WRAMA" at Robins AFB, Warner Robins, Georgia.) that encompassed weather reconnaissance capabilities and provisions to operate a newer variant of the China Lake developed Silver iodide flares ejectors, based on an early version of the Navy's (China Lakes) SUU-53/A Cold Cloud silver iodide seeder dispenser. The early Silver iodide smoke generator (flare) dispensers comprised a photoflash dispenser rack mounted to the existing aircraft's JATO rocket assist mounts on both sides of the aircraft, on the air deflector doors. The Silver iodide seeding flares burned for 36 seconds as they dropped down some 3,000 feet (914 m).

Aircraft Background: there is some public domain confusion over the C–130s Hercules used in Project Popeye (1966) and the WC–130A used in Operation Popeye (1967-72). The internet suggests the Hercules aircraft utilized in Project and Operation Popeye were to have been transport Hercules aircraft #s 56-519, 56-522 and 56-537 that were assigned to the 54th Weather Reconnaissance Squadron. However, this is not specifically the case. USAF archival

* Not fully understood within the public domain, and not constructively outlined in USAF historical and operational archival documents, is that the 14th TRS didn't actually arrive in-country (Thailand) at Udorn until 28 October 1967, at the moment that Operation Popeye seeding flights were ending for the year. Thus, the reality is that the 14th TRS did not actually participate in Operation Popeye in 1967. Given that public domain and general U.S. Government Popeye related document references suggest that during Operation Popeye "…. some 591 rainmaking sorties (expending more than 6,570 cloud seeding flares) were flown by unarmed and unescorted WC–130 and RF–4C aircraft in 1967 …." questions the veracity of these references -or- that "other" RF–4C jets flew for Popeye during 1967. Given that most of the existing references for Popeye all suggest that the 14th TRS flew weather modification (seeding) flights in 1967, (again) when they hadn't arrived in-country yet, a look around the base at Udorn for that time period reveals some interesting clues. Apparently, the 11th Tactical Reconnaissance Squadron, also assigned to the 432nd TR Wing, was based at Udorn between October 1966 to November 1970, flying RF–4C. An additional close examination of the 11th TRS's operational records establishes that during its time in Thailand, the squadron also flew "weather reconnaissance flights" (classified - speak for weather modification flights) over planned strike areas. Given the classified nature of Operation Popeye, this may be the best we get to proposing that the 11th TRS may have actually flown weaponized weather modification operations in 1967.

Operation Popeye WC–130A #519.

Project Popeye C–130A (#56-0518), now a Gate Guard display aircraft at Little Rock AFB in Arkansas, USA.

records indicate that the initial two C–130A transport aircraft used in Project Popeye (1966) were not among the three aircraft later used in Operation Popeye (1967-72) and were never assigned to the 54th WRS in Project Popeye. Project Popeye's two C–130As were more than likely aircraft #s 56-520 and 56-518 or 56-523 and were assigned to the 315th Air Division / Group out of Okinawa. The C–130A Hercules aircraft that were acquired, up-graded and modified into weather reconnaissance WC–130A were aircraft #s 56-519, 56-522 and 56-537. Due to the time it took to convert the aircraft, the WC–130A did not begin to filter into the first season of Operation Popeye until after June/July 1967. It was only then after these WC–130A were reconfigured and delivered to Guam did they officially become assigned to the Squadron. These Hercules aircraft were later phased out of Operation Popeye during June /July 1970 with the 54th squadron relegated to utilizing their own WC–130E weather reconnaissance / typhoon reconnaissance aircraft as seeding planes after July 1970. Additionally, some public domain and internet references suggest that after the retirement of the Squadron's WC–130As, the 54th WRS acquired WC–130Bs and flew them on Popeye rainmaking missions in SEA. This is also not specifically correct. In 1970-71, due to a lack of available aircraft (associated with Defense budget cuts, Depot maintenance and repairs during a peak in mission taskings for the AWS) the 54th WRS's typhoon reconnaissance mission was augmented by two WC–130B Hercules (and two flight crews) from the 53rd WRS from the US. There is no evidence in USAF AWS records of these two (53rd WRS) WC–130Bs having flown rainmaking flights in SEA. Later in 1970, the 45th was assigned three (new-ish) WC–130Bs, but these aircraft were immediately tasked with other AWS missions and borrowed by other AWS squadrons. Again, there is no evidence in the records of these newer B-model herks ever flying Popeye missions.

It's interesting to note; that one of the original Project Popeye C–130A transport Hercules (#56-0518) was later transferred to the South Vietnam Air Force (the Republic of Vietnam Air Force -or- RVNAF) in November 1972, at Tan Son Nhut AB, Saigon. Later during the fall of Saigon (29 April 1975), a South Vietnamese Air Force flight instructor pilot (known only as Maj. Phuong) commandeered this aircraft (one of the last aircraft at Tan Son Nhut, not already destroyed by NVA troops streaming into Saigon) and flew 450-plus refuges out of South Vietnam – landing hours later at RTAFB U-tapao, Thailand after getting lost. The aircraft at this point was reclaimed by the U.S. Air Force and continued to serve with the Air Force for many more years and is currently a gate guard (display aircraft) at Little Rock AFB in Arkansas, USA.

Under Operation Popeye, the Squadron's Hercules aircraft were the primary seeding aircraft, flying two seeding sorties per day, with one of the two Herks acting as a cloud scouting plane. This scout plane would go out and reconnoiter clouds in the target area to be seed and report back to the base for the other seeding aircraft to launch. The WC–130 would then direct the seeding aircraft to the cloud's position (coordinates) and provide the flight levels for the freezing layers by which to commence their seeding runs.

One 54th WRS aircraft and crew would rotate in and out of Udorn every 20 days, with no more than two WC–130s on the air base at any one time. Once arrived at Udorn, the flight crews and the aircraft were (temporary) administratively assigned to the AWS's 1st Weather Group. This facilitated the means to coordinate ramp spaces to park aircraft, logistics (meals and lodgings) for the aircrews as well as provide various aircraft maintenance and flight services while on the Thai Air Base. There was limited ramp space and logistical lodgings at this busy base, and specifically for Operation Popeye, no more than 50 personnel could be accommodated at any one time.

The operational Popeye seeding missions were conducted over Laos, Cambodia, parts of South Vietnam and North Vietnam. Although some public domain references like to focus on those seeding flights that were flown over North Vietnam, U.S. DoD and Congressional (Popeye) records show that seeding flights flown into areas of southwestern North Vietnam (just over the border) only occurred for a few short weeks in 1967 and a 5-6 week period between September and early November 1968. Other than these very short periods in 1967-68, there are no other archival records or evidence that indicates Popeye ever flew over North Vietnam again. The Popeye missions were focused specifically on those key areas of the HCMT, along the Viet Cong resupply and infiltration routes, as part of a much wider U.S. military counter – insurgence, trail interdiction program.

However, according to other U.S. Government archive documents, Operation Popeye flew a number of seeding missions off the coast of North Vietnam. Although unconfirmed and not proven in fact currently, is the possibility that these known seeding flights in North Vietnamese coastal areas were associated with alleged *"storm"* seeding flights conducted on tropical storms, remnant typhoons or convective thunderstorms. *This issue will be discussed later in the pages ahead.*

As the tactical weather modification operations continued, other issues arose that were not *(well)* reported within the public domain and are presented here probably for the first time. One issue comprised the fact that flying these cloud seeding missions, in a combat zone, were not without its hazards. Popeye seeding aircraft were shot at, damaged, and in one case, shot down during rainmaking operations.

WC–130A Battle Damage

On June 11, 1970, while supposedly conducting an Operation Popeye cloud seeding mission, one of the 54th WRS's WC–130A (#56-0522) received "battle damage". Back at AWS Headquarters (at Scott AFB, Illinois), during the commander's morning (reconnaissance) ops briefing, it was reported that a 54th WRS aircraft was damaged, a victim of combat action. A civilian Air Force Historian (John F. Fuller) who had been permitted to sit-in on the AWS's morning briefs, made a formal request of the organization's commanding officer to write-up a news release of the aircraft battle damage sustained in SEA. Mr. Fuller presented the case that this was the "first" instance of an AWS aircraft receiving combat battle damage in the Vietnam War and more importantly ever in AWS history. However, Fullers' request was denied. Given that the 54th WRS was known as a weather reconnaissance unit that (publicly) conducted typhoon reconnaissance flights in the Western Pacific, the Air Force would be hard pressed to explain why the aircraft received combat damage in the skies over Vietnam.

Unfortunately, not much more is known of this situation. Apparently, the squadron did not file an accident report on the aircraft. Potentially because the area of damage was confined and easily repairable, given that this particular aircraft was already scheduled to be retired from squadron soon, it might have been seen as a waste of time and money to fix the aircraft on the 54th's dime. Additionally, any official paperwork on this aircraft for battle damage repair might have opened up the covert program to disclosure and this was to be avoided at all times.

However, the circumstance of the battle damage is still in question. Popeye seeding flights occurred at approximately 18,000 - 19, 000 feet *(5486 -5791 m)*, which is well outside the range of small arms fire from the ground at about *3500 feet (1067 m)*. At normal operating altitudes, one might suspect a SAM missile strike against the WC–130A. But even a near-miss missile strike, would have produced potentially more damage than was reported.

Others might suggest that the battle damage occurred during the unit's weather reconnaissance flights, known

This photo of undamaged WC–130A (56-0522) was at Andersen AFB, Guam in 1970. [taken by Tom Robison]

(according to the public domain) to have been flown in SEA, conducted at lower altitudes – except for one specific and salient point. The 54th WRS "did not" fly weather reconnaissance flights in or over SEA (towards regional forecast and warnings) despite public domain references to the contrary.

It has been presented in the public domain (and referenced in some USAF historical summaries) that the 54th WRS flew weather reconnaissance flights in SEA, towards support of regional weather services' forecasts. However, this situation is not historically correct. The weather activities conducted in SEA are too comprehensive to express here, but suffice it to say, there were countless U.S. weather station detachments and smaller weather units in operation all around the SEA region.

This misunderstanding of the 54th WRS having conducted weather reconnaissance flights comes from a couple of different elements. One, in an effort to disguise the secret rainmaking operations in AWS headquarters internal comments and references, the Popeye operations were referenced as "special weather reconnaissance flights in SEA", as a cover, later misinterpreted by public domain writers and historians. Another associated reference that appears in some public domain rainmaking documents and narratives about the 54th WRS flying weather reconnaissance flights deals with the dropping of dropsondes to capture weather data supporting regional forecasts. Again, this has been misconstrued. There are other public domain assumptions that the squadron conducted weather flights, suggesting that the squadron's WC–130s loitered over areas of Eastern Laos, the HCMT, and over areas of the Mekong Delta, off Da Nang and elsewhere. Although, the 54th did drop dropsondes during "specific" seeding operations and shared this dropsonde weather data with their AWS counterparts at the 1st Weather Group at Tan Son Nhut AFB, they "did not" fly dedicated weather reconnaissance flights in SEA.

In reality, the AWS, through the 1st Weather Group, placed experienced AWS weather officers onboard USAF EC–121 Big Look intelligence & reconnaissance aircraft (of the 552nd AEW&C Wing), supporting tactical strike aircraft operations, coordinating North Vietnamese Mig jet intercepts and communications control and relay missions. From here the weather data collected on the AEW&C EC-

121 aircraft, loitering over these various areas of SEA, found its way to the 1st Weather Group at Tan Son Nhut – that helped produce the regional weather forecasts and warnings. And finally, there are public domain references to the 54th flying weather reconnaissance flights out of Udorn over SEA and the Bay of Bengal (BoB) in the Indian Ocean supporting the weather picture for Vietnam War. In reality, again, the 54th did not fly weather reconnaissance flights over SEA. However, the 54th WRS was tasked to fly weather reconnaissance (and tropical cyclone reconnaissance flights) over the BoB and the Indian Ocean, beginning in October 1971. But not in support of the Vietnam War.

The 54th WRS's weather reconnaissance / TC reconnaissance flights were flown by squadron WC–130Es to support the deployment of the U.S. Navy's 7th Fleet, USS Enterprise carrier battle group [Task Force 74] into the Indian ocean – associated with escalated tensions in the on-going Indo-Pakistan War. The area weather reconnaissance flights and those reconnaissance flights flown into Indian Ocean (BoB) tropical cyclones were not associated with the war in SEA. So, the Hercules battle damage was not on a count of flying non-existing weather reconnaissance flights.

Although it's currently unclear specifically how this Popeye WC–130A Hercules received its battle damage, DoD archival documents (including Pacific Air Force Command "Contemporary Historical Evaluations of Combat Operations or CHECO" reports in SEA) establishes that as U.S. Government officials requested further increases in B–52 Bomb strikes along the HCMT areas of Laos between 1968-72, North Vietnam officials had no choice but to move new mobile SAM missile and (KS-19) 100mm anti-aircraft guns into areas adjacent to the HCMT in Laos.

Given the aircraft's normal cloud seeding attitudes, its possible to have had the explosion of a SAM missile in close proximity by which to have cause the minor damage to the cloud seeding Hercules. Additionally, the apparent battle damage may have been derived from the 100mm anti-aircraft artillery (AAA) guns. A civilian ex-China Lake employee, who worked on the Navy weaponized weather modification program in Udorn, reported the issues associated with the placement of SAM missiles and AAA guns along the HCMT. He reported, that every time they popped out of cloud they seeded, every person on the aircraft was looking for the plumes of fire along the ground indicative of a SAM missile launch or ground fire flashes of AAA guns. It was also suggested that flying at lower altitudes, 2000 feet (610 m) or so, somehow affected the targeting radars of the SAM missiles, but would then put the aircraft within range of the 100mm AAA guns and small arms fire. The cloud seeding Hercules were not the only Popeye aircraft affected by this situation of anti-air defenses integrated into the North Vietnam's defense of the HCMT.

This situation of flying in a hostile airspace further affected the Popeye RF–4C Jets used, leading to a little-known story of a cloud seeding jet that was shot down during a Popeye mission in Laos.

11th TRS RF–4C.

Popeye RF–4C Loss

The genesis of this story of a RF–4C jet having been shot down during a Popeye mission comes down to us from the same civilian ex-China Lake employee that participated in Popeye operations at Udorn during the latter 1960s. It's his recollections, that a TRS RF–4C that he had been supporting, was shot down by a SAM missile during a cloud seeding mission towards the latter part of 1967.

As mentioned before, the 14th TRS did not arrive in Udorn until October 28, 1967, when Popeye ops were winding down for the year. Additionally, this squadron's first aircraft loses didn't occur until January 1968, and Popeye operations didn't start again until March 1968 of that year. As mentioned earlier, it's now believed that the 11th Tactical Reconnaissance Squadron (11th TRS) RF–4Cs based in Udorn, supported the Popeye weather modification flights during Popeye operations in 1967 and it's more than likely one of the 11th TRS's aircraft was shot down.

With this in mind, a vast review of USAF aircraft loss records for 1967 (demonstrating that approximately 97 F–4 Phantom IIs were lost in 1967; according to aircraft loss statistics), USAF aircraft crash / accident reports, other Air Force squadron and wing records for units & commands at the RTAFB Udorn, and other archival records and reports, identified three primary 11th TRS RF–4C losses in the latter part of 1967. Of the three, one 11th TRS RF–4C loss stands-out in terms of a Popeye mission location, the fact that it was shot down by SAM missile and other accident report items. Although there is an USAF (archival) after-action, accident report on this aircraft loss, it is wholly incomplete as accident reports go. Allot of the operational location, accident location, stated mission and physical loss information has been omitted from the report (lots of "unknowns") believed to be associated with the classified nature of the rainmaking mission. The accident report is conspicuous by its lack of reported information, as compared with other accident reports in the USAF database, given that both aircrewmen survived and were rescued!

What little was gleaned from this accident report, subsequently proved to be important information that briefly indicated that both the pilot and the backseat Recon Nav-

A reconnaissance camera image of a 11th TRS RF–4C SAM strike over the Ho Chi Minh Trail.

Downed pilot rescued by Jolly Green Giant CSAR helicopter.

igator (i.e. the Reconnaissance Systems Officer) survived this ordeal and were rescued – mentioning their names. A subsequent search of these officers' names revealed additional accident and mission details that were by-chance associated with citations and medals awards.

It now seems more than likely, that a 11th TRS (432nd Wing) RF–4C [#65-0839] on a Popeye cloud seeding / reconnaissance mission into southern Laos, along the HCMT network, was hit by a SA-2 SAM missile (and apparently also AAA artillery gun fire) that caused severe damage to the aircraft's right wing. With the attack located just a few miles northwest of the Vietnamese DMZ, over the border in Laos, the aircrew decided to stay with the damaged aircraft and push northwestward toward the Thai border with Laos. Whether to get as close to their home base as possible, at Udorn in Thailand, or because they had classified weather modification equipment attached to their aircraft, the aircrew pushed the limits of their damaged jet – only ejecting from the plane when it was evident they could go no farther and the jet was going to crash into the jungle below.

Both crewmembers survived their ejections and were rescued by a Sikorsky HH–3E Jolly Green Giant CSAR helicopter from Detachment 2, of the 37th Aerospace Rescue and Recovery Squadron based at Udorn.

Although still unacknowledged in the primary USAF records that this aircraft was part of Operation Popeye, the various "other" references found surrounding the loss of this aircraft suggest otherwise.

Broader Applications

During the original Project Popeye experiment in 1966, Saint-Amand looked around the region (or more likely the war itself) and envisioned broader applications for China Lake's weaponized weather capabilities. Given that Saint-Amand was always tweaking Popeye operations in the field, developing better seeding materials and seeding equipment to achieve greater efficiency, some of those improvements and or ideas became broader applications of the tactical weather modification effort that seemingly gained the interest of regional commanders. In fact, this concept of broader applications probably came to Saint-Amand from a seemingly competing project that also sought to interdict traffic along the Ho Chi Minh Trail network.

Commando Lava (1966-67)

Identified as "Commando Lava", in declassified Vietnam War CHECO reports, this experiment involved the test use of chemical soil destabilizing compounds (referred to as "Emulsifiers") to make sections of the Ho Chi Minh Trail system impassible from mudslides and the creation of deep mud through chemical destabilization of the soil. This project involved the aerial dispersing of a chemical compound (trisodium nitrilotriacetic acid and sodium triphosphate, commonly found in most detergents and cleaning products produced by Dow Chemical Co.) to break down the molecular structure and or cohesion of the soil. The emulsifying agents when dispersed and combined with rainfall, destabilizes the soil, breaking down the chemical bonds that binds the soil together. The soil loses all consistency and creates a particularly soft and loose deep mud that is very sticky.

It was this project, not Operation Popeye, that inspired the now famous phrase; "Make Mud, Not War", which was coined by U.S. Ambassador William H. Sullivan (Ambassador to Laos 1964–1969) in a State Department dispatch back to Washington in 1967.

Commando Lava was another trail interdiction operation authorized by SACSA, which like Project Popeye, utilized flight aircrew elements from active USAF squadrons in the regions. In the case of Commando Lava, aircrews of the 374th Troop Carrier Wing /41st Troop Carrier Squadron (home based in Naha, Okinawa under the 315th Air Division) were forward deployed to Ubon, Thailand and Cam Rahn Bay, South Vietnam, to fly the Commando Lava missions.

These mission flights encompassed the aerial spreading of the emulsifiers along various sections of the Ho Chi Minh trail network in the Laotian Panhandle and along

Takeoff of Commando Lava C–130 Hercules.

the trail's associated infiltration routes, to literately soap up the ground and make the trails, paths and tracks slippery to foot traffic and cause the soil to break down under the weight of trucks and other vehicles. Conducted during daylight hours and flown at an altitude no more than 200 ft m (61 m), test flights primarily targeted hillside roads and trails in southern Laos, to destabilize the soil, create mudslides and the deep loose mud. The first test flight was met with great success; the compound was dispensed along a hillside road, below the crest of a ridgeline. Later, with heavy rains, the whole road washed away and slid down the hill. The second test flight was less than successful. Although dispensed adequately, the follow-up rainfall never occurred and failed to achieve any results. (It was at this point that Saint-Amand was brought into this project. The operation folks want to know if it were possible to combine Commando Lava with Project Popeye to maintain a better control of when and where the rain would occur to activate the emulsifying agent and muddy up the roads and trails) The third test flight was suddenly aborted when one of the C–130As took heavy ground fire in the seeding area and later crash landed at Chu Lai.

Although area commanders wanted to go fully operational with the emulsifying project and expand its applications throughout the whole Ho Chi Minh Trail network and the infiltration routes, there was a problem. Apparently, there was no mechanical dispensing system for the spreading of the emulsifying material. During the early test flights, the compound was hand-shoveled out the back of an opened cargo door-ramp of the C–130A Hercules. Additionally, the aircraft had to fly at very low altitudes (200 ft / 61 m) to disperse the material properly. As previously mentioned, at least one aircraft came under fire over the seeding area. It was said that the Commanding Officer of the 41st TCS refused to fly anymore missions after one of his aircraft was effectively shot down.

Although this would seemingly have spelled the end of the project, a second version of the program got underway in July 1967. Called "Commando Lava II", this effort continued the dispensing of emulsifying compounds over different areas of Ho Chi Minh Trail system and its associated infiltration routes, through the utilization of UC–123 Providers, from another unit previously involved in "Ranch Hand" defoliant flights. It's believed that this revisioning of the Commando Lava project was a direct result of Saint-Amand's input, combining the emulsifiers and the water together on the aircraft and spraying them over targeted areas of the trail.

USAF C–130 Wreckage at Chu Lai air base.

Although Commando Lava (combined) flew 28 sorties, dispensing approximately 120 tons of soil destabilizers and did cause mudslides that were said to have wiped out two roads and a road junction along infiltration routes within the A Shau Valley (South Vietnam), the program failed to cause widespread destabilization of the soil along other parts of the HCMT system. It's been suggested by U.S. military intelligence units that the Communists caught onto the Commando Lava scheme and literally sent out "sweepers" to sweep up the chemical compound off the roads and trails before it had a chance to rain. Other intelligence reports suggested the VC sweepers would also lay camouflage bamboo matts down on the roads and trails to catch the "soap" sprayed by U.S. aircraft, protecting the trails from destabilization.

A word about perspective; this project is mentioned here as an example of another U.S. counter-insurgency warfare application applied against the enemy's trail network, (and was a potential inspiration to Saint-Amand and his concept of broader applications of cloud seeding technology in the war) it was not an example of cloud seeding or weather modification itself, despite what some public domain references might suggest. It was more of a "chemical" counter-insurgent weapon application, where chemicals were used to achieve a tactical result – much like Ranch Hand defoliant spraying operations – which were also not a weather modification application as some internet references would have you think.

Historical Note: this brings up another issue that needs correcting. Public domain perceived histories of Popeye weaponized weather modifications operations in SEA

USAF UC–123 Provider used towards Commando Lava II.

Ranch Hand UC–123 defoliant -spraying aircraft ; not a photo of Project Popeye weather modification aircraft.

A resupply C–130 Hercules trying to land in Khe Sanh fog.

often illustrate their presentations with a photo of Ranch Hand defoliant spraying aircraft, inferring that this photo is of Popeye aircraft conducing weather modification. This is not historically nor generally accurate.

Besides the potential of the proposed joint Popeye – Commando Lava project, the first (known) broader application of Saint-Amand's tactical weather modification capabilities in Southeast Asia encompassed the use of cloud seeding techniques towards warm fog clearing.

Khe Sanh Fog Clearing (1968)

In 1968, the long-troubled U.S. Marine Corps combat base (outpost) at Khe Sanh, located in Quang Tri Province, just south of the Vietnamese Demilitarized Zone (DMZ), had its logistical supply line under near constant attack by enemy forces. The base's lifeline was the almost daily air support and logistics supply flights it received from transport aircraft, made possible by a (3900 foot / 1189 m) airstrip build next to the base. Unfortunately, persistent, and ground-hugging fog would roll in over the hills and settle down over the base daily during monsoon season, making it difficult to get re-supplied and unable to see the enemy sneaking up on the Marines' positions.

Khe Sanh Fog was a protracted event during the monsoon season that was actually comprised of four different types of precipitation; two different types of fog, drizzle and light rain, that caused a widespread low overcast (low ceiling) down to the ground that prevented resupply aircraft from landing on the airstrip – which provided an opportunity for the North Vietnamese to over-run the camp during an 11-week siege in early 1968.

It was at this point that Saint-Amand was approached to devise a way to disperse the warm fog and make it dissipate – in support of the US's Operation Pegasus effort to relieve the base and break the siege. Utilizing hygroscopic compounds (a mixture of sodium chloride salts and water), Saint–Amand secured the use of several USAF Ranch Hand (Agent-Orange defoliant) spray-equipped UC–123 Providers, (forward deployed to Da Nang) and flown by USAF's 309th Air Commando Squadron, to fly fog-clearing missions over Khe Sanh. More than 15 fog clearing sorties were flown over the base, before it was determined that the seeding solution was not that effective.

It's been said that Saint-Amand (and his China Lake team) then came up with a modified Silver iodide compound (flare cartridge) that could be fired from a hand-held AN/M-8 (pyrotechnic) "Very pistol" (flare gun). Capable of streaking upwards of 1500 feet (457 m) into the low-lining fog and clouds, the Very pistol technique could be utilized by the Khe Sahn troops themselves on the ground to dissipate the fog. Unfortunately, there are no specific records to suggest if Khe Sanh base fog operations ever worked successfully, given that there were no other metrics recorded towards this effort, and the implementation of the ability of resupply aircraft to LAPES (Low-Altitude Parachute-Extraction System) supplies to the beleaguered Marines – which eventually broke the siege.

It's interesting to note; that a few months later (June 1968) Khe Sanh was abandoned completely, leaving the A Shau Valley open to North Vietnamese forces, with a clear shot to infiltrate northern South Vietnam.

It was at this point that another cloud-seeding application materialized and was established to help the Marine base and the wider – regional tactical air operations within the whole of the A Shau Valley itself.

A Shau Valley Rainmaking (1968)

The A Shau Valley weather modification application was established as a separate cloud seeding effort to those weather modification missions over the HCMT. Flown by Popeye aircraft, the project seemingly sought to "clear the skies" over the A Shau Valley to support tactical air operations and bombings along the HCMT infiltration routes (in Laos) and other key entry points into South Vietnam – as an extension of new operations at Khe Sanh, called Operation Delaware, to interdict communist forces logistically staging out of the valley towards their journey down the HCMT through Laos.

The A Shau Valley, scene of many heavy conflicts.

Strategically, the A Shau Valley lay just 30 miles (50 kms) to the southwest of Hue and approximately 1.2 miles (2 kms) to the east of the Laos boarder and those HCMT routes through Laos and Cambodia. Unique to the valley, was its short window of good weather in April to strike North Vietnamese forces that amass in the valley. Beyond April, the Valley is usually shrouded in low ceiling fog and drizzle with occasional thunderstorms – cutting combat visibility to zero. According to a USAF Air Weather Service Support to the U.S. Army in Vietnam report, the weather in this part of Vietnam was "like another enemy".

The proposed A Shau Valley weather modification plan was to fly cloud seeding operations to "over-seed" the clouds to rain-out and dissipate them, to clear up the skies, providing improved visibility towards air combat operations. In the words of the above-mentioned AWS report, "…. an inch of rain that falls in 30 minutes, then clears, is much better than a light mist and fog that [persists] for 24-hours or more …."

It's interesting to note; that it was during this cloud seeding application over the A Shau Valley that the 54th WRS began utilizing the deployment of dropsondes, collecting horizontal (flight level) and vertical weather data that would subsequently be shared with the 1st Weather Group weather center (Det. 14) at Tan Son Nhut Air Base – that fueled the misinterpreted belief that the squadron conducted weather reconnaissance flights in SEA.

Under this China Lake weather modification application, more then 175 cloud seeding sorties were flown within the A Shau Valley over a five-month period (January to May 1968) that were separate and apart from the 734 cloud seeding sorties conducted in 1968 under Operation Popeye.

Quang Tri Rainmaking (1972)

As the Vietnam conflict continued, those few senior regional commanders aware of Operation Popeye requested additional weather modification support. DoD historical references suggest that operational commanders directing the air war in SEA, were hampered by foul weather (low

ceilings, rain and fog as well as overcast stratus clouds) obscuring bombing targets and interfering with tactical aircraft supporting allied ARVN [Army of the Republic of Vietnam] ground troops engaged in battles with North Vietnamese Army. This situation came to ahead in March 1972 during the Easter / North Vietnamese offensive in Quang Tri Province. The poor weather conditions favored the enemy's advances, due to the inability of U.S. Tac Air assets to see the ground (targets) near ARVN ground troops. Thus, weather modification was proposed and requested to break up the poor weather conditions to advance U.S. tactical operations to counter the enemy's offensive.

Unfortunately, as the story goes, neither the China Lake control group, nor the 54th WRS seeding assets were in-country at the time and subsequent technical information provided by others weather experts suggested a limited effectiveness with the weather conditions being experienced in the region by the cloud seeding capabilities available. Thus, no cloud seeding flights were known to be conducted to lift the siege at Quang Tri.

However, it has been suggested in other DoD /USAF (CHECO) reports that cloud clearing and precipitation reducing cloud seeding operations were conducted to benefit U.S. tactical air missions at various times during the war between 1966 and the end of Popeye in 1972.

SEA Acidic Rain

One potential broader application, that continues to resist disclosure (verification), is the SEA Acidic Rain cloud seeding project. Believed to have been conceived in 1968, this cloud seeding technique comprises the seeding of warm stratus clouds with chemical compounds that not only caused seeded clouds to dump their precipitation, but also creates something akin to a caustic "Acidic Rain".

First presented into the public domain in the original Rainmakers of SEA newspaper stories in 1971-72, the understanding of this seeding project (according to unnamed civilian and Air Force cloud seeding program personnel interviewed by the press at the time) was for a caustic rain to fall over North Vietnamese controlled areas and corrode and / or rust metal it came in contact with. The hope was that the caustic rain would foul the mechanical and electrical components of SAM air-defense targeting radars as well as other mechanical air defense systems to make them fail during U.S. B–52 bomb strikes.

According to various military history publications, some related to specific SA-2 (two-stage) SAM missiles, weapons museums and organizations associated with Vietnamese missileers veterans; suggest that there were "no" SAM missile and / or radar guidance / targeting operation issues during the Vietnam war – associated with caustic, corrosive, acid rains. It's not fully understood where specifically the newspaper reporters of the day, their sources, came up with this story of corrosive "Acidic Rain" weather modification*.

Korean WxMod Application

Another broader application of tactical weather modification in SEA, and in the greater surrounding Asian region, comprises the potential use of weaponized weather modification applications against North Korea. Conducted between 1968-69, this application of (alleged) weaponized weather modification in North Korea coincides with the urgent escalation of (war) tensions between the U.S. Government and North Korea, during the Korean Crisis of 1968-69, precipitated by the capture of the USS Pueblo (AGER-2) Intelligence (spy) Ship on January 23,1968, by North Korean gunboats. This crisis was complicated by the perception that any wrong reactions by the U.S. to the ship being seized, could have easily provoked a reengagement of the Korean War between North Korea and South Korea – that could then escalate into a World War III scenario.†

Despite a more aggressive posture, that encompassed a number of cross-border attacks along the DMZ, an attempted assignation of South Korean President Park Chung-Hee and the shootdown of American EC–121 electronic intelligence aircraft prior to (and again months after) the taking of the Pueblo (that included beating and torturing the ship's crew), the North Korean's did "not" specifically mobilize for an all-out war with the West – according to U.S. overhead reconnaissance spy planes. While the U.S. DoD & Joint Chief's of Staff strongly recommended punitive retaliatory strikes, the Johnson administration chose to exert constraints, and presented a strong "show of force" action in concert with diplomatic pressure to force the return of the crew of the Pueblo.

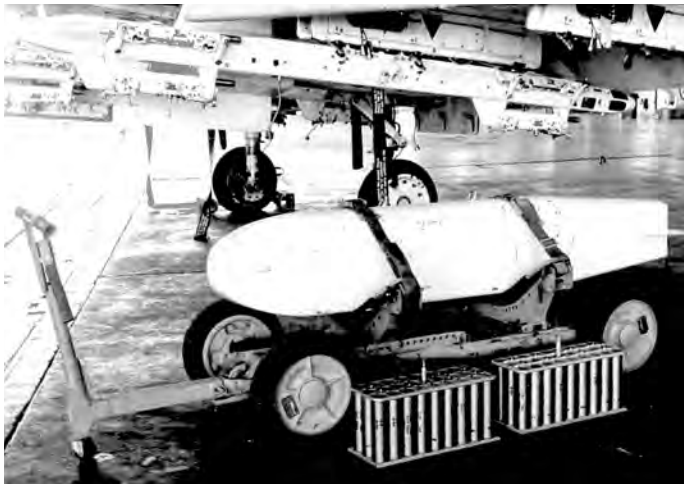
15th Tactical Recon Squadron RF–4C aircraft.

Rather than take any potential (pre-emptive) punitive action; i.e. conduct tactical air attacks on North Korean military targets (airfields, bases -etc-), attack North Korean Patrol Boats, seize or sink North Korean merchant vessels, air attacks on industrial manufacturing facilities, electrical power plants, railways – with a potential extreme option of the use of a tactical nuclear device; Johnson chose to utilize a less provocative show of force without causing the establishment of a second theater of hostilities within Asia. In this concept, Johnson had a large contingent of U.S. troops in Vietnam, redeployed to South Korea, newly trained solders and material on the way to Vietnam were redirected to South Korea, with high-altitude intelligence/-reconnaissance spy planes (the CIA's A–12 Oxcart and the Air Forces' SR–71) flying missions in SEA redirected to South Korea, with elements of the U.S. Navy's 7th Fleet (a large carrier task force built around the USS Ranger CVA-61 and USS Enterprise CVN-65 and approximately 28 additional surface combatants and a nuclear submarine armed with nuclear Polaris missiles) redeployed to the Sea of Japan, taking up station off the east coast of North Korea in international waters, as counter-measures to armed conflict.

It was also within this constrained environment, that more covert actions were presented, such as the use of in-

* Some additional random internet sources suggest that B–52 Bombers themselves may have been involved in this potential project as seeding aircraft utilized in the SEA Acidic Rain weather modification project.

† Given that the original Korean War (1950-53) had only been paused, with cession of hostilities curtailed via the signing of the Korean Armistice Agreement on July 27, 1953, separating the two countries along the subsequent Korean Demilitarized Zone (DMZ) between North and South Korea (along the 38th Parallel North) and no real specific peace treaty was ever signed, reengagement of the war between the two Koreas was ever present and had the potential of destabilizing the entire Northeast Asian region - escalating into a third World War.



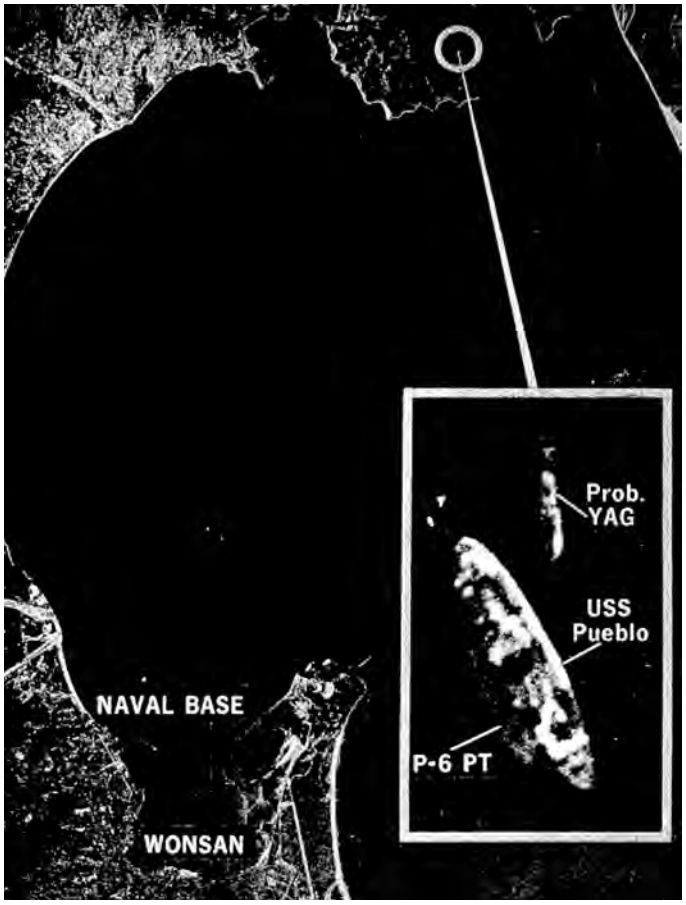
Navy China Lake developed fast-jet weather modification (cloud seeding) generator Pods, devices used in Operation Popeye in Southeast Aisa.

telligence gathering drones to compliment overhead reconnaissance, electronic countermeasures flights, flown to purposely disrupt North Korean early warning and air defense systems and (for this discussion) the presumptive use of tactical weather modification.

The cloud seeding aircraft utilized in this unique environment are believed to have been tactical reconnaissance RF–4C from the 18th Tactical Fighter Wing / 15th Tactical Reconnaissance Squadron, equipped with the same (type) Navy China Lake designed fast-Jet cloud seeding generator / flare ejector systems, being utilized in Operation Popeye by Air Force RF–4C Jets in SEA.

Under the reactionary deployment of forces and aircraft into South Korea, in the wake of the *Pueblo* Incident, the 18th TFW sent a 6-9 plane detachment of RF–4Cs from Kadena AB (Okinawa, Japan) to Osan AB in South Korea. Records show that the squadron operated from Osan between February and June 1968, before re-deploying to Itazuke AB in Kyushu, Japan to continue their area air defense mission over North Korea*.

Any weather modification mission in Korea would have been conducted to support U.S. and South Korean interdiction / anti-infiltration efforts against North Korean incursions across the DMZ and generally harass the North Koreans during the period that they held the crew of the *Pueblo*. This issue of interdicting cross border incursions by North Korean commandos became a priority action and the use of tactical weather modification as an anti-infiltration countermeasure (like that being conducted in SEA by



The imprisoned USS Pueblo captured by CIA A–12 Oxcart overhead spyplane.

Operation Popeye) would have been seen as a viable action to employ in Korea.

It's interesting to note; that for an extended period (well before September 1– November 30, 1968) the North Korean Pyongyang (-Sunan) Airport reported some form of precipitation "everyday" during this time. Including mists, drizzle, light rain, intermittent rain, rain, fog, freezing rain, flurries and light snow, or a combination of all these forms of precipitation, for several months straight during the 1968 crisis.

The *Pueblo* crew of 82 were eventually released 11 months after having been captured. The *Pueblo* itself is still held captive to this day. It was never decommissioned by the U.S. Navy and is still on the books as an active serving Naval vessel.

Cambodia / Laos Cloud Seeding (1969-72)

As part of the CIA's secret war in Cambodia & Laos, conducted between 1960-73, escalations occurred in 1968-69 fueled by an up-tick in infiltration of North Vietnamese Army troops into Cambodia via western adjunct routes of the Ho Chi Minh Trail network – in the north and southern panhandle region of Laos. The NVA were building *"sanctuary"* areas, truck parks and logistical storage areas, all protected by newly introduced anti-air defenses *(SAM missiles)* just over the border in Cambodia, as well as develop-

* By June 1968, area U.S. Commanders became concerned with the high number of U.S. Aircraft in South Korea, should a surprised escalation and or attack come from North Korea. Thus, a plan was established to redeploy U.S. tactical aircraft back to Japan, rotating a smaller number of aircraft back and forth to South Korea, from Japan, every 4-8 days. Besides those rotating aircraft, additional U.S. tactical aircraft could be quicky deployed to Korea within a few short hours of any attack.

A representative image of the area where another weaponized weather modification application was employed.

ing new trail sections of the HCMT. In some case, new drivable sections of the trail through the various mountain passes were being developed*.

To generally harass the Chinese road builders, unseat NVA troops in Cambodia and support the Royal Lao Government against the Pathet Lao and Viet Minh communist insurgents in the Laotian civil war, the CIA and U.S. Special Forces fought an unconventional secret war, for the most part separate from the Vietnam War being fought just over the border. In these covert efforts, the CIA also fought to interdict NVA infiltration and resupply routes branching off the HCMT into Cambodia and Laos†.

Besides persistent B–52 Bomb strikes conducted throughout the year, over several years, between March – June 1970, President Nixon sent regular U.S. Combat troops from Vietnam to invade Cambodia after months of secret bombings there in Laos, in areas adjacent to the Ho Chi Minh Trail.

Given the priority of these covert operation in Laos and Cambodia, it seems evident that additional cloud seeding operations were also conducted, independently employed to interdict the North Vietnamese supply lines into this area. What is known, is that the monsoon rains of 1969 were the heaviest ever seen on record in Southern Laos – while at the same time experiencing 100-year drought conditions. Both USAF Air Weather Service records and CHECO reports suggest that a specific *(and separate)* cloud seeding / weather modification effort, to that of Popeye, was

Dr. Edwin X. Berry (left) with Dr. Pierre Saint-Amand, in the Philippines for Project Gromet II, in 1969.

established to specifically focus weather modification operations on Laos and Cambodia.

It is here that public domain references and inferences have suggested that this specific cloud seeding operations conducted in Laos and Cambodia may have employed the use of B–52 bombers as cloud seeding aircraft. Besides a random mention of the proposed effort in a DoD report on weather modification in SEA, one of the more public references of B–52s as seeding aircraft comes from an unlikely source, a webpage on the internet.

The potential of B–52 Bombers utilized for weather modification comes to us via an internet website belonging to Dr. Edwin X. Berry (Ph.D.) (The original website is now archived at; www.kimberry.com/ARCHIVES/edwin_x_berry/ed_in_philippines_1969.html). Dr. Berry is an American Atmospheric Physicist that at one time was one of Pierre Saint-Amand's contracted specialists involved in NWC China Lake weather modification projects in the Philippines and potentially on Operation Popeye, in 1969. It's clear from information on Berry's website, and from personal conversations directly with him, Saint-Amand

* It has long been known within military intelligence circles that China had (grand) secret plans to conquer all of the nations in SEA, including Thailand, and complete a new modern highway from southern China all the way south, to a new "Chinese" port on the Indian Ocean. In this regard, over 6000 Chinese military personnel, mostly engineering troops and security soldiers, were building extensions of a road and support facilities in northeastern Laos – independent of the North Vietnamese. Since the 1950s, the CIA mounted covert commando raids in northern Burma and Laos to harass the Chinese road builders, by blowing up construction equipment, setting up booby-traps, ambushes along supply lines and outright killing Chinese personnel when detected.

† At this time other "In-Country" SEA conflicts were waged that encompassed the USAF's secret [Project 404] to conduct covert bombing missions in Cambodia and Laos via Thailand. A subset of this project "Commando Hunt" sought to counter North Vietnamese aggression in Northern Laos; to interdict material support to the Pathet Lao / Viet Minh from adjunct sections of the HCMT and the drivable road sections being built as well as sanctuary camps (and to prevent the communists insurgents from penetrating further west reaching Lao villages) [previously known as Operation Steel Tiger] And other USAF missions in Southern Laos (panhandle) to interdict NVA and VC forces moving down the HCMT to South Vietnam - through Laos and Cambodia –[previously known as Tiger Hound].

USAF B–52 Bomber in the western Pacific circa 1969.

USAF Air Weather Service WC–135B weather reconnaissance aircraft at Clark AFB Philippines (circa 1969).

had Berry train USAF B–52 pilots (based nearby at Clark Field) in the art and science of cloud seeding – during Operation GROMET II cloud seeding / drought relief operations conducted in the Philippines in 1969.

Berry additionally reports that later, while still in the Philippines at Clark AB, he saw Silver iodide cloud seeding dispensers mounted to the airframes of B–52 bombers at Clark Field. The seeding devices were mounted aft of the wings, between the aircraft's wings and the tail sections of a B–52 bombers.

Unfortunately, it's fairly clear from Dr. Berry's website that he is somewhat in the dark about this aspect of his participation in weather modification for Saint-Amand. It is his understanding that the B–52 cloud seeding aircraft and aircrew training were just part of Operation Popeye. However, no currently available archival documents to date (those from the DoD, Congressional or Navy / China Lake archival sources) mentions cloud seeding operations by B–52s, nor associated with Operation Popeye. In fact, there is currently no archival information or references to date that suggest any cloud seeding operations were conducted by B–52 aircraft. Dr. Berry's website and his comments are the only current reference source that identifies USAF B–52s as having been (potentially) used as cloud seeding aircraft, and directly links Pierre Saint-Amand (China Lake) to other weather modification efforts in SEA.

No disrespect to Dr. Berry intended, but there are a few simple facts on the surface that dissuade B–52s at Clark Field from being utilized as seeding aircraft. Principally, there were "no" B–52s stationed at Clark Field in the Philippine during this period or at all – so he could not have seen them on the tarmac equipped with seeding dispensers. The fact is, the wing span of B–52's are too long for the narrow taxiways around Clark AFB. Configured with engines out near the wingtips, these engines would easily suck-up gravel and other debris during taxing. However, there were both WB–47E Stratojets and WC–135B Stratolifters from the U.S. Air Forces' Air Weather Service at Clark during Berry's time there. The WC–135B looks something like a B–52 and could have easily been mistaken by Berry back in 1969.

Armed with this knowledge, it is potentially evident that the secret weaponized weather modification application conducted over Laos and Cambodia in 1969-72 could have easily been conducted by USAF AWS WC–135B weather reconnaissance aircraft equipped with cloud seeding dispensers.

It's interesting to note; that at this same timeframe between 1968-70, covert WC–130Es and WC–135Bs were stationed in Ubon (Thailand) on secret weather reconnaissance missions, scouting air-to-air refueling areas over the South China Sea (and over Thailand itself) towards the refueling of the CIA's A–12 Oxcart spy planes forward deployed to Kadena air base on Okinawa. (the CIA's A–12s, under Project "Black Shield" flew overhead photo reconnaissance missions of North Vietnam, along the border of North Vietnam and Southern China and Laos) These AWS support weather reconnaissance scout flights were flown by a special detachment of the AWS's 55th Weather Reconnaissance Squadron (utilizing WC–130s from the 54th WRS at Guam and WC–135B aircraft from the 56th WRS based in Yokota, Japan). Air Force archival records (as well as declassified CIA archival [CREST] documents) also identified that the 55th WRS also flew "Special Meteorological Reconnaissance Flights", during this same time, which is similar to the "Special Weather Reconnaissance Flights" designator utilized in internal AWS memos (when) talking about the 54th WRS's rainmaking operations in SEA. As cloud seeding missions go in SEA, these AWS aircraft at Ubon were in very close proximity to Laos and Cambodia by which to have also conduct these little-known cloud seeding missions*.

* Although this Laos cloud seeding project is barely perceptible within the public domain, with most of these details only discernable in military archival records, it should not be confused with a little-known 1968 aerial HCMT interdiction effort, where USAF UC–123 and C–130 "Blind Bat" flare-ship aircraft (flying out of Udorn) deployed "tear gas" along the Ho Chi Minh Trail area in Laos and Cambodia to hamper enemy infiltration. Under this effort, tear gas chemicals were carried in 55gal drums, and equipped with explosive detonators, were dropped over areas of Laos and Cambodia. The barrels would then explosively dispersed tear gas at ground level in different infiltration sites to hamper enemy troops. Military records indicate that this operational program failed its objective, further curtailed with the discontinuation of Blind Bat flare-ships and their subsequent development into AC–130A Spectre gunships.

Cloud-seeding device being installed on the side of an unspecified USAF aircraft.

USAF Air Weather Service WC–130 Hercules in Pacific typhoon eye clouds.

Though some of the northern areas of Laos may have been seeded as part of a normal component of the ongoing Popeye operations by the 54th WRS in their WC–130s, other Air Force AWS records suggest that two other AWS aircraft were assigned and equipped for specific rainmaking operations in Southern Laos and Cambodia, to specifically interdict North Vietnamese infiltration down the HCMT through Laos and Cambodia. And if that weren't enough, one of the two "other" AWS seeding aircraft was tasked to conduct Drought Relief cloud seeding in Laos and Cambodia.

Drought Relief

It's interesting to note: that despite seasonal monsoons in Southeast Asia, many areas of SEA experienced severe droughts during the latter decade of 1960s / early 1970s. In fact, most of the world was experiencing an emergence of anthropogenic driven [human induced] severe droughts during the over-lapping decade, with more than 36 countries experiencing severe drought conditions causing heavy crop losses, including India, Pakistan, China, Korea, the Philippines, Indonesia and several countries in SEA. Both rice and corn production (yields) were dangerously low in Thailand, Cambodia, Laos and elsewhere in SEA at this time.

The artificial rains from cloud seeding / weather modification flights in Laos and Cambodia would go a long way to easing the stress of potential famine in Laos and Cambodia. Drought relief weather modification was one of Saint-Amand's more successful applications of weather modification.

Popeye: Storm Seeding

One of the more controversial suspected weaponized weather modification applications potentially conducted as part of Operation Popeye or more likely separately, was "typhoon modification". Leveraging off years of China Lake's experimental hurricane seeding operations in the Atlantic (believed to have been operationally implemented by this time in the Atlantic, creating, intensifying and steering hurricanes towards Cuba to destroy its economy), it was not outside the realm of possibility for China Lake to take tactical weather modification operations in SEA one step further and seed typhoons and tropical storm clouds, affecting Vietnam, in order to create an even more destructive outcome.

What is known is that between 1970-71, based on circumstantial anecdotal and largely unsubstantiated "hearsay" evidence, its believed that the Popeye folks conducted seeding operations on clouds associated with convective thunderstorms, tropical storms, typhoons / or the remnants of typhoons that tracked into or near Vietnam. If confirmed, the seeding of clouds within the circulation of a storm, with the express interest of increasing rainfall over strategic areas of North Vietnam, meant to inflict severe damage on the enemy – aimed to specifically washout railways and bridges, flood urban highways and roads as well as cripple the electrical generating capability of North Vietnam - is perceived as criminal. This concept of deliberately seeding storms initially evolved from congressional investigators for Senator Pell, who suspected that particular tropical storms (i.e. remnants of Western Pacific typhoons) affecting Vietnam were potentially cloud seeded to ultimately caused catastrophic flooding and damages throughout the whole of North Vietnam.

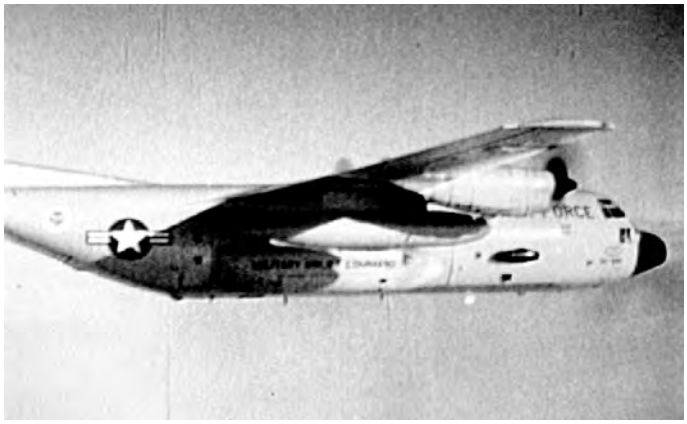
The fact of the matter is that unusual torrential rains did occur in August 1971 and contributed to severe flooding, that wrought significant destruction on to North Vietnam, that had not been seen there since before WWII. Known generally as the severe flooding of August 1971, unusually heavy and prolonged (widespread) torrential rainfall, flooded three different river systems in the north, that breached 1000-year-old dikes surrounding the heavily populated city of Hanoi. More than 618,000 acres (250,095 hectares) were flooded, wiping out the annual rice crop of North Vietnam (for that year), and killed approximately 100,000 people, rendering approximately 300,000 homeless and ultimately affecting more than 2.7m people. It's been said that the Nixon Administration had been reluctant to bomb these same dikes and or attack the food (rice) supplies of North Vietnam, because of the bad press that it would have generated towards his administration.

(Above & below) Storm damage from Typhoon Hester, October 1971.

It's interesting to note; that Typhoon Kate (October 14-25, 1970) is known to have inundated 140 square miles of Vietnam, including South Vietnam (south of Da Nang) creating the worst floods in the region since 1964. Several storms in 1971, Typhoons Harriet (June 30 – July 8, 1971), Severe Tropical Storm Kim (July 8-14, 1971) and Typhoon Della (September 24–October 1, 1971), impacted North Vietnam with severe heavy rains causing catastrophic flooding. DoD statistics recorded significant drops in movement along the Ho Chi Minh trail network during June - July 1971, the same period of some of these storms. During Typhoon Patsy (November 14-22, 1970) the weaken tropical storm made landfall near the DMZ between the two Vietnams and potential effects from the seeding of this storm had disastrous consequences on U.S. combat operations, including the November 15, 1970 "Son Tay Raid".

The raid encompassed a U.S. Special Forces assault on a small enemy compound of Son Tay, 23 miles (37 kms) west of Hanoi, believed to have been housing approximately 65 American POWs. Unfortunately, when the assault force finally reached the POW camp it was empty – no POWS. It's been suggested that severe rainfall (flooding) from a presumed Popeye cloud seeding operation on the remnants of this storm, caused the North Vietnamese to move the POWs sometime before the raid. The Popeye cloud seeding operations were so secret, even in-country, that the Raid's military planners were not informed or were unaware of the potential effects of artificially induced flooding would have on the rescue mission.

Despite efforts in the public domain and in military circles to blame the failure of the raid on Popeye weather modification activities, potentially on storms in November 1970, the reality is that it was an intelligence failure in the Raid's planning. The POWs at Son Tay had actually been moved to a facility 15 miles (24 kms) closer to Hanoi on July 14, 1970 (approximately 4 months earlier) due to potential flooding from a tropical storm – that eventually veered away to make landfall in China.



54th WRS WC–130E Hercules that took over Operation Popeye flights.

Another Vietnamese storm suspected of having been seeded by Popeye includes Typhoon Hester (October 18-24, 1971). Hester developed in the southern Philippines Sea and tracked northward into the South China Sea. The storm struck central Vietnam on October 23, 1971 and brought all combat operations within the whole of Vietnam to a halt. There was heavy damage to both sides of the conflict with severe flooding in North Vietnam killing thousands, while causing damaged to a number of U.S. and ARVN facilities in South Vietnam.

Again anecdotal, and not proven in fact, is that persistent rumors of typhoon(s) seeded by an unspecified U.S. Military organization echoed through the hallways of the Joint U.S. Military Western Pacific weather services, during this time period (1970-71). In one alleged storm seeding mission, referenced by a (perceived) member of Operation Popeye, it's been claimed that one key strategic bridge in North Vietnam was undermined and washed away, having previously resisted repeated bombings.

Given that the 54th WRS was a "typhoon reconnaissance squadron" and equipped with weather modification capabilities, coupled with Saint-Amand's vast experience in seeding hurricanes in the Atlantic, all the elements were in place by which to conduct weather modification operations of available tropical cyclones to further cause damage to the enemy. It's all very plausible, but currently no definitive archival evidence exists to verify that it ever occurred.

Apparently, Senator Pell himself firmly believed that the U.S. military forces (i.e. DoD /U.S. Air Force) had seeded a storm or storms which ultimately killed tens of thousands of people in North Vietnam in 1971. Nearly every witness that appeared before Senator Pell's Committees, was asked if they knew anything about seeding typhoons and manipulation of tropical storms causing severe flooding in North Vietnam. Despite testimonies before Congress, that no seeding flights were ever conducted during tropical storms (as stated in the transcripts of the Congressional hearings on the rainmaking operations in SEA 1972-74), comments by others claiming to have been associated with Operation Popeye, suggest that storm(s) "were" seeded and caused the very types of damage seen in the aftermath of these known storms in North Vietnam.

Senator Claiborne Pell of Rhode Island (left - seated) during congressional hearings with other Senators, aides, and committee members.

Although not discussed publicly, Pell it seems personally viewed the weaponized weather modification operations in SEA as criminal and specifically the seeding of storms (that caused the death and destruction seen in 1970-71) as tantamount to "war crimes". Pell was so adamant about this aspect of the secret rainmaking operations in SEA, that he repeatedly sent letters to DoD officials, U.S. Air Force Chief of Staff and Director(s) of the CIA, specifically asking if rainmaking seeding flights were ever flown into tropical cyclones in SEA. (according to declassified CIA archival [CREST] documents).

The Beginning of the End

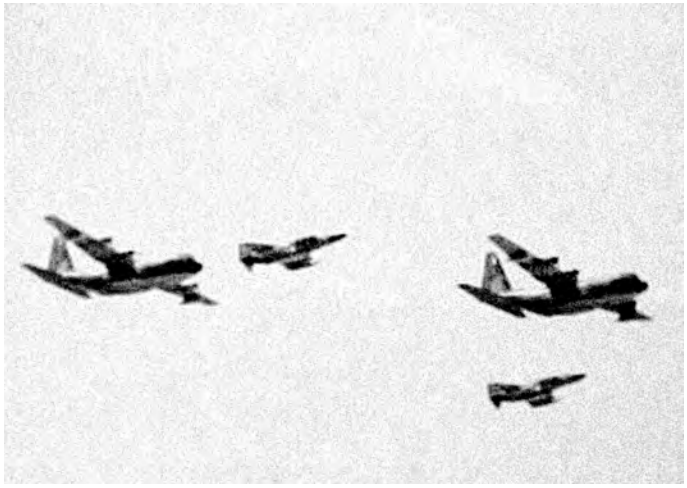
Although not revealed at the time, these letters of inquiry from Pell were concerning to the CIA. Coupled with continued press interests in the Rainmaking in SEA story, the agency was hard-pressed to devise a strategy to deal with the situation. Revealed now to some extent through declassified CIA archival [CREST] documents, internal memos and adjunct support strategy (memos) specifically directed towards responses to Pell's inquiries, the CIA ended up sacrificing Popeye as a means to end public interest (and that of Pell's') in this story. But more importantly, to protect their on-going covert geophysical warfare campaign against Cuba – which just so happened to include the manipulation of hurricanes as a weather weapon of war.

It's interesting to note; that the CIA struggles to strategize an acceptable response(s) to Pell's inquiries, was made difficult because the CIA could not be seen to be actually lying and simultaneously appear truthful in their response without having to answer difficult questions. [the old UFO "swamp gas" or "nothing to see here" remarks were not going to suffice] As indicated in numerous declassified CIA archival [CREST] documents - internal memos associated with the CIA's crafting direct responses to Pell's inquiries - CIA lawyers forbade the agency to lie in writing. Written lies are subject to disclosure in the event of subsequent legal or government investigative proceedings. With telling the truth not necessary an option, the only way for the agency to communicate a lie would be verbally (hopefully not recorded on tape or film) which presents additional legal issues. The result of this situation for the CIA, encompassed a number of elements. Telling the truth (or a version of the truth) to steer away unanswerable questions, deflections to avert the truth, through the use of messengers who are unrelated to the topic in question, and thus, who can offer up "…. to the best of my knowledge …." and not be lying, and or the traditional go-to comments that didn't actually answer the question and invoked some level of National Security. Thus, SACSA (under its guise as the DoD / JCS support staff office) chose a combination of all these options and offered to provide Pell's committee with a Top Secret / Classified briefing of the Rainmaking Operations in SEA in 1974.

Additionally, knowing that Pell would not be able to resist disclosing the classified brief to the public (Remember this was the era of Watergate, the disclosure of the Pentagon Papers just a month or two before and major public displays of civil disobedience) it was hoped that the distraction of the dissemination of Operation Popeye and the true(ish) details of the presented cloud seeding / weather modifications operations in SEA, would divert attention away from Pell looking any further into the U.S. Military's weather modification operations. The subsequent effort taken towards the eventual Environmental Modification ban treaty (ENMOD) also lent itself to easing continued interest in their covert weather modification efforts – to some degree.

In the end, Operation Popeye (specifically) conducted approximately 2602 cloud seeding sorties, expending approximately 47,409 canisters (flares) of Silver iodide seeding materials over North Vietnam, Laos, Cambodia and South Vietnam, at a cost of $21.6 million dollars, between 1967-72.

Although the results of these secret weather modification operations were played down, once the project was made public in 1974, to a total rainfall increase of 10 percent over normal precipitation, it's believed that the actual



Operation Popeye aircraft after their 500th cloud seeding mission on July 31, 1968.

total was much higher or as much as a 30 percent increase in precipitation along different areas of the HCMT network. The program's further goal of extending the seasonal monsoon conditions to 30 days or more was also achieved, with upwards of 37 days on average extended to the southwest monsoon seasons. Peak for the cloud seeding project occurred between 1969-71, coinciding with record annual rainfalls of more than 48 inches of rain in the month of July 1969 alone. DoD / Defense Intelligence Agency (DIA) reports establish that trafficability of enemy combatants along the Ho Chi Minh Trail dropped from 9000 per week to 900 per week in June 1971 due to an unusual period of heaviest rains.

Public domain references on this issue downplayed the successfulness of Popeye because that was what was stated in the released classified briefing presented to Pell's Committee. Unbeknown to the public, Popeye eventually established capabilities to collect rainfall data along the HCMT and analyze it. The unexpected higher rates of rainfall estimates came as a result of rainfall data collected as part of an ongoing DIA information gathering project associated with tracking the increases and decreases of enemy movements along the Ho Chi Minh Trail network and infiltration routes. Known as "Project Roadwatch", special indigenous 12-man reconnaissance guerrilla teams, integrated with U.S. Special Forces personnel, were employed to specifically surveil the trail system. (declassified DoD reports and operational histories associated with the various interdiction operations in SEA, reports that Project Roadwatch was actually a CIA operation established under the "Studies & Observation Group" [SOG] division of MAC-V [i.e. MAC -V- SOG]. SOG was established by SACSA in 1964 and placed under MAC-V.)

In an effort to better support Popeye operations, SACSA arranged for USAF Air Weather Service weather personnel to train Roadwatch guerrillas in basic weather observations and reporting. The guerrillas were also taught how to collect rainfall measurements along areas of the HCMT system (via rain gages). Twice a day, Roadwatch personnel sent local area weather reports, with rain gage / rainfall measurements to Popeye HQ via specialized CIA radio circuits. These rainfall measurements and their analysis supporting trafficability estimates were also backed-up by electronic intelligence sensor data collected as part of a monitoring component of another anti-infiltration / interdiction project known as "Igloo White."

This photo of the Viet Cong moving along a section of the Ho Chi Minh Trail was taken by a MAC-V-SOG guerrilla monitoring enemy movements along the trail system under Project Roadwatch.

Igloo White components utilized included this CIA-operated P–3 Orion (above), as well as Acoustic Brown Buoys (sound activated listening devices) dropped along the HCMT system (below).

Igloo White was a covert (DoD) military operation that introduced "Electronic Warfare" into the SEA War. (i.e. the "Electronification" of the war) Igloo White was a state-of-the-art Electronic network of systems, sensors and instruments (as well as a clandestine P-3 Orion operated by the CIA), collectively creating an electronic barrier to detect and track mechanical and human foot trafficability along the HCMT and other areas of infiltration in SEA. This was the system that McNamara requested be established – per his September 17, 1966 letter request – and was to be operationally implemented by 1967. As it was, Igloo White via a number of various sub-component elements developed through 1967, saw final operational status in January 1968.

Although a number of road sections, trails and dikes were completely washed away, and much flooding was produced (destroying 10 % of the total North Vietnamese Rice crop during Popeye's 5-year run) Popeye might seemingly have been considered a technical success. However, there

as indicated by this image, the Viet Cong were able to overcome the problematics of flooded trails with bicycles replacing trucks.

is no statistical evidence that Popeye had any appreciable tactical effects on the movements of the enemy's logistical supplies or troop infiltrations into the south along the Ho Chi Minh trail system. Although it can be said that Popeye slowed infiltration down to some degree, it did not halt trafficability altogether – which was the hoped goal. The Vietnamese were seemingly very adept at approaching a situation and overcoming any or all obstacles. It would seem logical to assume that NVA and VC had previously conceived of techniques by which to move supplies and personnel along the trail system during a normal rainy monsoon season (based upon Project Roadwatch trafficability reports and statistics). It would have been easy for them to have just continue those procedures if the monsoon conditions persisted beyond their normal period – or develop new ones to overcome increased rainfall and flooding along the trail system. In this view, Popeye was a futile attempt to use weather as weapon, when the weapon was useless in the kind of environment that was the Vietnam Conflict.

Ultimately Operation Popeye came to an end on July 5, 1972, when the last cloud seeding missions were flown. The end was precipitated by the virtually concurrent public disclosure of the rainmaking operations in SEA, by a series of *New York Times* newspaper articles written by investigative journalist Seymour Hersh beginning on July 3, 1972. This series encompassed *"Rainmaking Is Used As Weapon by U.S.", "Cloud-Seeding in Indochina Is Said to Be Aimed at Hindering Troop Movements and Suppressing Antiaircraft Fire"; "Rainmaking Used for Military Purposes by the U.S. in Indochina Since '63"* and *"67 Ordered to End Rainmaking,"* were all published between July 2-5, 1972. Hersh had only recently joined the newspaper in April, 1972, after his freelance reporting of the My Lai Massacre.

It's interesting to note; that the first actual disclosure of the "Popeye" weather modification in Southeast Asia occurred in August 1971, through the unauthorized release of the so-called *"Pentagon Papers"* by Daniel Ellsberg, wherein early versions, Volume 4, Number 8 mentions: *"cause interdicting rains in or near Laos."* The Pentagon Papers [officially entitled *"the Report of the Office of the Secretary of Defense – Vietnam Task Force"*] was a 3000-page historical record of the U.S. involvement in Indochina. Analysis of the document illustrated the Government's gross mismanagement of the war, the Government's misleading of the U.S. public with regards to its handling of the Southeast Asian conflict and the conclusion that through all the death and destruction, the war was unwinnable and futile, and that they knew this early on—and yet they continued the war anyways.

Among its many pages were references to the weather modification operations in Southeast Asia, that comprised Project Popeye (1966) and the first year or so of Operation Popeye (1967), but were generally missed for some months amongst all the other pertinent information regarding the U.S. Military's prosecution and management of the war.

Most public domain stories about Popeye report that it was syndicated newspaper columnist Jack Anderson that first disclosed the rainmaking operations in Vietnam in his Washington Post column *"Air Force Turned Rainmakers in Laos"* on March 18, 1971. Despite his newspaper story sourced by supposed U.S. Government informants and information provided by a slew of (hired) confidential investigators, the story he told was not quite right. It is now evident that Anderson did not have (early) access to the *Pentagon Papers*, that at the time were floating around Washington in various versions seeking a means to be published in any newspaper that would dare. If Anderson had seen the "papers" and noticed the references to weather modification in SEA, his story would have been much different and more accurate.

Despite Anderson's article, some of the very first accurate reporting of the weaponized weather modification in SEA, derived from the Pentagon Papers, was a newspaper article published in a local Chicago paper in early May 1972. The article, published in the READER; Chicago Free Weekly, [Vol.1 No. 29, 12 May 1972], entitled *"Report Implicates Pentagon in Weather Warfare"* by Andrew Segal, highlights "…. Geophysical warfare rain-making, earthquakes and tidal wave control, and other forms of climate modification for military purpose – is being research and developed by the Pentagon …." .

This article was based on a preliminary report written by the Chicago Collective of "Science for Viet Nam" or SFVN. The SFVN was in-turn a component of the national [university - based] "Scientists and Engineers for Social and Political Action" or SESPA, which produced its own magazine called *"Science for the People"*, where another article based upon their report was published, later in March 1975 issue of the *Science for the People (Vol. 7, No.2)*. The SFVN report *"The Big Gun, is The Rain"* was a preliminary (semi-technical) report on the use and potential of Geophysical Warfare by the United States (circa April 1972).

The Chicago Collective (chapter) of Science for Viet Nam, made up of a group of science-based professors, engineers, grad-students and students at the University of Chicago (where there was a strong meteorological program), were already involved in world climate change debates and the ethics of weather modification – when someone in the group noticed references to weather modi-

fication embedded in a circulating copy of the *Pentagon Papers*. It was decided by the collective, to create an investigative sub-committee to looking into the references of weather modification within the Pentagon Papers and any other references to government [geophysical] weather modification in meteorological literature and government reports, papers and records. It was this investigative effort, that lead to the SFVN's report that fed into Andrew Segal's article.

The SFVN and the SESPA story is an interesting peek into a little-known chapter of the anti-Vietnam War history of the 1970s. As educated and liberal American scientists, the SFVN and the SESPA tried to equalize the playing field in reactions to the devastation wrought by the U.S. Military and the conservative U.S. Government on the Vietnamese people. These scientists made visits to North Vietnam and had university -to- university connections (like with the University of Hanoi) to provide their counterpart Vietnamese professors and scientists with the latest knowledge of agricultural science, medical, meteorology and atmospheric [science] papers, reports and publications – as scientist -to-scientist peace offerings.

Unfortunately, these actions ran a foul of the FBI and separate investigations were undertaken against the SFVN and the SESPA, labeling them radical, leftists, socialist / communists and more than likely guilty of revolutionary activities. For full disclosure, this story of the SFVN and the SESPA is much more comprehensive than can be told here. However, the irony is that this story might never be told, if it weren't for the FBI's investigations that included surveillance, confidential informants who infiltrated the groups and an entertaining sub-plot of lost (or intercepted) luggage that the FBI found to contain copies of the SFVN's paper *"The Big Gun, is The Rain"* earmarked for the (North) Vietnamese "Commission for the Investigation of Crimes of War" in Hanoi. Thanks to the FBI, the components by which to produce the next new binge-worthy streaming series are waiting in declassified FBI archives.

A word about Codenames: when Operation Popeye was disclosed by Jack Anderson in the Washington Post in March 1971, he actually never mentioned the codename of the Southeast Asian weather modification project as being "Popeye". Instead, he used the codename "Intermediary - Compatriot". The actual name Popeye was not used for more than a year after Anderson. Only first appearing in the series of New York Times articles, beginning in early July 1972, on the weather modification project in Southeast Asia, as reported by Seymour Hersh.

It's been suggested on internet webpages and elsewhere in the public domain, that the original name of the Southeast Asia cloud seeding project was called Popeye initially and later, having been compromised on a couple of occasions, changed its code name to "intermediate" and or "compatriot" or both as in the case of Anderson's reporting. However, this is not actually the case and this understanding of codenames is not historically accurate.

After deep archival review of U.S. State Department, Congressional, DoD and U.S. Navy (China Lake) archival records, it seems evident now that all the various agencies and services that directly supported or had over-view of the rainmaking project in SEA, utilized their own individual codenames for these weather modification applications in SEA. The Military Assistance Command–Vietnam (MACV) used the codename "Flat Tire" for Project Popeye (1966). The 54th WRS used the codename "Motorpool" for discussions (and scheduling) of the cloud seeding flights within the squadron. The codename "Compatriot" apparently stems from a memo from White House National Security Advisor Walt Rostow to Defense Secretary, Robert McNamara in early 1967. (Compatriot was also used in a memo to McNamara from CM Wheeler at the State Department May 1967) In the previously mentioned Rostow memos to President Johnson, the codename "Compatriot" was used. However, Ambassador Sullivan in Laos used the Popeye codename in all his cables to Washington on the subject of the SEA weather modification effort during the same 1966-67 timeframe. (It's now evident, that Anderson's initial source for his article on the Rainmaking in SEA, was from the White House or the State Department)

Ultimately it was China Lake's codenames Project Popeye and Operation Popeye, that stood the test of time and were never compromised. (except in the *Pentagon Papers* that few noticed) The reason that Operation Popeye did not come to a screaming halt in March of 1971, with the publishing of Jack Andersons article, is that "Intermediary-Compatriot" was not the name of the project. However, once Seymour Hersh published his articles in early July 1972, all cloud seeding flights in Southeast Asia, suddenly ceased on 5 July 1972.

Despite public domain assertions that the SEA rainmaking operations had been compromised and had to change codenames several times, this is historically inaccurate. It's also dismissed by the level of secrecy surrounding the program and the lengths that SACSA (disguised as the DoD / JCS) would go through to keep it all secret. In this regard, you don't have to look any further than what happened to USAF Capt. Jeffrey E. Millard, assigned to the AWS's 54th WRS in Guam.

In April 1971, Capt. Millard had been rotated to Udorn AB, Thailand, his first time participating in Operation Popeye rainmaking operations over southern Laos and sections of South Vietnam. Like many squadron members from the 54th, they didn't learn what their mission was until they landed in Thailand and received their first brief on the on-going operation. After just one operational cloud seeding flight, Millard approached his detachment Officer-in-Charge and questioned the operation on moral grounds. He apparently went on to say that "in all good conscience" he could no longer fly these weather modification flights, that in his mind they "were against his ideology". He is also said to have requested a transfer back to Guam and to the squadron, or if need be, reassign him on to another squadron to serve out his tour of duty. As the story goes, Millard was told that he would be immediately sent back to Guam and reassigned to another unit. However, once he landed in Guam, he was immediately grounded and detained. He was then told that he would be transferred to

Senator Claiborne Pell, democratic senator from Rhode Island, and Deputy Chairman of the Senate Foreign Relations Committee.

another unit back in the United States and was subsequently put on a transport aircraft for the U.S. Once there, he was detained again and the U.S. Air Force (more likely the CIA) put him through a series of debriefs, while preparing the paperwork (for him to sign) to separate him from the service, despite any objections. Within a few short weeks of that first Popeye rainmaking flight in SEA, Capt. Millard was a civilian again and disappeared – fading back into the fabric of American society.

The point to this story is that, despite the subsequent newspaper and news stories of the secret rainmaking in SEA, weather as a weapon of war, and the public congressional hearings on the truth of weaponized weather modification conducted by the U.S. Military, nobody came forward to say "hey, I know about that" or "hey, I participated in rainmaking flights in SEA". No one "ever" came forward. Especially anyone with the name of Millard.

As a result of all the newspaper articles written by Anderson, Hersh and later Victor Cohn from the Washington Post Service, detailing the clandestine cloud seeding operations, Senator Claiborne Pell (D - RI) began a Congressional investigation and subsequent hearings on the weather modification program in Southeast Asia. Although public opinion in the wake of the newspaper disclosures centered mostly on the moral implications of this type of warfare, Pell and other lawmakers saw the weaponization of the weather " …. as opening a door on a new and dangerous form of warfare causing large-scale and quite possible uncontrollable (and unpredictable) destruction …." much like the way atomic weapons were viewed after Hiroshima. The Popeye seeding operations had created a negative environment, within the U.S. and elsewhere around the world, towards the artificial interference of Mother Nature and the manipulation of the world climate in general.

Senator Pell, at the time, was the Deputy-Chairman for the Senate's Foreign Relations Committee, and Chairman of its sub-committee on Oceans and International Environment. It was in these capacities that Pell began looking into the rumors and newspaper accounts regarding rainmaking by the U.S. Military in Southeast Asia. Pell began with a letter writing campaign in September of 1971, requesting information (and the somewhat disclosure) of rainmaking in SEA from the Secretary of Defense and other DoD officials, the U.S. Air Force Chief of Staff and the Director(s) of the CIA. In most cases Pell did not receive many replies to the letters he sent. In a couple of responses he did get, he was given curt replies citing "classified program and National Security" that he (as a U.S. Lawmaker) was not privy to. When Pell question these responses, the subsequent replies were terser in the strongest terms, telling him that subject mentioned was none of his %#@&! business.

Accordingly, with the start of the new year (1972), Senator Pell formally instigated an official Senate investigation (and a series of public hearings) into Rainmaking in SEA issue, through his sub-committee on Oceans and International Environment. A number of Senate investigators, from the Library of Congress's "Congressional Research Service" were assigned to the task and Pell began sending "invitations" for Military representatives, government officials as well as other technical witness to appear before his sub-committee to discuss and inform the committee on the science of weaponized weather modification and if the witnesses themselves had any knowledge of the secret military weather modification activities being carried out in SEA.

Unfortunately, again important government officials with potential knowledge of the military weather modification activities in SEA refused to appear before his committee. In one case, Pell had to think outside the box quickly, when it became known that the Defense Secretary Melvin Laird was scheduled to appear before the Senate's Foreign Relations Committee, to discuss the Government's resumption of bombings in North Vietnam (the so-called spring bombing and mining operations) in early 1972. On April 18, 1972, Laird appeared before the Foreign Relations Committee. Pell, attending the committee as the Deputy Chairman, (as well as other Senator members of the committee) turned the tables on Laird and ardently began to question the Defense Secretary about the published accounts of military weather modification operations in SEA. Appearing to be evasive in answering any questions about the SEA weather modification activities, eventually later, Pell asked Laird one last time "…. Has the U.S. engaged in weather modification activities for military reasons in SEA …." Laird, perhaps tired by all the repetitive questioning, finally made a statement "…. We have never engaged in that type of activity [weather modification] over North Vietnam …." Thus, this was the final comment from the Defense Secretary on the subject during this hearing.

However, for Pell, the statement presented more questions than answers. Laird had said "over North Vietnam" but nobody had asked him about specifically weather modification over North Vietnam. His answer additionally did

Secretary of Defense Melvin R. Laird, Jr. (seated).

Pierre Saint-Amand from NWC China Lake.

not address potential weather modification efforts over South Vietnam, Laos and Cambodia. Did he Lie to Congress (?)

It's interesting to note; that although the Defense Secretary was willing to discuss the military [B–52] bombing campaigns in SEA before the Senate's Foreign Relations Committee, he was not inclined to discuss any possibility of military weather modification in the same countries.

The question if Laird lied to congress is fleeting. After subsequent public disclosure by the released classified DoD brief on the Rainmaking operations in SEA, Laird is quoted as having said "[he was] Ignorant of the whole operation" and that "he never approved it" according to Seymour Hersh. Laird also is said to have remarked, in a subsequent letter to Congress (to Pell) "…. I have just been informed …." and that he was unaware of the rainmaking program in SEA previous to his earlier statements.

The reality of whether Laird knew about Popeye before his appearance before the Senate's Foreign Relations Committee on April 18, 1972 is unclear. However, the facts of the matter, according to U.S. State Department archival documents, establishes that Laird had a secure long phone conversation with Presidential National Security Advisor / Aid General Alexander Haig on April 21, 1972. In this exchange, Laird and Haig spoke regarding [SEA] troop redeployments and "cloud seeding". Did Laird know about Popeye prior to this discussion or was this moment the first-time hearing about the secret weaponized weather modification program, in the wake of his testimony before Congress.

Did He Know (?)

Although not obvious to anyone at the time, there was another important witness to testify before Senator Pell's Oceans and International Environment sub-committee on July 26, 1972; Pierre Saint-Amand. Saint-Amand actually appeared before Senate congressional hearings before (in 1966) to present the DoD (i.e. U.S. Navy`s) point of view in support of weather as a weapon of war. At that time, he is quoted as saying "….I don't think using weather to discourage people from moving is a bad thing to do …." which seems like a paraphrasing of another known supportive weaponized weather modification quote "…. If an adversary wanted to keep me getting from point A -to- point B, I'd rather he stop me with a rain-storm than stop me with a bunch of bombs …." These quotes are meant to instill a measure of humanity into the justification of weaponized weather activities.

In his further testimony, Saint-Amand stressed the importance for the U.S. to acquire and develop these weather modification capabilities before the Soviets could develop them and use these weather weapons against the U.S. Homeland. In these and subsequent Congressional hearings Saint-Amand echoed others who said "that weaponized weather is no more than military applications of artificial weather change". Personally, Saint-Amand was often unapologetic regarding his views of the military's (right to the) utilization of weather as a weapon and the U.S. government's "potential" development of weaponized weather.

In these appearances before Congressional committees, Saint-Amand always presented himself as a U.S. Navy scientist familiar with the concepts of Geophysical Warfare. It was never disclosed that Saint-Amand was actually "the" pioneer of the weaponization of weather, nor that he had been the man in charge of Popeye on the ground in Southeast Asia and weaponized weather in general.

During the Congressional hearing with Pell, Saint-Amand focused most of his prepared and live comments on the cloud seeding development by the U.S. Navy at China

Lake, that to some extent was already public knowledge, as well as some other cloud seeding projects that were less-known. (to Pell, these encompassed cloud seeding support to other countries) Saint-Amand otherwise was more vague regarding questions about more or less secret weaponized weather modification efforts. Although he was supportive of the notion of weaponized weather, he presented a view that was less than cognizant as to the existence of any secret weaponized weather modification efforts in SEA – to the best of his knowledge. However, asked at point blank if he knew anything about military weather modification / rainmaking activities in Southeast Asia (?) Saint-Amand said "No".

No disrespect intended toward Mr. Saint-Amand here, but it is now known that his specific response was not historically accurate. If one were to review the transcript, of his appearance before Senator Pell's committee, there are other occasions where he misrepresented his knowledge of military weaponized weather modification operations in SEA and elsewhere and deflected other questions without actually answering them – skirting others. However, in retrospect, some of the blame for Saint-Amand's testimony before Congress is due to Pell's own lack of understanding of the subject at hand, that he was investigating. [retrospectively] Pell had no understanding of the specifics that he was questioning witness about, no perspective and no understanding of who he was really questioning and if they were actually telling him the truth. One example of this was where Pell missed a potential line of questioning encompassing Saint-Amand's mention of the experimental cloud seeding effort out of Brownsville, Texas, into the Gulf of Mexico. The reality is that this mention was the tip-of-the-iceberg of the geophysical warfare / weather modification program being conducted against Cuba – that created severe droughts.

Again, looking at the transcript, another area of China Lake's public weather modification capabilities that Saint-Amand avoided altogether, was any mention of its (ongoing) efforts towards hurricane modification – publicly supporting Project Stormfury. At the time of Saint-Amand's appearance before Pell's committee, the Navy (China Lake) was conducting a secret Geophysical warfare campaign against Cuba sending weaponized hurricanes and causing widespread drought to destroy Cuba's economy. Saint-Amand essentially had visibility of these weaponized weather modification applications against Cuba, if not being out-right in-charge of them. Thus, it is unclear, if Pell ever knew who Pierre Saint -Amand really was, and what "it" was really all about.

As Pell continued to excavate for the truth and bring the (still) secret weather modification operations in Southeast Asia out into the open, he began a Congressional effort to establish guidelines towards the banning of future development of environmental modification (ENMOD) as a weapon of war. It was at this moment that his dogged determination was about to pay off.

As previously mentioned, the pressure placed upon the CIA by Pell's inquiries, hearings and a renewed letter writing campaign, resulted in the agency presenting the Senator with what he'd been looking for, in the great hopes of dissuading, distracting, and derailing any further inquiries into weaponized weather programs. The object that they were willing to disclose was a Classified / Top Secret briefing on the U.S. military's weather modification activities in SEA. (i.e. Popeye)

The so-called "Brief" was presented to a classified session of Pell's "Oceans" sub-committee on March 20, 1974. (by this time, Operation Popeye and other SEA weather modification projects had been discontinued for over two years) The brief was presented by representatives of the DoD and JCS that consisted of U.S. Army Lt. Col. Harry "Ed" Soyster, (representing the JCS), Mr. Dennis J. Doolin, DoD's Deputy Assistant Secretary of Defense [for East Asia and Pacific Affairs] and U.S. Air Force Lt. General Raymond B. Furlong, (principal) Deputy Assistant Secretary of Defense [for Legislative Affairs].

It's interesting to note; that although public domain and internet references suggest that Soyster and his colleagues were from the organization that conducted the weaponized weather modification in SEA, and that Soyster himself was the leader of these weather modification operations, this is not historically accurate. Lt. Col. Soyster was in fact assigned to JCS as Operations and Plans officer, for the Joint Reconnaissance Center, of the Operations Directorate at the time. He was "not" from SACSA and therefore would not have any direct knowledge of weaponized weather modification operations in SEA – beyond the brief he provided. Doolin, previous to his position as a DoD's Deputy Assistant Secretary of Defense, was with the CIA as an East Asian expert, but again, had no direct knowledge of Popeye. General Furlong was there to represent the Defense Secretary, with questionable knowledge of the operations to be briefed.

The 36-page brief, although seeming very comprehensive, only outlined the basic information associated with Project Popeye and Operation Popeye and did not mention any of the other weaponized weather modification "applications" mentioned in the pages above. Subsequent Committee questions posed to these military briefers were often met with "I don't knows" and "to the best of my knowledge" or ambiguous answers that didn't really answer the questions posed to them. Some of the more probing questions of Pell's, centered around were storms modified and are there any other weaponized weather modification programs (?) were met with standard "no – not to my knowledge", which actually meant that these specific representative of the DoD / JCS "didn't" specifically know anything – and therefore were not specifically lying. This is also not the same as the DoD /JCS agencies themselves denying the existence of any other potential weather modification programs.

One of the more interesting aspects of this presented DoD briefing, is that it seriously contradicted the testimony (or statements) of the previous Secretary of Defense Melvin Laird, made before a congressional oversight committee and who had denied that the U.S. had conducted military weather modification in SEA. This official government briefing essentially undercut Laird and implicated him in congressional perjury or (i.e.) lying to Congress.

It wasn't until later, after Senator Pell disclosed the DoD briefing, publishing it in the U.S. Congressional Record, that former Secretary of Defense Laird realized what had been done to him and raced to send Congress (Pell) an apology letter. The letter (in part) categorized his previous comments as "mis-statements", and acknowledged that - "he was unaware of any U.S. military weather modification activities conducted over North Vietnam - .i.e Southeast Asia on the whole - during the Johnson Administration" and that "…. I have just been informed …." Again, this situation (if Laird wasn't actually lying) demonstrates to what lengths the SACSA (i.e. the CIA) would go to deflect from their current (at the time) ongoing weaponized weather operations. It further re-emphasizes that the Popeye weather modification operations were not actually DoD programs and that the military organizations, like the U.S. Air Force, were just covers for those who were really conducting these activities.

In the aftermath of the congressional disclosure of the Popeye activities to the public and press, in May 1974, Pell introduced a Senate Resolution No. 281 (SR-281) to prevent any more U.S. weaponized weather modification programs in the future. Reintroduced as SR–71, Pell's resolution subsequently passed in the Senate by a vote of 82-10 in July 1974. This resolution would eventually lead to a United Nations international treaty banning all forms of environmental (geophysical) weather modification or warfare. Later in 1974, the Nixon Administration signed international agreements, limiting environmental *(weather)* modification towards geophysical warfare – save only for scientific investigations of peaceful purposes.

In May 1977, the UN General Assembly ratified the international "Environmental Modification Treaty" or ENMOD Treaty that had as its main tenant; "…. that each party to this convention undertakes not to engage in military or any other hostile use of environmental modification techniques having wide-spread, long-lasting or severe effects as means of destruction, damage or injury to any other party ….". Many will tell you that this agreement (treaty) is riddled with loop-holes and allows for those who will, to violate the main tenant of this agreement and conduct continued weather modification projects towards weapons of war.

In the Wake

After passage of Pell's Congressional resolution to ban all forms of environmental modification, to include weaponized weather modification, personnel at China Lake involved in weather modification projects (and their colleagues) were disgusted by the actions taken by the U.S. Congress against, what they saw as their vital work and perceived mission of fighting communism throughout the world. Saint-Amand in-turn was hailed as a Cold Warrior and a hero trying to protect the United States against the evil empire of the Soviet Union, by China Lake and the conservative enclave of Ridgecrest, California. Pierre Saint-Amand is still revered there today, many years after his passing.

Senator Pell eventually became the full Chairman of the Senate's Foreign Relations Committee. Although he should have been pleased to have constructively spear-headed one of the few instances of active "checks-and-balances" of a modern Democracy, he continued to question if they had been given the full truth regarding the military's utilization of weather as a weapon. In fact, Pell always suspected that there was more. That the military did modify typhoons that stuck Vietnam, that caused so much death and destruction, and that there were more weaponized weather programs out there, and that there had been an active program against Cuba.

As late as July 1976, Pell wrote a letter to then CIA Director, George (H.W.) Bush, inquiring if the U.S. (i.e. the CIA or DoD) had conducted a Geophysical warfare program against Cuba that encompassed "….seeding clouds near Cuba to have caused droughts [to destroy Cuba's export economy] in the 1960-70s …." This information was mentioned (in passing) in a recent book by a former specialist with "International Research and Technology Corp" (a government funded think- tank) turned author "Lowell Ponte", in his 1975 book *"The Cooling"*.

According to declassified CIA archival [CREST] documents, encompassing internal memos and CIA legal opinions surrounding "how" Director Bush was going to answer Pell's question, again suggested that they cannot lie in writing. The subsequent crafted response scheme consisted of a two-sentence (paragraph) written statement "…. You will recall that in connection with our correspondence earlier this year (your 23 January letter to Mr. Colby and my 19 February reply) my colleagues briefed two members of your personal and committee staff(s) on certain Southeast Asian activities, none of which were directed against harvests or obviously – against Cuba. I would be happy to discuss this further with you personally if you wish. …." Then another paragraph statement "…. "no". The CIA has never been involved in any project employing weather modification techniques against Cuba, off the coast of Cuba or against any [other] nation's harvest activities …." to be presented to Pell "verbally", uttered by Director Bush the next time he came across Pell, face-to-face, at an official Government function. In this manner, Bush could lie (to Pell's face) with a legal "he said -vs- he said", that was inadmissible in any court or legal proceedings. All in an effort to get Pell to stop investigating potentially other weaponized weather modification projects in SEA and now against Cuba.

It's interesting to note; that although this was the CIA's preferred method of replying to Senator Pell, according to declassified CIA archival [CREST] documents, it was not the one that George Bush went with. During the deliberation on how the CIA Director should respond to the Pell inquiry, Bush was offered a chancy reply that principally encompassed a direct letter with both the proposed paragraphs (one that was an all-out-lie) presented to Pell in a letter. According to declassified CIA archival [CREST] documents, encompassing internal memos and CIA legal opinions surrounding "how" Director Bush should reply to Pell, an internal memo suggested "…. On the other hand, you

may not care to sail quite this close to the wind so far as the written record is concerned and, hence, may want to incorporate something like the suggested second paragraph in the actual written response …." And that is just what Bush did.

The reality is that there "were" other weaponized weather modification programs being conducted, and particularly against Cuba. As it's understood currently, the Geophysical warfare campaign against Cuba continued by SACSA and the Navy (China Lake), with the perceived blessing of the Nixon Administration (i.e. Kissinger) until 1975, when the weaponized hurricane and drought weather modification programs came to an abrupt end.

Various public domain references suggest that the secret team office of SACSA quietly disappeared from the Pentagon in 1971, perceived to have been disestablished with the winding down of the U.S. involvement in the Vietnam War. Public domain references additionally tried to establish the actual identities of SACSA commanders over this perceived period of the office's existence, with limited details and results.

The reality of those that ran SACSA, between 1961-1975, comprised: USMC Major General Victor H. Krulak (1961-1964); USAF Maj. Gen. Rollen H. (Buck) Anthis (Feb 1964- Jan 1966); USAF Maj. Gen. William R. Peers (Jan 1966 – Jan 1967); U.S. Army Maj. Gen. William E. Dupuy (1967 - 1969); U.S. Army Brig. Gen John F. Freund (Jan 1969 – Aug 1969); U.S. Army Brig. Gen. Donald D. Blackburn (Aug 1969 – Feb 1971) and USAF Brig. Gen. Leroy J. Manor (Feb 1971 – Feb 1973).

During the SACSA tenure of General Manor, issues were presented to reorganize SACSA. According to declassified CIA archival [CREST] documents (including an internal March 1971 letter), the difficulty with the visibility of Counterinsurgency operations within the government was highlighted, with recommendations presented to lower the view (visibility) of SACSA by making the organization more palatable within the civilian agencies [such as Congress]. Thus, shortly after General Manor took over the position of SACSA, this area of the CIA's counter insurgency and special operations was reorganized as the office of Special Operations Division (SOD), positioned under the DoD / JCS Operations (J-3 OJCS) [now JP-3-05 Special Ops] Section – where General Manor became the Deputy Director of Operation, JCS/ SOD that assumed all the responsibilities, operations and missions of the previous SACSA office.

To continue with the SACSA / SOD (special ops) management of the weaponized weather modification operations through July 1972 in SEA, and the Geophysical warfare campaign against Cuba through March 1975, the SOD office was led by U.S. Army Col. Clarence E. Skoien as Director of Special Operations Division, JCS Operations from February 1973.

The irony is, that the weaponized weather operations were shut down not because of any of the mighty efforts spearheaded by Senator Pell. It all came to a screaming halt due to the Congressional Amendments of the Hughes-Ryan Act. Enacted in late 1974, the Hughes-Ryan Act established new U.S. Congressional oversight controls specifically introduced against the American Intelligence Agencies (the CIA, DoD / DIA and NSA) in an effort to limit any and all U.S. covert operations against Cuba and any other countries. This Congressional Amendment required the President to be responsible for, and report, all non-Intelligence (related) CIA covert operations to a congressional select oversight committee in a timely fashion – as a means to increase (mostly) CIA accountability to Congress. Failure to do so, prohibited the use of government appropriated funds (tax dollars) for the conduct of such covert actions.

So, it was in the CIA's advantage to discontinue all the geophysical warfare operations against Cuba, and perhaps other adversaries, before having to disclose said operations to Congress – under Hughes-Ryan Act. Thus, came the end of the military's development and utilization of weaponized weather applications – as far as it is authoritatively known for this specific period in history.

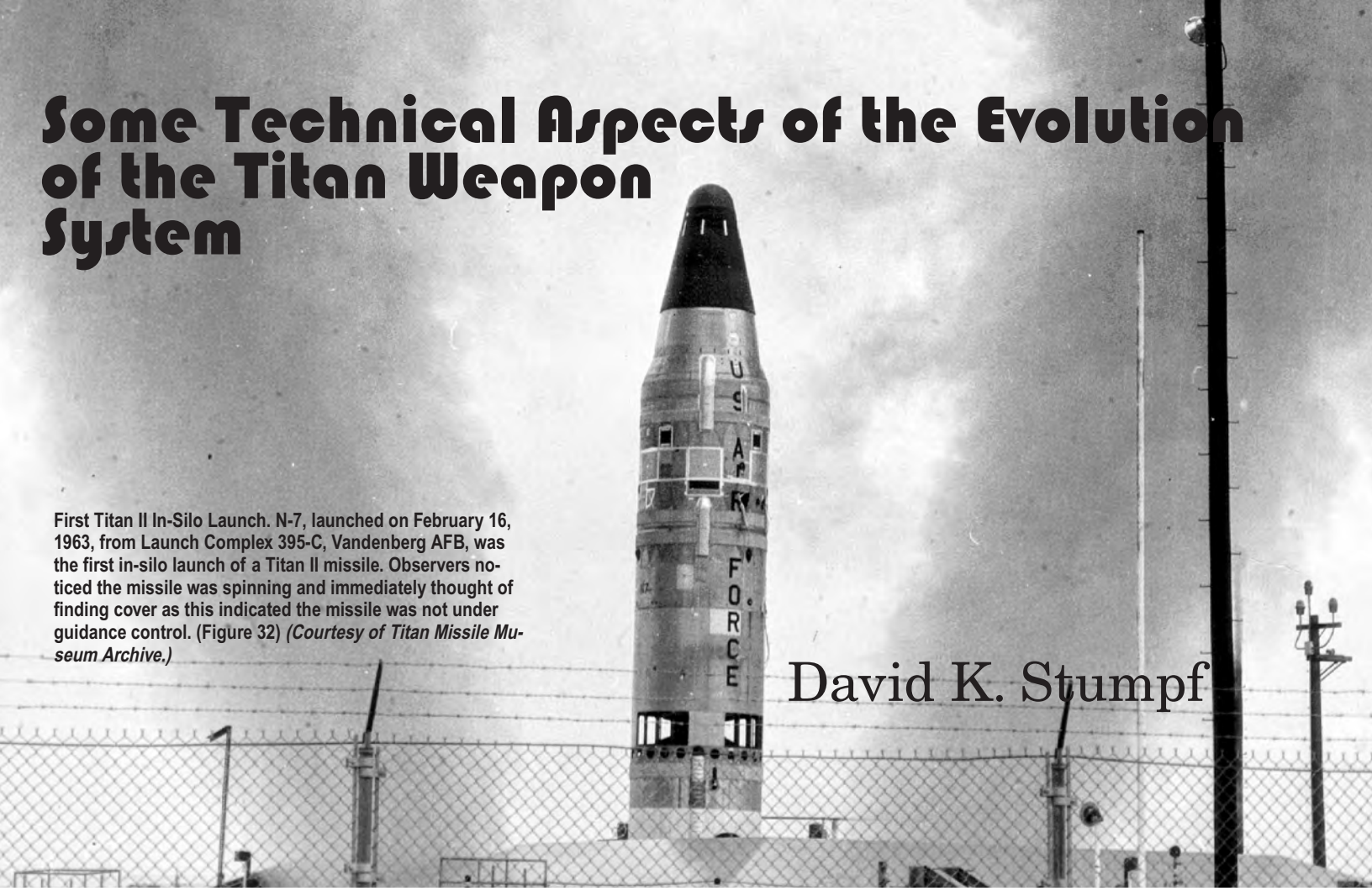
The perception -vs- reality of history, of the Popeye story, is important towards setting the record straight in the public domain with regards to the actual history of weather modification and the development of weather as a weapon during this period of the Cold War. In that, this comprehensive history serves as a guide, pointing out the flaws, inaccuracies, superficialness, and bias conspiracy-leaden weather modification history information currently prevailed within the public domain and its perceived instances of weaponized weather modification. In this age of "fake news" and "historical fiction" being accepted as historical fact, those times when the truth is actually known, it's important to point these facts out to correct the public's perception and present the true history.

Epilogue

In November 1972, four-months after the cessation of Operation Popeye in Southeast Asia, the Nixon Administration began a systematic B–52 bombing campaign to carpet bomb key areas of the Ho Chi Minh Trail and a network of dikes.

P.S. *It's interesting to note*; that in military communications (Brevity – codewords) the codeword for flying in clouds / flying in weather with reduced visibility is "POPEYE" ■

Some Technical Aspects of the Evolution of the Titan Weapon System



First Titan II In-Silo Launch. N-7, launched on February 16, 1963, from Launch Complex 395-C, Vandenberg AFB, was the first in-silo launch of a Titan II missile. Observers noticed the missile was spinning and immediately thought of finding cover as this indicated the missile was not under guidance control. (Figure 32) *(Courtesy of Titan Missile Museum Archive.)*

David K. Stumpf

The Titan Weapon System origin reaches back to February 8, 1954 with the publication of a report by B. W. Augenstein, a mathematician at the RAND Corporation. Augenstein pointed out that the reliability of liquid propellant rocket engine ignition at high-altitude had increased sufficiently that a two-stage design was now feasible. In the early 1950s, reliably starting liquid propellant engines at a high altitude and achieving smooth combustion was still an unknown.[1]

On July 21, 1954, the Atlas Scientific Advisory Committee recommended a second propulsion contractor for the nascent Atlas ICBM project. On October 25, 1954, Brigadier General Bernard A. Schriever, Commander, Western Development Division, responsible for the development of the ICBM program, went further and recommended development of an alternative configuration to the Convair design for Atlas. Schriever wanted to introduce an element of competition as well as possibly provide a substantially superior design. On January 4, 1955, the ICBM Scientific Advisory Committee agreed with Schriever and recommended development of an alternative to Atlas as a backup.[2]

On May 2, 1955, the Air Force authorized the Air Research and Development Command to issue a request for proposals from Bell Aircraft, Douglas Aircraft Company, General Electric, Lockheed Aircraft and Glenn L. Martin Company (the Martin Company) for the alternate design ICBM. On October 27, 1955, a letter contract, AF 04(645)-56, was issued to Martin Company to build a two-stage alternate ICBM, Titan, using the same propellant combination as Atlas.[3]

Encouraged by advances in the development of hypergolic storable propellants, on January 15, 1958, the Air Force Ballistic Missile Committee, recommended the conversion of Titan I to storable propellants. On December 1, 1959, the Air Force announced the Titan II program. On 1 April 1961, Titan I and Titan II became separate programs.[4]

The short life of the Titan I ICBM program obscures its importance in the development of the Titan II ICBM program. This article describes several key aspects of the Titan I program and evolution into the highly successful Titan II program.

From Atlas to Titan I

Atlas

The precursor to Atlas was the Convair MX–774. The MX–774 pioneered the concept of gimbal engines, replacing the jet vanes that had been used with the V–2. In an effort to minimize airframe weight, the MX–774 design replaced the traditional airframe fuel tanks, which used skin/stringer construction, with a pure monocoque design. Due to funding difficulties, only three flight test missiles were built before the program was canceled in July, 1947. The three flight tests

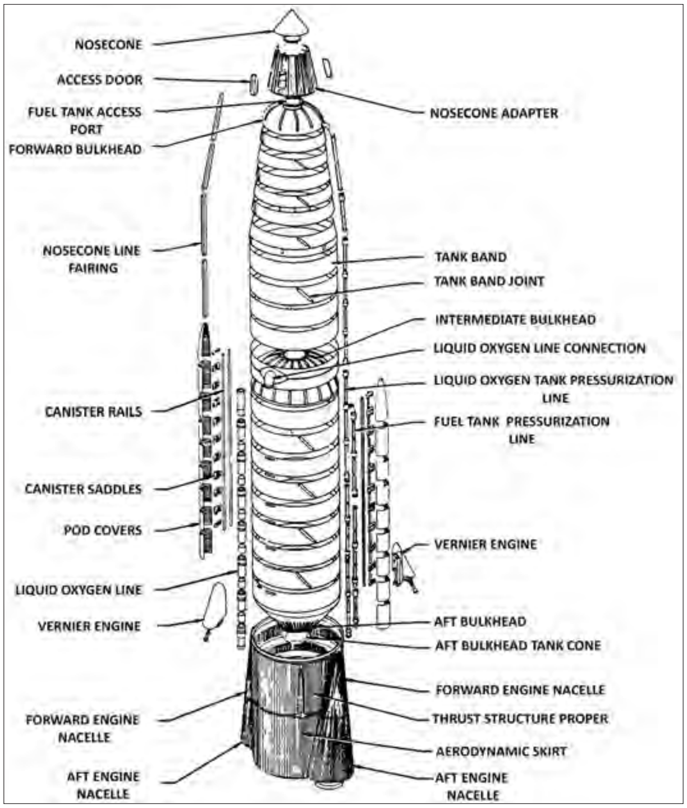


Figure 1: Atlas Series A Missile-1957. An expanded view showing the unique barrel hoop construction technique. The propellant tanks, when empty, had to be inflated with helium, or in a stretched configuration, to keep the airframe from collapsing. ***Courtesy R.E. Martin.***

validated the gimbaled engine concept as well as the feasibility of the monocoque propellant tanks. All three flights suffered engine failures subsequent to launch. For the next four years Convair engineers worked on various aspects of the MX–774 program. In January, 1951, the Air Force Research and Development Command awarded Convair a new contract designated Project MX–1593, Atlas.[5]

Due to concerns with the MX–774 engine operation at altitude, the decision was made to design Atlas as a stage-and-one-half missile. The two booster engines and one sustainer engine were ignited at sea level. At 250,000 feet altitude the booster engines would drop away and the sustainer, the one-half stage, continue powered flight. The sustainer engine exhaust nozzle expansion ratio, the ratio of

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Table 1. Comparison of Airframe Design: V-2, Atlas, and Titan

Missile[1]	PMF Launch[2]	PMF Staging	Airframe(lbs)[3]	Propellant (lbs)[4]	%Airframe/Propellant[5]
V-2	0.78	—	8,818	19,640	33
Atlas F	0.93	—	18,900	254,886	2.2
Sustainer	—	0.82	11,101	63,663	13
Titan I	0.95	—	15,000	200,000	7.5
Stage II	—	0.89	8,219	40,800	4.5
Titan II	0.95	—	22,758	301,000	3.1
Stage II	—	0.91	13,175	57,000	4.1

1. Data: V-2, "V-2"; Atlas F, "Atlas: The Ultimate Weapon;" Titan I, II "Titan II: A History of a Cold War Missile Program."
2. PMF = 1-(weight of airframe + reentry vehicle/(airframe + propellant + reentry vehicle))
3. Airframe includes engines and reentry vehicle: V-2, 2,205; Atlas F and Titan I, Mark 4, 3,797; Titan II, Mark 6, 7,500
4. Propellant remaining at BECO, 63,663.
5. % A/P = [illegible]

the area of the nozzle throat to the exit diameter, was built for operation at altitude and was therefore inefficient at sea level. The aluminum monocoque propellant tanks used in MX–774 were replaced with stainless-steel "balloon" tanks that were unique to the Atlas missile family (Figure 1). While this saved airframe weight, the need for continuous pressurization of the tanks introduced additional complexity to missile operations. As is shown in Table 1, at liftoff, Atlas F had a propellant mass fraction (PMF) of 0.93, a significant improvement over the V–2 at 0.78. At booster engine cut off (BECO), the PMF was now 0.82. A PMF of 0.94 means that 6 percent of the mass is airframe and engine. Atlas at liftoff had a value of 7 percent and at BECO, 18 percent. The higher value at BECO was the weight penalty due to the partially empty propellant tank which could not be discarded during the sustainer phase of flight (18 percent of the propellant remained after BECO).[6] Comparison of percent airframe/propellant where the ratio of the weight of the structural elements of the airframe to the weight of propellant gives a value of 33 percent with V–2 and 2.2 percent for Atlas. While this is a significant achievement for the boost phase of Atlas F flight, at BECO, the sustainer ratio is 13 a nearly sixfold decrease, reflecting carrying the entire tankage during sustainer flight.

Titan I

Martin Company engineers realized that the solution for a lightweight but self-supporting airframe was to include the structural members in the missile skin propellant tank walls. This idea had been dismissed by the Convair engineers in their desire to eliminate extraneous weight. Semi-monocoque construction uses lightweight stringers to carry the airframe load. The result was that Titan I had a PMF of 0.95 at liftoff, essentially the same as Atlas but without the complication of keeping the propellant tanks inflated. At staging, the Stage I tankage and engine was discarded, leaving Stage II with a PMF propellant mass fraction of 0.89, or a 11 percent airframe/propellant ratio but in this case there was a full load of propellant. When the percent airframe/propellant ratio is examined, Titan I at liftoff was quite close to Atlas and at staging was considerably more efficient 4.5 percent versus 13 percent. The Titan I airframe design achieved the weight performance of Atlas at boost phase, improved by a factor of nearly 3 the sustainer phase while eliminating the operational complexity of the stainless-steel "balloon."[7]

Table 2. Titan I Specifications (Lot M)[1,2]		
Fully Assembled Airframe (feet)	**Length**	**Maximum Diameter**
Stage I (including stage transition)	56.6	10
Stage II	25.5	8
Reentry Vehicle Adapter	4.62	8
Mark 4 Mod I Reentry Vehicle	10.79	2.75
Nominal Missile Weight (lbs)	**Stage I**	**Stage II**
Airframe Empty (including engine)	7,741	4,484
Oxidizer	118,044	28,468
Fuel	51,682	12,441
Mark 4 reentry vehicle and warhead	4,100	
Total Weight (including reentry vehicle)	222,860	
Engine	**Thrust (lbs)**	
Stage I LR87-AJ-3 (sea level)	300,000	
Stage II LR91-AJ-3 (vacuum)	80,000	
Range (nautical miles)		
Mark 4 reentry vehicle and warhead	5, 500	
Circular Error Probable (nautical miles)	0.65[3]	

1. "Structural Description, SM-68," February 1961, Martin Company.
2. "General Arrangement, Lot M, Sheet 327-1000501" 18 July 1960.
3. *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*

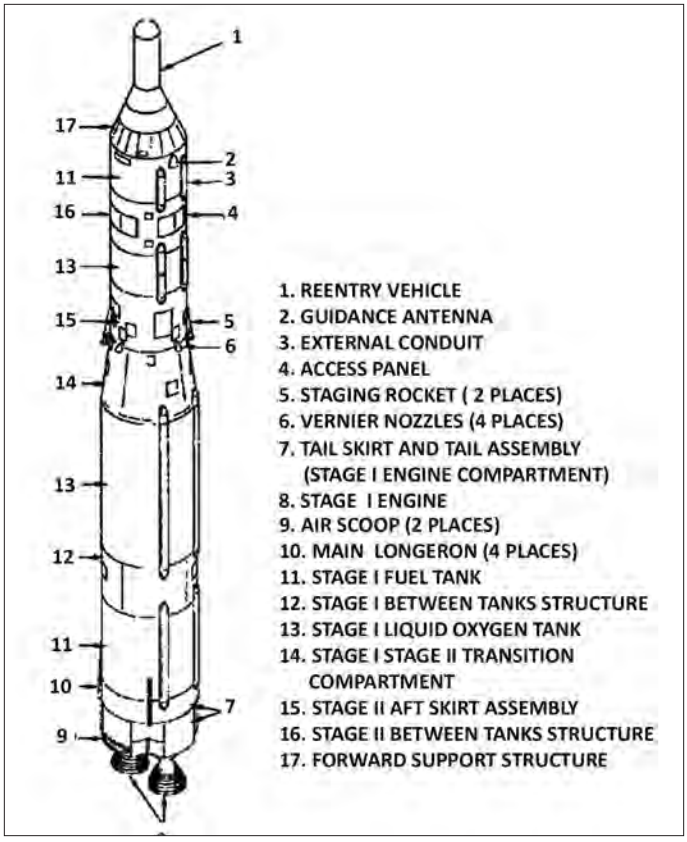


Figure 2: Titan I Missile Configuration. ***Courtesy Titan Missile Museum Archive.***

Airframe

The Titan I airframe was fabricated from 2014-T6 aluminum, a high-strength alloy with a high copper content (3.9 to 5 percent) and smaller quantities of iron, magnesium, manganese, silicon, titanium, and zinc. Because these materials were known to be difficult to work with, the Baltimore Division of Martin Company had developed a tungsten inert gas welding process for use with the 2014 alloy.[8]

Manufacture of the Titan I airframe began with the chemical milling of the aluminum tank panels. Chemical milling permitted the propellant tanks to be fabricated for maximum strength yet minimum weight by the removal of aluminum in a complex pattern in specified areas. The process required that each component be masked with chemically resistant, asphalt-like material in the desired pattern. Immersed in a sodium hydroxide bath, aluminum was removed at a rate of approximately 0.003-inches thickness per minute of exposure. Those areas that had to be etched the most had no masking at the start of the process; those that were to be etched the least were masked until the last exposure process. Typically, three or four thicknesses had to be etched on each tank panel.

Once the flat panels had been etched and rinsed, they were moved to the horizontal weld fixture. The Stage I tank barrels consisted of 12 panels that were welded to form the tank cylinder, first into quarter panels, then the four quarter panels were welded to form the cylinder or barrel. The weld was made using a machine welding process, and was performed by the weld torch traveling longitudinally over the weld joint. The tank barrels had to be supported by rings in the horizontal position until the domes were placed and welded. Each weld was x-rayed and hydro-tested (the tanks were pressurized with water). Weld repairs were usually small and done manually. No Titan I or Titan II missile was lost during flight due to tank weld failure (Table 2).[9]

A feature unique to the Titan missile family airframes was a slight discoloring of the exterior skin surface. This was the result of the application of Iridite, a chromium chemical conversion coating which was applied to the surface to prevent corrosion. The distinct coloring on the different panels was due to how that particular batch of 2014-T6 aluminum reacted with the Iridite process (Figure 2).

Guidance

In April 1955, the ARMA Bosch Corporation received the contract to develop the inertial guidance system for Titan as well as Atlas. However, delays developed due to reliability and weight issues. Rather than delay the Titan program any further, on October 18, 1955, Bell Laboratories received the contract for a radio-inertial guidance system for Titan. On May 26, 1958, a contract change was made to transfer the ARMA inertial guidance system from Titan I to Atlas.[10]

Engines

Engines for Titan I were fabricated by Aerojet-General Corporation (Aerojet), Folsom, California. On January 14,

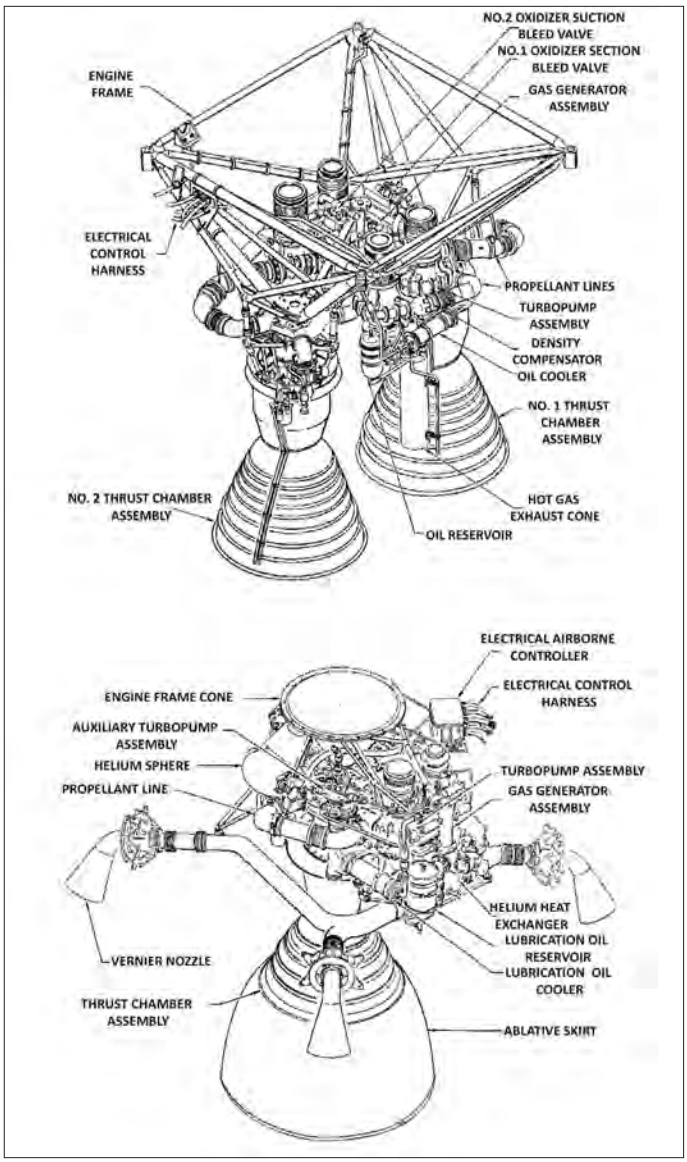


Figure 3: Titan I Engines. Upper: Titan I Stage I Engine. Lower: Titan I Stage II Engine. ***Courtesy Titan Missile Museum Archive.***

1955, Aerojet had begun research and development work on rocket engines for an as yet unnamed two stage missile. Stage I would be powered by two identical engines while the second stage would be powered by a single engine of similar design, optimized for vacuum start. Aerojet's design and development of these engines would serve as a backup to the North American Aviation team working on the Atlas engines, with the possible result of a better engine for use in Atlas.

Both the Stage I and Stage II engines had two design configurations, the LR87-AJ-1 and LR87-AJ-3 (300,000 pounds thrust at sea level) and the LR91-AJ-1 and LR91-AJ-3 (80,000 pounds thrust, vacuum). Design changes from the -1 to -3 configurations included reduction in weight and reducing the total number of parts. While the LR87 engine used regenerative cooling for the thrust chamber, the LR91 engine thrust chamber required a larger expansion ratio due to ignition taking place at an altitude of 250,000 feet. The increased expansion ratio required a larger thrust chamber bell which was difficult to effectively regeneratively cool using fuel as in Stage I. Replacing part of the cooled chamber jacket with an asbestos-based ablative skirt greatly simplified engine operation, as well as saved weight. Constant turbine speed, and thus constant propellant flow, was accomplished by metering main engine propellants to the gas generator which powered the propellant turbopumps. Stage I used a gaseous nitrogen turbopump start that was then taken over by the propellant-supplied gas generator. Gaseous helium was used for the Stage II engine turbopump start (Figure 3).[11]

Propellants

Titan I used RP-1 and liquid oxygen as fuel and oxidizer respectively. As with Atlas, the fuel was stored onboard the missile, while the cryogenic liquid oxygen had to be stored on site and quickly loaded during the countdown but before raising the missile to the surface. This was a problem with the first-generation ICBMs and was a major component of the approximately 14-minute response time for Titan I between launch key turn and missile away (see Response Time).

Staging

Staging with Titan I took place upon depletion of Stage I propellants which triggered a sensor that cut off propellant flow to the Stage I engines. A short delay allowed for thrust tail-off, then explosive nuts were triggered and two small solid propellant separation rockets moved Stage II, along short guide rails, clear of Stage I. At the same time, the acceleration forced the propellants to the Stage II engine inlet to assure engine start once clear of Stage I. Stage II roll control was provided by four vernier thrusters.

Reentry Vehicle

The Mark 4 was a sphere-cone-cylinder-biconic flare shape, 126.7 inches long, 33 inches in diameter at the cylindrical mid-section and 48 inches in diameter at the base of the flare. The Mark 4 flare varied from 7 to 22 degrees with two very small spin fins at the base of the flare. The nose cap was made of Avcoite, a ceramic material contained in a magnesium honeycomb matrix, varying from 0.82 to 2.332 inches thick; the cylindrical body and flare were protected by oblique tape-wound Refrasil at thicknesses of 0.32 to 0.61 and 0.44 to 0.86 inches, respectively. The afterbody was protected with fiberglass. The Mark 4 with warhead weighed 3,800 pounds. A second reference gives the operational Mark 4 as weighing 4,100 pounds of which 3,100 pounds was the warhead. The Mark 4 was deployed on Atlas E and F and Titan I from 1962 to 1965. The Mark 4 was flown once on Titan II during the Titan II research and development program (Figure 4).[12]

Launch Facilities

Titan I was deployed in the HGM-25A configuration (H = silo stored, surface launched; G = ground attack; M =

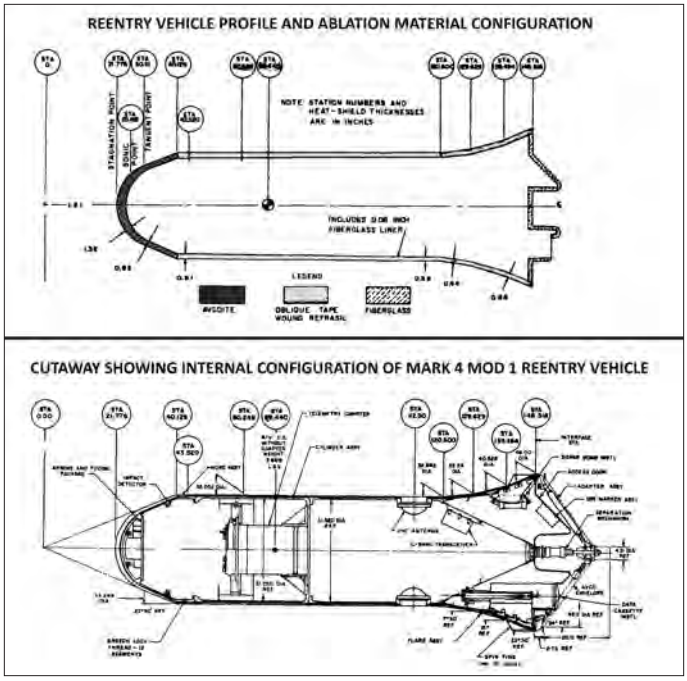


Figure 4: Mark 4 Reentry Vehicle. Upper: location of ablative materials on the Mark 4 reentry vehicle. Lower: inboard profile of the Mark 4 Mod 1-11 reentry vehicle. ***Courtesy Titan Missile Museum Archive.***

guided missile; 25 = twenty-fifth major design; A = model). At least eighteen nautical miles separated Titan I launch complexes of three missiles per launch control center, three launch control centers per squadron, hardened to withstand 100 psi overpressure.[13]

Silo/Crib

The Titan I silo was 161 feet deep, including a 6-foot-thick foundation, with an interior diameter of 40 feet. The Titan I silo door was a bi-parting, hinged design: each half weighed 102 tons, was 12-feet wide, 19-feet long and 4-feet thick. It took approximately one minute for both doors to fully open. The doors were designed to withstand 100 psi overpressure.[14]

The silo housed a crib structure,132 feet tall and 21 feet wide, weighing 490 tons, including the missile. The crib structure housed the support equipment for the missile and the silo as well as the launch platform elevator. Engineers evaluated several shock isolation systems for the crib, such as base- or side-mounted spring assemblies for improved pitch stability. Both systems had the drawback of requiring a re-leveling system to compensate for any permanent tilt of the silo following a ground shock.

Titan I used a pendulous spring system which consisted of four pairs of 16-foot springs (four 48-inch-long, 22-inch-diameter subassemblies) attached at the corners of the crib base and to a silo wall bracket 32 feet off the silo floor. The vertical center of gravity was above the spring attachment level on the crib but well below the missile center of gravity because of the elevator weight. When the vertical center of gravity of the missile and crib structure is higher than the shock isolation systems point of attachment on the crib, pitch stability is often difficult to attain.

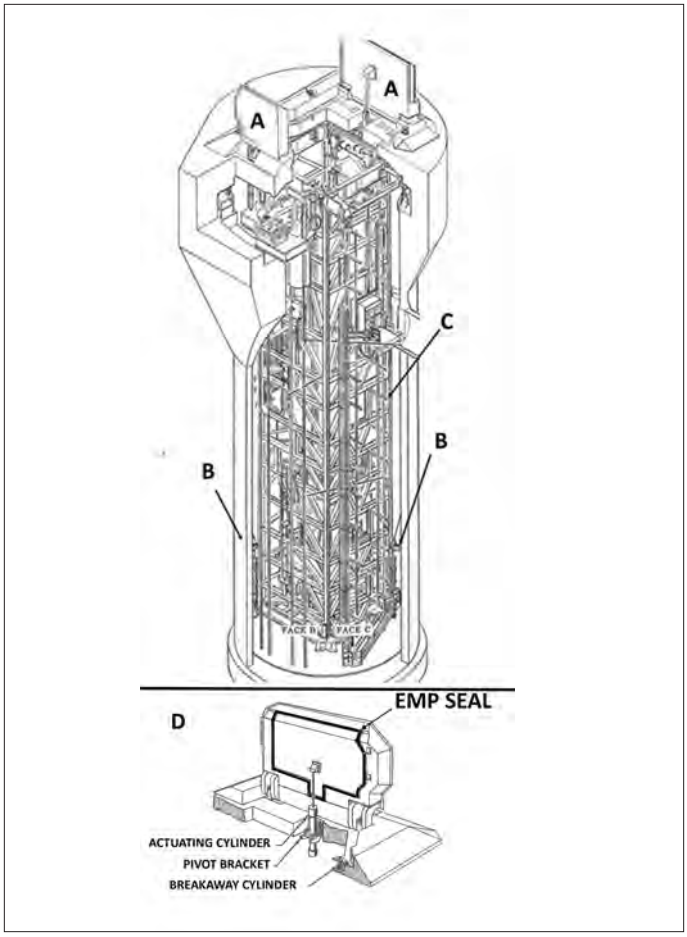


Figure 5: Titan I Silo Crib Detail. (A) The silo closure doors weighed 115 tons each. Structural isolation of the door foundation minimized transmission of surface shock to the missile silo. (B) Four pairs of springs were attached at the corners of crib platform for shock isolation. (C) There were five levels of maintenance platforms on the crib which provided a continuous walkway and working area completely encircling the missile except on the fifth level. (D) Silo closure door mechanism detail. It took 50 seconds to open both doors. ***Author's Collection.***

Initial studies indicated it would be necessary to cross-couple the vertical springs to manage pitch stability. When the ground shock criteria were revised, the spring elements were made stiffer which eliminated the need for a coupling mechanism. Coil spring elements were chosen over pneumatic springs because of their higher reliability. Hydraulically operated crib locking mechanisms at the top of the crib securely positioned the crib prior to raising the missile to the surface (Figure 5).[15]

Response Time

The Titan I countdown took 14.2 minutes from the start of loading liquid oxygen, T-850 seconds, to lift off at T+4 seconds. The shelter (silo) doors began opening at T-235 seconds and were fully open at T-185 seconds. This meant the silo was exposed to the environment, or "soft," for nearly 4 minutes (239 seconds from door opening to launch). The launch platform began elevating at T-185 seconds and was up and locked on the surface at T-55 seconds (2.25 minutes). Once the missile reached the surface, the countdown continued for another 55 seconds (Figure 6).[16]

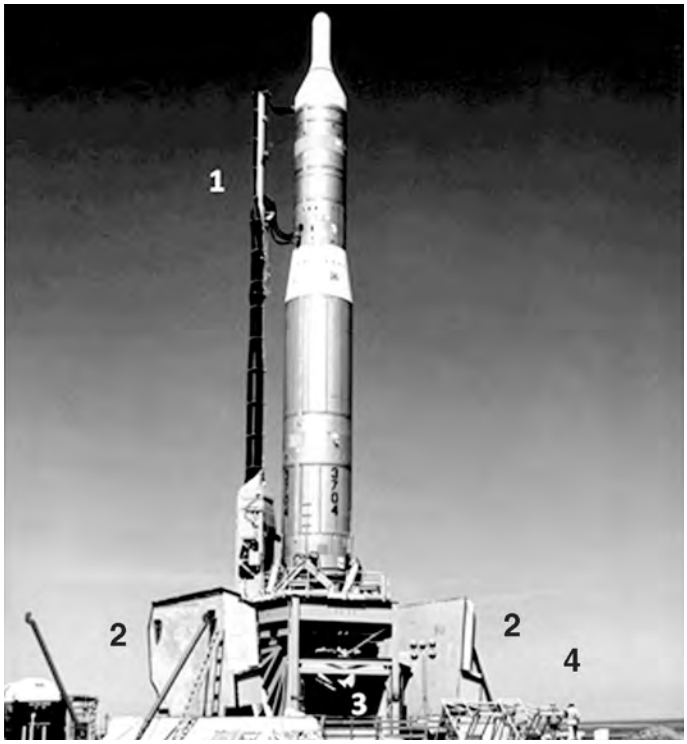


Figure 6: Titan I Ready for Launch. Titan I (60-3704) in launch position during a training exercise at Silo 3, Site-C Royal City, 568 SMS, Larson AFB, Washington. The service tower, (1), provided power, guidance and liquid oxygen to top off the oxidizer tanks. The "closure" doors (2) each weighed 115 tons. The flame bucket (3) deployed an extension to cover the gap between the launch platform and the silo wall. Note the construction worker (4). *Courtesy Titan Missile Museum Archive.*

Research and Development Flight Test

A total of 163 missiles were fabricated in eight lots of which 62 were research and development (R&D) airframes (Table 3). There were 67 launches in the program; 47 R&D

Table 3. Titan I Missile Fabrication Lots[1]

Designator	Lot	Description
XSM-68	A (6, 4)[2]	Simplified first stage; dummy second stage, limited range.
	B (7, 2)	Complete first and second stages with reduced second stage engine duration; open closed-loop radio guidance.
	C (6, 4)	Complete first and second stages with reduced second stage duration; radio guidance; separable scale model reentry vehicle.
	D, E, F	Eliminated from test program.
	G (10, 7)	Complete two-stage missile; closed-loop radio guidance, separable reentry vehicle; range up to 4,000 nautical miles.
	H, I	Eliminated from the test program.
	J (22, 22)	Complete missile capable of flights up to 5,000 nautical miles; later missiles to carry operable reentry vehicle and warhead without reactive material.
	K, L, S, T	Eliminated from the test program.
	V (3, 3)	Same as Lot J exception of instrumentation range safety equipment to be used as part of operational system testing at Vandenberg AFB and the Pacific Missile Test Range.
	VS (1, 1)	Same as Lot V except for an inert second stage; to be used in conjunction with the in-silo launch test facility at Vandenberg AFB.
XSM-68A	M (7, 7)	Same as Lot J except equipped with inertial guidance system to serve as test bed for SM-68B (Titan II) guidance system.
SM-68A	101	Operational missiles
Total	163	

1. Titan Master Schedule, 31 July 1963, AFHRA, Maxwell AFB, AL.
2. number built, number launched

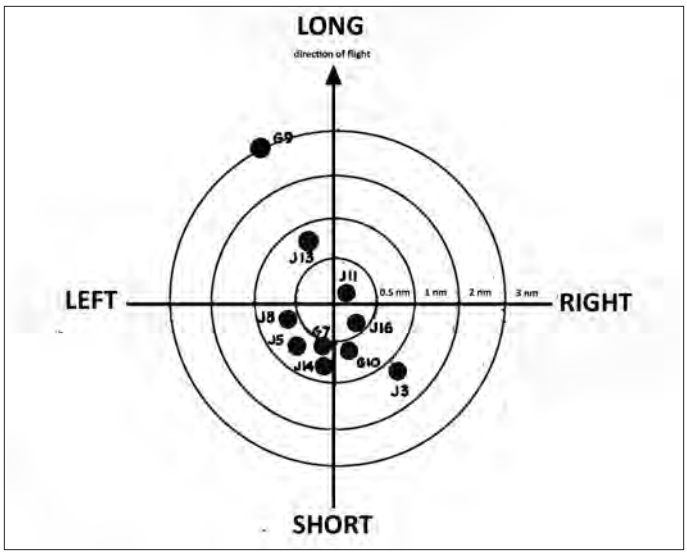


Figure 7: Titan I Ascension Island Splash Net Impact Points. Target accuracy as of June 1961. Ten missiles had been flown to Ascension Island with accuracy as an objective. Eight landed within one nautical mile of the target. *Author's Collection.*

at Cape Canaveral, Florida (four failures and nine partial successes); and 20 conducted at Vandenberg AFB (VAFB), California (one failure and seven partial successes) including five operational launches.[17]

Lot A missiles had a dummy second stage and were flown to demonstrate Stage I operation. Lot B demonstrated Stage II operation with a range of 2,020 nautical miles. Lot G tests demonstrated both Stage I and II performance to a range of 3,200 nautical miles. Lot J was the operational prototype and demonstrated range performance and reproducible accuracy at ranges from 4,385 to 5,337 nautical miles (Figure 7). Lot M missiles enabled early evaluation of the prototype Titan II inertial guidance system with seven launches and six successful flights. One Lot VS missile was used to successfully establish the feasibility of in-silo launch. There were 48 fully successful flights out of 67 launches, including the operational missile test program, for an overall flight reliability of 72 percent (Tables 4 and 5).[18]

Titan I was deployed in six strategic missile squadrons. Titan I was first placed on alert at the 724th Strategic Missile Squadron, 451st Strategic Missile Wing, Lowry Air Force Base, Colorado on April 20, 1962. Titan I (and Atlas) quickly became obsolete because of much faster response time with Titan II and Minuteman. On May 24, 1963, less than one year after deployment, the Air Force announced the phaseout of the Atlas and Titan 1 programs starting in 1965, to be completed by 1968. On May 16, 1964, Secretary of Defense Robert McNamara directed that all Titan I missile squadrons be deactivated by the end of 1965.[19] The last Titan I was removed from alert at the 569th Strategic Missile Squadron, Mountain Home Air Force Base, Idaho on April 1, 1965.[20]

Titan II

Unlike the Atlas program where major program changes were implemented as they became available, the

Table 4. Patrick AFB Titan I R&D Flight Record[1]

Key:
Lot A - booster flight, dummy second stage
Lot B - two-stage separation, second stage ignition
Lot C - two-stage performance over limited range
Lot G - two stage performance over extended range
Lot J - operational prototype - Titan I
Lot M - test bed for Titan II inertial guidance system
Lot V - assembled for OSTF/SLTF
Lot SM - operational configuration - Titan I

No.	Missile	Date	Pad	Outcome	Remarks
1.	A-3	2/6/59	15	Successful	Stage I operation only, the second stage was filled with water and not equipped with an engine. All objectives were met, structural integrity was demonstrated and Titan I became the first missile program to have a successful flight on its first launch.
2.	A-5	2/25/59	15	Successful	Dummy Stage II
3.	A-4	4/4/59	15	Successful	Dummy Stage II
4.	A-6	5/4/59	15	Successful	Stage I separation test was completed successfully with a water-filled second stage without an engine.
5.	B-5	8/14/59	19	Failure	Premature lift off, automatic destruct
6.	C-3	12/11/59	16	Failure	Accidentally destroyed on pad by destruct system
7.	B-7A	2/2/60	19	Successful	First attempt at complete staging at high altitude was successful. Guidance system was fully operational on this medium range flight.
8.	C-4	2/5/60	16	Partial Success	Nose cone fairing fell away due to structural failure 50 seconds into flight
9.	G-4	2/24/60	15	Successful	First attempt to separate the Mark IV nose cone was successful. This was the first long range flight, reaching nearly 5,000 nautical miles.
10.	C-1	3/8/60	16	Partial Success	Stage II ignition failure
11.	G-5	3/22/60	15	Successful	Capsule recovered
12.	C-5	4/8/60	16	Partial Success	Stage II premature shutdown
13.	G-6	4/21/60	15	Successful	Capsule recovered
14.	C-6	4/28/60	16	Successful	Final limited range shot
15.	G-7	5/13/60	15	Successful	Capsule recovered
16.	G-9	5/27/60	16	Successful	Capsule not recovered due to high seas
17.	G-10	6/24/60	15	Successful	Capsule recovered
18.	J-2	7/1/60	20	Failure	Lost hydraulic power to Stage I, destroyed 11 seconds into flight
19.	J-4	7/28/60	20	Partial Success	Stage I premature shutdown
20.	J-7	8/10/60	19	Successful	Capsule not recovered, 5,000 nautical mile flight
21.	J-5	8/30/60	20	Successful	Capsule not recovered, 5,000 nautical mile flight
22.	J-8	9/28/60	19	Successful	Capsule recovered
23.	G-8	9/28/60	15	Successful	Flew 6,000 nautical miles
24.	J-3	10/7/60	20	Successful	Capsule recovered
25.	J-6	10/24/60	19	Successful	Capsule recovered, flew 6,100 nautical miles
26.	J-9	12/20/60	20	Partial Success	No ignition Stage II
27.	J-10	1/20/61	19	Partial Success	No ignition Stage II
28.	J-11	2/9/61	20	Successful	5,000 nautical mile flight
29.	J-13	2/9/61	19	Successful	5,000 nautical mile flight
30.	J-12	3/2/61	20	Partial Success	Premature shutdown Stage II
31.	J-14	3/28/61	19	Successful	5,000 nautical mile flight
32.	J-15	3/31/61	20	Partial Success	Premature shutdown Stage II
33.	J-16	5/23/61	20	Successful	5,000 nautical miles
34.	M-1	6/23/61	19	Partial Success	Premature shutdown Stage II, inertial guidance systems worked well
35.	J-18	6/20/61	20	Successful	5,000 nautical mile flight
36.	M-2	6/25/61	19	Successful	5,000 nautical mile flight
37.	J-19	8/3/61	20	Successful	5,000 nautical mile flight
38.	J-17	9/5/61	20	Successful	6,100 nautical mile flight, data capsule recovered
39.	M-3	9/7/61	19	Successful	4,500 nautical mile flight
40.	J-20	9/28/61	20	Successful	4,500 nautical mile flight
41.	M-4	10/6/61	19	Successful	5,000 nautical mile flight
42.	J-21	10/24/61	20	Successful	6,100 nautical mile flight
43.	J-22	11/22/61	20	Successful	6,000 nautical mile flight
44.	M-5	11/29/61	19	Successful	5,000 nautical mile flight
45.	J-23	12/13/61	20	Successful	5,000 nautical mile flight
46.	M-6	12/15/61	19	Successful	5,000 nautical mile flight
47.	M-7	1/29/62	19	Successful	5,000 nautical mile flight

1. "Titan I Airframe Disposition."

Table 5. Vandenberg AFB Titan I R&D Flight Record[1]

No.	Missile	Date	Outcome	Remarks[2]
48.	SM-2	9/23/61	Successful	5,300 nautical mile flight, launched from VAFB, 395A-1
49.	SM-4	1/20/62	Partial success	No Stage II ignition, launched from VAFB, 395A-3
50.	M-7	1/29/62	Successful	5,000 nautical mile flight
51.	SM-18	2/23/62	Partial success	No Stage II ignition, launched from VAFB, 395A-1
52.	SM-34	5/4/62	Successful	Guidance tape error
53.	SM-35	10/6/62	Successful	"Pickle-Barrel" launched from VAFB, 395A-1
54.	SM-11	12/5/62	Successful	Launched from VAFB, 395A-1
55.	SM-8	1/29/63	Successful	"Pickle-Barrel" launched from VAFB 395A-1
56.	SM-3	3/30/63	Successful	"Pickle-Barrel" launched from VAFB 395A-2, SAC-DASO
57.	V-1	4/4/63	Successful	"Pickel-Barrel" launched from VAFB 395A-1
58.	SM-3	4/13/63	Successful	"Pickel-Barrel" launched from VAFB 395A-3, SAC-DASO
59.	V-4	5/1/63	Failure	5 seconds of flight, launched from VAFB, 395A-1
60.	SM-24	7/16/63	Partial success	No Stage II ignition, launched from VAFB, 395A-2
61.	SM-7	8/15/63	Successful	"Pickle-Barrel", launched from VAFB, 395A-1
62.	SM-56	8/30/63	Partial success	gas generator shutdown, launched from VAFB, 395A-3
63.	SM-83	9/17/63	Successful	"Pickel-Barrel", launched from VAFB, 395A-2, SAC
64.	SM-68	11/14/63	Successful	"Pickel-Barrel", launched from VAFB, 395A-1, SAC
65.	SM-85	12/8/64	Partial success	Premature shutdown Stage I, launched from VAFB, 395A-1, SAC
66.	SM-33	1/14/65	Partial success	No Stage II ignition, launched from VAFB, 395A-3, SAC
67.	SM-80	3/5/65	Partial success	Propellant depletion, launched from VAFB, 395A-2, SAC

1. "Titan Ballistic Missile Development Plan, 30 April 1960.
2. Pickle-Barrel refers to the launch being used in determining the impact accuracy of the reentry vehicle.

Titan program combined all the technical developments into one advanced model, Titan II. Titan II PMFs and percent airframe/propellant values were nearly identical to Titan I (Table 6). Among the major design advances found in Titan II were: increase in second stage diameter; inertial guidance; storable propellants; propellant tank pressurization; the staging concept; advanced reentry vehicle; and in-silo launch (Figure 8).[21]

Airframe Design Changes

There were three major changes made with the Titan II airframe design. The first and most obvious was the second stage diameter was increased to ten feet to provide

Table 6. Titan II ICBM Specifications[1]

Fully Assembled Airframe (feet)	Length	
Stage I including interstage structure, Stage I engines	70.17	
Stage II	19.54	
Reentry Vehicle Adapter	3.74	
Mark 6 Reentry Vehicle	10.17	
Diameter (excluding conduits, air scoops)	10	
Total	**103.4**	
Nominal Missile Weight (lbs)	**Stage I**	**Stage II**
Airframe, empty (includes engine)	9,583	5979
Oxidizer	160,637	37,206
Fuel	83,232	20,696
Total	**317,333**	
Engine	**Thrust (lbs)**	
Stage I LR87-AJ-5 (sea level)	430,000	
Stage II LR91-AJ-5 (vacuum)	100,000	
Range (nautical miles)		
Mark 6 Reentry Vehicle	5,800	
Circular Error Probable (nautical miles)	0.78	

1. " Detailed Design Specifications for Model SM-68B Missile (Including Addendum for XSM-68B).
2. *Titan II: A History of a Cold War Missile Program.*

greater range and payload capability. The second difference was the overall missile length was increased from 98 to 103.4 feet (including reentry vehicle), mostly in the Stage I tankage. Some structural modifications, mainly increasing skin thickness and adding ring frames, were necessary due to the in-silo launch environment as well as the increased density of the propellants. One source of problems in the Titan I airframe had been the Stage I fuel tank longeron structures. The longerons served as the point of attachment of the missile to the launch mount. These were bolted onto the Stage I fuel tank skin and then sealed. Leakage had been a recurring problem in this area in the Titan I program. With Titan II, the longeron panel was

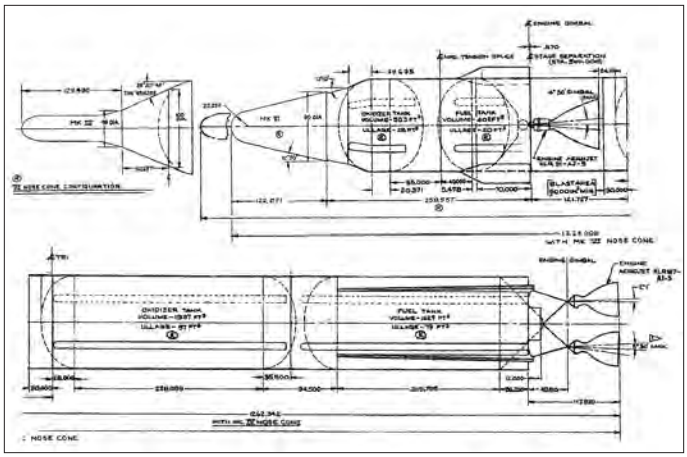


Figure 8: Titan II Stage I and II Inboard Profile Conceptual Drawing 6 June 1960. Note the inclusion of the Mark IV reentry vehicle profile. The total airframe length, including the Mark 6 reentry vehicle, was 101.91 feet. The as-built length of the missile was 103.39 feet. The difference is in the length of the reentry vehicle adaptor section. ***Courtesy of Lockheed Martin Astronautics, Denver.***

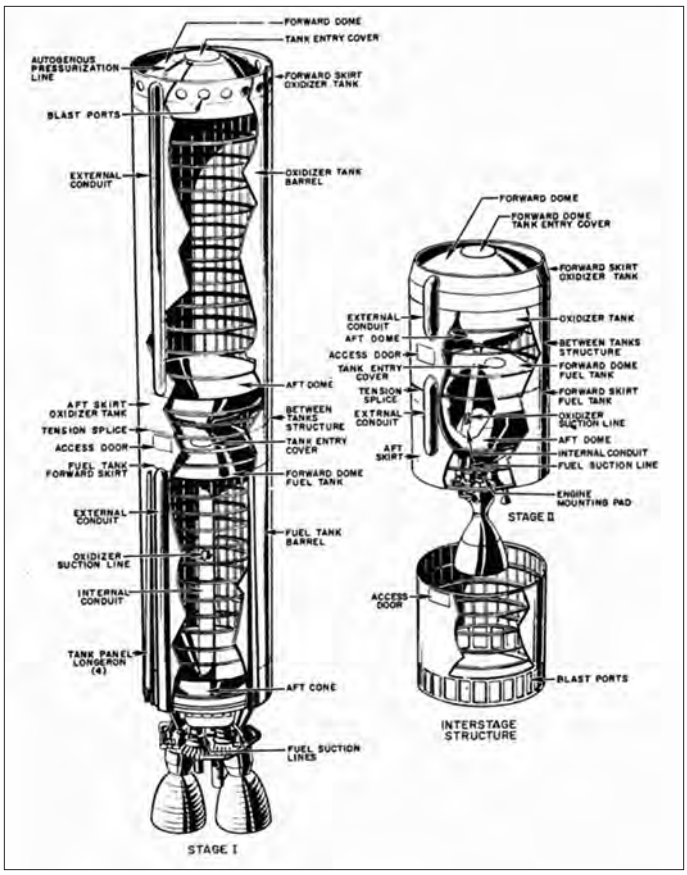


Figure 9: Titan II Airframe Configuration. The semi-monocoque airframe made the airframe self-standing without propellant load. The thickness of the metal skin ranged from approximately 0.050 inches to 0.170 inch depending on location. For comparison a U.S. dime is 0.053 inch thick, while a quarter is 0.068 inch. ***Courtesy of the Titan Missile Museum Archive.***

welded directly to each quarter panel. After the quarter panels were welded together to form the fuel tank, a machined fitting was then riveted to the longeron panel, eliminating tank skin penetration (Figure 9).[22] The third major difference was the "fire-in-the-hole" staging technique which is discussed below under Staging.

Guidance

The original contract for the Titan II guidance system was awarded to AC Spark Plug on April 14, 1959.[23] AC Spark Plug contracted with IBM for the design, development, fabrication and production of a rotating drum memory digital computer that interfaced with the inertial measurement unit (IMU). AC Spark Plug designers worked with Davidson Corporation and Perkin-Elmer Corporation in the development of the ground optical alignment system used to provide a precision pre-launch azimuth alignment reference. AC Spark Plug also designed, tested and produced the associated aerospace ground equipment and operating ground equipment that was required to test, operate and maintain the airborne components. The inertial measurement unit used three 2FBG-2C floated beryllium stabilization gyroscopes and a 25 PIGA (pendulous integrating gyroscopic accelerometer) accelerometer. The IMU was nicknamed the "Gold Ball" due to the coat of a gold-colored resin-based paint for protection from oxidizer leaks. The IMU weighed 184 pounds, Missile Guidance Computer weighed 100 pounds. Over the next 16 years this first guidance system required only eight modifications, all of which were completed by May 15, 1965.[24]

In the mid-1970s, the Air Force faced a dilemma with the original guidance system for the Titan II program. Nearly two decades after the design of the original guidance system, advances in the electronics industry made the system difficult to support. Major suppliers were not interested in maintaining the capability of building obsolete equipment in small lot sizes. In some cases, the older components simply did not exist as suppliers had phased them out of their product line. Headquarters Strategic Air Command realized that at predicted failure rates, critical parts would no longer be procurable by December 1977.[25]

Fortunately, an existing state-of-the-art replacement was available: a modified Delco Electronics Carousel inertial guidance system called the Universal Space Guidance System (USGS). The USGS had been in use with the Titan IIIC program on 13 December 1973; six launches with one failure in the guidance system at the time of the decision to modify it for use with Titan II. The Carousel IV inertial navigation system was standard equipment for the Boeing 747 and had been retrofitted into the Boeing 707 and McDonnell-Douglas DC-8.

The USGS hardware was composed of the Carousel IV IMU and the Magic 352 computer: each weighed 80 pounds (the commercial aircraft computer was the Magic III series). Modification of the basic Carousel IV inertial reference unit for space applications had been relatively simple, repackaging the instrumentation for the thermal environment as well as vibrational stresses of a missile launch. The Titan II autopilot was used with minor modifications, as was most of the airborne wiring. The umbilicals to the missile did not need to be replaced (Figure 10).[26]

While the missile silo environment, as well as the missile flight profile, were obviously significantly different than that seen by the commercial aircraft Carousel IV and Magic III systems, the missile installation had a major advantage: the guidance system would be turned on after installation, advanced to the "READY" mode and, except for maintenance or repair requirements, remain in this steady-state operating environment for months or even years. In the aircraft installation, the Carousel IV system was turned on and off several times a day depending on aircraft operations. This caused degradation in system accuracy and reliability due to the short-term operating times and the effect of heating and cooling. Once up and running, the USGS system self-calibration procedures continually fine-tuned the system and was most stable if simply left on.

Between October 15, 1975 and June 27, 1976, Delco engineers and technicians were able to modify two sets of flight systems from the already flight-proven USGS of Titan III. Included within this eight-month time frame was the design and fabrication of a new telemetry system for use during the qualifying flight(s) since the original teleme-

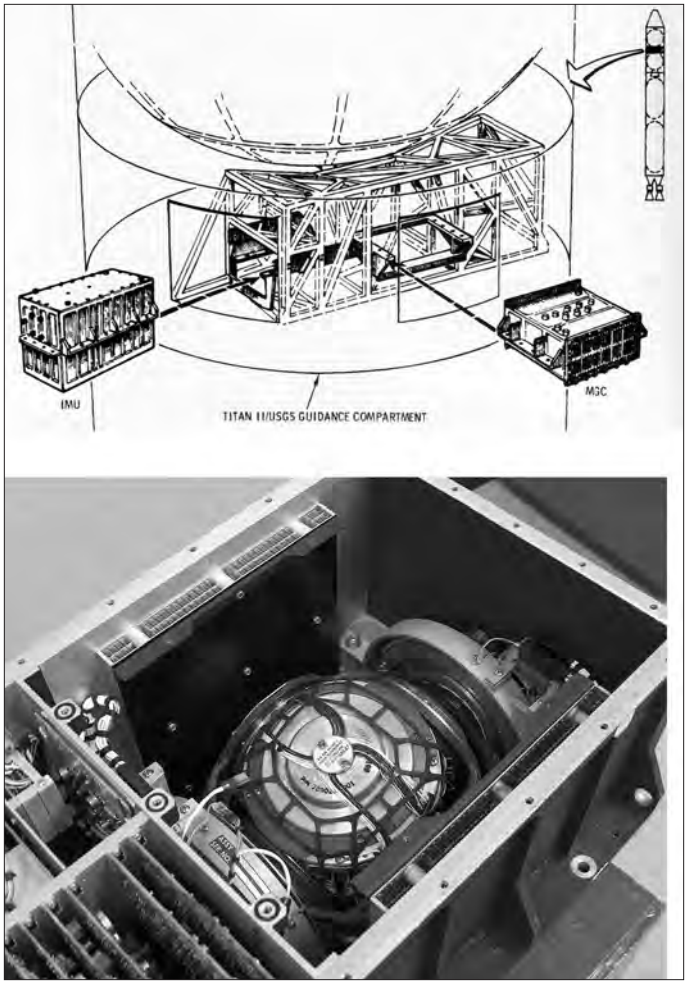


Figure 10: USGS. Upper: Location of the USGS inertial measurement unit and missile guidance computer between the Stage II propellant tanks. Lower: The cover is off the new IMU, revealing a much more compact inertial measurement unit. ***Courtesy of Titan Missile Museum Archive.***

try system sets had been used up during the previous flight test program.[27]

The fourteenth launch operation for the 308 SMW, and the last launch in the Titan II ICBM program was given the name Project "Rivet Hawk." At 0213 (Z), June 28, 1976, the missile combat crew composed of: Capt. Roger B. Graves, MCCC; 1st Lt. Gregory M. Gillum, DMCCC; Staff Sergeant David W. Boehm, BMAT; and Staff Sergeant Kenneth R. Savage, MFT, began the launch procedure. Keyturn took place at 0214 (Z) and within seconds a GUIDANCE HOLD occurred due to an INERTIAL GUIDANCE SYSTEM NO-GO signal. The shock produced during pre-valve opening had been sensed by the inertial measurement unit, triggering the hold. The new software had retained both MEMORY and BLAST DETECT modes so the launch team returned the guidance system to the READY mode, the countdown recycled and after downrange checks, the countdown resumed 18 minutes later. Since the pre-valves were now already open, the second launch attempt, at 0240 (Z), encountered no problems. Liftoff occurred at 0240:53 (Z). The flight to target was successful but the reentry vehicle impacted approximately 1.46 nautical miles long and 0.36 nautical miles cross range.[28]

As one might imagine, this was more than a little disconcerting. Review of the telemetry from the guidance system, as well as extensive computer modeling, revealed an error in the software. The unique feature of the USGS inertial measurement unit was the rotating X-Y platform. This feature mitigated a source of error in the X-Y plane that had to be accounted for in a non-rotating system. The newer computer in the system allowed the continuously changing X-Y instrument outputs to be monitored for updating the platform alignment. In the USGS equipment used on Titan III, the platform rotated at one revolution per minute. For deployment in the operational Titan II fleet, the decision was made to slow the platform down to one-quarter revolution-per-minute due to a failure rate with the one-revolution-per-minute system that was unacceptable for the Titan II program. With Titan III the guidance system was on for perhaps 24-48 hours before launch. With Titan II, the guidance system would be on for weeks and months, perhaps years between required maintenance.

It seems that Titan II USGS programmers failed to provide a program path for the updating of the instrument coefficients after one minute; rather, it was after one revolution or four minutes. The resulting uncompensated instrument errors actually grew exponentially and after four minutes were unacceptably large. This was not known at the time but, by a quirk of fate, the instrument error compensation values at the time of launch were four minutes old, causing the resulting impact error. Post-launch review of the guidance software clearly revealed the cause of the error. The fix, which did not require another launch, was to refresh the instrument compensation factors after 90 degrees of rotation, or with a one-quarter revolution per minute system, once a minute as before. With only four spare Titan II missiles remaining in the inventory, including one each at the three operational Titan II wings, and Pacific Missile Range support equipment unavailable in time for a second launch before the USGS purchase decision date of October 1, 1976, the decision was made to proceed with the USGS modification.[29]

Engines

Titan II engine development began in January 1960. Valves, pumps and cooling jackets for the thrust chamber were not seen as major hurdles. Workhorse steel injector patterns were fabricated, in sub-scale first and then full scale, to see how the propellants interacted in order to achieve maximum performance. These were hot-fire tested for limited duration using uncooled steel thrust chambers to determine design parameters such as combustion stability and chamber wall thermal loads, flow rate combinations, mixture ratios and propellant temperatures. With determination of mixture ratios complete and initial injector plate patterns finalized, the timing of propellant movement through the engine cavities could be evaluated. Subsystems were being worked on simultaneously; e.g., the turbopump team was designing the turbines, gearboxes and impellers to move the propellants that the thrust

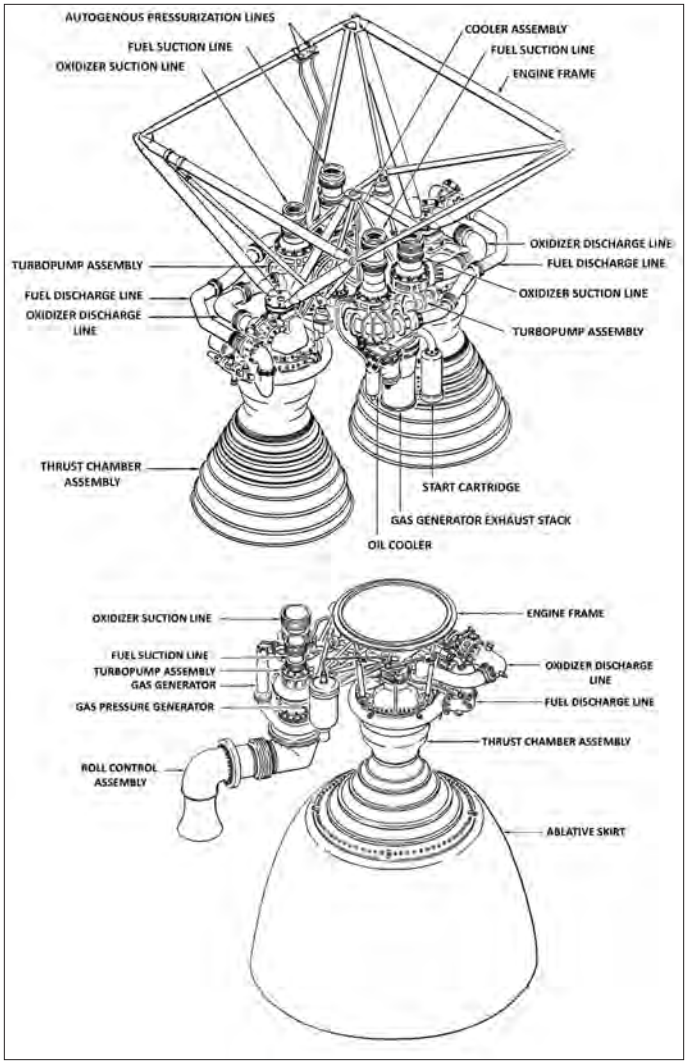


Figure 11: Titan II Engines. Upper: Titan II Stage I Engine; Lower: Titan II Stage II Engine. At first glance, the Titan II Stage I looks identical to the Titan I Stage I engine. The most obvious difference was a shorter turbopump exhaust stack. For Stage II, the vernier nozzles were replaced by one nozzle which used the exhaust from the Stage II gas generator for roll control. The Titan II vernier final velocity adjustment was provided by two solid propellant motors located in the Stage II engine compartment. ***Courtesy Titan Missile Museum Archive.***

chamber team needed for optimum operation; likewise, the gas generator team was developing the cavitating venturis concept; the autogenous pressurization team was working on the sonic nozzles, etc. Finally, the systems were placed together and system integration began.[30] Preliminary testing using Titan I engine hardware began in May 1960. The first Titan II engine prototypes were available for testing in September 1960. After approximately 80 engine tests, the engine configuration was frozen in December 1960. Delivery of the Stage I research and development engines began in January 1961. Hundreds of tests were run around the clock to get the correct hydraulic balance or mass flow rate for the most efficient operation. In March 1961 the first full duration firing of a Stage I engine was successfully accomplished and in July 1961 the first production Stage I engines were accepted by the Air Force.[31] Because of the experience gained in developing the Titan I engines, the task of developing Titan II engines took little more than two years from design inception to first flight in February 1962 (Figure 11).[32]

Along with the change to storable propellants came the opportunity to greatly simplify the engine control system. Titan I engines had 125 active control components, this was reduced to 30 for Titan II.[33] These changes were reflected in a similar decrease in power control operations, 107 to 21 respectively. Examples of the important changes: (1) elimination of the ignition system since Titan II propellants were hypergolic; (2) an autogenous pressurization system that used cooled gases from turbine exhaust to maintain propellant tank pressure; (3) use of solid propellant start cartridges instead of stored pressurized gas to start turbopump operation; (4) use of the Stage II turbopump exhaust stream as the power source for the Stage II roll nozzle, eliminating the need for an auxiliary power drive assembly for the vernier rockets, greatly increasing reliability; (5) use of cavitating venturis and sonic nozzles to provide passive control to the gas generator and autogenous pressurization system; and, (6) propellant supply lines from pump to thrust chamber designed to have the ability to articulate, allowing motion of the thrust chamber for thrust vector control, eliminating rotary seals that were possible leak paths.[34]

Two key manufacturing differences were also important. In Titan I, the thrust chamber injector assemblies were milled from solid forgings, a time consuming and costly process. With Titan II, the injector was formed from plates that were welded together. Titan I used both a fuel and oxidizer manifold whereas Titan II used a fuel manifold and an oxidizer dome feed system.[35]

Stage II Combustion Instability

The Titan II Stage II engine development was another matter. While reliable rocket engine ignition at high altitude had been successfully demonstrated with Titan I, such was not to be the case with Stage II engine development for Titan II. Roy Jones, a development engineer for Stage II, recalled the first time he witnessed a Stage II ignition combustion instability. He was watching the television monitor of a Stage II engine test, when much to his surprise, he saw the thrust chamber drop away from the injector dome as if someone had taken a sharp knife and sliced it off. After several engines failed in this manner, review of the test data indicated that a combustion instability with a period of 25,000 cycles per second had swept around the injector face, cutting through the combustion chamber wall like an ultrasonic saw 1.5 inches below the attachment point. Thrust chamber pressure was cycling through $\pm$ 200 pounds per square inch at 25,000 cycles per second.[36] This was unexpected since it had not happened with Titan I Stage II engines. This did not happen each time an engine was tested and was in fact statistically almost insignificant for use in the ICBM program, occurring in just two percent of the ground tests. However, since Titan II had been selected by NASA as the Gemini Manned Spacecraft Program launch vehicle, even two percent was too much of a risk and a solution had to be found.[37]

In September 1963, Aerojet General began work on the Gemini Stability Improvement Program, also known as GEMSIP, to resolve the Stage II combustion instability. The direct cause of the problem was known. In Stage I, the propellants flowed into the engine cavities against sea level air pressure and engine bleed-in timing could be monitored and adjusted for. At the high-altitude present for Stage II bleed-in prior to engine start, this process was very different from that at sea level since there was no air pressure to act as a barrier. The first real resistance encountered by the fuel or oxidizer was the injector plate itself. This resistance was due to the small orifices that the fuel and oxidizer had to flow through to develop the spray pattern needed for efficient combustion. The physical shock was not a problem. The engine was robust enough, as was the airframe mounting, to take the impact. The problem was the resultant combustion instability at the injector plate face.

Aerojet went through 20-30 Stage II thrust chambers trying to resolve the problem. The simple test of high-altitude bleed-in theory was to fill the thrust chamber wall tubes of the regenerative cooling system with water. When tested at 70,000 feet equivalent air pressure at the Aerojet facilities, the water provided enough hydraulic resistance to mimic that of the sea level condition. Combustion stabilized significantly as the hydraulic shock was reduced to that found at sea level. However, the use of water was not an operational fix for an engine sitting in a launch duct for years, nor was it truly feasible for the Gemini Program. The water-filled thrust chamber tubes did, however, allow for continued engine system integration. The primary solution, and the only one truly considered by both Aerojet and the Air Force, was a stable injector and a dry thrust chamber jacket start. Baffles were a logical control mechanism to break up the instability long enough for initiation of smooth combustion. The design evolved into a baffle that had oxidizer injection for thin film cooling. The final design was altitude tested in the Air Force Arnold Research Center Facilities at Tullahoma, Tennessee, and proved sound. The GEMSIP program took 18 months to complete and cost $13 million. The changes were incorporated into the ICBM program engines. Ironically, none of the R&D missile failures were attributable to a Stage II hard start, and perhaps even more ironic, NASA launched the first six Gemini flights with the old-style injector plate (Figure 12).[38]

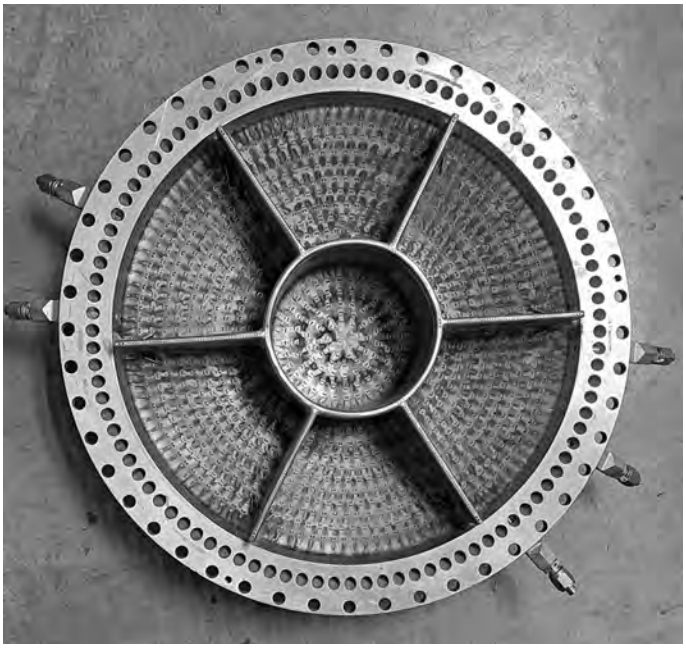


Figure 12: Titan II Stage II Injector Plate. The center baffle prevented formation of the combustion instability shockwave. The injector was 17.5 inches in diameter. ***Courtesy Titan Missile Museum Archive.***

Stage II Gas Generator

A second problem, and one that proved more troublesome, was that of Stage II gas generator failures in flight during high altitude start-up. The gas generators utilized fuel and oxidizer to generate high pressure gas for powering the turbopumps during flight. Solid-propellant start cartridges provided the initial high-pressure gas for spinning the turbines and then the gas generators took over. The problem first occurred in the flight of N-1, the second launch of a Titan II. Telemetry indicated that the Stage II engine had reached only fifty percent thrust immediately after ignition and the vehicle was destroyed by the range safety officer. Unfortunately, the limited flight telemetry data provided insufficient information to the Stage II design team to solve this critical problem. The flight program continued with two partial failures in the next seven flights. Review of the accumulated telemetry data indicated that the small orifices at the injector plate for the gas generator were being partially plugged by particles on all the flights.

Careful review of the flight data indicated that backpressure was being developed due to the clogged orifices, decreasing propellant flow to the gas generator with subsequent loss of power. After trying to super-clean the gas generator components in a clean room prior to assembly, transporting the assembly to Cape Canaveral separately from the engine and conducting a preflight nitrogen blowdown before each flight to verify the flight item cleanliness, the actual solution to the problem was found to be very simple and cost effective.[39]

At sea level the air trapped in the gas generator interior served as a cushion, preventing combustion gases and solid fuel particles produced by start cartridge ignition from reaching the injector plate of the gas generator on the Stage I engine. Due to the problems of vacuum testing large liquid-fueled rocket engines, the Aerojet facilities could only reach the equivalent of 70,000-foot altitude. This was assumed to be close enough to the Stage II start altitude vacuum at 250,000 feet and the Stage II system was tested successfully.[40] However, even at 70,000 feet altitude, sufficient air was present to provide a barrier to the start cartridge combustion product particles. At 250,000 feet, the higher vacuum meant no such barrier existed and particles were being blown into the gas generator, clogging the oxidizer orifices. On many of the flights the result was not of sufficient magnitude to cause a problem, but on three of the first 20 flights it was significant. The solution to this problem was simple. A rupture disc was placed on the roll

Figure 13: Operation Wrap up. Streaks of corrosion on the top of the Stage II oxidizer tank in the between tanks area of Titan II B-23. Missiles returned during Operation Wrap Up were segregated in a separate factory area where work was conducted around the clock to get the missile tanks and valve joints repaired and the missiles returned to the operational bases. ***Courtesy Lockheed Martin Astronautics, Denver.***

nozzle, the endpoint of the Stage II gas generator exhaust, entrapping the sea level atmosphere (i.e., pressure) until start cartridge ignition took place. The cushion of air was retained at altitude, preventing combustion products from reaching and plugging the orifices.

Storable Propellants

The use of storable propellants was an attractive option to eliminate the long response time. At the beginning of 1951, the Navy's Rocket Branch of the Bureau of Aeronautics contracted with the Metallectro Company and Aerojet to synthesize hydrazine derivatives and investigate their usefulness as rocket propellants. If used as the fuel half of a hypergolic propellant pair in tactical rockets, the hydrazine or mixtures of hydrazine derivatives had to have a freezing point no higher than -65°F. By 1955, researchers at Aerojet had selected a 50:50 mixture of unsymmetrical dimethylhydrazine and hydrazine (Aerozine 50) which met that specification. The freezing point specification was of no consequence for Titan II as the missile was located in a launch duct held at a temperature of 60±2°F. Nitrogen tetroxide was selected as the oxidizer. Both of the propellants were highly toxic and special protective suits were necessary when propellant transfer operations took place.[41]

Oxidizer Tank Leaks

Contract AF04(647)-213, May 15, 1962, stated ". . . it shall be a design requirement that the allowable pressure decay with the propellant tanks loaded at flight pressures, shall be less than 2.0 psi in 30 days, except for Stage II fuel tank, which shall be less than 3.0 psi in 30 days. There shall be no visible leakage... ."[42] However, by mid-1963, early in the deployment of Titan II missiles in operational silos, leaks began to appear in the oxidizer tanks. Nitrogen

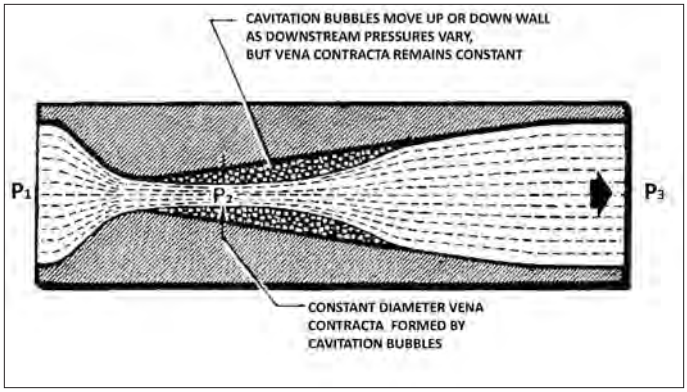


Figure 14: Cavitating Venturi. The cavitating venturi is a device used to assure a constant weight flow in liquid systems. It has no moving parts and combines the venturi principle with the fact that liquids boil when their static pressure is equal to their vapor pressure. ***Author's Collection.***

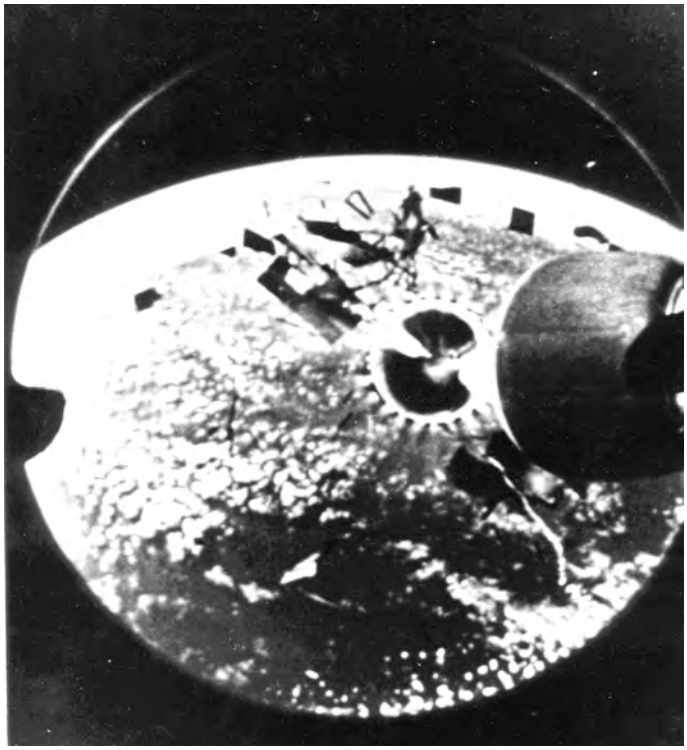
tetroxide, leaking through holes too small to be detected by the original quality control methods, was mixing with water vapor in the humid environment of the launch duct. The result was the formation of highly corrosive nitric acid, causing small leaks to turn into larger and more problematic leaks. The problem had not been detected earlier because none of the N-series flight test operations had necessitated the prolonged storage of propellants. Tank pressurization decays in excess of these requirements were observed, oxidizer vapor leaks sufficient to trigger the vapor detection system occurred and finally, visible leaks were noted. Seventeen missiles of the 60 missiles deployed or awaiting deployment were recalled to Denver for inspection and rewelding. This recall program was given the name Operation Wrap Up. Originally the tanks were checked via x-ray of the weld, hydrostatic and nitrogen pressure tests. Now the quality control methods were to retake the weld x-rays, fix defective welds, pressurize the tank with helium and then check each weld with a helium sniffer that was extremely sensitive. This new test equipment increased the leak detection sensitivity 10,000-fold. After hydrostatic testing, the tanks were baked to dry out all the water in the system, the welds painted with sodium silicate and then pressure-checked again prior to return to the field. A total of 15 fabrication changes were made during Operation Wrap Up. Only three missiles built after October 1963 had to be returned to Denver for rewelding (Figure 13).[43]

Propellant Tank Pressurization

Titan I utilized pressurized helium gas to pressurize the propellant tanks. The pressure regulators and valves were a source of unreliability. Titan II used what is called an autogenous pressurization system. The oxidizer tank was pressurized with vaporized oxidizer which was bled from the main oxidizer feed line. The liquid oxidizer was vaporized in a heat exchanger that was supplied by exhaust from the turbopump gas generator. The innovation was the use of cavitating venturis to control the gas pressure. Cavitating venturis are passive devices which limit the maximum flow of fluids regardless of downstream pressure (Figure 14).[44]

Figure 15: (Above) Titan II Stage II Exhaust Vents. The system of vents facilitated "fire-in-the-hole" staging by quickly venting the Stage II engine exhaust. *Author's Collection.*

Figure 16: (Below)Titan II Staging. A frame from an external camera showing the fragmentation of the interstage splice at Stage II ignition. Cameras on the flight of N-33, 23 March 1964, confirmed the integrity of the redesigned interstage structure. *Author's Collection.*



The fuel tank pressurization system utilized gas from the main engine turbine gas generator exhaust which was cooled in a heat exchanger similar to that of the oxidizer system. Stage I and II fuel tank pressurization was essentially the same, while the Stage II oxidizer tank relied on the tank pressure present at launch.[45] Reliability was increased tremendously with the elimination of valves and pressure regulators used in Titan I.

Staging

The third major difference was a change in the staging sequence. Nicknamed "fire-in-the-hole," Stage II was ignited during Stage I thrust tail-off while still attached to Stage I. The decaying thrust of the Stage I engines maintained sufficient acceleration to keep the Stage II propellants at the turbopump inlets prior to Stage II ignition. The forward dome of the Stage I oxidizer tank was protected from the Stage I engine exhaust by a layer of ablative material. Explosive nuts fired at Stage II thrust buildup, releasing Stage II. This eliminated the guide rails and the separation rockets used in Titan I. A swiveling secondary nozzle redirected the exhaust from the Stage II turbopump for roll control, eliminating the vernier thrusters.[46] Stage II engine exhaust was vented through large openings in the forward skirt of Stage I. Ground-based tracking cameras revealed that the "fire in the hole" was causing breakup of the Stage I interstage structure with the possibility of damage to Stage II from the debris. Camera data from most of the flights showed that the point of failure was the interstage-oxidizer tank junction. Film from the flight of N-33 verified that interstage had been successfully reinforced and the fix was applied to operational missile fabrication (Figures 15, 16). [47]

Reentry Vehicles

Detailed design documents for the Titan II ICBM list both the Mark 4 and Mark 6 reentry vehicles as possible payloads.[48] The reason for listing the Mark 4 may have been as a fallback if the development of the Mark 6 was unsuccessful. Interestingly enough, a single and successful launch of a Titan II carrying a Mark 4 did take place on December 6, 1962 from Cape Canaveral; however, the flight was not successful (Figure 17). [49]

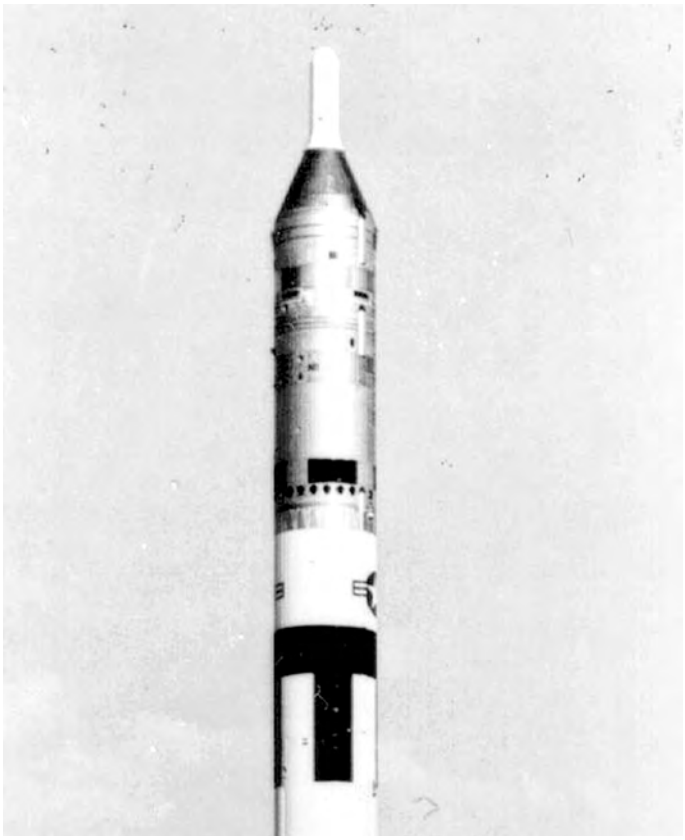


Figure 17: The Mark 4 reentry vehicle was only flown once on a Titan II. On 6 December 1962, N-11 was successfully launched from Cape Canaveral Pad-16. Carrying a Mark 4 Mod 2A reentry vehicle, the flight was normal until oscillations in Stage I were severe enough to cause a thrust chamber pressure switch in Stage II to shut down the engine with subsequent impact short of target. *Author's Collection.*

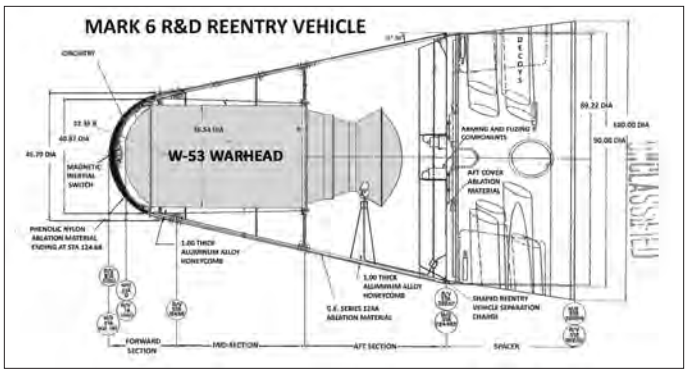
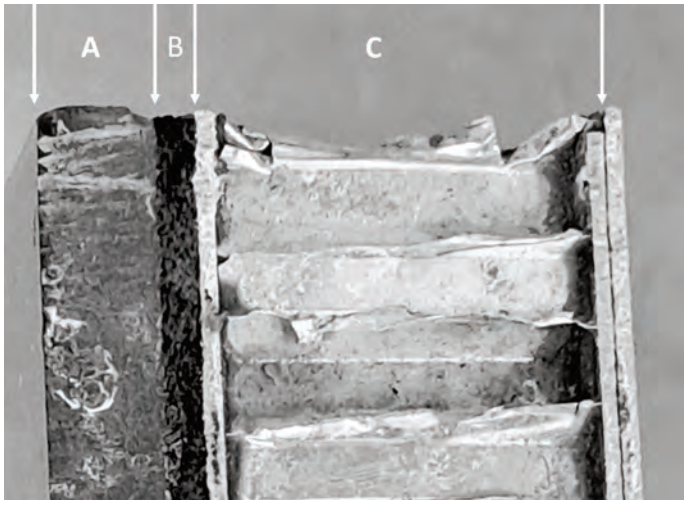


Figure 18: (Above) Outboard Profile of the Mark 6 Reentry Vehicle and Decoy Spacer. The Mark 6 carried the W-53 warhead which was an adaptation of the B-53 gravity bomb and had a yield of 8.9 Mt, the largest warhead used in the ICBM program. The Mark 6 reentry vehicle was 10.2 feet tall with a base diameter of 7.4 feet. *Author's Collection.*

Figure 19: Mark 6 Heatshield Detail. Cross-section of conical frustrum of the Mark 6 reentry vehicle heatshield. (A) The outer layer was Century Series 124A plastic, 0.295-inch thick; (B) neoprene, 0.094-inch thick; (C) aluminum alloy honeycomb, 1-inch thick. The nose cap was composed of chopped phenolic nylon, 2.33-inches thick tapering down 0.385 inch. *Author's Collection.*



The General Electric Mark 6 reentry vehicle deployed on Titan II utilized ablative materials for both the nose cap and heatshield. The nose cap was composed of phenolic nylon (66-Nylon cloth impregnated with phenolic resin), chopped into 0.5-inch squares and pressure molded to the nose cap shape. The main body of the heatshield was composed of the General Electric Century Series 124A plastic. The basic ingredients for the plastic were: Dow Epoxy—Novolac 438; methylnadic anhydride, a curing agent; polypropylene glycol to increase flexibility to make fabrication easier and N-(n-butyl) phosphoric acid as a charring agent.[50] The Series 124A plastic was easily fabricated by casting the liquid epoxy into molds having the conical frustrum shape of the heatshield and hardening in an oven without pressure. The complete heatshield was assembled from three pieces; the nose cap and two conical sections of the main body. The only machining required was to square off the top and bottom edges to the final length dimension. The Mark 6 heatshield, 0.295 inches thick, was bonded to a 0.094-inch-thick layer of neoprene rubber which was in turn bonded to a 1-inch-thick aluminum honeycomb aluminum

Okay Table 7. Developmental Mark 6 Reentry Vehicle Designations.

Mod 1:	Modified Mod 2 vehicle with GE/RSD lightweight dummy payload ballasted to duplicate Mod 3 weight, 7,400 pounds.
Mod 1B:	Modified Mod 2 vehicle with GE/RSD lightweight dummy payload. 7,200 pounds.
Mod 2:	Fully instrumented R&D vehicle with Sandia payload; weight in excess of Mod 3.
Mod 2A:	Modified Mod 4 vehicle with Sandia payload, 7,800 pounds.
Mod 2B:	Modified Mod 4 with FTU and certain other instrumentation added, 8,000 pounds.
Mod 2C:	Modified Mod 4 with FTU and certain other instrumentation added, 7,900 pounds.
Mod 3:	Operational vehicle configuration; the prime vehicle to carry an FTU or scoring kit.
Mod 4:	Partially instrumented R&D vehicle with GE/RSD dummy payload ballasted to duplicate Mod 3 weight.
Mod 4A:	Mod 4 vehicle modified to carry special experiments in support of the ARPA-sponsored vehicle instrumentation program.
Mod 4B:	Modified Mod 4 vehicle, using lightweight dummy payload, 7,000 pounds.
Block 0:	Initial R/V design with dome-shaped aft cover, a questionable tension cone to support the payload, a plane spacer assembly (i.e., not designed for decoy installation) and, in general, a one half-ampere no-fire squib requirement.
Block 1:	Block 0 design with flat aft cover, decoy spacer.
Block 2:	Operational vehicle configuration; Block 1 design with tension straps for payload support, and incorporating propellant compatibility requirements.

1. "WS 107C Titan II Weapon System Final Report, January 1965."

layer attached to the reentry vehicle airframe. The coefficient of expansion of the plastic was much higher than that of the aluminum airframe and the rubber served both as an insulator and as an elastic interface which could stretch to accommodate heatshield expansion. The nose cap had a maximum thickness of 2.33 inches (Figures 18, 19). [51]

While these dimensions seem small when the material is to be exposed to reentry temperatures of several thousand degrees, in the short time of exposure, several porous char layers 1-2 millimeters thick are formed in sequence. The first one plugged up and was sloughed off by aerodynamic forces. A new char layer formed as the process repeated itself. Large amounts of pyrolysis gases that formed as the material degraded served to inhibit heat transfer from the hot boundary layer to the ablating surface, greatly reducing the actual heating at the vehicle surface.[52]

Unlike the missiles launched at the WTR which were below ground and out of the sun, the missiles at Cape Canaveral had prolonged exposure to the sun and so the reentry vehicles were painted white to reflect the sun and help cool the reentry vehicle.[53]

Developmental Mark 6 Reentry Vehicles

Table 7 lists the developmental Mark 6 reentry vehicle designations and characteristics. The initial Mark 6 reentry vehicles were designated as Mod 2 and Mod 4. The Mod 2 vehicle was fully instrumented with sensors embedded in the heatshield for ablation measurements; motion sensors and telemetry equipment to monitor reentry vehicle functions. A Sandia National Laboratory Flight Test Unit (FTU) was installed as well as telemetry link equipment. The result was that the Mark 6 (Mod 2) weighed approximately 8,100 pounds. Mark 6 (Mod 4) had fewer instruments and weighed 7,400 pounds.

Several reports from the Operational Test and Follow-On Test Programs shed some light on details of operational Mark 6 specifications.[54] The Mark 6, including decoys, reen-

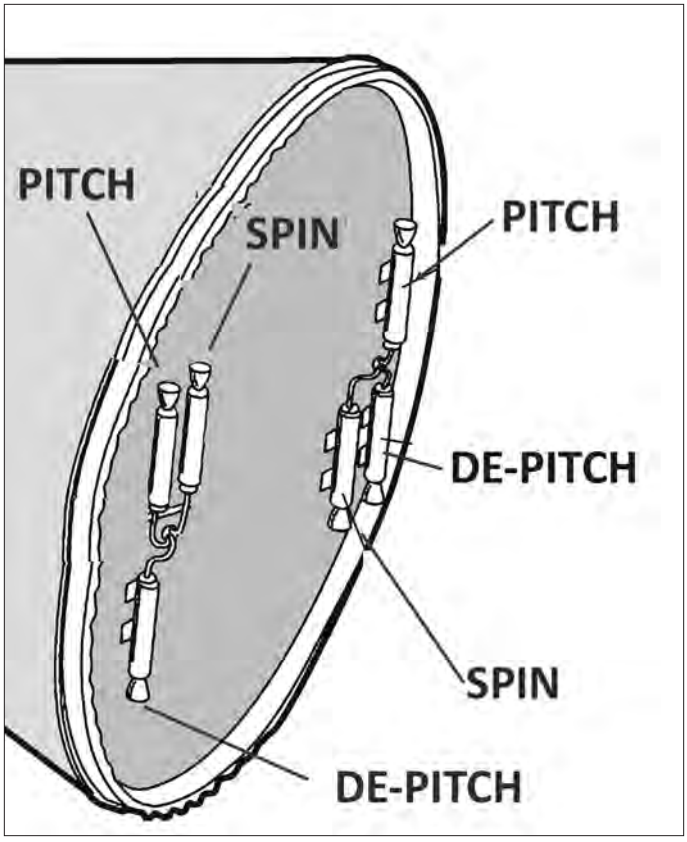


Figure 20: Mark 6 Attitude Control System. The attitude control system positions the reentry vehicle at the required entry attitude angle . Depending on the target, the reentry angle was between 19.9 and 24.98 degrees. Stage II had translation rockets which moved Stage II away from the reentry vehicle as a decoy. The flight test program developed the timing for initiating the translation procedure without affecting the reentry vehicle trajectory. ***Author's Collection.***

try vehicle adaptor and W-53 warhead weighed 8,380 pounds. The W-53 warhead weighed 6,200 pounds and was the largest yield warhead used in the U.S. strategic missile forces, with a yield of 8.9 MT. When launched from VAFB, the Mark 6 carried either a denuclearized W-53 warhead that still contained the Grade II high explosive components for air burst tests, or a scoring kit utilized for surface impact flight profiles. The Mark 6 Mod 3 reentry vehicle adapter/spacer could carry up to eight terminal decoys (Optically Enhanced, Model 1037J) and six mid-course decoys (Operational, Model 1026BP).

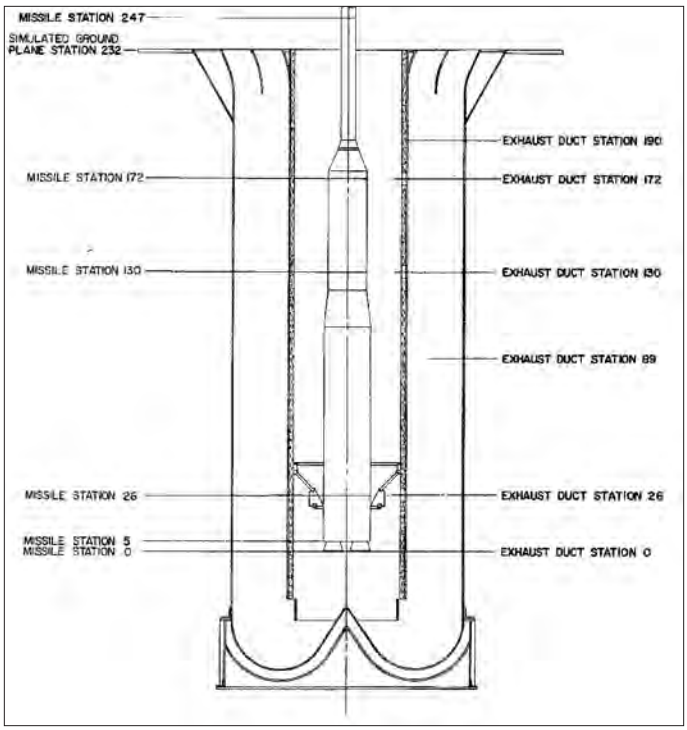
Re-orientation of the reentry vehicle immediately following separation to that required for low angle of attack was performed by an attitude control system consisting of two pitch, two de-pitch and two spin rockets. The original design of the Mark 6 included a rounded aft cover to facilitate reorientation of the reentry vehicle in the event of an initial backward reentry followed by the failure of the attitude control system. The results of the flight test program indicated a flat aft cover design permitted better attitude control and was used in all operational Mark 6 reentry vehicles (Figure 20). [55]

Launch facilities

Titan II was deployed in LGM-25C configuration (L = silo stored and launched; G = ground attack; M = guided missile; 25 = twenty-fifth major design; C = model number). Testing of the in-silo launch concept began in April 1959. The Air Force contracted with Aerojet General at the Azusa, California facilities, to build and test a 1/6th scale model of a proposed Titan II silo.[56] The development of this ducted launcher, as it was then called, was a crash program that required only 60 days to build both the scale model silo and scale model Titan II airframe fitted with Nike-Ajax engines (Figure 21, 22).

Figure 21: (Above) Construction of the Silo Model. The launch duct and exhaust ducts were installed in one piece. ***Courtesy R. Pickford.***

Figure 22: (Below) Schematic Drawing of the In-Silo Launch Model. The general configuration of the launch duct, flame deflectors and exhaust ducts. Previous work in Britain had used a J-shaped deflector. The W-shaped deflector demonstrated superior stability in airflow past the missile since it was symmetrical. Launch duct and exhaust duct acoustical lining position and thickness was also tested with this model. ***Courtesy Aerojet General Corporation.***



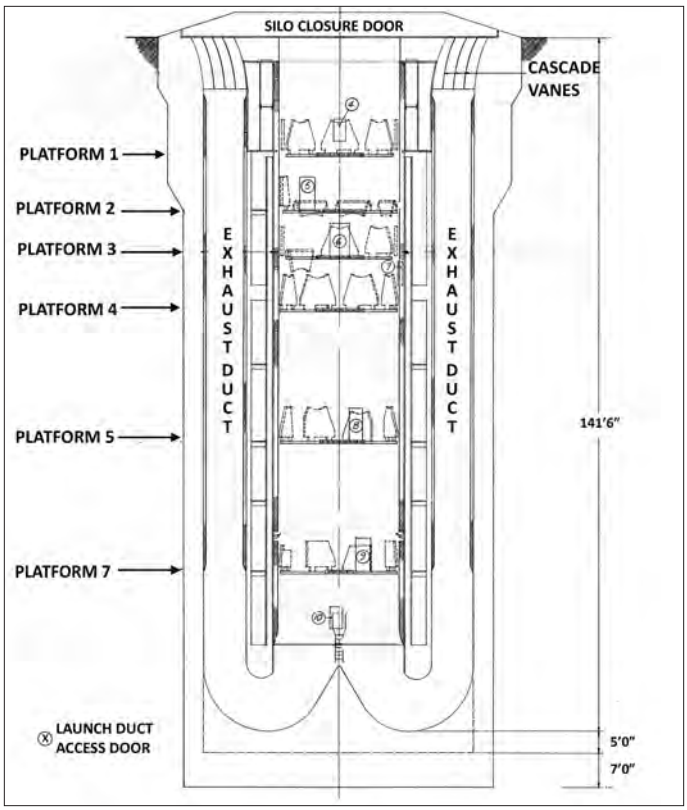


Figure 23: Titan II Silo. A sectional view of a Titan II silo. The silo was composed of two concentric cylinders; an inner cylinder called the launch duct with an inner diameter of 26 feet which housed the missile; and an outer cylinder with an inside diameter of 55 feet. The space between the two was called the silo equipment area. There were retractable work platforms on six levels in the launch duct. The upper outer wall of the silo was eight feet thick from the surface to a depth of 30 feet and then tapered to four feet thickness. The 700-ton silo closure door was supported by four massive box girders, 19 feet in height, four feet in width and 51 feet in length, filled with concrete. *Courtesy of Titan Missile Museum Archive.*

The scale model silo was constructed completely above ground for easy access through hatches built in the silo and launch duct wall. The ground plane was simulated by a 35-foot diameter circular platform placed at the top of the silo. The entire silo, launch duct and exhaust tubes were built by a steel fabricator in San Pedro, California and trucked 40 miles to the Azusa facilities. The over-size nature of the load required careful plotting of the route to avoid underpasses. As it was, telephone and power company crews still had to proceed ahead of the truck to disconnect or raise interfering wires.[57]

The first test firing took place on June 6, 1959. By the time of the successful launch of Titan I VS-1, modified for in-silo launch from the Silo Launch Test Facility (SLTF) at VAFB on 3 May 1961, a total of 36 firings within the special silo test stand had been conducted. The first 23 were conducted using Aerojet Nike-Ajax production line engines. Originally designed for 2,500 pounds of thrust, two engines were modified to produce 4,200 pounds of thrust each.[58] These tests generated data on the general acoustic, aerodynamic and thermal environments in a 1/6th scale-model W-tube type launcher. The feasibility of the concept was shown, but in late 1959 it was clear that the Titan I airframe would have to be modified to withstand the in-silo launch environment. From February to September 1960, the test program concentrated on the specific design of the SLTF, developing and evaluating techniques for reducing potential damage to the missile systems.[59]

The last phase of the test program continued where the second phase had left off in September 1960 and was completed by February 1961. The final 13 tests were conducted using the same engine and a propellant supply package used in the first two phases, but modified for use with the Titan II propellants at a thrust of 6,000 pounds. Since engine start pressure pulse and exhaust products for the modified system were unknown, the acoustic, thermal and aerodynamic environments were again thoroughly evaluated.[60] Combining the results of these tests provided a set of pressure pulse, temperature differentials and acoustical energy profiles that permitted a launch duct acoustical liner concept to be developed.[61] The critical problem that had been addressed, modeled and solved was that of sound-induced vibrations. A sound energy of 148-decibels on the skin of the missile as it emerged from the silo had been predicted and an actual value of 158-decibels was measured.[62]

The scale model provided insight on the design of the exhaust ducts. By positioning the scale model missile sequentially higher and higher in the launch duct, engineers discovered that by the time the guidance compartment of the missile emerged from the silo, an unacceptable 163-decibel acoustical energy level was present. This was a result of not only the acoustical energy in the launch duct itself but also the sound energy coming from the twin exhaust ducts. The solution was to line the exhaust ducts with acoustical panels, reducing the resultant decibel level and providing an adequate safety margin when combined with other design features. The pressure pulse generated by ignition of the engines was also a major design constraint. The scale model again proved invaluable as a water deluge system was developed which directed high-pressure water into the engine exhaust plumes. This reduced the magnitude of the pulse to an acceptable level. The water deluge also reduced the exhaust plume temperature significantly (Figure 23).[63]

Shock Isolation System

The Titan II launch concept differed significantly from Atlas F and Titan I in that the missile was launched from inside the silo. The storable propellants eliminated the need for time-consuming propellant transfer during the countdown. The silo crib and shock isolation system where no longer needed. The silo, 55 feet in diameter and 145 feet deep, housed the equipment area between the silo wall and the launch duct, which was a cylinder 26.5 feet in diameter. The missile rested inside the launch duct on the 11.5-ton thrust mount which was shock isolated using four 35-foot pendulous springs. Each spring assembly consisted of four coil springs, 20 inches in diameter, mounted in series. The top of the spring assemblies attached to the launch duct wall at the midpoint of the Stage I airframe and, at the bottom, to the thrust mount (Figures 24, 25).

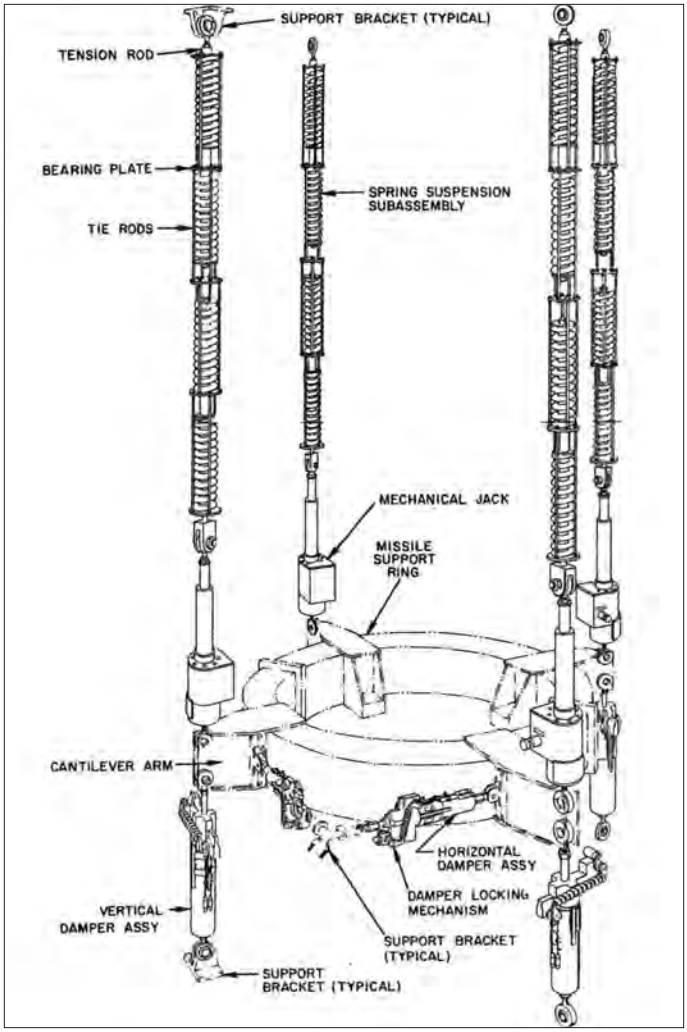


Figure 24: The Shock Isolation System. The missile was held on a thrust mount which was suspended by four 35-foot shock isolation spring assemblies attached to the launch duct wall. Lateral and vertical dampers quickly re-centered the thrust mount after a nearby blast. Prior to launch, the dampers locked the thrust mount in place to provide a stable launch platform. *Courtesy Titan Missile Museum Archive.*

The fully fueled missiles center of gravity was 10 feet above the shock isolation systems point of attachment to the launch duct wall. Use of the horizontal dampers at the thrust mount eliminated the potential for pitch instability with this design. Vertical and horizontal dampers were attached to the launch duct wall and the thrust mount, respectively, and also locked the thrust mount into the launch position.

The peak acceleration limits were 0.8 g vertically and 0.1 g horizontally. Predicted vertical motion was 12 inches maximum and 4 inches horizontally. Oscillations due to a nearby blast were damped within 60 seconds to allow for thrust mount lockup and launch. The shock isolation system design was such that the missile was returned to within plus or minus 0.25 inch of vertical neutral position; 0.4 inch of neutral horizontal position; and 0.25 degree of verticality for the missile axis. Requirements of the optical azimuth alignment system for aligning the missile guidance inertial platform necessitated these exacting specifications. To provide a stable platform for launch, the shock isolation system was locked prior to engine ignition. In the

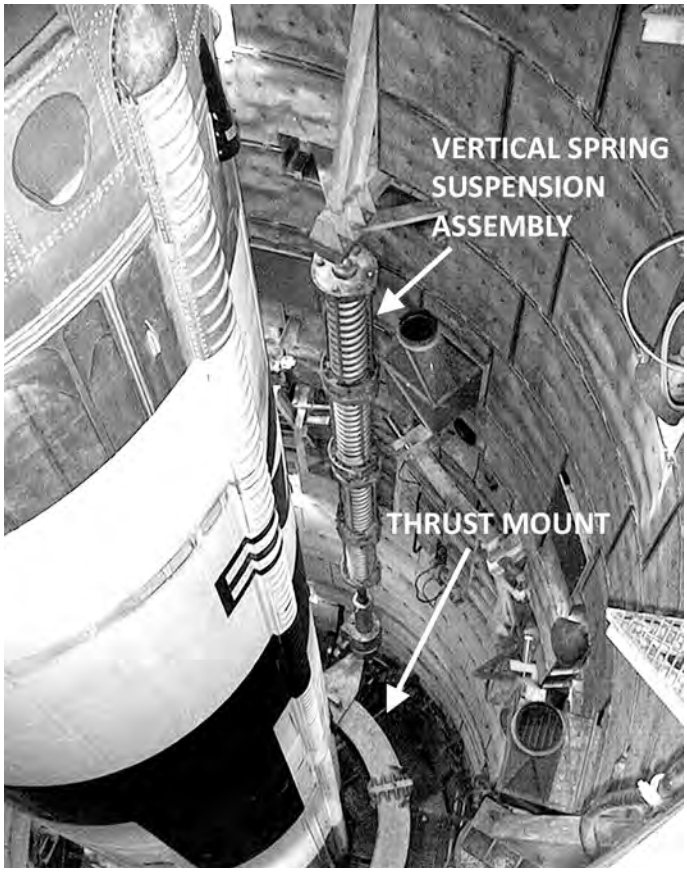


Figure 25: Vertical Spring Suspension Assembly. One of four vertical spring suspension assemblies which provided shock isolation for the missile. Each assembly weighed approximately 1000 pounds, was 14 inches in diameter and 56 inches free height. The spring load rate for each isolation system had to be matched within 1 percent. In the early 60s, they were the largest such assemblies in the Free World. *Author's Collection.*

locked condition, it was considered soft because it no longer provided protection against nearby blast. [64]

The Titan II Stage I engine took approximately one second to reach 77 percent thrust at which time three 1.8-second timers started. Aerojet engineers knew from extensive testing that if the Stage I engines reached 77 percent thrust, they would go on to reach full thrust. When they timed out, four explosive hold-down nuts fired, and the missile lifted off of the thrust mount.[65]

One of the more interesting tests involving a complete Titan II airframe was the twang test conducted on February 11, 1963 at Launch Complex 395-D, VAFB. Airframe N-3 (60-6810) had been installed in the silo on November 29, 1962. After completion of full-scale propellant transfer system design verification tests, which lasted from December 12 to December 27, 1962, the missile propellant tanks were purged and filled with water. On February 11, a series of tests, nicknamed twang tests, began evaluating the missile shock isolation system under dynamic conditions. The missile shock isolation system thrust mount, with the water-filled missile in place as if ready to launch, was pulled down or to the side of the silo with chains held by explosive bolts. The bolts were fired, quickly releasing the missile, simulating ground shock conditions from a nearby explosion being mitigated by the missile shock isolation

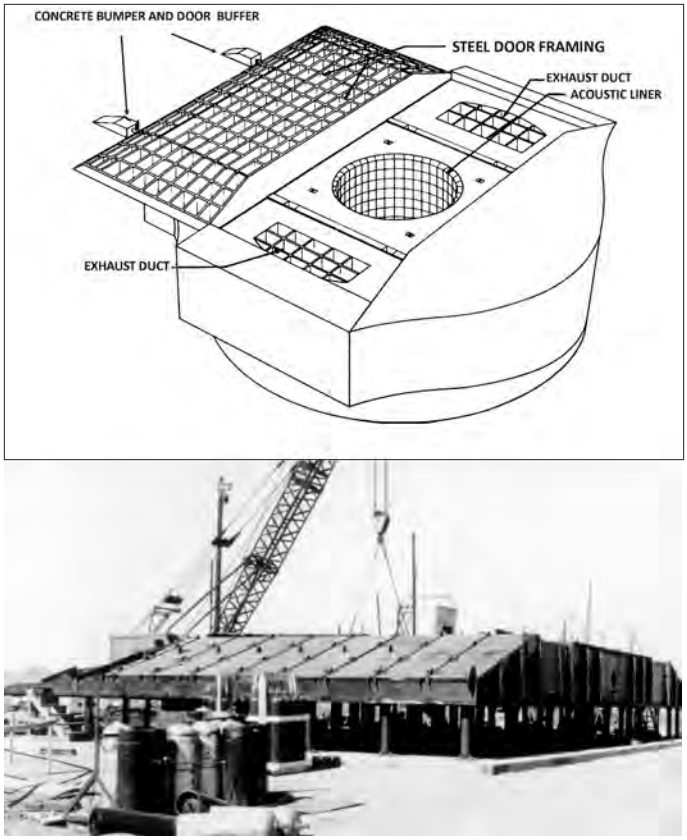


Figure 26: Silo Closure Door Detail. Upper: Diagram illustrating the "eggcrate" construction of the massive 700-ton silo closure door. The top and bottom plating was 3.5-inch battleship armor. The interior webbing supports varied from 1.375 inches to 2.5 inches in thickness. Lower: The silo closure door was prefabricated in sections and assembled on site. The pedestals will be removed and the door lowered onto temporary rails for movement onto the silo. *Courtesy Titan Missile Museum Archive.*

system. The test got its name from the sound the airframe made as it absorbed the displacement movement.

The twang testing resulted in major system changes to all sites, including spring centering devices and new spreader jacks for unlocking the dampers. Engineers designed ratchet-type positive shuttle lock mechanisms to prevent the dampers from unlocking due to vibration during the time between engine ignition and lift-off. A special lubricant was found to facilitate damper unlocking and inhibit corrosion.[66]

Silo Closure Door

The Titan II silo closure door had to cover not only the launch duct but also the two exhaust ducts. Therefore, the Titan I design was not applicable. The door was designed to withstand 300 psi overpressure:

Criteria for design of the Titan II silo closure door to resist nuclear weapons effects include ground shock, blast overpressure, thermal effects, nuclear radiation effects, and electromagnetic pulse effects. In addition, the door was designed to open/close in a matter of seconds. It was also required that the door be capable of operating, within the timescale allowed, against 6 inches of debris covering the door and 6 inches of debris in the path of its movement.[67]

Like the rest of the ICBM facilities which were built with the concurrency strategy, i.e., the launch facilities were under construction during the flight testing of the missile, the first full-scale silo closure door was built next to Launch Facility 395-B. The silo closure door originally weighed 700 tons and was 64 feet wide, 42.5 feet long with a maximum height of 5 feet.[68] The interior of the door was built with an egg crate design and the center cells were partially filled with concrete. The top and bottom surfaces were 3.5" battleship steel armor. The door opened and closed by rolling on double railroad-rail steel tracks using four double sets of railway wheel trucks.

Modifications to the original door design before testing included:

Addition of plows directly in front of the two leading wheel trucks. It was found that the wheels would otherwise ride over the debris on the rails causing the door to stall.

The drive drums were re-reeved from 3-1/2 wraps to 2-1/2 wraps to prevent the cable from wrapping around itself.

Pretension the drive cables with a tension of 20,000 to 25,000 pounds was found to be required to prevent slippage of the cable on the drive drums.

A wheel stop was added to the rails at each of the rear bridges.[69]

Testing began in April 1962 and ended in June 1962. One hundred sixty-nine maintenance runs included operating the door with 3 inches debris (an additional 26 tons of soil), without impulse actuator four operational runs with 3-inches of debris and three operational runs of 6-inches of debris (52 tons) were conducted.[70] The door traveled approximately 3 feet before uncovering the launch duct, permitting soil debris to drop onto the concrete rather than down into the launch duct and potentially damaging the reentry vehicle (Figure 26, 27).

Figure 27: Silo Closure Door at Launch Facility 395-B, Vandenberg Air Force Base. The silo closure door was assembled as close to the launch duct as feasible. Here the door is being moved to Site 395-B. *Author's Collection.*

Table 8. Categories of Titan II R&D Flight Test Programs[1]

Category I Subsystems Development, Test, and Evaluation	
ETR	N-1, N-2, N-4, N-5, N-6, N-9, N-11, N-12, N-13, N-14
WTR	N-7, N-8, N-19, N-22, N-26, N-27, N-30
Category II Weapon System Development, Test and Evaluation	
ETR	N-15, N-16, N-17, N-18, N-20, N-21, N-24, N-25, N-29, N-31, N-32, N-33, N-3A
WTR	N-23, N-28, B-15
Demonstration and Shakedown Operations	
WTR	B-28, B-9, B-7, B-1, B-32

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Response Time

The response time from key-turn to liftoff for Titan II was 58 seconds. The silo closure door started opening at approximately T-35 seconds and was completely open at approximately T-14 seconds. Exposure time was therefore approximately 35 seconds compared to 235 seconds for Titan I.

Research and Development Flight Test

The lessons learned with the Titan I flight test program translated into all Titan II flight test vehicles being flown with operable engines on both stages, operationally configured inertial guidance systems, and reentry vehicles. Thirty-three Titan II Lot N research and development airframes were built, with 32 launched. The remaining airframe, N-10, was used as a trainer at Sheppard Air Force Base, Texas and eventually donated to the Titan Missile Museum, Sahuarita, Arizona. This small sample size was insufficient to determine the variance of individual parameters. The Lot N missiles were grouped into two categories flown at the ETR and three at the WTR. Category I testing was focused on subsystem development, test and evaluation, providing for redesign at an early point in system development. Category II was focused on weapon system development test and evaluation. Category III utilized operational missiles and VAFB Launch Facilities 395-B, C and D (Table 8).[71]

Table 9 lists the specific modifications that occurred during the Lot N Titan II research and development flight test program. Several were minor modifications for installation of instrumentation. Many were changes made as the longitudinal oscillation "Pogo" problem was resolved. The only visual change took place on airframes N-1 through N-9 with the installation of exterior reinforcing bands referred to as "belly bands."[72]

Range safety requirements drove the planning of the flight test program. The instantaneous impact point (IIP) would be moving downrange at 150 nautical miles per second at Stage II engine cut-off. The flight path from the ETR launch facilities at Patrick Air Force Base did not overfly inhabited islands. The WTR had a requirement to protect the land areas of Kwajalein Atoll which meant the IIP could not cross an inhabited island. This requirement limited acceptable targets in the Kwajalein area during the research and development flights, preventing impact in the

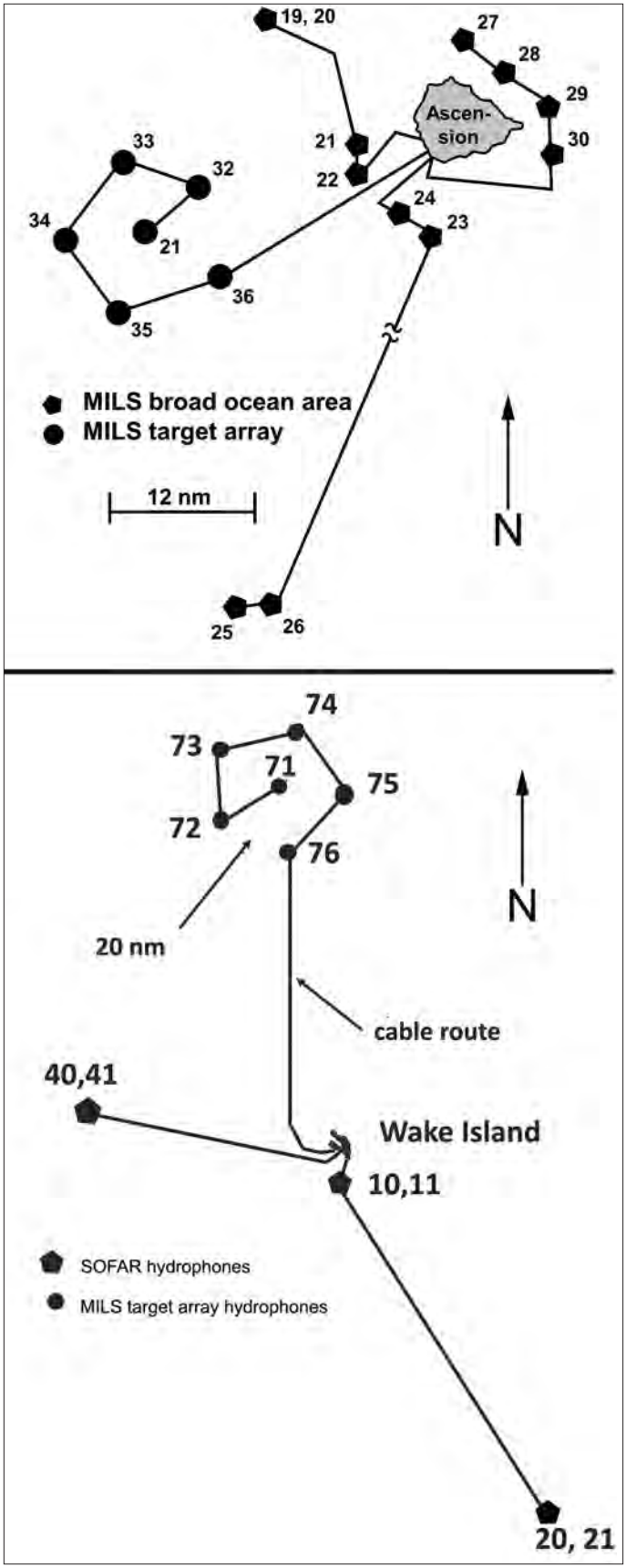

Figure 28: Missile Impact Location System. Approximate location of hydrophones at Ascension Island and Wake Island, for target array and broad ocean area signal detection. At Wake Island, the target array north of the island was installed first followed several years later with the six-hydrophone broad ocean array west and south of the island. *Author's Collection.*

Table 9. Titan II Lot N Structural Changes

Change	N-Series Number																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	3A
1. Belly Bands																																		A
2. Beefed Up Waffle & Skins																																		B
3. One Piece Conduit Stage I																																		
4. Built-Up Conduit Stage I																																		
5. Built-Up Cone Fuel Tank Stage I																																		
6. One Piece Cone Fuel Tank Stage I																																		
7. Oxidizer Dome Support Stage I Forward																																		
8. Weld Land Area Increase																																		
9. Interstage Riveting																																		
10. R/V Adapter Martin (Mk-4)																																		
11. R/V Adapter G.E. (Mk-6)																																		
12. Translation Rockets																																		
13. Spectroradiometer																																		
14. Scientific Passenger Pod																																		
15. Malfunction Detection System																																		
16. 40-foot Staging Cable																																		
17. Air Duct Stage I Engine Compartment																																		
18. External Camera Pod																																		
19. Steel Feed Line (Suction)																																		
20. Aluminum Feed Line (Suction)																																		C
21. Beefed Up Transport Section																																		
22. Internal Camera Pod																																		

N-10 was used as a trainer and is now at the Titan Missile Museum
Note A: belly bands Stage I oxidizer tanks only
Note B: Stage I fuel, Stage II fuel and oxidizer tanks
Note C: suction line modified to Gemini Launch Vehicle specifications

Kwajalein Lagoon. Later operational test flights of Minuteman and Titan II did utilize the Kwajalein Lagoon as a target. The Eniwetok Lagoon was a target as well as the Wake Island Splash Net and broad ocean areas near Kwajalein (Figure 28).[73]

Cape Kennedy, Air Force Eastern Test Range

Titan II operations at the ETR utilized much of the infrastructure from the Titan I program. All of the aboveground launch complexes, P-15, P-16, P-19, and P-20 were modified for the storable propellants and aligning the new inertial guidance system.

The east coast of Florida was ideal for tracking-camera locations for covering the early aspects of missile flight from Cape Canaveral. The staging process caused a telemetry blackout near the launch point. Tracking stations at Vero and Melbourne Beach provided excellent optical coverage of the staging process while the tracking station at Grand Bahama Island had a better angle for receiving telemetry during the staging event.

The evaluation of range and payload capability at the ETR was somewhat hampered by the relatively short range to the Ascension Island Splash Net. A key data point for the program was determination of propellant mixture ratios. The short range meant that a significant amount of residual propellant was left at powered flight termination, covering the low propellant sensors. The solution was special trajectory shaping in the later portion of the program to increase propellant usage and powered flight without materially affecting the ballistic portion.

The Caribbean Island chain provided excellent locations for a variety of tracking systems, including Azusa, GE Mod III, and MISTRAM (Missile Trajectory Measurement) systems. The Ascension Island Splash Net hydrophone system was used to determine impact points. Radar tracking with various FPS-16 installations on the island chain provided additional data.

The evaluation of system accuracy involved monitoring engine cut off, reentry vehicle separation, reentry vehicle attitude control, and Stage II translation. The instrumentation required for this included: (1) airborne telemetry of guidance functions, post-cut off velocity, and separation velocity over the missile-frame link, (2) telemetry of post-separation velocity errors over the reentry vehicle link, (3) external tracking data to provide trajectory reconstruction, and (4) accurate impact data.[74]

Many non-weapon system projects were also carried out during the Titan II R&D program at the ETR. One of the primary ancillary investigations was resolution of the POGO Stage I longitudinal oscillation problem. Titan II had been selected as the launch vehicle for the Gemini program. While the POGO effect was a minor obstacle for development of the weapon system, it needed to be resolved in order for the Gemini program to make progress.

There were two particularly dramatic flight tests at the ETR, N-4 and N-20. The first attempted launch of N-4 on June 28, 1962 was aborted when a combustion instability in the Stage I Subassembly 2 thrust chamber caused the thrust chamber to be cut off at the fuel manifold and blown out the flame deflector several hundred feet. The automatic sequencer instrumentation sensed that the Stage I engines had not come to full power and shut down the engines, saving the missile. Combustion instability had been a problem with the Stage II engine but not Stage I. Subsequent investigation found that the most probable explanation was residual alcohol left from cleaning the engine after an acceptance test firing. The "tangential combustion instability" high frequency oscillations had acted as an ultrasonic saw which cut through the thrust chamber wall. The engine was replaced and N-4 was successfully launched on July 25, 1962 (Figures 29, 30).

N-20 was successfully launched on May 29, 1963. Immediately after launch, stress corrosion of the Stage I caused a leak in the thrust chamber fuel valve which ignited and damaged the flight controls. The missile pitched

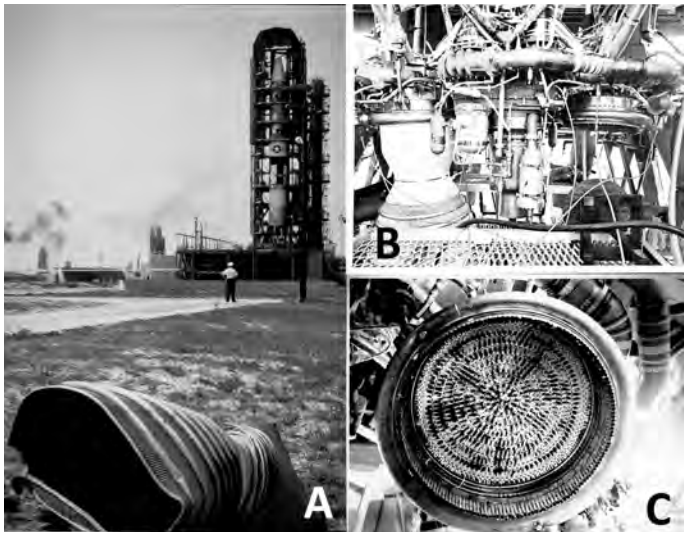

Figure 29: Titan II Ground Abort. (A) Titan II N-4 (60-6811) on Pad 16, 28 June 1962, shortly after the first and only ground abort in the Titan II ICBM research and development program. A combustion instability at the Stage I subassembly 2 injector cut the thrust chamber off. It came to rest several hundred feet from the flame deflector. (B) Stage I engine set on N-4 after the ground abort. The combustion instability worked like an ultrasonic cutoff saw, cleanly cutting off the thrust chamber bell which was expelled from the flame deflector by the exhaust gases. The airframe suffered no damage. (C) The injector face of Stage I engine subassembly 2. The thrust chamber cooling tubes can be seen at the edge of the injector plate, cleanly sheared off by the combustion instability. The engine was replaced and N-4 was successfully launched on 25 July 1962. *Courtesy R. Stahl.*

Figure 30: Belly Bands. Titan II N-2 is ready for launch on March 3, 1962 from Cape Canaveral Launch Complex 16. The arrow indicates one of six "belly band" structural reinforcements. The belly band modification was necessary for Missiles N-1 through N-9 after which it was incorporated into the airframe at the factory. *Author's Collection.*

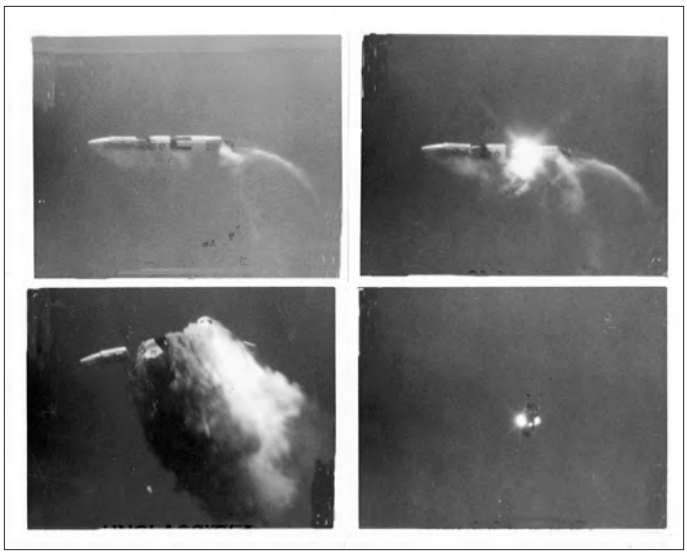

Figure 31: Titan II N-20 In-Flight Failure. N-20 was launched from Cape Canaveral on 29 May 1963. Stress corrosion in the Stage I thrust chamber fuel valve caused an engine compartment fire with resultant loss of engine control. Clockwise from upper left: rapid missile pitch over and interstage collapse prior to breakup; major airframe failure and Stage I premature separation destruct triggered; complete breakup of Stage I and separation of Stage II; command destruct of Stage II. *Courtesy D. Kemper.*

over and broke up 52 seconds into flight. Replacing the 7075T6 aluminum alloy with 7073T6 solved the problem and the modification was installed all the operational missiles and Gemini-Titan launch vehicles (Figure 31).[75]

Twenty-three Titan II Lot N missiles were launched between March 16, 1962 and April 9, 1964. 15 of the flight tests were successful (80 percent of test objectives achieved); six were partially successful (20 to 80 percent of test objectives achieved); and two were failures (less than 20 percent objectives achieved). Twenty-two missiles carried variations of the Mark 6 reentry vehicle. N-11 carried the Mark 4 reentry vehicle in a test to demonstrate the capability and interchangeability between the Mark 4 and the Titan II airframe. Successful RV separation occurred on 20 flights, 14 using the primary release circuitry with reentry vehicle impact in the target area. The remaining six were released using the backup system which allowed reentry data to be collected when full range was not achieved.[76]

Overall objectives of the Titan II R&D test program at ETR were fully achieved. Range capability of the Titan II missile was demonstrated to be in excess of 5,800 nautical miles with a Mark 6 reentry vehicle; a CEP of 0.99 nautical miles was better than the specified CEP requirements and in-flight reliability, as demonstrated by flight tests, exceeded the weapon system design goals (Table 10).[77]

Vandenberg Air Force Base, Air Force Western Test Range

The Titan II launch facilities at VAFB were prototype facilities for the three operational Titan II wings. The three launch facilities that made up Titan II Test Facility (TF-2) were 395B, 395C and 395D. They differed from the opera-

Table 10. Patrick AFB Titan II R&D Flight Record[1]

Flt. #	Date	Airframe #	Launch Site	Description
				Category I
	1962			
1	16 Mar	60-6809	Pad 16	The successful first Titan II launch operation was conducted on 16 March 1962, 28 months after the first storable propellant feasibility studies had begun. N-2 boosted the payload to the full 5,000 nautical mile range and the R/V impacted in the target area. Mark 6 Mod 4
2	7 Jun	60-6808	Pad 15	N-1 partial success, Stage II gas generator restricted, failed to develop full thrust. Mark 6 Mod 4
3	11 Jul	61-2729	Pad 15	N-6, flight test objectives achieved. Mark 6 Mod 2
4	25 Jul	60-6811	Pad 16	N-4, launch attempt #1 (27 Jun) aborted by combustion instability in Stage I engine, launch attempt #2 successful, flight was a partial success, Stage II fuel pump leak. Mark 6 Mod 4
5	12 Sep	60-6812	Pad 15	N-5, first successful launch of a Titan II ICBM with decoys took place at Cape Canaveral. Mark 6 Mod 4
6	12 Oct	61-2732	Pad 16	N-9, flight test objectives achieved. Mark 6 Mod 2
7	26 Oct	61-2735	Pad 15	N-12, flight test objectives achieved. Mark 6 Mod 4
8	6 Dec	61-2734	Pad 16	N-11, failure, Stage II bootstrap line severe vibration, thrust chamber pressure switch shut down. Mark 6 Mod 2A
9	19 Dec	61-2736	Pad 15	N-13, flight test objectives achieved Mark 6 Mod 1.
				Category II
	1963			
10	10 Jan	61-2738	Pad 16	N-15, partial success, Stage II gas generator restriction. Mark 6 Mod 1
11	6 Feb	61-2739	Pad 15	N-16, flight test objectives achieved, first attempted launch of a Titan II by a SAC crew was successful on 6 February 1963 at Cape Canaveral. The missile traveled 5,800 miles and the reentry vehicle impacted in the target area. Mark 6 Mod 1
13	21 Mar	61-2741	Pad 15	N-18, flight test objectives achieved. Mark 6 Mod 1
14	19 Apr	61-2744	Pad 15	N-21, partial success, Stage II bootstrap, premature engine shutdown. Mark 6 Mod 2A
16	9 May	61-2737	Pad 16	N-14, partial success, Stage II oxidizer leak, premature shutdown. Mark 6 Mod 1
18	24 May	61-2740	Pad 15	N-17, successful, flight test objectives achieved. Mark 6 Mod 2A
19	29 May	61-2743	Pad 16	N-20, failure, thrust chamber fuel valve failure, leak and fire in Stage I engine compartment. Mark 6 Mod 2A
21	21 Aug	61-2747	Pad 15	N-24, successful, flight test objectives achieved. Mark 6 Mod 2A
23	1 Nov	61-2748	Pad 15	N-25, successful, flight test objectives achieved. Mark 6 Mod 4A
25	12 Dec	61-2752	Pad 15	N-29, successful, flight test objectives achieved. Mark 6 Mod 2A
				Category III
	1964			
27	15 Jan	61-2754	Pad 15	N-31, successful, flight test objectives achieved. Mark 6 Mod 1
30	26 Feb	62-1867	Pad 15	N-32, successful, flight test objectives achieved. Mark 6 Mod 2C
32	23 Mar	62-1868	Pad 15	N-33, successful, flight test objectives achieved. Mark 6 Mod 4A
33	9 Apr	60-6810	Pad 15	N-3A, successful, flight test objectives achieved, last Titan II ICBM launch from Cape., Mark 6 Mod 2C

1. [illegible]

Table 11. Vandenberg AFB Titan II R&D Flight Record[1]

Flt. #	Date	Airframe #	Launch Site	Description
				Category I
	1963			
12	16 Feb	61-2730	Complex 395-C	N-7, first Titan II silo launch successful. Stage II umbilicals failed to disconnect properly, missile self-destructed at 18,800 feet. Successful in that missile cleared silo intact. Mark 6 Mod 2A
15	27 Apr	61-2731	Complex 395-C	N-8, flight test objectives met. Mark 6 Mod 2A
17	13 May	61-2742	Complex 395-D	N-19, successful, flight test objectives achieved . Mark 6 Mod 2A
20	20 Jun	61-2745	Complex 395-C	N-22, partial success, Stage II gas generator failure. Mark 6 Mod 4B
24	9 Nov	61-2750	Complex 395-C	N-27, successful, flight test objectives achieved. Mark 6 Mod 2B
	1964			
28	23 Jan	61-2749	Complex 395-C	N-26, successful flight test objectives achieved. Mark 6 Mod 2B
31	13 Mar	61-2753	Complex 395-C	N-30, successful, flight test objectives achieved, last flight of N-series missiles from VAFB
				Category II
	1963			
22	23 Sep	61-2746	Complex 395-D	N-23, successful, flight test objectives achieved. Mark 6 Mod 1B
26	16 Dec	61-2751	Complex 395-B	N-28, successful, flight test objectives achieved. Mark 6 Mod 1B
				Category III
	1964			
29	17 Feb	61-2769	Complex 395-B	B-15, successful, flight test objectives achieved, first technical data launch, first launch of operationally configured missile. Mark 6 Mod 3.

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tional bases in lacking the inter-complex radio communication system equipment. Launch facilities 395-C and 395-D also had the extensive range safety and support equipment for the flight testing. Upon completion of the Category I and II flight tests, 395-C and 395-D were refurbished to duplicate the instrumentation system used at 395-B during the Functional Demonstration Launch (Table 11).

Category I testing at TF-2 consisted of four separate groups of test operations: verify conformance of individual subsystems with basic design specifications; demonstrate performance of specified functions under normal operating conditions. Principal subsystems development testing involved the propellant transfer system; silo closure door; missile thrust mount shock isolation and the CMG-4 simulation control chassis.

Category II included testing and evaluation of integrated subsystems through the mating process that evolved into a complete system. The program was accomplished in a realistic operational environment beginning with missile receipt and continuing to preparation, inspection and maintenance for several days before launch. The Category II series included an exercise designated as Functional Demonstration Launch.

The Category I and II test objectives at VAFB were designed to complete developmental testing of the Titan II Weapon System in an operational environment. In addition to verify demonstrate the capability of the Titan II weapon system to meet established operational requirements. One LG-25C (operational series) and the nine Lot-N missiles were allocated to the VAFB flight test series. Seven Category I and three Category II flight tests were programmed for TF-2.

Category I Flight Tests

The first launch of a Titan II ICBM from a silo environment was scheduled to take place on 15 February 1963. About midnight, two days before the launch, Don Kundich, a Martin Marietta Company engineer who was the "missile mother," the engineer responsible for expediting and ensuring that all changes to the missile were completed, George Teft, Martin Marietta Company engineer and John Adamoli, the Martin Marietta Company Flight Test Conductor, along with several other engineers, were finishing the preflight inspection of N-7 (61-2730). The group walked around the missile at all six levels where there were work platforms. This inspection was the last chance to look for the unusual connection or situation that might have passed the earlier walk-throughs.

The group looked at the way the umbilical lanyards were attached to the launch duct wall. These umbilicals were "flyaway" in that they were pulled free of the missile as it rose off the thrust mount, rather than being mechanically ejected. The umbilical lanyards were stainless steel cables attached to the wall at one end and to the umbilical connector at the other. When the missile lifted off the thrust mount, the lanyards were pulled taut, activating the connector release and then pulling the connector and cable free of the missile. The lanyard attachment points on the launch duct wall were just D-rings of metal on galvanized pipe, mounted directly on the wall. Kundich and Adamoli recall that the entire group commented that they just did not look strong enough. The only other silo launch, that of Titan I VS-1, May 3, 1961, had a completely different umbilical release mechanism. The Titan II launches at Cape Canaveral used booms to support the umbilicals and were not a valid comparison. They decided to re-analyze the rise rates of the vehicle to see if the lanyard would tighten and snap the D ring. The concern was that the lanyard had to pull tight to activate the plug release mechanism, fingers of metal that pulled up and allowed the connector to be

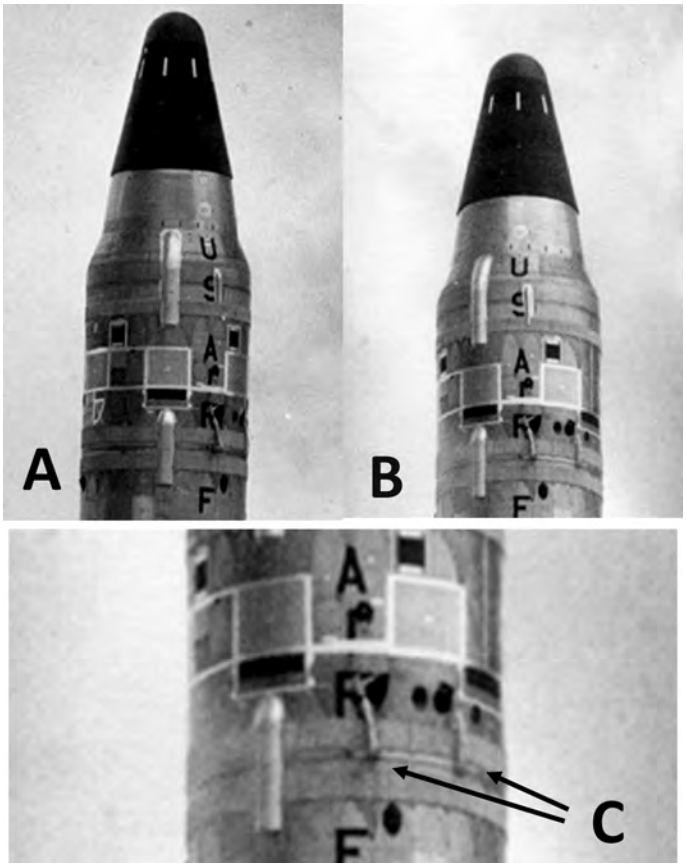

Figure 33: Detail of N-7 Launch. (A) N-7 has just cleared the launch duct, note the location of the U.S. Air Force lettering. (B) N-7 is now approximately 100 feet above the launch duct, rotating to the left, as can be seen by the shift to the left of the U.S. Air Force lettering. (C) Arrows point to the dangling umbilical connectors. ***Author's Collection.***

pulled free. A phone call to Denver the next day resulted in a recalculation and reassurance that the installation was strong enough.

At 2144 (Z), February 16, 1963, the first in-silo launch took place (Figure 32, on first page). Robert Popp, an engineer at Delco Electronics, the supplier of the inertial guidance system, had driven to the official viewing area to watch this inaugural Titan II launch. He had remained in his car, filming the launch through the long sloping windshield of his Buick. As the missile emerged from the silo, he noticed an unusual spinning motion. As the missile cleared the silo, the programmed roll and pitch maneuver did not take place. Popp panned up until the roof blocked his view. He started to get out of the car with his camera and then thought better of it when he realized a lot of top Air Force brass was nearby and might not like the idea of his amateur cinematography. Nearly simultaneous with this decision on his part was the breakup of N-7 at 18,000 feet. Popp dove back into the car realizing that while he was a good two miles from the launch site, debris was starting to spread from the explosion of Stage I.[78]

Kundich and Adamoli were among the Martin Marietta Company employees watching the launch from the engineering compound. They noticed that the missile was spinning as it left the silo and immediately knew something was very wrong. Both Kundich and Adamoli clearly recalled seeing the Stage II electrical umbilical connectors,

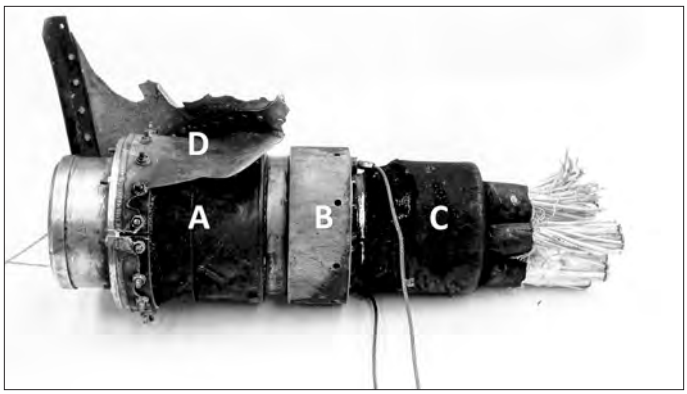

Figure 34: Umbilical 2B1E. The (A) airborne; (B) release mechanism, (C) ground umbilical connectors prior failure analysis. (D) missile skin. ***Courtesy of F.C. Radaz .***

normally flush to the surface of the missile, dangling out at the end of about three feet of wiring (Figure 33).

At 18,000 feet the missile leaned over and the stages separated due to the weight of Stage II. Stage I's inadvertent separation activated the destruct system and destroyed Stage I. The range safety officer had tried to destroy the missile but the system did not work since the missile logic still sensed it was on ground power due to the electrical umbilical connector problem. Stage II fell into the water more or less intact and the expanding cloud of propellant vapor was luckily blown out to sea. The primary objective of the test had been accomplished, that of a Titan II successfully clearing the silo environment intact, but all involved were hardly celebrating.[79]

Later that night, Kundich and Adamoli returned to the silo to find that the Stage I electrical umbilicals had pulled properly but that electrical umbilicals 2B1E, 2B2E and 3B1E of Stage II had not. The airborne half of the connector and a piece of the missile skin was dangling from each umbilical. The missile had been spinning, or more correctly, rolling, because with the umbilicals not physically disconnected, the logic circuitry had sensed that the missile had not lifted off, returned the missile to ground power and left the range safety system disarmed. The missile had left the silo without any airborne electrical power or guidance. The force of the umbilicals not releasing properly had started the spinning motion and without electrical power to the missile components, the guidance system could not stop the spin. This spin was fortunate, in a sense, because it imparted some stability to the missile and might have helped it clear the silo intact (Figure 34).

Further investigation showed that the lanyards became taut too quickly and snapped before they could activate the release mechanism in the umbilical connectors. The interim fix was a spring mechanism that cushioned the shock of the umbilical becoming taut. The final fix was to make the D-ring fixture into a J-bar shape that gave enough by bending to absorb the shock and permit the lanyard to pull tight and release the umbilical properly (Figure 35).[80]

Damage to the launch duct equipment and components was extensive, including: air conditioning; communication and camera cables; propellant transfer fill and

Figure 35: New Umbilical Release System. The solution to the lanyard failure was to replace the rigid D-ring attachment point on the launch dock wall with a flexible, J-shaped bar. The J-shape allowed it to flex slightly when the release lanyard pulled taut, permitting the mechanism to release. The umbilical pull problem did not reoccur. ***Courtesy of F.C. Radaz.***

drain lines and valves; vapor detection system components; and umbilicals. While the thrust mount received only superficial damage, the flame deflector was damaged, and 55 acoustic modules in the launch duct and a further 209 in the exhaust ducts needed replacement or repair.[81]

On March 31, 1963, the first Titan II ICBM was placed on alert that Launch Complex 570-2, 570th Strategic Missile Squadron, 390th Strategic Missile Wing, Davis-Monthan AFB, Arizona. After 24 years, one month and 6 days of strategic alert, on May 6, 1987, the last Titan II ICBM was taken off alert at Launch Complex 373-8, 373rd Strategic Missile Squadron, 308th Strategic Missile Wing SMW, Little Rock Air Force Base, Arkansas.[82]

Operational test and evaluation launches took place from 1964 to 1976 with 51 launch attempts, 48 launched with 40 successful flights for a launch reliability of 94 percent and 83 percent successful flights. While the accuracy of the Titan II Mark 6 has not been officially released, calculation of available test data gives a circular error probable of 0.78 nautical miles (Figure 36) .[83]

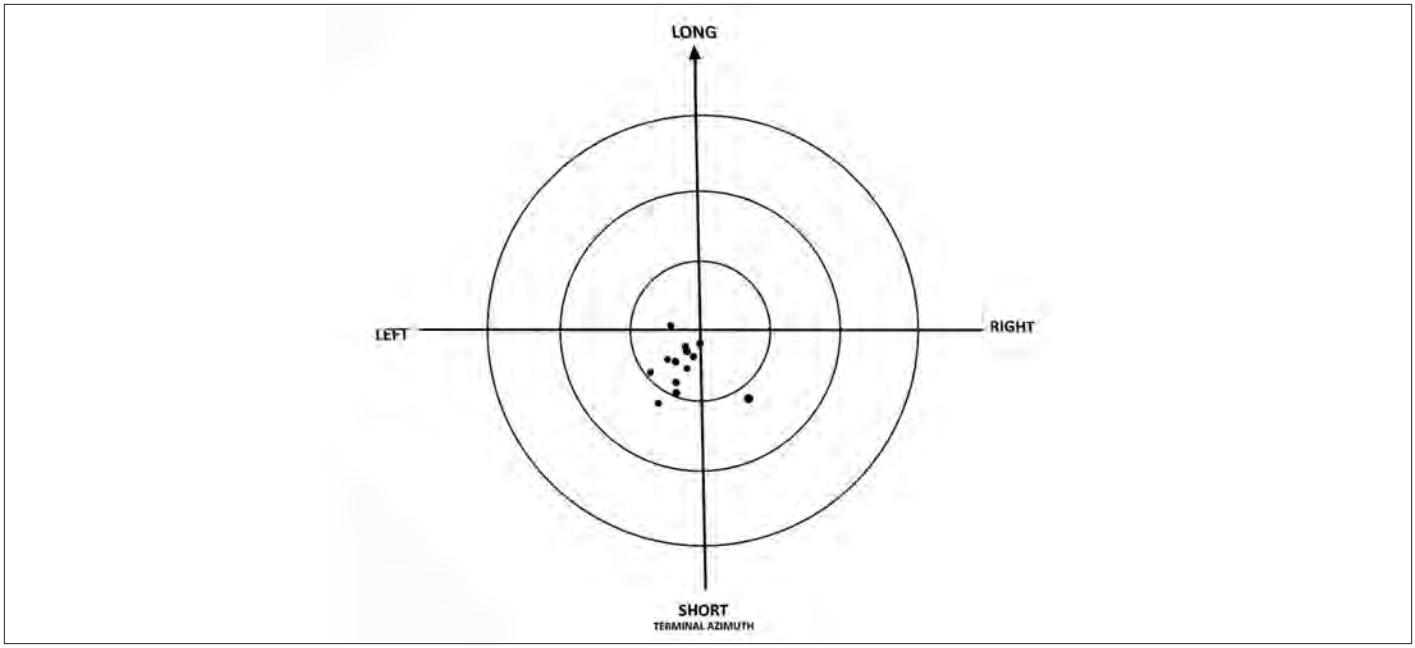

Figure 36: Titan II Operational Test Impact Points. The Titan II Operational Test Program was successfully completed on 20 April 1966. Nineteen missiles were launched, of these, 14 successfully impacted in the designated target area and five experienced in-flight failures. The result in-flight success ratio was 74 percent. Four of the missions were airburst missions ranging in altitude between 13,000 and 14,000 feet. ***Courtesy of Titan Missile Museum Archive.***

Summary

The short operational life of the Titan I ICBM program has tended to obscure the relationship between the Titan I and Titan II programs. This brief comparison of aspects of the two programs reveals that the lessons learned with Titan I, both in the missile itself and the deployment mode, led to the highly successful Titan II ICBM program. The Titan II design became the basis for the equally successful Titan family of space launch vehicles, Titan IIIA-E, Titan IIIM, Titan 34D and Titan IV. All because of the decision to provide a backup for Atlas! ■

NOTES

1. B.W. Augenstein, A Revised Development Program for Ballistic Missiles of Intercontinental Range, 8 February 1954, Special Memorandum Number 21, U.S. Air Force Project RAND; C. Walker and J. Powell, *Atlas: The Ultimate Weapon by Those Who Built It,* (Apogee Books Publication, 1971), pages 24-25.
2.. Warren Greene, *The Development of SM 68 Titan*, AFSC Historical Publication Series 62-23-1, 1962, page 11. The Western Development Division (WDD) was headquartered in Inglewood, California. WDD was a development management group whose sole responsibility was to oversee the research and development, testing, and production leading to creation of a successful ICBM. This document is available from the Homeland Security Digital Library, https://www.hsdl.org/.
3.. Technically, the Titan I designation was not used until the programs were separated. The term Titan I is used for consistency's sake.
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5. J. L. Chapman, *Atlas: The Story of the Missile*, (Harper and Brothers, New York, 1960), page 61; I. Pike, "Atlas: Pioneer ICBM and Space-Age Workhorse," *Flight International,* Volume 81, January 1962, pages 89-96.
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8. V. Selby, personal interview and correspondence, June, 1996.
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23. Greene, pages 114.
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35. R. Jones, personal interview, August, 1996.
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37. *On the Shoulders of Titans: A History of Project Gemini,* B.C. Hacker and J.M. Grimwood, 1977, (Scientific and Technical Information Office, National Aeronautics and Space Administration), page 140. Hereafter referred to as OTSOT.
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42. N. Nieberlein, "Titan II Operation Wrap-Up and Its Effect upon the Gemini Launch Vehicle," October 1963, LV-301, page 3-6. Titan Missile Museum Archive.
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44. *Titan II Propulsion Subsystem, September 1981*, (Aerojet Liquid Rocket Company, September 1981), Section 6, 24. See Figure 13. (a) The flow approaches the convergent or inlet section of the venturi shown in Figure 14 at a static pressure given by P1. As the area of flow is reduced, the fluid velocity must increase in order that the flow rate remain constant. This increase in flow velocity results in a decrease in the static pressure of the liquid. At the throat, the narrowest flow area, the static pressure is decreased to P2. Where the area of flow again increases, in the divergent or exit section of the venturi, the flow velocity is reduced, and the static pressure increases to the downstream pressure P3. (b) The cavitating venturi is designed so that throat pressure P2 is equal to the vapor pressure of the liquid. This causes the liquid to boil (cavitate) at the throat. This region of cavitation extends into the outlet section of the venturi to the point where the static pressure of the liquid is again greater than the vapor pressure. The lower P3, the greater the volume of cavitation; and, conversely, the higher P3 the smaller the region of cavitation. As long as any cavitation exists, P2 is constant; and if P1 and the throat area are also constant, the weight flow rate will remain constant. The cavitating venturi, therefore, controls weight flow against any fluctuation in downstream pressure P provided that P3 never gets great enough to prevent cavitation at the throat. It has been found, generally, that the condition of zero cavitation occurs for downstream pressures greater than 85% of the upstream pressure P1.
45. Adams, pages 212-217.
46. Stumpf, *Titan II*, page 37
47. *Final Report,* pages 415-416.
48. "Detailed Design Specifications for Model SM-68B Missile (including addendum for XSM-68B), page A-7.
49. "Detailed Design Specifications," page A-8. The Mark 4 reentry vehicle, including the W-49 warhead, weighed 4,000 pounds.
50. While all of the components were critical, the suggestion of n-butylphosphoric acid by I.J. Grundfest was a particularly key point. Personal interview, William T. Barry, February 1997.
51. Both dimensions are a cross section of the reentry vehicle created by Martin Marietta Company for use as a satellite fairing. Author's Collection.
52. Barry, personal interview, February 1997. This mechanism was developed by Barry in conjunction with the formulation of the Series 100 plastic, U.S. Patent 3,177,175; 1965.
53. C. Radaz, personal communication, November 2023.
54. Operational Test Report, LONG LIGHT, Titan II, LGM-25C, AFSN 62-12298 (B-53), 20 April 1966, page 23. Microfilm NO568, AFHRA, Maxwell AFB, AL.
55. Detailed Design Specifications, , page 16.
56. Models Aided Titan II Silo Shot , *Missiles and Rockets*, June 19, 1961, pages 27-30.
57. Personal communications with Rollo Pickford, May 1998.
58. The scaling factor was 36 for a 1/6th scale model so the Nike-Ajax engines were excellent matches for this program.
59. Models Aided, pages 27-30.
60. Scale-Model Test of Silo-Type Ducted Launcher, Volume V - Scale Tests Simulating Titan II (Phase III), R. Loya, C.W. Heinz, L.P. Rayno and T.R. Mills, May, 1961, Aerojet General Corporation, page 20.
61. A two-inch thick acoustic liner proved as effective as a 6-inch liner used in the earlier work. This meant that a 12-inch thick liner, rather than a 36-inch liner could be used in the full-scale silo.
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63. Models Aided, page 27-30.
64. *Study of Shock Isolation for Hardened Structures, 560-563; Technical Manual, Missile Weapons System Operation, USAF Model LGM-25C, (T.O 21M-LGM25C-1, 18 December 1986)*, pages 1-76. Titan Missile Museum Archive.
65. *Titan II Propulsion Subsystem, September 1981, Aerojet Liquid Rocket Company*, no date, Section 3-17; "Missile Systems Analyst Specialist, Volume 3: Launch Site Operations," 1973, 56. Both documents Titan Missile Museum Archive.
66. Personal interview, Andy Hall, October 1996; Personal correspondence, Elmer Dunn, April 1997.
67. *Design Analysis WS 107 A-2 Titan II Operational Base Facilities, Phase II Construction, Volume II, 5 January 1961*, page 2. Titan Missile Museum Archive.
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73. *Final Report*, 396; D. K. Stumpf, "Did We Hit the Target? A Brief History of Missile Impact Location Systems, 1959-2020, *Air and Space Power History,* Winter 2021, Volume 68, Number 4, 23-38.
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76. *Final Report*, pages 439-451.
77. *Final Report*, page 27.
78. "Special Report N-7 Flight Analysis," March 1963, Martin-Denver, page 2.TMM Archive.
79. "Special Report," pages 3-5.
80. Personal interviews with Don Kundich, October 1996; John Adamoli, June, 1996.
81. "Special Report," pages 6-11.
82. Stumpf, *Titan II,* pages 131 and 141.
83. Stumpf, *Titan II*, page 184.

THE "BLOODY HUNDREDTH" AND "MASTERS OF THE AIR"

Mark Clodfelter

This B–17 suffered massive flak damage during the Schweinfurt-Regensburg Raid in August, 1943.

The 9-episode mini-series"Masters of the Air," appearing on Apple TV+, is a depiction of America's World War II bombing of Germany that is simultaneously riveting, tragic, and terrifying. Based on the 2006 book with the same title by historian Don Miller, the series complements the previous World War II television productions "Band of Brothers" and "The Pacific," and indeed Steven Spielberg and Tom Hanks served as executive producers for all three series. The focus of "Masters of the Air" is the 100th Bomb Group, a part of the Eighth Air Force of the Army Air Forces stationed in England that flew B–17 bombers against Nazi Germany from June 25, 1943 to April 20, 1945. During that span, the group lost 177 bombers—each carrying ten men—and received the moniker, "the Bloody Hundredth."

"Masters of the Air" offers an incredibly realistic representation of what it was like to fly those missions, especially during 1943 when the 100th, like all American bomber crews, flew high-altitude, daylight raids against Germany without fighter escorts because none had the range to accompany the bombers very far beyond the English Channel. The Eighth Air Force's assault on Nazi Germany hearkened to interwar instruction at Air Corps Tactical School at Maxwell Field, Alabama, that had taught 261 of the 320 general officers in the Army Air Forces by the end of World War II. The centerpiece of the School's ideas was the "industrial web theory," which stated that the industrial apparatus essential to a state's war-making capability was also necessary to sustain its populace in normal, day-to-day life. Hence, if that capability could be destroyed, its will to resist would also collapse. Instructors at Maxwell determined that transportation and oil systems were two vital war-making components of German industry that would also wreck civilian infrastructure.

They further deemed that the B–17, a four-engine heavy bomber with the range to carry a significant bomb load against industrial targets and nicknamed "Flying Fortress" because of the 12 .50 caliber machine guns that defended it, could wreck Germany's war-making capability without needing fighter escorts. When paired with the Norden bombsight, remarkably accurate for the time and so "Top Secret" that Americans never shared it with their British allies (the series does a great job of showing how revered the bombsight was, and how it had to be destroyed if a crash became imminent), Maxwell's instructors believed that the bomber force of B–17s and its sister aircraft, the B–24 Liberator, could demolish Germany's ability and desire to wage war without having to engage in costly ground assaults, like World War I's trench warfare.

In fact, the Commanding General of the Army Air Forces, General Henry H. "Hap" Arnold, its Commanding General, and Lieutenant General Ira Eaker, the Commander of Eighth Air Force, thought that massive bombing could wreck Germany's capability and will to fight without an invasion of Europe being necessary. But the bombing force in England was slow to build up—the North African Theater and the Pacific limited the amount of bombers that could launch on a single

raid in 1943 to roughly 300—not enough to cause significant damage—and the conviction that tight formations of "Flying Fortresses" could defend themselves against the Luftwaffe proved fictional.

More than two years in production and relying on the modern, sophisticated filming techniques, "Masters of the Air" cost a whopping $300 million to make. The film crew reconstructed the 100th's airfield at Thorpe Abbots, England, and all actors had to endure a "boot camp" before filming began to assure that they understood how to portray their roles. The series highlights the invaluable contributions of the ground crews who readied the bombers for combat, as well as the mission planners who outlined routes to targets. Yet the focus is on aerial combat and the dangers it posed to crewmen. The production team built two full-scale mock-ups of B–17s, both of which could taxi, as well as a complete B–17 cockpit and replica of the bomber's ball turret. Filming emphasized how the ten men aboard each plane had to work together to survive—and showed that even when they perfectly accomplished their tasks, survival was far from guaranteed.

For the war, Eighth Air Force suffered 26,000 fatalities—more than the entire U.S. Marine Corps lost in the Pacific. Seventy-seven percent of the Americans who flew against Germany before D-Day became casualties.

In Episodes 3 and 5, the mini-series graphically reveals the horrifying nature of those losses, focusing on the "Bloody Hundredth" in its respective missions against Regensburg and Munster. On August 17, 1943, Eighth Air Force launched a double-strike on the Messerschmitt factories at Regensburg and the ball-bearing plants at Schweinfurt, one of the darkest days for the "Bloody Hundredth" and the Army Air Forces in World War II. The raids comprised 361 unescorted B–17s. Sixty of those bombers were shot down; another 87 were written off because they were too damaged to fly.

Obviously, those were not the results envisioned in designing the simultaneous raids. The Fourth Bomb Wing, 139 bombers strong and containing 22 "Bloody Hundredth" B–17s, was to depart for Regensburg 15 minutes before the First Wing followed it to Schweinfurt. The Regensburg mission would initially draw the Germans' attention, and by the time the First Wing's bombers approached Schweinfurt, German fighters would have landed to refuel and rearm, which would allow the Schweinfurt force to proceed to its target unhindered. Meanwhile, after bombing Regensburg, the Fourth Wing would avoid further combat by flying across the Alps and the Mediterranean and landing in North Africa.

For the plan to succeed, it required near-perfect weather, crisp coordination between multiple layers of command, and zero mishaps as two large formations of heavy bombers took shape in the skies over East Anglia. But as "Masters of the Air" reveals, Clausewitzian friction in the form of dense fog shrouded the British bases that morning. The Fourth Wing, led by Brigadier General Curtis LeMay, departed for Regensburg 90 minutes behind the originally scheduled time. The First Wing departed for Schweinfurt five hours later than scheduled. As a result, almost three hundred Luftwaffe fighters were available to attack both formations for the duration of their time over the Reich.

Unlike the dismal weather in Britain, German skies were crystal clear, making them ideal for bombing—and for fighter assaults against the B–17s. As the series shows, the Bloody Hundredth flew as the low and trailing squadrons in the larger formation comprising the Fourth Wing, positions known as "The Coffin Corner" because fighters often attacked those parts of the formation first and then moved against the higher groups.

The portrayal of those assaults in the third episode was mesmerizing. Few Hollywood depictions of war—other than perhaps the opening sequence of "Saving Private Ryan"—have the impact of that episode—and yet the depiction of Regensburg was undoubtedly far, far worse in real life. Given that Steven Spielberg was a key part of the series, the realism probably should not have been surprising.

But it was.

The Bloody Hundredth lost nine of the 22 B–17s that participated in Regensburg raid, 40 percent of its attacking force, and had the highest losses of any bomb group on the mission. LeMay's Fourth Wing lost 24 bombers total. It had to abandon almost 60 of the B–17s that made it to North Africa because of heavy damage; several of those belonged to the 100th Bomb Group.

Three weeks after Regensburg, the 100th attacked the rail yard in Munster, Germany, on 10 October 1943, as de-

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picted in Episode 5. The 100th had flown previous missions on the 8th and 9th, suffering severe losses against Bremen's submarine pens, and could muster only 17 B–17s for the Munster attack. Four of those turned back for mechanical problems, and as soon as the range-restricted escorting fighters returned to base, the Luftwaffe responded. Highly accurate flak claimed several bombers, and then 350 German fighters attacked the formation, which also included bomb groups from the 3rd Air Division.

By the time the 100th reached the target, seven of its B–17s had been shot down, and of the six that dropped their bombs, five fell after Luftwaffe fighters resumed their attacks. Only one B–17 from the 100th, *Royal Flush* piloted by 1Lt Robert "Rosie" Rosenthal on his third mission, survived, and did so because of his adroit airmanship despite losing two engines and the intercom and oxygen system. Rosie (portrayed by actor Nate Mann) would go on to fly two combat tours—an incredible 52 missions—and was shot down twice, evaded capture, and received the Distinguished Service Cross, two Silver Stars, two Distinguished Flying Crosses (plus the British equivalent), and two Purple Hearts. In addition, Rosenthal, a lawyer who enlisted in the Army Air Forces the day after Pearl Harbor, served as part of the Allied prosecutorial team at the Nuremberg Trials.

The episode vividly displays the horror and tragedy of the Munster raid; including that attack, the Eighth Air Force lost 88 bombers and almost 900 men in a three-day span. Four days later, on October 14, the Eighth Air Force again attacked the ball bearing factories at Schweinfurt, losing 60 bombers out of 229 dispatched; five more crash landed in England, and 20 of those that returned to base had to written off because of battle damage. For the week of October 8-14, which soon became dubbed "Black Week," Eighth Air Force lost 148 bombers and 1500 men.

The episode also accents the moral dilemmas that many crewmen had after learning that their target in Munster was in the center of the city's residential section. Returning to the question raised in the previous episode about bombing ethics, it reiterated: What's moral in a war for unconditional surrender against an enemy that's fundamentally evil? For some crewmen, the answer was, "The Germans brought this response on themselves"; others countered that it was "Justified payback for the men that the 100th had lost." Fittingly, the series does not provide a definitive answer to the question, and simply notes that no one in the unit refused to fly the mission that claimed 12 of the 100th's B–17s.

Episodes 6-9 reveal conditions for downed airmen in German Prisoner of War (POW) camps, focusing on Stalag Luft III, the camp in Poland from which a mass escape of British POWs occurred in March 1944 (depicted in the movie, *The Great Escape*), resulting in the Gestapo's execution of 50 of those recaptured. Two of the main characters in the series, Major Gale "Buck" Cleven (portrayed by Austin Butler, the 2023 Best Actor Oscar winner for *Elvis*), shot down on the October 8, 1943 Bremen raid, and Major John "Bucky" Egan (portrayed by Callum Turner), downed on the October 10, 1943 strike on Munster, both original members of the 100th's first 35 crews and veterans of more than 20 missions, defied the Germans by constructing a crude radio that allowed American POWs to hear the BBC. After the execution of the escaped British POWs, they faced the agonizing choice of how far to take their resistance of the Germans, whose camp commander, a Luftwaffe officer, informed them that any further escape attempts would result in a camp controlled by the Gestapo and SS.

Episode 8 highlights another dilemma for the POWs in Stalag Luft III. The Germans began placing downed P–51 Mustang pilots in the camp from Fifteenth Air Force's famous 332nd Fighter Squadron, the African-American Tuskegee Airmen who lost only 27 bombers that they escorted in 179 missions—the lowest downed bomber total by far for the Fifteenth Air Force's four escorting fighter groups. The Army Air Forces, like all American World War II military units, were segregated, and putting Black pilots in a previously all-White prison camp could have disrupted POW harmony. Yet, as the series shows, it did not—the prisoners all united against the Germans, and many White POWs praised the heroism of the African-American pilots in their distinctive red-tailed Mustangs who had protected them against Luftwaffe fighters.

A further quandary appears in Episode 7, after the loss of 15 Bloody Hundredth bombers on March 6, 1944—the Eighth Air Force's first major raid on Berlin—despite having P–51s with new Rolls Royce engines and drop tanks escorting them all the way to the target and back. At the end of 1943, General Carl "Tooey" Spaatz became commander of the newly created U.S. Strategic Air Forces (USSTAF), comprising the Eighth Air Force and the recently founded Fifteenth Air Force, based in Italy. Spaatz and Army Air Forces leaders realized that their bombers were unlikely to end the war by themselves, but they would be vital to obtain the necessary air superiority over the European continent for a successful invasion of France. The desired build-up of B–17s and B–24s in Britain had finally occurred, and Spaatz could now attack Germany with 1000 bombers on a single raid. He decided to wage a brutal campaign of attrition, knowing that he now had the manpower and materiel to overcome the Luftwaffe. The bombers, as the series points out, would serve as "bait" to draw the German fighters in the air, where Spaatz counted on his escorting Mustangs to shoot them down.

As shown in Episode 7, after the 100th flew its third mission against Berlin in three days, the Bomb Group Commander told now-Captain Robert Rosenthal that his B–17s would relentlessly attack the German aircraft industry to lure the Luftwaffe into attacking the bombers. "Rosie" had completed his 25th mission over Germany on March 8, making him and his crew eligible for stateside duty for the remainder of the war. But once Rosenthal learned that Spaatz has raised the mission requirement to 30 to return home—although he would be "grandfathered" and allowed to head to the states immediately—he decided to fly another tour of duty. Rosie believed that taking a stateside assignment would be unfair to other crewmen who now had to fly additional missions—even though he knew the danger of flying missions as bait. Spaatz's logic paralleled that of Ulysses S. Grant in the latter stages of the American Civil

War when Grant knew that he had a decisive advantage in manpower and materiel against the Confederacy. The goal in both cases was to end the war as soon as possible, yet the series rightly begs the question, "Was attrition the proper strategy to achieve that objective?"

Spaatz's approach ultimately achieved the desired results. In "Operation Big Week" in February 1944, the Eighth Air Force pounded the German aircraft industry and compelled it the Luftwaffe to defend it—resulting in its decimation by Mustang and P–47 Thunderbolt escorts that also had drop tanks. The Allies won the air superiority necessary for the invasion, but the cost among bomber crews was enormous—by D-Day, 27 of the Bloody Hundredth's original 35 crews had been killed, wounded, or captured.

Some reviewers of the series have criticized it for lack of character development. Yet that is a major theme of the series—*most of its characters did not survive the 25 or 30 missions necessary to complete a tour of duty.* Gale "Buck" Cleven, John "Bucky" Egan, Robert "Rosie" Rosenthal, and navigator Harry Crosby (portrayed by Anthony Boyle) get the most time on the series because they *did* survive—but only Rosenthal flew the full complement of missions, and he was shot down twice. Cleven and Egan spent the last two years of the war in Stalag Luft III, and then in the desperate march the Germans made from the camp in the snow after Russian ground forces approached it, as depicted in Episode 9. Crosby lived because his navigation skill moved him from bomber crew member to the mission planning staff, limiting the number of missions that he could fly. Additionally, the men appearing in the combat scenes all looked alike, for most of the time they wear oxygen masks, necessary above 10,000 feet, that obscured their facial features.

Today, more than 80 years after the most harrowing missions flown by the Bloody Hundredth, its legacy endures as the 100th Air Refueling Wing based at RAF Mildenhall, England, a short distance from hard-surface runways, control tower, and Quonset huts maintained as a tribute to 100th Bomb Group at Thorpe Abbotts, Norfolk. Colonel Ryan Garlow, the current 100th ARW commander, is the step-grandson of Technical Sergeant James P. Scott, who flew in B–17s from Thorpe Abbotts, and Garlow has worked tirelessly to assure that his unit's ties to the Bloody Hundredth are not forgotten.

On October 10, 2023, the 80th anniversary of the 100th Bomb Group's disastrous raid on Munster, the 100 ARW held a ceremony commemorating "Black Week," when the Eighth Air Force lost 138 bombers, 24 fighters, and more than 1,500 airmen over Germany in a six-day span. The Bloody Hundredth lost 12 B–17s and 121 crew members. Attending the ceremony was retired Major John "Lucky" Luckadoo, thought to be at 101 years old the only surviving 100th pilot from the original cadre of 35 crews.

"We never had time to grieve; you were just here today, gone tomorrow," Lucky, who flew 25 missions at age 22, stated. Between the August 17, 1943 Regensburg mission, and the October 14, 1943 mission to Schweinfurt, most of the original 35 crews were killed, wounded, or captured—109 days after their first mission.

To commemorate that sacrifice, Colonel Garlow had the nose art of the B–17 "Silver Dollar" painted on the nose of a KC–135 Stratotanker stationed at Mildenhall during the 80th anniversary of "Black Week." The original "Silver Dollar" survived 102 missions.

Lucky Luckadoo and the *Silver Dollar* were the exceptions to the rule for the Bloody Hundredth; indeed, they were the exceptions for Eighth Air Force Bomber Command and its sister unit in Italy, the Fifteenth Air Force. During the summer and fall of 1943, the requirement to fly 25 bomber missions before being released for stateside duty was rarely met, as shown in the celebration of the occurrence in Episode 4 of the mini-series. Indeed, 11 missions was the average survival rate, and many crew members were lost before they ever flew double-figure sorties.

For the war, the Army Air Forces in the European and Mediterranean theaters lost almost 36,000 men killed, and Eighth and Fifteenth Air Forces combined lost 8,759 bombers. Along with the tributes to those men at Thorpe Abbotts, the American Air Museum at Duxford, England, containing many World War II aircraft, is a memorial to the 30,000 Americans who perished in the war while flying from Britain. So too is the Cambridge American Cemetery, containing the remains of 3,812 Americans who died in the Combined Bomber Offensive or the Battle of the Atlantic.

The series rightly emphasizes the losses suffered by the "Bloody Hundredth"—and the Eighth Air Force as a whole. It is truly a fitting tribute to those who, Abraham Lincoln said a century before, "gave the last full measure of devotion." Everyone with Air Force ties—Air Force Academy and ROTC cadets, enlisted personnel, officers, civilians, and retirees—should watch it, but, more importantly, *all Americans should view the series*. It graphically depicts the courage that is the cornerstone of the modern U.S. Air Force, as well as the overarching commitment of America's "Greatest Generation" to preserving liberty and defeating tyranny. ■

Cambridge American Cemetery and Memorial in Cambridgeshire, England

Winged Victory: The American Air War Over Europe in World War II by Phillip S. Meilinger

"Airpower in the Second World War created winners and losers; either they had it or they didn't."

— Paul Kennedy (***Engineers of Victory***, 226)

Airmen had dreamed prior to 1939 that the airplane could eliminate the horrors of the World War. No longer would a generation of young men have to impale themselves on barbed wire in Flanders. Airpower would, in a sense, humanize war by making it less likely to occur; but, if war did occur, it would be over quickly. In reality of course, that is not what happened. The hecatomb of World War I was not avoided: the trenches were merely moved to twenty thousand feet.

I will discuss the story of the Army Air Forces (AAF) in the European war thematically, and then note the best accounts that describe those events. Overall, the starting point is the monumental official history published following the war. The AAF hired two highly respected academics, Wesley F. Craven and James L. Cate, to edit the outstanding seven volume, ***The Army Air Forces in World War II*** (Chicago, 1948-58). These cover all aspects of the air war. In addition, Henry H. "Hap" Arnold, the AAF's commanding general during the war and the only airman to ever wear five stars, wrote a valuable memoir that covers this entire period, ***Global Mission*** (Harper, 1949). For bios of Arnold, see Thomas M. Coffey, ***Hap: General Henry H. "Hap" Arnold*** (Viking, 1982) and Dik A. Daso, ***Hap Arnold and the Evolution of American Airpower*** (Smithsonian, 2000).

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Following the World War, the U.S. retreated into an isolationist shell: America wanted a return to normalcy, and that meant hard times for the armed forces—even before the Great Depression hit. The Army was hurt badly by the budget cuts of the 1920s and 30s, but its nascent Air Service (Air Corps after 1926) suffered worse. Between the wars the air branch received, on average, less than 12 percent of the Army's straitened budget, and as late as 1939 there was not a single airman who had reached general officer rank on the permanent list. It was these perceived slights that so infuriated Col Billy Mitchell, leading to outspoken condemnations of his superiors—which in turn led to his court-martial. During these years the air arm was also severely deficient in combat aircraft, especially bombers. When war broke out in Europe in September 1939, the Air Corps possessed less than thirty B–17s. Mobilization then occurred on a grand scale, but although 21,000 aircraft were purchased over the next two years, only 373 of these, 1.8 percent, were heavy bombers. Small wonder the AAF entered the war with insufficient combat resources and personnel. For the interwar years, see Maurer Maurer, ***Aviation in the U.S. Army, 1919-1939*** (Office of Air Force History, 1987), and DeWitt S. Copp, ***A Few Great Captains*** (Doubleday, 1980). For procurement details see I.B. Holley, ***Buying Aircraft: Materiel Procurement for the Army Air Forces*** (GPO, 1964), and Jeffrey S. Underwood, ***The Wings of Democracy: The Influence of Air Power on the Roosevelt Administration, 1933-1941*** (Texas A&M, 1991).

One of Billy Mitchell's attempts to redress deficiencies in the air arm was to found a branch school, like the Infantry or Cavalry School, to educate airmen on their profession. This would become the Air Corps Tactical School (ACTS) located at Maxwell Field, Alabama.

Just about anyone who would be anyone in the air arm during World War II had attended ACTS earlier in their careers—many had taught there, including Hoyt Vandenberg, George Kenney, "Santy" Fairchild, Pat Partridge, Larry Kuter (all later four stars), and several other future general officers. These men, lieutenants and captains when teaching, had imbibed the heady ideas of their intellectual mentor, Billy Mitchell. They devised a theory of precision strategic bombing of an enemy's industrial homeland to defeat it from within—to destroy its vital centers—rather than fight the old-fashioned way with bloody land battles that consumed a country's youth by the millions. Aircraft could fly over these deadlocked armies and achieve decisive results at the outset of war.

This was a faith-based theory. Air Corps doctrine relied on speculation, not experience, and war would show that it was badly flawed. The best description of what went on at Maxwell is Stephen L. McFarland, ***America's Pursuit of Precision Bombing, 1910-1945*** (Smithsonian, 1995). For the memoirs of a founding father of strategic bombing doctrine see Maj Gen Haywood S. Hansell, Jr., ***The Air Plan that Defeated Hitler*** (Higgins-McArthur, 1972). Phil Haun (ed.) ***Lectures of the Air Corps Tactical School and American Strategic Bombing in World War II*** (Kentucky, 2019) is also useful.

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Before the war, U.S. political and military leaders had met with their British counterparts and agreed that if war came against Germany and Japan the wisest course would be a "Europe First" strategy. Germany was the most powerful and dangerous foe, so she must be the focus of Allied efforts. The "Day of Infamy"—the attack on Pearl Harbor—threw that decision into question: Americans wanted revenge. As a result, the U.S. hiked up its pants and de-

cided it would *simultaneously* fight Germany and Japan.

In the European theater, this meant an invasion of Axis-held North Africa in November 1942. Airpower would be crucial to any such amphibious landing, but there were precious few airplanes and crews to spare. As a result, the 8AF, which was then building in England to bomb targets in Germany, was denuded of assets to supply the new 12AF that would support Operation TORCH. The code name for the 12th, appropriately and cynically, was "Junior." The 8th, then under the command of Maj Gen Ira Eaker, protested this diversion of his resources, but was overruled.

TORCH was a success, and American airpower worked closely with the Royal Air Force (RAF) to win air superiority over the battlefield. Not surprisingly, prewar tactical air doctrine proved deficient, and combat operations forged a new understanding between air and ground officers that led to success.

Once North Africa was secure, the Allies moved across the Mediterranean to attack Sicily, preparatory to an invasion of Italy proper. This was a contentious decision. Italy was seen by some as a minor theater—the real enemy was Germany, and she was most easily confronted in France. The Soviets insisted that the U.S. and Britain open this "Second Front" and were irritated at what it considered their foot-dragging. Fortunately, cooler heads prevailed: it would do the Soviets no good for the Allies to land in France, only to be pushed back into the sea. We were not yet ready for a French invasion.

Italy was also chosen because it was believed she was so weak that a determined shove would knock her out of the war. That in fact happened: after the bombing of Rome's rail yards in July 1943, Mussolini was overthrown, and the new government made peace overtures. Unfortunately, Germany got wind of this and quickly flooded troops into Italy and took over its erstwhile ally. It would prove difficult to root her out. In the southern part of the peninsula, airfields were built and a new air force, the 15th, was stood up to fly ground support and bomb Germany. For the story, see Robert S. Ehlers, Jr., ***The Mediterranean Air War: Airpower and Allied Victory in World War II*** (Kansas, 2015), DeWitt S. Copp, ***Forged in Fire*** (Doubleday, 1982), and Christopher M. Rein, ***The North African Campaign: U.S. Army Air Forces from El Alamein to Salerno*** (Kansas, 2012).

The Mediterranean Theater was famous for another aviation reason. Blacks had always served honorably in the U.S. military, but were segregated into all-black units led by white officers. In the Air Corps there were no black pilots because it was thought they were incapable of handling combat aircraft. Social and military pressures forced a change. In July 1941 a flying school was set up at Tuskegee, Alabama, to train a group of black pilots. The "Tuskegee Airmen" went to war as fighter pilots, the 332nd Fighter Group, and were commanded by Lt Col Benjamin Davis, Jr.—a black West Point graduate. The 332nd, widely known by its red-tails, amassed an excellent combat record, in no small part paving the way for integration of the armed forces following the war. For their story, see J. Todd Moye, ***Freedom Flyers: The Tuskegee Airmen of World War II*** (Oxford, 2015). For the memoirs of the unit's commander, the Air Force's first black general officer, read the moving ***Benjamin Davis, American*** (Smithsonian, 1990).

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Nothing like the mighty armadas of a thousand heavy bombers and a like number of fighter escorts, and their thousands of piston engines drumming in a mighty roar, had ever been seen or heard before on earth—and never would again.

The heavy bombers of the 8AF based in England were mostly B–17s. In addition, the 8th contained fighter planes whose mission was to escort the bombers to their targets and back, but they were unavailable for deep penetration strikes until early 1944. As a result, the bombers had to go it alone much of the time, trusting to large formations of hundreds of bombers—each aircraft armed with ten machine guns to defend itself against enemy fighters. This was not good enough. Yet, fighters were only part of the problem. Antiaircraft artillery, referred to as "flak," was the bombers' most dangerous threat. Studies showed that over 70 percent of bomber crew casualties were caused by flak. The crews knew this, and held a special hatred and fear of the enemy cannons not only because of their deadliness, but because so little could be done to defend against them. The bombers' guns could respond to enemy fighters; there was no such antidote for flak. For this story, see Edward B. Westermann, ***Flak: German Anti-Aircraft Defenses, 1914-1945*** (Kansas, 2001).

The perils faced by the bomber forces were great. Indeed, more men died in the 8AF alone than in the entire U.S. Marine Corps during the war, worldwide. To give these men some hope for survival, air leaders devised a rotational plan that allowed crewmembers to return to the U.S. after completing twenty-five combat missions. This was not an easy accomplishment. A 1944 study tracked 2,051 crewmembers spread over four bomb groups—only 26.8 percent completed their twenty-five missions. Indeed, when mission loss rates hit 5 percent, aircrews were quick to figure the odds: how could a man survive twenty-five sorties when losses averaged 5 percent on each one? In truth, the awful missions, such as those to Schweinfurt-Regensburg in August 1943 and to Schweinfurt again in October, each lost sixty bombers—over six hundred men. This was a loss rate of 20 percent of the bombers sent on each strike. At such horrendous rates the entire force would be gone in a mere half-dozen missions.

How did young men cope with such dismal prospects? A unique aspect of air warfare is that combat is episodic—crews were exposed to enemy fire for perhaps three or four hours; upon return to England, they would attempt to recover their mental and physical strength for the next ordeal. The interval between combat missions was usually

two to three days, but during periods of extended bad weather (as during winter), the down time could stretch to a week or more. The crews would then find comfort in sleep, drinking in the ubiquitous English pubs, and trips to London. It is an open question whether the crews based in England benefitted or suffered from such a unique situation.

The B–17s and B–24s each contained ten crewmembers: four officers who were the pilot (and aircraft commander regardless of rank), copilot, navigator and bombardier—and six enlisted men: the engineer, radio operator, two waist gunners, the ball turret gunner and the tail gunner. Neither bomber was pressurized, and the waist ports were uncovered. At altitude, temperatures could easily reach 40° below zero, so hypothermia (particularly for the waist gunners) and hypoxia caused by a faulty or battle-damaged oxygen system, were ever-present dangers. Crewmembers received rudimentary first-aid training, and this often was essential. Wounded men were hastily bandaged and given a morphine shot to hold them until landing back in England. There are numerous books on the bombing campaign over Europe, but the best available on the 8AF is Donald L. Miller, ***Masters of the Air*** (Simon & Schuster, 2006). See also Alan J. Levine, ***The Strategic Bombing of Germany, 1940-1945*** (Praeger, 1992). The American efforts in daylight are often discussed along with the bombing campaign carried out at night by the RAF's Bomber Command. For the best summary of this Combined Bomber Offensive see the short but insightful, Noble Frankland, ***The Bombing Offensive Against Germany: Outlines and Perspectives*** (Faber & Faber, 1965). For an extended view see, Robin Neillands, ***The Bomber War: The Allied Air Offensive Against Nazi Germany*** (Overlook, 2001). Also review the memoirs and biographies of key participants: Richard G. Davis, ***Carl A. Spaatz and the Air War in Europe*** (Smithsonian, 1992); James Parton, ***"Air Force Spoken Here": General Ira Eaker and the Command of the Air*** (Adler & Adler, 1986); Gen Jimmy Doolittle with Carroll V. Glines, ***I Could Never Be So Lucky Again*** (Bantam, 1991), and Dik A. Daso, ***Doolittle: Aerospace Visionary*** (Brassey, 2003); Gen Curtis E. LeMay with MacKinlay Kantor, ***Mission With LeMay*** (Doubleday, 1965), and Thomas M. Coffey, ***Iron Eagle: The Turbulent Life of General Curtis LeMay*** (Crown, 1986),

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Fighter pilots always get the glamor, a fact established in the Great War and solidified in the Second. Aces—those with five aerial victories—became public heroes—in all countries. In Britain they were known as "The Few," and in Germany they received special decorations, the highest being the Knight's Cross with oak leaves, swords and diamonds. American aces were no less heralded. Although the top two U.S. aces flew in the Pacific, the European Theater had its share of legends: "Gabby" Gabreski, Robert Johnson, George Preddy, "Hub" Zemke and Don Gentile among others.

Most of these men achieved their victories when flying escort for the bombers. Early in the war the U.S. fighters, notably the P–47 Thunderbolt (termed the "Jug" due to its chubby shape) and the P–38 Lightning, had not the range to accompany the bombers all the way to targets deep in Germany. The reasons for this deficiency were both technical and doctrinal.

Airplane designers reasoned that for a fighter to make the 1,000-mile roundtrip to central Germany it would need a great deal of fuel. That would make the aircraft quite large and thus probably require two engines to maintain a good speed. Such a large and ungainly aircraft would more resemble the bombers it was escorting than the enemy fighters it would encounter, so these escorts would be easy pickings for the fast and nimble Messerschmitts and Focke-Wulfs that guarded the air approaches to the *Reich*.

But there was also a doctrinal reason for the failure to develop a long-range escort. Fighter pilots considered aggressiveness as their greatest asset in battle. Protecting bombers implied a passive, defensive mission that would rob them of the initiative. Fighter instructors at ACTS, notably Claire Chennault and Hoyt Vandenberg, rejected the notion of escort. That was a mistake.

The horrendous losses suffered by the bombers over Germany in late 1943 demanded creative solutions. Technically, the answer proved surprisingly simple—the drop tank. Fighter planes were fitted with cheaply made fuel tanks carried under their wings. As the planes took off, climbed to altitude and headed for the enemy coast, they sucked the fuel from these makeshift tanks. When empty, they were simply jettisoned—the planes still held a full complement of internal fuel. The results were stunning: without tanks the P–47 could fly out 230 miles; with tanks it had a radius of 475 miles. With the P–51 the advance was even more impressive: 475 versus 850 miles. By the end of the war the Mustangs could fly all the way to Vienna—farther than the B–17s!

Overcoming the doctrinal hurdle proved similarly easy. When Maj Gen Jimmy Doolittle took over the 8AF in early 1944 he noticed a sign at fighter headquarters that read: "Your duty is to protect the bombers." He ordered the sign replaced by one that read: "The first duty of Eighth Air Force fighters is to destroy German fighters." This seemingly simplistic semantic change was of great significance. The fighter pilots' new mission was to aggressively seek out and destroy the enemy air force wherever and whenever they found it. If they did so, the bombers *would* be protected. This was what the fighter jocks had been waiting for!

The results were dramatic. During February 1944, a period of good weather resulted in six days of bombing missions deep into Germany. The *Luftwaffe* rose up to challenge the bomber armadas, but instead met the Jugs and Mustangs. By the end of "Big Week," the back of the *Luft-*

waffe was irreparably broken. On D-Day, the Germans had barely 300 aircraft serviceable in the west; the Allies had nearly 7,000—the *Luftwaffe* was outnumbered 20 to 1. The Allies flew 12,000 sorties that day; Germany flew less than 100. That is air supremacy.

It must also be noted that many fighters seldom flew escort. Indeed, the 9AF—which was larger than the entire *Luftwaffe*—had as its primary mission the support of the 12th Army Group. The Lightnings, Jugs and Mustangs of the 9th (and also the 12AF) strafed or dropped bombs on enemy columns, depots, bridges, airfields, and vehicles throughout northwest Europe. Ground attack was extremely dangerous. One P–47 pilot noted that in his squadron the attrition rate was 400 percent during the last year of the war. Even the great aces Gabreski and Zemke were shot down and captured when they dared to swing low on strafing attacks against enemy airfields. The best books about tactical air are Richard P. Hallion, ***Strike from the Sky: The History of Battlefield Air Attack, 1911-1945*** (Smithsonian, 1989), and Robert V. Brulle, ***Angels Zero: P–47 Close Air Support in Europe*** (Smithsonian, 2000). For the air-to-air fight, see Stephen L. McFarland and Wesley P. Newton, ***To Command the Sky: The Battle for Air Superiority Over Germany, 1942-1944*** (Smithsonian, 1991). For bios of important tactical airmen, see Phillip S. Meilinger, ***Hoyt S. Vandenberg*** (Indiana, 1988) and Thomas A. Hughes, ***Over Lord: General Pete Quesada and the Triumph of Tactical Air Power in World War II*** (Free Press, 1995).

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Approximately 33,000 American airmen were captured by Germany and Italy during the war, and these prisoners of war (POWs) were sent to camps called *stalag lufts*. The most famous of these, *Stalag Luft III*, held over 10,000 Allied air officers.

The rights of POWs had been specified in the Geneva Conventions of 1929. Prisoners had a right to send and receive mail and parcels, and to be fed, clothed, housed and given proper medical care. It was prohibited to withhold food as punishment. The POW camps themselves were to be sited near "healthy areas" and not near military targets—to lessen the chances of fratricide when those military targets were attacked. The camps should have fresh water, sanitation facilities, heat, and room for exercise/recreation. POWs were to have freedom of religion. Enlisted prisoners could be made to perform physical labor; officers could not.

Those were the rules. For the most part, the Germans tried to honor them, especially in the case of Allied airmen. The *stalag lufts* were run by the *Luftwaffe*, and its officers were less rigid than were their ground counterparts. Indeed, after the war the "alumni" of *Stalag Luft III* would invite their former camp guards to their annual reunions. This perceived leniency would eventually pose problems.

In March 1944 a group of eighty men escaped from *Stalag Luft III*. This, the "Great Escape" of legend, was not successful. Three of the men made it to Britain, but the rest were captured, and of these, fifty prisoners were summarily executed by the *Gestapo*. This cold-blooded murder was the worst such atrocity of the war for Allied airmen in Europe. In addition, the commandant of *Stalag Luft III*, a decent and professional airman, was then court-martialed and his place taken by someone far stricter. Aircrews were warned that the German populace considered them "terror flyers" and they might murder anyone caught parachuting from their planes or evading through the countryside. This in fact happened on dozens of occasions. As a result, there were few escape attempts after the summer of 1944. In addition, in December 1944, the Germans separated out those POWs who were Jewish. Although some camps resisted this illegal segregation, around 350 POWs were nonetheless rounded up and sent to a concentration camp in Berga.

The life of the POWs was one of endless boredom and hunger. Worse, because most of the camps, including the four *stalag lufts*, were sited in eastern Germany, the prisoners were herded west as the Soviet armies began closing on those areas in early 1945. These forced marches often occurred in snowstorms and suB–zero temperatures. The inmates of *Stalag Luft IV* were especially cursed, and on their trek of six hundred-miles, hundreds died. For POW life in the camps, see Arthur A. Durand, ***Stalag Luft III: The Secret Story*** (Simon & Schuster, 1989), and for personal accounts, see Lt Gen Albert P. Clark, ***33 Months as a POW in Stalag Luft III*** (Fulcrum 2004), and Kenneth W. Simmons, ***Kriegie*** (Lucknow, 2016). ("Kriegie" was the term given to a German-held POW.)

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A subject often overlooked is the importance of intelligence and its related art, analysis. This neglect is due largely to the newness of the field—although intelligence on an enemy had been necessary for millennia, air warfare required new thinking. Because strategic bombing was a form of economic warfare, it was necessary for air planners to understand how an economy functioned, and, more importantly, to determine how to break it. This was new territory. Land and sea forces did not need to know where an enemy's key factories were located, or the intricacy of its transportation systems or raw material networks, simply because they could not *do* anything with such information: their focus was on the armies and navies to their front. Air warfare required new types of information. Bombers could hit just about anything, but they should not or could not hit everything. Targeting was the key.

Air commanders began by asking basic questions regarding tactics, procedures, and cause and effect. How did you, for example, disrupt a rail system, or what size bombs would best disable a factory? What was the ideal bomber formation to maximize accuracy while minimizing risk? To address these types of questions a discipline was founded

called Operations Research (OR), the use of scientific and mathematical methods to study military operations and make them more efficient and effective. OR became a crucial tool for air commanders.

In September 1942, Maj Gen Eaker at 8AF set up an OR section for studying bombing accuracy and loss rates. At the same time, Gen Arnold established the Committee of Operations Analysts in Washington composed of mathematicians, engineers and lawyers. Their first task was to determine bombing accuracy and suggest ways to improve it. Data showed that the better the weather, the better the accuracy: electronic bombing aids were therefore essential because of the chronically poor weather over Germany. Nonetheless, bombing through weather never equaled visual bombing in accuracy, regardless of the electronic aids employed. By October 1944, 41.5 percent of 8AF bombs were falling within one thousand feet of the aim point when bombing visually. Using only radio or radar aids, accuracy plummeted to 5 percent falling within one thousand feet.

In one study, post-strike photographs revealed that bombing accuracy was enhanced if an entire group dropped when its leader did, rather than if each bombardier chose his own drop point. Another problem involved the relative danger of enemy interceptors versus flak. The worst situation existed for stragglers: when a bomber fell out of formation, it was quickly pounced on by fighters. The bombers usually fell out of formation, however, because their engines had been hit by flak. The solution: put armor around the engines to limit such damage, which would then reduce stragglers.

Such technical problems had not been ignored before the war. A review of the ACTS curriculum reveals the concern over issues of accuracy and bomb types. Unfortunately, very little practical work was done, and this led to assertions later proven absurd, as one Bombardment text stating that 100 lb. demolition bombs were "particularly efficacious against the average factory or warehouse." Such small bombs proved useless in combat.

It was because of muddled thinking before the war that OR was so essential during it. Gens Carl Spaatz and Eaker recognized this and gave the scientists their full support. They also faced a more difficult problem. Doctrine *assumed* that bombing enemy industry would have decisive results. OR provided guidance on how best to destroy specific parts of that infrastructure. The broader question remained: what effect did destroying an oil refinery or rail yard have on the enemy's ability to fight? Because you know *how* to destroy a factory does not necessarily mean you *should* destroy it. OR told air commanders how to hit the target right; they now needed to know how to hit the right target. For the OR story, see Charles W. McArthur, ***Operations Analysis in the U.S. Army Eighth Air Force in World War II*** (American Mathematical Society, 1990).

Targeting was crucial, but the doctrine the AAF took into World War II offered little more than a laundry list of broad categories: rail lines, bridges, tunnels, marshalling yards, power plants, oil refineries and "other similar objectives." Such bromides were insufficient. Air planners therefore contacted businessmen, engineers and bankers for information regarding factories in Europe that American banks had financed or that American construction companies had built. In other cases, experts instructed planners on how U.S. systems and networks operated, assuming those in Germany would be similar. There was a danger here: besides mirror-imaging, the types of intelligence available and examined will shape one's view on how a system operates. If planners had copious information on the German ball bearing industry, for example, then they might place too much emphasis on its role in the war economy, while at the same time overlooking other target systems. Yet, it was a beginning.

The role of intelligence was crucial in all of this, specifically, the high-grade ciphers used by the Germans. The British had broken the Enigma codes early in the war and established a center at Bletchley Park near London to decode and analyze this Ultra intelligence. When the U.S. joined up they shared this source. Ultra proved invaluable to the air war, and for insights into its use by the AAF, see Diane T. Putney, ***ULTRA and the Army Air Forces in World War II*** (Office of Air Force History, 1987), and John F. Kreis, ed., ***Piercing the Fog: Intelligence and Army Air Forces Operations in World War II*** (Air Force History and Museums Program, 1996). For the history of Ultra Intelligence in general, see Ralph Bennett, ***Ultra in the West: The Normandy Campaign, 1944-45*** (Charles Scribner, 1980), Ronald Lewin, ***Ultra Goes to War*** (McGraw-Hill, 1978), and Stephen Budiansky, ***Battle of Wits: The Complete Story of Codebreaking in World War II*** (Free Press, 2000).

Organizations established to study vulnerabilities within the German economy and advise air leaders did not always agree. One variance concerned the importance of oil. Germany had limited oil resources—only 7 percent of peacetime needs were met by domestic sources. She therefore had to get it either through conquest, alliance, or devise a substitute. In 1940, Germany allied with Rumania, which then provided 60 percent of the needed crude. In addition, German scientists produced oil from coal in an expensive process called Bergius hydrogenation. Some air planners therefore saw Germany as oil vulnerable. Intelligence intercepts noted a trend in the spring of 1944—the increasing concern of German leaders regarding attacks on oil. Flying training and support flights were cut due to the lack of fuel, and as the oil situation worsened, the *Luftwaffe* was unable to defend German airspace. This issue generated a major debate between the British and Americans.

Planning for the Normandy invasion was in full swing in early 1944, and the question of how best the bombers could support the landings was discussed. American analysts argued that oil should become the top priority. If the oil refineries and hydrogenation plants were knocked out,

the enemy war machine would halt. RAF planners focused instead on the German rail network. Troops, supplies, equipment and raw materials all moved primarily by train. If the rail lines were cut and trains stopped, especially in France, it would be difficult for the Germans to resupply the coast.

The question was resolved on March 25, 1944, when Gen Dwight Eisenhower, the OVERLORD commander, opted for the rail plan. The key factor to him was time: he wanted the beachhead isolated from German reinforcements *before* the invasion, not sometime in the months that followed. Although Eisenhower agreed the lack of oil would be catastrophic to the German war machine, such a collapse could not occur until late 1944—too late for his troops in Normandy. The rail plan won the day for the logical reason that it promised a solution to an immediate problem.

Even among rail plan advocates there was disagreement. If it was desired to halt rail traffic, then what specific parts of the rail system should be targeted: rail cars, locomotives, repair facilities, switching mechanisms, marshalling yards, or rail bridges? This was a classic OR question. British analysts pushed for marshalling yards and the Americans favored bridges. Air leaders resolved the issue in their usual manner—they bombed both. There was enough Allied airpower by mid-1944 to follow a number of targeting strategies: rail bridges and marshalling yards, as well as oil refineries, submarine pens, rocket-launcher sites, airplane and engine factories, and the enemy front lines.

There is a bit more to the story. In January 1945 the German rail system, which had been employing its own teletype network for transmitting status reports, began using the toP–secret Enigma machine because their teletype system and landlines had been knocked out by bombing. Allied intelligence had ignored rail messages, believing them of little import, but when it began using Enigma—not by design but necessity—analysts started paying attention. Enigma revealed the crucial role played by coal in the German economy, powering 90 percent of industrial production. More to the point, coal was moved largely by train. Since the rail plan had been in effect, coal shipments had slowed, causing a serious decline in German production. The implication was clear. To deliver a death blow to German industry and military capability, one had to stop the flow of coal, and that meant stopping the trains.

To understand the crucial oil vs. rail plan controversy, see Robert S. Ehlers, Jr., ***Targeting the Third Reich: Air Intelligence and the Allied Bombing Campaigns*** (Kansas, 2009), Ronald C. Cooke and Roy Conyers Nesbit, ***Target: Hitler's Oil*** (William Kimber, 1985), Solly Zuckerman, ***From Apes to Warlords*** (Harper & Row, 1978), Walt W. Rostow, ***Pre-Invasion Bombing Strategy*** (Texas, 1981), Alfred Mierzejewski, ***The Collapse of the German War Economy, 1939-1945: Allied Air Power and the German National Railway*** (North Carolina, 1988), and Albert Speer, ***Inside the Third Reich*** (Macmillan, 1970).

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The big question regarding the strategic bombing campaign against Germany concerns its effectiveness. The United States spent $183 billion on armaments during World War II, and the AAF share was $45 billion (24.6 percent). With that money it bought 230,175 aircraft, of which 34,625 were heavy bombers (15 percent). These bombers cost $9.2 billion—20.4 percent of AAF expenditures and 5 percent of the U.S. total. Did the taxpayer get his money's worth? That question has been debated for decades, but those arguments shed more heat than light. There was, however, a massive effort conducted at the end of the war to answer the question of strategic airpower's effectiveness: the U.S. Strategic Bombing Survey (USSBS). Its findings are difficult to dispute because of the massive amounts of facts and details that were uncovered and recorded.

USSBS was the brainchild of Maj Gen "Santy" Fairchild, who had been an instructor at ACTS in the 1930s. He remained keenly interested in the bombing offensive and its effect on the German war effort and in early 1944 believed a bombing survey was essential to answer questions regarding effectiveness. At the same time, Gen Spaatz in England was having similar thoughts and wrote Arnold suggesting a study, emphasizing it must be done by impartial civilians. Arnold met with Robert Lovett, the Assistant Secretary of War for Air, who in turn approached the president. On 9 September, President Roosevelt approved the formation of a bombing survey team.

Franklin D'Olier, president of Prudential Insurance, accepted the job as head and organized his team, which eventually numbered 1,600 officer, enlisted, and civilian personnel. All the groups and divisions in USSBS were headed by civilian businessmen, engineers, lawyers, or bankers. The quality of the men chosen was exceptional and most were picked for their specific expertise: Robert Russell of the Standard Oil Company was to be director of the oil division, Theodore Wright, the Director of U.S. Civil Aeronautics, was appointed head of the aircraft division, etc. The Survey's military advisers were also first-rate: Gens Omar Bradley and Lucius Clay and Adms Richard Byrd and Robert Ghormley.

Over the next year USSBS teams visited scores of bombed sites, measuring, photographing and collecting data, while also interviewing hundreds of individuals, from generals and diplomats to civilian workers.

The Survey concluded that "Allied air power was decisive in the war in Western Europe." Airpower was not the only decisive factor: Soviet armies in the east were chewing up German divisions at an astonishing rate. The American and British forces in the west faced fewer German troops, but the Normandy invasion caught Germany in a vice it could not escape. Bombing had a catastrophic effect on the enemy economy and transportation system, which in turn fatally impacted their armed forces.

USSBS presented scores of charts, graphs, and tables

illustrating the impact of bombing. At its peak, the Allied air campaign employed 1.34 million personnel and over 27,000 aircraft. Bombers flew 1.44 million sorties and dropped 2.7 million tons of bombs—54.2 percent by the AAF and the remainder by the RAF. The bombing campaign was costly—nearly 160,000 airmen were lost by the British and the Americans (almost exactly the same number by each), and 40,000 aircraft were destroyed (22,000 RAF and 18,000 AAF). Significantly, 85 percent of all bombs dropped by the AAF on Germany fell *after* D-day. In truth, the Combined Bomber Offensive did not really begin until the summer of 1944—the third year of war for the Americans and fifth for the British.

Graphs regarding production in key German industries are dramatic—virtually every important commodity began a severe decline in the summer of 1944—long before Allied armies crossed into Germany and occupied its industrial areas. Production of aviation fuel, for example, plummeted from 316,000 tons/month to 107,000 tons in June and 17,000 tons by September. Synthetic fuel fell from 175,000 tons in April 1944 to 30,000 tons by July and just 5,000 tons in September—a 90-percent drop in four months. The largest oil refinery, Leuna, was bombed 22 times, reducing its output to 10 percent of its previous capacity. The effects of this fuel drought were felt throughout the *Wehrmacht*—aircraft stopped flying and tanks stopped rolling. In March 1945 the Soviets overran 1,200 German tanks that had run out of gas. Because of the aviation fuel shortage, new *Luftwaffe* pilots entered combat with perhaps 145 flying hours compared to 525 for the AAF.

Bombing attacks on the German transportation system were critical: 40 percent of all rail traffic was coal—21,400 train carloads per day at the beginning of 1944, but by the end of the year that number had fallen to 9,000 cars daily. Rail traffic in general had nosedived 50 percent by mid-1944. Steel production was related to this collapse, suffering an 80-percent drop in three months. Similar declines were experienced in the production of explosives, synthetic rubber, chemicals, powder, and munitions.

The effect of the bombing campaign on the German labor force was also significant: 2.5 million workers were engaged in "debris clearance, reconstruction and dispersal projects and other types of repair activity necessitated by the bombing." One million more workers were producing civilian goods that had been destroyed by bombing, and another one million were devoted to making antiaircraft guns, which consumed 20 percent of all ammunition produced. Indeed, that much aluminum could have built an additional 40,000 fighter planes.

Did bombing weaken morale? The Survey said yes: "bombing appreciably affected the German will to resist. Its main psychological effects were defeatism, fear, hopelessness, fatalism, and apathy. It did little to stiffen resistance through the arousing of aggressive emotions of hate and anger." Nearly five million German civilians became refugees, and this had a cascading effect that put heavy burdens on the transportation system, food distribution efforts, medical and community services, etc. In addition, bombing effected German troops, causing "a chronic cause of fear, discouragement and confusion, and potentially disrupter of discipline . . . Air power when employed against lines of communication and transportation plays a vital role not only in producing the more obvious military isolation of the battlefield, but intensifying feelings of anxiety and frustration."

Yet, a valid question remains: was low morale a meaningful measure of merit? Absenteeism would seem to be more appropriate. Regardless of whether a worker admits to having low morale, does he or she report for work? Increasingly, they did not. Absenteeism approached 25 percent in key factories, causing a corresponding loss in productivity. Not only did production decrease, it also shifted in focus. The *Luftwaffe* built more fighters. Bombers, which had consumed over half of German aircraft production in 1942, declined to only 18 percent by mid-1944. By D-Day, defense against Allied air attack—which ultimately proved futile—absorbed one-third of the German war economy.

The survey argued that air superiority was essential to the bombing campaign's success. This air dominance was not achieved until early 1944 (the "Big Week" air campaign mentioned earlier), allowing the bombing campaign to achieve its dramatic results. Indeed, it is important to remember that the invasion of France was pushed back from 1942 to 1943 and finally occurred in June 1944—a major reason for this delay was that air superiority over the beachhead was deemed essential for success.

The survey also confirmed that certain targets within a system had a disproportionate importance. Plus, there was a synergism between target sets: bombers razed the steel mills as well as rail lines leading to them, along with marshaling yards serving the railroads. Taking down oil refineries meant there was little fuel to power the airplanes and tanks that were produced, and Allied aircraft destroying military equipment in combat also contributed to the German military collapse. In other words, although specific bottleneck targets existed, it was repeated, heavy attacks against several components of the industrial system that collapsed the enemy infrastructure.

The German economy was akin to a living organism that adapted to attacks against it. The Germans changed behaviors and produced work-arounds. German resiliency was a disturbing surprise. Even so, when the bombing campaign launched powerful attacks beginning in mid-1944, the result was dramatic: USSBS depicts a cascading, cataclysmic failure throughout the German economy, a failure that spelled doom for the enemy war effort.

USSBS is a subject overlooked by most historians. A total of 215 reports were written for Europe, but only the overall summary report has been published by Air University Press and been readily available to interested observers. David MacIsaac, ***Strategic Bombing in World***

War Two: The Story of the United States Strategic Bombing Survey (Garland, 1976) wrote an excellent account of the survey apparatus itself. Garland then published seven volumes containing 31 of the most important reports, including summaries of the major targeting divisions: oil, aircraft, munitions, morale, etc. These are an invaluable source—if you can find them. For a comparison, see the bombing report done by the RAF, Sebastian Cox (ed.) ***The Strategic Air War Against Germany, 1939-1945*** (Frank Cass, 1998).

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The subjects of legality and morality often arise when discussing the bombing campaign. The two are separate, but related. Legally, the issue is surprisingly simple: there was, in essence, no law specifically addressing bombing going into World War II. Attempts had been made since the beginning of the century to define laws regarding air bombardment, but agreement could not be reached. As a result, air commanders adapted existing laws dealing with war on land and sea.

An example was the legal maxim that armies could bombard a defended city or fortress even if it contained civilians. There were numerous examples of this occurring before and during the war (Leningrad), and using this precedent, airmen reasoned that when Allied bombers flew over Europe and were shot at by thousands of antiaircraft guns and intercepted by hundreds of enemy fighters, all of Nazi-occupied Europe was, in effect, a "defended fortress"; thus, all targets were open to attack.

The law also permitted navies to shell *undefended* fortresses and cities to destroy their military stores and facilities—even if this meant the death of civilians inside (Cherbourg). Because navies could not occupy a port as could an army, sailors were given wider latitude in shelling civilians. Aircraft, like ships, could not occupy a city, so the permissive rules of sea warfare seemed more applicable to air war.

What the law permits to armies and navies cannot be illegal for air forces.

The morality of war is not as apparent. For centuries, civilians have enjoyed an immunity in war; yet, they have still died by the millions. Nations at war tend to use whatever means are at their disposal to achieve victory: this is especially true when a nation feels its survival is at stake. This was the case in World War II. In such instances, morality is often viewed as a luxury available only to those whose survival is not at risk. This leads political and military leaders down a precarious path. After the *Luftwaffe* leveled Coventry in November 1940, Prime Minister Winston Churchill ordered Bomber Command to aim for city center on its raids over Germany in retaliation.

Was that targeting strategy justified? Philosopher Michael Walzer examined the issue and decided it was—at least initially. British leaders argued that a combination of reprisal and military necessity made city bombing acceptable. Walzer considered the military necessity rationale. A Nazi triumph was too awful to contemplate, and he conceded that in the dark days of 1941, before Russia and America entered the war, the future looked bleak for Britain. Its army had been thrown off the Continent at Dunkirk, and the Royal Navy was fighting for its life against Nazi submarines in the Battle of the Atlantic. Britain's only hope of hurting Germany and achieving victory was through strategic bombing. Given the inaccuracy of Bomber Command's night strikes, it was obvious thousands of civilians would die if such a strategy was employed. Viewing this as an instance of "supreme emergency," Walzer concluded that such a strategy was morally acceptable. However, this justification declined as the war progressed and it was clear the Allies would eventually win. With the specter of defeat no longer looming, with Allied armies closing in on the *Reich*, and with enhanced bombing accuracy, city busting lost its necessity and acceptability. At least that is the view of a philosopher writing several decades after the war. Ultimate victory was not so obvious to Allied commanders during the Battle of the Bulge in December 1944.

How many non-combatants died? One expert states that sixty million people died during the war and 40 million of those were civilians. Other experts broke down those statistics to determine cause of death, and these compilers agree that less than two million civilians died, worldwide, as a result of bombing. If so, it means that 95 percent of all the non-combatants who died during the war were the result of land and sea operations, not air warfare. There is a rich literature on the subject, but see especially, M.W. Royse, ***Aerial Bombardment and the International Regulation of Warfare*** (Harold Vinal, 1928), Michael Howard, ***Restraints on War: Studies in the Limitation of Armed Conflict*** (Oxford 1979), Micheal Clodfelter, ***Warfare and Armed Conflicts: A Statistical Reference to Casualties and Other Figures, 1618-1991*** (McFarland, 1992), R.J. Rummel, ***Death by Government*** (Transaction, 1995), Geoffrey Best, ***Humanity in Warfare*** (Weidenfeld & Nicolson, 1980), Sheldon M. Cohen, ***Arms and Judgment: Law, Morality, and the Conduct of War in the Twentieth Century*** (Westview, 1989), and Michael Walzer, ***Arguing About War*** (Yale, 2004).

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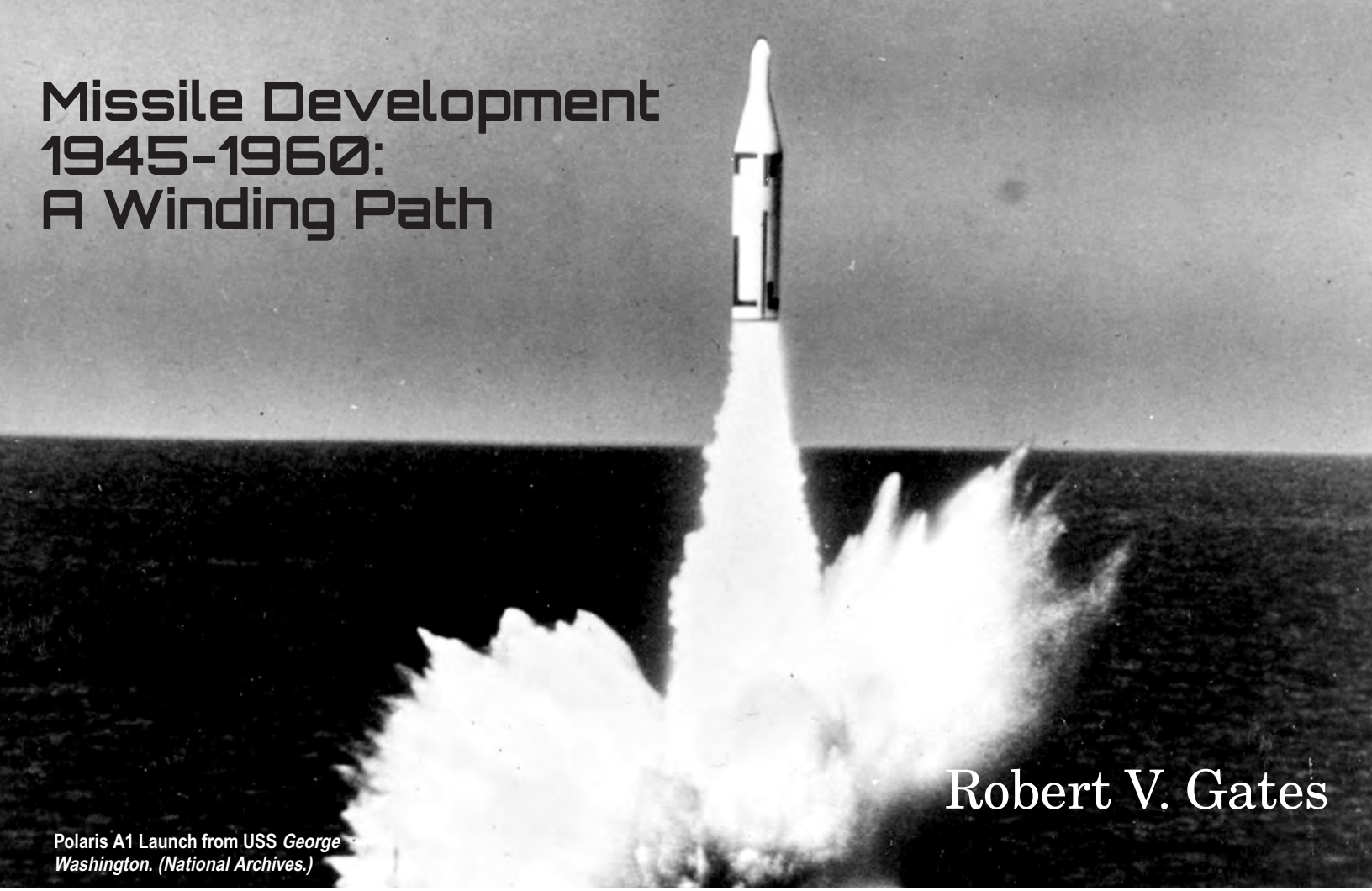
American airpower was a huge success story in World War II. It is not possible to imagine Allied victory without it. Had air superiority not been established over the *Luftwaffe* in the spring of 1944, there would have been no invasion. Had there been no Combined Bomber Offensive, the German economy would not have crumpled. Airpower was decisive in Allied victory. ■

Missile Development 1945-1960: A Winding Path



Robert V. Gates

Polaris A1 Launch from USS *George Washington. (National Archives.)*

The origin of rockets can be traced to China in the 12th Century and there have been attempts to use them in warfighting ever since. However, early efforts to study rocket technology are much more recent and can be traced to Robert Goddard in the United States, Hermann Oberth in Germany, and Konstantin Tsiolkovsky in the Soviet Union in the 20th Century. The first rocket research to receive financial assistance from the U.S. government was for Goddard to develop solid fuel rockets in 1941.

U.S. research during World War II was mostly focused on small solid fuel rockets for unguided surface to surface and air to surface missiles. The Germans, on the other hand, developed missiles like the V-1 subsonic aerodynamic missile (basically an early cruise missile) and the V–2, a liquid propellant ballistic missile that carried a 2200 pound high explosive warhead to a range of 200 miles. Some historians (e.g., Williamson Murray) believe that the Third Reich wasted a lot of money and its limited resources to build and deploy a missile that was inaccurate and unreliable and that, in the end, yielded little or no tactical and strategic advantage. Nevertheless, it was a significant step in rocketry and formed the basis for early developments in U.S. rocket systems.

Two V–2 test flights went astray and parts of the missile and, in one case, a nearly intact missile were recovered in Poland and Sweden and sent to Britain for study. As the war ended, teams from the U.S., U.K., and the Soviet Union raced to seize major German manufacturing facilities. The U.S. captured enough V–2 hardware to build 80-100 missiles. In addition, Wernher Von Braun and more than 100 important V–2 personnel surrendered to the Americans and were sent to Fort Bliss, Texas as part of Operation Paperclip.

In November 1944 the Army Ordnance Corps contracted with General Electric to study and develop long range missiles to be used against ground targets and high flying aircraft. Called Project Hermes, it was expanded in December 1944 to specifically study the V–2, including assembling and testing complete missiles. The first V–2 was subjected to static testing at White Sands Proving Ground on March 15, 1946 and launched on April 16. Unfortunately, it had a steering issue – a fin fell off – and the flight was terminated. The first successful flight occurred 3 weeks later. By the time GE's participation ended in 1951, 67 missiles had been launched. When the program ended, 75 V–2s had been launched, including one from the deck of the USS *Midway* (Operation Sandy) on September 6, 1947. The Navy used two other missiles in the aptly named Operation Pushover in late 1949. In this test the missile was set on a pedestal on a simulated ship's deck and was pushed over (by explosively blowing off 2 of the 4 legs of the pedestal) just after the rocket motor was ignited. The purpose was to assess the damage such a mishap would cause. The damage was extensive and opened the Navy's eyes to the danger of carrying liquid propellant missiles on ships. This realization indirectly influenced the Navy decision

V–2 launch from the USS *Midway*, September 6, 1947. *(U.S. Navy Photo.)*

to withdraw from the Army's Jupiter program a few years later.

The last V–2 flight at White Sands was on September 19, 1952. The last five flights were training flights launched by soldiers from the 1st Guided Missile Battalion.

GE's final report summarizes the objectives of Project Hermes as to study the development of future rockets by experiments and operational flight testing, to develop tracking methods, and to support upper atmosphere research. To this end, various configurations of the missile were tested. Although 58 were standard V–2s, some were modified for special experiments, including three that carried monkeys and one had a mouse. Others were modified more extensively – Six were "Bumper" V–2s that had a WAC Corporal solid propellant sounding rocket added as a second stage. While only 68 percent of the flights were considered successful, the program provided the U.S. with its first experience in handling and firing large missiles and set the stage for future developments.

The number of V–2s was limited and a replacement was needed as well as a missile better suited to research. There were other missiles, such as the WAC Corporal, available but their performance was inadequate. Consequently, the Naval Research Laboratory contracted with the Glenn L. Martin Company in 1946 to produce an American counterpart to the V–2. The Viking missile, originally named Neptune, was considered the most advanced large, liquid-fuel rocket developed in the United States. There were 12 flights between 1945 and 1955, including one from the deck of the USS *Norton Sound* on May 11, 1950. The Viking is considered to have been very successful as it reached record altitudes and carried a number of successful experiments.

The Navy proposed two further uses of the Viking. The first was as a guided missile with an unspecified warhead to a range of 150 miles. This required a more powerful rocket and a modified guidance system. Development of the rocket motor was cancelled after a year's work.

In 1955, the White House proposed to put a satellite in orbit during the upcoming International Geophysical Year and the Navy proposed a concept with a Viking first stage and an Aerobee as a second stage. The resulting missile was called Vanguard. It was accepted and the last 2 Vikings were used. While the ultimate Vanguard was different, this concept was used as Vanguard test vehicles. The launch of TV-1 on May 1, 1957 marked the end of the Viking program.

Changing Needs and Changing Budgets

The examples of the wartime use of the V–2 and the atomic bomb could not be ignored after World War II. The services looked at future threats and trends in technology and predicted the future weapon systems required if they were to successfully perform their traditional missions. The Army Air Force, for example, saw a future need for a system with a longer range and that was more survivable in order to perform their strategic mission. The obvious answer was a missile with a nuclear warhead. The Army projected that they would not be able to place artillery supporting the troops near the battlefront. Again, the solution was a missile – with a range of 200 miles and a small yield nuclear warhead. The Navy wanted a "supercarrier" that could carry nuclear-armed bombers.

However, these desires collided with post-war budget realities. The War Department and Navy budgets peaked at 76 billion in 1944 and was proposed to be $51 billion in 1945 and, in President Franklin D. Roosevelt's last budget (1946) was about the same level - $56 billion. However, President Harry Truman was driven to reduce the defense budget starting with his first budget in 1947. The first of these was the historic American response to the end of a war – the size of the military had to be reduced – personnel and hardware – and demobilization of service members had to be done quickly. There were also economic reasons. Inflation was unacceptably high and Truman chose to ad-

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dress that by reducing federal government spending and proposing a balanced budget. As a result, he proposed a defense budget of only $12.2 billion in 1947. It was held at about the same level in 1948 and 1949.

One immediate consequence was that the usual interservice rivalry was exacerbated. For example, there was disagreement between the Air Force and the Army. The Air Force accepted the Army's artillery-based argument but wanted to limit the range to 200 miles. The Army made an argument for missiles with a range approaching 1500 miles but the Air Force felt that was the mission of their fighter-bombers and medium bombers and objected to it.

Strategic attack was an Air Force mission and they alone had the ability to deliver the atomic bomb and they wanted to keep it that way. The Navy saw a need for a sea based nuclear strike capability. Existing aircraft had a limited range and carriers could get in range of targets without a need for overseas bases. The Navy proposed, and President Truman approved (in 1948), five supercarriers that could carry long-range bombers. The keel of the first of these, the USS *United States* (CVA-58), was laid in 1949 but the program was cancelled five days later by Secretary of Defense Louis A. Johnson. The subsequent "Revolt of the Admirals" saw the resignation of the Chief of Naval Operations, Admiral Louis Denfield, but this did not answer the question of which service would have the responsibility for nuclear weapons.

Further discussion of the roles and missions that had ostensibly been settled by the National Security Act of 1947 was needed. That Act had placed responsibility by geographical element – Army on land, Navy at sea, and Air Force in the air. This still did not answer the question and the Joint Chiefs of Staff (JCS) met in Key West in March 1948. The resulting agreement was not definitive but it did, however, confirm the existence of naval aviation and that the strategic mission belonged to the Air Force.

The subject was revisited at another conference in Newport, Rhode Island in August that same year. It was decided to temporarily defer a decision on the "control and control and direction of atomic operations." In addition, a supplement to the JCS "Functions" paper issued the previous April said that while each Service "must have exclusive responsibility for programming and planning" in the field of its primary missions, they must "take into account the contributions which may be made by forces by other Services."

In the end, these conferences did not resolve service differences and the significantly reduced budgets continually reopened the disputes.

This is the environment in which missiles were developed in the decade following the end of World War II.

Post-war Missile Development

Wartime experience could not be ignored and on 31 October 1945 the Army Air Force distributed letters throughout the aviation industry to solicit proposals for a ten year program of research and development on missiles of various sizes with ranges from 20 to 5000 miles. Within months, Consolidated Vultee Aircraft Corporation ("Convair") engineers had sketched out two concepts for 5000 mile missiles. One was a winged, subsonic, and jet-powered missile and the other was a ballistic missile. Three months later they received a contract and $1.4 million to study the two designs. This was the beginning of Project MX-774.

Convair developed three concepts, known as Designs A, B, and C. Design A was the subsonic version (known internally as "Teetotaler" because it was the only one of the three that did not use alcohol as a fuel). Design C was the ultimate 5000 mile missile (known as "Manhattan" because it was intended to carry a nuclear warhead). Design B (known as "Old Fashioned" because of its resemblance to the V–2) was a shorter range ballistic missile to test the technology that would ultimately be needed for the desired 5000 missile.

The design for the Old Fashioned fell into place quickly and Convair was ready to start fabricating parts by August. Convair started with the V–2 but made several important changes. First, they reduced the missile weight through material and structural changes. Most importantly, they added an improved rocket motor and replaced steering vanes with a gimballed nozzle for steering. The Army added another $493,000 to the contract in June and, while this was not enough to develop the Manhattan, it was a good sign,

But all was not as it appeared. In December Design A was cancelled in favor of a similar concept at Northrup (that years later evolved into the Snark cruise missile). Finally, as the first test missile neared completion, the Army cancelled MX-774 on July 1, 1947. However, Convair was allowed to use unexpended funds to develop and test three missiles, known to the Air Force as HIROC. The test flights took place at White Sands between July and December 1948. While all of them experienced in-flight failures, a lot was learned that eventually affected the design of the Atlas missile.

The cancellation was primarily the result of the budget cuts discussed previously. The reduced budget resulted in consideration of competing priorities. Another factor was the state of missile technology. First among them was the size of the existing atomic bomb. Its size meant that a very large missile was needed to carry it to the desired range. Further, a guidance system with sufficient accuracy and materials that could protect the warhead from the heat generated during re-entry did not exist. Estimates varied but it was thought that it would take ten years (and probably more) and billions of dollars before an operational long range missile would be available.

Finally, there were issues within the Air Force. The strategic mission was considered essential and the only way that existed to deliver the atomic bomb was by bomber. Development of an intercontinental bomber, the Convair B-36, began in 1941 and it flew for the first time in 1946. It was soon to go on operational status and clearly had priority.

Convair continued to fund research on intercontinental ballistic missiles (ICBM) in 1949 and 1950 and it paid off. In January 1951 the Air Force awarded Convair a contract to develop a long range missile. It was known as Proj-

ect MX-1593 and the resulting missile was known as Atlas. However, the Korean War had begun and while the defense budget had increased, ICBM priority was low. There were also many in Air Force leadership who regarded Atlas as a pipedream.

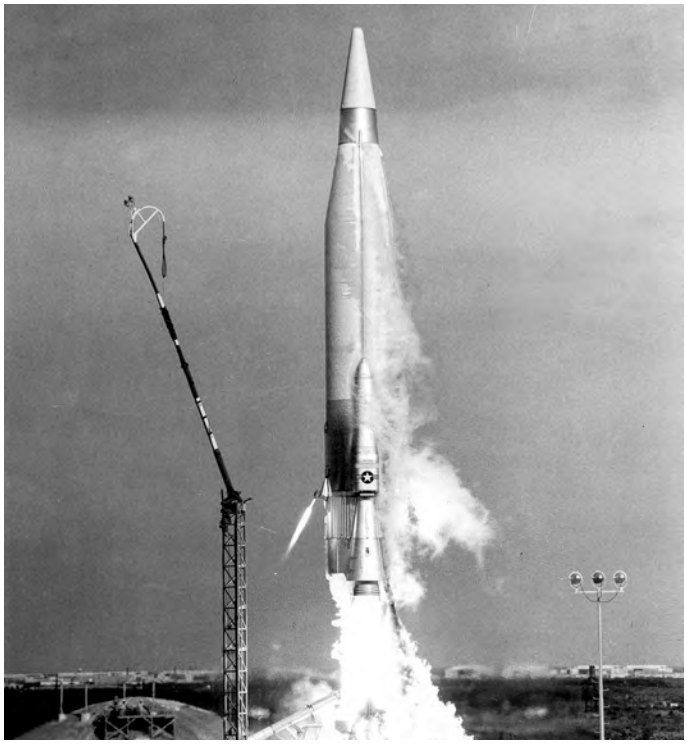
The Ivy Mike test of a hydrogen bomb on 1 November 1952 changed everything. The Mike device was a test device for proof of concept not a deliverable bomb but it raised expectations. Mike was a liquid reaction device that included very large refrigerating equipment. Development of a dry reaction device, which did not require refrigeration, was needed for a deliverable warhead. It was not certain that such a device was possible and research was ongoing. But the question was answered when a Soviet hydrogen bomb test was analyzed and it was determined that a dry process device had been tested. Further, intelligence reports that provided evidence that the Soviet Union was developing and testing a large missile with intercontinental range added to the sense of urgency.

But another boost was needed. It was provided by Assistant Secretary of the Air Force for Research and Development Trevor Gardner. He established the Strategic Missile Evaluation ("Teapot") Committee to study strategic missiles. Among other things, the committee, chaired by John von Neumann, concluded that the major Atlas subsystems were feasible and that an Atlas could be operational in 6 - 8 years. Another nuclear test in March 1954 confirmed that lighter, higher yield weapons were possible. This changed accuracy requirements and simplified the design of the Atlas.

The Teapot Committee also concluded that an operational ICBM could be available if it was assigned high priority. Further, the committee lacked confidence in Convair and recommended that a different management structure be put in place. In response, the Air Force established the Western Development Division (WDD), later called the Ballistic Missile Division, headed by Brigadier General Bernard A. Schriever, to oversee development of guided missiles. Atlas was given top priority in the Air Force and then in the nation.

The WDD took other steps to accelerate Atlas development. The first was concurrency. In other words, all elements of the system (e.g., missile, ground support equipment, and training) were developed in parallel rather than sequentially, assuming that everything would come together. Alternative versions of major missile subsystems were developed to guard against the possibility that the primary would not work. The ultimate hedge came in 1955 when development of a second missile – which became Titan – was ordered as a backup to the Atlas. It was thought that Titan would incorporate and test riskier technology and serve as a re-entry vehicle test platform. Titan development trailed the Atlas by two years and there was a push to cancel it in 1957. However, it offered several advantages over the Atlas – faster reaction time and more secure basing (in hardened underground silos) – and became a second ICBM.

The issues with liquid propellant missiles were well known but the capability to produce large solid propellant



Atlas test launch. ***(USAF Photo.)***

motors did not exist. The Navy and the Air Force collaborated in research in this area and the result was the Polaris and Minuteman missiles. Solid propellant resulted in a smaller and simpler missile that could be based in hardened silos and that had an appreciably shorter reaction time. Studies of the Minuteman started in 1955 and development started in 1958.

The first flight test of Atlas A occurred in June 1957. The operational models – Atlas D, E, and F – entered service in 1959 through 1962 in 13 squadrons. The Titan I entered service in 1962. Both Atlas and Titan I missiles were made obsolete when the Titan II and Minuteman became operational in the fall of 1962 and were withdrawn from service by 1965. However, the Atlas and many versions of Titan continued to be used in the space program. Titan II was retired in 1987 but an updated version of Minuteman continues in service today.

More Insurance – the Intermediate Range Ballistic Missile (IRBM)

The German scientists at Fort Bliss had almost no part in the V–2 tests at White Sands Proving Ground and were moved to the new Ordnance Guided Missile Center (OGMC), later known as the Army Ballistic Missile Agency, in Huntsville, Alabama in 1950. When the Korean War broke out in 1950, the OGMC was given the job of producing a surface-to-surface missile with a 500 mile range. The resulting missile, known as the Redstone, was a direct descendent of the V–2 and, to some degree, resembled it. Incorporation of various technological advances gave the required performance although, in the end, the weight of the warhead dictated by the Chief of Ordnance limited the

range to 200 miles. The first flight of the Redstone missile took place in August 1953 and it was in active service with the U.S. Army in Germany from 1958 until 1964 when it was replaced by the solid propellant Pershing missile.

The Army had long envisioned a "zone of combat operations" of some depth and, consequently, they needed a longer range missile. OGMC studied the issue and proposed a two stage missile based on the Redstone that yielded a 1000 mile range. As the design progressed so did technology. A more powerful rocket motor and a reduction in warhead weight resulted in a design for a missile with a 1500 mile range. The proposal for the Jupiter missile was presented to the Department of the Army in 1954 but did not become a funded program, over Air Force objection, until 1955.

In March 1954, President Eisenhower asked the Technical Capabilities Panel of the Strategic Advisory Committee to consider the vulnerability of the United States to surprise attack. The Killian Committee, after its chairman James R. Killian, studied intelligence reports and U.S. missile development programs and issued their final report on February 14, 1955. In addition to a review of the phases of U.S. vulnerability into the early 1960s, the committee made several recommendations. These included a "crash' program to develop the ICBM, a program to develop an intermediate range ballistic missile, and, specifically, a sea-based ballistic missile. The development of the IRBM was based on the assumption that it was a simpler missile that could take advantage of ICBM development and, thus, would be available before the ICBM.

The Army was ready with its Jupiter proposal but the Air Force objected on the basis that a missile with that range was strategic rather than an extension of artillery and, hence, was an Air Force mission. After study (and over the reluctance of General Schriever to embrace the IRBM program), the Joint Chief of Staff recommended that the Army and Air Force missiles be developed in parallel. The justification was that neither was far enough along in development to be certain which was best. Secretary of Defense Charles E. Wilson accepted the recommendation

Specifically, he authorized two IRBM projects: IRBM #1, a land-based missile to be developed by the Air Force, and IRBM #2, a joint Army-Navy project to produce a shipboard weapon and a land-based alternative to IRBM #1. However, they were not to interfere with ICBM development. He left open the question of which service would have operational control of the resulting IRBM. By early 1956, the Department of Defense had four missiles – two ICBMs and two IRBMs – under development.

By the end of 1955, contacts had been let for the major subsystems of IRBM #1, now known as Thor, and development started. The missile was to use existing technology, skills, abilities, and techniques in a concurrent development process in order to accelerate operational availability. The goal was a full flight test by July 1957 and operational deployment by July 1959. After some delays and flight failures, the first successful flight of the operational variant of the Thor took place in December 1958 and the first (of four) Royal Air Force missile squadron was activated in June 1959.

The Army established the Army Ballistic Missile Agency (ABMA), under the command of Major General John B. Medaris, in February 1956 to develop the Jupiter missile. The IRBM program was so critical to the Navy that they had created the Special Projects Office (SPO) in November 1955 rather than assign it to either the Bureau of Ordnance or Aeronautics. Rear Admiral William F. ("Red") Raborn was selected to head SPO.

The Army-Navy IRBM was to be based on the Jupiter missile. The proposed length, weight, and liquid propellant caused problems for the Navy and, after further discussion, a compromise was reached and a shorter and somewhat lighter missile was proposed. Even so, submarine deployment of a missile of that size was problematic and the Navy proposed initial basing on surface ships. Liquid propellant onboard ships was still of concern and, in March 1956, SPO sought permission to study a solid propellant IRBM. The Navy had started research in large solid rocket motor technology in 1955 and it was showing promise. That and a Lockheed study of missile options led the Navy to request separation from the Army Jupiter program. The potential for a 1½ year delay in the availability of an operational missile was a concern. Nevertheless, separation was approved by Secretary Wilson in December 1956 and now there were five missiles under development.

Army development of the Jupiter continued and the first flight tests took place in March 1957 and continued through the year. The 1957 deadline for selecting a single IRBM was approaching and in August an *ad hoc* committee was set up to answer the question and provide a recommendation by September 15. That date came and went and the committee was still deliberating when Sputnik was put in orbit in October. In the end, the Secretary recommended that development of both missiles be accelerated. After much discussion of deployment and a decision by the Secretary of Defense that the Air Force would have operational control of IRBMs, the first four operational Jupiter missiles were turned over to the Air Force in August 1958.

It was well known that the limited range of the IRBM would require overseas basing and negotiations with European countries was underway. The United Kingdom agreed early to the basing of sixty Thor missiles and the first RAF squadron was activated in June 1959. Tentative plans were for three Jupiter squadrons (with 45 missiles) to be deployed in France. After French President Charles DeGaulle declined, the option to base them in Italy and Turkey was explored. Two squadrons (30 missiles) were deployed in Italy in 1960 and one in Turkey in 1961.

By the time they were installed, Jupiter and Thor were largely obsolete and Atlas and Titan I would soon be operational. The Jupiters, and especially those in Turkey, were also increasingly vulnerable to Soviet attack. So, as expected, they filled a capability gap but their operational life was short.

The Navy's Polaris program was destined to have a different outcome. The Navy's first step after separating from the Army program was to design a solid propellant missile. They had agreed to use Jupiter technology when-

Jupiter test launch. ***(USAF Photo.)***

ever possible and the first concept was for a solid fueled Jupiter. The size of a booster is largely determined by the weight of the warhead and the range to be achieved. Since the Navy warhead was the same heavy one proposed for Jupiter, the resulting Jupiter S was a very large missile. It had six clustered solid propellant rockets as a first stage and a single solid propellant rocket as the second stage. Its size - 40 feet long, 105 inches in diameter, and fueled weight of 160,000 pounds – required a large submarine to carry it. The final submarine design was one that could carry four missiles in tubes at the rear of an extended sail.

As it happened, a study ("Project Nobska") was convened in Woods Hole, Massachusetts in June 1956 to discuss the anti-submarine warfare implications of nuclear submarines. In the course of discussing how a nuclear warhead could be made small enough for a torpedo, Dr. Edward Teller suggested that it was possible to develop a one megaton warhead that was small enough for a Polaris missile. He chided the Navy for designing a missile to be operational in 1963 but tying it to 1956 nuclear technology. After his concept was validated by the Atomic Energy Commission and SPO itself, SPO designed the much smaller missile required to carry the small warhead to a 1500 mile range. The resulting missile, Polaris, was 28 feet long, 54 inches in diameter, and weighed of 32,000 pounds.

By the fall of 1956, Admiral Raborn made the decision to concentrate on Jupiter S and Polaris but, before Secretary Wilson's decision to separate the Army and Navy efforts, had decided to drop the Jupiter S. SPO set out on a crash program to develop an operational missile in four years. This included more than the development of the missile; it included shipboard systems and, most importantly, a submarine.

Sputnik increased the pressure to deploy a system and SPO concluded that development could be accelerated if DOD would accept an interim missile with a 1200 mile range. Under this condition, three submarines would be ready by September 1961 and the first would be ready for sea by February 1962.

The first flight test of the interim missile, the Polaris A1, took place at Cape Canaveral in September 1958. A series of flight tests at Cape Canaveral continued through 1959 and into 1960 and culminated with the successful underwater launch of two Polaris A1 missiles from the USS *George Washington*, a *Skipjack* class fast attack submarine modified by the addition of a 130 foot ballistic missile section, on July 20, 1960. It departed Charleston, South Carolina on its first nuclear deterrent patrol on November 15, 1960. It carried a full complement of 16 A1 missiles and target data on 300,000 punch cards generated by the Naval Weapons Laboratory in Dahlgren, Virginia. By the end of the year, two submarines were on patrol. The missile was carried on the five submarines of the *George Washington* class until it was retired in October 1965.

The slightly larger 1500 mile missile, the Polaris A2, was being developed in parallel and the first A2 equipped submarine, the USS *Ethan Allen*, went on an operational patrol on June 26, 1962. It was deployed on the five boats in the *Ethan Allen* class and the first eight of the *Lafayette* class. It was retired in September 1974.

The ultimate Polaris, the A3, was a new design with greater capabilities. Design started in parallel with the A2, became operational in September 1964, and eventually replaced all of the A2s and was in service until 1981. It was incrementally replaced through the 1970s by the C3 Poseidon. The A3 was also deployed on four Royal Navy submarines and their first patrol took place in December 1969. The missile continued in service with the Royal Navy until the mid-1980s.

Polaris didn't suffer the same fate as the other IRBMs. Polaris was not limited to overseas bases and when submarines began to patrol in the Pacific Ocean, Polaris became a truly global system. Technology allowed constant improvements to the capabilities of the system and when Polaris was replaced by Poseidon and later Trident I and II, it was truly an ICBM system. It along with Minuteman, and the B-52 manned bomber became, and remain, the nation's nuclear deterrent force.

Epilogue

The lessons of the V–2 and Manhattan Project were learned well. Despite a halting start characterized by intermittent and uncertain funding, the United States responded to the growing threat and technological challenges and developed a robust and multifaceted nuclear deterrent in little more than a decade. The success of this is evidenced by the fact that a nuclear weapon has not been used since August 1945. ■

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My Darling Boys, A Family at War, 1941-1947. By Fred H. Allison. Denton: U of North Texas Press, 2023. Photographs. Notes. Bibliography. Index. Pp. 251. $34.95. ISBN: 978-1574419061

Many authors dream of writing a family novel or history, some kind of account that brings their family memories back to life. Often, the effort involves years of research, many surprises the author never knew about that include events, personalities, anything that enhances what they have known about their people, that will hopefully fill out their stories and will interest readers of many different groups. Fred Allison, holds a Ph.D. in military history with a career in the Marine Corps History Division in Quantico, Virginia. He is a retired Marine Corps major who is an experienced F–4 Phantom radar intercept officer. He describes a long family history that he knew well, yet knew there were gaps in what he knew. In this highly readable account of his pioneer family, he fills in these gaps not only for himself but also for the benefit of readers who might know their own families might have some, or maybe many, of the same memories.

The title comes from the affectionate greeting the loving mother of three Texas boys used to start her letters, often not always knowing where her sons were in the last three years of the war, even two years after the war's end in 1945. Although she and the family knew one fighter-pilot son, Wiley, was probably dead—certainly missing in action—the location of his crash and the exact details of his last mission remained to be discovered. It is hard to review this fine book in only 500 words. There is so much to include, but therein lies a reason to try: to promote enough interest in potential readers that they will find out for themselves.

When Harold, Oscar, and Wiley went to war, all three of them joined Army aviation—Harold and Wiley to fly as pilots. Oscar served as an enlisted flight engineer and gunner and eventually became a long-time prisoner of war when his B–24 was shot down by a Bf 109 on February 22, 1944. How the author kept all the details about family relations is beyond me, but these early chapters are necessary to establish the family lines as we finally get into the three brothers' experiences in the war. The description of the training each one received is unique and seldom seen in such depth in aviation histories and will be a real find for many readers, particularly in Wiley's fighter-pilot training.

Allison devotes many pages to Oscar's time as a B–24 flight engineer and top-turret gunner of the 716th Bomb Squadron, 449th Bomb Group, Fifteenth Air Force in the Mediterranean theater. These units receive far less coverage in other histories, probably because of the intense interest in the other theaters covered by such more easily-reached squadrons in the Eighth Air Force. But, of course, these aircraft and crews certainly faced the same dangers and trials as their compatriots in the western European theater.

We learn of Oscar's terrible experiences of winter cold, lack of decent food, and constant movement from one camp to another. It is truly a miracle that Oscar survived to finally return home to his family.

I've never seen such a book, so deeply felt, written by an author so strongly attached to a family going through one of the greatest upheavals in world history, living through their individual roles with such great love and concern for others wherever they might be.

CDR Peter B. Mersky, USNR (Ret), retired editor of Approach *magazine; book review editor for* Naval Aviation News

The Nature of World War I Aircraft: Collected Essays by Javier Arango. By Javier Arango. San Francisco: Ghosts, 2024. Photographs. Pp. 227. $30.00 (available exclusively at Ghosts.com).

This book is a compelling tribute to Arango's profound dedication and expertise in the field of World War I aviation. Tragically, he passed away in 2017 but left behind a legacy as a fervent collector and pilot of World War I-era aircraft, many of which featured original engines. This book, a collection of his insightful essays, correspondence, and research articles, serves not only as a memorial but also as a significant contribution to early aviation history.

Arango's unique approach of building and flying multiple aircraft types allowed him to explore and document the evolutionary nuances in aircraft design throughout the war. His observations, drawn from firsthand experience piloting these planes, provide an invaluable perspective on the individual variations in aircraft. He highlights the personalized nature of World War I aircraft manufacturing, where the quirks of each plane were often addressed by the meticulous work of ground crews and the adaptability of pilots, a stark contrast to modern production processes.

Furthermore, Arango delves into the subjective experiences of World War I pilots, challenging contemporary understandings of aircraft performance. His analysis of pilots' descriptions, such as Albert Ball's perception of his Nieuport 17, reveals a complex interplay between the physical characteristics of the aircraft and the intangible qualities that defined early aviation.

The book also offers insights into the broader context of World War I aviation, discussing the strategies of notable designers such as Anthony Fokker and Thomas Sopwith, the nuances of biplanes versus monoplanes, and the role of both skilled and unskilled labor in aircraft manufacturing. Arango's comparison of the Fokker D.VII and D.VIII models is particularly intriguing, shedding light on the subtle factors that distinguished one aircraft from another.

Illustrated with 44 exceptional photographs by Phil Makanna, whose unique and lasting relationship with

Arango engendered the capturing of him in his element, *The Nature of World War I Aircraft* is not just a tribute to Javier Arango's passionate engagement with World War I aviation; it's an enlightening journey into the era's aviation marvels, offering readers a nuanced understanding of the dawn of aerial combat.

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

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The "Blue Squadrons": The Spanish in the Luftwaffe, 1941-1944. By Juan Arráez Cerdá and Eduardo Manuel Gil Martínez. Warwick UK: Helion and Co, 2023. Tables. Illustrations. Maps. Photographs. Drawings. Appendices. Bibliography. Pp. 138. $45.00 paperback. ISBN: 978-1-804512-39-5

I was surprised when I learned that over 30 non-Axis countries contributed military personnel to serve the Third Reich. Most of the volunteers wore German uniforms and swore oaths of allegiance to the Führer. Some were occupied (e.g., Belgium, France, Norway). Others were members of the Allied coalition opposing the Axis (e.g., Britain, India, Russia). And some were nominally neutral (e.g., Spain, Switzerland, Sweden, Luxemburg).

This book addresses Spanish contribution to the Luftwaffe on the Eastern Front. Spain organized over 47,000 "volunteers" to serve in the German Army during its invasion of Russia. Service in the Army is an important distinction. Most foreign nationals were organized into Waffen SS units and served under the SS banner. Service in the Army still required a loyalty oath to the Führer but meant service would be in conventional formations conducting offensive and defensive actions and not in the more heinous activities of the SS. Spain had a sizable number of experienced combat pilots and offered them as volunteers to form an expeditionary squadron to support Spanish ground operations. Germany accepted the Spanish offer, provided equipment, training, and uniforms and sent the first of five squadrons directly into the front lines. Thus began a series of 6-month rotations until their final withdrawal—along with most ground troops—in the Spring of 1944.

One can make rough comparisons between German use of Spanish volunteer/augmentees and US use of Brazilian and Mexican aviators in the Pacific theater. Flores' *Mexicans at War: Mexican Military Aviation in the Second World War 1941-1945* is highly recommended. The US did not require its partners to swear a loyalty oath. Both the US and Germany initially allowed augmentees significant operational autonomy but later collocated foreign units with their own units. Collocation allowed for improved coordination and "mentoring" as well as streamlined maintenance and logistics. In exploring the parallels, the Spaniards' Civil War combat experience probably paid great dividends in the initial stages of their Eastern Front deployment. But as the war dragged on, and replacement personnel with less experience came on board, loss rates increased, and mission effectiveness decreased. The Mexican experience never really peaked, and eventually they were relegated to non-front-line missions. Given the nature of the war on the Eastern Front, the Spanish were in the heart of the war from the beginning to the end.

This was not an easy or casual reading experience. The oversized paperback format wonderfully displays the photographs but makes physical reading awkward. The narrative's syntax and word choice had me frequently rereading sentences, then referring to dictionaries and thesauruses to determine what exactly was meant. The absence of first-person oral history material was negatively noteworthy. And the pages of color profiles added little to the subject.

That said, the book has value. It highlights the fact that, in 1940, many people were so afraid of communism and Russian expansionism that they were willing to ignore German aggression and criminality and offer service to an occupying power. Maybe that willingness speaks to the effectiveness of the German propaganda machine or the adroitness of the German Foreign Ministry in building partnerships. History shows that there has always been a market for mercenaries. But perhaps my US-Mexican parallel was off the mark. A better American example would be the American Volunteer Group's experience in China.

Gary Connor, Cortland OH

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Russian Bombers. By David Baker. Horncastle UK: Tempest Books, 2023. Photographs. Diagrams. Maps. Index. Pp. 210. $34.25. ISBN: 978-1-911704-13-3

David Baker has written more than 100 books on space flight, aviation, and military technology and is the former editor of *Jane's Space Directory* and *Jane's Aircraft Upgrades*. He is a member of the International Academy of Astronautics and is a Fellow of the Royal Historical Society. A recipient of the American Astronautical Society's award for a sustained excellence in space coverage, he is currently a Fellow of the British Interplanetary Society and editor of *Spaceflight*, their monthly space-news magazine.

From the 1950s to today, Russian and Soviet bomber development underwent significant transformations that reflected changes in geopolitical dynamics, technological advancements, strategic priorities, economic and industrial considerations, and threat evolution. The primary role of the Russian long-range bomber force has been to serve as a credible nuclear deterrent. This role was somewhat reduced because of the advent of the nuclear ballistic missile. However, the reduction in ballistic missile numbers,

brought on by arms reduction talks, has increased the value and flexibility of both strategic and tactical bombing. Nonetheless, effectiveness of that bomber force also depends on operational readiness. Russia's program of rearming and modernizing its bomber fleet has been challenged by international economic sanctions and the draining of resources by the war in Ukraine.

Baker begins his excellent presentation of Russian bombers with the astounding Soviet reverse engineering of the B–29, which provided the stimulus for development of long-range bombers in the 1950s. He describes the Soviet parallel development of the turbojet engine which had been put on hold during World War Two. This ultimately led to the design of tactical, medium-range, jet bombers to compete with the introduction of these types by the UK and the US. Stalin's perception of threats from combined attack by Western nations provided the ultimate incentive for long-range, strategic, jet bombers.

The design efforts of the main bomber design bureaus (Tupolev, Myasishchev, and Ilyushin), coupled with parallel jet- and turboprop-engine evolution, arrived at the desired solutions. Baker provides an excellent overview of the political and technological struggles to develop needed long-range-bomber designs.

He devotes one chapter to the "Ubiquitous Bear," the inimitable Tu–95 long-range, turboprop bomber that met the desired trade-offs between power, range, and speed. It has served in many roles, such as midair refueling, cruise missile launch platform, maritime patrol and surveillance, anti-submarine warfare, electronic countermeasures, and as a flying research laboratory to measure the radiation environment of a nuclear propulsion system. This aircraft will continue to serve Russian air power into the 2040s.

Baker also describes the successes and failures of many supersonic designs, including the Tu–22, T–4, Tu–160, and the Tu–144 supersonic passenger aircraft. These provided lessons learned that will ultimately lead to the next generation of Russian aircraft.

This book is eminently readable and enjoyable. It provides a wealth of detailed knowledge and inside stories on the politics and technological development of weapons systems in the Soviet Union and post-Soviet Russia. There are many high-quality photographs and layouts. It is a worthy reference book for historians and technologists alike and is definitely worth the read

Frank Willingham, NASM docent

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Pigs, Missiles and the CIA Volume One: Havana, Miami, Washington and the Bay of Pigs, 1959-1961 & **Volume Two: Kennedy. Khrushchev, Castro and the Cuban Missile Crisis**. By Linda Rios Bromley. Warwick UK: Helion & Co, 2021 and 2023. Photographs. Illustrations. Maps. Notes. Bibliography, Pp. 62 and 92. $21.00 each. ISBN: 978-1-91-437714-3 and 978-1-91-507075-3

The 1961 Bay of Pigs fiasco was the precursor to the far more ominous Cuban Missile Crisis just a year later. The latter event brought the USSR and US closer than ever to a mutually annihilating thermonuclear war. Because this country should never again precipitate a crisis of that magnitude, it is essential to understand the events leading up to it. Volume 1 revisits one critical portion of that equation by examining CIA activities as it prepared to conduct an attack on Cuba itself.

That the CIA pursued operations against the sovereignty of other countries independent of congressional oversight and known to only a handful of people is disturbing. It orchestrated the overthrow of legitimately elected governments in Iran and Guatemala and interfered in the political process in other countries, such as Italy. It was not a reach to pursue the overthrow of the Castro government. Additionally, the State Department justified official rejection of Castroite Cuba's legitimacy by identifying it as a Soviet client posing a threat to the western hemisphere.

Bromley summarizes Cuban history from the revolution against Spain to Castro's overthrow of the Batista government. Why did the US strongly reject Castro's reforms? Recall that clandestine operations to overthrow the Iranian government in 1953 were in response to its nationalization of foreign oil interests. Highly successful CIA operations there created a sense of confidence for future clandestine operations. The Agency acted in 1954 to overthrow the Guatemala government on behalf of US commercial interests. When Castro nationalized the huge land holdings of US sugar corporations and oil refineries, the CIA focused on overthrowing the Cuban regime. Efforts to recruit pilots, aircraft, soldiers, equipment, and ships and establish bases for a planned attack on Cuba are described in this overview.

Very senior Pentagon officers were asked to assess the plan and said it had only a fair chance of success—and only with absolute air superiority. Choosing the Bay of Pigs area for the invasion only increased the possibility of failure. President Kennedy's closest advisors told him the plan was deeply flawed and would probably fail. As landings commenced, Kennedy wavered in his support causing further confusion leading to catastrophe—not his finest hour.
The final section provides a play-by-play description of the invasion, failure to support the troops on the ground, and the final abandonment of the brigade. The poorly planned and supported invasion wasn't the end of crises for Kennedy. Khrushchev soon humiliated him at the Vienna Summit followed by the Berlin Wall.

Volume Two seamlessly picks up the story with an overview of the two superpowers' confrontational relationship. Cuba, rightfully fearing a US invasion, played only a secondary role at that point. To counterbalance America's placing of nuclear intermediate-range missiles in Turkey

and Italy, Khrushchev (with Castro's agreement) began an, initially, secret placement of Soviet missiles in Cuba.

The Russian buildup was detected by U–2 flights, while the Russians rushed to construct the supporting infrastructure for the missiles, bombers, and defending SA-2 surface-to-air missile sites and MiG fighters. Russian merchant ships bound for Cuba were scrutinized for suspected weapons systems. Eventually there was clear evidence that intermediate and medium-range missile launch pads hade been constructed despite Khrushchev's assertion that no construction was ongoing—only the movement of agricultural machinery to aid in modernizing the Cuban agrarian sector.

Bromley then follows a timeline illustrating moves and countermoves by the two key players. US aircraft conducted reconnaissance over Cuba. Strategic Air Command dispersed its forces and maintained armed, airborne B–52s in anticipation of possible nuclear strikes. Soviet submarines reached their stations off the US Atlantic coast and in the Caribbean, while the US Navy aggressively tracked them. Soviet anti-ship missiles were activated in Cuba. Kennedy declared a blockade (quarantine) of Cuba (an act of war?). The Soviets, on October 27, 1962, shot down a US U–2, potentially pushing the crisis to the brink. A few days later a Soviet submarine crew, unsure of whether or not they were already at war, came far too close to launching a nuclear torpedo at threatening US Navy surface vessels.

The Cuban Missile Crisis was the single most unnerving crisis of many during that era, one complicated by a chain of often unanticipated events. It might sound like a highly imaginative Cold War novel, but it did happen, as this monograph makes very clear.

A complicating sideshow was the need for each side to rein in its own players. The Pentagon's JCS wanted to invade Cuba. Submariners were ready to employ nuclear torpedoes. US destroyer commanders were itching to depth charge Soviet submarines. Somehow, both direct and indirect exchanges between the two sides managed to end the crisis.

These monographs very effectively revisit Cold War moments of incredible consequence. For those of us who have firsthand memories, reading the two volumes brought them all back. For readers with no firsthand knowledge, Bromley has provided an easy-to-follow account of what happened, the impacts, and how we escaped a nuclear war. Without a question, these are very good reference materials and well worth the time to read.

John Cirafici, Milford DE

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A6M2/3 Zero-sen; New Guinea and the Solomons 1942 & **Operation RO-GO 1943; Japanese Air Power Tackles the Bougainville Landings.** Both by Michael John Claringbould. Oxford UK: Osprey, 2023. Maps. Tables. Diagrams. Illustrations. Photographs. Appendices. Bibliography. Index. Pp. 80 and 96. Cost: $23.00 and $25.00 paperback. ISBN: 978-1-4728-5749-1 and 978-1-4728-5557-2-1

In these two books, Michael Claringbould take the reader to the South Pacific at the time when the Japanese juggernaut was stopped, and the allies began to take the initiative in the theater. The A6M2/3 plays a leading role in both books. Claringbould is an accomplished writer and an even better researcher, using his Japanese language skills to bring new anecdotes and lessons to a well-known story. He frequently drops Japanese terms and phrases throughout his writing (ofttimes, it seems more to establish his bona fides than to enlighten the reader).

A6M2/3 Zero-sen is most effective when it provides a uniquely detailed picture of the life of a Japanese aviator deployed to a forward area. By mid-1942, the Japanese supply chain was already stretched and under increasing pressure, so daily life and operations were harsh by any standard. Claringbould's research seems to have found a unique supply of anecdotes. He does not hesitate to call other writers to task for their failures to do the same, e.g., criticizing Martin Caiden for his sterilization of the 1957 Saburo Sakai biography *Samurai* for being an unrecognizable version of the original Japanese publication.

This book abandoned the usual color profiles in favor of color schematics of air engagements. While eye-catching, the two-dimensional diagrams were more confusing than helpful. In his previous publications, Claringbould also makes clear that he believes regional geography and climate are unappreciated factors that had significant tactical and strategic impact.

The A6M2/3 fighters were the heart of his story. The book shows that Japanese fighters were capable of dominating opposition when in the hands of skilled pilots. In the hands of novices, however, engagements with P–39s, F4Fs, and P–40s were more of an even match—and Japanese aircraft losses were much harder to replace. Pilots were irreplaceable. Claringbould notes that, while the upgrade of the A6M2 to the A6M3 standard was significant, the Sakae radial had reached the end of its evolution. Melzer states in *Wings for the Rising Sun* that the Sakae radial design was a direct outgrowth of the Pratt & Whitney-Mitsubishi partnership. Once the war ended that partnership, Mitsubishi hit a technological dead end.

Operation RO-GO 1943 moves the clock forward six months as the Japanese struggled to regain the theater initiative. In doing so, Claringbould shows the results of the Japanese inability to both effectively redress the Zero-sen's shortcomings and replace the loss of skilled aviators. He again beats the drum of geography and climate as operational factors that impacted the Japanese more than the allies. What began as a Japanese offensive stroke quickly turned into a defensive battle to protect Truk and Rabaul with demoralized and ill-equipped Japanese Army

aviation units. *RO-GO* planners recognized this problem and attempted to bolster army aviation by moving navy aviation units to the theater. While naval unit morale was considered high, the losses at Midway meant their experience level was just as low as their army colleagues.

Throughout *RO-GO*, Claringbould often defaults to positions critical of the allies. For example, he takes exception to published claims that the F4U Corsair attained a 11:1 victory-to-loss ratio. He says Japanese records indicate that in this campaign it is closer to 1:1. In most cases, the 11:1 statistic refers to the entire Pacific war, not a single isolated campaign.

One of the most interesting anecdotes Claringbould offers addresses the state of the Japanese supply chain as being "overwhelmed, unbalanced, inefficient." He cites a Japanese POW as saying that 70 percent of Japanese troops were involved in gardening. He goes on to say that this additional duty was helpful during the prolonged postwar repatriation phase in that the Japanese were used to short rations and feeding themselves.

The artwork of engagements was a pleasant departure from the *de rigueur* Osprey profiles, but the crisp and clean aircraft seemed a far-cry from the worn and battle-weary aircraft found in photos of the same events.

As to the books themselves, they are typical of what we have come to expect from Osprey: well researched and smoothly written, and they have superbly curated photographs and especially useful maps. But Claringbould lacks neutrality in his writing. While his word choice and arguments do not rise to the level of an apologist, they do carry a certain leaning. Allied victory claims are wildly exaggerated, while Japanese claims are merely inaccurate. Japanese executions of prisoners merit brief mention (if mentioned at all). I often found myself giving short shrift to Claringbould's ideas simply because the structure of his argument was so imbalanced. But that would be my problem and not his.

Gary Connor, Cortland OH

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Pacific Profiles Volume 11 Allied Fighters: USAAF P–40 Warhawk Series South and Southwest Pacific 1942-1945. By Michael John Claringbould. Kent Town, Australia: Avonmore Books, 2023. Maps. Tables. Diagrams. Illustrations. Photographs. Notes. Appendices. Glossary. Bibliography. Index. Pp. 108. $35.65. ISBN: 978-0-6457004-3-5

Where was this informative and stunningly illustrated short volume about the P–40 when I was toiling over plastic model aircraft kits as a teen, peeling airplane decals off my fingers, and wondering why I couldn't just paint my own descriptive markings? At the time I had no accurate primer showing real-life options. Now comes this appealing book, which is a remarkable resource for both the modeler and historian.

Claringbould, an aviation authority on the South and Southwest Pacific during the Second World War and author of over 25 books, has produced an exquisitely illustrated and well-researched history of the P–40 Warhawk in the Southern Hemisphere. If there is a source that Claringbould has not consulted (he lists as one of these *Aircraft Movements, Townsville Control Tower, 1942-1945*), I would be gobsmacked. There is so much detail, that it may challenge the casual reader.

Claringbould has a unique interest in the area. Raised in Papua New Guinea, he spent his professional years as an Australian diplomat throughout the South Pacific. During that time, he became fascinated with many aircraft wrecks that were scattered throughout the area. He is now an executive member of Pacific Air War History Associates.

The first Warhawks arrived in Australia on December 22, 1941. In eleven chapters, he reviews markings and technical notes; describes the first of the P–40s in Australia; profiles six fighter squadrons, a tactical reconnaissance squadron, and a bombardment group; and then adds a final chapter describing "unique warbirds." In impressive color detail, he has reproduced and profiled 110 aircraft, using as source documents many of the included 70 photos. I speculate these are from his personal collection, although he neither credits the photographs nor their provenance. All these aircraft flew for either the US Fifth Air Force in Australia and New Guinea or the Thirteenth AF in the South Pacific. P–40 pilots of the Fifth engaged mostly the Japanese Army Air Force, while those of the Thirteenth fought Japanese Navy units.

This impressive work is not for everyone. It held my attention solely because of the exceptional full-color "digitized" images of actual aircraft. Each is personalized with its own history. One learns that, in the South Pacific Theater, the paucity of aircraft necessitated cannibalization and interchangeability of many parts of the eight different variations of the P–40 (E-1/K/F-1/F-15/ M/N-1/N-5/N-15) which led to some confusion when painted fuselage parts were mismatched with other aircraft. Claringbould reveals, by example, some of these actual incongruities. To his credit, he does a yeoman's job in describing the variant's distinguishing characteristics and then illustrates their unique features in graphic detail. As he states in the book's first sentence, "Welcome to the treacherous complexity of the USAAF P–40 series . . ."

This book presents an important picture of the Warhawk's presence and history in the South Pacific during the Second World War. My only criticism is that Claringbould barely references Curtiss-Wright, the Warhawk's manufacturer, a fact that should have been stated in the opening paragraphs and not buried on page 19 under the title "USAAF Manufacturer's Stencil." Having said that, I can't imagine a more attractively illustrated volume of this famous aircraft. There is value in that alone.

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

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Clean Sweep: VIII Fighter Command Against the Luftwaffe, 1942-1945. Thomas McKelvey Cleaver. Oxford UK: Osprey Publishing. 2023. Photographs. Pp. 464. $32.00. ISBN: 978-1-4728-554-8

This book tells the story of the USAAF VIII Fighter Command (FC) from its arrival in the European Theater to the Allied Victory.

When the US entered World War II in December 1941, the USAAF was a mere shell of what it would become. While President Roosevelt had begun a rapid increase in the size and capability of the military, American fighter forces were ill-prepared for the global war; its front-line fighters were outclassed by their adversaries. The Lockheed P–38 had gone into full production just that summer, while the Republic P–47 and North American P–51 were still in testing. American airpower was in its infancy of capability.

When American fighters arrived in the United Kingdom, their initial numbers were sparse as the US worked rapidly to produce aircraft, pilots, and maintainers. The 31st Fighter Group was initially equipped with British Spitfires. Only later would it get P–38s, P–47s, and P–51s.

The new American fighter types all had mechanical difficulties and teething problems. One example was the P–38's controls locking up at high speeds during a dive. Cleaver explains these so that the lay reader can better understand them. Cleaver also relies on using aviators' personal experiences to explain the issues. One that initially plagued VIII FC was lack of range. Its fighters did not have the fuel capacity to escort heavy bombers all the way to targets deeper and deeper into Axis-held territory. Increasing fighter fuel capacity by using drop tanks allowed the fighters to fly to Berlin and back. The Luftwaffe no longer had any safe haven from American fighter attack.

A shift in fighter tactics also increased the German's loss of safe haven. When Lt Gen Doolittle took command, VIII FC focus shifted. After seeing a sign in headquarters that read, "The First Duty of the Air Force Fighters is to Bring the Bombers Back Alive!," Doolittle immediately replaced it with one that read, "The First Duty of Eighth Air Force Fighters is to Destroy German Fighters"—a significant shift in fighter employment. No longer would they be tethered to American bombers. Rather, bombers became the bait to attract the Luftwaffe. US fighters would ultimately protect US bombers by engaging the Luftwaffe wherever the Germans could be found—in the air or on the ground.

Senior Allied leaders understood that a successful cross-channel invasion required Allied air superiority. The Luftwaffe had to be destroyed. American industrial efforts produced more fighter and bomber groups. By June 1944, Allied fighters had achieved the necessary air superiority over Normandy. By the end of the war, VIII FC had grown to 15 groups. In three years of air combat, these had destroyed over 9,000 enemy aircraft. The *Luftwaffe* and Germany were defeated.

Clean Sweep is primarily the tactical history of VIII FC. Cleaver heavily relies on the use of "there I was stories." With a liberal use of quoting both American and *Luftwaffe* aviators, he clearly recognized the benefit of allowing the participants to tell their stories in their own words. This is a strength of the book. He used over 20 interviews with aviators as well as previously published memoirs.

Unfortunately, several obvious errors detract from the book. Two different incorrect dates are given for the first US bomber raid on the Roeun-Sotteville railyard in France. In one location, metres are converted to feet incorrectly. The errors are most likely typographical but were not caught during editing. This raises questions about what other dates and numbers presented as facts are incorrect or misprinted.

Despite these errors, *Clean Sweep* is an enjoyable and engaging book. The reader is immersed into the Command's brutal air war. Telling the complete history of the VIII FC in only 464 pages is an exceptionally challenging task. While not perfect, Cleaver's work is a solid effort to share the unit's impressive history.

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

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Only the Light Moves: Flying Covert Reconnaissance Missions in the Vietnam War. By Francis Doherty. Barnsley UK: Pen & Sword Books, 2023. Photographs. Bibliography. Pp. 206. $32.95. ISBN: 978-1-39905-701-1

Doherty served as an Army Captain who flew reconnaissance missions in a Cessna O–1 Bird Dog over the Ho Chi Minh trail during the Vietnam War. Once his Army commitment was finished, he became a commercial pilot for 32 years. He has written short stories and essays that have appeared, or are forthcoming, in *Creative Nonfiction, WLA Journal, Vietnam, and Western Airlines*.

This book gives an excellent summary of Doherty's military career as well as life afterward. He begins with an essay printed in *The Journal of Creative Non-Fiction* that gives a harrowing snapshot of living in a forward operating base and flying the O–1 in combat. This short, gripping, and emotionally riveting essay grasps the reader and does not let go and provides a preview of the body of the book.

Doherty had a love for flying heavily influenced by his father, a B–24 pilot in World War II and a commercial pilot. After graduating from college, he volunteered for the Army, hoping to get a flying assignment. Of course, he was assigned to the 3rd Armored Division in Bavaria. However,

armor had two fixed-wing training slots in every class, and he soon transitioned. Flight school consisted of learning how to fly the O–1, a two-seat liaison and observation aircraft. The Bird Dog's mission was reconnaissance, marking enemy ground positions with smoke rockets and directing attacks by fighter bombers, and other tasks. This book is divided into an opening essay, 18 chapters, and a section entitled "Last Words." The book is laid out so that it follows his ten-month assignment in Vietnam as part of the Second Platoon, 219th Airplane Reconnaissance Company, out of Kon Tum Province in the northernmost part of the Central Highlands region.

Each chapter describes flying over the region, specifically the Ho Chi Minh trail. Doherty nicely incorporates personal touches into every chapter including his close relationships with his family and comrades in arms and the emotional struggles that he had while completing his tour of duty. He describes, in detail, the harrowing missions that he flew as part of the Studies and Observation Group over the trail at tree-top level, all the while taking small-arms ground-fire from North Vietnamese Army troops. The Bird Dog also had a rear seat for an observer, and Doherty describes what it was like for the observer on various flights.

Once he left the Army, he was hired as a commercial pilot at Western Airlines (later absorbed by Delta). Doherty relates a rather light-hearted anecdote during his orientation and group school at Western. Each new student was to stand and give their aviation history. Doherty was the only Army pilot in the room. He described his O–1 missions. The instructor said, "And you have no jet time?" Doherty answered "no," and the instructor replied, "Mr. Doherty, I'm afraid you're going to have a hard time." Doherty went on to fly for Delta for 32 years, becoming a captain.

This book is very well written. Doherty writes from the heart. The descriptions of his missions are nothing less than hair-raising. He describes his struggles with coming to grips with the war and the senseless death of so many young men. As with many Vietnam War veterans, the war left him emotionally scarred. I highly recommend this book.

John Hladik, Columbus IN

The Eyes of Malta: The Crucial Role of Aerial Reconnaissance and Ultra Intelligence, 1940-1943. By Salvo Fagone. Warwick UK: Helion & Co., 2023. Maps. Tables. Diagrams. Photographs. Appendices. Bibliography. Pp. vii, 395. $44.30 paperback. ISBN: 978-1-804512-41-8

With an academic background in information technology, Fagone works as an analyst for a leading energy company. A native of Sicily, he has written numerous books and articles in Italian about World War II airpower, emphasizing the Mediterranean Theater. In recent years, he has begun researching the fate of American aviators lost during Operation *Husky*, the Allied conquest of Sicily.

In this effort, he examines, in daily detail, aerial operations in and around Malta and Sicily from 1940 to 1943. The title is a bit misleading, as he covers air-to-air engagements and bombing missions as well as aerial reconnaissance (recce).

Fagone proceeds chronologically. He initially reviews the status of aerial reconnaissance before the outbreak of the European portion of World War II in September 1939. He turns to the Central Mediterranean after Italy entered the war in June 1940. Here he examines the Italians' use of recce aircraft and the British focus on maritime patrols.

In the summer of 1940, Britain's aerial inventory verged on the breaking point. However, the British leadership realized the value of Malta's location between southern Italy, Sicily, and North Africa. From Malta, the Royal Air Force (RAF) first operated Martin Marylands, a twin-engine light bomber originally purchased by the French beginning in September 1940.

The Marylands were mismatched against German and Italian fighters. The RAF improved its recce capability with photo reconnaissance (PR) Hawker Hurricanes, which also were inferior to Germany's Messerschmitt Bf 109s. Nevertheless, they pressed on during the relentless German and Italian aerial attacks on Malta in 1941 and 1942.

With the Allied invasion of Vichy French-controlled northern Africa in November 1942, the assault on Malta began to diminish at the same time as the RAF was building up its bomber and fighter force. During the North African campaign, recce assets operating out of Malta played a key role in monitoring Axis air bases and ports on both sides of the Med as well observing marine traffic.

In 1943, the US Army Air Forces augmented the far more experienced RAF recce units with the forming of the multinational North African Photo Reconnaissance Wing. By then, the RAF was using Supermarine Spitfires and De Havilland Mosquitos, whereas the US primarily contributed the Lockheed F–5A and F–5B Lightning, derived from the P–38 fighter.

As might be expected given the author's Sicilian roots, about half the book deals with the preparation and execution of Operation *Husky.* All types of bombing missions—airfield suppression, port strikes, anti-shipping, road and railroad cuts, and close air support—are treated in detail with recce missions when applicable.

This book is highly recommended for students of the Mediterranean Theater. Besides accessing secondary sources, Falcone utilized Sicilian newspaper accounts as well as culling material from the national archives of several nations.

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

White Sun War: The Campaign for Taiwan. By Mick Ryan. Havertown PA: Casemate, 2023. Maps. Pp. xii, 340. $22.95. ISBN: 978-1-63624-250-7

Rarely does a review of a combat or science-fiction book appear in a scholarly journal, but Mick Ryan's novel merits this exceptional status. Written by a strategist and retired major general from the Australian Army, it first came to my attention when the National Security Space Institute (NSSI) released its 2024 Space Professional Reading List, which contained six new titles including *White Sun War*. A search revealed reviews of Ryan's book, published in May 2023, already had appeared in Air University's *Air & Space Power Journal*, in the Department of the Air Force *Journal of Indo-Pacific Affairs*, and in other well-known military periodicals.

While readers should remember speculative fiction is different than a rigorously researched history, a well-written novel can stir discussion among thoughtful readers who might have succumbed to slumber by trying to read the latter. Furthermore, Ryan has chosen to look into the possible—some would say probable—future, where most historians fear to tread. From the perspective of 2038, a decade after China launched a major war to conquer Taiwan, the storyteller lays out in surprising detail how the United States and other partners supported the Taiwanese to thwart mainland China's devastating invasion.

During four months in the summer of 2028, multidomain warfare involving highly sophisticated, fully integrated US land, sea, air, space, and cyber capabilities, augmented with artificial intelligence (AI), mounted a technologically stunning, cutting-edge response to advancing Chinese human and robotic forces. Joint planning and operations narrowly enabled a successful campaign against Chinese aggression.

Without divulging too many juicy details, purposely left for readers to discover on their own, suffice it to tell that US Space Force (USSF) and US Air Force (USAF) systems and personnel became major contributors to successful US Army, Navy, and Marine Corps engagement with the adversary. From employing Geosynchronous Space Situational Awareness Program (GSSAP) satellites that monitored the behavior of Chinese satellites, to "acquiring" an orbiting Chinese spacecraft that supported quantum-encrypted communication networks, USSF Guardians, who supported the US Space Command every day, became engaged even before the fighting began. In Operation *Grey Wizard*, the Guardians helped mask the transit of a US naval task force to Taiwan and, later in the saga, performed cislunar reconnaissance prior to coordinating closely with four other US clients and international partners who helped make a typhoon disappear in Operation *Chakra Rain*.

Lest the yarn Ryan has spun in *White Sun War* seems too fanciful, readers who finish his novel might find worthwhile a scholarly report released by the Center for Strategic and International Studies (CSIS) in January 2023. Titled "The First Battle of the Next War: Wargaming a Chinese Invasion of Taiwan," this document explicates a narrowly successful outcome—not unlike the one described in Ryan's book—favoring survival of an independent Taiwan, at least for the near term. Both the speculative novel and the scholarly report deserve thoughtful contemplation as the Department of Defense shifts its focus to renewed Great Power Competition.

Dr. Rick W. Sturdevant, Director of History, HQ Space Training and Readiness Command

El Salvador, Vol 1: Crisis, Coup and Uprising. and **Vol 2: Conflagration.** By: David Francois. Warwick UK: Helion and Company, 2023. Maps. Diagrams. Illustrations. Photographs. Notes. Bibliography. Pp: 80 each. $29.95 paperback each. ISBN: 978-1-804510-30-8 and 978-1-804512-18-0

Francois's two-volume set on El Salvador is an exceptional accomplishment. As part of Helion's "Latin America at War" series, the books offer a clear and concise description of a civil war on America's doorstep. As I read the books, I could dredge up vague memories of names, places, and events—memories most likely implanted by television news anchors. The habit of the same news outlets simplifying Spanish-language names into a myriad of acronyms only further confused memories. While he uses the same acronyms, Francois does an excellent job offering an entry-level survey of an extraordinarily brutal civil war that lasted for two decades.

While I found Francois's attempt to establish the Spanish conquest of Central America as setting the stage for the civil war to be forced, there is no question that the eventual Salvadoran societal economic polarization did plant the seeds of violence. The ultra-conservative elites did not hesitate to repress any expression of political thought that threatened their suzerainty. And, in the mid-twentieth century, the resultant class struggle would take place within the context of the Cold War with the attendant proxy wars. Francois does an excellent job creating a clear and concise narrative that is usually understood easily. Volume 1 sets the stage for Volume 2.

The breadth and depth of the conflict described in Volume 2 is breathtaking in its violence and brutality. At some point, the US decided that the El Salvadoran government must survive and could not be allowed to fall to the anti-government Marxist guerillas. Massive amounts of military equipment and training were provided, seemingly with no "end use" questions asked. The US Military Group provided hardware and financial resources to equip government and quasi-government militias with every conceivable piece of military hardware from radios to aircraft

to uniforms and transports. The financial aid allowed the government to buy everything from armored cars to attack-aircraft and associated weapons. Francois makes the case that the intent was to prop up the government and societal institutions long enough for social and political reforms to take effect and erode the guerillas' bases of support over time.

The peace agreements signed in 1992 put an end to the violence that racked El Salvador for decades. But the astute reader will realize that the accords followed closely on the heels of the collapse of the Soviet Union and the attendant loss of revolutionary resources. But even with the accords, Francois notes that it wasn't until the elections in 2009 that the civil war was "over."

These two volumes are meticulously researched and cited. Francois does allow his personal political and societal views to creep into the narrative, but the civil war as described was so brutal and polarizing, that I believe any reader will have strong opinions by the last page. The photography included is nicely curated and adds to the story. Helion includes its *de rigueur* color plates. I found the plates more of a distraction from the serious narrative. The notes and bibliography are extensive. As I prepared to pen this review, I wondered how much the Salvadoran gangs (e.g., Mara Salvatrucha (MS-13), 18th Street, Sombra Negra and Rebels 13) that are rampant in some US cities trace their roots to the violence of the civil war. Francois mentions that many guerilla documents are available on *Marxist.org*. I couldn't find that site, but I did find a *Marxists.org* site that offers various revolutionary documents in several languages. Maybe I'll do a deep dive some cold winter's night and see what 21st-century revolutionaries are thinking.

Gary Connor, Cortland OH

USAFE Tactical Units in the United Kingdom in the Cold War 1950-1992. By Doug Gordon. Stroud UK: Fonthill. 2022. Photographs. Glossary. Notes. Bibliography. Appendixes. Pp. 380. $60.00. ISBN: 978-1-78155-860-7

From an early age, aviation author Doug Gordon was fascinated by the US Air Force airplanes he saw flying overhead. Living next to RAF Bentwaters and Woodbridge, seeing American aircraft was a very common occurrence for him. This fascination with flying manifested itself in the long-term effort this book represents.

Gordon shares the history of the seven main tactical wings and four significant squadrons that were stationed in the United Kingdom. The seven tactical wings were the 81st TFW, 406th FTW, 47th BW, 20th TFW, 48th TFW, 10th TFW, and 66th TRW. The four significant tactical squadrons were the 42nd ECS, 420th ARS, 527 Aggressors, and the Skyblazers aerial demonstration unit. Gordon also includes a chapter on Tactical Air Command deployments to the UK. In each chapter, he lays out a tactical unit's history from standup to the modern day including moving out of the UK. Gordon's work is more than just a fact sheet, boilerplate history of these units. To bring the unit histories to life, Gordon mixes in a combination of historical narratives and "there I was" stories to share the history of these units. Mixed in with each wing or unit capture are numerous pictures specific to that unit: pictures that include both unit aircraft and personnel. What results are chapters that are both informative and engaging.

In addition to the chapters on the wings and significant squadrons, Gordon includes eight appendixes. He uses the appendix to provide additional technical data, such as the main aircraft assigned to the various units as well as support aircraft assigned. The remaining appendixes are used to discuss major events that affected all of the USAFE tactical units in the UK. These events included the policy of "Massive Retaliation" and "Flexible Response," the Hungarian Uprising, *Able Archer 83*, the Cuban Missile Crisis, Suez Crisis, and France leaving NATO.

In addition to the photos included within each chapter, Gordon includes a rather large color photograph insert section. The section is double the size of what readers normally would find in a book of this type and are primarily focused on the aircraft and patches of the various organizations. All of the images are high-quality and cover the complete Cold War period.

The combination of Gordon's text and large number of photos creates a thoroughly enjoyable history of the USAFE tactical units in the UK. Readers who crave more details and readers who crave more stories will both be pleasantly pleased. Gordon clearly went to great lengths to capture the numerous "there I was" stories. They bring each unit's history to life. His well-curated selection of photographs accents the text to build the complete story of each unit. This book should appeal to both aviation history readers and students of the Cold War. Based on the quality of this project, Gordon will, hopefully, write a similar work on USAF strategic units in the UK during the Cold War.

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

Pathway to the Stars: 100 Years of the Royal Canadian Air Force. By Michael Hood and Tom Jenkins. Toronto, Canada: University of Toronto Press, 2023. Illustrations. Photographs. Maps. Appendices. Bibliography. Index. Pp. xv, 248. $39.95. ISBN: 978-1-4875-4743-1

This is a beautiful book in both appearance and content. On 1 April 1924, the Royal Canadian Air Force was officially founded. The book tells the story of that illustrious organization and is a fitting tribute to its first century of operations.

And who better to tell this story than former Commander of the RCAF, Lt-Gen Michael Hood (2015-2018) and his co-author—a man with 50 years' affiliation with the RCAF—Tom Jenkins. Between them, they have experienced many varied facets of the service over nearly half of its existence.

In the First World War, Canada had no formal air force. Thousands of Canadians served in the Royal Air Force and its predecessor services. Anyone vaguely familiar with that war knows the names of Bishop and Barker—two among 82 Canadian aces—and both awardees of the Victoria Cross.

"Royal" was added to the small Canadian Air Force that was created after the war, and the RCAF was born. In the interwar years, it was primarily involved in opening up the huge country: photography, map making, rescues, transporting people and goods to the remote wilderness, and assisting law enforcement all contributed. A long association with the National Research Council began that has successfully led to many technical aerospace innovations.

Canada was determined to field its own forces in World War II. RCAF units served under the umbrella of the RAF but fought as Canadian units. No. 6 (Bomber) Group flew missions from ten bases in the UK. Another 15 squadrons flew fighter and attack missions. At home, the RCAF also had to defend Canada's vast coastline; and it provided what may have been the country's greatest contribution to the war effort: the Commonwealth Air Training Program that trained over 130,000 Allied pilots.

During the Cold War, the RCAF maintained an air presence in the skies over NATO. It also became, and remains, a full-fledged partner in continental defense against incoming bombers and missiles. Radar picket lines, manned interceptors, surface-to-air missiles, and joint manning of the North American Air Defense Command (NORAD) fell within the purview of the RCAF.

In the past several decades, the RCAF has become a fully expeditionary force. It has participated in numerous humanitarian and peacekeeping operations and has been a close ally with the US military in many major operations.

This isn't, however, just the story of weapons and operations. It is the story of people—men, women, Indigenous Peoples, minorities, and LGBTQ members—who have all shared in the history of the RCAF. The authors tell some stories; the people themselves tell others. In fact, this book centers around the people who have made the formidable RCAF what it is today. It is filled with high-quality pictures of all facets of RCAF life, the majority of which show people.

Hood and Jenkins have written a book that honors our neighbor and partner to the north. Happy birthday RCAF! May you enjoy many more decades of success.

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

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Fight for the Final Frontier: Irregular Warfare in Space. By John J. Klein. Annapolis MD: Naval Institute Press, 2023. Photographs. Diagrams. Notes. Bibliography. Index. Pp. xxii, 242. $34.95. ISBN: 978-1-55750735-8

Military strategists and policy analysts have long acknowledged and attempted to reckon masterfully with activities in that large, ill-defined "gray zone" between blissful peacetime and undesirable major force-on-force engagements. In *Fight for the Final Frontier*, John Klein, a retired US Navy commander, senior fellow and strategist with Falcon Research Incorporated, and adjunct professor at George Washington University's Space Policy Institute, offers concepts associated with irregular warfare in other domains—air, land, and sea—as a refreshing way of understanding and reckoning with adversarial behaviors in the space domain. He provides a solid intellectual basis for preparing the United States and its allies to endure competitively against rivals, such as Russia and China, without triggering a conventional war in outer space.

Klein emphasizes the value of delving deeply into historical experiences "to equip humanity to consider a range of potential futures regarding irregular space warfare." He plumbs past military, especially naval, history to reveal irregular warfare as vital in both the maritime and space domains, "albeit now mostly ignored in U.S. naval history." Referring to Charles Callwell's *Small Wars* (1896) as "illuminating for irregular warfare in space," Klein asserts that irregular or small space wars "will be conducted using methods and styles differing from those of major, conventional wars." He combines the enduring wisdom of Sun Tzu and Clausewitz with lessons drawn from countless conflicts over more than two millennia.

Based on his study of history, Klein discerns what most readers might perceive as truisms but that might, upon further reflection, merit careful consideration. For example, he declares, "If irregular actions lack significant consequences for one's access to and use of space, then no resources or efforts need be devoted to countering them." *Fight for the Final Frontier*, a volume densely packed with similar conceptual tidbits, merits deliberate rereading and serious contemplation, particularly since Klein himself has difficulty defining the term "irregular warfare" and resorts to synthesizing it as "conflict apart from major, conventional wars."

Since he is familiar with the latest thinking of senior leaders across the US Space Force and quotes or cites their remarks throughout his book, he completely understands the challenges of thinking in terms of—not to mention making plans for—irregular warfare in space. Near the beginning of his treatise, considering "time as a weapon," he quotes Colin Gray observing, "The Western theory of war and strategy pays too little attention to war's temporal dimension." Later, in his own words about the traditional American style of warfare and its pitfalls, Klein sees the US military as optimized for big, traditional wars, reliant

on technological superiority, and impatiently eager for quick, decisive victory. He finds this ill-suited to the kind of protracted strategy necessary for success in long-term irregular warfare.

Fight for the Final Frontier, however, concludes with a section emphasizing the critical importance of educating America's space warriors in terms of integrated irregular and regular warfare and cultivating public support for decades of space competition with dangerous adversaries, such as China and Russia. Klein outlines ten counter-strategies for the United States to succeed against adversaries using irregular warfare techniques and, in his next-to-last paragraph, confidently asserts, "A well-read space force and historically informed space strategy can avoid much loss in both blood and treasure, a goal for anyone in the business of warfare."

Dr. Rick W. Sturdevant, Director of History, HQ Space Training and Readiness Command

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Rooks in Afghanistan - Volume 1: Sukhoi Su-25 in the Afghanistan War, 1981-1985. By Andrey Korotkov. Warwick UK: Helion & Co, 2023. Photographs. Illustrations. Bibliography. Notes, Appendix. Maps. Tables. Glossary. Pp. viii, 72. $29.95 paperback. ISBN: 978-1-804510-13-1

This fascinating book covers development of the Su-25, training of flight and support crews, development of tactics, and initial employment in Afghanistan. Official reports, intimate personal stories and anecdotes, and never-before-seen photographs from personal collections provide a wealth of information for military and aviation historians.

The birth of the Su–25 Rook (Raven) is directly associated with Soviet realization that fighter-bombers and battlefield missiles were not going to satisfy the need for troop close support. In August 1968, ground-attack aviation was revived, and a requirement for a specialized armored assault aircraft was announced. The Sukhoi Su–25 and Ilyushin Il–102 competed until Sukhoi was declared the winner in 1975. Production began in 1978 in Tbilisi, Georgia.

After Soviet military entry into Afghanistan in 1979, an experimental air squadron was formed that included the pre-production Su–25. It was sent to western Afghanistan from March-June 1980 under Operation *Rhombus*. After 100 sorties and nearly 99 hours of flight time, the Su–25 was recommended for full-scale production in December. Training and tactics development commenced as well.

In June 1981, the recently designated 200th Independent Attack Aviation Squadron deployed to western Afghanistan with a full table of organization, equipment, and personnel to begin its first one-year combat deployment. Early operations revealed poor aircraft quality. Ground and flight crews were constantly making corrections, improvements, and alterations to delivered aircraft and communicating these to the factory where they would implement changes on the production line.

The squadron deployed to other airfields in Afghanistan—most notably Bagram near Kabul—to expand combat operations in support of ground troops. These forces became enamored of Su–25 support. The aircraft would always remain over the battlefield or escort a convoy as long as possible, following up bombing runs with strafing or missile runs to keep opposing-force action to a minimum. This was not without consequences, as many Su-25s returned with small-arms or heavier damage; and some aircraft and pilots were lost as anti-aircraft weapons became more potent and sophisticated. Owing to their armor protection, many Su–25s did return to friendly airfields (as evidenced by many of the photographs) and were able to fly in combat again.

However, the aircraft often did not fare as well against nature. The very primitive conditions in Afghanistan included temperatures often reaching 122°F and omnipresent sand that eroded engine turbine blades and managed to get into the fuel systems.

Volume 1 wraps up as the 200th IAAS became the 378th Independent Attack Aviation Regiment. In 1984-85, it flew 10,500 combat sorties with the loss of three pilots and two Su–25s.

Each of the book's six chapters is full of excellent maps, photographs, graphics, and text that well describe development and operation of the Su–25 during this period. The Glossary and Abbreviations section is essential to follow Soviet unit and equipment designations. There are a few typos; but, overall, this volume is an outstanding addition to the library of aviation historians and modelers. I look forward to Volume 2, which will cover 1985-1989.

Tim Hosek, USG (Ret) and former National Air and Space Museum docent

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Sunderland vs. U-Boat: Bay of Biscay, 1943-44. By Mark Lardas. Oxford UK: Osprey, 2023. Maps. Tables. Diagrams. Photographs. Bibliography. Index. Pp. 80. $23.00 paperback. ISBN: 978-1-4728-5481-0

Lardas, who formerly worked on the Space Shuttle program, has been a consistent contributor to Osprey's various series in recent years. As with his previous books that examined the impact of air power on naval operations and sea control in the Pacific and Atlantic in World War II, this subject is a natural for Osprey's popular *Duel* series.

Once Osprey embarks on a series, the company sticks to the same format for each volume. After an introduction

and chronology, the subject matter follows a topical approach. Lardas begins by examining the development of the Short Sunderland flying boat and the most numerous types of U-boats employed by the Germans in 1943-44.

In the next section, he addresses the technical characteristics of the Sunderland and the U-Boat. Here he explains the plusses and minuses of the weapons employed by the Sunderland. This aircraft had its greatest success with depth charges. Over the years, the Germans mounted increasingly lethal anti-aircraft guns on their subs. They also developed passive early-warning receivers that detected air-to-surface radar.

Lardas summarizes the strategic situation. In the war's early years, Britain lacked resources and tactics. After the Germans captured the French ports on the Bay of Biscay in 1940, Britain's situation became even more perilous. By the end of 1942, the subs were losing their advantage. The convoy system improved. The long-range Consolidated Liberators made operations in the North Atlantic, previously a happy-hunting ground, less effective.

After a chapter looking at the personnel situation, he turns to tactics. In the book's longest and most interesting chapter, he details the Sunderland's combat successes and U-boat losses. He includes excerpts from biographies that describe engagements from both sides.

Lardas concludes with a statistics-and-analysis section and brief mention of surviving Sunderlands and U-boats.

The technology employed by both sides represents one of the best "cat-and-mouse" aspects of World War II. Several other elements could have been included: the impact of the Enigma intercepts divulged through Ultra; and the German counterair effort using, primarily, long-range Junkers Ju 88s. That is probably why the Sunderlands tended to concentrate their patrols on the southeast portion of the Bay of Biscay, as far as possible from German airbases. But, overall, this book is an excellent introduction to the impact of the Royal Air Force's Coastal Command on the U-boat campaign.

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

RAZOR 03: A Night Stalker's Wars. By Alan C. Mack. Yorkshire-Philadelphia: Pen and Sword, 2022. Map. Photographs. Glossary. Pp. x, 245. $34.95. ISBN: 978-1-39901869-2

Alan Mack was a "Night Stalker," MH–47 Chinook pilot in the 160th Special Operations Aviation Regiment (SOAR), from 1993 to 2012. He began flying Chinooks fresh from flight school in 1990 and almost immediately deployed to Saudi Arabia for Operation *Desert Shield*. Following *Desert Storm*, he instructed on the Chinook before, in 1995, qualifying for the 160th SOAR, where he remained for the next 17 years.

The first chapters cover his helicopter background prior to his deployment on Operation *Enduring Freedom* in the very earliest stages. This includes flight school, *Desert Shield* and *Desert Storm*, his time as an instructor, and training up for the 160th. Even there, the pace moves along well: a reader won't want to put the book down.

The largest part of the story is about his missions in northern Afghanistan, and Mack does an excellent job of maintaining the tension. He covers the high points as well as the lows thoroughly; and a reader has a sense of—if not being there—looking over Mack's shoulder.

Interspersed throughout are his brief periods at home, where his wife was stressing out; and he was trying to keep her together as she slid into alcoholism and drug addiction. Even there, he pulls no punches. After her death, he left the Night Stalkers for a posting as commander of the West Point Flight Detachment, the posting from which he retired.

His high opinion of the Chinook is evident throughout. I only wish this book had come out earlier so my father, who was part of the original Chinook design team at Vertol and continued providing engineering support to it and the CH–46 *Phrog* the rest of his career, could have read it. The only shortcoming I can think of is that, though there is a glossary, too many of the acronyms aren't in it. No doubt they're part of the jargon that we all forget that not everyone knows. But keep a notecard handy while you read and jot down any unfamiliar terms. You won't regret reading this.

Jon Barrett, volunteer photographer/researcher, National Air & Space Museum

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

July 3-7, 2024
The International Organization of Women Pilots, better known as **The Ninety-Nines**, will hold its annual International Conference and Career Expo at the Pinnacle Harbourfront Hotel in Vancouver, British Columbia, Canada. More information can be found at What We Do - Advancing Women Pilots (The Ninety-Nines, Inc.).

July 15-17, 2024
The **American Astronautical Society** will present its annual Glenn Space Technology Symposium at Case Western Reserve University in Cleveland, Ohio. For additional information, see the Society's website at John Glenn Memorial Symposium | American Astronautical Society.

September 18-19, 2024
The **NASA History Office** will coordinate a symposium entitled "NASA and Archaeology From Space" to honor the pioneering work of former NASA archaeologist Dr. Thomas L. Sever in the field of archaeology and remote sensing over his many decades of service. The symposium seeks to highlight past archaeology projects at NASA, the current state of the field, and promising new opportunities in multiple sectors. The symposium will be held in Washington, D.C. For more details, see the Office's newsletter at NASA History - NASA.

November 4-7, 2024
AFHF will offer its Air Force Historical Foundation Symposium, Literary Awards, and Museums Conference at the Doubletree by Hilton Tucson - Reid Park, 445 South Alvernon Way, Tucson, AZ 85711-4198. The theme for the Conference is "Technological Change in the Air and in Space, 1920-2020," and is being co-hosted by the Pima Air and Space Museum. For registration and other information, reach out to the Foundation at Richard Beckerman (afhistory.org).

November 7-10, 2024
The **History of Science Society** will hold its annual meeting in Mérida, Yucatán, Mexico. This is the Society's centennial, and the theme of this year's gathering is "**Imperfect Pasts, Uncertain Futures**." For more details, see the Society's website at HSS 2023 Call for Proposals - History of Science Society (hssonline.org).

November 21-23, 2024
The **National World War II Museum** will host its 17th annual conference at the Museum in New Orleans, Louisiana. The program for this year's gathering will begin with a symposium on "The Battle of the Bulge, 80 years on." For details and registration, see the Museum's website at 17th International Conference on World War II | The National WWII Museum | New Orleans (nationalww2museum.org)

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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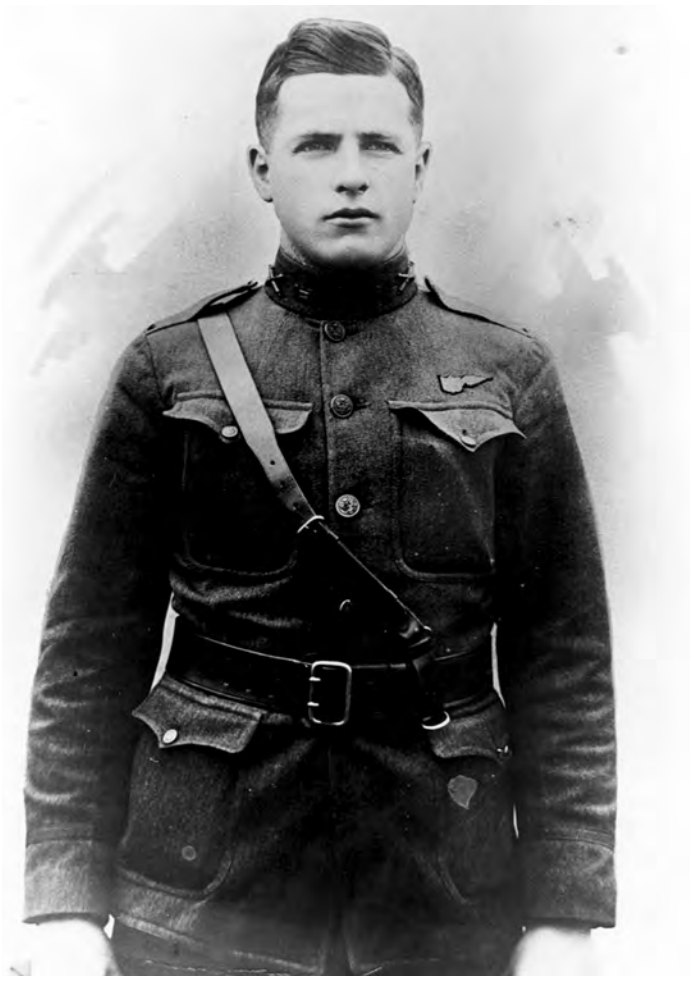
Guidelines for Contributors—We seek quality articles—based on sound scholarship, perceptive analysis, and/or firsthand experience—which are well-written and attractively illustrated. If a manuscript is under consideration by another publication, the author should clearly indicate this at the time of submission. Manuscripts should be prepared according to the Chicago Manual of Style (University of Chicago Press). Use civilian dates (month, day, year) and either footnotes or endnotes may be used. Because submissions are evaluated anonymously, the author's name should appear only on the title page. Authors should provide on a separate page brief biographical details, to include institutional or professional affiliation and recent publications, for inclusion in the printed article. Pages, including those containing illustrations, diagrams or tables, should be numbered consecutively. Any figures and tables must be clearly produced ready for photographic reproduction. The source should be given below the table. Notes should be numbered consecutively through the article with a raised numeral corresponding to the list of notes placed at the end. Submissions may be submitted either by mail or via email. Email is generally the norm. While Microsoft Word is the most common, any word processor may be used. Do not "Track Changes." Photographic illustrations are greatly appreciated. There is no restriction on the file format used. There is no standard length for articles, but 4,500-5,500 words is a general guide. Manuscripts and editorial correspondence should be sent to Richard Wolf, Editor, c/o Air Power History, 70 Shannon Way, Upton, MA 01568, e-mail: airpowerhistory@yahoo.com.

History Mystery Answer



Answer: At the start of World War I, the United States military did not have any aircraft capable of flying combat. The hundred or so aircraft in the Aviation section of the Signal Corp were obsolete. With the U.S. entry into the war, the War Department looked for a producable aircraft. Because of its simple design, they chose the DeHavilland DH–4. The DH–4 had a crew of two: pilot and observer/gunner. Known as the "Liberty Airplane, the U.S. had the DH–4 built by three manufacturers: Dayton-Wright, the Fisher Body Division of General Motors, and the Standard Aircraft Corporation. The first American DH–4s arrived in Europe in May 1918. The 50th Aero Squadron was one of the American units to fly the DH–4. The DH–4 served as an artillery spotter, observer, and daylight bomber.

On October 6, 1918, Lts Erwin Bleckley and Harold Goettler flew in search of the Lost Battalion of the 77th Division. They located the Lost Battalion, and began to drop supplies to the surrounded unit. While on their second supply drop mission, Goettler flew their DH–4 low to the ground to increase their airdrop accuracy. Well within range of the German gunners, their DH–4 was shot down by German ground fire. Both men were killed. For their actions, they were awarded the Congressional Medal of Honor.

Use the following links to learn more about the following topics;

DH–4 https://airandspace.si.edu/collection-objects/de-havilland-DH-4/nasm_A19190051000 **and**
https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/197397/de-havilland-DH-4/

Lt Erwin Bleckley CMOH Citation
https://www.cmohs.org/recipients/erwin-r-bleckley

Lt Erwin Bleckley
https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196834/lt-erwin-r-bleckley/

Lt. Harold E. Goettler CMOH Citation
https://www.cmohs.org/recipients/harold-e-goettler

Lt. Harold E. Goettler
https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196835/lt-harold-e-goettler/

The Lost Battalion
https://www.worldwar1centennial.org/index.php/233-lost-battalion.html

New History Mystery

by Dan Simonsen

This Issue's Quiz: Question: Today the 50th Attack Squadron flies MQ–9 Reapers. The squadron can trace its heritage back to the first World War. The capabilities of the MQ–9 would likely been unimaginable to World War I airmen. Two 50th Aero Squadron crewmen were posthumously awarded the Medal of Honor for their efforts in October 1918. For this month's question, what was the airplane the 50th Aero Squadron flew during World War I, specifically when the two airmen won the medal of honor. Can you name the two airmen?

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