

# AIR POWER

FALL 2017 - Volume 64, Number 3  
WWW.AFHISTORY.ORG

# History

know the past  
.....*Shape the Future*





## The Air Force *Historical* Foundation

Founded on May 27, 1953 by Gen Carl A. “Tooey” Spaatz and other air power pioneers, the Air Force Historical Foundation (AFHF) is a nonprofit tax exempt organization. It is dedicated to the preservation, perpetuation and appropriate publication of the history and traditions of American aviation, with emphasis on the U.S. Air Force, its predecessor organizations, and the men and women whose lives and dreams were devoted to flight. The Foundation serves all components of the United States Air Force—Active, Reserve and Air National Guard.

AFHF strives to make available to the public and today’s government planners and decision makers information that is relevant and informative about all aspects of air and space power. By doing so, the Foundation hopes to assure the nation profits from past experiences as it helps keep the U.S. Air Force the most modern and effective military force in the world.

The Foundation’s four primary activities include a quarterly journal *Air Power History*, a book program, a biennial symposium, and an awards program.

## MEMBERSHIP BENEFITS

All members receive our exciting and informative *Air Power History Journal*, either electronically or on paper, covering all aspects of aerospace history

- Chronicles the great campaigns and the great leaders
- Eyewitness accounts and historical articles
- In depth resources to museums and activities, to keep members connected to the latest and greatest events.

Preserve the legacy, stay connected:

- Membership helps preserve the legacy of current and future US air force personnel.
- Provides reliable and accurate accounts of historical events.
- Establish connections between generations.



# AIR POWER

Fall 2017 - Volume 64, Number 3  
WWW.AFHISTORY.ORG

# History

know the past  
....*Shape the Future*

Features	Leaflets, Loudspeakers and Radios, Oh, My! <i>Robert J. Kodosky</i>	5
	Reentry Vehicle Development Leading to the Minuteman Avco Mark 5 and 11 <i>David K. Stumpf</i>	13
	The French Pilot Training Experience at Oscoda Army Air Field During World War II <i>David K. Vaughan</i>	33
	Operation Vittles: The Berlin Airlift <i>Daniel L. Haulman</i>	47

---

Book Reviews	<i>Fighter Pilot</i> By L. C. Beck, Jr.	Review by Robert Huddleston	52
	<i>Wings of Valor: Honoring America's Fighter Aces</i> By Nick Del Calzo & Peter Collier	Review by Steve Agoratus	52
	<i>Gear Up, Mishaps Down</i> By Robert F. Dunn	Review by Golda Eldridge	53
	<i>Fighters over the Fleet</i> By Norman Friedman	Review by Joseph Romito	54
	<i>The Flight: Charles Lindbergh's Daring and Immortal 1927 Transatlantic Crossing</i> By Dan Hampton	Review by Robert Huddleston	54
	<i>So Far from Home: Royal Air Force and Free French Air Force Flight Training at Maxwell &amp; Gunter...</i> By Robert B. Kane	Review by Steven D. Ellis	55
	<i>Fighter! Ten Killer Planes of World War II</i> By Jim Laurier	Review by Steve Agoratus	56
	<i>Hangar Flying, Below the Zone and Roles and Mission</i> By Merrill A. McPeak	Review by Golda Eldridge	57
	<i>Airpower Applied: U.S., NATO, and Israeli Combat Experience</i> By John Andreas Olsen, ed.	Review by John F. O'Connell	58
	<i>Marked for Death: The First War in the Air</i> By James Hamilton-Paterson	Review by Steven D. Ellis	59
	<i>Hidden Figures: The American Dream &amp; the Untold Story of the Black Women Mathematicians Who...</i> By Margot Lee Shetterly	Review by Lawrence R. Benson	59

Departments	President's Message	4
	Upcoming Events, Letters, and Reunions	61
	New History Mystery	64



**Air Force Historical Foundation**

P.O. Box 790  
Clinton, MD 20735-0790  
(301) 736-1959

**E-mail: [angelabear@afhistory.org](mailto:angelabear@afhistory.org)  
On the Web at <http://www.afhistory.org>**

**Board of Directors**

Lt Gen Christopher D. Miller, USAF (Ret.)  
Chairman  
Lt Gen Charles L. Johnson II, USAF (Ret.)  
First Vice Chairman  
Lt Gen Nicholas B. Kehoe, USAF (Ret.)  
Second Vice Chairman  
Lt Gen Charles R. Heflebower, USAF (Ret.)  
Secretary  
Col Thomas A. Owens, USAF (Ret.)  
Treasurer  
Col Clarence R. Anderegg, USAF (Ret.)  
Col Scott C. Bishop, USAF (Ret.)  
Col William J. Dalecky, USAF (Ret.)  
Lt Col (Dr.) Dik Daso, USAF (Ret.)  
Lt Gen Robert J. Elder, USAF (Ret.)  
CMSgt Robert L. Frank, USAF (Ret.)  
Lt Col Steven Gress, Jr., USAF (Ret.)  
Lt Gen Charles R. Heflebower, USAF (Ret.)  
Ms. Jonna Doolittle Hoppes  
Maj Gen Timothy C. Jones, USAF (Ret.)  
Gen Lloyd W. Newton, USAF (Ret.)  
MSgt Keith A. Reed, USAF (Ret.)

**Emeritus**

Maj Gen Dale W. Meyerrose, USAF (Ret.)  
Chairman

**Editor, *Air Power History***

Richard I. Wolf

**Editor Emeritus, *Air Power History***

Jacob Neufeld

**Staff**

Lt Col James A. Vertenten, USAF (Ret.)  
Secretary to the Board and  
Executive Director  
Mrs. Angela J. Bear, Office Manager

**Patron Members**

Col Gerald F. Christeson, USAF (Ret.)  
Col Dennis M. Drew, USAF (Ret.)  
Maj Gen Charles J. Dunlap, Jr., USAF  
Lt Col Raymond Fredette, USAF (Ret.)  
Dr. Rebecca Grant  
Dr. Jerome V. Martin  
Capt Robert Maxson, NOAA  
Lt Gen George D. Miller, USAF (Ret.)  
Mrs. Marilyn Moll  
Col Bobby Moorhatch, USAF (Ret.)  
Lt Col Raymond C. Tagge, USAF (Ret.)

**President's Circle**

Col William J. Dalecky, USAF (Ret.)  
Lt Col Kenneth W. Sublett, USAF (Ret.)

**Benefactor**

Mr. Darrell Dvorak

**DONATIONS**

Mr. Michael Clarke  
Lt Gen Robert J. Elder, USAF (Ret.)  
Lt Gen Nicholas B. Kehoe, USAF (Ret.)  
Gen Lloyd W. Newton, USAF (Ret.)  
Maj Gen Dale W. Meyerrose, USAF (Ret.)  
Lt Gen Christopher Miller, USAF (Ret.)  
Lt Gen Stephen Wood, USAF (Ret.)

**CORPORATE SPONSORS**

**Gold Level (\$10,000 or more)**

Lockheed Martin Corporation

**AIR POWER**  
*History*

The Journal of the  
**Air Force Historical Foundation**  
Fall 2017 Volume 64 Number 3

**Editor**  
Richard I. Wolf

**Editor Emeritus**  
Jacob Neufeld

**Book Review Editor**  
Scott A. Willey

**Advertising**  
Jim Vertenten

**Circulation**  
Angela J. Bear

*Air Power History* (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.

Address **LETTERS TO THE EDITOR** to:

Air Power History  
3043 Sunny Ridge Drive  
Odenton, MD 21113  
e-mail: [airpowerhistory@yahoo.com](mailto:airpowerhistory@yahoo.com)

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

Air Power History  
P.O. Box 790  
Clinton, MD 20735-0790  
(301) 736-1959  
e-mail: [angelabear@afhistory.org](mailto:angelabear@afhistory.org)

**ADVERTISING**

Jim Vertenten  
P.O. Box 790  
Clinton, MD 20735-0790  
(301) 736-1959  
e-mail: [ed@afhistory.org](mailto:ed@afhistory.org)

Copyright © 2017 by the Air Force Historical Foundation. All rights reserved.  
Periodicals postage paid at Clinton, MD 20735 and additional mailing offices.

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

In this issue, we cover a wide variety of topics, with the largest number of pages devoted to a slightly esoteric topic, ICBM re-entry vehicles.

Our first article is in keeping with our coverage of the conflict in Vietnam in this year of commemoration. Robert Kodolsky has provided a most interesting story on psychological operations in Vietnam, concentrating on the leaflet programs.

Our second article is by David Stumpf, a well-published author on missile operations, who has provided a lengthy, slightly scholarly piece on Minuteman missile re-entry vehicles. It did not appear to lend itself to being split over two issues, so it is shown here in its entirety.

Our third article is a follow-on piece by David Vaughan on aircrew training at Oscoda Field during World War II. He previously wrote on the Tuskegee Airmen training there, and here, he discusses Free French and Royal Air Force training that took place at Oscoda.

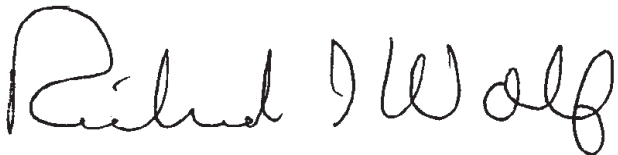
The fourth and final article is by a many times published contributor, Daniel Haulman, and his take on Operation Vittles, the Berlin Airlift in 1948-49.

As always, we include the usual accompanying book reviews, eleven reviews encompassing thirteen volumes, many of them rather intriguing. If you have read a book that seems to fit our subject category, and would like to contribute a review, take a look at the contact information on page 60 to send it to our book review editor.

Finally, we include our lists of upcoming historical conferences and events, reunions, and a letter to the editor, all starting on page 61.

Our next issue will include all of our annual award winners, as well as news of the proceedings surrounding the winners receiving their awards. If you plan to attend the award banquet and ceremonies, be flexible and check our web site regularly at [www.afhistory.org](http://www.afhistory.org).

Don't miss the Message from the President on the page following as our new Foundation President settles into office. Hope you enjoy it all.



*Air Power History* and the Air Force Historical Foundation disclaim responsibility for statements, either of fact or of opinion, made by contributors. The submission of an article, book review, or other communication with the intention that it be published in this journal shall be construed as prima facie evidence that the contributor willingly transfers the copyright to *Air Power History* and the Air Force Historical Foundation, which will, however, freely grant authors the right to reprint their own works, if published in the authors' own works.

## Dear members and friends of the Foundation:

My incoming message as your new President noted that our Foundation is now in its 63rd year of operation, not far behind our Air Force as it celebrates its 70th. As we reach that seven-decade milestone, your entire Board is united in their intent that the Foundation grow as a strong, independent voice within the air power community, filling a special role of promoting the legacy of Airmen, and educating future generations to understand and draw motivation from the monumental footsteps of those who “soared before.”

We do that best when we keep our eyes firmly fixed on the goal of educating senior leaders within the defense community and the general public about the contribution of *air power* to our nation’s security. Indeed, the Air Force contributes in a special way, when comparing it to the other Services. *Air Power History* bears witness that the Air Force is the *iconoclast* among the military departments, always seeking to find and use solutions that go *over* or *around* obstacles, rather than simply driving *through* them. As a case in point, the Air Force’s Secretary and Chief of Staff just published their top priorities, which are to 1) restore readiness; 2) cost-effectively modernize; 3) drive innovation; 4) develop exceptional leaders; and 5) strengthen alliances. In a very real way, such objectives—however different they have looked over time—are constants in Air Force history. Stories of overcoming technological, operational, and conceptual challenges fill the pages of *Air Power History* and the “to-do” lists of modern Airmen. As we at AFHF continue to tell our Air Force’s story—the Airmen, the machines, and the conflicts—innovation and ingenuity must remain a special point of emphasis. It links yesterday’s Airmen in an important way to those serving today.

Your board has been busy this past quarter narrowing down nominations for our major awards—those honoring the contributions of Spaatz, Holley, and Doolittle. Those selections will be announced in the near future. Some recognition may occur outside Washington (as we did last year), but we will honor all of our winners at the Annual Awards Banquet, including our Best Book Reviewed and Best Article awards from last year’s *Air Power History* issues.

In the spirit of overcoming obstacles, we are experiencing a slight setback as the small but mighty AFHF staff had to vacate regular office space at Andrews AFB while Civil Engineering replaces some ancient heating and air conditioning equipment. We hope work will be complete by September. Until then, we soldier on in true “virtual office” style—so far, so good.

A parting thought: The AF Historical Foundation is a remarkable national asset. In a world where too few take the time to record or reflect on the drumbeat of events, we occupy a special place in recording the history of America’s Air Force. Whether you are an expert historian, a reader of history, a serving or former maker of airpower history, or simply one who values the lessons and humanity that history transmits through generations – our role in capturing some of the most audacious and difficult endeavors in human history is not trivial. This is a worthy cause and one I hope you value. Your generous contributions to the Foundation—whether in time, wisdom, advocacy, or funds—*matter*. Without them we could not accomplish our mission, and we are deeply grateful. Come up on frequency and “check in” any time.

Respectfully,

Christopher D. Miller, Lt Gen, USAF (Ret)  
President and Chairman of the Board (Effective June 1, 2017)



# LEAFLETS, LOUDSPEAKERS AND RADIOS, OH MY!



Robert J. Kodosky

An O-28 drops its cargo of leaflets.

**D**espite the prominent role it occupied, the battle for hearts and minds that transpired from the skies over Southeast Asia remains largely neglected. Americans more than bombed Southeast Asia during the war in Vietnam. They pelted it with leaflets. Billions of them, each year. And they blasted the countryside. Here they used loudspeakers. The louder the better. Ones located on the U-10 Helio Courier usually sufficed. Offered a choice, however, pilots preferred “a higher powered system like the 1800 watt system in the O-2B.”<sup>1</sup> The louder the better. This created space. That alone, distance from the ground, provided operators with some sense of safety.

Psychological Operations (PSYOP) personnel in the skies over Southeast Asia averaged between 7,000 and 9,000 total flight hours while executing approximately 2,000 sorties per month. They utilized fifteen different types of aircraft, including C-130s. Critics dubbed these “B.S. bombers.”<sup>2</sup> Moreover, they derided the leaflet drop program as “one of the wildest excesses of the war.”<sup>3</sup> They estimated that by 1970, the United States had dropped 2,000 leaflets for every man, woman and child in Vietnam. One official questioned the effectiveness of the leaflets in reducing the numbers of the enemy. He suggested that rather than dispersing the leaflets, they should be dropped instead by the baleful. This way, he contended, “Maybe we’d get lucky and hit some VC [Viet Cong] on the head.”<sup>4</sup>

Perhaps the idea had merit. In 1968, American officials reported that one “particularly glum Vietcong member defected in the Delta.” When questioned, he revealed to interrogators the reasoning behind his defection. He became demoralized after the Americans killed his best friend. “A big bundle of paper dropped out of an airplane,” he explained, “and landed on his head.”<sup>5</sup>

This affords new meaning to the term “smart bomb.” It also suggests, in admittedly absurdist fashion, that the battle for hearts and minds that transpired over the skies of Southeast Asia proved more complicated than it first appears. As observed by Air Force officials in 1971, scrutiny of the entire airborne support of PSYOP in Southeast Asia renders “a nebulous picture of a protracted program which almost defies measurement, involving substantial expenditures in dollars and effort.”<sup>6</sup> It is one that promises a more sophisticated understanding of the air war in Southeast Asia while also offering potential insights applicable to the utilization of PSYOP in contemporary conflicts. Hearts and minds remain contested terrain between America and its adversaries.

In Vietnam, piloting over this landscape meant to embrace flying “Unarmed, Alone and Unafraid.” Even as missions often left operators “Unarmed, Alone and Terrified.”<sup>7</sup> Effective PSYOP delivery, especially via loudspeaker, meant flying low and slow, often lingering, over enemy concentrations. This rendered an attractive target for ground fire. PSYOP aircraft took hundreds of hits which, “on several occasions,” forced their operators to make emergency land-

ings.<sup>8</sup> United States Air Force Major Kenneth H. Moses, a PSYOP pilot with the 9th Special Operations Squadron, took six hits to his aircraft in two months. Yet he retained his conviction that PSYOP offered “the greatest potential of any new development in warfare.”<sup>9</sup>

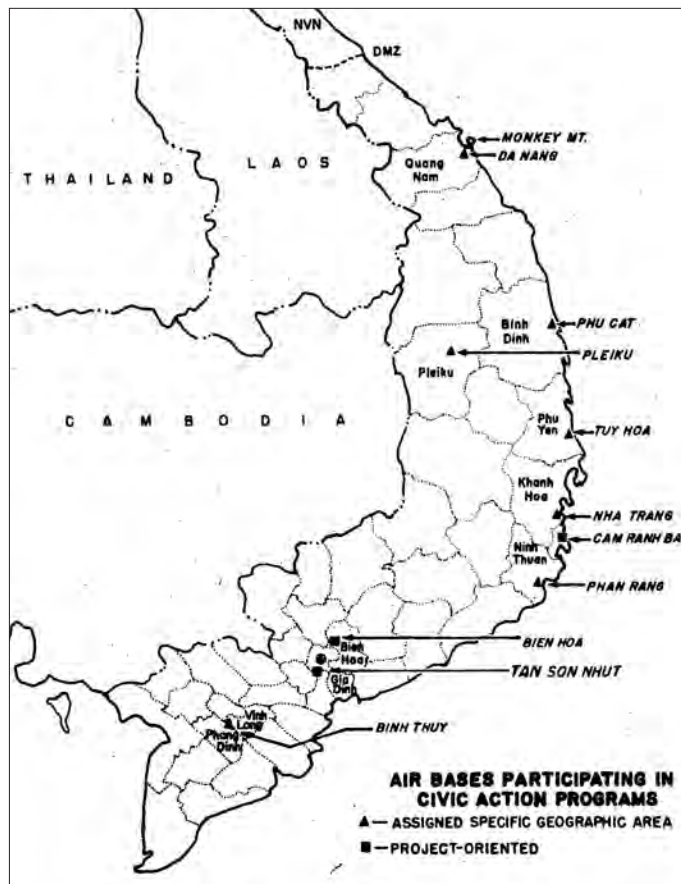
### Maximum Harassment

PSYOP in Vietnam hardly constituted anything new. The American commitment to it did. This began with the appointment of United States Air Force (USAF) Colonel Edward Geary Lansdale to head the Saigon Military Mission (1954-1957). Lansdale, drew from his experience with the Office of Strategic Services during World War II and his more recent efforts on behalf of the Joint United States Military Assistance Group, Philippines. There, his use of psychological warfare and civic action to combat the communist Hukbalahap on behalf of the American allied Filipino government earned him the praise of U. S. policy makers.

As early as April 1962, instructors from the United States Army, Pacific began to assist in developing the psychological training program within the Republic of Vietnam Air Force (VNAF). United States Mobile Training Teams (MTT) further provided assistance to the RVN in radio management, propaganda research, printing management and production, PSYOP and motion picture production management. In 1964, the RVN created the General Political Warfare Department (GPWD) assigned to carry out PSYOP that bolstered morale, carried out civic action and destroyed the enemy’s will.<sup>10</sup> The VNAF received the mission of airborne support along with the task of carrying out civic action.

These developments reflected the ideas of American policy makers. Following World War II, they increasingly embraced the importance of psychology in combatting communism. They perceived the Cold War as a contest

*Robert J. Kodosky earned his Ph.D. from Temple University (2006). He chairs the history department at West Chester University, Pennsylvania. He authored Psychological Operations American Style: The Joint United States Public Affairs Office, Vietnam and Beyond (Lexington Books, 2007) and his also appears in the Encyclopedia of Military Science, the American Intelligence Journal, The Routledge History of Social Protest in Popular Music, the Journal of Popular Culture, History: Reviews of New Books, the Michigan War Studies Review, Marine Corps University Journal, Encyclopedia of Greater Philadelphia, Origins and H-War. He has also contributed to C-Span, ABC News Radio, Comcast Newsmakers, the Philadelphia Inquirer, Smart Talk, the Washington Post and USA Today. Robert is a co-founder of Soldiers to Scholars, an initiative to bridge the gap between civilians and military veterans. In 2014, Robert proudly received the Legion of Honor Humanitarian Award granted by the Four Chaplains Memorial Foundation.*



Participating Air Bases in Vietnam.

of wills which necessitated the broad application of psychological considerations. They identified psychological operations as a more inclusive term than psychological warfare to characterize the expanding array of activities that America undertook to check communist expansion. The United States created the Psychological Operations Coordinating Committee in 1951, an interagency group that worked to incorporate psychological considerations systematically into the formulation of national policy.

On January 24, 1964, the United States established Military Assistance Command, Vietnam, Studies and Observations Group (SOG) under the Commander of the United States Military Assistance Command, Vietnam, charged with carrying out covert and clandestine activities against the DRV. Under the charter of OPLAN – 34A, MACSOG executed four types of unconventional missions against the DRV under the Footboy program. These included maritime operations (PARBOIL), airborne operations (TIMBERWORK), air operations (MIDRIFF) and psychological operations (HUMIDOR).<sup>11</sup>

### A Viable Concept

With the establishment of MACSOG, the USAF assumed an “ever expanding and increasingly large role in support of unconventional warfare operations.”<sup>12</sup> This included PSYOP, an element embedded in much of the unconventional activity. The goal of OPLAN-34A’s operations, collectively referred to as FOOTBOY, emerged as



persuasive. It aimed to “convince the DRV leadership that its current support and direction of the war” in the RVN and Laos should be “stopped and reexamined.” It called for strategic and tactical PSYOP targeted against the DRV leadership and the populace to “achieve maximum division, harassment and the establishment of resistance with the DRV.”<sup>13</sup>

The effort to provide air support began inauspiciously. It constituted the efforts of nine Air Force personnel, five officers and four enlisted men, who comprised First Flight Detachment. Under assumed names and in plain clothes at Nha Trang Air Base, the members of First Flight received the first of six modified C-123s on June 28, 1964, authorized by Secretary of Defense Robert S. McNamara as Project Duck Hook, later dubbed Heavy Hook. They soon undertook their primary mission, to train aircrews from Taiwan and the VNAF.

Before arriving in Vietnam, the Taiwan crews received initial training, including language instruction, in the United States at Lackland Air Force Base, Hurlburt Field and Mather Air Force Base. While the Americans found the Taiwan air men as “disciplined” and “professional,” the crews proved reluctant to fly over the DRV, particularly to execute psychological operations missions at night. Consequently, “for PSYOP missions,” MACSOG “obtained approval for the use of American C-123 crews.”<sup>14</sup> It also hastened to train Vietnamese crews, “to get rid of the Chinese crews.”<sup>15</sup> This aligned with pressures coming from policy makers in Washington who sought to get the mission going with Vietnamese utilized.

## Language immediately emerged as a barrier against effective communication

The difficulties inherent to training VNAF proved a harbinger. Language immediately emerged as a barrier against effective communication between Americans and their Vietnamese counterparts. The “very limited number” of Americans who could speak or understand Vietnamese “greatly complicated efforts” of training and supervision.<sup>16</sup> So too did the Vietnamese commitment to the mission. While MACSOG judged the Vietnamese crews as “at least as good as that of the Chinese,” it found them “more difficult to control.” It observed that the Vietnamese “seemed to feel that they were doing us a favor when they went on a mission.” They did not see it from a “nationalist point of view.”<sup>17</sup> Due to its “hardship,” MACSOG terminated the VNAF training program in 1966 with “minimal impact on operations.”<sup>18</sup>

Despite the issues in training Vietnamese, officials deemed the PSYOP initiative against the DRV as MACSOG’s “most successful program,” citing the “numerous North Vietnamese publications and broadcasts which denounced U.S. psychological warfare operations.”<sup>19</sup> The HUMIDOR operations steadily increased, from thirty PSYOP missions flown during the first year to forty-two



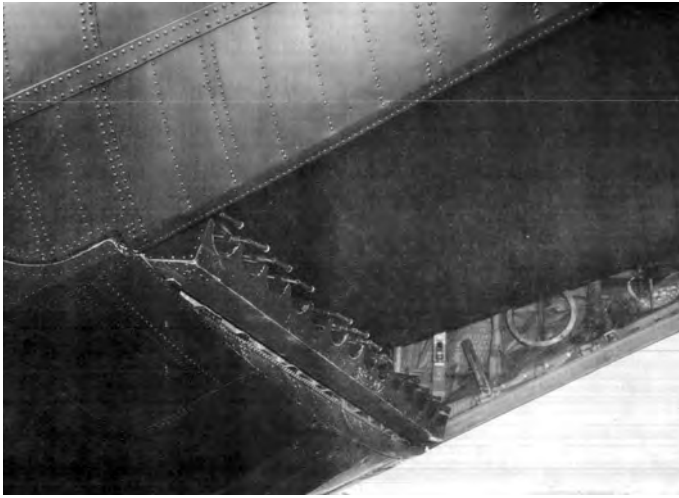
PSYOP missions required special leaflet boxes and pallets designed to minimize the work needed to handle them.

during the second and sixty-seven in the third. On November 3, 1966, MACSOG first utilized its newly arrived Combat Spear aircraft, modified C-130s, to execute a PSYOP mission. It initially requested C-130s in 1964, but the Joint Chiefs of Staff (JCS) denied this, deeming only American crews fit to operate the aircraft. This did not constitute a “viable concept under the current UW [unconventional warfare] program.”<sup>20</sup>

The C-130 held advantages over the C-123 for disseminating leaflets. It flew faster and higher, enabling drop points in relatively undefended areas for targets in heavily defended ones that had proved inaccessible to C-123s. Since the end of World War II, American PSYOP personnel experimented with targeting leaflets accurately. This benefitted C-130E crews who required oxygen masks to work in extreme altitudes of operation, up to 25,000 feet. C-130 PSYOP missions required special leaflet boxes and pallets designed to minimize the work needed to handle them.

Each pallet could hold thirty boxes of leaflets with the C-130 able to fit ten pallets, stacked in two tiers of five. Each box of leaflets, equipped with rollers, weighed approximately 140 pounds and could be deployed at a rate of once per every ten seconds by placing the aircraft in a slightly nose-high altitude enabling the boxes to roll to the aircraft’s rear. The cut boxes featured webbing attached to a static line. When pushed out the rear of the aircraft, they hit the end of the line and spilled their leaflets into the airstream.

Personnel worked throughout the war to improve the accuracy of drops. An early method involved cutting a cardboard box to fall apart and then retying it with a cord that passed through a fuse. After ignition, once the fuse burned through the cord, the box fell apart and released its contents, ideally from about 500 feet. BLIND-BAT flare ship personnel honed delivery further by developing a Delayed Opening Leaflet System (DOLS).



A flare rack, useful for deploying leaflets.

It used rejected flares that featured inserted leaflets in place of parachutes. Each modified flare could hold up to one thousand six-inch by three-inch leaflets. Personnel left the flare candle in and used the flare system in the BLINDBAT aircraft to deploy these DOLS. When dropped, once the timer fired the explosion dropped leaflets rather than opening a parachute. The ignited flare candle revealed the accuracy of the drop.<sup>21</sup>

PSYOP crews devised ingenious methods of delivery to take advantage of the C-130, but the biggest disadvantage remained, increased American exposure. Three American units came to be designated as almost exclusively supporting MACSOG operations over the DRV and, as the program expanded, Cambodia and Laos. These included the First Flight Detachment, the 90th Special Operations Squadron (formerly the 15th SOS) and 20th SOS. Crews wore standard flight uniforms and their aircraft carried USAF markings. Cover stories and stringent security became essential. In event of an incident, PSYOP crews received strict instructions to jettison all materials and claim to be on an authorized search and rescue mission for downed US aircrews.<sup>22</sup>

### The Difficulty of Assessment

As America's intervention in Vietnam escalated, the United States additionally mounted an expansive overt PSYOP initiative that the USAF supported. As a consequence of National Security Action Memorandum 330, issued by President Lyndon Baines Johnson on April 9, 1965, the Joint United States Public Affairs Office (JUSPAO) assumed direction for American PSYOP policy in Vietnam. In 1967, under United States Army General William C. Westmoreland, Military Assistance Command, Vietnam (MACV) took charge of executing PSYOP.

Within MACV, the Political Warfare Advisory Directorate, established in May 1965, to support the RVN's GPWD, became the Psychological Operations Directorate (MACPD). It directed tactical PSYOP in support of military operations while MACV Civil Operations and

Revolutionary Development Support (MACCORDS) orchestrated PSYOP on behalf of pacification and national development. The 6th PSYOP Battalion, expanded into the 4th PSYOP Group on January 1, 1968, offered tactical PSYOP support. The 7th PSYOP Group, based in Okinawa, used Commander in Chief, Pacific Command (CINPAC) funds to generate printed materials.

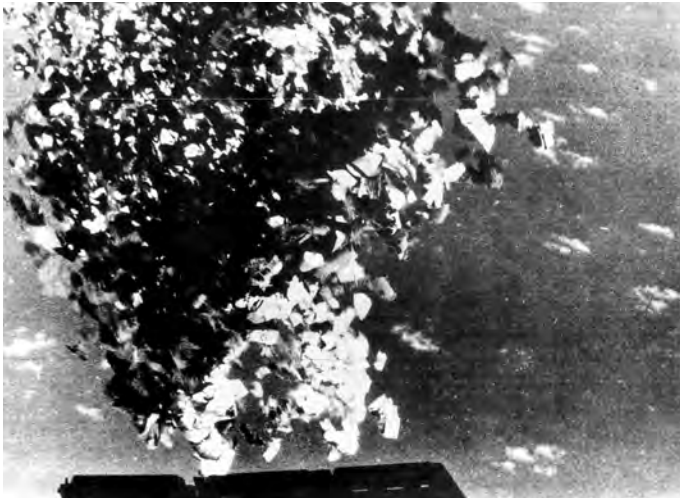
The USAF and the VNAF provided airborne support. To a lesser extent, both forces also engaged in civic action programs. The VNAF first received PSYOP responsibilities in 1964, in support of the RVN's General Political Warfare Department (GPWD). It tasked five tactical wings with PSYOP responsibilities, the 23rd (Bien Hoa), the 33rd (Tan Son Nhut), the 41st (Danang), the 62nd (Nha Trang) and the 74th (Binh Thuy). The wings possessed squadrons equipped mainly with U-17s and U-6s that featured speaker systems ranging from 250 to 1000 watts. Each wing had assigned to it one USAF PSYOP advisor while VNAF headquarters received two.<sup>23</sup>

On the American side, support derived from the 14th Air Commando Wing (ACW) under operational command of the Seventh Air Force. USAF support for overt PSYOP activities arrived in Vietnam shortly after the buildup of US combat troops in 1965. By the end of the year, fifty-four personnel had reported to the 5th Air Commando Squadron (ACS) at Nha Trang Air Base which resided under the operational control of the 6253d Combat Support Group (re-designated in 1966 as the 14th ACW).

By the time of its first major operation, Tet, from January 9-20, 1966, the 5th ACS possessed five C-47 "Gooney Birds," and 24 U-10, all equipped with loud-speaker systems. To complete its first operation, the 5th ACS borrowed four more C-47s and twelve U-10s. It flew 559 missions over the twelve day period, dropping 130 million leaflets and broadcasting 380 hours. It suffered nine aircraft hits that resulted in one wounded. The operation represented the largest PSYOP program ever carried out by US forces overseas.<sup>24</sup>

### The United States additionally mounted an expansive overt PSYOP initiative

Such efforts profited from the resources devoted by the Air Force to exploring "the possibilities of applying special air operations to special warfare ground operations" in the early 1960s.<sup>25</sup> In 1962, the Air Force established the Special Air Warfare Center at Eglin Air Force Base which encompassed Hurlburt Field in Florida to serve as the home for the newly activated 1st Air Commando Wing. Training concentrated on utilizing short takeoff or landing aircraft (STOL), such as the U-10, capable of taking off in 225 feet of runway, maneuverable at thirty-five miles per hour and capable of carrying two crew and more than 50,000 leaflets while remaining aloft for nearly four hours.



Leaflet dispersal out of the aircraft.

Exercises took place at various locations, including Panama. There, unit commander Lieutenant Colonel Kenneth D. Hill suggests, they developed the basic principles of PSYOP used in Vietnam. They flew into villages where runways did not exist. They dropped construction equipment from the aircraft to villagers on the ground and then employed leaflets and loudspeakers to guide them in building an airstrip. According to Hill, this constituted the first time that “this idea was used with such success.”<sup>26</sup>

In March 1967, airborne support for PSYOP increased with the formation of the 9th ACS, formed from resources from the 5th ACS. Formerly tasked with supporting PSYOP throughout the RVN, the 5th ACS now had responsibility for III and IV Corps while the 9th ACS took over the support role in I and II Corps. This remained the situation until October 1969, when, as a consequence of the Richard M. Nixon presidential administration’s Vietnamization plan, officials deactivated the 5th ACS and renamed the 9th ACS as the 9th Special Operations Squadron (SOS). The 9th SOS, at Phan Rang Air Force Base, remained as the only USAF squadron appropriately configured and dedicated to support PSYOP until the spring of 1971, when airborne support shifted to the Vietnamese, Laotians, Cambodians and Thais.<sup>27</sup>

Throughout the time it operated, much of America’s PSYOP in the RVN sought to induce defection through the *Chieu Hoi* (Open Arms) program. The appeal, delivered via leaflet and loudspeaker, targeted both regular soldiers and guerilla fighters. It promised amnesty to defectors (*Hoi Chanh*), fair treatment and resettlement. *Choi Hoi* centers, funded by the United States and administered by RVN officials, offered *Hoi Chanh* opportunities to transition back into civilian life. American officials hope to capitalize on *Hoi Chanh* for intelligence and for testimonials that might induce more defectors. The program ran from 1963 through 1971, and claimed success in securing nearly 200,000 defectors. Its overall effectiveness, debated at the time, remains contested.<sup>28</sup>

So does the impact of the various other PSYOP op-

erations that attempted to erode enemy morale, promote dissent and win the hearts and minds of civilians. Besides *Chieu Hoi*, the USAF supported operations FACT SHEET/FRANTIC GOAT (DRV), TRAIL (Cambodia and Laos), ARC LIGHT (B-52s), ELEPHANT WALK (rewards), RICE RIVER (Cambodia) and FIELD GOAL (LINEBACKER). Its personnel additionally worked in Thailand as advisors to the Royal Thailand Air Force, training two units in the “flight techniques to be used in aerial loudspeaker operations.”<sup>29</sup> Throughout, however, the difficulties of assessment persisted. Officials consistently found that the “results” of it all could “not be quantitatively evaluated.”<sup>30</sup>

### A Preference for Other Duties

While defectors could be counted, there motivations could not. There existed no way to connect the decisions made by defectors to surrender with their reception of PSYOP material. Officials cited the reactions of communist authorities to PSYOP campaigns, such as radio jamming, censorship and reactive messaging. This activity reveals an awareness of the materials, but it fails to show any direct effectiveness.

### The program ran from 1963 through 1971, and claimed success in securing nearly 200,000 defectors

Evidence remained largely anecdotal and mixed. For example, as part of Operation FIELD GOAL, executed in support of Operation LINEBACKER, a renewed bombing campaign against the DRV, one set of PSYOP leaflets counterfeited currency, the one piaster note. The drop occurred in August 1972, and in October American officials detected a response from the DRV broadcast over the radio.

Citing the leaflets, DRV controlled radio accused the Nixon administration of committing “another vile and despicable crime.” It condemned the “psychological warfare” ploy to destroy the “DRV’s financial and monetary system,” but credited citizens for displaying “intense patriotism” and “high revolutionary vigilance” for collecting the fake notes and turning them over to authorities.<sup>31</sup> Meanwhile, interrogations of captured enemy soldiers suggested that the fake currency failed to impress, the notes, pink instead of red, all possessed the same serial number.<sup>32</sup>

Air Force personnel acknowledged the fundamental problems with the PSYOP they supported, citing that it too often “lacked credibility,” and that “the quantitative approach” that stressed numbers of leaflets dropped and hours broadcast “overshadowed the qualitative approach of credible, imaginative, selective, programs of persuasion.”<sup>33</sup> They understood feedback about their mission remained “limited” and quantifying results proved “difficult,” but expressed a high level of satisfaction nonetheless. As one explained to an interviewer in 1968,



Loading up flares for dropping.

“everyone here feels he’s contributing something vital to the war effort.”<sup>34</sup>

An official report collaborated, stating that “high morale exists at the squadrons.”<sup>35</sup> Personnel rationalized that “the saving of human life when one fights a leaflet war need not be great.” They only asked, “How many leaflets are equivalent to one soldier’s life?”<sup>36</sup>

The fundamental issue with PSYOP from the perspective of many of its Air Force personnel resided in its lack of prioritization. Major Kenneth H. Moses, a pilot with the 9th SOS, identified “a stage of acceptance” for PSYOP “before its value is fully realized.” In Vietnam, he noted, “the glory kind of falls in other directions while we in PSYOP just go plodding along.”<sup>37</sup> While PSYOP crews believed in their mission, they became distressed by the lack of others to do the same.

The notion persisted throughout the war that PSYOP constituted a diversion of resources better suited to conventional warfighting. As the authors of a post war assessment of PSYOP observed, “psychological operations have not generally been viewed as an essential part of US strategic and tactical operations.”<sup>38</sup> As Air Force officials noted in regards to Operation FIELD GOAL, in war, “the question of allocating resources and is often difficult and complex.” PSYOP required “the use of strike and support aircraft that could otherwise have been employed in striking enemy forces and supporting friendly operations in progress.”<sup>39</sup>

Consequently, PSYOP missions received a “relatively low-priority rating,” often making it difficult “to obtain adequate equipment, facilities, personnel and even aircraft parking space.” PSYOP sorties merited

only a “Category 3” mission rating, compared to the “Category 2” offered to strike aircraft and forward air control. This proved difficult for PSYOP personnel to accept as their aircraft spent “as much or more time over targets” and “frequently” received “hits from ground fire.” This increasingly resulted in PSYOP crews that “preferred other duties.”<sup>40</sup>

### The Matter of Appearance

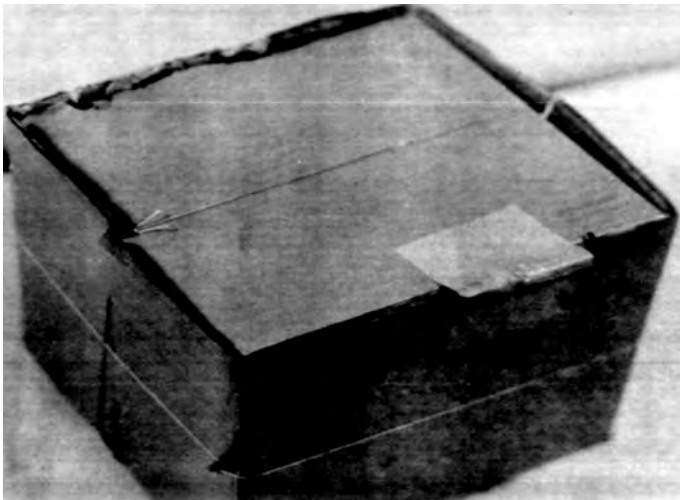
Even more problematic proved the reluctance of the VNAF to participate in the PSYOP effort, a reflection of the RVN’s own lack of commitment. The VNAF managed to support only about ten percent of the PSYOP support provided until the process of Vietnamization raised that level to thirty percent by 1971.<sup>41</sup> By 1972, when it became “apparent” that the RVN “could not support aerial PSYOP activities on a large scale,” CINPAC assumed management of PSYOP from MACV. Despite the process of Vietnamization as declared complete by American officials, the United States now operated to devise and execute “post-Vietnamization PSYOP aerial activity.” This development, planners recognized, “reduced the effectiveness of this current concept of PSYOP.”<sup>42</sup>

### The fundamental issue with PSYOP ... resided in its lack of prioritization

That concept of PSYOP, one formulated and carried out by Americans, had been flawed from the onset. This remained obscured, however, by the blaring of loudspeakers and billions of leaflets that covered Southeast Asia. American PSYOP crafted an image of the RVN. It remained up to the RVN to make that manifest. Americans served as an inadequate replacement.

This is most clearly evidenced by the Civic Action program, the American nation building effort that became part of the official Air Force mission in May 1966. Its objectives included, to improve living conditions in order to “remove one of the underlying causes of the insurgency,” and to “gain and maintain support of the people for the GVN [RVN].”<sup>43</sup> The VNAF, through the General Political Warfare Directorate (GPWD), initiated Civic Action at the same time and its designated personnel received assignment to USAF advisors.

For the Air Force, while “the concept of joint VNAF/USAF participation was unquestionably a desirable one,” it failed to work out “very satisfactorily.” The VNAF exhibited “problems concerning leadership.” Less than ten percent of the VNAF Political Warfare personnel “had any formal training.”<sup>44</sup> This resulted in efforts that proved counterproductive at best. For example, in an attempt to “improve the appearance of a VNAF housing area” the base commander “outlawed home laundries and ordered unsightly clotheslines removed.” While this improved appearances, it came at the price of “lower morale among VNAF dependents” who lost needed income as the result of the ban on laundries.<sup>45</sup>



A leaflet package.

In general, USAF personnel tasked with Civic Action found their VNAF counterparts reluctant to engage in manual labor and apathetic. The Americans attributed these characteristics to the “loyalty identification” demonstrated by members of the VNAF which remained “limited to family and clan, rather than to broader entities such as the Air Force or the government [RVN].”<sup>46</sup>

In all facets, this guided the VNAF’s reluctance to “place Psychological Operations on the same level of importance as that of U.S. officials.” The VNAF viewed as more pressing “the indoctrination of their own troops.” For USAF, this dictated that “opportunities for effectively utilizing Psychological Operations,” through the Civic Action program or otherwise, did not emerge as activities “vigorously sought by the RVNAF.”<sup>47</sup>

For USAF personnel, this meant attempting to compensate. Because there existed no officers attached to the VNAF’s Political Warfare Directorate who possessed the appropriate training, USAF advisors exhibited the tendency to “do the jobs themselves.”<sup>48</sup> This proved problematic. Too few of the USAF personnel possessed any expertise in Vietnamese language or culture. Training for USAF advisors included three months language training, four weeks at the Military Advisory Institute, Arlington, VA, and a six to ten week PSYOP course at Fort Bragg, NC.

This all fell far short of the ideal, even as identified at the time. The language training, for example, left advisors with an 800-word vocabulary that consisted of mostly Army-oriented terminology. PSYOP officials suggested that “at least language training” would provide the language capability deemed “necessary for their assignment.” They also stressed the need for courses in Vietnamese culture and history to help advisors “function more effectively in their dealings with the Vietnamese.”<sup>49</sup>

USAF personnel could not act in place of the VNAF to earn support for the RVN. Their lack of training in Vietnamese language and culture, and in formulating PSYOP, none of the assigned advisors possessed previous experience, presented formidable obstacles to overcome in engaging in meaningful Civic Action.



A safe pass.

### Faint and Fleeting

The efforts of a Civic Action Coordinating Group established at Tan Son Nhut in July 1966, resulted in a “deteriorated relationship” between VNAF and USAF Civic Action teams that sought to implement an “ambitious program.” The initiative sought to bring programs and supplies into the twelve hamlets that surrounded the base, ones that served as “relatively secure havens for many Viet Cong.” The plan “never really got off the ground” before the strains evident between VNAF and USAF personnel made it clear that “a disengagement seemed advisable.” Officials attributed the collapse to the USAF advisor who “may have been overzealous in pushing projects” causing the VNAF to “lose face” because they could not keep up with the Americans.<sup>50</sup>

Elsewhere, between April and September 1967, the Air Force provided assistance to forty-five orphanages. The Air Force learned afterwards that some of these Vietnamese orphanages “were not really orphanages in the American sense of the term.” They contained a large number of “day students,” the children of wealthy RVN citizens. To compound the matter, the Air Force directed “a majority of the aid” to Christian institutions despite Buddhism constituting the predominant religious group in Vietnam. This prompted a rebuke from RVN officials in April 1967, who cited “too much assistance from non-Vietnamese sources” potentially undercut RVN policy to “promote the participation of the people in social welfare projects as part of Community Civic Action.”<sup>51</sup>

Despite such proclamations, the RVN demonstrated little real commitment to the programs promised by

PSYOP, whether delivered by leaflet or loudspeaker, or through Civic Action, that represented its claims to legitimacy. That constituted the core of the problem. Americans erred in attempting to fill the vacuum. They knew too little about the hearts and minds of the people who resided there and proved unable to solicit from RVN officials the kind of legitimacy necessary to win them independently.

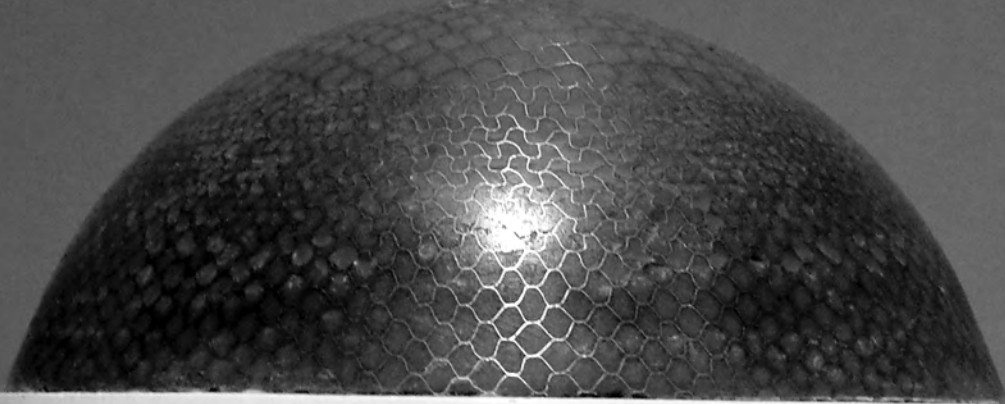
Air Force officials understood this. They identified the central problem of American PSYOP in Vietnam as one that often “transgressed elementary rules of persua-

sion and therefore lacked credibility.” Psychological appeals in Vietnam, they observed, “violated a basic rule,” that whatever the claims made, regardless of the number or form of appeals, “should not diverge widely from the facts as the target population sees them.”<sup>52</sup> In Vietnam, that divergence proved unbridgeable. Especially as RVN officials evidenced little sincerity in narrowing it. Billions of leaflets, regardless of how well engineered, could only inspire hopes of closing the gap. These proved both as faint and as fleeting as the reams of paper that Americans dispersed all along the Ho Chi Minh trail. ■

## NOTES

1. Interview Transcript with Lieutenant Colonel R. S. Barmetler re: Aspects of PsyOps Activities Conducted through MACPD and MACV - Support Document from Project CHECO Report #162, 2 July 1968, The Vietnam Center and Archive at Texas Tech University (VCATTU).
2. Project CHECO Southeast Asia Report #163 - Continuing Report: Psychological Operations: Air Support in Southeast Asia - June 1968 to May 1971, p. 12, VCATTU.
3. Peter R. Kann, “The War of Words: As Propaganda Battle Rages in Vietnam, Some Question U.S. Tactics,” *Wall Street Journal*, December 5, 1969, p. 1.
4. Report, Psychological Operations against the DRV, August 1970, VCATTU.
5. Kann, “The War of Words,” p. 29.
6. Project CHECO Southeast Asia Report #163, 56, VCATTU.
7. Dennis J. Murray, “Those Magnificent Men in Their PSYOP Machines,” undated, p. 2, VCATTU.
8. Project CHECO Southeast Asia Report, Psychological Operations by USAF/VNAF in GVN, 16 September 1968, pp. 31-32, VCATTU.
9. Murray, p. 2.
10. Project CHECO Southeast Asia Report, Psychological Operations by USAF/VNAF in GVN, 16 September 1968, 1, VCATTU.
11. Draft MACSOG Documentation Study, 10 July 1970, C-31, VCATTU.
12. Project CHECO Southeast Asia Report, The Role of the USAF in Support of Special Activities in SEA, 1 July 1976, p. 1, VCATTU.
13. Draft MACSOG Documentation Study, 10 July 1970, p. C-8, VCATTU.
14. *Ibid.*, p. 60.
15. *Ibid.*, p. 61.
16. Draft MACSOG Documentation Study, p. C-33.
17. Project CHECO Southeast Asia Report, The Role of the USAF in Support of Special Activities in SEA, 1 July 1976, 61.
18. Draft MACSOG Documentation Study, p. p. C-31.
19. Project CHECO Southeast Asia Report, The Role of the USAF in Support of Special Activities in SEA, 1 July 1976, p. 30.
20. *Ibid.*, p. 68.
21. Project CHECO Southeast Asia Report, Psychological Operations by USAF/VNAF in GVN, 16 September 1968, p. 23, VCATTU.
22. *Ibid.*, p. 72.
23. Interview, USAF Major Alan H. Stith, 12 June 1968, p. 2, VCATTU.
24. Project CHECO Southeast Asia Report, Psychological Operations by USAF/VNAF in GVN, 16 September 1968, p. 16, VCATTU.
25. Lieutenant Robert Pfohman, “Charlie’s Pen Pals: PSYOPS Squadron Gets the Word to the Enemy, *The Hurricane: A Publication of II Field Force in Vietnam*, number 13, November 1968, p. 34.
26. *Ibid.*
27. Project CHECO Southeast Asia Report #163, p. 59, VCATTU.
28. See J. A. Koch, *The Chieu Hoi Program in South Vietnam, 1963-1971*, January 1973: 37, folder 12, box 14, Douglas Pike Collection, Unit 03 – Insurgency Warfare, VCATTU; Robert J. Kodosky, *Psychological Operations American Style: The Joint United States Public Affairs Office, Vietnam and Beyond* (Lexington Books, 2007); Daniel C. Pollock, project director, *The Art and Science of Psychological Operations: Case Studies of Military Application*, 2 volumes (Washington, D.C.: Headquarters, Department of the Army, April 1976).
29. Project CHECO Southeast Asia Report #163, p. 50, VCATTU.
30. Project CHECO Southeast Asia Report, Psychological Operations against North Vietnam, July 1972-January 1973, 24 May 1974, p. 36, VCATTU.
31. *Ibid.*, p. 34.
32. *Ibid.*, p. 35.
33. Project CHECO Southeast Asia Report #163, p. 57, VCATTU.
34. Dennis J. Murray, “Those Magnificent Men in Their PSYOP Machines,” undated, p. 4, VCATTU.
35. Project CHECO Southeast Asia Report, Psychological Operations by USAF/VNAF in GVN, 16 September 1968, p. 38, VCATTU.
36. Project CHECO Southeast Asia Report #163, p. 70, VCATTU.
37. Dennis J. Murray, “Those Magnificent Men in Their PSYOP Machines,” undated, p. 2, VCATTU.
38. DTIC Technical Report, revised edition, US Defense Logistics Agency – A Study of Strategic Lessons Learned in Vietnam, Volume VI: Conduct of the War, Book 2: Functional Analysis – Part 2 of 3, May 2, 1980, pp. 13-22, VCATTU.
39. Project CHECO Southeast Asia Report, Psychological Operations against North Vietnam, July 1972-January 1973, May 24, 1974, p. 36, VCATTU.
40. Project CHECO Southeast Asia Report, Psychological Operations by USAF/VNAF in GVN, 16 September 1968, p. 38, VCATTU.
41. Project CHECO Southeast Asia Report #163, p. 24, VCATTU.
42. Project CHECO Southeast Asia Report, Psychological Operations by USAF/VNAF in GVN, 16 September 1968, p. 6, VCATTU.
43. Project CHECO Report, USAF Civic Action in Republic of Vietnam, April 1, 1968, p. 20, VCATTU.
44. *Ibid.*, p. 51.
45. *Ibid.*, p. 57.
46. *Ibid.*, p. 61.
47. Project CHECO Southeast Asia Report, Psychological Operations by USAF/VNAF in GVN, September 16, 1968, p. 28, VCATTU.
48. Project CHECO Report, USAF Civic Action in Republic of Vietnam, April 1, 1968, p. 31, VCATTU.
49. *Ibid.*, p. 52.
50. *Ibid.*, p. 28.
51. *Ibid.*, p. 41.
52. Project CHECO Southeast Asia Report #163, p. 57, VCATTU.

# Reentry Vehicle Development Leading to the Minuteman Avco Mark 5 and 11



Closeup view of Avcoite nose cap on an unflown Mark 5 reentry vehicle. Avcoite was a ceramic material contained in a magnesium honeycomb matrix and was used on the Avco Mark 4 and Mark 5 reentry vehicle nose cap. (Photo courtesy of National Atomic Museum.)

David K. Stumpf

**T**he Minuteman Intercontinental Ballistic Missile (ICBM) has been deployed for over fifty years. As one of two second generation ICBMs, Minuteman represented the ultimate solution to the concept of land-based offensive strategic weapons. The solid propellant propulsion system provided for a nearly instantaneous response while reducing maintenance efforts and costs significantly below those of the first generation cryogenic oxidizer Atlas and Titan I. Even the second generation Titan II with its storable liquid propellants and comparable response time was cumbersome in comparison.

Development of the business end of all the ICBMs, the reentry vehicles, likewise went from the first generation heatsink thermal protection system to the second generation ablative reentry vehicles enabling larger payloads (the reentry vehicle was lighter) to be carried as well as improving accuracy. This article discusses the evolution of reentry vehicle design and fabrication leading up to and including the Minuteman Mark 5 and Mark 11 reentry vehicles. Detailing the earliest efforts of the Army, Navy and Air Force reentry vehicle approaches puts the development of the Minuteman Mark 5 and Mark 11 reentry vehicles into the proper historical perspective. The discussion of the Army's effort covers only the Jupiter IRBM program and its pioneering work on ablation. The Navy's contribution was a much different approach to the heatsink concept with the discussion ending with the Polaris A-1 and A-2 as the follow-on programs closely resembled the later Air Force approach. Due to classification issues caused by current world events, the third generation Air Force reentry vehicle designs are not discussed in this article though they have been described in great detail in an earlier article by Lin.<sup>1</sup>

## Early Research

While bombardment rockets have been used for centuries, it was not until the creation of the German V-2 (also known as the A-4) that the warhead needed thermal protection due to reentry into the Earth's atmosphere.<sup>2</sup> Since the entire V-2 impacted the target, there was no true separable reentry vehicle.<sup>3</sup> The original design called for the use of a lightweight alloy of magnesium and aluminum but wind tunnel tests indicated that from an altitude of 43 nautical miles, the operational maximum altitude, reentry into the lower atmosphere at 3,345 miles per hour would result in a warhead compartment skin temperature of 1,250 degrees Fahrenheit. Therefore the decision was made to use 1/4 inch sheet steel resulting in the need to decrease the explosive payload to hold the total warhead weight to 2,200 pounds (the steel casing weighing 550 pounds). The explosive chosen for the warhead was Amatol, a mixture

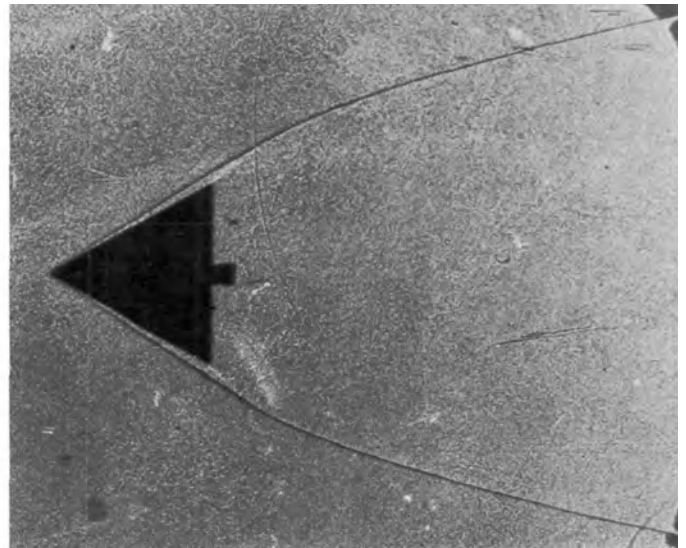
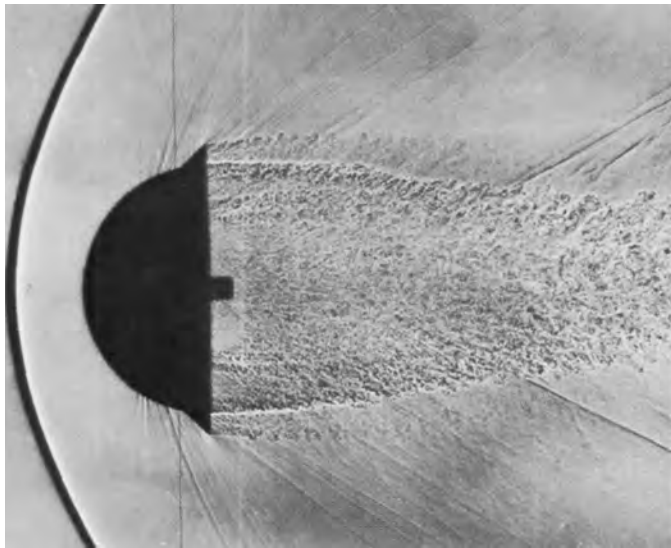


Figure 1: Atmosphere Entry Simulator Schlieren photographs illustrating the detached bow shock wave generate by a blunt reentry body compared to the attached shock wave with a pointed reentry body. The detached bow wave dissipates heat well away from reentry body (D. D. Baals and W.R. Corliss, Wind Tunnels of NASA, (Washington, D.C., 1981), SP-440, 76).

of sixty percent TNT and forty percent ammonium nitrate, which was insensitive to heat and shock. There was no warhead compartment insulation.<sup>4</sup>

Arming a guided missile derived from the V-2 with an atomic warhead was an obvious next step in strategic warfare since it was only a matter of time for atomic bomb design to catch up with guided missile delivery capability. Concerned with the vulnerability of the eastern United States to long range missiles from the Soviet Union, in 1945 the National Advisory Committee for Aeronautics (NACA) realized an urgent need to begin studying the problems of hypersonic flight (defined as greater than five times the speed of sound which is the speed at which aerodynamic heating begins to be significant). By the late 1940s, two major NACA facilities, Ames Aeronautical Laboratory (Ames), Moffett Field, California, and Langley Aeronautical Laboratory (Langley), Hampton, Virginia, responded by expanding their aeronautical work to study aerodynamic issues involved in ballistic missile flight.<sup>5</sup>

Theoretical research into the problem of aerodynamic heating of ballistic missiles upon reentry into the

atmosphere at high speeds was first published in 1949 by Carl Wagner.<sup>6</sup> The first comprehensive theoretical work was begun in 1951 by H. Julian Allen and A.J. Eggers, Jr., engineers at Ames. They studied the problem of reentry heating for ballistic, glide and skip-entry trajectories. Their investigation of the three types of trajectories was driven by the need to find a flight path that could best utilize the thermal protection materials then available. Allen and Eggers dismissed the pointed nose shape, a carry over from rifle bullet design, at the start, instead focusing their calculations on a blunt, hemispherical shape, recommending that “not only should pointed bodies be avoided, but that the rounded nose should have the largest radius possible.” (Figure 1)

It is important to note that these calculations were made with “light” and “heavy” missile options and no mention was made of a reentry vehicle as such. The “light” missile optimum nose shape from a heat transfer standpoint was a blunt shape; for the “heavy” missile a more slender shape was optimum. Their calculations showed that the high drag caused a detached shock wave thus the majority of the heat generated was dissipated back into the atmosphere leaving only radiated heat to contend with, unlike a sharply pointed body where the shock wave was attached to the tip, causing heat transfer and destruction of the body. Additionally the heat reaching the blunt body would be more evenly distributed, preventing hot spots more prone to burn through.

Allen and Eggers demonstrated that the maximum deceleration encountered by a reentry vehicle was a function of the angle of reentry as well as velocity and independent of the shape, size and mass or drag coefficient. The importance of shape was the amount of heat that was absorbed by the reentry vehicle. A team of Ames researchers led by Eggers and including Fred Hansen and Bernard Cunningham published a method

*David K. Stumpf, Ph.D., is retired plant biochemist living with his wife, Susan, in Tucson, Arizona. He has written two nuclear weapon histories, Regulus the Forgotten Weapon, a history of the Navy's Regulus I and II cruise missiles and Titan II: A History of a Cold War Missile System, as well as contributing to the Air Force Missileers history. He is currently working on a comprehensive history of the Minuteman ICBM program endorsed by the Office of the Secretary of the Air Force. He volunteered at the Titan Missile Museum, Sahuarita, Arizona, as museum historian and as a tour guide for 15 years. He was instrumental in the effort to gain National Historic Landmark status for the museum.*



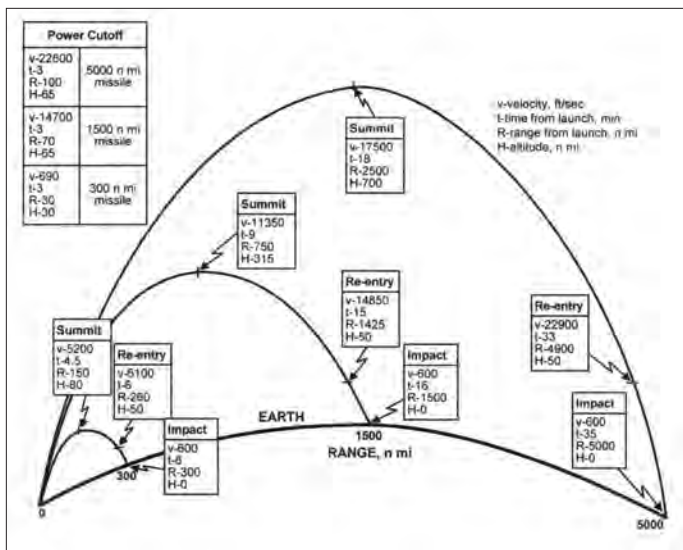


Figure 2: Short, Medium and Long Range Ballistic Missile Trajectories (adapted from Figure 1-1, *Ordinance Engineering Design Handbook, Ballistic Missile Series: Trajectories*, 1967. Drawing by Mitch Cannon).

for predicting heat transfer to blunt bodies in 1958 though the work was done and in use much earlier but not published for six years due to classification issues.<sup>7</sup>

In order to reach targets 4,000 to 6,000 nautical miles away, ballistic missiles would need to be accelerated to speeds of up to approximately Mach 20 (15,223 miles per hour, just short of orbital velocity), 10 times the speed of a high-powered rifle bullet.<sup>8</sup> Reentry into the atmosphere at these speeds would generate a shock wave in which the atmosphere is heated to many thousands of degrees, even approaching 12,000 F, which exceeded the melting point of tungsten, the metallic element with the highest known melting point, 6,116 degrees Fahrenheit.<sup>9</sup> At this temperature the air plasma is also highly chemically reactive. There is a transport of heat by mass conduction from the air plasma to the vehicle surface which is dependent on both the temperature and density of the air in the plasma. At high altitudes where the air density is low, the mass transport of heat is low, in spite of the very high shock wave temperature. Conversely, at lower altitudes, the higher density plasma results in a higher heat flux for equal reentry vehicle velocities (Figure 2).<sup>10</sup>

Before discussing individual test and operational reentry vehicles, a brief discussion of testing methods, both for ground and flight is necessary.

## Reentry Research Tools

## Hypersonic Wind Tunnels

While the history of the military use of ballistic missiles rightly starts with the development of the A-4 (V-2) missile, perhaps just as important was the discovery by Allied troops of two highly advanced wind tunnel facilities at Peenemünde in the summer of 1945. One had apparently been in operation, a small diameter (1.2 foot)

super-supersonic wind tunnel for intermittent use up to Mach 5 and a larger diameter (3.3 foot) continuous flow super-supersonic wind tunnel designed for speeds up to Mach 10.

In 1945 the first hypersonic wind tunnel in the United States was proposed by John Becker at Langley. Design difficulties and a perceived lack of urgency by NACA and Langley administrators delayed the construction for over a year but on November 26, 1947, the first tests were successfully run at Mach 6.9.<sup>11</sup> Eggers at Ames, proposed a continuous flow hypersonic tunnel and it was completed in 1950. Between these two facilities, hypersonic research began in earnest, mainly focusing on aerodynamic issues directed towards supersonic aircraft research.

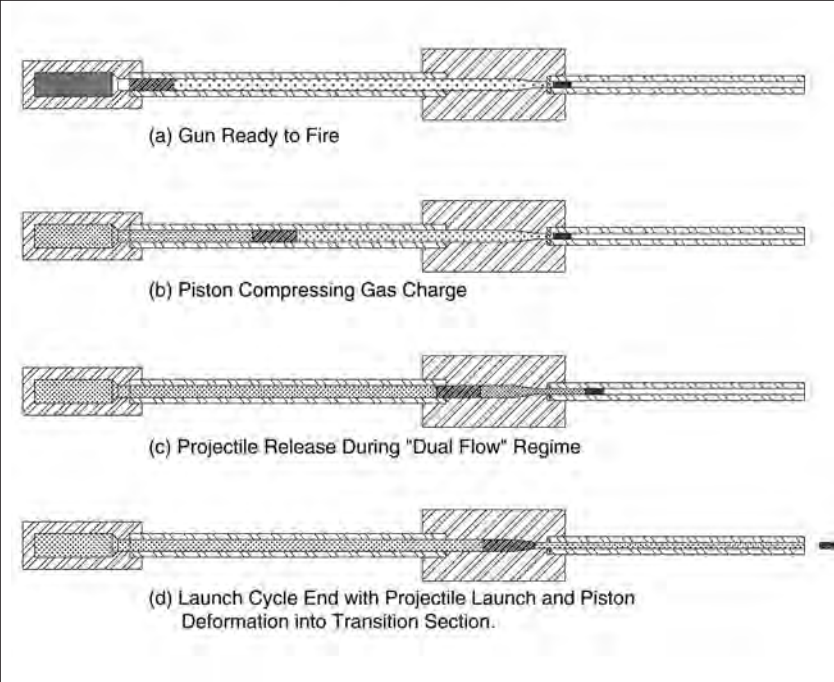
By 1955, the three major ballistic missile programs, the Air Force Thor (IRBM) and Atlas (ICBM) and the Army Jupiter (IRBM), made reentry vehicle research a high national priority. Two flight regimes required detailed study. The 1,500 nautical-mile IRBM Thor and Jupiter warhead reentry speed would be nearly 15,000 feet per second while the 5,000 nautical mile range ICBM would be nearly 25,000 feet per second.<sup>12</sup> Basic ballistic shapes, along the lines suggested by Allen and Eggers were tested up to the Mach 7-10 capabilities of the early hypersonic wind tunnels, confirming their theoretical results. However, the limitations in run times and temperatures, as well as atmospheric densities, soon illustrated the need for additional testing facilities.

## Shock Tubes

The first shock tube was built in France in 1899 by Vielle to study flame fronts and propagation speeds resulting from explosions.<sup>13</sup> The concept languished until 1946 when Payman and Shepard in Britain published a thorough description of the design and use of shock tubes in studying explosions in mines.<sup>14</sup>

There are many variations of shock tube design but all share a basic two chamber concept. The first chamber is separated from the second with a burst diaphragm calculated to burst when the gas in the first chamber is compressed to a predetermined value. Since 1949, shock tubes have been used to augment aerodynamic studies using hypersonic wind tunnels, in particular the use by the mid-1950's was focused on reentry vehicle design and material selection since speeds greater than Mach 10 could easily be achieved, as well as much higher temperatures. The major drawback was the limited duration of test conditions.<sup>15</sup> Both Ames and Langley's Wallops Island Flight Test Range utilized shock tubes for reentry vehicle research.<sup>16</sup>

Avco Corporation learned of the shock tube work of Arthur Kantrowitz at Cornell University's School of Aeronautical Engineering funded by the Naval Ordnance Laboratory. Kantrowitz ran test models of the Mark 4 reentry vehicle that Avco was developing as a back-up for the General Electric Mark 3 for Atlas and for use as the primary reentry vehicle for the Titan I. In 1956 he left Cornell to



**Figure 3: Light Gas Gun Schematic (H.F. Swift, *Light-Gas Gun Technology: A Historical Perspective*, in *High-Pressure Compression of Solids VIII*, with permission from the publisher.)**

head up the Avco Everett Research Laboratory where he led development of the ablative materials for the final Mark 4 design as well as for the Minuteman Mark 5 and Mark 11 reentry vehicles.<sup>17</sup>

### Light-Gas Gun

The two stage light-gas gun was invented in 1948 by E.J. Workman at the New Mexico Institute of Mining as a method to dramatically increase projectile velocity. Despite the impressive German and Russian developments in artillery during World War II, perhaps the most famous of which was the German Tiger Tank 88 mm gun, projectile velocities remained at an upper limit of 9,000 feet/second.

The basic concept of the light-gas gun was to replace the gaseous byproducts of conventional gun powders which propelled the projectile, with a column of hydrogen or helium. A standard gunpowder cartridge was used to fire a plug down a barrel filled with helium or hydrogen (hence the term light-gas) which would compress to the bursting point a diaphragm immediately behind the actual test projectile. When the diaphragm burst, compressed light gas would propel the projectile down a second barreling allowing far greater velocities to be achieved since the molecular weight of the propellant gas would now be approximately 1/8th of that of the water, carbon dioxide and nitrogen byproducts of gunpowder combustion (4 g/mole for helium versus approximately 30 g/mole) (**Figure 3**).

Workman's research group received funding from the Army Ballistic Research Laboratory (BRL) and proved the concept, reaching a velocity of 9,800 feet per second and quickly extending it to nearly 14,000 feet per second. The results caught the attention of the BRL managers, the device declared classified and removed,

with all of the associated equipment, to the BRL facilities. Work did not continue at BRL for reasons that are not clear.

With the need for a relatively inexpensive method to "flight" test small models of proposed Atlas and Thor reentry vehicles, in the mid-1950's the light-gas gun concept was given new life via contractors and universities as well as researchers at both Langley and Ames. Velocities were soon extended beyond 25,000 feet per second.<sup>18</sup>

### Atmospheric Entry Simulator

In early 1955, Eggers at Ames pondered the idea of simulating reentry through the varying densities of the upper and lower atmosphere. Could a method be found for launching a test article at reentry speeds into a test chamber that could simulate the gradual increase in atmospheric density which was the most problematic for the thermal stress of reentry? A light-gas gun could be used for launching the test article as their development had progressed to provide reentry velocities but how to simulate the atmosphere at 100,000 feet where most of the aerodynamic heating takes place? The necessary 100-fold variation in atmospheric density in this part of the reentry envelope might be achieved using components of a supersonic wind tunnel, the settling chamber and the exit portion of a Mach 5 supersonic nozzle. Eggers reasoned that the light-gas gun could be used to fire a small scale reentry vehicle model into the Mach 5 supersonic nozzle and then caught for detailed examination. The result was a small prototype Atmospheric Entry Simulator (AES) which was built in 1956, and successfully tested in 1957, evolving into a larger version in 1957.<sup>19</sup> This large AES was used successfully in exploratory work on blunt body copper heatsink designs meant for use on the shorter range and substantially lower heat regime IRBM missiles with reentry speeds of 15,000 feet per second.<sup>20</sup>

### Arc Jet

Major drawbacks to the methods already addressed was still the relatively short duration of velocities, temperatures and inability to reach the higher temperatures of reentry in a continuous flow wind tunnel. After investigating several possibilities, the solution appeared to be the use of an arc-jet heater. Research at Ames began in 1956 and resulted, six years later, in the Gas Dynamics Laboratory devoted to further arc-jet development for use in stand-alone testing of ablation materials. While arc-jet wind tunnels are used to study reentry phenomena in a step-wise manner, they are unable to simulate conditions of a constantly descending reentry vehicle.<sup>21</sup> Several different types of arc-jet heaters, including subsonic air arc jet heaters and arc-jet radiant heaters are also used outside of a wind tunnel to study the ablative properties of materials. The arc-jet, with its more easily managed test conditions as

well as longer test duration times, along with the fact that the test model was held in place, eventually replaced the AES for study of ablative materials at Ames.

Avco Corporation's Everett Research Laboratory and General Electric's Missile and Space Vehicle Division, amongst other labs, also employed variations of the arc-jet in their research and development of ablative materials for use on reentry vehicles. In 1958 James Fay, from the Massachusetts Institute of Technology and Avco's Frederick Riddell published a theory that allowed calculation of boundary layer conditions in high speed flight:<sup>22</sup>

*The boundary-layer equations are developed in general for the case of very high speed flight where the external flow I in a dissociated state. In particular the effects of diffusion and of atom recombination in the boundary layer are included. It is shown that at the stagnation point the equations can be reduced exactly to a set of non-linear ordinary differential equations even when the chemical reactions proceed so slowly that the boundary layer is not in thermochemical equilibrium.*

P.H. Rose and W. I. Stark at Avco published a paper at the same time comparing the theory against shock tube experimental results:<sup>23</sup>

*Simulation of flight stagnation conditions at velocities up to satellite velocity of 26,000 feet per second is shown to be possible in shock tubes and data has been obtained over a large altitude range at these velocities.*

These two papers extended that of Lester Lees published in 1956 which had been found to underestimate by as much as 30 percent heat transfer rates at the reentry vehicle tip.<sup>24</sup> Now reentry vehicle researchers had both experimental and theoretical methods for evaluating ICBM reentry vehicle materials and possible designs.

## **Rocket Motor Exhaust**

Development of the Jupiter IRBM reentry vehicle took place at the Army Ballistic Missile Agency (ABMA) facilities at the Redstone Arsenal, Huntsville, Alabama. Researchers there used the exhaust from a number of different liquid rocket engines to test candidate jet vane materials to replace the troublesome graphite vanes used in the V-2.<sup>25</sup>

## **Solutions to the "Reentry Problem"**

Theodore von Kármán, perhaps the leading aerodynamics expert of his time, described what he called "the reentry problem" at a symposium in Berkeley, California, June 1956. Reentering the atmosphere at speeds of Mach 12-20 was "perhaps one of the most difficult problems one can imagine. . . a challenge to the best brains

working in these domains of modern astrophysics."<sup>26</sup> While the workers at Ames, Langley and other facilities had partially met the challenge via theoretical calculations about vehicle shape which led to the design of testing facilities, what was the solution to the remaining aspect, taming the thermal load encountered at these high speeds?

Four categories of cooling were considered: a) radiant cooling via emittance from the vehicle surface, b) solid heatsinks which would have sufficient mass to absorb the heat and protect the payload, c) transpiration and film cooling which would cause heat removal by material phase change, d) ablation which would allow heat dissipation via the many protective processes associated with surface removal.

Each of the four options had specific environments where they were most effective. Radiant cooling was best for long duration reentry environments where heat load was relatively low and constant and in practice worked best at temperatures below 2,000 F. Solid heatsinks could accommodate higher temperatures as long as the heating rate was not so rapid as to melt the material. Additional large structural mass was necessary to store the heat and protect the payload. Transpiration and film cooling would be able to work over a wide thermal environment but were mechanically complicated which might reveal hidden reliability issues. Ablation worked well for short duration, high temperature environments, the question was one of which materials to select and how to test them.<sup>27</sup> Only two of these concepts, heatsink and ablation, were used in research and operational reentry vehicles.

A key description of a reentry vehicle is its ballistic coefficient, beta ( $\beta$ ). is defined as  $W/(C_d \times A)$ , where  $W$  is the weight of the reentry vehicle,  $C_d$  is the coefficient of drag and  $A$  is the cross-sectional area. With reentry vehicle weight being held constant, reentry vehicles with a low  $\beta$  (high coefficient of drag and cross-sectional area, and thus high air resistance) decelerate at a relatively high altitude, where the density of the atmosphere is low and heat fluxes are lower but reentry times are longer, facilitating radar detection while simultaneously resulting in decreased accuracy. Medium  $\beta$  vehicles decelerate at a medium altitude with higher heat fluxes but shorter detection times and increased accuracy. High  $\beta$  vehicles decelerate at much lower altitudes, encountering much denser air and hence higher heat fluxes but for a shorter time, allowing less time for radar detection and also greatest accuracy. Obviously these considerations were critical to mission requirements but were constrained by both the materials and testing facilities available at the time.

## **The First Generation - Heatsink**

The work of Allen and Eggers had clearly shown the importance of selecting a relatively blunt nose shape for ballistic missile reentry vehicles to minimize aerodynamic heating. There was still an enormous amount of

<b>Mark 1</b>	Atlas D, Thor	General Electric (development, not flown)
<b>Mark 2</b>	Atlas D, Thor	General Electric
<b>Mark 3</b>	Atlas D	General Electric
<b>Mark 4</b>	Atlas E, F, Titan I	Avco
<b>Mark 5</b>	Minuteman IA	Avco
<b>Mark 6</b>	Titan II	General Electric
<b>Mark 7</b>	Skybolt	General Electric (cancelled)
<b>Mark 8, 9, 10</b>	not assigned	
<b>Mark 11, 11A, 11B, 11C</b>	Minuteman IB, Minuteman II	Avco

Miller, B., *Studies of Penetration Aids Broadens*. 20 January 1964, *Aviation Week and Space Technology*, 79.

heat to be dealt with and this meant selecting the best temperature-resistant and high strength materials. Allen and Eggers research showed that most of the aerodynamic heating would be outside the boundary layer and not in direct contact with the reentry vehicle provided the boundary layer remained laminar. A considerable amount of radiative heat still had to be dissipated. Since radiation varies as the fourth power of the temperature, it was likely that the reentry vehicle would not be an efficient radiator with the result that surface temperature would rise beyond either the structural stability of then currently available materials or the tolerance level of the enclosed equipment, i.e., fusing and actual warhead. Heavily influenced by Allen and Eggers seminal work in conjunction with the paucity of high temperature stable materials, the first choice for reentry vehicle heat control was the heatsink concept. Both the Navy and Air Force elected to use the heatsink concept for their first generation reentry vehicles. The Air Force program is known in greater detail but both are discussed next because the Navy had a novel approach to reentry vehicle design (**Table 1**).

## Navy

### Mark 1

As with Thor and Atlas, the reentry vehicle (the Navy used the term reentry body but reentry vehicle is used here for consistency) needs for Jupiter-S (progenitor to Polaris) coincided with the viability of the heatsink concept since ablative material research was still relatively new in 1955 had not progressed far enough. (**Figure 4**).

The Navy quickly moved from the Jupiter-S program to Polaris. Due to weight constraints imposed by the Polaris missile solid engine performance, the reentry vehicle/warhead combination had to be much lighter than the Jupiter payload with a goal of a nearly seventy

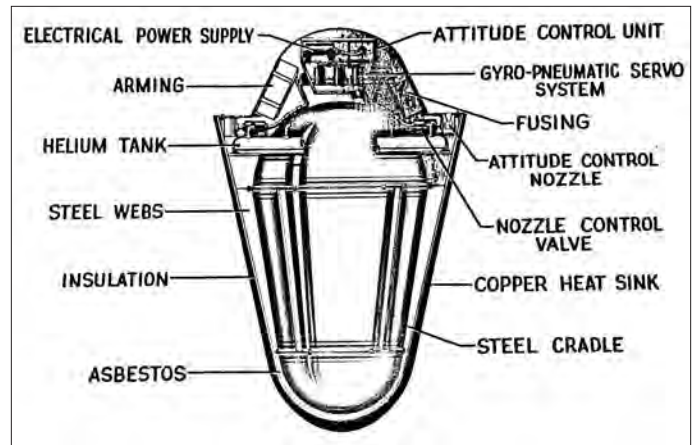
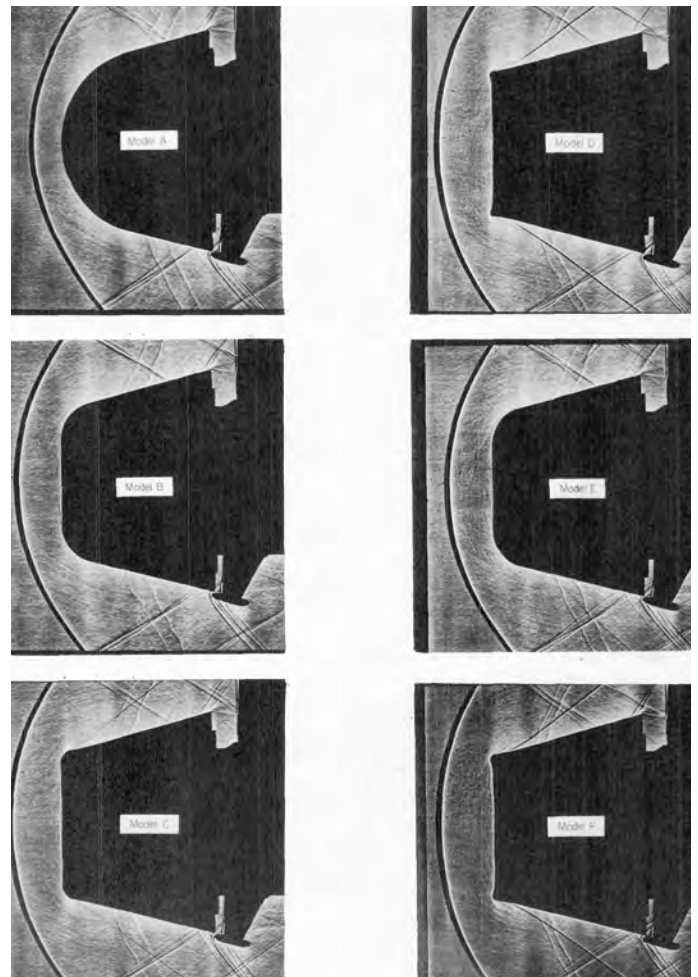


Figure 4: Early Reentry Vehicle Design for Jupiter-S missile. (U.S. Navy Photograph, author's collection.)

percent reduction to 1,000 pounds, at most. Consequently, the Navy was focusing, unlike the Air Force and Army reentry vehicle designs, on a reentry vehicle that did not encase the warhead. Instead, the warhead would ideally be an integral part of the design.<sup>28</sup>

Figure 5: Evaluation of Flat-Faced Blunt Nose Reentry Vehicle Shapes (National Advisory Committee for Aeronautics, "Heat Transfer and Pressure Distribution on Six Blunt Noses at a Mach Number of 2," H.S. Carter and W.E. Bressette, NACA Research Memorandum L57C18, (18 April 1957), 10.



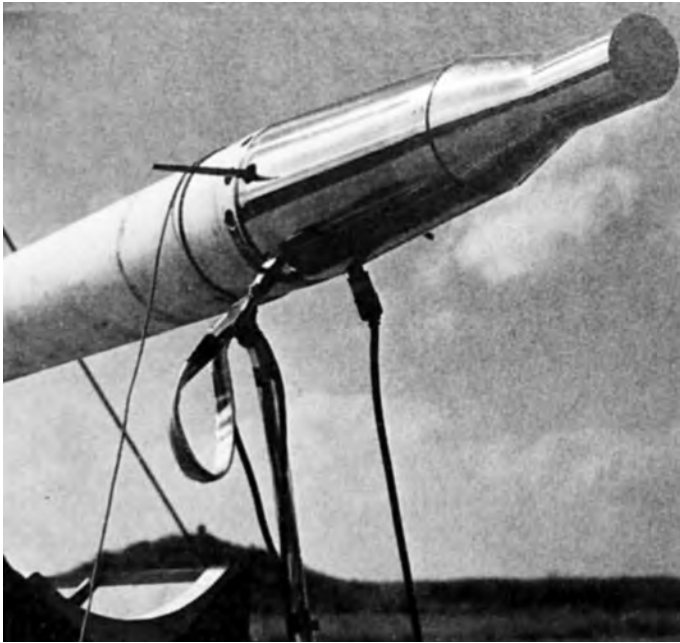


Figure 6: Free Flight Flat-Faced Blunt Nose Reentry Vehicle Sub-scale Model (J.A. Shortal, *A New Dimension*, Wallops Island Flight Test Range: The First Fifteen Years.), 518.

On December 21, 1956, the Navy Bureau of Ordnance asked the NACA to study reentry body shapes for use in the new Polaris IRBM program. Just one day earlier a flight test at Wallops Island had shown that using a flat-faced cylinder sub-scale model made of copper, the design could survive reentry speeds of Mach 13.9. Additionally the superiority of copper over Inconel-X was also proven.<sup>29</sup> Earlier work in 1956 with five flat-face and one hemispherical shape at Mach 2 illustrated the potential for blunt nose shapes with the flat-face shapes showing substantially reduced heat transfer (**Figure 5**).<sup>30</sup> In mid-1958, a feasibility study was published by James R. Hall and Benjamin J. Garland of Wallops Island Pilotless Aircraft Research Division. Two possible flat-faced cylindrical shapes with flared ends were evaluated. Their calculations showed that a flat-faced cylindrical shape with a flared afterbody was possible and if made of beryllium (the cylindrical part was assume to be the outer casing of the warhead) the resultant vehicle would be 134 pounds lighter than if composed of copper (**Figure 6**). Soon backed up by additional ground and flight testing, the Polaris reentry vehicle shape was close at hand.<sup>31</sup>

The Navy used flight test systems at Cape Canaveral and Wallops Island. At Cape Canaveral a modified Air Force X-17 rocket was used in a four flight FTV-3 series to evaluate reentry vehicle shapes and materials. These flights took place from July 17, 1957 to October 1, 1957 and all were successful. Three flight test programs were conducted at Wallops Island in support of the Polaris reentry vehicle development, with fifteen flights between March 1958 and August 1959.<sup>32</sup>

The addition of a hydrodynamic fairing which covered the flat nose shape and was ejected once the missile began flight was all that was left to complete the shape

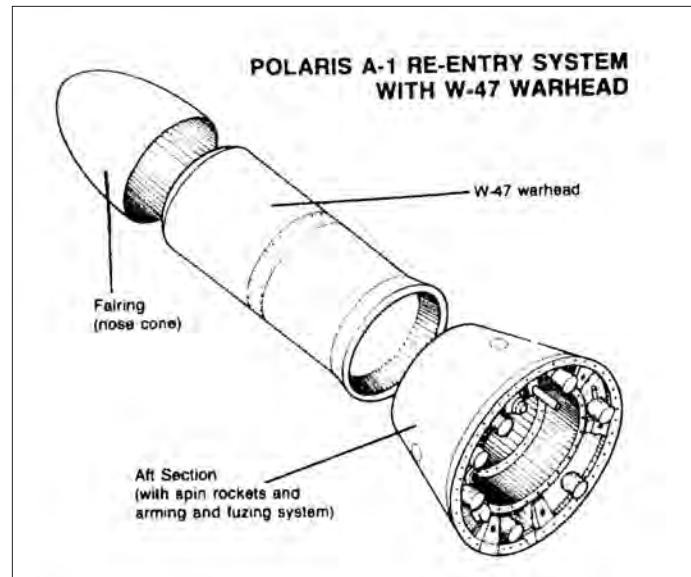


Figure 7: Polaris A-1 reentry vehicle major components (U.S. Navy photograph).

of the Mark 1. At the September 26, 1957 meeting of the Special Projects Office Steering Task Group, evaluation of heatsink materials had narrowed down the W47 nose cap material to beryllium or copper. Knemeyer at China Lake had read a RAND study on reentry heat shield materials and noticed that beryllium was an excellent candidate from a heat shield standpoint as well as the fact that the warhead casing was also made of beryllium.<sup>33</sup> The decision to use beryllium, at the time not a commonly used metal or readily available in the United States and which had only been used in alloy with copper, was somewhat controversial. The controversy stemmed from the issue that the Atomic Energy Commission (AEC) was being told by the Navy which material should be used for the casing of the warhead. The AEC resisted the suggestion at first but armed with the results of the Hall and Garland study, the Navy persisted and prevailed. (**Figure 7**).<sup>34</sup>

## Air Force

On January 24, 1955, the Air Force and Lockheed Aircraft Corporation (Lockheed) signed a letter of intent authorizing Lockheed to develop and conduct a program into the design of reentry vehicles. At this time none of the currently available aerodynamic research facilities in the country could simulate the high thermal and velocity conditions of long range ballistic missiles. New techniques were becoming available but the conclusions reached from them needed to be confirmed with actual flight test data.

The result was the X-17, designed to achieve a reentry speed of Mach 15 and achieve a Reynolds number of 24 million (the Reynolds number is an indication of viscosity with a high value indicating viscosity is negligible) while measuring boundary layer conditions and the transition from laminar (desired) to turbulent (unde-

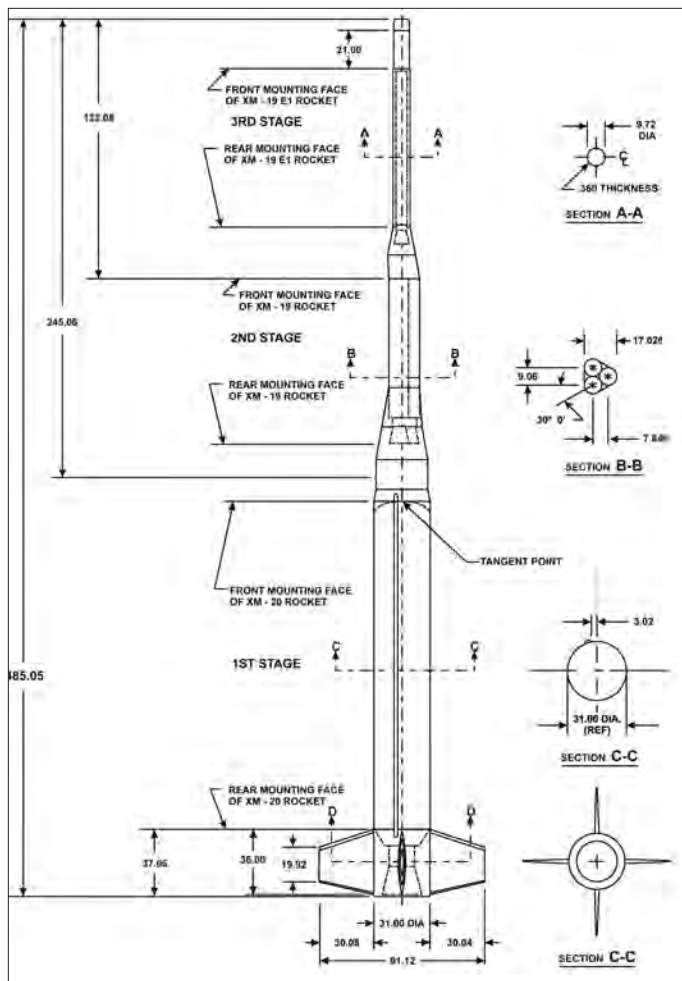


Figure 8: X-17 Full Scale Configuration (adapted from R.W.Roy and R.A Foster, "Final Report: Re-Entry Test Vehicle X-17, 10 May 1957", History Air Force Missile Test Center 1 July - 31 December 1957, Vol IV Supporting Documents Appendix F, AFHRA and (R.Smelt, "Lockheed X-17 Rocket Test Vehicle and Its Applications," American Rocket Society Vol 29, No. 8, (1959), 565-567. (Drawing by Mitch Cannon.)

sired) flow around the reentry vehicle. The Air Force reasoned that the X-17 would be able to provide the required data without waiting years for full-scale Atlas or Titan missiles to be ready while also being much less expensive. Sub-scale reentry vehicle shapes and material could be screened quickly and appropriate conversion of the data to full-scale models could be made.<sup>35</sup>

On February 17, 1955, representatives from the Western Development Division, Ramo-Wooldrigde and Lockheed visited the Langley facilities at Wallops Island where a few months earlier the first Mach 10 flight of the Langley Pilotless Aircraft Research Division (PARD) had taken place using a four stage solid propellant vehicle. Unlike the proposed X-17 flight profile which focused on high speed reentry, the PARD program Mach 10 speed had been reached at 86,000 feet with a coast up to 219 statute miles and a down range distance of 400 nautical miles. The X-17 program was described with the hope that the PARD program could be expanded to include the X-17 program. The Air Force schedule of a dozen flights at Mach 15 within a year was incompatible with the existing PARD programs but the Air Force de-

cide to support the ongoing PARD programs by transferring some of the Sergeant rocket motors assigned to the X-17 program to Langley for use at Wallops Island.<sup>36</sup>

The X-17 was a three stage solid propellant missile designed to expose sub-scale re-entry shapes and materials to conditions of Mach 15 and a Reynolds number of 24 million. The program had four phases, using quarter- and half-scale rockets for development purposes and full-scale airframes for the research phase. For the full-scale rocket, 40.5 feet in length and weighing 12,000 pounds (8,500 pounds of propellant), the first stage was a single 31 inch diameter Sergeant motor, the second stage was a cluster of three Recruit motors 18.4 inches in diameter and, and the third stage a single Recruit motor, 9.72 inches in diameter.<sup>37</sup> The X-17 flight program began on May 23, 1955 using quarter-scale models, moving to half-scale on June 23, 1955 and the full-scale rocket on August 26, 1955, ending with the seventh full-scale flight on June 26, 1956. The fourth phase began on July 17, 1956 and ended on March 21, 1957 with only two failures out of thirty-six test flights. The two failures were caused by airframe problems and not propellant or staging issues, thus demonstrating the reliability, of multistage a solid propellant system.<sup>38</sup>

The flight profile emphasized the type of reentry conditions foreseen for ICBM reentry vehicles. The first stage propelled the airframe to 90,000 feet at burnout (Figure 8,9). The missile then coasted to an altitude of 300,000 to 517,000 feet depending on the launch angle and vehicle weight. As the missile fell back to earth, the four fins on the first stage assured that the missile orientation was nose down. At an altitude of 90,000 to 70,000 feet, depending on the test objectives, a pressure probe initiated stage separation and ignition of the second stage along with activating a delayed signal for third stage ignition. At third stage burnout, speeds of Mach 11.2 to 14.5 were reached at 55,000 feet, again depending on launch angle. No effort was made to recover the reentry vehicle models, they lasted only long enough for telemetry on heating rates to be transmitted and often completely consumed. Of the 24 research phase flights, 18 were completely successful, one partial successful and five were failures. Blunt, hemisphere and cubic paraboloid reentry vehicle nose shapes were flown with six flights each for the General Electric and Avco blunt heatsink shapes being developed for the Atlas and Thor programs.<sup>39</sup>

## Mark 2

The smaller the radius of the nose cone, the higher the temperature generated by atmospheric friction. By 1955, the scientists at the Army Ballistic Missile Agency (ABMA) had demonstrated to their satisfaction that the ablation method was the obvious direction to pursue, but the Air Force had opted for the more conservative approach of the heatsink method. If an ICBM was to be developed in a timely manner, to the Air Force way of thinking there was no other option but to go to a large

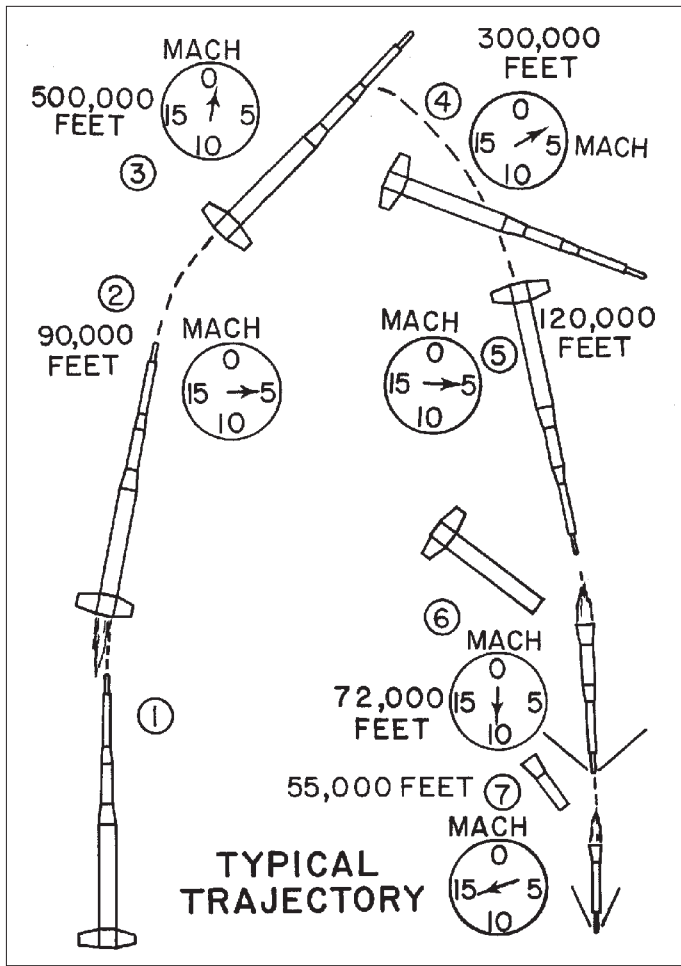


Figure 9: Typical X-17 Trajectory (R.W.Roy and R.A Foster, "Final Report: Re-Entry Test Vehicle X-17, 10 May 1957", History Air Force Missile Test Center 1 July - 31 December 1957, Vol IV Supporting Documents Appendix F, AFHRA.

radius, low  $\beta$  reentry vehicle, the heatsink approach.

Much earlier work by Convair, the Atlas prime contractor, had pointed towards transpiration cooling for the reentry vehicle. The resultant weight, approximately 7,000 to 8,000 pounds, necessitated the original five engine design. Convair wanted to use a ceramic reentry vehicle, possibly due to the Army's work on Jupiter but at the time fabrication techniques for this large a vehicle were not available. When Ramo-Wooldridge (R-W) became the systems engineering contractor for the Western Development Division in 1954, they took a systems approach to reentry vehicle development. A blunt heatsink reentry vehicle design was well within the laboratory investigation abilities at that time. On December 22, 1954, R-W, Sandia Corporation and the Atomic Energy Commission agreed that the proposed Convair reentry vehicle weight could be cut in half and still provide space for the one megaton yield warhead the Air Force required. The decrease in reentry vehicle weight, combined with a new 2,000 pound warhead, meant that the overall weight of the missile could decrease from 460,000 pounds to 260,000 pounds and the propulsion unit reduced from five to three engines.<sup>40</sup>

General Electric (primary contractor) and Avco (backup contractor) were awarded an Air Force contract in 1955, to design, develop and manufacture a heatsink reentry vehicle for use on the Atlas ICBM. In this design, the heat of reentry was conducted from the surface to a mass of high heat capacity material rapidly enough to keep the surface temperature below the melting point of the shield material. Additionally, the mass of the heatsink absorbed the heat and prevented the payload from suffering thermal stress. The Air Force's scientific advisors concurred with the heatsink decision and the General Electric "froze" the design in terms of the warhead dimensions and heatsink method on 5 September 1956.<sup>41</sup> When the Air Force was assigned the Thor IRBM program, the Atlas reentry vehicle design was shifted to accommodate both missiles, saving development costs since an reentry vehicle designed for ICBM conditions would easily withstand the less strenuous conditions of IRBM reentry.<sup>42</sup>

Work by Jackson Stadler at Ames in 1957, evaluated copper, Inconel-X, graphite and beryllium for use in heatsink reentry vehicles. Copper represented an example of an easily machined material with high thermal conductivity but relatively low melting point, 1,984 F. Inconel-X was an example of refractory metal (resistant to heat and wear), but had low thermal conductivity and a 1,200 F melting point as well as being difficult to machine. Beryllium was an example of a lightweight metal with high strength, excellent thermal conductivity, a melting point of 2,348 F, but was difficult to machine as well as being hard to supply in quantity at the time. Additionally the dust generated by machining was highly toxic. Graphite was an example of a semi-metal with high thermal conductivity and highest melting point, 6,442 F, and high sublimation temperature. Stadler's evaluation included: a) thickness of material to prevent melting or sublimation at the surface, b) weight of material thick enough to meet (a), and c) determining thermal stress due to temperature gradients in the material.

Stadler concluded copper was a likely candidate due to the mass of material being resistant to thermal shock (weight was a drawback) and protection from oxidation would be needed. Inconel-X was "completely unsatisfactory" due to the low thermal conductivity causing melting to occur early in reentry and little heat was transferred to the interior. Graphite was superior to copper from the standpoint of weight, requiring 1/24 the weight of copper for equivalent protection. Unfortunately it would require to be coated which would inhibit exploitation of the high sublimation temperature. Beryllium was attractive due to a higher melting point than copper and being much lighter, 1/6th the equivalent weight of copper, but it was brittle and difficult to form in large pieces at that time.<sup>43</sup>

For the General Electric Mark 2 design copper was selected due to its ease of machining, high heat capacity and high thermal conductivity which meant the heat generated would be rapidly absorbed into the mass of copper and not cause melting at the surface. Avco scien-

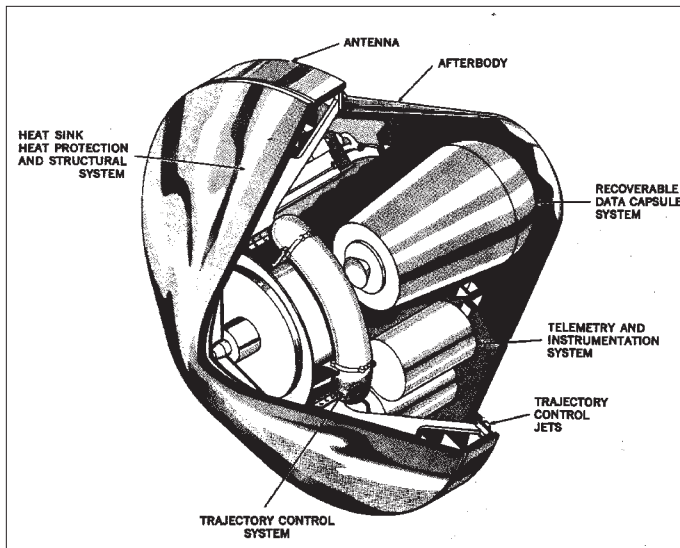


Figure 10: General arrangement of the General Electric Mark 2 heatsink reentry vehicle (M.Morton, *Progress in Reentry Recovery Vehicle Development*, Philadelphia, PA: General Electric, Missile and Space Vehicle Division, 1961, 6.)

tists pursued the use of beryllium and were successful in creating a Mark 2 reentry vehicle but it was too late as ablation took over as the method of choice. The techniques developed were used to fabricate early research and development beryllium heat shields for Project Mercury.<sup>44</sup>

Work by Katherine C. Speegle at Wallops Island's preflight jet test facility in 1957, investigated the best shape for the nose and the compartment that would contain the warhead. Six blunt nose shapes with identical afterbodies were tested at Mach 2.0 velocities. The results showed that the selected truncated cone afterbody was completely surrounded by the separated flow region, meaning heating would be acceptable.<sup>45</sup> The final design was known as a blunt conic sphere. The Mark 2 had a maximum diameter of 63.6 inches and was 60 inches in length, weighing nearly 2,000 pounds (Figure 10).<sup>46</sup> The blunt conic-sphere was inherently unstable and prone to oscillations causing turbulent flow to develop on the nose of the vehicle so a trajectory control system was incorporated to provide rate damping of the oscillations as well as impart spin to increase accuracy. A Mark 1 reentry vehicle was initially developed as a flight article but due to changes in missile flight schedules was not flown and instead used for development fit testing and as a flight reserve article.<sup>47</sup> The surface of the Mark 2 was coated with a thin layer of nickel to decrease radiative heating and was highly polished to prevent localized hot spots.<sup>48</sup>

The X-17 program had demonstrated that an ionized air layer surrounding the vehicle during the highest temperature period of reentry caused a telemetry black-out. For full-scale flight testing of the Mark 2, General Electric engineers developed a buoyant data capsule. The capsules were 18-inch spheres made from two hollow hemispheres of polyurethane foam which housed a tape recorder, radio

beacon, battery pack, dye pack and SOFAR (sound fixing and ranging) device for locating the capsule. The bottom half of the capsule was coated with shark repellent after a test capsule was recovered with a shark bite mark. The capsule was attached to a small rocket to boost it free of the reentry vehicle. The urethane sphere was encapsulated in an ablative shell which shattered on impact (40,000 g's), releasing the buoyant capsule. Contact with salt water triggered the release of dye, the SOFAR device and the radio beacon.<sup>49</sup>

The Atlas Mark 2 flight test program began on July 19, 1958 and ended on December 19, 1959, a total of seventeen flights; seven Atlas B, four Atlas C and six Atlas D, nine were successful flights. The Thor Mark 2 flight test program began on November 5, 1958 and ended on December 17, 1959, a total of twenty-eight flights, with twenty-four successful. Details on Mark 2 reentry vehicle performance on these flights remains classified. The Mark 2 Mod 4 operational warhead weighed 3,500 pounds of which 1,600 pounds was warhead weight and was only deployed on Atlas D gantry sites at Vandenberg AFB from 1959 to 1964 and on Thor missiles in England from 1959 to 1963.<sup>50</sup> (Figure 11).

## The Second Generation - Ablative

The first to actually describe ablation was Dr. Robert H. Goddard in 1920:<sup>51</sup>

*In the case of meteors, which enter the atmosphere with speeds as high as 30 miles per second, the interior of the meteors remains cold, and the erosion is due, to a large extent, to chipping or cracking of the suddenly heated surface. For this reason, if the outer surface of the apparatus were to consist of layers of a very infusible hard substance with layers of a poor heat conductor between, the surface would not be eroded to any considerable extent, especially as the velocity of the apparatus would not be nearly so great as that of the average meteor.*

The process of ablation during reentry is described as follows:<sup>52</sup>

*As heating progresses, the outer layer of polymer may become viscous and then begins to degrade, producing a foaming carbonaceous mass and ultimately a porous carbon char. The char is a thermal insulation; the interior is cooled by volatile material percolating through it from the decomposing polymer. During the percolation process, the volatile materials are heated to very high temperatures with decomposition to low molecular weight species, which are injected into the boundary layer of air. This mass injection creates a blocking action, which reduces the heat transfer in the material. Thus, a char-forming resin acts as a self-regulating ablation radiator, providing thermal protection through transpirational cooling and insulation. The efficiency, in terms of heat absorbed per weight of material lost, is about 40 times that of the earlier copper heatsink design.*





Figure 11: Mark 2 reentry vehicle (shown upside down) being inspected prior to loading on a Thor missile in England. (Courtesy of Jim Causby)

## Army

### Jupiter

Ablation provided thermal protection for the Jupiter reentry vehicle. Earlier work had shown the transpirational cooling approach, while it worked, required complicated plumbing that would likely be hard to support in the field. The heatsink concept would work but was determined to be too heavy. The ablative approach came from a fortuitous result of research begun in 1953, investigating materials to replace graphite for jet vane application during the development of the Redstone missile (jet vanes were used for directional control instead of gimbaling the engine). The trouble was one of quality control because while a source of the right grade of material was found, the manufacturer's poor quality control meant that only twenty-five percent of the jet vanes were acceptable. In an attempt to find a replacement, researchers tested several materials including a jet vane made of commercial grade fiberglass-reinforced melamine. Exposure to the Redstone rocket motor exhaust eroded the vane as expected but much to the surprise of the researchers, one-quarter inch beneath the surface the material was not only undisturbed but the embedded thermocouples revealed no heating had taken place. While the tested material was not used as a jet vane, the ABMA re-

searchers skipped past the heatsink concept and went straight to ablative reentry vehicle materials.<sup>53</sup> Ceramic material was also carefully evaluated and found to be too sensitive to thermal shock at that time though sufficient work was done with a method of ceramic manufacture called slip forming to successfully fabricate the necessary shape.

Scientists at ABMA estimated the weight of five candidate materials: Refrasil-phenolic, fiberglass-melamine, unfired ceramic, beryllium and copper to provide thermal protection for a proposed heat shield design. Refrasil, fiberglass-melamine and ceramic were found to be the materials of choice. An expedient method for evaluating candidate materials was to expose flat plates of the material to rocket exhaust at a heat flux of 100 BTU/ft<sup>2</sup>-sec and a velocity of 6,700 feet per second. The plates were four inches square and tilted at a 45 degree angle in the exhaust stream. Further research in resin based ablative materials revealed that asbestos reinforced phenolic resin would be the best overall material for the Jupiter reentry vehicle environment. After initial evaluation of the plate material, reentry vehicle shapes were tested both with the rocket exhaust technique and via shock tube studies by Arthur Kantrowitz at Cornell University.<sup>54</sup> Using a variety of rocket motors, researchers were able to simulate heating rates up to 2,500 BTU/ft<sup>2</sup>-sec. Transonic wind tunnel tests of a half-scale model Jupiter reentry vehicle were



Figure 12: Jupiter-C sub-scale reentry vehicle attached to the spinning “tub.” This vehicle was an early fiberglass-melamine ablative material flown on 15 May 1957. While not recovered, the telemetry showed that the ablative concept worked well on an IRBM trajectory. (NASA photograph courtesy of Joel Powell.)

conducted at the Air Force’s Arnold Engineering Development Center, Arnold Air Force Base in June 1957 and at the hypersonic test facilities of the Naval Ordnance Laboratory, White Oak, Maryland in September 1957, confirming the full-scale nose cone design.<sup>55</sup>

For flight testing of the one-third scale Jupiter reentry vehicle designs, the Army’s Redstone tactical ballistic missile was modified into a three stage booster. The first stage had an elongated fuel tank and used a more powerful fuel called Hydne (unsymmetrical dimethyl hydrazine). The forward section of the first stage was strengthened to support the new upper stages. The second stage was made up of a cluster of eleven scaled-down Sergeant solid propellant missiles, six inches in diameter, housed in a cylindrical fairing called the “tub.” The third stage was located in the center of the second stage and made up of three additional scaled down Sergeant missiles. Atop the third stage was a 300-pound, 1/3rd-scale ablative ( 1/10th surface area) reentry vehicle composed of a welded steel shell supporting the heat shield. While fabrication techniques were being perfected for the resin-asbestos material, a heat shield made of layered disks of melamine, a commercially available laminated fiberglass-resin was flown first. The tub was spun up by electric motors at launch to provide ballistic stability. The resulting vehicle was called Jupiter-C (Jupiter Composite) and now had a range of over 1,500 nautical miles with an apogee of over 175 nautical miles.<sup>56</sup> (Figure 12)

Only three of a scheduled of thirteen flights were necessary for the Jupiter-C program. The first launch was on September 20, 1956, Jupiter C Missile RS-27,

with the missile reaching 600 nautical miles in altitude and a speed of Mach 18. This was a test of the modified propulsion and staging system and was successful. The second flight, Jupiter C Missile RS-34, was launched on May 15, 1957. The missile pitched up at 134 seconds into flight so while the planned range was not reached and the reentry vehicle was not recovered, telemetry indicated that the fiberglass melamine ablative material had functioned as expected. The first sub-scale operational Jupiter reentry using a phenolic resin asbestos ablative material was flown on Jupiter C Missile RS-40, August 8, 1957. The booster and high-speed upper stages worked well. Failure of the reentry vehicle to separate from the third stage changed the reentry trajectory, reducing the angle of attack at the point of maximum heating. Nonetheless, the reentry vehicle traveled 1,168 nautical miles, achieving a velocity of 13,000 feet per second and withstanding a temperature of over 2,000 degrees F, conditions similar to those expected for an IRBM reentry vehicle. While the reentry vehicle did not separate as planned, the heat of reentry melted the magnesium ring of the separation system and the recovery system deployed successfully. Analysis of the ablative covering showed only a one and a half percent loss (the reentry vehicle was displayed in President Eisenhower’s office and is in storage at the National Air and Space Museum in Washington, D.C.) Ablation technology had been proven with the ultimate test, full IRBM range and velocity.<sup>57</sup>

Full-scale Jupiter reentry vehicles were successfully recovered on three flights; Jupiter Missile AM-5, launched on May 18, 1958, the first recovery of an IRBM reentry vehicle; Jupiter Missile AM-6, July 17, 1958, which also carried a lightweight high explosive warhead; and Jupiter Missile AM-18, May 28, 1959, which carried two monkeys, Able and Baker, which survived unharmed. While the reentry vehicle flown on AM-5 showed an ablation depth of three-eighths inch at the greatest point of loss, the remaining flights showed considerably less, validating the ablative concepts of the sub-scale model flown and recovered earlier (Figure 12).<sup>58</sup>

The deployed reentry vehicle, built by Goodyear Aircraft Corporation, was an hermetically sealed conical aluminum shell with a twelve and a half-inch radius spherical tip attached to a cone frustrum with a base 65 inches in diameter and an overall length of nine feet. The molded nose cap was composed of thirty percent, by weight, phenolic resin with seventy percent Type E glass; the frustrum material was a layer of a mixture of forty-five percent phenolic resin and fifty-five percent Chrysotile asbestos.<sup>59</sup> A key design feature, also found in other reentry vehicle designs, was a convex dish shaped aft cover which conferred the ability to recover from any attitude to the correct reentry alignment. The ablative material was much thinner than the sub-scale fiberglass melamine heatshield. (Figure 13). The complete reentry vehicle with warhead, weighed 2,617 pounds, the W49 weapon weighed 1,600 pounds.<sup>60</sup>

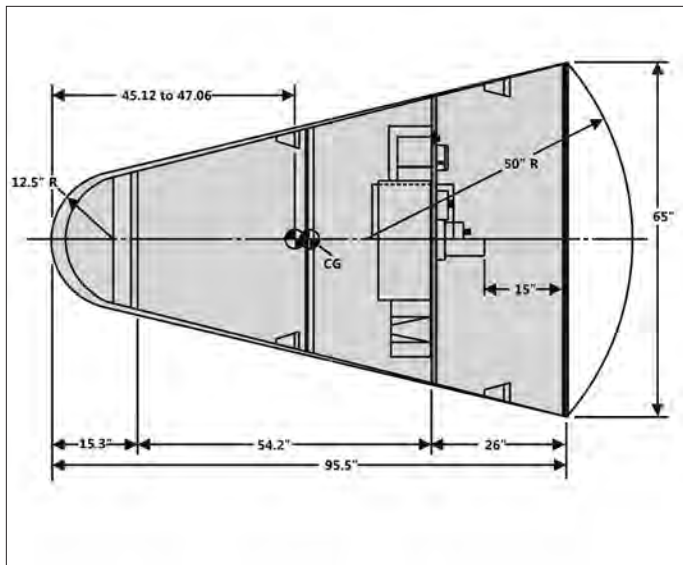


Figure 13: Operational Jupiter reentry vehicle dimensions (adapted from National Aeronautics and Space Administration, NASA History Office, "Facing the Heat Barrier: A History of Hypersonics," by T.A. Heppenheimer, NASA History Series, SP-2007-4232 (2007), 46. Drawing by Mitch Cannon).

## Air Force

### Atlas and Titan I

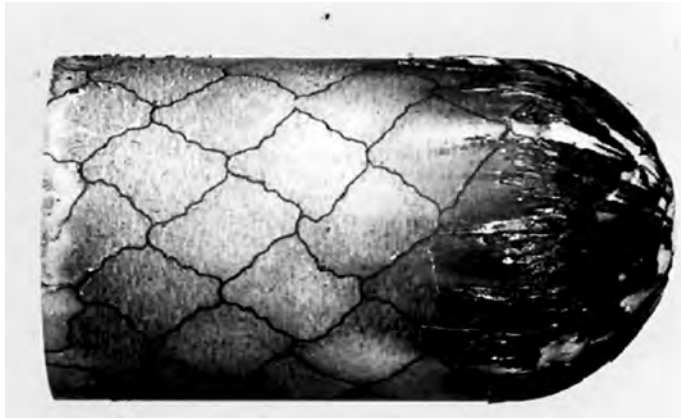
The Air Force was not new to the concept of ablation. Indeed the two contractors selected in 1955, to develop the Atlas reentry vehicle, General Electric and Avco Corporation, were directed to look at all methods for solving the reentry problem. Wright-Patterson's Air Research and Development Command were also evaluating ablation materials as was Langley Aeronautical Laboratory and Ames Research Center. The decision to work with the heatsink concept had stemmed from recommendations of a number of scientific advisory committees and panels. On June 16, 1953, the Department of Defense Study Group on Guided Missiles, better known as the Teapot Committee, had been created to evaluate the status of guided missile development by the Air Force. On February 16, 1954, the committee submitted its report. It recommended that the reentry problem be reinvestigated as Convair's approach (transpirational cooling) was insufficiently broad.<sup>61</sup>

On August 31, 1957, in the 21st Monthly Report on Progress of ICBM and IRBM Programs, a shift in reentry vehicle design was noted. While the heatsink design for Atlas and Thor was sufficient, developments in materials and testing capability indicated that ablation reentry vehicles could have ballistic coefficients five to eight times greater than the Mark 2 heatsink which would lead to greater accuracy and decreased vulnerability. Dispersion caused by wind would also be greatly decreased, the error due to wind was calculated to be approximately 500 feet in CEP (circular error probable, a circle within which fifty percent of the reentry vehicles impacted) at a 5,500 nautical mile range.<sup>62</sup>

On August 28, 1958, after only two Atlas B flights with the Mark 2 and just before the start of the Thor Mark 2 flight testing, almost exactly one year after the highly successful conclusion of the Army's Jupiter-C reentry test vehicle program, Brigadier General O.J. Ritland, Vice Commander of the Ballistic Missile Division, notified the Air Research and Development Command of the decision to reorient the ICBM reentry vehicle program from heatsink to ablative technology. The decision was based "recent developments aimed toward improving the solution to the ICBM reentry problem." The Mark 2 heatsink reentry vehicles would be supplied for all WS-315A (Thor) and early operational WS-107A-1 Atlas missiles at the two operational sites at Cooke Air Force Base (Cooke had not been renamed Vandenberg yet). All Avco work on heatsink development was to be discontinued. General Electric was now assigned development responsibility for a light weight second generation reentry vehicle capable of carrying a 1,600 pound warhead, and to be flight tested on the Series D Atlas missiles with deployment starting at Warren Air Force Base. This was the Mark 3. Avco was assigned responsibility for a heavy weight second generation reentry vehicle capable of carrying a 3,000 pound warhead to be flight tested on lot J Titan I missiles. This was the Mark 4.<sup>63</sup>

As early as 1956, plastics had been examined for use in the high temperature environment of ramjet engines. Researchers at the Marquardt Aircraft Company exposed model ramjet inlet cones made from three fiberglass reinforced plastics, Conolon 505 (phenolic), DC 2106 (silicone) and Vibrin 135 (polyester) for twenty minutes at temperatures up to 500 to 600 F at a speed of Mach 2. They found that all three materials showed little or no detrimental effects, concluding that reinforce plastics might have a role in missile development.<sup>64</sup>

Researchers at General Electric's Missile and Ordnance Systems Division in Philadelphia expanded on the Marquardt work by estimating a candidate ablative material's ability to absorb heat up to 8000 F under equilibrium conditions. The results showed that plastic materials had the highest theoretical heat absorbing capacities, more than twice that of beryllium. The more gas a material generated upon heating, again under equilibrium conditions, the better the material. Heat capacity and gas generation values were useful indicators but could not be used as guides in selection of materials because of the non-equilibrium conditions of the operational environment. When the material melted, the liquid would be swept away in the air stream, upsetting the thermal equilibrium. The higher the melting point and the more viscous the resulting liquid, the more optimal the thermal effect. Phenolic resin plastics were found to decompose slowly at high temperature and did not liquefy, instead forming gaseous byproducts and a char layer that protected to the base material. Exposure of phenolic-glass cloth with sixty-five percent resin to 12,000 F in a high temperature arc showed only 1.4 percent erosion; phenolic-Refrasil (Refrasil is the trade



**Figure 14: Shock tube development sample of Avcoite. Avcoite was a ceramic material contained in a magnesium honeycomb matrix and was used on the Avco Mark 4 and Mark 5 reentry vehicle nose cap (author's collection).**

name for a high silica content glass) with forty-one percent resin only 2.1 percent erosion and phenolic-nylon cloth with fifty-seven percent resin only 1.0 percent. The organic reinforcement's lower erosion rate was due the organic fiber's lower thermal conductivity. Key variables were type of resin, orientation of the fibers, type of fiber and ratio of resin to fiber. Phenolic resins gave a higher yield of carbon char. Large variations in performance were found amongst the various suppliers. Orientation of the fibers had a significant effect on performance with random orientation giving the best results. At temperatures above 5,000 F amorphous silica fibers were superior to ordinary glass and organic fibers were found superior to glass fibers. Resin to fiber ratio optimization had somewhat counter intuitive results. Higher glass fiber content gave better mechanical properties but was slightly detrimental to thermal erosion above 5,000 F. At plasma jet temperatures, 12,000 F, higher resin content gave greatly improved performance. Clearly ablative materials had come of age for use in ICBM reentry vehicle heat shields.<sup>65</sup> The result was the General Electric's Mark 3 reentry vehicle deployed on Atlas D.

Avco Corporation began defense contract work in 1955, with the creation of the Avco Everett Research Laboratory. Victor Emanuel, president of Avco Corporation, knew of the work of Dr. Arthur Kantrowitz, a physicist working at Cornell University with shock tube experiments in the study of the hypersonic flight. Emanuel approached Kantrowitz with a proposal to come work at Avco and apply his theories towards the solution of the "reentry problem." Enticed by the prospect of a new, modern facility to be built for him, Kantrowitz agreed and the Avco Everett Research Laboratory was built. At the same time and undoubtedly due to Kantrowitz's presence, the lab's Research and Advanced Development Division won the backup contract for the Mark 2 heatsink reentry vehicle and was the primary contractor for a similar design for Titan I. Like General Electric, Avco was also studying and developing ablative as well as heatsink material. Unlike the engi-

neers at General Electric who had studied ceramics and dismissed them as too difficult to work with compared to reinforced plastic resins, Avco engineers decided to pursue the use of ceramics for the nose section of the reentry vehicle where the heating was the most severe.

Expanding on the ceramics research by Georgia Institute of Technology and Battelle Memorial Institute for the Jupiter program, Avco researchers focused on solving the brittle fracture problem which was preventing the fabrication of the large and complicated reentry vehicle shapes light enough to be practical. The weight issue was the result of the amount of material needed to be structurally sound and not one of thermal protection efficacy. The decision was made not to search for new materials but rather to focus on new fabrication techniques. One solution investigated was the use of small ceramic tiles. This was rejected due to the thinness of the tiles and difficulty in assembling them on the curved nose section. The eventual solution was to use a metal honeycomb structure to hold small "pencils" of ceramic which did not easily fracture. By orienting the pieces in honeycomb cells at ninety degrees to the surface, optimum thermal protection and structural strength was obtained. In 1959, Avco's Research and Advanced Development Division announced the development of Avcoite, a magnesium honeycomb reinforced ceramic for use on the nose of the Mark 4 reentry vehicle originally destined for Titan I but which was also deployed on Atlas E and F (Figure 14).<sup>66</sup>

### Flight Testing

Once the feasibility of ablative material had been experimentally determined, flight testing of sub-scale reentry vehicles began. The primary research and development flight testing for evaluating the early Air Force sub-scale and full-scale ablative ICBM reentry vehicles were the Thor-Able 0 and II, Atlas D and Titan I Lot J programs.

### Thor-Able

The first in a series of ballistic missiles used for Air Force reentry vehicle development was the Thor-Able launch vehicle. Use of research and development flights of the Atlas ICBM was considered and rejected at this point as integration of reentry vehicle testing would interfere with the early development objectives. In October 1957, the Ballistic Missile Division and Space Technologies Laboratory began the design of the Advanced Reentry Test Vehicle (ARTV) that could be ready for use within six to eight months using existing hardware. The critical capability of the ARTV would be to reach ICBM reentry speeds of approximately 24,000 feet per second carrying a one-half scale reentry vehicle. A variety of possible test vehicle combinations were examined but only one that met the requirements of availability and performance; a Thor first stage and Vanguard second stage modified with eight spin rockets was configured

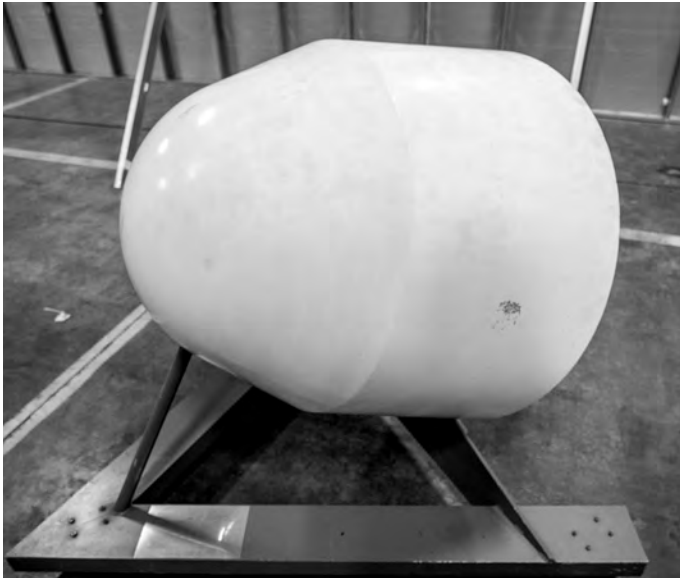


Figure 15: Thor-Able 0 RTV. Courtesy Northrup Grumman.

by STL with autopilot and cutoff controls assembled from available Thor and Atlas components.<sup>67</sup>

### Able RTV

The Thor-Able 0 program flight tested three General Electric reentry vehicle development models, designated Able RTV's. The RTV's were biconic-spheres 34 inches long and a base 38 inches in diameter, weighing 620 pounds and (Figure 15) fabricated with ablative material and flown from Cape Canaveral from April 23, 1958 to July 23, 1958. There was one failure due to booster malfunction and two partial successes. All three flights carried biomedical experiments with mice and while the two successes clearly demonstrated the efficacy of ablation at ICBM ranges and speeds, the reentry vehicles were not recovered as planned. The data provided by these tests helped determine how much the heat shield weight could be decreased and still be effective as well as verifying the superior performance of ablative materials compared to the heatsink materials. A description of the RTV series vehicle's ablative materials has proven elusive.<sup>68</sup>

### Able RVX-1

For the Thor-Able II program, a modified Thor booster was used with its guidance package removed and the radio-inertial guidance system for the Titan I ICBM installed in the RVX-1 reentry vehicle. These six flights were designated as Precisely Guided Reentry Test Vehicle launches with two goals; evaluating the new guidance system which would also indicate the exact point of impact as well as continue to evaluate new ablative materials.<sup>69</sup>

Instead of using the recovery system from the Jupiter reentry vehicle test program which had been proven unsuccessful with the Thor-Able 0 flights, Gen-

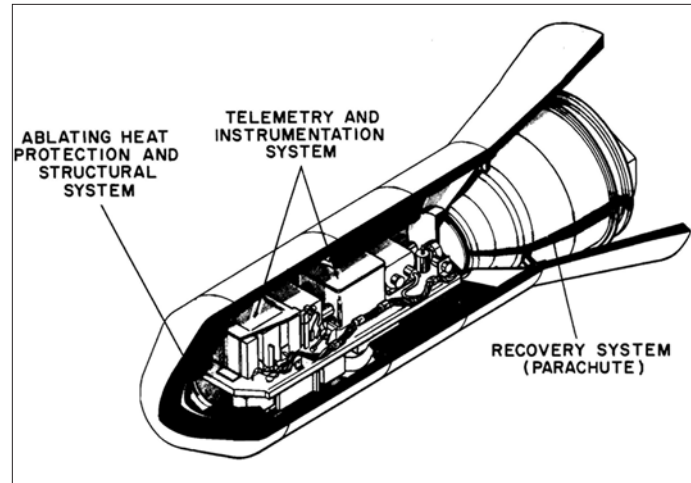


Figure 16: General arrangement of the RVX – 1 experimental reentry vehicles. The maximum diameter was 28 inches at the base of the flare, length was 68 inches. ( M.Morton, Progress in Reentry Recovery Vehicle Development, Philadelphia, PA: General Electric, Missile and Space Vehicle Division, 1961, 6. Measurements courtesy of Craig Brunetti, National Air and Space Museum).

eral Electric developed a more robust system to handle the much heavier RVX-1 vehicles. Additionally, the data capsule concept used in the Mark 2 program was used to record the telemetry during the flight and reentry phase when ionization phenomena prevented telemetry transmission.

General Electric provided the RVX-1 internal frame used to test both the General Electric and Avco Corporation ablative materials. The RVX-1 was a conic sphere flared-cylinder configuration (Figure 16), sixty-seven inches long with a cylinder diameter of fifteen inches and a flare diameter of twenty inches, and weighed 645 pounds. The flights began on January 23, 1959, starting with the RVX-1 carrying General Electric materials and alternating flights with Avco materials, and ended on June 11, 1959 with one failure, three partial successes and two complete successes. The General Electric RVX-1 tested three types of phenolic nylon ablative materials (phenolic nylon, phenolic glass and phenolic Refrasil) in sixty degree segments repeating every 180 degrees on the cylinder and flare. The nose was made of a thick layer of molded phenolic resin with one-inch squares of nylon cloth.<sup>70</sup>

The Avco RVX-1 vehicles (sixty-eight inches in length with a nose cap of eleven inches, a cylinder diameter of seventeen inches, cylinder length of thirty-nine inches, a flare length of eighteen inches and a flare base diameter of twenty-eight inches) had Avcoite on the nose and phenolic Refrasil tape covering the mid-section and flare.<sup>71</sup> On the April 8, 1959, the Avco RVX-1-5 was successfully flown 5,000 nautical miles down range with a maximum altitude of 764 miles and a reentry speed of 15,000 miles per hour (Figure 17). The nose cap easily withstood the heat of reentry as had the Refrasil material coating the cylinder and flare sections. The Avcoite ceramic had melted and flowed back asymmetrically a short distance down the cylindrical body as expected.



Figure 17: The Avco RVX – 1, launched on 8 April 1959 on Thor missile 133, was the first recovered reentry vehicle flown on an ICBM trajectory. Before being put on display to the press the original nose cap was removed and replaced with a mockup for security reasons. This artifact was given to the Smithsonian Institute and is in storage at the National Air and Space Museum (photograph courtesy of Phil Fote).

Telemetry results indicated no effect on aerodynamic stability. Soon after recovery the nose cap was removed for further inspection and replaced with a mock-up due to security concerns. The RTV-1-5 is now in storage along with the removed nose cone at the National Air and Space Museum's Garber facility.

On May 21, 1959, the second General Electric RVX-1 flown was also successfully recovered, looking much the same as the Avco vehicle except that the reinforced phenolic-chopped nylon nose cap simply ablated and did not flow back along the cylinder.<sup>72</sup>

The RVX-1 flight program, even with the failures due to not recovering all of the vehicles (complete telemetry was obtained via the data capsules), further confirmed the maturity of ablative materials for use in high speed reentry as the RVX-1 vehicles were exposed to temperatures exceeding 12,000 F. The RVX-1 test vehicles were the direct progenitors of the General Electric Mark 3 (Atlas D) and Avco Mark 4 (Atlas E, F and Titan I) reentry vehicles.<sup>73</sup>

### RVX-2 Series

By mid-1960 Atlas D missiles were available for use in the final phase of ablative material testing, flights of full-scale reentry vehicles at operational ranges and reentry speeds. The RVX-2 series involved tests of newer plastic ablative materials. Ranges flown varied from 4,400 nautical miles to the Ascension Island impact area to 6,400 nautical miles off the coast of Capetown, South Africa and further yet, 7,900 nautical miles to the South-

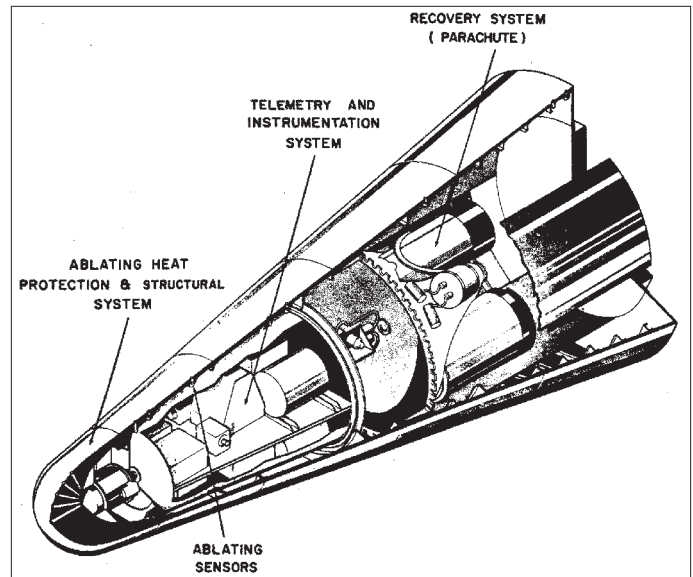


Figure 18: General arrangement of the RVX – 2 and RVX – 2A experimental reentry vehicles. The RVX – 2 had maximum diameter of 5 feet and was approximately 12 feet long. (M.Morton, Progress in Reentry Recovery Vehicle Development, Philadelphia, PA: General Electric, Missile and Space Vehicle Division, 1961, 8).

ern Atlantic off of the Prince Edward Islands. The reentry evaluation portion of the program commenced on March 8, 1960, and ended on January 23, 1961.<sup>74</sup>

### RVX-2

Three General Electric RVX-2 reentry vehicles were flown to test a new type of ablative material, unreinforced phenolic resin, General Electric Series 100, for the proposed Titan II Mark 6 reentry vehicle.<sup>75</sup> The RVX-2 was a conic-sphere configuration, twelve feet tall and five feet in diameter, weighing over 2,000 pounds, the largest reentry vehicle yet flown with what appears to a phenolic resin-chopped nylon nose cap and unreinforced phenolic resin side frustrum panels. The first two flights suffered guidance and booster failures; March 17, 1959 and March 18, 1959 respectively, but the last flight, on July 21, 1959, was successful and the reentry vehicle was recovered intact after a flight of 5,000 nautical miles. (Figure 18). Photographs of the recovered vehicle show a close resemblance to the General Electric Titan II Mark 6 reentry vehicle which also used these materials.<sup>76</sup>

### RVX-2A

The RVX-2A program had three flights during the Atlas D test flight program, August 12, 1960, September 16, 1960 and October 13, 1960. The RVX-2A vehicle had the same dimensions as the RVX-2 and weighed slightly more than 2,700 pounds. The main difference between the two was the instrumentation, the RVX-2A was used for extensive scientific experiments beyond reentry. The eighteen experiments included black and white and

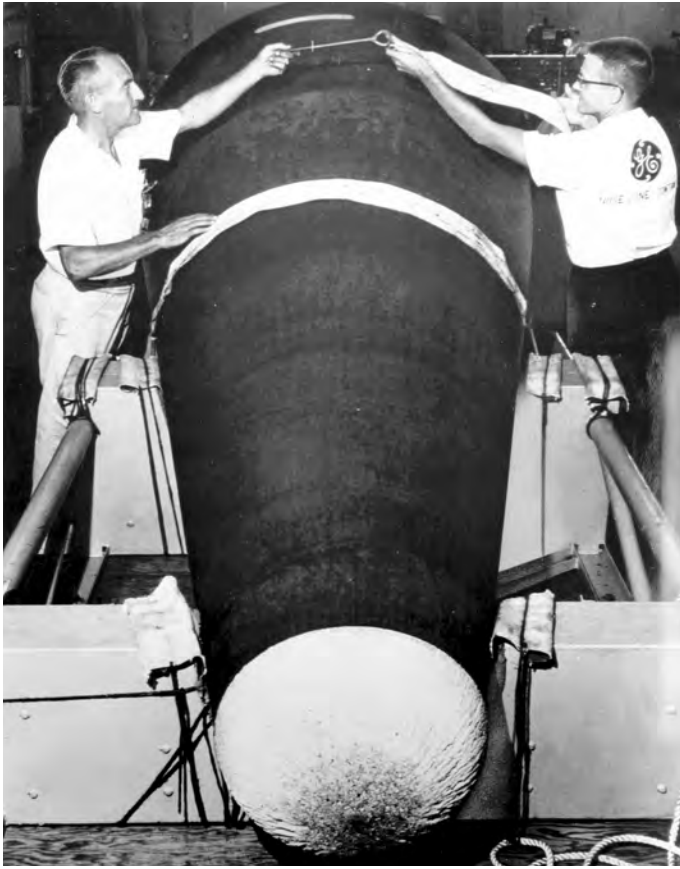


Figure 19: General Electric RVX-2 reentry vehicle being prepared for transport after successful recovery on 21 July, 1959 (photograph courtesy of Donald Schmidt).

color photography, live mice, radiation phenomena, reentry physics including transpirational cooling, electromagnetic propagation and fuel cell prototypes. A recovery system similar to that of the RVX-1 program was used on all of the flights with successful recovery on only the final flight.<sup>77</sup>

The General Electric portion of the RVX-2A program were the first and third flights, testing the General Science Century Series of unreinforced phenolic resin for use on the conic frustrum part of the conic sphere design for the Titan II Mark 6 reentry vehicle. Four formulations, GE Type 123, 124 and 135 as well as GE Type 525 were used. General Electric researchers had discovered a radical departure from previous ablation research. Under laboratory test conditions simulating reentry, unreinforced phenolic resin formed several porous char layers one to two millimeters thick were formed in sequence. The first one quickly plugged up, was sloughed off by aerodynamic forces and was replaced instantly by the formation of a new char layer. Large amounts of pyrolysis gases that formed as the material degraded served to inhibit heat transfer from the very hot boundary layer to the ablating surface, greatly reducing the actual heating at the vehicle surface. These results greatly simplified the design of the large Mark 6 reentry vehicle and saved considerable weight.<sup>78</sup> The maximum internal temperatures reached in the two flights were

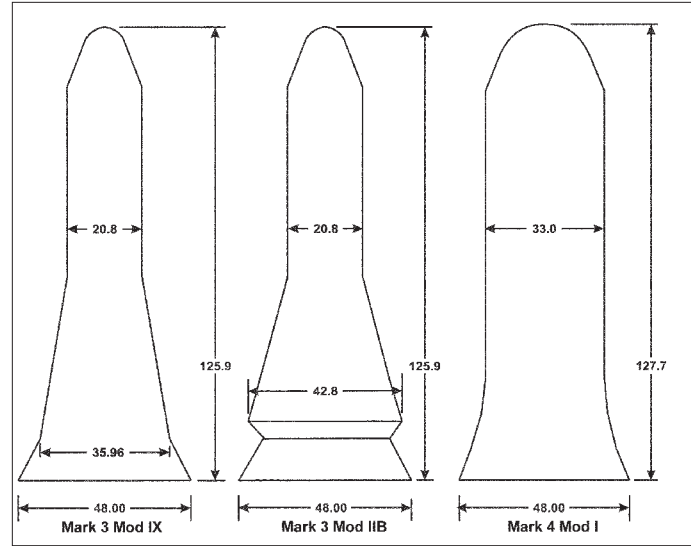


Figure 20: Comparison of Mark 3 Mod I, Mark 3 Mod IIB, and Mark 4 Mod I (adapted from Flight Summary Report Series D Atlas Missiles, (San Diego, CA: General Dynamics/Astronautics, DTIC AD0833337, 21 June 1961), 8-6, 8-7 and 8-33. Drawings courtesy of Mitch Cannon).

90 and 100 F, well below the 350 F expected. Nose cap ablation was greater than expected. Degradation of the Series 100 phenolic resin was comparable to that of nylon reinforced phenolic resin and was in agreement with computer modeling (Figure 19).<sup>79</sup>

Avco flew one RVX-2A flight on September 16. The nose cap was RaD 58D followed by a twenty-six-inch frustrum section of RaD 58B and 100 inches of tape wound Refrasil. Test plugs of Avocoat x3007 and RaD 58E were inserted at alternating ninety-degree intervals in the forward portion of the tape wound Refrasil section. The RaD 58E was a candidate material for the Minuteman missile reentry vehicle and the Avocoat was a proposed low temperature ablation for the boost phase of the Minuteman trajectory. Telemetry problems prevented transmission of thermal and ablation data.<sup>80</sup>

### Mark 3

The Mark 3 reentry vehicle was designed for the Atlas F missile, as mentioned earlier, but deployed only on Atlas D. The Mark 3 was a direct descendant of the General Electric RVX-1 program. Measuring 114.8 inches in overall length, there were two Mark 3 shapes (see Figure 20). Both had the sphere-conical nose shape, 29.22 inches in length and a cylindrical mid-section 20.7 inches in diameter and 40.6 inches in length. The Mark 3 Mods I, IX and IA had a single biconic frustrum flare, 35.9 inches in diameter, that blended smoothly with the reentry vehicle adapter spacer atop the missile. The Mark 3 (Mods IB and IIB) had a biconic-2 shape with a second, wider flare at the base, 42.8 inches in diameter, resulting in a characteristic "skirt" conical ring slightly outwards above the spacer which was not modified to affect a more streamline appearance. The second flare aided in reentry stability by mov-

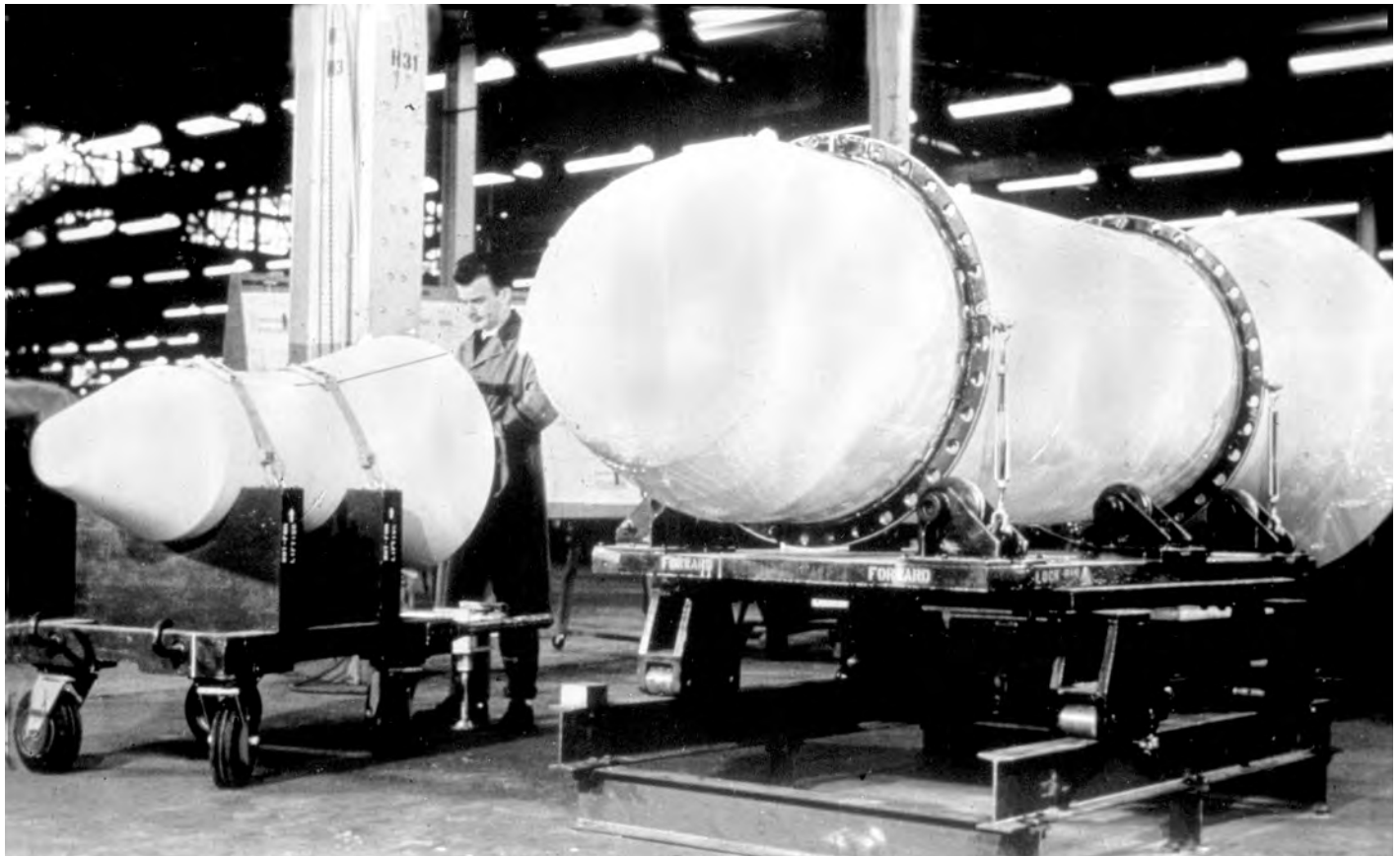


Figure 21: Mark 5 (left) and Mark 4 (right) operational reentry vehicles on factory floor at Avco facility. (Photograph courtesy of Phil Fote.)

ing the aerodynamic center of pressure toward the rear of the vehicle. (Figure 20). Available photographic evidence indicates that the biconic-2 modification was the deployed version. The nose section was thermally protected by molded phenolic nylon, the mid-section and flare by tape wrapped phenolic nylon.<sup>81</sup>

Eleven full scale Mark 3 reentry vehicles were flight tested as part of the Atlas D research and development program from March 8, 1960 to January 23, 1961, with ten successful and one failure due to booster failure prior to launch.<sup>82</sup> The Mark 3 was deployed on Atlas D missiles from 1960-1965.<sup>83</sup> Mark 3 Mod 3 operational RV weighed 2,200 pounds of which 1,600 was the warhead.<sup>84</sup>

#### Mark 4

Unlike the General Electric Mark 3, the Avco Mark 4 design required additional experimental flights designated RVX-3, a 0.72 scale model and the 0.94 scale model RVX-4 due to modified Air Force requirements. The RVX-3 was flight tested on 5 Titan I C missile flights from December 12, 1959 to April 28, 1960. The RVX-4 was to have been the full-scale model but the diameter of the warhead was changed slightly, leading to the actual full-scale Mark 4. The RVX-4 was flight tested on one Atlas D and seven Titan I Lot G missiles.<sup>85</sup>

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 Avocite varying from 1.32 to 0.82 inches thick, the cylindrical body and flare protected by oblique tape wound Refrasil at 0.61 to 0.32 and 0.44 to 0.66 inches respectively; and the afterbody was protected with fiberglass. The Mark 4 with warhead weighed 3,800 pounds.<sup>86</sup> A second reference gives the operational Mark 4 as weighing 4,100 pounds of which 3,100 pounds was the warhead.<sup>87</sup>

The Mark 4 was flight tested on one Atlas D, seven Atlas E, seven Atlas F and twenty-eight Titan I Lot J and M missiles from October 11, 1960 to May 1, 1963. The Mark 4 was deployed on Atlas E and F and Titan I from 1962 to 196.<sup>88</sup> One Mark 4 was flown on Titan II during the Titan II research and development program.<sup>89</sup>

#### Mark 5

On January 13, 1958, in discussions within the Nose Cone Division of Space Systems, Ballistic Missile Division, a decision was made that initial design responsibility for the advance reentry vehicle for Minuteman would be Avco Corporation due to the heavy technical load already assigned to General Electric. On February 5, 1958, a letter was issued to Avco confirming the request for an advanced reentry vehicle design study which included design specifications. This was not a sole source contract for the reentry vehicle production, as





**Figure 22** The effect of reentry on the Avcoite nose cap material of a Mark 5 reentry vehicle, left and right, before and after respectively. The modified Avcoite ceramic material did not melt and flow as much as on the Mark 4 (photographs by author of artifacts at the National Atomic Museum).

with other reentry vehicles the contract would be a competitive one.<sup>90</sup>

With contractor bid proposals to be evaluated in late June, on May 28, 1958, the Nose Cone Division clarified the desire, previously discussed in the proposed preliminary operational concept of Minuteman dated April 8, 1958, for two reentry vehicle designs and two warheads.<sup>91</sup> One vehicle would have a weight of 790 pounds, including a 600 pound warhead for a range of 5,500 nautical miles; the second vehicle would have a weight of 550 pounds including a 350 pound warhead for a range of 6,500 nautical miles. The two designs would permit the preliminary operational plan target coverage from bases located in the southwest portion of the United States. The designs would be optimized for maximum range target coverage permitting each missile to fly to the maximum range estimated for the payload, negating the need for lesser range targeting for a given missile. Phase I and Phase II warhead feasibility studies had already been completed, permitting reentry vehicle dimensions to be established. Requests for proposals were issued to ten contractors for the reentry vehicle studies covering either or both of the reentry vehicles.

The Nose Cone Division explained the need for two reentry vehicles.<sup>92</sup>

*There are several reasons which in our opinion make it imperative that we continue with development of both vehicles. These relate primarily to the warhead development itself. At the present time this country is considering a moratorium on testing, the duration of this being somewhat indeterminate. For this reason, AEC laboratories are endeavoring to carry out during Hardtack all tests which appear to them of importance in development of weapons for which requirements have been stated. At the same time the AEC is attempting to get acceptance by DOD of the concept of multi-use warheads. Under this concept which has been favorable reception a weapon system requiring a warhead of a particular weight will be forced to use an already available or planned weapon which in some instances will have been developed for quite different requirements. In our case for example the smaller warhead will be that now under development for Nike-Zeus. Provided that the Minuteman requirements are incorporated in the weapon design initially which*

*can be done if we establish our need for this weapon, there will be no difficulty in obtaining maximum performance of the system (the same is not true for the 600 pound Polaris warhead which must be modified to a considerable degree to meet Minuteman requirements.) If on the other hand we do not today establish a firm requirement for a second, lighter warhead, it will be designed on the basis of Nike-Zeus requirements and will be completely incompatible with the Minuteman system in the event that we choose to use the second reentry vehicle at some later date.*

*We feel emphatically that development must continue on both warheads and hence both reentry vehicles since a requirement for one can not be established without the other.*

On July 20, 1958, AFBMD announced that Avco Corporation had been selected from a group of seven proposals ( Aerophysics Allison, Avco Corporation, Ford Aeronautics, General Electrical, McDonnell, Republic Aviation and Douglas/Goodyear) to develop the two Minuteman reentry vehicles. Avco's role as the Mark 2 alternate source, as well as its research and development expertise with the new ablative materials gained from their work on alternatives to the Mark 2 were a key in their selection. The contract required development of a light and heavy reentry vehicle to accommodate two possible warheads designs weighing 350 and 600 pounds respectively, with warhead dimensions to be forthcoming.<sup>93</sup> The contract was formally awarded to Avco on September 19, 1958.<sup>94</sup>

The light version was cancelled December 4, 1958 to reduce costs (Avco was directed to continue studying the light version on a lower priority basis). The decision was based on the lower yield available for the light vehicle warhead as well as complications introduced into the missile test program by multiple combinations of reentry vehicles and the missile airframe. The result was a 790 pound reentry vehicle of which 600 pounds was due to the warhead. The larger reentry vehicle could also more easily accommodate changes in warhead dimensions.<sup>95</sup>

After nearly a year of indecision on the Minuteman warhead design on September 1, 1959, the Minuteman warhead was finally authorized. Avco's reentry vehicle sphere-cone-cylinder-flare design was based on the Mark 4 shape but was considerably smaller due to weight constraints. ( **Figure 21** ) Development work commenced on what was now called the Mark 5 reentry vehicle. Extensive wind tunnel and light gas gun evaluation of ablative material composition and thickness as well as studies of attitude control and structural design to withstand deceleration forces of twenty to fifty G's were undertaken. Flight test vehicles (Mark 5 Mod I) were in production by the end of 1960. Like the Mark 4, the Mark 5 had a nose cap of Avcoite, in this case Avcoite-1, bonded to the top of the cylindrical and flare sec-

tions which were machined out of a block of RaD-58B phenolic resin-Refrasil material. Reformulation of the ceramic material reduce the melting and flowing which occurred with the Mark 4 (**Figure 22**). The aft closure was configured to stabilize the RV during early reentry and was coated with Avcoat . The Mark 5 did not have an active attitude control system. It and the Mark 4 tumbled and upon entering the atmosphere small fins induced a stabilizing spin before the fins ablated early in reentry.<sup>96</sup>

The full-scale research and development flight test program began on February 1, 1961, with the successful launch and flight of FTM-401, a fully configured Minuteman IA, from the Launch Complex 31A pad, Cape Canaveral Air Force Station, Florida. Two more pad launches took place, March 19, 1961 (failed) and July 27, 1961 (successful). Silo research and development launches at Cape Canaveral began on August 30, 1960 with a spectacular failure and ended on February 20, 1963 with six failures out of twenty-one launches. Mark 5 flight tests also utilized Atlas D (1), E (4) and F(3) missiles with one failure. The Atlas flight tests commenced on May 13, 1961 with a Mark 5 Mod I flown on an Atlas E and ended on July 31, 1963 with a successful Atlas D flight (**Figure 23**).<sup>97</sup> The Mark 5 Mod 5B weighed 300 pounds including SOFAR bomb. The Mark 5 was deployed on 150 Minuteman IA missiles beginning in 1962 and ending in 1969.<sup>98</sup>

### Mark 11, 11A, 11B and 11C

In October 1960, the Department of Defense and the Atomic Energy Commission authorized development of an advanced version of the XW-56X1 warhead. In December 1960, the Air Force requested development of a lighter and higher yield warhead, designated the XW-59. One month later it was decided to have Avco develop a new reentry vehicle, the Mark 11, able to carry either of the new warhead designs and to be deployed starting with the second Minuteman wing, equipped with Minuteman 1B at Ellsworth Air Force Base. The Mark 11 series reentry vehicle had an operational requirement for a reduced radar cross section during the exoatmospheric portion of its trajectory.<sup>99</sup> (**Figure 24**)

The Mark 11series, 11, 11A, B and C, had a somewhat similar size and shape to the Mark 5 but was slightly longer. Avcoite was not used in the nose section. RaD 58B was high silica content phenolic resin which was pressed into a block, machined to shape and then bonded to the reentry vehicle forecone. For the Mark 11, the body of the vehicle was made of RaD 60, a molded silica phenolic using chopped silica fibers which was machined to fit over an airframe made of fifty magnesium ribs that were covered with a spin formed magnesium skin for both the cylindrical and flare section (formed separately). The two assemblies were bonded with epoxy, the final machining completed, a radar cross section reducing mesh applied and final layer of Avcoat 2 applied.

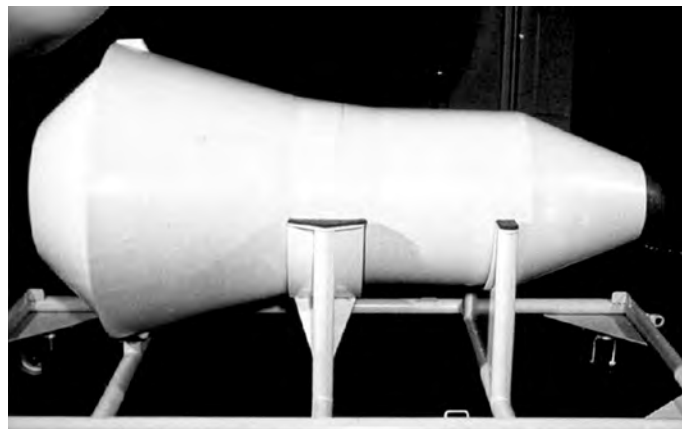


Figure 23: Mark 5 reentry vehicle on handling dolly. Note the small spin fins located at the top and bottom of the flare (*photography courtesy of the National Atomic Museum*).

The pointed tip, a distinguishing feature of the Mark 11 series was made of glass fiber resin impregnated cloth molded on a mandrel and epoxied to the nose. It is used to provide protection to the nose section radar cross section material from boost-phase heating. Once the Mark 11 entered the atmosphere, the nose and base fairing as well as the radar cross section reducing mesh were removed by ablation. At this point in reentry the vehicle was producing a highly ionized and readily detectable wake which was unavoidable. Unlike the Mark 4 and 5, the Mark 11 had small spin rockets to confer spin stabilization prior to reentry.

The Mark 11A, B and C had a different fabrication process from the Mark 11. The new aluminum frame was heavier than the Mark 11 magnesium frame but was stronger, a feature required for the nuclear hardening of the vehicle, a new operational requirement due to advances in the Soviet AntiBallistic Missile (ABM) system in the process of development. The flare, cylindrical body and nose cap frames were bolted together and then the heatshield applied using Oblique Tape Wound Refrasil by a unique process developed by Avco. After curing, the heatshield was machined to tolerance, the radar cross section reducing material applied and covered with a final layer of Avcoat 2. The aft fairing was specifically designed to reduce the radar cross section.<sup>100</sup>

While the Mark 4 and 5 tumbled at first during reentry and thus provided a large radar return, the Mark 11 was spin stabilized so as to present a reduced radar return for as long as possible. The Mark 11 deployed from the third stage with only a slight increase in velocity so the third stage served almost like a radar beacon for Soviet ABM systems.

Virtually indistinguishable in outer appearance, the Mark 11 series were approximately 100 inches in height, with cylindrical section nineteen inches in diameter, a base diameter of thirty-two inches and all used the same ablative material. The Mark 11 was deployed on Minuteman IB. All four variants were deployed on Minuteman II. For the Mark 11A and 11B, Avco developed a

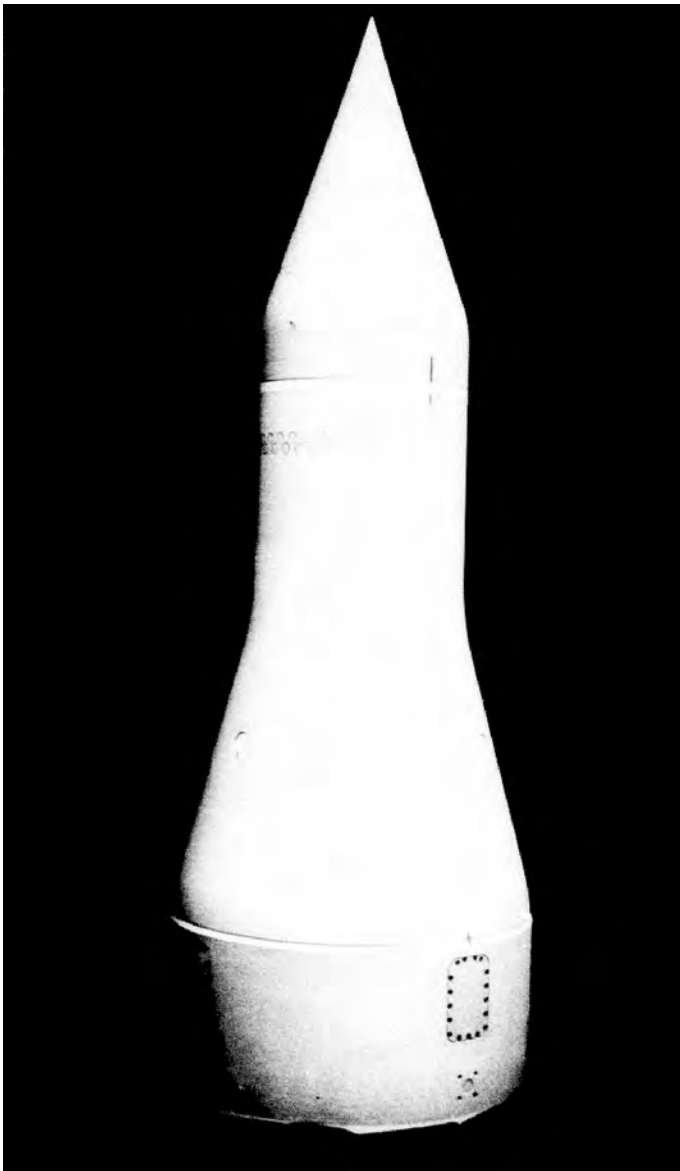


Figure 24: Mark 11C on top of chaff dispenser (author's collection).

retro rocket spacer that had ten small thrusters which fired in pairs to provide a random velocity to the third stage. Before firing the retro rocket thrusters, a tumbler motor fired perpendicular to the centerline of the third stage to impart a rotation rate. This combination randomized the third stage position relative to the reentry vehicle and thus reduced the problem of the third stage serving as a radar beacon.<sup>101</sup>

For the Mark 11C the retrorocket spacer was replaced with a chaff spacer which carried a number of Mark 1A chaff dispensers, each equipped with different level impulse thrusters. This was in response to the low frequency Soviet ABM radars. The chaff dispenser was connected to the Mark 11C via a lightweight spacer made of beryllium rather than aluminum as this configuration was up against a weight limit due to the chaff system and beryllium was thirty percent lighter than aluminum. After Mark 11C release, the chaff dispensers were fired up and down the range insensitive axis to

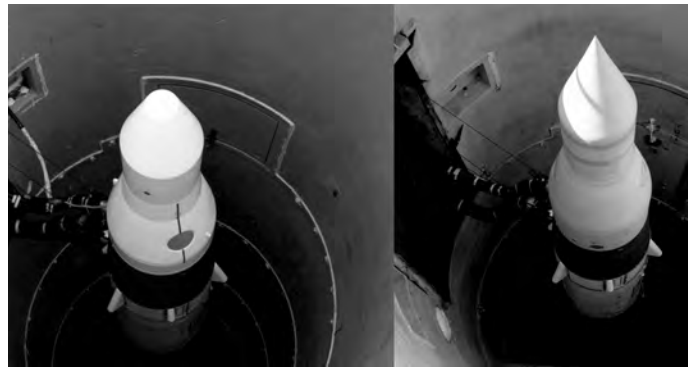


Figure 25. Mark 5 on Minuteman FTM IB 423A in LC31B, 7 January 1963 (left) and Mark 11 on Minuteman FTM IB 425 in LC-31B, 14 March 1963, Patrick Air Force Base (courtesy of Air Force Space Museum, Cape Canaveral Air Force Station.) the triangular fin protrusions were telemetry antennas and not flown on the operational vehicles.

generate a train of chaff clouds spaced far enough apart that the defensive systems would have to target each cloud.<sup>102</sup>

The Mark 11 research and development program included six flights on Atlas D missiles beginning on August 28, 1963 and ending February 12, 1964 with one successful flight, the failures were due to booster malfunctions. Minuteman IB flight tests began on December 7, 1962 and ended on December 8, 1967 after forty-one flights with six failures. The Mark 11C penetration aids capability was tested on the final six flights which began on April 28, 1967.<sup>103</sup> (Figure 25).

The weight of the Mark 11 was 200-250 pounds. The Mark 11A, B and C were twenty-five percent heavier than the Mark 11.<sup>104</sup> The Mark 11 series reentry vehicles were deployed on Minuteman IB and Minuteman II from 1963 to 1973 (Minuteman IB) and 1995 (Minuteman II).<sup>105</sup>

## Summary

There were three key technologies that needed to be developed for the Minuteman program to succeed: large diameter solid propellant motors, lightweight inertial guidance systems and lightweight reentry vehicles. The evolution of reentry vehicle design began with the need to quickly design and field a reentry vehicle system for a relatively large warhead using readily available materials. The result was the first generation heatsink concept used with the Air Force Thor and Navy Polaris A-1 and A-2 IRBMs.

The second generation reentry vehicle system, ablation, was demonstrated first by the Army in its development of the reentry vehicle for the Jupiter IRBM. The Air Force quickly saw the advantage of ablation technology which permitted the design of lighter, more streamlined and hence more accurate, reentry vehicles. The Mark 5 and Mark 11 reentry vehicles represented the culmination of the pyrolytic or charring method of ablation with their small size and greater accuracy compared to heatsink reentry vehicle systems. ■

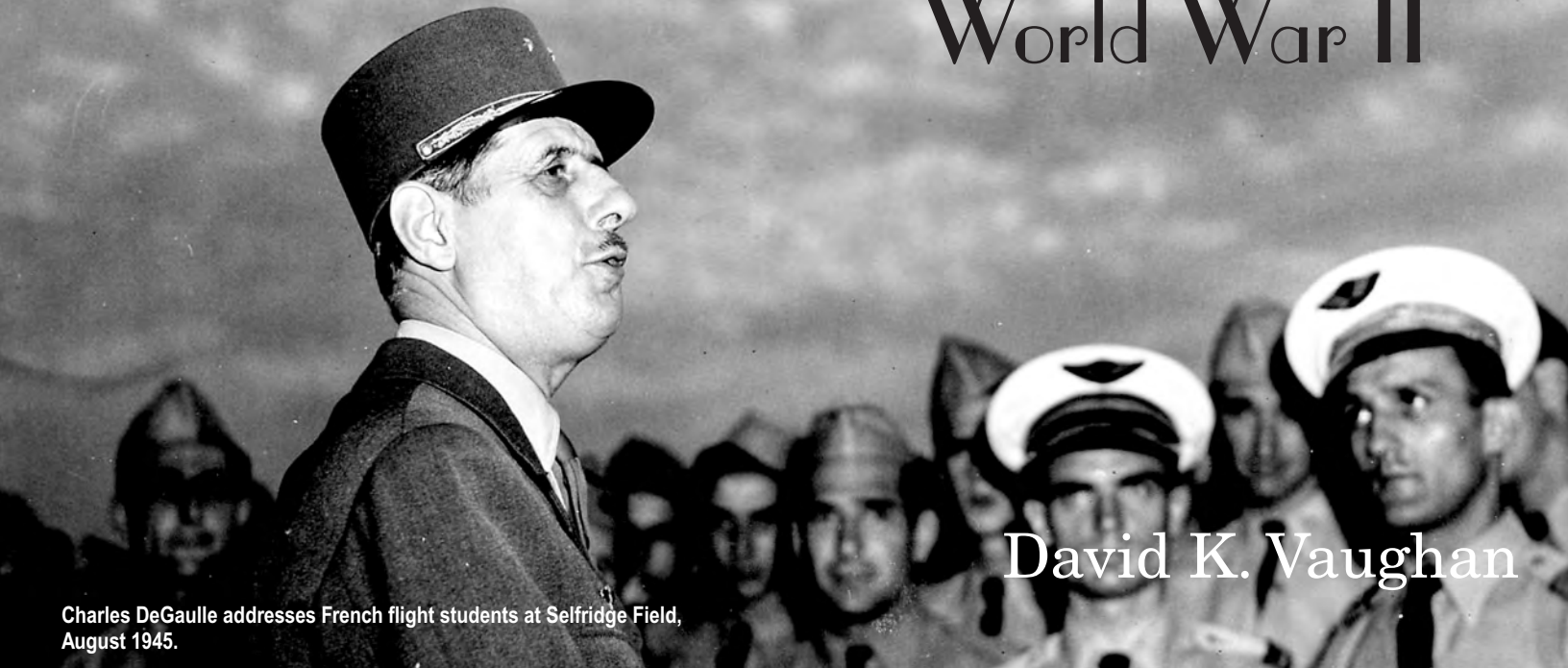
NOTES

1. T.C. Lin, Development of U.S. Air Force Intercontinental Ballistic Missile Weapon Systems, *Journal of Spacecraft and Rockets*, Vol. 40, No. 4, July August 2003, 503-506.
2. W. Johnson, The Rise and Fall of Early War Rockets, *International Journal of Impact Engineering*, 1994, Vol.15, No.4, 365-383; Winters, F., *The First Golden Age of Rocketry: Congreve and the Hale Rockets of the 19th Century*, (Washington, D.C.): 1990, Smithsonian Institution Press 1 9, 215 224.
3. W.E. Greene, The Development of the SM-68 Titan: Vol. I, Narrative, 1962, *AFSC Historical Publication Series 62-23-1*, footnote page 111. In March 1957, Avco proposed changing the term nose cone to reentry vehicle. Initial response was negative but the term was eventually accepted and is used throughout this text to avoid confusion.
4. W. Dornberger, V-2, (New York: Viking Press), 1954, 222; Gregory P. Kennedy, *Vengeance Weapon 2*, (Washington, D.C.: Smithsonian Institution Press, 1984), 68-69.
5. D.D. Baals, and W.R. Corliss *Wind Tunnels of NASA*, (National Aeronautics and Space Administration, Scientific and Technical Information Office, 1981) SP-440, 55; J.R. Hanson, *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958*, (National Aeronautics and Space Administration, Scientific and Technical Information Office, 1986) SP-4305,343.
6. C. Wagner, *The Skin Temperature of Missiles Entering the Atmosphere at Hypersonic Speed*, (U.S. Department of the Army, Ordnance Research and Development Division), Technical Report No. 60 October 1949, 1.
7. H.J. Allen and A.J. Eggers, Jr., *A Study of the Motion and Aerodynamic Heating of Missiles Entering the Earths Atmosphere at High Supersonic Speeds*, National Advisory Committee on Aeronautics, 1953, RM A53D28, 17, 25 27. These two authors published several updated versions of this seminal paper. It is not clear to this author what was updated, the conclusions in each of the sequential papers appear to remain the same; E.P. Hartman, *Adventures in Research, A History of Ames Research Center 1940-1965*, (National Aeronautics and Space Administration, Scientific and Technical Information Office, 1970), NASA Center History Series, SP-4302, 216 218.
8. H.J. Allen, Hypersonic Flight and the Re-Entry Problem, *Journal of the Aeronautical Sciences*, Vol. 25, No. 4, 223, Fig. 9.
9. T. von Karman, Aerodynamic Heating - The Temperature Barrier in Aeronautics, in *Proceedings of the Symposium on High Temperature - A Tool for the Future*; Berkeley, California, June 1956, (Menlo Park, California: Stanford Research Institute, 1956), 140 142; *CRC Handbook of Chemistry and Physics, 52nd Edition*, 1971 72, (Cleveland, Ohio: The Chemical Rubber Company, 1971), D-142.
10. A.J. Eggers, C.F. Hansen and B.E. Cunningham, Stagnation-Point Heat Transfer to Blunt Shapes in Hypersonic Flight, Including Effects of Yaw, National Advisory Committee for Aeronautics, 1958, Technical Note 4229, 1 2.
11. J.V. Becker, Results of Recent Hypersonic and Unsteady Flow Research at the Langley Aeronautical Laboratory, *Journal of Applied Physics*, (July 1950), 620.
12. D. Schmidt, Hypersonic Atmospheric Flight, in *Environmental Effects of Polymeric Materials*, (New York: Interscience Publishers, 1968), 489.
13. P. Vielle, Sur Les Discontinuités Produites par la Brusque de Gas Comprimes, 1899, *Comptes Rendus* 129, (1899), 1228.
14. W. Payman and C.F. Shepard, Explosion Waves and Shock Waves. VI. The Disturbances Produced by Bursting Diaphragms with Compressed Air, 1946, *Proceedings of the Royal Science Academy*, Vol 186, (1946), 293.
15. B.D. Henshall,, On Some Aspects of the Use of Shock Tubes in Aerodynamic Research, (Aeronautical Research Council, Great Britian, 1957) Reports and Memoranda, No. 3044, 6; H.J. Davis and H.D. Curchack, Shock Tube Techniques and Instrumentation, (U.S. Army Material Command, Harry Diamond Laboratories, March 1969) TR-1429, 1 16. Available as Defense Technology Information Center AD692295.
16. Hartman, *Adventures in Research*, 241; J.A. Shortal, *A New Dimension: Wallops Island Flight Test Range, the First Fifteen Years*, National Aeronautics and Space Administration, Scientific and Technical Information Office, (1978) NASA Reference Publication 1028, 433.
17. G.H. Stine, *ICBM: The Making of the Weapon That Changed the World*, (New York: Orion Books, 1991), 187.
18. H.F. Swift, Light-Gas Gun Technology: A Historical Perspective, in *High Pressure Shock Compressions of Solids, Vol. VIII*, (Berlin Heidelberg, Germany, 2005), 1 6.
19. A.J. Eggers A Method for Simulating Atmospheric Entry of Long Range Ballistic Missiles, National Advisory Committee for Aeronautics, Ames Aeronautical Laboratory, 1958, TR-1378, 1009 1012.
20. Hartman, *Adventures in Research*, pp. 238, 264.
21. *Ibid.*, 339.
22. J.A. Fay and F.R. Ridell, Theory of Stagnation Point Heat Transfer in Dissociated Air, *Journal of Aeronautical Sciences*, Vol 25, No 2, (February 1958), 73-85.
23. P.H. Rose and W. I. Stark, Stagnation Point Heat-Transfer Measurements in Dissociated Air, *Journal of Aeronautical Sciences*, Vol 25, No 2, (February 1958), 86-97.
24. L. Lees, Laminar Heat Transfer Over Blunt-Nosed Bodies at Hypersonic Speeds, *Jet Propulsion*, (April 1956), 259-269.
25. W.R. Lucas and J.E. Kingsbury, A Brief Review of the ABMA Ablation Material Program, (Redstone Arsenal, AL: Army Ballistic Missile Agency, 12 May 1960) ABMA DSN-TM-7-60 1, 3.
26. Von Karman, *Aerodynamic Heating*, 142.
27. D.L. Schmidt, *Ablative Plastics for Reentry Thermal Environments*, (United States Air Force, Air Research and Development Command, Wright Air Development Division, 1961), Rep 60-862, 4 5.
28. R.A. Fuhrman, The Fleet Ballistic Missile System: Polaris to Trident, *Journal of Spacecraft*, Vol 15, No. 5, (Oct-Sept, 1978), 270 271.
29. J.R. Stoney and A.J. Swanson, Heat Transfer Measured on a Flat-Faced Cylinder in Free Flight at Mach Numbers Up to 13.9, NACA Research Memorandum L57ER13, 17 June 957, 1 2.
30. H.S. Carter and W.E. Bressette, Heat Transfer and Pressure Distribution on Six Blunt Noses at a Mach Number of 2, NACA Research Memorandum L57C18, 18 April 1957, 10.
31. J.R. Hall and B.J. Garland, A Feasibility Study of the Flare-Cylinder Configuration as a Reentry Body Shape for an Intermediate Range Missile, NACA Research Memorandum L58C21, 28 May 1958, 11.
32. Shortal, *A New Dimension*, 556-561; J.P. McManus, *A History of the FBM System*, (Lockheed Missiles and Space Company, Inc., 1989), A-11.
33. G.A. Hoffman, *Materials for Space Flight*, (Santa Monica, CA: RAND Corporation, P-1420, 1 July 1958), 1-26.
34. Rear Admiral Robert Wertheim, personal interview with author, May 2015; Fuhrman, The Fleet Ballistic Missile System, 272.
35. R. Smelt, Lockheed X-17 Rocket Test Vehicle and Its Applications, *American Rocket Society* Vol 29, No. 8, (1959), 565-567.
36. Shortal, *A New Dimension*, 377, 441 444.

37. Re-entry Research: The Lockheed X-17, *Flight*, 6 February 1959, 181; R.F. Piper, *The Development of the SM-80 Minuteman*, (U.S. Air Force Historical Office, Deputy Commander for Aerospace Systems, April, 1962), *Memorandum for Secretary, Ordnance Technical Committee, Office of the Chief of Ordnance, Department of the Army, Subj: JATOs, T64 and T65 Establishment of DOA Project 517-1-032 (TU2-2032)*, 6 April 1955, Vol. II Supporting Documents, Document 1(1962), 2 4. The propellant weights differ slightly from other sources but this appears to be the original contract information.
38. E.S. Sutton, From Polymers to Propellants to Rockets: A History of Thiokol, in 35th AIAA/ASME/SAEA/ASEE Joint Propulsion Conference and Exhibit, (Los Angeles, California: American Institute of Aeronautics and Astronautics, June 20-24, 1999), Paper 99-2929, 13.
39. R.W.Roy and R.A Foster, Final Report: Re-Entry Test Vehicle X-17, 10 May 1957", *History Air Force Missile Test Center 1 July - 31 December 1957, Vol IV Supporting Documents Appendix F*, Air Force Historical Research Agency, IRIS NO. 484479, Reel 15345, K241.01, Vol. 4, 1 6, 30; T.A. Heppenheimer, *Facing the Heat Barrier: A History of Hypersonics*, (National Aeronautics and Space Administration, NASA History Office, 2007) NASA History Series, SP-2007-4232, 44.
40. Colonel Bogart Staff Study on R W Role, Air Force Historical Research Agency, IRIS 1040339, Reel 35267, 168.7171-191, Report No. 20, frame 211, no pagination; Recoverable Data Capsule Designed for Thor and Atlas Test Missiles, *Aviation Week*, 24 November 1958, 71 72.
41. The Scientific Advisory Committee's First Report on Ballistic Missiles to the Secretary of Defense, 11 February 1956, Digital National Security Archive, (<http://www.proquest.com/products-services/databases/dnsa.html>), NH00553, 3; Monthly Report on Progress of ICBM and IRBM Programs (Report No. 16), 31 March 1957, U.S. Declassified Documents Online (<http://www.gale.com/c/us-declassified-documents-online>, CK234914 9174, 2 July 2016), 6.
42. M. Morton, *Progress in Reentry Recovery Vehicle Development* (Philadelphia, PA: General Electric, Missile and Space Vehicle Division, 1961), 6. The author is indebted to Donald L. Schmidt for this document.
43. J.R. Stalder, The Useful Heat Capacity of Several Materials for Ballistic Nose Cone Construction, NACA TN-4141, (November 1957), 1-8.
44. P. Fote, personnel interviews with author, July 2015, May 2017. Fote is Chief Engineer Missile Systems, Textron Systems Corporation. Fote was a reentry vehicle design engineer for Avco Corporation for the Mark 4, 5, and 11; Two Approaches Used in First Production Nose Cones, *Aviation Week*, 12 May 1958, 65.
45. K.C. Speegle, Pressure Measurement on an Afterbody Behind Various Blunt Nose Shapes at a Mach Number of 2, NACA RM L5714, 27 December 1957, 5.
46. Morton, *Progress*, 7; Ballistic Missile Program Progress Report, 15 October 1956, Eisenhower Library, Papers as Pres. of the US, 1953 61 (Ann Whitman File), Folder: Guided Missiles (5), Box 16, v.
47. Morton, *Progress*, 7; Holaday, W.M., *Monthly Report on Progress of ICBM and IRBM Programs, Report 23, 31 October 1957*, U.S. Declassified Documents Online (<http://www.gale.com/c/us-declassified-documents-online>, CK2349205928, 27 November 1957), 4.
48. D.J. Stewart, Nose Cones: The Case for Heat Sink, *Missiles and Rockets*, 8 June 1959, 16-17.
49. Smithsonian News Release, 14 May 1959; Recoverable Data Capsule Designed for Thor and Atlas Test Missiles, *Aviation Week*, 24 November 1958, 71 72.
50. Progress of ICBM and IRBM Programs, April, May, June 1960, United States Air Force, Office of the Director of Defense Research and Engineering, Digital National Security Archive, (<http://www.products-services/databases/dnsa.html>), NH00710, 17; F.X. Ruggerio, *Missileers Heritage* (Air University, Maxwell AFB, 1981), Report Number 2065-81, 34-69.
51. R.H. Goddard, *Report Concerning Further Developments*, Smithsonian Institution Archive, March 1920, 4.
52. P. Juneau, Composite Materials, Ablative, *Encyclopedia of Chemical Technology*, 3rd Edition, (1978), Vol. I, 10-26. The author thanks Juneau for providing this reference, and for personal correspondence, February 1997.
53. E. Stuhlinger, Army Activities in Space, *IRE Transactions in Military Electronics*, Volume MIL, Issue 2, (April-July 1960), 65.
54. U.S. Congress, House of Representatives, *Organization and Management of Missile Programs, Eleventh Report by the Committee on Government Operations: Hearings Before a Subcommittee of the Committee on Government Operations*, 86th Congress, 1st session, 2 September 1959, 108.
55. E.J. Redman and L. Pasuk., Pressure Distribution on an ABMA Jupiter Nose Cone (13.3 Degrees Semi-Vertex Angle) at Nominal Mach Numbers 5, 6, 7, and 8, NAVORD Report 4486, U.S. Naval Ordnance Laboratory Aeroballistic Research Report 381, 27 September 1957, 6. Available from Defense Technology Information Center, AD0158516; H.C. Dubose and R.C. Bauer, Transonic Dynamic Stability Tests of a Half-Scale Model of the Jupiter W-14 Re-Entry Configuration, U.S. Air Force, Arnold Engineering Development Center, AEDC TN-58-1, (February 1958), 3. Available from Defense Technology Information Center AD778200.
56. J.M. Grimwood and F. Strowd, *History of the Jupiter Missile System*, U.S. Army Ordnance Missile Command, (1962), Appendix 8, 8-1. Available from Defense Technology Information Center, ADA434109; Explorers in Orbit, Army Ballistic Missile Agency, 10 November 1958, National Archives and Record Administration, Record Group 156, Stack Area 290, Row 902, Compartment 9, Shelf 1, Box 10, 38-42 and 112-119; Lucas and Kingsbury, A Brief Review of the ABMA Ablation Materials Program, 6.
57. M.C. Cleary, *Army Ballistic Missile Programs at Cape Canaveral 1953-1988*, (45th Space Wing History Office, Patrick Air Force Base, Florida, 2006), 52; Grimwood and Strowd., *History of the Jupiter Missile System*, Appendix 8, 8-1.
58. *Ibid.*, Appendix 9, 9-2, 9-4.
59. W. von Braun, *Letter to D.L. Schimdt, Technical Manager for Ablative Materials, Air Force Materials Laboratory, Wright-Patterson AFB, Ohio, 14 September 1969*, National Archives and Research Administration, SE, RG 255, 01-0002, Box 24, 2; Grimwood and Strowd, *History of the Jupiter Missile System*, 65. Cutting off the tip of a right circular cone generates a frustum; J.C. Brassell, Jupiter: Development Aspects and Deployment, Mobile Air Material Area, Brookley AFB, Historical Office, Office of Information, 1962, Air Force Historical Research Agency, IRIS 474833, Reel 14643, K205.0504-2, Vol 1, 30.
60. C. Hansen, *The Swords of Armageddon: U.S. Nuclear Weapons Development Since 1945*, Volume VII, (Sunnyvale, CA: Chuckelea Publications 1995), 323; M. Yaffee Two Approaches Used in First Production Nose Cones, 12 May 1958, *Aviation Week*, 61.
61. J. Neufeld, *The Development of Ballistic Missiles in the United States Air Force 1945-1960*, (Office of Air Force History 1990), Appendix 1: The Tea Pot Committee Report, 259-260; U.S. Congress, House of Representatives, *Organization and Management of Missile Programs: Hearings Before a Subcommittee of the Committee on Government Operations*, 3 March 1959, 383.
62. *Monthly Report on Progress of ICBM and IRBM Programs, Report 21, 31 August 1957*, Department of Defense, Office of the Director of Defense Research and Engineering, U.S. Declassified Documents Online (U.S. Declassified Documents Online [tp://www.gale.com/c/us-declassified-documents-online](http://www.gale.com/c/us-declassified-documents-online), CK2349145648), 2.
63. W.E. Green, *The Development of the SM-68 Titan*, (History Office, Deputy Commander for Aerospace Systems, Air Force Systems Command, August 1962), Vol II. Supporting Docu-

- ments: Letter, Brig Gen O J Ritland, V Cmdr, AFBMD, to Cmdr, ARDC., Subject: Reorientation of Nose Cone Program, 22 Aug 1958, Air Force Historical Research Agency, IRIS 897235, Document 57, 1-2.
- 64.** A.V. Levy, Evaluation of Reinforced Plastic Material in High Speed Guided Missile and Power Plant Application, *Plastics World*, Vol. 14, (March 1956), 10-11.
- 65.** I.J. Gruntfest and L.H. Schenker, Behavior of Materials at Very High Temperatures, *Industrial and Engineering Chemistry*, Vol. 50, (October 1958), 75A-76A; G.W. Sutton, Ablation of Reinforced Plastics in Supersonic Flow, *Journal of Aero/Space Sciences*, (May 1960), 378. Refrasil is approximately 90 percent silicone oxide, made by leaching out the lower flux oxides of E glass fibers found in fiberglass.
- 66.** M.C. Adams and E. Scala, The Interaction of High Temperature Air with Materials During Reentry, in: *Proceedings of an International Symposium on High Temperature Technology: Asilomar Conference Grounds, California, October 6-9, 1959*, (New York: McGraw-Hill, 1960) 54-60; M. Yaffee, Ablation Wins Missile Performance Gain, *Aviation Week*, (18 July 1960), 57; *Flight Summary Report Series D Atlas Missiles*, (San Diego, CA: General Dynamics/Astronautics, 21 June 1961), 8-36. Available from Defense Technical Information Center, AD0833337.
- 67.** U.S. Air Force, Study on the Future of AFBMD/MCO/SACMIKE/STL (R-W) Co., Air Force Historical Research Agency, IRIS # 01040315, 168.7171-167, reel 35264, n.d., 74-79.
- 68.** J.W. Powell, Thor-Able and Atlas Able, *Journal of the British Interplanetary Society*, Vol 37, (1984), 219-220, 222; Thor Able Launched in Nose Cone Test, *Aviation Week*, 28 July 1958, 27; D.L. Schmidt, Ablative Plastics for Thermal Protection, Wright Air Development Division, U.S. Air Force, WADD Report 60-862, August 1968), 58. This report was provided to the author by Don Schmidt in June 1999; M. Morton, *Progress*, 11. The author thanks Don Schmidt for a copy of this paper.
- 69.** W.M. Arms, Thor, the Workhorse of Space A Narrative History, (Huntington Beach, CA: McDonnell Douglas Astronautics Company, (31 July 1972), 4-1. The author thanks Joel Powell for a copy of this report.
- 70.** Powell, Thor-Able, Atlas-Able, 220; Heppenheimer, *Facing the Heat Barrier: A History of Hypersonics*, 47; I. Clausen and E.A. Miller, Intelligence Revolution 1960: Retrieving the Corona Imagery that Helped Win the Cold War, (Washington, D.C.: U.S. Department of Defense, Center for the Study of National Reconnaissance, 26 April 2012), 46.
- 71.** The author thanks Craig Brunetti for the Avco RVX-1 measurements.
- 72.** Ablative Nose Cone Shows Reentry Effect, *Aviation Week*, 25 May 1959, 30.
- 73.** Arms, *Thor: The Workhorse of Space, A Narrative History*, 4-4, 4-6; M. Morton, *Thor-Able and Atlas Reentry Recovery Programs*, (Philadelphia, PA: General Electric Defense Electronics Division, Missile and Space Vehicle Department, no date.), 1-7. The author is indebted to Don Schmidt for this document; Schmidt, Ablative Plastics for Reentry Thermal Protection, 58-59.
- 74.** *Flight Summary Report Series D Atlas Missiles*, 2-1.
- 75.** W.T. Barry, personal interview and correspondence with author, February 1997. Barry was a materials scientist consultant at the General Electric Space Sciences Laboratory in Philadelphia during the development of the Titan II Mark 6 reentry vehicle. The Series 100 plastic ablation process was patented by Barry, U.S. Patent 3,177,175 (1965).
- 76.** While not explicitly described as such, the available pictures of the recovered vehicle appear to show material similar to the RVX-2A reentry vehicle which did have these materials.
- 77.** Morton, *Thor-Able and Atlas Reentry Recovery Programs*, 22-23.
- 78.** Barry, personal interview by author, February 1997.
- 79.** *Ibid.*
- 80.** *Flight Summary Report*, 8-38.
- 81.** *Ibid.*, 8-5 to 8-11.
- 82.** *Ibid.*, 8-2.
- 83.** F.X. Ruggerio, *Missileers Heritage*, 34-69.
- 84.** *Progress of ICBM and IRBM Programs, April, May, June 1960*, Department of Defense, Office of the Director of Defense Research and Engineering, Declassified Documents Online (U.S. Declassified Documents Online [tp://www.gale.com/us-declassified-documents-online](http://www.gale.com/us-declassified-documents-online), CK2349126998), 17.
- 85.** W. Greene, *The Development of the SM-68 Titan*, 25.
- 86.** *Flight Test Summary*, 8-32 to 8-37.
- 87.** *Progress of ICBM and IRBM Programs, April, May, June 1960*, 17.
- 88.** F.X. Ruggerio, *Missileers Heritage*, 34-69; J. Neufeld, *Ballistic Missiles of the United State Air Force*, 234, 276.
- 89.** J. McDowell, personal interview by the author and extracts from unpublished *History of Flight*. The data can also be found at his website, <http://www.planet4589.org/space/lvdb/index.html>. McDowell's database is considered the gold standard of civilian missile launch records.
- 90.** *Memos, May 1958*, Personal Collection of Gen. B.A. Schriever, AFHRA, IRIS # 01040258, K168-7171-110, Reel 35259, 1-2.
- 91.** R.F. Piper, *The Development of the SM-80 Minuteman*, Vol 2, Supporting Documents, Proposed Preliminary Operational Concept for Minuteman, 8 April 1958, Document 76, 6.
- 92.** *Ibid.*, Letter, Col H.L. Evans, Asst D/Cmdr, Space Sys, to Col C.H. Terhune D/Cmdr, Ballistic Missiles, 28 May 1958, Subject: Minuteman Warheads and Reentry Vehicles, Air Force Historical Research Agency, IRIS 897233, K243-012-5, Document 80, 1-2.
- 93.** Personal interview by the author with Secretary of the Air Force Thomas Reed, May 2015. The companies were listed in his personal diary entry for Monday, 23 June 1958.
- 94.** Space and Missile Systems Organization: A Chronology, 1954-1979, U.S. Air Force, Space Division, (Chief of Staff History Office, October 1979), 57.
- 95.** R.F. Piper, *The Development of the SM-80 Minuteman*, Vol 2, Supporting Documents, Cancellation of the Light Minuteman Reentry Vehicle, 9 December 1958, AFHRA IRIS#, 897233, K243-012-5 Document 94, 1.
- 96.** Fote, personal interview by author, May 2017; Piper, *The Development of the SM-80 Minuteman*, Vol 1, 190-195.
- 97.** McDowell, unpublished.
- 98.** Operational Test Report: ELM BRANCH, Minuteman IA, LGM-30A, FTM 631, 1st Strategic Air Division, AFHRA, IRIS 918812, reel 26122, 2; J.C. Hopkins, *The Development of the Strategic Air Command 1946-1981: A Chronological History*, (Office of the Historian, Headquarters Strategic Air Command, 1 July 1982), 112, 157.
- 99.** R.F. Piper, *The Development of the SM-80 Minuteman*, Vol I, 190-196.
- 100.** Fote; M.L. Yaffee, Mark 11A Hardened Against Air Bursts, *Aviation Week and Space Technology*, 24 August 1964, 50-60.
- 101.** Fote; M.L. Yaffee, Mark 11A Hardened Against Air Burst, 50-59.
- 102.** Fote.
- 103.** McDowell.
- 104.** Operational Test Report: NICKED BLADE, Minuteman Missile IB, LGM-30B, FTM 1101, 1st Strategic Aerospace Division, AFHRA, IRIS 918790, reel 26121, 4; Fote.
- 105.** Air Force News Service, <http://www.af.mil/News/Tag/51024/air-force-news-service>; Unites States Air Force Supporting Studies, *A History of Strategic Arms Competition 1945-1972*, June 1976, 362; J.C. Hopkins, *The Development of the Strategic Air Command 1946-1981: A Chronological History*, 191.

# The French Pilot Training Experience at Oscoda Army Air Field During World War II



Charles DeGaulle addresses French flight students at Selfridge Field, August 1945.

David K. Vaughan

**D**uring World War II, approximately 150 French pilots received operational flight training at Oscoda Army Air Field (OAAF), Michigan, located approximately 200 miles north of Detroit. From July 1944 through March 1945, several detachments of French pilots were stationed at OAAF, where they flew the P-47 aircraft as they practiced their flying training skills prior to returning to France to participate in aerial combat in the closing months of WWII. The pilots in each detachment were given an intensive six-weeks course in combat flying. Because this training program was a one-time event and was of relatively short duration, little is known about this unique chapter of the U. S. Army Air Force's World War II training program. The history and details of this specialized combat training program are probably better known to French military historians than to Americans. This account details the training activities and experiences of this little-known program.

The French training program at Oscoda followed closely after another unique training program which was conducted at OAAF, when the Tuskegee Airmen of the 332nd Fighter Group completed their training in 1943. The 332nd, which consisted of three fighter squadrons flown by the men known today as the Tuskegee Airmen, the first group of African-American aviators to fly in the Army Air Forces, received operational training at OAAF during nine months of 1943.<sup>1</sup> The following year, the French fliers received their operational training over a nine-month period as well, during the last six months of 1944 and the first three months of 1945. Although Selfridge Army Air Field (SAAF), near Detroit, had been the home of origin for several fighter squadrons that had been established during WWII, operational combat training for units based at Selfridge occurred at OAAF due to the fact that no usable training areas existed in the Detroit vicinity, while there were many training areas available in the Oscoda and northern Michigan area. The Army Air Field at Oscoda was traditionally been described as a "sub-base" of Selfridge Field, but it was the site of gunnery and target ranges for units assigned to Selfridge Field (and units assigned to other fields as well) since it had been established in the 1920s.

## The Army Air Field at Oscoda

The airfield at Oscoda had first been established in 1924, when the commanding officer at Selfridge Field, Major Carl Spaatz, later a key general in the air war in Europe during World War II, urged the citizens of Oscoda to join in a cooperative effort to make the field suitable for use by the Army Air Service. The local citizens enthusiastically welcomed the idea of building an airfield for the Air Service, as a devastating fire had burned through the adjoining towns of

Oscoda and Au Sable in 1911. The field was named Camp Skeel, to commemorate a well-known Selfridge Air Corps pilot, Burt Skeel, who was killed in a Dayton, Ohio, air race in the fall of 1924. The airfield at Camp Skeel was used regularly for gunnery practice during the summer and fall months in the 1920s and 1930s and was used even in the winter months so that Selfridge pilots could practice winter flying techniques.

After the Japanese attack at Pearl Harbor on December 7, 1941, construction efforts at Camp Skeel increased significantly. Airfield facilities were significantly improved at Camp Skeel in 1942, including three concrete runways, a taxiway, and an apron. Prior to the construction of these runways and taxiway, the landing and taxi area had consisted of grass-covered and sandy surfaces. The old buildings were torn down and more modern buildings were constructed.<sup>2</sup> In August, 1942, the field was officially renamed Oscoda Army Air Field, a name it held throughout the remainder of World War II. The mission of the field was to provide operational training, primarily tactical flight training and gunnery practice for units about to be sent to active theaters of war.

### **The mission of the field was to provide ... primarily tactical flight training and gunnery practice**

A third phase of construction started in December, 1942; in this phase a fire station and utility yard were built and hospital and maintenance facilities were added.<sup>3</sup> Instead of standard barracks buildings, a number of "hutments" were built. These sixteen by sixteen-foot square huts held four men each. These were placed among the pine trees that populated the field. One permanent hangar was constructed on the field, located at the north end of the aircraft parking area. The control tower was located at its northwest corner.<sup>4</sup> A number of huts close to the flight line were converted into administrative and training buildings, in which two link trainers, a deflection trainer, and a range estimator were placed. Other buildings included the Commissary, Base Exchange, enlisted men's club, and officers' club. Army trucks provided shuttle service to Oscoda, and later, to East Tawas.<sup>5</sup>

By the spring of 1943 the capability of the field had changed significantly from its pre-war status, and it was

*David K. Vaughan is Professor Emeritus of the Air Force Institute of Technology, where he taught courses in technical communication, military ethics, and the literature of the US Air Force. He is a graduate of the United States Air Force Academy and flew a variety of training and cargo aircraft during his twenty-year Air Force career. He received his MA from the University of Michigan and his PhD from the University of Washington. He has published several articles and books in the areas of aviation history and literature.*



Entry Gate at Oscoda Army Air Field, 1944. Credit: Ailes Francaises en Amerique du Nord, 1943-1958

fully operational and ready to receive its first training units. The first units to be assigned at Oscoda for wartime training were the 100th Fighter Squadron, the 301st Fighter Squadron, and the 302nd Fighter Squadron. These squadrons, consisting of African-American pilots trained at Tuskegee Institute, were assigned to the 332nd Fighter Group, the first members of which arrived in the middle of April, 1943. During the time that the Tuskegee airmen were in training, on July 23, 1943, operational control of the airfield passed from the Third Air Force to the First Air Force.<sup>6</sup> First Air Force was responsible for the air defense and training of the Northeast sector of the continental United States. The last of the Tuskegee airmen concluded their training at OAAF in December, 1943, prior to shipping out for combat duties in the Mediterranean and European Theaters in WWII early in 1944. For the next six months there was relatively little flying activity at OAAF until the French airmen arrived in the summer of 1944.

### **The French Flight Training Program in the United States**

When the German forces invaded and conquered France in May and June, 1940, French forces still in France or in areas under French control were obligated by the terms of the French surrender agreement to fight in support of the Nazi German government. However, the French military forces in North Africa were freed from their obligation after the successful Allied invasion known as Operation Torch, conducted from November 8-16, 1942, and Allied military commanders offered flight training to French soldiers and airmen freed from their wartime restrictions in North Africa. Even though the French government was still under the control of the Nazis, the





Mrs. Janine Davidson translates the flight instructions given by Flight Instructor David Thomas to three French flight students at Van de Graaf Field at Tuscaloosa, Alabama, November, 1943. The French insignia is visible on the students' left arms.

American government made Lend-Lease assistance available to Free French Forces.<sup>7</sup>

The U. S. Army Air Force put a plan into effect that provided for an extensive flight training program for qualified French soldiers.<sup>8</sup> A similar training program for pilots had been conducted at Maxwell Field and Gunter Field, Alabama, from 1941 to 1943 on behalf of the Royal Air Force. This program had concluded early in 1943, and flying facilities that had been used to train British pilots were now available to train Free French pilots.<sup>9</sup>

### **Facilities that had been used to train British pilots were now available to train Free French pilots**

After their arrival in the United States, the French airmen were assigned to a variety of different training programs, determined by preliminary testing. In addition to flight training, there were training programs for navigators, bombardiers, radio operators, gunners, mechanics, and photographers. Of the approximately 5000 French participants initially in the program, over 4000 completed it. Men who were eliminated from the pilot training program were channeled into other flying roles, including navigators and bombardiers. Of the 4,209 men who completed the program, 1,339 became pilots, 81 were trained as navigators, 264 as bombardiers, 957 as gunners, 397 as radio operators, 1078 as mechanics in different specialties, and 93 as photographers.<sup>10</sup> Once the French airmen com-

pleted their training, they were assigned to combat duty in Europe.

The French aviators arrived from North Africa in sequential groups, or detachments. There were a total of 23 detachments, with an average of 130 men in each detachment. The first detachment arrived in June of 1943 and the last arrived in April of 1945, averaging about one detachment a month. Those men in the first seven detachments were able to proceed through the entire training program before the war ended; the men in the remaining sixteen detachments were still in training when the war ended. At the end of World War II, the men remaining in the United States were returned to France in February, 1946.

The initial flight training plan for the French pilots was thirty-four weeks long. It consisted of four weeks of initial testing and pre-flight training conducted at Craig Field, outside of Selma, Alabama, followed by ten weeks of primary flight training, during which trainees accumulated a total of sixty-five hours of flying time. Starting in June, 1943, this phase of flight training was conducted at Van De Graaff Field, near Tuscaloosa, Alabama. This training was initially provided by the Alabama Institute of Aeronautics (AIA). Training operations ceased at Van De Graaff Field on September 8, 1944, and primary flight training was then conducted by the Hawthorne School of Aeronautics (HSA) at Orangeburg, South Carolina.

Then followed ten weeks (eighty-five hours of flying time) of basic flight training at Gunter Field, in Montgomery, Alabama. After completing training at Gunter Field and officially being awarded their wings, the French aviators were divided into two groups: single engine pilots and multiengine pilots. Those aviators who qualified as single-engine pilots were sent to Craig Field, Alabama, where they received an additional ten weeks of training (ninety hours). Those designated as multi-engine pilots were sent to Turner Field in Albany, Georgia, where they received nine weeks (115 hours) of flight training in multi-engine aircraft. When the multi-engine pilots completed their advanced training, they were sent to Dodge City, Kansas, where they flew B-26 aircraft; later in the program, some of these pilots were sent to Frederick Field in Oklahoma for training.<sup>11</sup>

### **The French Flight Training Program at Oscoda**

Once the single-engine pilots completed their training at Craig Field, they were sent to operational training units (OTUs) for specialized training in P-47s. Early in the program, from January through June, 1944, these OTU fields included Dale Mabry Field, near Tallahassee, Florida, and Norfolk Army Air Field in Virginia. However, the airfield that received the greatest numbers of single engine students and provided most of the OTU training was Oscoda Army Air Field, which was designated as the primary P-47 training base on July 11, 1944. On July 15, thirty-four pilots from the 4th detachment of French aviators flew from Norfolk Field to Oscoda, where a training program was established that was exclusively devoted to the train-



Specially designed insignia for French flight students who trained at Oscoda. The phrase, "Ils Grandiront" means "they will fly."

ing of French pilots. From this date, all P-47 training for French pilots from detachments four through eight was conducted at OAAF. Oscoda Army Air Field, which had always been a sub-base (or auxiliary field) of Selfridge Field, was, for the first time in its existence, declared an independent airfield on July 12, three days before the first French pilots arrived.<sup>12</sup> By the time the French aviators arrived at Oscoda, they had completed approximately 240 hours of flying time and had been in the training pipeline for over thirty-four weeks, or eight months. At Oscoda, each detachment of French pilots received an additional three months of training before being released for assignment to French Air Force units. After completing their combat training, the French pilots were sent to Bolling Air Field, Washington D.C., where they received orders assigning them to flying units in the European theater.

## French aviators continued their operational training under the instruction of Army Air Force pilots

The first group to train at Oscoda consisted of the members of the 4th detachment of French fliers. They started training in September of 1943 as members of flying training class 44-D, proceeded through their primary flight training at Van de Graaff Field and their basic training at Gunter Field, and were awarded their wings six months later, on March 15, 1944. Those pilots selected to fly *avions de chasse*, single engine fighters, received advanced flight training in T-6 and P-40 aircraft at Craig Field, which lasted approximately three months. The members of this group then proceeded to Norfolk Field where they received indoctrination flights in the P-47 aircraft prior to their arrival in Oscoda in July of 1944.

In addition to 34 pilots, one non-flying officer, Hubert D'Irumberry de Salaberry, served as the commandant, or senior military officer, in charge of the pilots. These men were joined by a contingent of enlisted personnel from the

recently closed airfield at Blackstone Army Air Field in Virginia. These men formed the maintenance and supply sections serving the French airmen, all part of the 134th Air Base Unit. The enlisted personnel supporting the training program were American, not French, as there were no provisions for training French enlisted men. With the arrival of the French airmen and the enlisted personnel from Blackstone AAF, the number of personnel assigned to OAAF jumped from approximately 220 men on July 1, to nearly 1000 men by July 31.<sup>13</sup> Six months later, at the end of January, 1945, there were 132 officers, 759 enlisted men, and 173 civilians assigned to the field; thus, throughout the nine-month period that French aviators trained at OAAF, the total personnel strength of the field averaged just over 1000 men.

The purpose of the training program at Oscoda was Preparation for Overseas Movement, or POM:<sup>14</sup>

*The purpose of the training program was to standardize training; to train all Oscoda personnel for combat warfare; to improve the efficiency of the soldier; and to generally qualify personnel for the manifold duties that will confront them in combat.*

On August 12, 1944, one month after the first detachment of French pilots arrived, a special ceremony was held in which the French tricolor flag was raised near the barracks area of the field where the French cadets were housed. The unit history reported that relations with the local civilian population were good: "the townspeople are kindly disposed toward all military personnel [and] there are numerous invitations for house parties, dinners, hot dog roasts, and swimming and fishing parties. The USO, which maintains two well-equipped buildings in town, has done much in the way of arranging these affairs."<sup>15</sup>

At Oscoda the French aviators continued their operational training under the instruction of Army Air Force pilots as they were introduced to combat tactics and practiced formation flying, aerial combat, and gunnery. The first group completed its training on September 16, 1944. The second group of French aviators, from the 5th detachment, began training in the United States in October, 1943, completed their primary and basic training as members of flying training class 44-E, and received their wings on May 23, 1944. After completing advanced flight training at Craig Field, they proceeded directly to Oscoda, arriving in August of 1944; they completed their training by November 15, 1944. The members of the 6th detachment (class 44-F) began training early in November 1943, received their wings on June 27, 1944, and completed their training at Oscoda on December 26, 1944. The members of the 7th detachment began training late in November, 1943, started their flying program early in January, 1944 (class 44-G), received their wings on August 4, 1944, and completed training at Oscoda on March 8, 1945. The members of the 8th detachment, the last detachment to complete P-47 training at Oscoda, began their training in February of 1944, received their wings on 16 October 1944 (class 44-H), and completed their training at Oscoda on

April 12th, 1945. Of the over 150 French fliers who entered the combat training program at Oscoda, a total of 132 completed their training at Oscoda, thirty in Detachment 4, twenty-three in detachment 5, twenty-eight in Detachment 6, thirty-two in Detachment 7, and nineteen in Detachment 8.

The most significant problem associated with the training program was that few American ground or flight instructors spoke fluent, or even passable, French. The need for French-speaking flight instructors was so great that those pilots in the United States who spoke minimally acceptable French were placed in the training program, even if they had expressed a desire to fly in combat. The inability to communicate clearly in the cockpit was a serious concern, as the French pilots often did not understand exactly what the instructor pilot was asking them to do. In the early phases of the training program, in the preflight and primary flight instruction phases at the flying fields located in the southern states, French-speaking civilians were hired to serve as classroom instructors and flight line translators.<sup>16</sup>

Some American pilots assigned as flight instructors were members of the support staff at OAAF. Other instructors were stationed at Selfridge Field and were transferred to Oscoda for brief intervals. Two of these instructors were Captain Howard Askelson and Captain Arlie Blood, who were assigned to Selfridge in December, 1944. Arlie Blood had flown P-47s in the European Theater in 1943. On one mission he was shot down over France and managed to avoid capture by the German forces, eventually making his way into Spain. Undoubtedly his ability to survive in France during difficult times made him a likely candidate as an instructor for the French aviators assigned to Oscoda, even if his knowledge of the French language was incomplete. Blood brought his wife, Lucille, with him to Oscoda; they drove north in the middle of the cold northern Michigan winter and rented a log cabin, designed for summer, not winter visitors, and stayed there for three months while he provided flight instruction to the French cadets.<sup>17</sup>

His experience as a P-47 combat pilot in Europe was invaluable in guiding the pilots in gunnery practice. He described how shooting at a towed target was evaluated:<sup>18</sup>

*A six foot by thirty foot cloth banner was towed behind another aircraft with a steel cable about a thousand feet behind the airplane. One hundred rounds of fifty caliber ammo was loaded in each of two guns. The tips of the fifty caliber ammo were dipped in paint. Each aircraft was loaded with different colors. The leader usually carried red tipped ammo. After firing at the towed banner it was brought back to the field, dropped, and then the holes were counted. X number red, X number blue, etc. Sixty of the two hundred rounds had to hit the . . . banner to qualify [the pilot] as an expert gunner.*

The aircraft practicing their gunnery skills shot at the target as the tow plane towed the aerial target in a



Captain Arlie Blood diagrams a flight maneuver for French flying students at Oscoda AAF. (Credit: Arlie Blood, *Only Angels Have Wings*.)

southerly direction, parallel to the Lake Huron shoreline. A government aeronautical chart dated June 8, 1944, shows a danger area whose northern boundary begins ten miles eastward from the Lake Huron shore extending from approximately ten miles north of Harrisville south to the northern edge of the town of Oscoda.

### **[Blood's] experience as a P-47 combat pilot in Europe was invaluable in guiding the pilots in gunnery practice**

One Oscoda resident vividly described the scene as the P-47s flew their attack patterns at the targets extending behind the tow-planes as they flew south along the Lake Huron shore line:<sup>19</sup>

*It was a common war-years sight to watch the fighter planes swooping down at the white target some 900 yards behind the tow plane. Their guns blazing and drumming out the familiar machine gun sound, the sight brought the war home vividly to us. . . . The fighter planes made a giant wheel in the sky, as they bore in on the target and then, their shooting finished on this strike, swooped up quickly in a huge arc to avoid the angry guns of imaginary planes behind them.*

*Back and forth the tow plane went, month after month, turning back south off the town of Harrisville, going down the lake to the Tawas, then swinging north again. . . . The sound of machine gun fire over the twin towns of Oscoda and Au Sable was as common as the clop, clop of the [local] farm horse pulling the quaint little box of a milk cart around the towns each day.*

In addition to the Lake Huron target area, a fifteen mile by fifteen mile danger zone was located just to the north and west of the Oscoda airfield; aircraft attacking ground targets at the west edge of the OAAF airfield



Oscoda AAF Executive Officer, Lt Col Andrew Reynolds, briefs French flight students prior to flight, summer, 1944.

would maneuver in this area. Danger areas were also located over Lake Margrethe, near Grayling, where there was an auxiliary flying field, and even over the Beaver Islands, northwest of Traverse City. In general, P-47 aircraft flown by the French pilots could be seen maneuvering in a fifty-mile radius of OAAF, from Alpena in the north to East Tawas and Tawas City to the south to Grayling in the west.

Arlie Blood related one story about how two of his students aborted one gunnery mission, claiming that their aircraft engines were showing low oil pressure. He told them to return to the field and land, and he continued the gunnery mission with his remaining student. When he returned to the field, he was asked where his missing two students were. He replied that they had said their aircraft had experienced engine problems and he assumed they had returned to the field. Soon after, he related, the Highway Patrol reported that both students had made belly landings on the highway north of Oscoda. When they were questioned, they reported that they had fought an aerial duel over the affections of the same local Oscoda girl and had shot each other down. Arlie's comment was: "What an instructor they must have had!"<sup>20</sup> Unfortunately, official aircraft accident reports do not indicate two aircraft experiencing emergency landings on the same day during the winter of 1944-1945, or at any time during the nine-month

period that the French pilots were in training at Oscoda. But the story is too good not to have some element of truth in it.

Not that there might not have been girls in Oscoda who would have appealed to the French pilots; the town was inhabited by many families with French-Canadian backgrounds, families that had been started by men from Canada who had come to Oscoda and Au Sable to work during the lumbering years from 1850 to 1910. Names such as Bissonette, Michaud, Gagnier, Lavoie, and Thebault were common.

### **Some of the French pilots brought their wives or girlfriends ... and installed them in local resort cabins**

Some of the French pilots brought their wives or girlfriends with them and installed them in local resort cabins. Jerry Wagner, whose family lived near the entrance to the airfield, reported visiting one such cabin on a warm summer's day shortly after the first group of pilots arrived in the summer of 1944. When he walked up to the door to deliver a note from the French pilot, he could see, through the screen door, the French airman's wife doing her ironing in the cabin wearing nothing above the waist. The half-



French flight students' shoulder insignia.

dressed woman came to the door to take the note, and received it without registering any concern. This surprising experience provided Wagner with a “cherished war-years memory.”<sup>21</sup>

In order to converse with the French pilots, Wagner bought a French language instructional manual. Wagner often worked with his stepfather and some other men on the west side of the base near the ground firing range, where they had a contract to remove the trees that had been cut when the firing range had been constructed. Although they always checked with the base operations office to ensure that no gunnery practice was scheduled when they went out to clear the fallen trees, they were often surprised by the French pilots flying their P-47s low overhead as they worked. Wagner was sure that the pilots intentionally looked for them, hoping to put a fright into them, which they did.

Wagner thought that the French pilots were “fearless”:

22

*These fearless men, so far away from their homeland and possibly already angry at losing their beloved country to Hitler, threw caution to the wind. At buzzing people and buildings, they were absolutely the most reckless and care-free pilots that ever trained at the base. . . . They flew [their P-47s] with consummate skill.*

Wagner recalled that aircraft flying low, or “buzzing,” the Oscoda beaches was a “common war years occurrence,” and that residents often saw a P-47 flying at high speed “no more than one hundred feet in the air and traveling the length of the beautiful [Lake Huron] beach from the mouth of the Au Sable River north” to the northern boundary of town.<sup>23</sup> But the residents never seriously complained, believing that it was “unpatriotic to complain about such things” while a war was being waged.

The shortage of flying instructors proficient in French resulted in a decision to assign some of the more proficient French pilots as instructors as well.<sup>24</sup>

*The American instructor was quite aware that it was his*

*inability to explain on the spot—and those spots were short in time—rather than the lack of ability of his student to fly that was the source of the problem. Because of the latent danger created by poor communication, Training Command asked and obtained from the French Headquarters in Washington the permission to keep some of the trainees for flight instructor's duty from the very beginning.*

The French flight instructors (or *moniteurs*, as they were referred to in the French language), helped French flying students to resolve communication problems. Rene Leveque, a member of the first detachment of French aviators to arrive in the United States, and one of the first French flight instructors at Gunter Field, stated that he “often took the job of saving French Cadets from being ‘washed out’ because communication failed in a certain phase of training.”<sup>25</sup> Eventually, some French pilots were assigned as instructors at every field that was used in the French pilot training program, including Oscoda Army Air Field.

At least six *moniteurs* served at Oscoda during the nine-month period when the French pilots were assigned to the base: Guy Brunet, a member of the 3rd detachment; Francois Messinger, a member of the 5th detachment; Andre Maccary, also in the 5th detachment; Jacques Noetinger, a member of the 6th detachment; Serge Lazarevitch of the 6th detachment; and Jean Kisling, a member of the 13th detachment. Two of these six *moniteurs* died in aircraft accidents while they were at Oscoda, and a third died in a non-flying accident.

### **In order to converse with the French pilots, Wagner bought a French language instructional manual**

The first fatality was Francois Messinger, who died on a training flight on September 17, 1944, two months after the training program at Oscoda began. Messinger was an element leader in a four-ship formation led by Guy Brunet. The other pilots were Jean-Louis Jacquet, Brunet's wingman, and Andre Maccary, Messinger's wingman. The mission was a high altitude formation flight, designed to familiarize the pilots with the techniques and sensations of high altitude formation flying. Prior to take-off at Oscoda, the pilots discussed the procedures associated with their radio communications, fuel management, and oxygen equipment. After takeoff, the formation flew north and then headed east over Lake Huron, climbing for altitude. As the group passed through 8,000 feet, Brunet called for all pilots to engage their engine turbo superchargers, which would enable their engines to perform more efficiently in the thinner air of the higher altitudes. Brunet also called for oxygen checks periodically.

After levelling at 25,000 feet, Brunet turned to the left in a ten degree bank, a relatively shallow bank. All of the other aircraft followed except for Messinger's aircraft, which turned to the right on a southerly heading. It also started a gradual descent. Maccary, who was flying on



Classroom instruction, Oscoda AAF, 1944. Credit: Ailes Francaises en Amerique du Nord, 1943-1958.

Messinger's right wing, called to Messinger on the radio but received no answer. Maccary alerted Brunet that Messinger was not responding to his calls. Messinger's plane started to descend in a series of steep spirals. Maccary followed Messinger's aircraft to an altitude of 4,000 feet, when he leveled off and watched as Messinger's aircraft continued its descent until it struck the surface of Lake Huron three miles northeast of Sturgeon Point on the Lake Huron coast, four miles north of Harrisville, Michigan.<sup>26</sup>

### **There were twenty-five aircraft incidents or accidents involving French pilots**

Maccary stated that when Messinger's aircraft struck the surface of the water, he saw "a large geyser and a white spot that settled rapidly." Although the accident investigation board was unable to determine the cause of the crash, it was probably due to a lack of oxygen. Either Messinger had not attached his oxygen mask, or it was not feeding him oxygen under pressure at high altitude as it should have. A lack of oxygen at high altitude can cause hypoxia, a condition in which the brain loses consciousness, incapacitating the pilot. In August, 2012, sixty-eight years later, pieces of Messinger's P-47 washed up on the Lake Huron shore at Sarnia, Ontario, over 100 miles south of the crash site.<sup>27</sup> Sadly, Messinger's wingman, Andre Maccary, died less than two months later in a non-flying accident. He drowned while duck hunting in a marsh near Cedar Lake, located just north of the airfield, on November 10, 1944. The second *moniteur* to die in an aircraft accident was Serge Lazarevitch, who was killed when his aircraft struck the ground while maneuvering at low altitude six miles west of Harrisville, Michigan, on March 30, 1945.

Jacques Noetinger had been a *moniteur* in T-6 aircraft at Craig Field before arriving at Oscoda. He had a

long and productive flying career after the war. Even though he did not receive his training at Oscoda, Jean Kisling, a member of the 13th detachment, served as a *moniteur* in the P-47 program at Selfridge and Oscoda. After World War II ended, he became a commercial pilot for Air France, and accumulated over 26,000 hours of flying time.

Including the accidents mentioned above, there were twenty-five aircraft incidents or accidents involving French pilots during the nine months they trained at Oscoda. Of these there were four fatalities, including the two *moniteurs* mentioned above. The third fatality was Jacques Martin, who was killed when his aircraft struck the ground three miles west of Greenbush, Michigan, on December 29, 1944. The fourth fatality was Marcel Oules, who was killed in an aircraft crash six miles west of Mikado, Michigan, on March 26, 1945. Of the twenty-five incidents and accidents, four occurred while the aircraft was taxiing on the airfield, five occurred during landing, and three occurred when the aircraft struck the large cloth aerial target that was being towed over the aerial gunnery range off the Lake Huron shoreline. There were five forced landings due to mechanical failure.

Three non-fatal crash landings occurred during the nine-month training period; the first occurred on September 8, 1944, when an aircraft crashed on a local farm, owned by Edward Vaughan, located on the southern banks of the Au Sable River, two miles south of the airfield.<sup>28</sup> According to one local account, the pilot clipped the tops of several trees before his aircraft<sup>29</sup>

*belly-smashed into their field. It skidded in the black soil of their plowed field for seven or eight hundred feet then smashed into a large [oak] tree that stopped the out-of-control ride. When the grinding of metal ceased and the smoke cleared, the Vaughans had a fighter plane and a Free French flyer almost in their living room.*



French flight students at Oscoda AAF. (Credit: Ailes Francaises en Amerique du Nord, 1943-1958.)

As the aircraft struck the ground, one wheel broke loose from the plane and came to rest on the Vic Merkel farm, located across the Au Sable River from the Vaughan farm. The pilot, Maurice Meuret, though seriously injured, survived. The second crash occurred fifteen miles north of Traverse City and one mile west of Bellaire, Michigan, on February 2, 1945; a third occurred seven miles south of West Branch on April 12, 1945.

The most unfortunate incident associated with the French flight training program occurred on August 8, 1944, less than a month after the first group of French pilots arrived at Oscoda. A flight of three aircraft, led by Lieutenant Kenneth Wassing, an army air force instructor pilot, buzzed low over Lake Margrethe, located just southwest of the central Michigan town of Grayling. Wassing's two wingmen were French pilots Andre Erard and Antoine Fabby. One of the three aircraft flew so low the propeller of one of the three aircraft struck Mrs. Mary Meyer as she sat in a rowboat with her son, Oscar. The seventy-two year old woman and her son, from Madeira, Ohio, were vacationing in Grayling. Mrs. Meyer, who was trying to crouch low in the boat, was nearly cut in half by the propeller of one of the aircraft. Her son, who threw himself flat in the boat, was not injured.

The lead aircraft was flown by Lieutenant Wassing; Erard and Fabby were both members of the newly arrived 4th detachment of French pilots. The base commander of Oscoda Army Air Field, Colonel John Crosthwaite, convened a court martial board which found Wassing guilty of violating two articles of war, flying too low and endangering civilians. Wassing was sentenced to eighteen months at hard labor, dismissal from the service, and forfeiture of all pay and allowances. Because they were flying close formation, following the lead ship flown by Wassing, Erard and Fabby were allowed to continue in the program and graduated with the other members of their detachment in September.<sup>30</sup>

After the Allied forces successfully pushed the German army out of France and began to take control of large sections of Germany in the spring of 1945, the French flight training program experienced adjustments as the war in Europe came to a close. On March 27, 1945 a forest fire ignited six miles west of Oscoda. Strong winds assisted the fire in spreading east towards Oscoda and threatened both the airfield and the town before volunteer fire fighters were able to stop the fire from advancing. Three hundred military personnel from Oscoda Army Air Base were among the volunteers who helped to halt the fire. By the time the fire was stopped on March 28, almost 20,000 acres of grass and forest land had been burned. All aircraft at OAAF were flown from Oscoda to Selfridge Field as a precautionary measure in case the fire could not be controlled.<sup>31</sup> The fire was stopped at the western boundary of the town, where the Detroit and Mackinac Railway train station was located; several sheds and small buildings near the D&M depot were destroyed before the efforts of the firefighters, assisted by reduced winds, stopped the advance of the fire.

### **The gunnery range at Oscoda continued to be used by French pilots ... at Selfridge until August 1945**

Although the forest fire probably was not the reason, on April 11, all formal combat training at Oscoda ceased, and operational training in P-47s moved to Selfridge Field. The gunnery range at Oscoda continued to be used by French pilots in training at Selfridge until August 1945, when the war ended and all training ceased.<sup>32</sup> Although French pilots were still moving through the training pipeline, a number of factors were responsible for the decision to close the program. The major factor was end of the war in Europe on May 6, 1945; the need for French combat pilots was no longer as urgent as it had been earlier in the war. When Japan surrendered on August 14, the need for trained French combat pilots was over. General Charles De Gaulle, provisional president of France, visited Selfridge Field on August 27, and inspected the French airmen who had assembled for his visit. In February 1946, the training program was officially terminated and all French airmen in the United States returned to France.

Although many of the French airmen did not complete their training in time to fly in combat over their home country, some of the early graduates did so. At least one of the Oscoda trainees, Maurice Pochet, flew the P-47 over Germany before the war ended. Many of the trainees became pilots in the French Air Force after the war.

The airfield at Oscoda continued to be used for gunnery training by French and American pilots stationed at Selfridge Field throughout the summer of 1945, but after the departure of the French pilots, on April 12, the base again reverted to its status as a sub-base of Selfridge Field. The field was largely deserted, affording those military personnel still assigned to OAAF the opportunity to live their lives at a more leisurely pace. Jerry Wagner re-

called being a passenger in a Chrysler automobile driven by one of his friends, Neddy Gilardino, along with one of the base's military policemen, Corporal Davis, as Gilardino drove it down the military airfield's deserted runway one afternoon in late summer, trying to see if it could reach a speed of one hundred miles an hour.

Suddenly a dark shadow passed overhead, accompanied by a very loud roaring noise. They then saw a P-51 fly over them, its wheels down, so low that they could read the black stenciled letters on the bottom of the fuselage. The aircraft quickly passed them, retracted its wheels, and circled around for another attempt at landing. Gilardino drove his car off the runway and over to the base operations office, where Corporal Davis knew the pilot of the aircraft, Lt Col Ralph Jenkins, the base commander, would be parking. Corporal Davis stood at attention while Jenkins stepped down from the P-51.

As Jenkins approached, he asked Corporal Davis, "Have your friends been up in the tower, Corporal Davis?"

Corporal Davis replied, "No, sir, they haven't."

"Then by all means, show them the tower." He paused briefly, then added, "We all know they have seen the runway."

Lt Col Ralph Jenkins had been Captain Arlie Blood's P-47 squadron commander in the 510th Fighter

Squadron in Europe.<sup>33</sup>

When the combat training program for the French pilots ended, a significant chapter of the history of Army Air Force experience at Oscoda came to an end. Two special groups of pilots, the Tuskegee Airmen and the Free French airmen, had conducted their training programs at Oscoda, the only American airfield to accommodate these two unique groups of airmen for extended training programs.

The field was officially closed on December 31, 1945. However, as the Cold War intensified and international tensions rose as a result of the Korean conflict (1950-1953), the airfield at Oscoda became increasingly active as more flying units conducted training there. In 1950, the field again opened as an active installation under the command of the 10th Air Force of the Continental Air Command. In 1951, an interceptor squadron flying jet-powered F-86s was assigned to the field and the field was transferred to the Air Defense Command. The field was renamed Wurtsmith Air Force Base in 1953, in honor of a recently deceased Air Force general officer, Paul Wurtsmith, and shortly after became one of the northern tier of bases in the Strategic Air Command. It eventually was home to both B-52 and KC-135 aircraft. As world tensions decreased after the fall of the Berlin Wall in 1987, the need for large numbers of global reach nuclear-capable bombers also decreased, and the base eventually closed in 1993. ■

## NOTES

1. For a full discussion of the World War II training program for the Tuskegee Airmen at Oscoda during World War II, see David K. Vaughan, "The World War II Training Experiences of the Tuskegee Airmen at Oscoda Army Air Field," *Air Power History* (Winter 2016), pp. 25-40.
2. Mary T. Wolf, *Wurtsmith Air Force Base, 1924-1980*, p. 8. Unpublished (1980). A draft copy prepared by Sergeant Mary Wolf, 379th Bomb Wing Historian.
3. Wolf, pp. 9-10.
4. *Unit History* (1), p. 9.
5. *Unit History* (1), p. 14.
6. Wolf, p. 11.
7. Robert B. Kane, *So Far From Home: Royal Air Force and Free French Air Force Flight Training at Maxwell and Gunter Fields during World War II* (Montgomery AL: New South Books, 2016), pp. 53-54.
8. Wesley Frank Craven and James Lea Cate, eds., "Men and Planes," *The Army Air Forces in World War II, Vol. 6* (Office of Air Force History, 1983), pp. 697-698.
9. Kane, *So Far From Home*, pp. 55-56.
10. Patrick Ehrhardt, Jean-Paul Quentric, and Jean Fleury, *Ailes Francaises en Amerique du Nord, 1943-1958* [*French Wings in North America, 1943-1958*] (Association pour la Recherche de Documentation sur l'Histoire de l'Aeronautique Navale [ARD-HAM], 2009). Statistics pertaining to French training program in the United States during WWII are found in Section I, pp. 15-277. Kane provides slightly different figures: 1,351 pilots, 74 navigators, 253 bombardiers, and 955 gunners (*So Far From Home*, p. 76).
11. Ehrhardt, Quentric, and Fleury, *Ailes Francaises*, Section I.
12. *Unit History* (1), p. 20.
13. *Unit History* (1), p. 21.
14. *Unit History* (1), p. 28.

15. *Unit History* (1), p. 60.
16. *Unit History* (1), p. 44.
17. Arlie Blood, *Only Angels Have Wings* (Privately printed, 1997), p. 106.
18. Blood, p. 107.
19. Jerry Wagner, *World War Two, Oscoda and Au Sable* (Iosco County Historical Association, 1987), p. 23.
20. Blood, p. 108.
21. Wagner, p. 21.
22. Wagner, pp. 20-21.
23. Wagner, p. 20.
24. Rene C. Leveque, "The Early Training of French Pilots in the U. S.," *Aerospace Historian*, December 1982 (Vol. 29, No. 4), pp. 257-258; see also Janelle Dupont, "French Lessons," *Air&Space*, March 2004, pp. 55-60.
25. Leveque, p. 257.
26. *Unit History* (2), *Oscoda Army Air Field, 1 August 1944 to 31 October 1944*, pp. 12-13; see also Barbara Simpson, "Unlocking the Mystery Behind P-47 Wreckage," *Sarnia [Ontario] Observer*, 28 August 2012; found on *Sarnia Observer* web site, 9 February 2015.
27. Simpson.
28. *Unit History* (2), p. 12.
29. Wagner, p. 22. For many years afterwards, the oak tree on my grandfather's farm bore a whitewashed scar testifying to its role in the accident.
30. *Unit History* (2), pp. 13-15; "Buzz Flight' Killing Aired," *Circleville [Ohio] Herald*, 2 September 1944; article found on *Newspapers.Com*.
31. *Unit History* (4), *Oscoda Army Air Field, 1 February 1945 to 12 April 1945*, p. 8.
32. *Unit History* (3), *Oscoda Army Air Field, 1 November 1944 to 31 January 1945*, p. 3.
33. Wagner, pp. 61-62.



# OPERATION VITLES: THE BERLIN AIRLIFT



Some of Berlin's children watch an incoming shipment.



Daniel L. Haulman

When the Allies defeated Hitler in the spring of 1945, they divided Germany up for temporary occupation according to the terms of the Potsdam agreement. The Union of Soviet Socialist Republics (USSR, or Soviet Union) occupied the eastern zone of Germany, while the United States, Britain, and France occupied the western zones.<sup>1</sup> Berlin, the German capital, lay in the middle of the eastern Soviet zone, but it, too, was divided for occupation among the four victorious Allies. Soviet troops occupied the eastern side of the city, and American, British, and French forces occupied the western side. Western Berlin was 110 miles from the non-Soviet zones of western Germany, but was connected to them by highway, railroad, and three air corridors. A written agreement among the occupiers, signed at the end of November 1945, defined the air corridors, but there was no such agreement for the land routes.<sup>2</sup>

For the next three years Germany underwent a slow reconstruction, the western zones of Germany and Berlin accommodating themselves to new democratic institutions and a free market economy, while the eastern zones fell under the strict communist control. The Soviet Union's Red Army left the countries of eastern Europe with one-party communist governments loyal to Soviet dictator Joseph Stalin. As early as March 1946, British former Prime Minister Winston Churchill warned in a speech that an "Iron Curtain" was descending across Europe, with freedom denied in those eastern European countries that Stalin dominated.<sup>3</sup> In February 1948, the Soviet Union engineered a coup in Czechoslovakia that overthrew its democracy and replaced it with a communist regime loyal to Stalin.<sup>4</sup>

Fearing Stalin's designs for Germany, representatives of the United States, Britain, France, the Netherlands, Belgium, and Luxembourg met in London in February and March 1948 to discuss the future of western Europe. They agreed to merge the western zones of Germany economically in preparation for a federal republic there. In an attempt to pressure the Western leaders to reverse course, Stalin began restricting rail and road traffic between western Germany and Berlin on April 1. The next day, Gen. Lucius Clay, the military governor of the United States zone of Germany, arranged with Lt. Gen. Curtis E. LeMay, commander of United States Air Forces in Europe, to airlift supplies to the military garrisons of Berlin, using C-47s. The crisis intensified on April 5 when a Soviet fighter that was buzzing a British cargo plane crashed into it, taking it down with no survivors. On April 10, the Soviet Union relaxed the land route restrictions, and the crisis eased, but the airlift continued, in case Stalin changed his mind again.<sup>5</sup>

On June 18, 1948, the United States, Britain, and France, announced plans to create a unified German currency within the next two days, and the new currency would apply to their three occupation zones in western Germany. The next day, June 19, Marshal Vassily D. Sokolovsky, Soviet Military Governor of eastern Berlin, declared that all of Berlin, including the western zones, was part of the Soviet zone of eastern Germany. The Soviet government announced that its

eastern zone of Germany would have its own currency, and that would also apply to all of Berlin. Western leaders immediately announced that the western German currency would also be used in their western Berlin occupation zones. On June 23, Stalin initiated a blockade of all land routes between western Germany and western Berlin, including railroad and highway communications, and the next day, the blockade was complete. On June 25, his government announced that food deliveries from the Soviet zone would no longer be allowed to reach western Berlin. The blockade separated the two and a half million western Berliners from their normal sources of supply. Either Stalin wanted to pressure the western governments to cease the creation of a non-communist West German state, or he wanted a new communist East German state that would include all of Berlin.<sup>6</sup>

The Western powers had four options. First, they could cancel the currency reform, and with it the movement toward union of the western zones into an independent democratic West Germany. A second alternative would be for them to abandon western Berlin, allowing its millions of people and their businesses to be absorbed by the surrounding communist Soviet zone in a new East German state. A third option would be to try forcing an armored column across eastern Germany to western Berlin, which could have precipitated another world war, with the probability of defeat because of the presence of thirty Soviet divisions in the immediate area, and far fewer American or British forces.<sup>7</sup> A fourth option would be to vastly expand the airlift that had begun in April to resupply the western



Gen. Curtis E. LeMay

garrisons in Berlin by air. The expanded airlift would have to deliver enough supplies not only to sustain the garrisons, but also two and a half million people in western Berlin.

The big question was whether such a massive airlift could be organized and maintained long enough to outlast the Soviet blockade. Western Berlin was then an island in a Soviet sea. The city needed not only food but also massive amounts of coal and other supplies. Another question was whether the Soviet Union would allow the vast expansion of flights over the Soviet zone. That, too, ran the risk of war. Airlift had never before sustained a large encircled population for long. It had been tried at Stalingrad, just five years earlier, where a German army had been completely surrounded by Soviet troops, and that airlift had failed miserably.<sup>8</sup>

The Berlin Airlift began officially on June 26. The operation started small, building on the earlier April airlift, now called the “Little Lift,” and grew until it became one of the largest humanitarian airlifts in history. At first it was two different airlifts, one American and one British. President Truman authorized “Operation Vittles,” the American part of the airlift, using the new United States Air Force that had been created the previous year from the Army’s aviation organizations. The British Royal Air Force called its part of the airlift “Operation Plainfare.” Both names suggested food deliveries, but they were outnumbered by coal deliveries, since western Berlin needed even more tonnage of fuel than food. Economic experts estimated that the city would need at least 4,500 tons of coal and food per day to survive the Soviet blockade.<sup>9</sup>

General LeMay was the first commander of the Amer-

*Daniel L. Haulman is Chief, Organizational Histories, at the Air Force Historical Research Agency, Maxwell AFB, Alabama. After earning a BA from the University of Southwestern Louisiana and an ME (Master of Education) from the University of New Orleans, he earned a Ph.D. in history from Auburn University. Dr. Haulman has authored several books, including Air Force Aerial Victory Credits, The USAF and Humanitarian Airlift Operations, and One Hundred Years of Flight: USAF Chronology of Significant Air and Space Events, 1903-2002. He has written several pamphlets, composed sections of several other USAF publications, and compiled the list of official USAF aerial victories appearing on the AFHRA's web page. He wrote the Air Force chapter in supplement IV of A Guide to the Sources of United States Military History and completed six studies on aspects of recent USAF operations that have been used by the Air Staff and Air University. He has also written a chapter in Locating Air Force Base Sites: History's Legacy, a book about the location of Air Force bases. The author of twenty-nine published articles in various journals, Dr. Haulman has presented more than twenty historical papers at historical conferences and taught history courses at Huntingdon College, Auburn University at Montgomery, and Faulkner University. He co-authored, with Joseph Caver and Jerome Ennels, the book The Tuskegee Airmen: An Illustrated History, published by New South Books in 2011.*



Maj. Gen. William H. Tunner

ican part of the Berlin Airlift, since he was commander of the United States Air Forces in Europe (USAFE). At his disposal at first were the 60th and 61st Troop Carrier Groups, both of which flew C-47 twin engine cargo planes. LeMay had 102 USAF C-47s available in Europe at the start of the airlift. The 60th was first based at Kaufbeuren Air Base but in December moved to Wiesbaden by the end of the year, while the 61st was stationed at Rhein-Main. The largest western airport in Berlin was Tempelhof, in the American zone. LeMay had a reputation as a bomber pilot and former commander of the XXI Bomber Command, the command that had marshalled B-29s in the massive bombing raids on Japan only three years earlier. This time, instead of hosts of bombers dropping explosives and incendiaries on enemy targets, he would orchestrate hosts of transports that would be landing at the western Berlin airports delivering food and fuel from western Germany. He needed help from those more expert in transport operations. On June 29, LeMay appointed Brig. Gen. Joseph Smith at Wiesbaden to be commander of a temporary airlift task force, but he continued to support the airlift with all his energy.<sup>10</sup>

### **The operation started small, building on the earlier April airlift, now called the “Little Lift”**

July 1948 was a crucial month for the airlift. LeMay and Smith convinced Air Force Chief of Staff Gen. Hoyt Vandenberg to transfer many of its C-54 transports from the Military Air Transport Service to USAFE for Operation Vittles. Each four-engine C-54 could carry almost ten tons of cargo, but each twin engine C-47 could carry little more than three tons.<sup>11</sup> They gradually outnumbered and eventually replaced all the C-47s on the airlift. In the middle

of the month, President Truman agreed to deploy sixty B-29 bombers to Britain, to discourage the Soviet Union from any interference with the airlift. At the time, the United States was the only country with atomic weapons, and it was known that B-29s could deliver them, as they had over Japan.<sup>12</sup> At the end of the month, LeMay also obtained from the Military Air Transport Service Maj. Gen. William H. Tunner, the world’s leading airlift expert, who during World War II had managed a massive airlift over “the Hump” from India to China. Tunner succeeded Smith as head of the airlift, and introduced a regularity and clockwork precision that was probably more instrumental than any other factor in the airlift’s success. Building on Smith’s foundation, Tunner developed flight patterns to avoid collisions and facilitate loading and unloading at regular intervals. He also initiated one-way flights through each of the three flight corridors.<sup>13</sup>

One of Tunner’s major contributions to the Berlin Airlift, besides managerial expertise, was his successful effort to acquire larger aircraft so that fewer round trips were needed between western Germany and western Berlin. He eventually replaced all the twin-engine C-47s on the operation with four-engine C-54s. He also acquired the use of a C-74 Globemaster aircraft, a very large transport that could carry 25 tons at a time, more than twice the capacity of each C-54. Between mid-August 1948 and the end of September, the Globemaster flew 24 trips to Berlin, carrying outsize cargo.<sup>14</sup>

As USAFE commander, Lt. Gen. LeMay remained Tunner’s superior, but he and Tunner got along very well. In mid-October 1948, LeMay succeeded in obtaining for the Berlin Airlift a unified command. The British agreed to the establishment of a Combined Airlift Task Force, with Tunner as commander and British Air Commodore John W. F. Merer as his deputy. The blending of Operation Vittles with Operation Plainfare allowed the Allies to create an even more efficient airlift operation. Just after the creation of the Combined Airlift Task Force for the Berlin Airlift, LeMay left Europe for the United States to assume command of Strategic Air Command. Succeeding him as USAFE commander was Lt. Gen. John K. Cannon, and Tunner had a new boss.<sup>15</sup>

United States airlift airplanes consisted primarily of USAF C-54s, of which there were eventually over 200 available. An average of 128 of them were in commission daily, the rest being in various stages of periodic maintenance. American aircraft were cycled for maintenance at first to Oberpfaffenhofen and later to Erding Air Depot in Germany, or to Burtonwood Air Depot in England. R5Ds, U.S. Navy versions of the C-54, also took part on the airlift. For outsize cargo, besides the C-74, Tunner used a small fleet of C-82s, which could be loaded and unloaded more easily, since they had a rear door. The Royal Air Force used Dakotas, their version of the twin-engine C-47, and four-engine Avro Yorks and Handley Page Hastings aircraft, which were modified World War II bombers. The British also used civilian aircraft under contract.<sup>16</sup>

The end of 1948 and beginning of 1949 presented the Berlin Airlift with one of its greatest challenges: “General

Winter,” which had helped the Soviet Union defeat Germany earlier that decade. Fog and ice threatened to reduce the number of flights to and from Berlin, and increase the number of accidents. Despite bad weather threats, the airlift continued to grow except for the months of November 1948 and February 1949.<sup>17</sup> In the other months, there was steady progress. In foggy and cloudy weather, and a night, Berlin airlift crews had to use instruments constantly. Planes failing to land in Berlin as planned had to return to their base of origin to avoid pileups. The Soviet Union harassed some of the flights with fighter aircraft, anti-aircraft artillery, and searchlights, but did not actually shoot any of the transports down. Between August 1948 and August 1949, there were more than 700 such incidents, but none serious enough to interrupt the airlift. The Soviets did not jam radio communications, which might have seriously threatened the flights, since many of them depended so much on instruments.<sup>18</sup>

Working with Cannon, Tunner increased the daily tonnage to Berlin until it exceeded the 4,500-ton minimum daily requirement. A master of airlift efficiency, Tunner managed the operation as if the three corridors were conveyor belts constantly moving to or from western Berlin. He succeeded in getting a cargo plane landing at Berlin every three minutes. He reserved the northern and southern air corridors to carry transport planes from Rhein-Main, Wiesbaden, Fassberg, and Celle in the western zones of Germany to Tempelhof, Gatow, and Tegel airports in western Berlin, while reserving the middle corridor to carry planes from Berlin back to western Germany. The people of West Berlin contributed greatly to the airlift by helping construct new runways at Tempelhof in the American zone and Gatow in the British zone, and contributing to the building from scratch of a new airfield, Tegel, in the French zone.<sup>19</sup>

### **Operation Vittles exceeded expectations...because of the huge amount of...resources devoted to the airlift**

Operation Vittles exceeded expectations, partly because of the meticulous planning, but also because of the huge amount of personnel and aircraft resources devoted to the airlift. On April 16, 1949, in what was called the “Easter Parade,” U.S. and British aircraft delivered a record 12,941 tons of coal and food to Berlin in 24 hours.<sup>20</sup> 1st Lt. Gail Halvorsen supplemented the regular airlift by dropping candy, attached to small handkerchief parachutes, to the children of Berlin, a practice which was dubbed “Operation Little Vittles.”<sup>21</sup> Such success stories reinforced public support for the airlift and its expense.

Finally convinced that the Berlin blockade was not achieving its goals, the Soviet Union reopened land routes between western Germany and Berlin on May 12, 1949. The Allies continued the Berlin Airlift through the summer, in case Stalin changed his mind. The Combined Airlift Task Force was inactivated at Wiesbaden on 1 September 1949, but USAF airlift flights continued to the end of the month.<sup>22</sup>

The Berlin Airlift statistics were staggering. The Allies



The C-47 Skytrain was an airlift workhorse.

transported 2.3 million tons of cargo and 227,655 passengers during the Berlin Airlift. American planes airlifted 77 percent of the total. Most of the cargo, by weight and volume, was coal, but much of it was food. Of the 277,569 flights, the Americans flew 68 percent of the total. Thirty U.S. military personnel lost their lives during Operation Vittles, including 22 USAF pilots. The Royal Air Force lost 15 personnel. USAFE reported 70 major and 56 minor accidents, while the Royal Air Force reported 46 accidents requiring salvage.<sup>23</sup>

The Berlin Airlift remains one of the largest humanitarian airlift operations in history, but its importance was more than statistical. It was enormously significant in political and diplomatic terms, and demonstrated the tremendous utility of air power as an instrument of national and international policy. Operation Vittles proved above all that airlift could sustain a very large population that was completely surrounded by an enemy. The non-Soviet half of Berlin escaped absorption into the communist zone, while it and the western zones of Germany drew closer to each other. Western Germany continued to move toward unified democratic statehood. Demonstrating President Truman and other Western leaders’ enormous commitment to contain Soviet expansion, the Berlin Airlift saved the city without war. It also demonstrated the ability of the United States, Britain, and France to work together against a common enemy.

Perhaps most significantly, the Berlin Airlift provided the background and impetus for creation of the North Atlantic Treaty Organization (NATO), which was born on April 4, 1949, during Operation Vittles. The United States, Britain, and France were signatories, but they were joined in the new military alliance by Italy, the Netherlands, Belgium, Norway, Denmark, Portugal, Iceland, and Canada. In this, the most important military alliance since World War II, nations of western Europe joined with nations of North America to protect democracy against aggression by the forces of international communism led by the Soviet Union and its dictator, Joseph Stalin.<sup>24</sup>

For the Air Force, Operation Vittles provided abundant lessons about airlift and its potential, as well as the potential of various aircraft used to accomplish it. In addition to yielding a wealth of information about scheduling, loading,

air traffic control, and flight patterns, it exposed the need for larger transport aircraft, stimulating the technological development of a new generation of cargo aircraft, including the C-124. Civilian air travel also benefitted from the Berlin Airlift experience, with lessons about how to manage large airports with massive numbers of flights coming and going from different directions in all kinds of weather. The airlift also stimulated the development of better radar and communication technology. Operation Vittles and the Berlin Airlift were great victories, not only in the struggle against communist dictatorship, but also in the improvement of both military and civilian aviation.

## **The Berlin Airlift...demonstrated the tremendous utility of air power as an instrument of...policy**

Years later, in 1961, Berlin again became a crisis spot in Cold War history, as East Germany, with Soviet support, built a wall across Berlin to separate the eastern and western parts. Its primary purpose was to keep the people of East Berlin from migrating to West Berlin and West Germany, where they were escaping in the hundreds seeking

more freedom and prosperity. The Berlin Wall became a symbol of the failures of communism because it demonstrated the tremendous unpopularity of one-party rule and socialism. East Berliners risked their lives attempting to cross over or under the wall, and many of them died in their quest for freedom.

In the late 1980s and early 1990s, the final chapter in the story was written. In 1989, communism collapsed in East Germany, the Berlin Wall was destroyed by the people themselves, and Germany reunited peacefully. Within a few years, communist regimes collapsed all over Eastern Europe, and countries long under Soviet domination became free and independent states that allowed democracy and free markets. Communism even collapsed in the Soviet Union itself, and the Soviet Union split into fifteen independent republics. Some of the former Soviet-dominated countries of Eastern Europe, and even some of the former republics of the Soviet Union, became members of NATO, hoping to avoid any return to domination by Moscow. The seeds of these events were planted with the Berlin Airlift, one of the most successful military operations in the history of the world, which demonstrated the magnificent utility of air power as an effective political and diplomatic instrument. ■

### NOTES

1. Dwight D. Eisenhower, *Crusade in Europe* (Garden City, NY: Doubleday, 1948), p. 431.
2. Roger G. Miller, *To Save a City: The Berlin Airlift, 1948-1949* (Washington, DC: Air Force History and Museums Program, 1998), pp. 3-4.
3. David McCullough, *Truman* (New York, NY: Simon and Schuster, 1992), p. 489.
4. Stephen E. Ambrose, *Rise to Globalism* (London, UK: Allen Lane The Penguin Press, 1971), p. 164.
5. Curtis E. LeMay and MacKinlay Kantor, *Mission with LeMay: My Story* (Garden City, NY: Doubleday, 1965), p. 415.
6. Berlin Airlift: A USAFE Summary, AFHRA call number 570.04B, 26 Jun 1948-30 Sep 1949, p. 185; William H. Tunner, *Over the Hump* (Washington, DC: Office of Air Force History, 1985), p. 157.
7. William H. Tunner, *Over the Hump* (Washington, DC: Office of Air Force History, 1985), p. 157-158.
8. Williamson Murray, *Strategy for Defeat: The Luftwaffe, 1933-1945* (Maxwell AFB, AL: Air University Press, 1983), pp. 152-154.
9. Berlin Airlift: A USAFE Summary, AFHRA call number 570.04B, 26 Jun 1948-30 Sep 1949, pp. 185; USAFE Interim Report, Operation Vittles, 30 Jun-30 Jul 1948, AFHRA call number 572.101A, p. 1; Roger G. Miller, *To Save a City: The Berlin Airlift, 1948-1949* (Washington, DC: Air Force History and Museums Program, 1998), pp. 35 and 53.
10. Curtis E. LeMay and MacKinlay Kantor, *Mission with LeMay: My Story* (Garden City, NY: Doubleday, 1965), p. 415; USAFE Interim Report Operation Vittles, 30 Jun-30 Jul 1948, AFHRA Call number 572.101A, p. 1 and tab A; William H. Tunner, *Over the Hump* (Washington, DC: Office of Air Force History, 1985), p. 158.
11. Berlin Airlift Briefing for Mr. Symington and Party, 24 December 1948, AFHRA call number 572.153A dated 24 Dec 1948; William H. Tunner, *Over the Hump* (Washington, DC: Office of Air Force History, 1985), p. 158.
12. Roger G. Miller, *To Save a City: The Berlin Airlift, 1948-1949* (Washington, DC: Air Force History and Museums Program,

- 1998), p. 24; Stephen E. Ambrose, *Rise to Globalism* (London, UK: Allen Lane The Penguin Press, 1971), p. 173.
13. Curtis E. LeMay and MacKinlay Kantor, *Mission with LeMay: My Story* (Garden City, NY: Doubleday, 1965), p. 416.
14. Berlin Airlift: A USAFE Summary, AFHRA call number 570.04B, 26 Jun 1948-30 Sep 1949, p. 188; Berlin Airlift Briefing for Mr. Symington and Party, 24 Dec 1948, AFHRA call number 572.153A.
15. Berlin Airlift: A USAFE Summary, AFHRA call number 570.04B, 26 Jun 1948-30 Sep 1949, p. 188; Roger G. Miller, *To Save a City: The Berlin Airlift, 1948-1949* (Washington, DC: Air Force History and Museums Program, 1998), p. 50.
16. Berlin Airlift: A USAFE Summary, AFHRA call number 570.04B, 26 Jun 1948-30 Sep 1949, pp. 11, 92, 100; Roger G. Miller, *To Save a City: The Berlin Airlift, 1948-1949* (Washington, DC: Air Force History and Museums Program, 1998), p. 35.
17. Roger G. Miller, *To Save a City: The Berlin Airlift, 1948-1949* (Washington, DC: Air Force History and Museums Program, 1998), pp. 88-89, 95, 98.
18. See also Daniel Haulman, *The United States Air Force and Humanitarian Airlift Operations, 1947-1994* (Washington, DC: Air Force History and Museums Program, 1998), pp. 233-235.
19. Berlin Airlift: A USAFE Summary, AFHRA call number 570.04B, 26 Jun 1948-30 Sep 1949, pp. 3, 188; William H. Tunner, *Over the Hump* (Washington, DC: Office of Air Force History, 1985), pp. 174-175.
20. Berlin Airlift: A USAFE Summary, AFHRA call number 570.04B, 26 Jun 1948-30 Sep 1949, p. 189.
21. William H. Tunner, *Over the Hump* (Washington, DC: Office of Air Force History, 1985), pp. 207-208.
22. Berlin Airlift: A USAFE Summary, AFHRA call number 570.04B, 26 Jun 1948-30 Sep 1949, p. 189.
23. Roger G. Miller, *To Save a City: The Berlin Airlift, 1948-1949* (Washington, DC: Air Force History and Museums Program, 1998), pp. 108-109.
24. Stephen E. Ambrose, *Rise to Globalism* (London, UK: Allen Lane The Penguin Press, 1971), p. 174.

**Fighter Pilot.** By 1st Lt L.C. Beck, Jr., USAAC. Whitefish Mont.: Kessinger Publishing, 2010 (Reprint of 1946 volume). Photographs. Appendices. Pp. 200. \$19.96 Paperback ISBN: 978-116318789-0

On June 6, 1944, D-Day, the long-awaited Allied invasion of continental Europe took place. Success required full cooperation between American and British ground, sea, and air forces.

The first demand of air support was to ensure no enemy aircraft attacked the invasion forces. The German *Luftwaffe* was notably absent. Air support was also to prevent the Germans from bringing-up reserve forces to bolster their defenses. This involved air attacks on rail and road traffic and—especially crucial—destroying bridges that would slow reinforcements to the battle.

The U.S. Ninth (Tactical) Air Force based in England provided much of the needed air support for the invasion. Medium bombers attacked rail lines, marshaling yards, and tunnels; while fighter-bombers attacked bridges and vehicles headed towards Normandy. Bridges, extremely difficult to destroy and routinely defended by *Luftwaffe* fighters, were assigned to squadrons of P-47 Thunderbolt fighter-bombers. Armed with 1000-pound bombs, they would destroy bridge supports causing a collapse.

Beck, a P-47 pilot with the 406th Fighter Group (FG), led a flight on June 29 as top cover for a flight of P-47s bombing a bridge. A flight of German Fw 190 fighters attacked his flight and damaged his engine; Beck was forced to crash land. He escaped serious injuries and, with amazing good fortune, found himself in the company of French resistance fighters. They rushed him to a nearby farmhouse and, later, to the sleepy little town of Anet.

Holed-up in a small room on the third floor of a cafe while awaiting resistance fighters to smuggle him out of German-held territory, Beck decided to write his autobiography—on the back of old cafe minus! When the time came to move on to Paris as the first stop to freedom, he placed his manuscript in a box with his parents' address and instructed his French host to mail it when victory was achieved. His parents received the package on January 6, 1946.

What happened to Beck from then on came from others who survived the war. He departed Anet on July 17, eighteen days after crash landing. He understood that he would be taken to an airstrip where an American aircraft would take him to England. It was not to happen. Instead, Beck was escorted to Paris. "Lieutenant Beck and several other flyers [were taken] to the Pigalle section of Paris and left at the Piccadilly Hotel," reported a survivor. "The same afternoon, a German *Luftwaffe* officer, in disguise represented himself to the aviators as a French resistance chief . . ." Following three days where the German sought to gain information, "They were given quite a tour of Paris, before being driven directly to Gestapo headquarters . . . and imprisoned in the Fresnes

prison as political prisoners."

Prior to D-Day, the Germans incarcerated downed airmen in *Luftwaffe stalags*. POWs received decent treatment, and their status was reported to Allied authorities and, hence, to the families. Following D-Day, things changed. Hitler labeled airmen as *terrorflieger* (terror flyers) who deserved to be lynched. Allied airmen seeking to escape with aid from the French were considered "political prisoners." Packed into boxcars in lots of seventy, several French and two American airmen managed to pry open the floor of a boxcar and escaped before the train left Paris. The German response was to order the prisoners to remove all their clothes. And if any did attempt to escape, grenades would be thrown into the boxcars.

After five days and nights naked, with no water and little food, they finally reached their destination, the Buchenwald concentration camp.. Beck would not survive his incarceration in Buchenwald. A young Belgian who attempted to aid him wrote to his parents that their son had died during the night of October 29/30, 1944. "He suffered of a purulent pleurisy, which he caught during his stay in the camp."

I discovered *Fighter Pilot* and was drawn to it on reading that Beck had flown the P-47 with the 406th FG; I flew the same aircraft with the 404th FG. My interest in the fate of Beck led to one of his 406th colleagues, retired USAF Lt Col Frank Lewis. He had done considerable research on all 168 American airmen incarcerated in Buchenwald and learned that official reports *failed to mention American airmen incarcerated in Buchenwald*. The "oversight" convinced him that American authorities preferred that the atrocity remain classified. The Cold War was on, and the Germans were now on our side. The public need not be reminded of the inhumane treatment afforded American "political prisoners" in one of Germany's most notorious concentration camps.

Americans in Buchenwald had become America's forgotten heroes.

*Robert Huddleston, Chapel Hill NC, WWII fighter pilot in the European Theater*



**Wings of Valor: Honoring America's Fighter Aces.** By Nick Del Calzo and Peter Collier. Annapolis, Md.: Naval Institute Press, 2016. Photographs. Bibliography. Pp. 250. \$40.00 ISBN: 978-1-5911-4641-4

When all the celebration or recrimination, analysis of strategy and tactics, and endless statistics are done, war inevitably comes down to people. This book presents respectful, lively and lighthearted vest-pocket biographies of eighty-two aces from World War II, Korea, and Vietnam. Accompanying each essay is a photographic portrait of the

man as he appeared at the time the book was written. Carefully posed, gazing contemplatively into the camera, accompanied by a reminder of the ace's service—a flight jacket, medals, a wartime background shot, or even just a unit patch—these professional portrayals are intended to bring out the strength, fortitude, and spirit of the subject.

The topic is familiar, but this is not just another collection of war stories. It emphasizes another dimension of memory and legacy, a bequeathal to the future on the cusp of the departure of the Greatest Generation. Photojournalist Nick Del Calzo and writer Peter Collier have carved out a genre for themselves on those who fought the wars. This is the latest in their series. They previously issued *Medals of Honor: Portraits of Valor Beyond the Call of Duty*, and *Choosing Courage: Inspiring Stories of What It Means to Be a Hero*.

As the authors note, Frank Olynyk's *Stars and Bars: A Tribute to the American Fighter Ace, 1920-1973* is the standard reference. They are not trying to top that. Terming these men Eminent Americans, their theme is to formally portray the character of their subjects. Drawing on fresh interviews with their subjects wherever possible, the profiles are candid and in some cases self-deprecating. They explore the range of emotions these men experienced during the course of their service from enthusiasm to fear to horror. Ironies abound: Navy ace Dean Laird of VF-4 "Red Rippers" ended up, some twenty-five years after the war, as one of the pilots hired to fly the simulated enemy planes for the movie *Tora! Tora! Tora!*

The authors cite autobiographies, biographies, oral histories, and standard references. Some of these stories have been heard many times before—Steve Pisano's classic autobiography *The Flying Greek* is one of the better known—but the point is to explore how these men, drawn from a number of walks of life and with varying degrees of preparation, became aces.

The scope is those available for interview at the time the book was composed, including such well-known aces as Alex Vraciu, Bob Galer, Ralph Parr, Donald J. Strait, and Steve Ritchie. The authors delved deeply to profile the five- and six-kill pilots who comprise the bulk of the aces' list. Each has two or three pages. The authors have expertly distilled the crucial circumstances of the aces' lives. The Depression dominated the lives of many. Scrambling for the next meal and a job was an experience common to most. Knowing war was coming, some men held off on careers and marriage (Paul Tibbets once notably remarked to an interviewer, "the war interrupted my life."). Others were in college or simply in the family business. The legend that Lindbergh and Rickenbacker inspired American youth to take to the sky is true for quite a few of these men. Others, however, enlisted for the steady salary or chose aviation simply because they did not want to be in the infantry.

Once in combat, some garnered the bulk of their kills in one big day. Others came widely spaced. Due to U.S.

rotation policy, some of these pilots were deployed no more than six months. After that they were stateside, usually as flight instructors, for the duration. Some made a career of the military. Others went on to finish college and entered a career unrelated to flying. A few simply picked up where they left off before the war.

A few errors in nomenclature and discrepancies from other publications appear. For instance, a pilot is noted as assigned to the "Fourth Air Force" in England when, clearly, the 4th Fighter Group is what is meant. Careful proofreading eliminated most typos, although the noted actor and pilot is Wallace Beery, not Berry.

This book is intended as a last testament. Printed on acid-free paper, it is intended for perusal and contemplation on the courage and experience of these Eminent Americans of the Greatest Generation.

*Steve Agoratus, Hamilton, New Jersey*



**Gear up, Mishaps Down.** By Vice Adm. Robert F. Dunn. Annapolis, Md.: Naval Institute Press, 2017. Tables. Diagrams. Illustrations. Photographs. Notes. Appendices. Glossary. Bibliography. Index. Pp. XI, 204. \$29.95 ISBN: 978-168247005-3

This is a practitioner's book. Its theme is the development of aviation safety practices in the United States Navy from the end of World War II to the present. In many ways it is the story of any industrial enterprise as it develops new technologies and grows, always seeking more efficiency and better results. Oftentimes in the past, those results came at a significant cost in lives and equipment, as a concern for safety was usually secondary to performing the task at hand. In the case of Naval aviation, the end of World War II and the decade following provided a watershed as leaders came to realize old ways of doing business and the associated costs were unsustainable. Losses in aircraft and trained crews which, during airpower's early years and throughout World War II, were often seen as inevitable became insupportable. This book chronicles the Navy's efforts over decades to come to grips with this problem and eventually to find outstanding solutions that today make it one of the safest and most-efficient flying organizations in the world—and this in an organization dedicated to combat.

Dunn was a career naval aviator who once served as commander of the Naval Safety Center; he certainly is well placed to tell this story. His writing, for the most part, is clear and concise. He tells the story both chronologically and topically. This is possible since many of the innovations he discusses followed each other in time. He focuses on Naval aviation but recognizes the impact of advances and contributions made by the Air Force and civilian aviation industries to Naval aviation safety and

vice versa. The book is written with a clear overall plan and easy to follow. Dunn discusses all relevant aspects impacting aviation safety from technology to procedures, comparing technical innovations (e.g., angled deck and steam catapult) to the impact of processes (training, regulations, accident investigations) on improving safety including often overlooked factors such as aerospace medicine. He uses data where available and readily acknowledges when there are none and then describes how and why he reaches his conclusions. The summary chapter, while only two pages long, is a good outline and recap of his argument. The book's weaknesses are few, mainly editorial, and do not detract from its overall usefulness or readability.

As mentioned before this is a practitioner's book. It outlines the Navy's progress—sometimes pushed from within by forceful personalities, sometimes from without by external pressures such as budget and public relations—in developing the safety programs of today. While it focuses on aviation safety and is most useful to people in that arena, it has applicability beyond aviation. The Navy recognized this when it used the Aviation Safety Center as a model for creating safety programs in other areas of naval operations. In the end it is the story of a bureaucracy that got it right. Price for the hardback is prohibitive for most readers; but, fortunately, the book is available from the Naval Institute Press as either an e-book or downloadable pdf.

*Dr. Golda Eldridge, Lt Col, USAF (Ret)*



**Fighters over the Fleet: Naval Air Defence from Biplanes to the Cold War.** By Norman Friedman. Annapolis Md.: Naval Institute Press, 2016. Tables. Illustrations. Photographs. Notes. Appendices. Bibliography. Index. Pp. 460. \$72.00. ISBN: 978-1-59114-616-2

Norman Friedman's books on naval warfare would fill a decent-sized bookshelf. In each of his previous works he has addressed his subject in a detailed, comprehensive fashion, with enough breadth and depth to satisfy the most avid reader. This book is no exception. He sets out to tell the history of fleet air defense of the US Navy, the Royal Navy, and the Imperial Japanese Navy. The Japanese part of the story, of course, ends with World War II, but for the others he continues the discussion through to almost the present day, culminating with Cold War developments.

Unfortunately, Friedman's vast knowledge of the subject matter cannot compensate for an exceptionally dense writing style in this book that makes it difficult for the reader to follow the story coherently. He routinely packs so much information into a single sentence or paragraph, with frequent parenthetical diversions that

stray from the topic, that keeping track of the story is a challenge. There is also a lack of consistency in the way he addresses technical subjects. For example, in a discussion of how the advancement of fighter aircraft performance was a function of engine advances, he provides a clear, helpful primer on the principles of aero propulsion. But two chapters later, when he begins the story of how radar technology contributed to fleet air defense in the early days of World War II, he provides no such primer but seems to assume that the average reader fully understands the technical details of how radar operates; the net result is several pages of text that are nearly incomprehensible.

If one can see past these major criticisms, the book nonetheless does provide some interesting insights. Two are worth noting.

Friedman's narrative on the Battle of the Philippine Sea, which culminated in the well-known "Great Marianas Turkey Shoot," is an excellent, concise telling of that story. And he deftly compares and contrasts it with a detailed discussion of "Pedestal," a Royal Navy convoy staged to support the besieged island of Malta. While each operation was successful for the Allies, they were successful for different reasons, and Friedman does a fine job of explaining the differences and similarities.

When Robert McNamara became Secretary of Defense in 1961, one of his consistent goals was to hold down the cost of national defense by developing aircraft that could be used, with little or no modification, by both the Air Force and the Navy. The impact of McNamara's plans and decisions had ripple effects throughout both services, to include an impact on how the Navy met its fleet air defense requirement. Friedman's discussion of this complex issue is extensive and illuminating, and contains none of the dense writing that is found elsewhere in the book.

It is unfortunate that many of the difficult portions of this book occur in the first few chapters, because this might cause a reader to set the book aside before getting very far into the narrative. Perhaps the best recommendation is this: buy the book if you want to read about the subject in a well-researched, highly informative book, but at the same time be prepared to skip sections that lack the clarity we deserve in a book by such a well-regarded author.

*LTC Joseph Romito, USA (Ret), Docent, National Air and Space Museum's Udvar-Hazy Center and National Mall Facility*



**The Flight: Charles Lindbergh's Daring and Immortal 1927 Transatlantic Crossing.** By Dan Hampton. New York: William Morrow, 2017. Glossary. Bibliography. Notes. Index. Pp. 317. \$18.86, \$12.99 (Kindle) ISBN: 978-006246439-2



Another book about Lindbergh's 1927 flight from New York to Paris! Overkill was my initial reaction; the Lindbergh shelf is overloaded! As a nonagenarian born before "Lucky Lindy's" historic flight—who read *We*, his personal account of the experience, as soon as I could read—what could Hampton possibly tell me that I didn't already know? The answer: *A lot!*

Three key elements make the book an excellent addition to the Lindbergh story: Hampton's subject matter expertise, his prodigious research, and the ability to meld both into excellent prose.

A retired Air Force fighter pilot, Hampton says his "purpose in these pages is to put the reader into the cockpit of the *Spirit of St. Louis* during those thirty-three and a half hours on May 20 and 21, 1927, and to fly along with him." Not to second-guess Lindbergh the pilot, but to clarify, for readers, what Lindbergh had to know and what he had to do to achieve his goal. For example, in preparing the aircraft for the flight, Lindbergh assisted designer Don Hall in modifying it. Hall stated that "The presence of Charles Lindbergh, with his keen knowledge of flying, his understanding of engineering problems, his implicit faith in the proposed flight, and his constant application to it, was a most important factor in welding the entire [aircraft] factory organization into one smoothly running team."

Yes, Lindbergh was a brilliant pilot, but he was also informed and effective in dealing with all facets of the flight including the unexpected. Flying solo, Lindbergh also had to be the navigator. Drifting off-course early in the flight would cost fuel leaving the aircraft short of the goal. Hampton explains in detail how Lindbergh mastered the navigation and dealt with other contingencies.

Hampton's prodigious research about not only Lindbergh but also the decade in which the historic flight was achieved, enhances the book's value. It was a turbulent world that Hampton describes in detail. As newspapers were the principle source of information about the flight, Lindbergh discovered that, in the absence of facts, reporters would make-up stories. His publisher, G.P. Putnam, assigned a writer to ghostwrite the New York-Paris account based upon on his interviews with Lindbergh. Lindbergh found the result "terrible, a largely first-person work of fiction . . ." The writer, the Lone Eagle decided, "apparently believed that the power of the pen granted him the privilege of rewriting factual events to suit his story line." Lindbergh, an aviator, not a writer, rewrote the book himself and published it as *We*.

Are details of the Roaring Twenties important to *The Flight*? Hampton makes the case of Lindbergh becoming an international hero, not only for what he accomplished, but also for being a needed hero for the times. His exalted celebrity status, something not matched even in today's cult of celebrities, lends credence to Hampton's interpretation.

The third important factor, simply put, is that

Hampton can write! "The dying light," he writes as the *Spirit of St. Louis* reaches the open sea, "catches the little silver plane and for a long moment the [aircraft] is perfectly framed by the rocky pillars, feathery salt spray, and angry gray water. Then suddenly it's gone. One machine, one man—swallowed up by the darkness filling the eastern sky.

Of lesser importance, but appreciated, is Hampton's use of footnotes to clarify points not widely known. For example, Lindbergh departed from Roosevelt Field, "Named for President Theodore Roosevelt's youngest son, twenty-year-old Lieutenant Quentin Roosevelt. A fighter pilot with the 95th Aero Squadron, Quentin was killed in a dogfight over Chamery, France, on July 14, 1918. Sagamore Hill, the Roosevelt estate in Oyster Bay, lies about ten miles north of Lindbergh's take-off point."

A well-written book worthy of any reader's time.

*Robert Huddleston, a WWII combat pilot, is the author of a novella, An American Pilot With the Luftwaffe*



**So Far from Home: Royal Air Force and Free French Air Force Flight Training at Maxwell and Gunter Fields during World War II.** By Robert B. Kane. Montgomery Ala.: New South Books, 2016. Tables. Photographs. Notes. Appendices. Bibliography. Index. Pp. xii, 139. \$23.95 paperback. ISBN: 978-1-60306-369-2 (print); 978-1-60306-370-8 (ebook).

Robert Kane became director of history at Air University, Maxwell AFB, Alabama, in 2010. In this, his first book, he has tackled a relatively obscure but important topic—how the Army Air Forces undertook the flight training of British and French pilot candidates during World War II.

Hanging on against Nazi Germany in the first 18 months of the European war, Britain desperately needed more flight crews. One way to increase the numbers was to ship prospective candidates to North America, first to Canada and then to the United States. However, the United States was officially neutral. The Roosevelt administration overcame this obstacle by concluding that such training could fall under the auspices of the Lend-Lease Act passed by Congress in March 1941.

By late summer 1941, the program was well underway. British service members were training side by side with Americans. In addition to providing training, Maxwell served as the regional administrative hub for flight training, a responsibility that also included civilian contractors. By the summer of 1942, the British Commonwealth Air Training Plan had reached the point where it was producing enough flight crews that training in the U.S. was no longer necessary. The final British class graduated in February 1943.

Meanwhile, the United States and Great Britain had recognized the French National Committee (better known as Free France), led by Charles de Gaulle, as an ally. Training the French beginning in 1943 proved much more challenging because of language differences. Perseverance by all concerned, however, enabled the program to succeed.

From a statistical standpoint, the British and French pilots generally fared about as well as their American counterparts. In terms of contributing to the war effort, about 10 percent of the 131,000 pilots and navigators who served in the Royal Air Force during World War II trained in the U.S. With their homeland occupied by the Nazis, the French were far more dependent on the U.S. Consequently, American-trained French pilots, most of whom hailed from the country's North African colonies, played quite a significant role.

For anyone with a serious interest in Army Air Forces training in World War II, this work is essential. The numerous appendices nicely complement the data-filled narrative.

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



**Fighter! Ten Killer Planes of World War II.** By Jim Laurier. Minneapolis Minn.: Voyageur, 2016. Illustrations. Photographs. Tables. Pp. 192. \$40.00 ISBN: 978-0-7603-4952-6

Before we get into this, let's settle something: there is no such thing as too many books on World War II fighter planes. Now that we've got that off our minds, we can concentrate on Laurier's marvelous book. Lavishly illustrated with his stunning paintings, schematic drawings, profiles, and vintage photos, this coffee-table volume is definitely something to buy now. A well-known aviation artist, pilot, and historian, Laurier has flown many of the aircraft depicted. Throughout his career he has interviewed pilots who flew them in combat. He has illustrated many such books over a wide variety of military topics as *USAF F-4 Phantom II MiG Killers 1965-68* (2004), *Mirage III vs MiG-21: Six Day War 1967* (2010), *Bf 110 vs Lancaster: 1942-45* (2013), and *Red SAM: The SA-2 Guideline Anti-Aircraft Missile* (2007).

Laurier picked ten key fighter aircraft of the war: P-38, P-40, Bf 109, Fw 190, Hurricane, Zero, Spitfire, P-47, P-51, and Me 262. There always will be arguments about those aircraft not selected, such as the F4F, F6F, F4U, Ki-84, and Ki-43. So, Volume 2, anyone? Each plane has its own thoroughly researched chapter. Cockpit illustrations, each accompanied by a diagram with labels on each instrument and control, appear for each plane. There is a three-position view, spread over two pages, of each aircraft. There is no anonymity here; each painting, each

illustration is in the markings of a specific pilot at a significant point in time. Laurier is out to satisfy our curiosity. The paintings depict those key, critical moments in combat missed or inadequately captured by still or gun cameras: the instant before a 357 FG Mustang bagged JG 300's Klaus Bretschneider's Fw 190 on a Dec. 24, 1944, Defense of the Reich mission; the 4709th FG's Lt Robin Olds leading a low-level P-38 strafing attack on an enemy airfield in August 1944; the last moment Lt Col Neel Kearby's P-47 was seen over New Guinea on March 5, 1944. Carefully selected contemporary photos provide context: the aircraft on the ramp, surrounded by ground crew; captured examples of enemy aircraft in U.S. markings; an early model P-51 on a test stand in a wind tunnel.

Sketches of the design, development, production, flight characteristics, and fighting experiences of each aircraft appear, as well as a historical summary to tell the reader why the plane is important. Laurier relates personally to each plane, recounting his own experiences flying them, as well as quoting combat pilot experiences. The style is approachable and direct, pulling the reader into the story. The text has a few repetitions; it may have needed one more pass of proof-reading. Laurier makes an intriguing assertion or two that, unfortunately, cannot be checked, as there is no bibliography. For instance, he notes that proposals to prototype a Lightning with Merlin engines were quashed by political pressure from the manufacturer of the existing Allison engine. No doubt that factored into the discussion, but fighter development histories reveal that many influences went into engine-selection decisions, especially during the design and production scramble of the late 1930s and early 1940s, with war on the horizon and a desperate need to field a U.S. fighter plane that could stay in the sky with the best of foreign designs.

Aviation art purists like to see their aircraft in the full flower of the colorful markings that characterized WWII aircraft, and Laurier has indulged us. An expert on these planes, he got the markings, details, and dimensions right. Very often in real life, shadows and the angle of view, as well as distance, obscure or dim these colors. Here Laurier puts the reader right in the action, with a front-row seat at ideal lighting and perspective. Those who fuss over the color registry (more of us than you may think) will find it matches well against the official plates in Robert D. Archer's *Monogram Color Guide*. Laurier uses every inch of the book: the dust jacket depicts a P-38 in action (temptingly frameable, for those courageous enough to take scissors to it), and the cover itself has a wraparound P-40 Flying Tiger mural. Voyageur got the important aspects just right.

A welcome addition to the stable of World War II combat aviation art books, this oversize, hardcover, cloth-bound volume nicely complements other such folios in its field. Robert Taylor's *The Air Combat Paintings of Robert Taylor* (1987) is probably the all-time foundation of the

field. *The Aviation Art of Keith Ferris* (1978) is a paperback, but Ferris' striking images still come through. Among the most popular multi-artist compilations is Kitchens and Murray's *Aviation Art of World War II* (2008), an authoritative presentation of over two hundred works by such noted aviation artists as Roy Grinnell, Jim Dietz, Stan Stokes, Robert Bailey, and many others. Murray's *Bomber Missions: Aviation Art of World War II* (2001), and Murray and Nalty's *Flying Aces: Aviation Art of World War II* (2000) focus on specific air war aspects.

Printed on heavy archival-quality stock, *Fighter!* is a terrific reference, conversation piece, and just plain muse that the reader will return to again and again.

*Steve Agoratus, Hamilton, New Jersey*



**Hangar Flying, Below the Zone, and Roles and Mission.** By Gen Merrill A. McPeak. Lake Oswego Oregon: Lost Wingman Press, 2011-2017. Photographs. Notes. Appendices. Glossary. Index. Vol 1 Pp. 364, Vol 2 Pp. 252, Vol 3 394. \$24.95 each paperback. ISBN: 978-0-9833160-1-5, 978-0-9833160-5-3, and 978-0-9833160-0-1

As a young officer, I lived through some major historical events (end of the Cold War and Desert Storm and its aftermath) and the changes Gen McPeak helped institute or implement in the Air Force in response. I was interested in hearing the story from his perspective.

General McPeak served as the 14th USAF Chief of Staff from 1990-1994. As such he participated in some of the most fundamental changes the Air Force has experienced in its 70-year history. He helped shape the current major command structure (Air Combat and Air Mobility Commands from Strategic Air, Tactical Air, and Military Airlift Commands), managed one of the largest drawdowns in Air Force history, and dealt with the Air Force response to major social issues with the changing roles of women and gays in the military. As the Chief at that time, he is uniquely positioned to tell the story of those events.

Gen McPeak doesn't limit himself to a memoir of his time as Chief of Staff. His project is more ambitious in that he tells his life story up to his retirement from active duty. While he never explicitly says it, I think he felt the need to provide his side of the story of a turbulent and difficult time in the nation and the Air Force's history. That story is divided into three volumes. The first focuses on his life before the Air Force through his experiences in Vietnam as a fighter pilot and Misty FAC. The second follows his career from his return from Vietnam, including a stint as a Thunderbird solo, through his selection as Chief of Staff. The final volume focuses on his time as Chief. Gen McPeak's approach works well, because he was responsible for responding to and implementing so much

change that an appreciation for where he came from, how he was trained, and what he values and believes in are crucial to understanding his time as Chief. Without the perspective and personal insights he provides in the earlier volumes, the last wouldn't make nearly as much sense.

Gen McPeak's writing holds its own against virtually any memoir I've read. He uses direct language and is an engaging storyteller. You don't have to be a pilot (or, more specifically, a fighter pilot) to appreciate his gift. The narrative is, for the most part, chronological; he has a habit of injecting short paragraphs describing events occurring in the same timeframe as his personal story. The only time he deviates from a strict chronology is during his time as Chief, and this is to maintain the continuity of the subject matter. Despite an overall length in the three volumes of nearly a thousand pages, the story reads quickly, and I didn't find myself getting bored or tired.

One of the most obvious elements in all three volumes is his fighter-pilot bias. This comes through loud and clear. He is quick to acknowledge his mistakes in the air or as a leader (when he recognizes them)—an admirable quality—but his comments on other career fields and leaders make it clear he doesn't believe non-trigger-pullers are suited for the highest echelons of command. He states in several places that if you aren't at the pointy end of the spear shooting and getting shot at you are not a "warrior." In one sense, I understand the days when most of the Air Force stayed safely at home base while the aircrew flew into harm's way are long gone. In an era when many of our forces forward deploy to dangerous locations, and anyone anywhere can be a terrorist target (Khobar Towers occurred just two years after he left office), his lack of appreciation for the broader institution contributed to what I see as his failure to connect with the Air Force as effectively as some others have done.

Volume one is the story of his life through his service in Vietnam. It is entertaining but he doesn't make any effort to present leadership philosophy or lessons learned. That comes later in volumes two and three. In the preface to volume two, he says this is where he relates the leadership and management lessons. In volume three, one finds the explanations for his actions as Chief. In my view, the main leadership lessons are found in the comparison between volumes two and three. In volume two he says a commander must identify goals and objectives, make them simple, and repeat them over and over again and share them with everyone to ensure they understand, accept, and buy into the vision. Then in volume three he mentions his only attempt to explain his actions to the entire Air Force was a 75-minute video that was not well received—for obvious reasons. He did base visits and the other things expected of the Chief, but nowhere does he revisit the formula he says made him successful as a wing commander—share the vision with everyone, all the time. As a young officer, I never felt I understood the vision. He

then shows through his actions how he tended to be a very hands-on Chief, wanting to manage and participate in every decision. He admits quite candidly that with matters he considered of the greatest importance he didn't share information even with his own Vice Chief. He tended to go it alone and, as a consequence, often left his own Vice Chief in the cold. He admits he could be abrasive and that he didn't share information. This, coupled with his inability to communicate his vision, definitely affected his impact and ultimately reflected on his legacy as a USAF Chief.

The joke we young officers shared as we watched changes during Gen McPeak's tenure was that he must have been keeping track through his career of all the things he would change one day if he were Chief: now he was cutting loose. From major command reorganizations, to his efforts to redesign the uniform and simplify heraldry (patches), to dealing with the drawdown and social issues, he was responsible for implementing or overseeing a bewildering array of changes—some good, some maybe not-so-good. He argues these things were necessary and his time was limited, so he had to push hard and not be too concerned with upsetting apple carts. I understand this mindset, and I think in the long run the Air Force is better for his efforts. But I have to wonder if he tried to do too much in too short a time; and, by failing to make better use of others, if he accomplished less of permanence than he might have.

In the end, Gen McPeak takes responsibility for his successes and failures and, I believe, does his best to explain his thinking and why he took the actions he did. His candor is admirable, and his willingness to share his thoughts provides an invaluable window into a difficult time. I recommend these volumes to anyone interested in the processes of decision making in the highest levels of the military and government. They are available electronically for \$9.99 per volume making the entire three volumes an affordable addition to anyone's library.

*Dr. Golda Eldridge, Lt Col, USAF (Ret)*



**Airpower Applied: U.S., NATO, and Israeli Combat Experience.** By John Andreas Olsen, Ed.. Annapolis, Md.: Naval Institute Press, 2017. Index. Bibliography. Notes. Pp. xviii, 413. \$49.95 ISBN: 978-168247075-6.

*Airpower Applied* is a fascinating and discriminating look into air combat experience involving the United States, NATO, and Israel in a series of conflicts beginning in 1941 and ending in this century. There are five chapters, the first dealing with the United States from Pearl Harbor to *Desert Storm*, and the second with the United States and NATO nations from *Deny Flight* to *Inherent Resolve*. Chapter Three covers the founding and growth of the

Israeli Air Force and its combat experience during the Arab-Israeli wars of the 20th Century. Chapter Four deals with the Israeli Air Force in *asymmetric conflicts* from 1982 to 2104. Chapter Five, by Colonel John Warden, discusses the Airpower Profession writ large and the education and qualities needed by the would-be airpower professional to succeed in a rapidly changing world.

Each of the first four chapters stands on its own in a penetrating discussion of what went right and what went wrong during the period under review. There is a common thread that exists in each chapter: that airpower ultimately serves a political end. However successful the application of airpower to achieve a military goal, unless the political goals of the nation or other entity are achieved, the result is meaningless.

In Chapter 1, Richard Hallion expertly sketches the growth of American air power from World War I through Desert Storm, the first "Gulf War." He touches lightly on the overrated and underperforming strategic bombing campaigns of World War II and goes on to deal with the Korean War and its lessons about the limitations of battlefield air interdiction when the opponent is not carrying out offensive moves. He points out the continuing importance of air superiority in a conflict that had many political limitations placed upon friendly forces. In Vietnam, he breaks the conflict down into a set of "air wars," each with its own limitations on unrestricted use of air power. In his discussion of Linebacker I and II he illustrates the effective use of aerial bombardment on North Vietnamese formations on the offensive that lead to their clear defeat. In Desert Storm all the pieces of aerospace power came together in what was a "perfect storm" for Saddam Hussein. Aerospace power was applied to block a possible invasion of Saudi Arabia, then to decimate Iraq's conscript divisions and unbalance its elite Republican Guard formations so that fast moving Allied armor forces and artillery could defeat Iraq in Kuwait.

In Chapter 2, Benjamin Lambert describes a series of air wars that were conducted by NATO with U.S. air power playing a leading role, but not the only role. These air campaigns illuminated some of the limitations of various NATO nations in the area of ISR aircraft, air mobility, and aerial refueling as well as political constraints on air warfare produced by the need to have national consensus on actions to be taken.

In Chapter 3, Alan Stephens discusses the remarkable growth of the Israeli Air Force from a ragtag auxiliary to the new Israeli Army in the 1948 War of Independence to its central role in the 1956 Suez War and subsequently.

In Chapter 4, Rachael Rudnick and Ephraim Segoli describe the problems facing the current-day Israeli Air Force in dealing with asymmetric warfare by Palestinian and other irregular forces. The lessons here are applicable to other conflicts in which the U.S. finds itself engaged.

Olsen's outstanding work on airpower should be on the required reading list at Air Force, Army, and Navy war

colleges in any nation. The distinguished authors have done an exceptional job of examining specific periods and forces and drawing appropriate lessons.

*John F. O'Connell, Captain, USN (Ret), Docent, National Air & Space Museum*



**Marked for Death: The First War in the Air.** By James Hamilton-Paterson. New York: Pegasus, 2016. Photographs. Bibliography. Notes. Index. Pp 356. \$27.95 ISBN: 978-1-68177-158-8.

This effort marks the author's second with an aviation theme, following *Empire of the Clouds*, a discussion of the Golden Age of British civil aviation. *Marked for Death* focuses on the Royal Flying Corps and the emergence of pursuit aviation. Rather than approach the subject chronologically, Hamilton-Paterson has chosen a thematic approach.

In his introduction, he touches on popular portrayals of World War I aviation that emerged in movies and novels before World War II. In the first chapter, he discusses the ignorance of decision makers with regard to the possible role of the airplane before World War I. Setting the scene allows him to go in different directions.

Whenever possible, he integrates anecdotes, mostly from secondary sources such as Arthur Gould Lee's *No Parachute* (possibly the best World War I pilot autobiography), into the narrative, much of which is culled from contemporary sources. He also recognizes the contributions of key personalities whenever possible.

He tackles the classic topics first: how the biplane emerged as the dominant design, the evolution in gunnery, and the types of missions aviators were asked to perform. Training, a subject generally overlooked, is followed by insight into the lifestyle of units deployed to the front. Of course, a chapter on aces is included.

In many ways, the closing chapters offer the freshest material. Hamilton-Paterson examines aviation physiology, certainly a topic worthy of discussion. Flying frequently above 14,000 feet, aircrews, especially early in the war, were totally unprepared to deal with the elements. The decision by the Air Ministry to deny their crews the use of parachutes warrants a chapter. Lee understandably is quite critical of this policy. Hamilton-Paterson suggests another reason why the aircrews were unwilling to pursue a change: peer pressure. No one in a squadron wanted to be the first to don a parachute (which, by the way, was difficult to use), because it might be considered less manly.

The Zeppelin raids and later the Gotha and Giant bomber attacks in southeast England prompted a call for home defense, but the growing pains endured for far too long, according to the man on the street.

The penultimate chapter, followed by a postscript, looks briefly at operations in East Africa, Mesopotamia, and the Balkans, theaters seldom examined with regard to the air war.

While there is nothing terribly new here, the format makes for easy reading. Some redundancy occurs, but not enough to be a distraction. For the generalist, this work is an excellent introduction to the Royal Flying Corps. While my favorites for the big picture remain *Shooting the Front* by Terrence Finnegan, *The Rise of the Fighter Aircraft* by Richard Hallion, and *The Great War in the Air* by John Morrow, *Marked for Death* is a nice complement.

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



**Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race.** By Margot Lee Shetterly. New York: William Morrow, 2016. Notes. Bibliography. Index. Pp. xviii, 347. \$27.99. ISBN: 978-0-06-236359-6.

This fascinating book, which inspired the award-winning motion picture of the same title, features compelling biographies of four remarkable women as they overcame racial discrimination, entrenched segregation, and traditional gender stereotypes to make major contributions to the National Advisory Committee on Aeronautics (NACA) and the National Aeronautic and Space Administration (NASA). Shetterly, who grew up in Hampton as the daughter of a senior scientist at NASA's Langley Research Center, supplemented her local knowledge of southeastern Virginia with extensive research and numerous interviews. Her book skillfully presents the careers of these and other women at Langley (both black and white) within the context of evolving technology, sociology, civil rights, and national policies over several decades.

Much of American aviation technology since 1920 was developed by NACA scientists, engineers, and technicians at the Langley Memorial Aeronautical Laboratory in Hampton. As aircraft designs grew in sophistication, ever more voluminous data had to be collected and analyzed. Processing these data led to a growing number of mathematically inclined female employees—known then as computers—who used pencils, paper, slide rules, and adding machines to crunch the numbers.

During World War II, empowered by new federal fair-employment practices, Langley began hiring more African-Americans to meet growing employment needs. Many of them were women, including a number of math teachers from segregated high schools, who formed a pool of "colored computers" on the expanding west side of the complex in 1943. This West Computing Group continued its work during the Cold War as growing quantities of raw data

on such phenomena as transonic and supersonic flight, much of it generated in powerful new wind tunnels, made the women's mathematical computations ever more challenging.

The Langley Center then took on a key role in the Space Race against the Soviet Union with the creation of NASA in 1958. At the same time the introduction of more potent and versatile IBM electronic computers rapidly began to make the role of human computers obsolete. As head of the West Computing Group since 1949, Dorothy Vaughn was the NACA's first African-American manager. She preemptively learned the FORTRAN (FORmula TRANslation) computer language and began training her staff for the digital era. In May 1958 her group, which by then was Langley's last vestige of segregation, was disbanded; its remaining nine members were reassigned, with Dorothy moving on to become a full-time computer programmer.

Among the women Vaughn had hired and mentored over the years were Mary Winston Jackson, who became NASA's first black female engineer; and Katherine Goble Johnson, a mathematical prodigy. According to the book, Johnson helped plot the trajectory of Alan Shepard's suborbital flight and reportedly confirmed the computer-generated orbital parameters of John Glenn's Mercury mission. Johnson later helped calculate the orbital mechanics of Apollo missions and early Space Shuttle flights until her retirement in 1986. In 2015, at the age of 97, she was awarded the Presidential Medal of Freedom.

The movie *Hidden Figures* focuses on the experiences of these three women. As expected in most Hollywood "biopics," the screen writers condensed the sequence of events, exaggerated certain incidents, created composite characters, and took liberties with some of the book's historical facts to create a highly entertaining and uplifting story for a large audience. Hopefully, the motion picture may help inspire more girls to pursue courses in the STEM subjects of science, technology, engineering, and mathematics.

The fourth woman featured in the book is Christine Mann Darden, another precocious math teacher Katherine Johnson recruited to join NASA in 1967 as a data analyst. While still a low-ranking mathematician in 1975, she

greatly improved upon an existing theory to create a comprehensive computer code that became the basis for designing aircraft to mitigate the shock waves that cause the sonic booms and have prohibited civilian aircraft from flying faster than sound over land. After earning a doctorate in mechanical engineering in 1983 (specializing in fluid dynamics), she became NASA's top supersonic boom investigator. Tests of a specially modified F-5 jet fighter in 2003 proved the validity of her aerodynamic principles and algorithms. (I conducted telephone interviews and exchanged emails with Dr. Darden while writing *Quieting the Boom*, a history of NASA's sonic boom research and testing published in 2013.) By the time of her retirement in 2007, she had become the first African-American woman at Langley to be promoted into the Senior Executive Service.

I think the book presents enough technical information to satisfy those readers knowledgeable about aeronautic and astronautic history but not too much for most general readers. If this book has a serious shortfall, it is the inexplicable absence of any photographs or illustrations of the people, facilities, and equipment mentioned in the text.

*Lawrence R. Benson, retired USAF historian, Albuquerque New Mexico*



#### PROSPECTIVE REVIEWERS

Anyone who believes he or she is qualified to substantively assess one of the new books listed above is invited to apply for a gratis copy of the book. The prospective reviewer should contact:

Col. Scott A. Willey, USAF (Ret.)  
3704 Brices Ford Ct.  
Fairfax, VA 22033  
Tel. (703) 620-4139  
e-mail: [scottlin.willey@gmail.com](mailto:scottlin.willey@gmail.com)

# Coming Up



Compiled by  
George W. Cully

#### September 18-20, 2017

The **Air Force Association** will hold its annual convention and exhibition at the Convention Center in National Harbor, Maryland. For details and registration, see the Association's website at <https://www.afa.org/airspacecyber/delegates/ata glanceconv>.

#### September 20-23, 2017

The **Society of Experimental Test Pilots** will hold its 61st Symposium and Banquet at the Grand Californian Hotel in Anaheim, California. For registration details, see the Society's website at <http://www.setp.org/annual-symposium-banquet/60th-annual-symposium-banquet-registration-2.html>.

#### September 22-23, 2017

The National Museum of the United States Air Force will hold its biennial **WWI Dawn Patrol Rendezvous** on the museum grounds adjacent to Wright-Patterson AFB in Fairborn, Ohio. Vintage aircraft, automobiles and re-enactors galore. For more information, see the website at <http://www.nationalmuseum.af.mil/Upcoming/Events/>.

#### October 3-6, 2017

The **Aviation Engine Historical Society** will hold its fourteenth annual convention at the Pima Air and Space Museum and the Titan Missile Museum in Tucson, Arizona. For registration, see the Society's website at <http://www.enginehistory.org/Convention/Convention2017.shtml>.

#### October 4-8, 2017

The **Oral History Association** will hold its annual meeting at the Hilton Minneapolis Hotel in Minneapolis, Minnesota. For further details, see the Association's website at <http://www.oral-history.org/annual-meeting/>.

#### October 9-11, 2017

The **Association of the United States Army** will hold its annual meeting and exposition at the Walter E. Washington Convention Center in Washington, D.C. For registration details, see the Association's website at <http://ausameetings.org/2017annualmeeting/>.

#### October 19-20, 2017

The National Security Agency's **Center for Cryptologic History** will present its biennial Symposium at the Johns Hopkins Applied Physics Laboratory's Kossiakoff Center in Laurel, Maryland. Following the Symposium, on Saturday, October 21, participants will be given an opportunity to tour the National Cryptologic Museum and participate in a workshop on sources for research in cryptologic history. The theme for the 2017 Symposium is "Milestones, Memories, and Momentum." For more information, contact Program Chair Betsy Rohaly Smoot at [history@nsa.gov](mailto:history@nsa.gov) or to her care at The Center for Cryptologic History, Suite 6886, 9800 Savage Road, Fort George G. Meade, MD 20755.

#### October 24-26, 2017

The **American Astronautical Society** will host its annual Wernher von Braun Memorial Symposium at the University of Alabama - Huntsville in Huntsville, Alabama. For more details as they become available, see the Society's website at <http://astronautical.org/calendar/>.

#### October 26-30, 2017

The **Society for the History of Technology** will hold its annual meeting and symposium in Philadelphia, Pennsylvania. For further details as they become available, see the Society's website at <http://www.historyoftechnology.org/index.html>.

#### October 28-29, 2017

The **National Aviation Hall of Fame** will hold its annual enshrinement ceremony during the Alliance Air Show to be held at the Alliance Fort Worth Airport in Fort Worth, Texas. For additional information, see their website at <http://www.nationalaviation.org/national-aviation-hall-fame-hold-2017-enshrinement-ceremony-alliance-air-show-fort-worth-texas-2/>.

#### November 9-12, 2017

The **History of Science Society** will hold its annual meeting in Toronto, Canada. For more details as they become available, see the Society's website at <http://hsonline.org/meetings/annual-meeting-archive/>.

#### November 16-18, 2017

The **National WWII Museum** will host its 10th International Conference on World War II at the Museum complex in New Orleans, Louisiana. The schedule includes a pre-conference symposium on the theme of "Hitler in History." For registration and other details, see the website <http://www.ww2conference.com> or call (877) 813-3329, ext. 511.

#### November 23-24, 2017

The **European Space Agency History Project**, in collaboration with the University of Padua and its Giuseppe Colombo University Centre for Space Studies and Activities, will host an international conference on Space History in Padua, Italy. For further details, see the Project's website at [http://www.esa.int/About\\_Us/Welcome\\_to\\_ESA/ESA\\_history](http://www.esa.int/About_Us/Welcome_to_ESA/ESA_history).

#### November 28-30, 2017

The **Association of Old Crows** will hold its annual meeting at the Marriott Marquis DC and Convention Center in Washington, DC. For more signal, ping a crow at <http://www.crows.org>.

#### January 4-7, 2018

The **American Historical Society** will hold its 132nd annual meeting at the Marriott Wardman Park Hotel in Washington, DC. The meeting theme will be "Race, Ethnicity, and Nationalism in Global Perspective." For details, visit the Society's website at <https://www.historians.org/annual-meeting/future-meetings>.

#### January 8-12, 2018

The **American Institute of Aeronautics and Astronautics** will host its annual Science and Technology Forum at the Gaylord Palms Hotel in Kissimmee, Florida. The gathering serves as a platform for eleven specialist events. For more information, see their website at <http://scitech.aiaa.org/Program/>.

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:

George W. Cully  
3300 Evergreen Hill  
Montgomery, AL 36106  
(334) 277-2165  
E-mail: [warty@knology.net](mailto:warty@knology.net)

## Reunions

**4th Fighter Group Assn.** Sep 28 - Oct 1, 2017, Fairborn, OH Contact:

Keith Hoey  
120 Bay Breeze Dr,  
Belleville, Ontario ON K8N 4Z7  
613-962-2461  
khoey98@hotmail.com

**12th TFW** (MacDill AFB, Cam Ranh AB, Phu Cat AB), **389 & 480 TFS** (Da Nang), **555th TFS** (1964-1966), **12th FEW/SFW** (Bergstrom AFB & Korea) Apr 4-7, 2018, Tucson, AZ. Contact ;

E J Sherwood  
480-396-4681  
EJ12TFW@cox.net

**38th Tactical Recon Sqdn.** Oct 3-6, 2018, Dayton/Fairborn, OH Contact:

Greg Hartley  
4304 Beaumont Ct,  
Fairfax, VA 22030  
571-238-6273  
pghartley@hotmail.com

**58th/60th Fighter Interceptor Sqdn.** Sep 20-23, 2017, Fairborn, OH. Contact:

Richard Doritty  
5598 St Rt 37,  
Sunbury, OH 43074  
740-965-2455  
voodoo101b@gmail.com

**91st Bomb Group Memorial Assn.** May 16-19, 2018, Dayton, OH Contact:

Mick Hanou  
607 Blossom Ct,  
Pleasanto, CA 94566  
925-425-3220  
mhanou@comcast.net

**302nd Buckeye Wing Assn.** Aug 16-18, 2018, Fairborn, OH. Contact:

Jerry Millhouse  
6715 Yorkcliff Pl,  
Dayton, OH 45459  
937-433-3156  
jmillhouse@aol.com

**366th Fighter Assn.** Sep 19-24, 2017, Fairborn, OH. Contact:

Paul Jacobs  
2409 Mallard Ln, Apt. 1,  
Beavercreek, OH 45431  
614-906-4470  
paul@jacob.net

Letter to the editor

Dear Sir,

In reference to the article *Men and Planes of World War I and a history of the Lafayette Escadrille*, by Juliette A. Hennessy. I have read this article or parts there of several times of the years and there are a number of glaring inaccuracies. These include such items as mentioned on page 47, the Benet-Mercier Machine gun did not weigh 1,700 pound but a mere 26.5 lbs. Ms. Hennessey also statements concerning aircraft engine size which are incorrect. Aircraft engines typically ranged from 70 to 260Hp. and topped out at 400Hp. Liberty engine during World War I.

Her claims that "The Zeppelins were not too successful" and "It is difficult to imagine an easier target to shoot down" which is quite off the mark. From 1915 to 1918 the German Zeppelins attacked England 53 times killing 556 and wounding 1358. The real impact from there terror attacks was that the British Government was forced to maintain 400 anti-aircraft guns, 200 pilots and 17,000 personnel in the British Isles to counter

the threat. The last Zeppelin air raid occurred in August 1918.

The Germans built 83 airships nominally all called Zeppelins but were made by several different manufactures. Only 17 were shot down by either aircraft or anti-aircraft ground fire. Compare this to the 63 different aircraft raids on England, aircraft loses were far higher. For example, on May 18th 1918, 40 Gotha bombers took off in an effort to attack London but only 13 made it to the target and of these 6 were shot down.

Though I do realize that this is a dated article, these kinds of errors raise the appropriateness of continuing to publish it.

Col. Talbot N. Vivian, USAF (Ret.) DHA, LFACHE

*Ed. The article in question was chosen to note the current cenntennial commemoration of American entry into World War I. It has indeed been printed before, and for all of its shortcomings, and dated usage and scholarship, is still useful for the purpose intended. The staff meant no insult to those scholars who feel its time has passed. An update is probably overdue.*

**425th Tactical Fighter Training Sqdn.** Oct 3-4, 2017, Fairborn, OH. Contact:

Richard Kaercher  
P.O. Box 446,  
Cedarville, OH 45314  
937-766-2502  
rlmjkaercher@reagan.com

**463rd Airlifters Assn.** Oct 17-21, 2017, Fairborn, OH Contact:

Jerry Haines  
2411 S. Tecumseh Rd,  
Springfield, OH 45502  
937-325-9306  
gerald\_haines@yahoo.com

**531st Transportation Unit.** Sep 29 - Oct 1, 2017, Fairborn, OH Contact:

George Biehle  
1507 Woodland Dr,  
Loveland, OH 45140  
513-575-3795  
gfbiehle@fuse.net

**548th Recon Technical Grp.** Jul 12-14, 2018, Fairborn, OH. Contact:

Cecil Brown  
2459 S Old Oaks Dr,  
Beavercreek, OH 45431  
937-426-0948  
cecilb211@ameritech.net

**553rd Recon Wing, Batcat.** Sep 28 - Oct 1, 2017, Oklahoma City, OK. See: [www.westin553.net/batcat19.htm](http://www.westin553.net/batcat19.htm)

**610th Military Airlift Support Squadron.** August 23-25, 2018, Fairborn, OH. Contact:

Harold Mitchell  
354 Sussex Cir,  
Vacaville, CA 95687  
707-447-3536  
mitch610mass@aol.com

**3973rd Combat Defense Sqdn (Air Police)** of Morón Air Base, Spain. Oct 2-5, 2017, Dayton, OH. Contact:

Bill Vickery  
Phone: 850-423-0996  
www.vjr@cox.net or  
Diane Hughes at  
dihughes@att.net

**AF Officer Candidate School.** Oct 5-9, 2017, Seattle, Wash. All classes (1943-1963) are encouraged to attend. Contact:

Dave Mason  
757 820-3740  
blokemason@verizon.net



**Cam Rahn Bay AB.** Sep 28 - Oct 1, 2017,  
Dayton, OH. Contact:

Diana Westphal  
673 West Rock River Circle,  
De Pere, WI 54115  
920-609-5672  
dwestphal8@new.rr.com

**PTC-68H (Moody AFB).** Jun 7-9, 2018,  
Fairborn, OH. Contact:

Tom Crowley  
9168 Woodstream Ln,  
Dayton, OH 45458  
937-885-5286  
tj-bj@woh.rr.com

**UPT Class 69-05E (Webb AFB).** Oct 26-  
29, 2017, Fairborn, OH Contact:

A. J. Thrush  
186 Skyline Dr,  
Lancaster, OH 43130  
740-653-7585  
ajthrush@sbcglobal.net

**PTC-68A.** Oct 16-19, 2017, Fairborn, OH  
Contact:

Bil Fitzpatrick  
2869 N. Teetime Ct,  
Wichita, KS 67205  
316-640-1373  
wfitzpatrick1@att.net

**PTC-69-03.** 28 Sep 28 - Oct 1, 2017,  
Dayton, OH. Contact:

Emery Kiraly  
9221 Aldershot Dr,  
Bethesda, MD 20817  
301-469-0838  
madlazlo@yahoo.com

**List provided by:**

Rob Bardua  
National Museum of the U.S. Air Force  
Public Affairs Division  
1100 Spaatz Street  
WPAFB, OH 45433-7102  
(937) 255-1386

## History Mystery Answer



The Army officer was Lt **Benjamin "Benny" Foulois**. In 1910, recognizing that the winter weather at College Park Maryland was not suitable for flying, the Army transferred its infant aviation activities to Fort Sam Houston, San Antonio, Texas. Foulois was put in charge. Foulois being known as "the last of the first" comes from his being the last of the first group of pilots trained by the Wright Brothers. Unfortunately, Foulois also received the least amount of training as he had been sent to Europe for an aeronautical conference rather than complete his flight training with the Wright Brothers. Until he was ordered to Ft Sam Houston, he had never soloed an aircraft. While at Ft Sam Houston, Foulois flew the Wright military plane which was designated "**Signal Corps No. 1**" (also known as Old Number 1). Today, Signal Corps No. 1 is on display at the Smithsonian Air & Space Museum. Foulois describing his learning to "fly by mail" comes from his describing his corresponding with the Wright Brothers to ask them questions about how to fly.



In 1916, Francisco "Pancho" Villa led a cross border attack on tiny town of Columbus, New Mexico. In response to the attack, President Woodrow Wilson ordered the army to go after Villa. This expedition became known as the **Mexican Punitive Expedition**. Brigadier General "Blackjack" Pershing led the expedition. The 1st Aero Squadron, commanded by Capt B.D. Foulois, took part in the Punitive Expedition. Equipped with 8 "well-used" Curtiss JN3 aircraft, the unit fared poorly in the inhospitable environment.

Foulois would later be selected to serve as the Chief of the Army Air Corps in 1931. He served as the Chief from 1931 to 1935. During his tenure as Chief, he established the requirements for the aircraft that would lead to the development of the B-17. Foulois' tenure as Chief was mired by the Airmail Fiasco. Tasked in 1934 to deliver Airmail, the Air Corps proved unable to successfully complete the task. Poor training and poorly equipped aircraft resulted in 66 crashes and 12 deaths. Use the following links to learn more about General Benjamin Foulois:

*"Kept Alive by the Postman": The Wright Brothers and 1st Lt. Benjamin D. Foulois at Fort Sam Houston in 1910*

<https://media.defense.gov/2011/Apr/05/2001329937/-1/-1/0/110405-D-LN615-001.pdf>

*1907-1911 — Signal Corps No. 1, the Army's First Airplane.*

<http://www.afhistory.af.mil/FAQs/Fact-Sheets/Article/458960/1907-1911-signal-corps-no-1-the-armys-first-airplane/>

*A Preliminary to War: The 1st Aero Squadron and the Mexican Punitive Expedition of 1916*

<https://media.defense.gov/2010/Sep/28/2001329805/-1/-1/0/AFD-100928-064.pdf>

*Foulois and the U.S. Army Air Corps: 1931-1935*

<https://media.defense.gov/2010/Sep/24/2001330068/-1/-1/0/AFD-100924-038.pdf>



Test your knowledge of air power history by trying to answer this quarter's history quiz. Since the goal is to educate and not merely stump readers, you should find the question challenging but not impossible. Good Luck

This Army officer is known as “the last of the first.” He described himself as “*the first, and only, pilot in history to learn to fly by mail.*” During his aviation career, he accomplished a series of numerous firsts including being the Army’s first dirigible pilot, the sole officer in the Army’s Aeronautical Division and leading the Army’s entire air force while it deployed for an active campaign. The army gave him the charge of flying the Army’s first aircraft. He would later become the Chief of the Air Corps in 1931. For this multipart question: Name the officer. Name the aircraft and finally name the expedition.

You can find the answers on page 63.



Air Force *Historical* Foundation  
P.O. Box 790  
Clinton, MD 20735-0790



To: Air Force *Historical* Foundation  
P.O. Box 790  
Clinton, MD 20735-0790

Visit Us Online at:  
[www.afhistory.org](http://www.afhistory.org)



Know the Past,  
Shape  
the Future



A I R F O R C E H I S T O R I C A L F O U N D A T I O N M E M B E R S H I P F O R M

NAME \_\_\_\_\_ PHONE \_\_\_\_\_ E-MAIL \_\_\_\_\_

STREET ADDRESS \_\_\_\_\_ CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_

**Associate Membership (\$25/year) (on-line magazine access)** (Visit our Web site at [www.afhistory.org](http://www.afhistory.org))

**Sustaining Membership (\$45/year)**

GIFT FOR (NAME) \_\_\_\_\_

**Gift Membership (\$45/year)**

ADDRESS \_\_\_\_\_

**Life Membership (Inquiries to the Foundation)**

**Become a Patron or Contributor (Please ask)**

CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_

\* Non-US recipients please add \$8.00 for postage (See Web site for additional membership options)

**Check enclosed, payable in US Funds to Air Force *Historical* Foundation**

**Please charge my credit card (VISA/MasterCard/Discover)**

CARD NUMBER: \_\_\_\_\_ EXPIRATION DATE: \_\_\_\_\_

SIGNATURE: \_\_\_\_\_ DATE: \_\_\_\_\_

Send form, along with your remittance to:  
**Air Force *Historical* Foundation**  
**P.O. Box 790**  
**Clinton, MD 20735-0790**

