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Sparks Over Vietnam

The EB-66 and the Early Struggle of Tactical Electronic Warfare

Captain Gilles Van Nederveen, USAF

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College of Aerospace Doctrine,
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Air University

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Executive Summary

Technology has often been a key component in turning the tide of battle, particularly so in modern air wars. From the Battle of Britain to the Bekaa Valley to the most recent air operations against Iraq and Serbia, an invisible but vital duel was waged for control of the electromagnetic spectrum, with victory going to the side best prepared to exploit it while at the same time denying its effective use to the enemy. Both the Gulf War and the Air War Over Serbia illustrated the vital role of airborne electronic warfare, rekindling concerns for effective electronic systems, techniques, doctrine, and platforms. Contrary to many peoples' impressions, stealth technology has not negated the need for electronic jamming. Rather it has increased both the desirability of and potential benefits for judicious disruption of enemy electronic defense networks.

This study underscores the important use of electronic intelligence and jamming as an electronic countermeasure. Three decades ago, the USAF faced a North Vietnamese electronic air defense threat about which little was known. Through some extraordinary efforts, the USAF ably countered that threat employing an obsolete aircraft, the EB-66, only refitted and upgraded for mid 1960s missions. Since the aircraft was at the end of its projected lifecycle, and a new jammer was on the drawing board, the air staff would not fund additional EB-66 modifications and maintenance requirements. Parallels are easy to draw with today's jammers, as essentially the same situation exists with the EA-6B.

The number of EB-66 aircraft during the Vietnam War was inadequate to meet both operational and training requirements. Thus, crews were trained on the job, often during combat operations, and the "boneyard" at Davis-Monthan was often the site of scavenger hunts for repair parts needed to keep the aircraft aloft. The advent of the Pueblo crisis created an additional demand for the EB-66 forcing a partial redeployment of the fleet from Thailand to Korea. Training assets were also flown from Shaw to Germany during the same period to monitor the escalating air defense threat in the Warsaw Pact nations. Missions and employment doctrine had to change to match electronic counters by adversaries from all directions.

It became evident to all Air Force leaders that the requirement for airborne electronic warfare surpassed capability. The situation exists still, witness the open-ended commitment of EA-6Bs in support of the Northern and Southern Watch No-Fly Zones as well as in the Balkans and Korea. The ability of the existing EA-6B forces to support additional contingency operations is questionable at best. What is clearly evident is that without an effective means to gather electronic threat data and to conduct jamming operations in order to suppress enemy air defense capability, American strike aircraft will be endangered. Therefore, it is imperative that DOD invest in new technologies and improved airframes to maintain technical superiority in both ELINT and ECM operations. Without doing so, airmen will be forced to relearn the lessons that should have been learned with the story of the EB-66.

This book is dedicated to the crews of the EB-66.

Courtesy of Col K. Taylor, USAF Ret.

An EB-66C crew (pilot, navigator, gunner, and four electronic warfare officers) at Yokota AB, Japan in the late fifties. Crew and aircraft assigned to the 11th Tactical Reconnaissance Squadron.

Foreword

Captain Van Nederveen's paper can truly be a one source document describing the trials and tribulations of procuring and employing one of the Air Force's first "unique" aircraft during peace, war, and military operations other than war (MOOTW). "The EB-66C and the Early Struggle of Tactical Electronic Warfare" is an excellent read; methodical, historical, and reminiscent of a true workhorse in the United States Air Force. It is short enough to read in a few short sittings. The lessons learned are immediately apparent and applicable in today's declining budgets. Read this paper for its intellectual content, educational value, or for pure enjoyment.

Major General Glen D. Shaffer, USAF
Director of Intelligence, Surveillance and Reconnaissance
DCS, Air and Space Operations

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1. Introduction

The EB-66B/C/E aircraft flew Air Force tactical electronic warfare missions from 1956 until 1974. These aircraft were derived from the B-66 Destroyer that had been developed as a tactical bomber, itself a modified version of the Navy attack bomber, the A3D Skywarrior. During early development work on the Air Force B-66, the Korean War requirement for a reconnaissance platform delayed development of the bomber variant. The Air Force leaders recognized that they needed a quick replacement of their obsolete reconnaissance aircraft, the RB-26, in Tactical Air Command (TAC). The first prototype of the B-66 was thus not a bomber, but a reconnaissance aircraft designated RB-66A (see chart on page 3).

The five prototype models, the RB-66As, exhibited some severe flight handling difficulties. Once those were corrected, beginning in 1954, Douglas Aircraft in Tulsa, Oklahoma simultaneously built the B-66 bomber and RB-66B photo-reconnaissance airframes. Later when TAC also required specialized intelligence collectors it again choose the B-66 airframe to meet these needs. Between 1955 and 1957 the Air Force bought thirty-six tactical electronic reconnaissance versions, the RB-66C, and thirty-six WB-66D weather reconnaissance aircraft. These were the last B-66 airframes off the production line in 1958. These last two variants, the RB-66C and WB-66D had a modified bomb-bay that housed aircrew members and electronic equipment.

In the early fifties TAC had been forced to rely on Strategic Air Command (SAC) assets to handle a large share of its electronic intelligence needs. Eager to emerge from under the strategic nuclear umbrella that dominated American defense planning, TAC wanted to operate its own aircraft. The RB-66C, later redesignated EB-66C, in 1967 gave the tactical air forces their own jet powered reconnaissance aircraft. This improved capability allowed TAC to prepare for and fight the so-called "limited wars" of the sixties that would involve the extensive use of electronic warfare.

Electronic warfare (EW) is a term that encompasses a wide range of activities. Since these activities are closely tied to the various missions the EB-66s performed during their operational careers it is important to delineate the sub-functions of electronic warfare. Electronic countermeasures (ECM) is jamming that disrupts an adversary's radar, communications, and even missile guidance systems. When an adversary counter-jams, the friendly response is termed electronic counter-counter measures (ECCM). These activities are designed to defeat the hostile jamming. During the Vietnam War the Air Force used the term electronic support measures (ESM) to describe the collection of signal data that would facilitate jamming against North Vietnamese air defenses. Electronic reconnaissance (ER) denotes all forms of electronic data gathering, whether or not it is used for jamming purposes. An additional term, electronic intelligence (ELINT) gathering, is sometimes used interchangeably with electronic reconnaissance. The EB-66 fleet flew all the missions listed.

For nearly two decades the RB-66C/EB-66C was the centerpiece of tactical electronic warfare operations in the United States and overseas. It flew secretive reconnaissance missions along communist borders in the Cold War, assisted in the Cuban missile crisis, and concluded its career by flying the bulk of electronic warfare missions in the Vietnam War. Tactical electronic warfare formed a central theme in the development and operation of this aircraft, and the challenges posed by the introduction of newly developed electronic equipment are corollary issues worthy of careful investigation. Not only did the airframe suffer from shortcomings as a result of mis-engineered modification work, its electronic equipment, usually at the cutting edge of technology, experienced its share of complex maintenance and readiness problems.

The existence of only thirty-six EB-66C airframes and competing theater intelligence requirements in Vietnam, Korea, and Europe during the sixties meant this unique asset was always in demand. In today's military parlance it was a low-density, high-demand asset like Rivet Joint, AWACS, JSTARS, and EA-6B Prowlers. This situation forced the Joint Chiefs of Staff to move the aircraft like chess pieces from crisis to crisis around the globe. Losses in the air war over North Vietnam only made the calculus more complex. One theater would have to give up or severely curtail its electronic reconnaissance activities to allow another theater to conduct its own operations.

In addition to the original thirty-six C models, the Air Force initially fielded thirteen jammer variants, the B-66B Brown Cradle, which were converted from existing B-66 bomber airframes. This small number reflected uncertainty about the future of tactical electronic jamming as well as budget shortfalls which only allowed limited funds to be devoted to electronic warfare aircraft. These thirteen were later supplemented by another fifty-one airframes pulled from desert storage during the Vietnam conflict when jamming became indispensable to the air war over North Vietnam[1]. With the conclusion of the Vietnam War in 1974 the entire EB-66/B-66B fleet was retired. The successor EF-111 Raven would serve for 17 years. After its retirement in 1998 the USAF would be left to depend on the Navy's EA-6B for tactical electronic warfare support.

[1] Other sources such as Martin Streetly list fifty-two; USAF records at Maxwell AFB only support fifty-one conversions.

Type	Designation	Number Built	Vietnam War Era Designation (after 1967)	Type of Electronic Mission flown
Prototype	RB-66A	5	*Retired*	none
Original Bomber Variant	B-66	72	*Retired*	none
Photoreconaissance Variant	RB-66B	145	*Retired*	none[2]
Electronic Reconnaissance Variant	RB-66C	36	**EB-66C**	**ER, ECM**
Weather Reconnaissance Variant	WB-66D	36	*Retired*	none
First Jammer Conversion	B-66B (Brown Cradle) From B-66 Bombers	13	**EB-66B**	**ECM**
Vietnam Era Jammer Conversion	EB-66E (from RB-66B and B-66)	51	**EB-66E**	**ECM**

Note: The aircraft and missions in **bold** in the table are the EB-66 variants and missions described in this study.

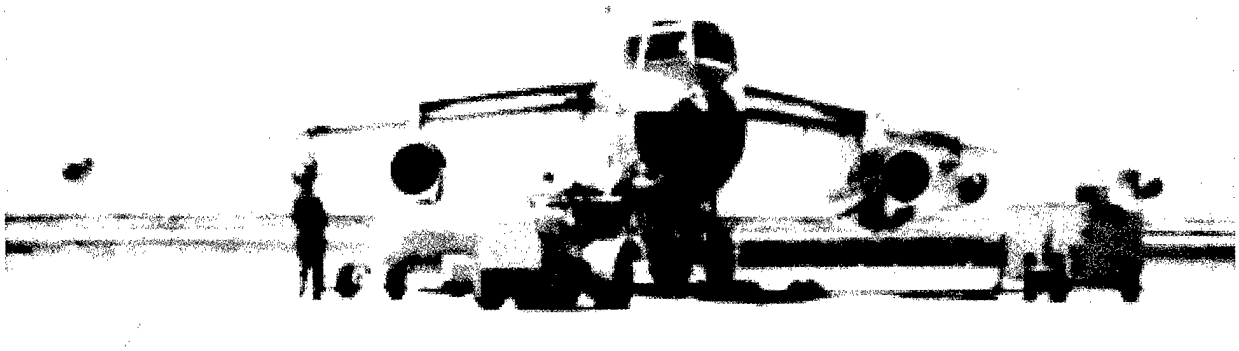

Photo by Colonel K. Talyor (USAF, Ret.)

Figure 1. An RB-66C on the ramp at Yokota AB, Japan in the late fifties. Notice the wing tip pods, these gave the C model its distinguishing feature.

[2] Some RB-66Bs were fitted with an ECM tailcone and used to fly electronic jamming training missions, see Chapter 3 Overseas Deployments.

2. An Electronic Warfare Primer

Electronic warfare (EW) was first used in the 1904 Russo-Japanese War. In World War I it consisted of jamming and intelligence analysis of radio and morse transmissions used by ground formations. Radios were too heavy and bulky for the World War I airplanes. During the inter-war years technological developments reduced the weight of radios and just prior to the outbreak of World War II radar was developed. Radar allowed for the detection and tracking of aircraft. Airborne electronic warfare was used extensively by the United States Army Air Force (USAAF) in both the European and Pacific theaters during World War II. Its purpose was to ensure that bombers got through the enemy's radar-guided defenses to bomb targets in Japan or Germany.

Before radar countermeasures could be conducted effectively considerable knowledge of enemy radar emissions, referred to as ELINT (electronic intelligence) or RADINT (radar intelligence), needed to be collected and analyzed. Specially modified aircraft, equipped with radar investigational equipment, for the most part bombers, such as the B-24 or B-17, were used to "ferret" out enemy signals. B-24s and B-17s were outfitted with jamming equipment and these accompanied the bomber streams. With electronic intelligence the jammers could be tuned to the correct frequencies blinding the enemy's radar or electronic aids during the bombing missions. Much of this jamming capability would be jettisoned in the swift demobilization that took place after V-J Day.[3] The belief that the peace would be maintained or war waged by atomic bombs that could be carried by a single aircraft able to penetrate any enemy's defenses fostered the idea that jamming aircraft would no longer be needed. The Korean War in 1950 found the U.S. unprepared for electronic warfare.

Although lacking jamming capability, the U.S. did have some electronic reconnaissance capability when the Korean conflict began. It was limited to strategic bomber units, since atomic bombing missions still needed to get through enemy defenses with atomic bombs. The Air Force mapped electronic radar sites so bombers could reach their targets undetected or at least with minimal exposure to an enemy's air defense system. Tactical air forces, in contrast, relied on speed, maneuverability, and the cover of darkness to carry out their interdiction missions. They did not develop electronic counter-measures to defeat the enemy electronic ground defenses consisting of radar-controlled guns and searchlights.[4]

During the Korean War, Far East Air Force (FEAF), operating from Japan and South Korea, faced a formidable number of Soviet supplied air defense systems on the

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[3] See Martin Streetly, *Confound and Destroy. 100 Group and the Bomber Support Campaign* (New York, NY: Jane's Publishing Group, 1978) and Martin Streetly, *Airborne Electronic Warfare, History, Techniques and Tactics* (New York, NY: Jane Publishing Group, 1988).

[4] Major M. Lusk, *History of Tactical Electronic Reconnaissance* (Maxwell AFB, AL: Thesis, Air University, June 1967), 32.

Korean battlefield. Initially both FEAF and SAC (which controlled the B-29 bombers) were unwilling to use the small number of jammers in the USAF inventory for fear of revealing U.S. capabilities. However, in 1952 as North Korean radar-guided guns began to take their toll on B-26 night intruder strikes and B-29 bombing raids, this tactic was changed. B-29 raids flew with jammer equipment fitted on board. The tactical aircraft unfortunately did not have jammers. FEAF and Fifth Air Force had one RB-26, which could locate North Korean radar signals and then photograph the actual radars for later strikes, but this system was too cumbersome to be effective in North Korean combat. Fifth Air Force began to convert more B-26s in an effort to build both an electronic reconnaissance and jammer force for its tactical bomber units.

After the Korean War, electronic warfare continued to develop as a series of electronic countermeasures (ECM) [5] to enemy radar and communications systems were introduced. This approach was valid as long as these systems were few and isolated. By the late fifties, however, modern air defense systems employed a large number of radars integrated through a complex command and control communications net. This linking of air defense weapons radars and command posts allowed an air defense commander to direct more assets towards penetrators, making detection and destruction of attackers all the more likely. In the context of tactical electronic warfare, the term tactical retained its classic distinction from the term strategic. It connoted a greater sense of immediacy—the application of EW during and in direct support of tactical air operations. This separated it from operations conducted to acquire strategic intelligence, such as the accumulation of information on an enemy's electronic order of battle.[6] A thorough evaluation of an enemy's electronic order of battle took too long to be of any use to a tactical air force commander.

SAC had maintained a small but capable force of electronic reconnaissance aircraft since the end of World War II, and after the Korean War modernized the platforms to meet the needs of its strategic bombing force. SAC processed the collected information at Offutt AFB and distributed to others in the USAF, but the process took time and TAC felt that threat systems on the battlefield were not being studied sufficiently. Rivalries, funding shortfalls, and an emerging national intelligence community that wanted to centralize all military reconnaissance activities left TAC with little useful electronic reconnaissance data. Tactical air forces wanted and needed some control over collection assets and the production of electronic reconnaissance intelligence data for integration in TAC units.

Electronic reconnaissance (ER) missions are flown to acquire information on the enemy's electronic system such as radars and communications nets. The electronic intelligence (ELINT) information these flights gather is charted to produce a

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[5] By 1964, the USAF defined ECM as "that division of military use of electronics involving actions to prevent or reduce an enemy's effective use of radiated electromagnetic energy, and actions taken to insure our own effective use of radiated electromagnetic energy." (AFM 51-3, "EW Principles," May 63, 1-1, 1-6.)

[6] Lt Col Richard E. Fitts, *The Strategy of Electromagnetic Conflict* (Los Altos, CA: Peninsula Publishing, 1980), 36.

comprehensive overview of an enemy's electronic network, referred to as its electronic order of battle (EOB). In the Cold War years ferret flights captured and identified signals emanating from the constantly changing equipment of adversaries. The purpose was to pinpoint the transmitting stations before the Soviets, Chinese, or others were alerted to the presence of the collecting aircraft.[7] ELINT collection requires sensitive receivers, direction finding (DF) equipment to pinpoint the location of sites, and sophisticated equipment to measure the operating characteristics of electronic systems. Due to the weight of the equipment and the personnel required to operate it, bomber aircraft were reconfigured as electronic reconnaissance platforms during World War II. In the fifties bombers were still felt to be the best platforms to operate electronic reconnaissance missions, since they were capable of transporting the electronic gear and had the ability to accompany a strike force to its target area.[8]

In TAC's view electronic reconnaissance was to provide warning of AAA/SAM radar activity to help strike forces initiate evasive maneuvers, guide strike aircraft away from SAM infested areas, help hunter-killer teams in suppressing enemy radar and SAM sites, and gauge the effectiveness of jamming on enemy systems. These reconnaissance missions were to be performed in support of air operations and they were distinct and separate from strategic intelligence collection efforts. They were to be oriented to information collection that had an immediate and significant effect on the conduct of tactical air operations. The product of the electronic intercept and direction finding activity was to be used initially to counter the enemy and, as a second priority, to provide inputs for intelligence efforts.

The data gathered through tactical electronic reconnaissance is not analyzed for signal parameters or subject to complex electronic signal breakdown, but instead is used to detect tactical advantages over the battlefield. For example, when a tactical air commander plans the next day's mission he desires precise operating data on the actual state of the enemy's air defense systems, which sites are operating, and which could pose a threat to his aircraft. Air operations planners must know where each site is located, whether any have relocated, and if any new ones have appeared that could affect strike aircraft. They are also vitally interested in detecting changes in enemy electronic warfare tactics. The value of this information is directly proportional to its currency.

Accurate and timely electronic intelligence allows the attacker to employ jamming, the second part of electronic warfare. In order for a penetrating strike force to bypass hostile defenses, jammer aircraft flying with the strike force use a variety of methods to blind enemy radars from seeing the strike force. The best method to overwhelm enemy radar is with a stronger transmitter, thus blanking out the radar scope at an enemy radar site. Blocking a single frequency is called spot jamming. Disrupting an entire band of frequencies is barrage jamming. A similar method of jamming is to drop chaff. Chaff consists of small metallic fibers that are dropped from aircraft to create aircraft-sized returns on enemy radar. It can create corridors through which radars cannot

[7] See Paul Lashmar, *Spyflights of the Cold War* (Gloucestershire: Sutton Publishing Ltd., 1996).
[8] Richard G. Wiley, *Electronic Intelligence: The Interception of Radar Signals* (Dedham, MA: ARTECH House, 1985), 2-3.

see. Chaff drops so slowly that it takes many hours to reach the ground from altitudes above 10,000 feet thus creating a lingering effect. Deception jamming, another method, uses a signal generator to plant a false target in the enemy radar system. This process, however, requires detailed knowledge of the hostile radar operating frequencies. If the jammer aircraft cannot accompany the strike force into the target area, it can orbit outside a threat envelope for instance, using powerful jammers to provide protection. This tactic is called standoff jamming.[9]

Electronic warfare specialists learned from air operations in World War II and Korea that one never achieves unequivocal superiority through ECM, because the enemy can apply electronic counter-counter measures (ECCM).[10] ECCM developments are in turn countered by new electronic methods, jamming or passive techniques, thus initiating a continuous cycle of technological improvements. The electronic battlefield is never stable and the superiority or advantage of either side is dependent upon its ability to implement technological improvements whether in ECM or ECCM.

Jamming enemy air defense works only if the enemy system parameters and operating techniques are understood. The purpose of an air defense system is to prevent hostile aircraft from destroying friendly targets. The entire spectrum of defenses ideally blends together to raise the price of penetration to some unacceptable level for hostile forces. In order to meet the objective of air defense a variety of classical strategies is available to the defender. A perimeter defense of SAMs or fighter aircraft could be used, or a series of point defenses surrounding important assets might be appropriate.

The Korean War was a reminder that tactical air forces required sophisticated electronic reconnaissance capabilities in order to operate in enemy airspace. In 1950 the Fifth Air Force in Korea found itself with only one RB-26 capable of detecting enemy electronic emissions. More were ordered[11] but did not arrive in time to take part in the war.[12] Strategic Air Command's RB-29 and RB-45 aircraft were pressed into service to collect ELINT over North Korea and neighboring communist countries.[13] Similar electronic reconnaissance missions were flown around the Soviet Union to help ensure that strategic bombers would be able to reach their targets. Since the end of World War II, Strategic Air Command had flown modified bombers as strategic electronic reconnaissance aircraft. The most important were the RB-29, RB-50, RB-45, RB-36, and RB-47. The ELINT data collected underwent lengthy and comprehensive analysis at Offutt AFB.[14]

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[9] See J.P.R. Browne, *Electronic Warfare* (London, UK: Brassey's, Vol. 4, Brassey's Air Power Series, 1998).

[10] Lusk, 46-48.

[11] Recognizing that it needed aircraft capable of finding and destroying radars, FEAF started to convert four more B-26 airframes into RB-26 configuration in Japan. The work was not completed until after the armistice.

[12] Lusk, 35.

[13] Robert F. Futrell, *The USAF in Korea 1950-1953* (Washington, D.C: Office of USAF History, 1983), 545-56 & 711.

[14] See *Strategic Air Command. People, Aircraft and Missiles* (Annapolis, Maryland: The Nautical and Aviation Publishing Company, 1979).

TAC needed to "remake" itself if it wanted to obtain the scarce defense dollars of the mid-fifties. After the Korean War had ended in a stalemate rather than a nuclear showdown, it was eager to reorganize its forces to fight the "brush wars." This term was given to conflicts in the Third World that did not go nuclear, such as those in Malaysia, French Indochina, Lebanon, and the Persian Gulf. In order for tactical bombers and fighters to conduct operations for these regional conflicts, a more complex and sophisticated reconnaissance infrastructure was needed. Since "tactical" nuclear targeting was also becoming an issue in the European and Korean theaters, the reconnaissance modernization came at an opportune time. Not willing to be a junior partner to SAC, TAC wanted to acquire airborne electronic, photo, and weather reconnaissance assets of its own. The Korean War proved that tactical electronic warfare was improving with the infusion of new electronic technologies, and that the Soviet Union, which supplied the bulk of electronic warfare equipment to the communist world, was capable of producing rugged gear, capable of disrupting U.S. tactical air operations.

Beginning in 1954, and mindful of the lessons learned in the Korean War, TAC equipped one squadron in each of its reconnaissance wings with RB-26 aircraft.[15] It was a compromise. Aside from the fact the B-26 airframe was old and slow, it also lacked the endurance and sophisticated equipment necessary to do anything but basic ELINT work. The RB-26 lacked both the space and power generators to employ sophisticated electronic equipment. After a mission the aircraft's electronic warfare officer (EWO) and the navigator had to collate the information collected during the mission and write their report. The data collected was then analyzed by a team of specialists on the ground and tape recordings forwarded with the report to a national intelligence agency or theater ELINT center. This process was very time consuming and cumbersome. As the number of electronic intercepts increased, the EWO was inundated to the extent that he was unable to process all but the most significant data. This frequently occurred along the inter-German border as the Soviets and their satellite countries expanded their radar networks.

TAC was also eager to acquire jet powered aircraft, a light jet bomber to replace the RB-26[16] for the ELINT mission. TAC also wanted the new electronic warfare aircraft to conduct ECM operations in addition to ELINT, thus combining the intelligence collection and jamming mission together in one aircraft. This would reduce the logistical burden on maintenance crews and reduce procurement costs by acquiring one aircraft to perform two primary missions.[17]

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[15] Lusk, 50-51.

[16] TAC also flew RB-26 in a photo reconnaissance role and WB-26 as weather observation aircraft, these subvariants were incorporated into the RB-66 program.

[17] Frederick A. Alling, *History of the B/RB-66 Weapon System (1952-1959) Volume 1* (Wright-Patterson AFB, Air Material Command, January 1960), 3.

3. Development of the B-66 Bomber and its Reconnaissance Variants

The Air Force used piston-powered, World War II vintage, B-26 aircraft for tactical bombardment in the Korean War. During that conflict it sought a jet-powered replacement. In 1950, the Air Force evaluated a number of multi-engine light jet-bomber aircraft: the B-45 (Tornado), AJ-1 (Savage), XB-51, and the Canadian CF-100 (Canuck). None of these aircraft offered the performance that TAC sought. The B-45, based on a World War II design, was considered too slow, as was the U.S. Navy's AJ-1. The tri-engine XB-51 held promise but was only in the experimental stage. The CF-100 was a large fighter that could not be turned into a fighter-bomber and it was eliminated.[18]

At the conclusion of the bomber flight tests the Air Force brought the RAF's Canberra light bomber to Andrews AFB for a flight demonstration. TAC liked the handling characteristics of the plane, and in 1951 ordered 250, designating them as B-57s. This airframe, modified on the assembly line into a reconnaissance platform, the RB-57, was built only for photo-reconnaissance duty. The narrow fuselage of the B-57 did not accommodate either the complex electronic reconnaissance suite or the additional crew members required for ferret operations.[19] Many of the initial B/RB-57s delivered to TAC suffered fatal accidents which were the result of tail-plane trim actuator problems. Frequently grounded for safety checks and engine difficulties, TAC's initial pleasure with the B-57 soured considerably and production ceased.[20]

Still seeking a tactical bomber airframe, in February 1952 TAC instituted another search. This time the service considered the B-45, B-47, a revised B-51, a redesigned B-57, and the Navy A3D Skywarrior. Certain aircraft were considered again because there were no other airframes that met the Air Force required specifications. Most of these aircraft were eliminated from the competition for performance reasons. The B-45 did not have the required speed, the B-47 (SAC's current medium bomber) was too heavy and expensive, and the XB-51 was still too experimental. The redesigned B-57 did not offer any great improvement over the original design. This left the Navy's A3D. It was compact and had a bomb bay which could hold most tactical nuclear weapon shapes, and its speed and range were considered adequate for TAC's light bomber missions.[21] For lack of a better choice, TAC selected the A3D and redesignated it the B-66 Destroyer.[22]

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[18] Robert Jackson, *Canberra. The Operational Record* (Washington, DC: Smithsonian Institution Press, 1989), 114-115.

[19] On the RB-57D and WB-57F see Robert C. Mikesh, *B-57 Canberra at War 1964 –1972* (New York, NY: Charles Scribner's Sons, 1980).

[20] Mikesh, 16-21.

[21] Bill Gunston, *Bombers* (London, UK: Hamlyn, 1978), 161-64.

[22] Bill Gunston, *Bombers* (London, UK: Hamlyn, 1978), 128-33.

The Navy's A3D was the largest and heaviest aircraft to operate from a carrier deck.[23] The USAF encountered numerous difficulties in turning a Navy aircraft into an efficient land based system and thus the project fell behind an ambitious schedule. The extensive modifications of the aircraft for Air Force operations encompassed the wing, fuselage, crew compartment, and engine pylons. These structural changes would lead to problems that plagued the B-66 fleet until its retirement from the Air Force. For example, the wing on both versions held integral fuel tanks, and the Air Force redesign of the wing caused stresses resulting in the sealant cracking, leading to excessive fuel leaks and corrosion. The crew compartment and fuselage changes led to window pane cracking, excessive vibration, and noise in the cockpit.

Since the need for a tactical reconnaissance aircraft was actually more critical than for a light bomber, TAC decided that it would configure the first B-66 airframes off the production line as reconnaissance aircraft. Within a year Douglas produced three different versions of the RB-66: the RB-66B for photographic work; the WB-66D for weather data gathering; and the RB-66C to conduct electronic warfare operations.[24]

The 1954 test flight of the first B-66 variant, designated RB-66A, showed numerous aircraft handling deficiencies, the most severe a buffet problem which had to be solved by stiffening key areas of the structure. Subsequent redesign work continued until 1956 when the first RB-66B entered the USAF inventory.[25] The aircraft's major problem, which continued to plague it until its retirement in 1974, was engines. The manufacturer, Douglas Aircraft, favored the Pratt and Whitney J57, but, because it was earmarked for several other aircraft, the USAF instead settled for the Allison J71. The engine, used only in the B/RB-66 fleet, produced an under-powered aircraft.[26] The Navy's A3D had more adequately powered J57 engines.[27] The Allisons produced about 10,000 pounds of thrust each, while the J57s gave 12,400 pounds of thrust. Indeed, the better engine performance allowed the US Navy to fly the A3D until the late eighties.

The RB-66 was capable of in-flight refueling, and similar to other tactical aircraft of the time, used a probe and drogue method.[28] TAC had chosen the British system for ease in operation and had its own tanker fleet of KB-50s. The probe and drogue system was incompatible with the boom system adopted by SAC for its bomber fleet and this led to problems in later years. While the boom-equipped SAC KC-97/KC-135 tankers could be a equipped with a drogue hose, this could only be done on the ground and meant that the KC-135 could only refuel probe equipped aircraft.

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[23] The Navy retired the last A3D from active service in 1992 and the last reserve EKA-3D "Whale" in 1994.
[24] Alling, 23.
[25] Alling, 15.
[26] Alling, 10-11.
[27] Gunston, 131.
[28] TAC used a probe and drogue method while SAC used a boom. TAC tankers at the time were the KB-29P and KB-50. After the retirement of the KB-50 there were no more TAC tankers, and SAC provided all tanker support.

The electronic reconnaissance version, the RB-66C, was the heaviest of the RB-66 variants. It entered operational service in 1956 and was manned by seven crewmembers: pilot, navigator, four electronic warfare officers (EWOs), and a gunner. The gunner was eliminated when the tail turret was removed, replaced with a tailcone that housed additional electronic equipment. The four EWOs were stationed in the bomb bay, rebuilt as a crew compartment and electronic equipment bay. The EWOs sat in downward firing ejection seats. The Air Force bought 36 RB-66C aircraft, 12 for each of the three electronic and weather squadrons in TAC's major tactical reconnaissance wings.[29] This fleet would soldier on until the end of the Vietnam War in 1974.

The core of the RB-66C ELINT system was the APD-4, an automatic receiver system, that rapidly and automatically handled a multitude of signals. Its thirty-six horn antennas, mounted in streamlined fiberglass pods on the wingtips and under the belly of the aircraft, were designed to give 360 degrees of coverage. The automated system proved to be a failure. Signals received simultaneously while the RB-66C was flying a reconnaissance mission saturated the recording film, making analysis impossible.[30] TAC replaced it with a manual collection system in 1959 which used some of the same antennas. The APD-4 data required a lengthy ground analysis, up to four hours for every one sortie hour, making the system unsuited for tactical operations.[31] Electronic intelligence soon reverted back to the tried and proved method of paper and pencil. Each EWO monitored an assigned frequency band. The intercepted signals were graphically displayed on a pulse analyzer, which identified the type of signal. Geographic plots were then made using the airborne direction finder to obtain relative bearings and, by triangulation, determined the approximate position of the intercepted signal. Since range information was not available, these plots were dependent upon knowing the exact location of the RB-66C at the time a bearing was taken, emphasizing the importance of accurate navigation.[32]

In order to conduct jamming the RB-66C carried nine jamming transmitters. These were designed to jam any of the signals a RB-66C was expected to encounter in 1956. Miniaturized electronic developments in the sixties would soon antiquate this part of the RB-66C electronic suite. While the jamming power output was never impressive, the RB-66C had four EWOs who could monitor the jamming in real-time.[33] The officers could modify and pattern the jamming energy directly towards the threat and monitor its effectiveness. The nine jammers could be tuned in flight, providing better frequency coverage against an enemy system. This allowed the aircraft's crew to select, prioritize, and blind the gravest threats.

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[29] The wings were: 67th in PACAF (Yokota AB, Japan); 10th in USAFE (Spangdahlem AB, Germany and later three bases in the United Kingdom), and 363rd at Shaw.

[30] A film system was used before magnetic tape recorders replaced this somewhat cumbersome system.

[31] Alfred Price, *The History of Electronic Warfare* (Arlington, VA: Association of Old Crows, 1984), 179-80.

[32] Lieutenant Colonel William J. Bally, *History of Tactical Reconnaissance: An Analysis of Aerial Collection Capabilities 1950-1966* (Maxwell AFB, AL: Air War College Report # 3284, May 1967), 50.

[33] Jammer variant discussed in chapter 4. It was later designated EB-66B.

Internal electronic interference on board the RB-66C was a source of great concern. Communication radios and navigation instruments would blank out part of the frequency spectrum during missions. Troubleshooting and remedies to these problems took time because of low experience level of the ground maintenance crews and a lack of training and documentation manuals. The electronic subsystems on the RB-66C were state of the art for the late fifties, and training of personnel lagged behind service introduction. Most of the worst interference problems were solved between the Cuban Missile Crisis in 1962 and deployment to Southeast Asia in 1965 when funding was made available.[34]

The bomber variant, B-66B, disappeared from the TAC inventory in 1962.[35] It had been assigned to the 17th Bomb Wing at Hurlburt Field, Florida from 1956 until 1958. The aircraft were transferred to the 47th Bomb Wing[36] at RAF Sculthorpe in 1958 and remained there until inactivated in 1962. TAC wanted to retire the RB-66C aircraft in 1964 and replace it with a modified fighter, however, a lack of funding killed this plan. The reconnaissance versions continued in squadron service as there was no replacement. Eager to acquire a supersonic reconnaissance force, TAC had proposed a RF-105, later renamed RB-105, which would carry electronic sensors in a pod for either reconnaissance or jamming, but this was not to be. Curtailment of the F-105 buy in 1960 forced TAC to hold on to its RB-66C force.[37]

TAC extended the RB-66C retirement date each year, but this sort of force management with yearly extensions led to numerous problems. Lack of funding for overhauls and replacement of worn parts or new engines caused the aircraft to encounter serious safety of flight issues. By 1960 the increase in gross weight from 83,000 pounds to over 85,000 pounds with no increase in engine thrust left the aircraft under-powered. The production line at Douglas aircraft had closed in 1959, leaving the Air Force with a limited number of spare parts. Numerous parts had to be manufactured in small uneconomical lots by a variety of suppliers. As the airframe and its subsystems passed their programmed life-span, recurring problems arose forcing curtailment of operations and wide spread cannibalization.[38]

Meanwhile TAC's operational plan for the aircraft changed. During employment and suitability testing by Air Proving Ground Command in November 1957, the RB-66C was ruled to be incapable of performing its escort combat mission over hostile territory.[39] The RB-66C did not have the speed to keep up with TAC fighter-bombers or to evade

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[34] Lieutenant Colonel Courtland Moore, *EB-66C Out-Country Electronic Reconnaissance 1965-1967 A Case Study* (Maxwell AFB, AL: Air War College Report # 3655, 1968), 13.

[35] Replaced by the F-105, a MACH 2 fighter-bomber, which could carry the new smaller, lighter tactical nuclear weapons. The F-105s were later replaced by the F-4 Phantom.

[36] Replacing USAFE B-45 aircraft in the 17th Bomb Wing. See Rene Fancillon and Mick Roth, *Douglas B-66 Destroyer* (Arlington Texas, Aerofax, Inc, 1988).

[37] See chapter 4 on the 363rd TRW at Shaw AFB.

[38] Tactical air forces deployed overseas were oriented toward a nuclear strike role. The result was that non-nuclear forces faced funding shortfalls. Considerable concern was present within TAC however over the lack of capability to fight small "brush fire" wars, i.e., limited non-nuclear conflicts.

[39] Tactical Air Command, *History, 1 July 1957-31 December 1957* (Langley AFB, VA: Chapter 2), 91.

enemy interceptors, and could not operate at lower altitudes at high speed. Without any conflicts on the horizon to help with funding priorities, RB-66C operations were limited to ELINT missions and training. The aircraft did perform a peripheral reconnaissance mission near communist countries without major difficulties in the early sixties. Deployed overseas and constituting one reconnaissance wing stateside, the RB-66C provided new capabilities to the tactical air forces. TAC finally had the electronic warfare platform it had wanted since the Korean War, but the aircraft was rapidly being overtaken by developments in electronics and tactical aircraft design.

Courtesy of MSgt Floyd Miller, USAF Ret

Figure 2. An RB-66C assigned to the 42nd Tactical Reconnaissance Squadron at an open house in 1960 at RAF Chevelston. The aircraft still has its tail gun turret. This view also shows the wing pods that gave the RB-66C its distinctive look.

4. The Perspectives from Shaw AFB (1956-1974)

The RB-66C force in the continental United States was concentrated at Shaw AFB, South Carolina in the 363rd Tactical Reconnaissance Wing (TRW). The first RB-66C arrived on 1 Feb 1956, and the aircraft would continue to operate from Shaw until its retirement in 1974. Twelve RB-66Cs initially flew with the 9th Tactical Reconnaissance Squadron (TRS),[40] and then later with various training squadrons including the 4417th Combat Crew Training Squadron (CCTS), 4411th CCTS, and 39th Tactical Electronic Warfare Training Squadron (TEWTS), as well as the 4416th Test Squadron (TS).[41] In addition to their training function, Shaw personnel participated in all major exercises and tested and evaluated the new reconnaissance aircraft and equipment. The wing was also to augment, within 72 hours, either of the overseas tactical air forces (PACAF and USAFE) in case of crisis or war. Most early flying of the RB-66C was devoted to getting the aircraft and crew ready for deployment and operations. It took longer than expected to have the electronic gear on the RB-66C operational, as the equipment was continually being modified. Readiness rates for the RB-66C in the late fifties and early sixties were below average, especially when compared to other new aircraft, such as the RF-101, introduced into the wing at Shaw during that same time.

In order to test the electronic warfare capabilities of the US armed forces in 1958, the Institute for Defense Analysis formulated a comprehensive set of tests referred to as weapons evaluation (WEXVAL). In the fifties, TAC jamming capability consisted of a few T-33 and obsolete B-26s and B-29s fitted with chaff dispensers and jammers that provided a minimal amount of countermeasures training for command exercises. In the first test in 1958 SAC's jammer fleet, equipped with RB-47s, performed well against Air Defense Command (ADC) radar sites. TAC was directed to provide the jamming aircraft for the 1959 test. With SAC and TAC competing for scare Department of Defense funds, TAC knew it had to perform satisfactorily in the 1959 test. In order to acquire a more modern and powerful jamming capability TAC decided to modify some of its B-66 bombers into dedicated jamming platforms.[42] The only mission of these modified aircraft was to jam enemy radar and radio frequencies. These B-66B conversions were code-named "Brown Cradle," after the SAC modification of the B-47, which had been called "Blue Cradle."[43]

The B-66Bs were withdrawn from the 17th Bomb Wing at Hurlburt Field for conversion. TAC fitted a jammer "cradle" into the bomb bay. In addition, the tail guns in the tail turret were replaced by a tail cone that contained additional jammers and chaff

[40] Tactical Air Command, *History, 1 January 1956 to 30 June 1956*, Volume I, Langley AFB, VA, 57.
[41] The 39th was known by two different names: Tactical Reconnaissance Training Squadron (TRTS) and, after February 1970, Tactical Electronic Warfare Training Squadron (TEWTS). It would be the last USAF squadron to fly the EB-66.
[42] Price, 249-50.
[43] Price, 249-50.

dispensers. Initial plans called for these jammers to be mounted on removable pallets, however electrical wiring and the tight fit of the "Brown Cradle" jamming equipment made this impossible. TAC decided to leave the modified aircraft permanently in the jammer configuration. A total of thirteen aircraft were so modified.[44]

The bomber crew -- pilot, navigator/bombardier, and gunner--was changed to a pilot, navigator, and an EWO to operate the electronic equipment. The EWO took over the gunner's seat that now had access to large fold-away panels on which he could monitor the performance of the jamming gear. The jammers were preset on the ground, making it impossible to retune them in the air as the crew did not have access to the bomb bay or jamming gear. This arrangement required that numerous collection missions be flown to register all enemy frequencies and to determine which ones required the jamming that permitted evasion of hostile air defense systems for the fighter-bombers. The arrangement required that an RB-66C fly sorties to gather the frequencies which were to be jammed, and, upon its return, pass the information on to the B-66B "Brown Cradle." During the 1959 WEXVAL exercises TAC flew the F-100s in mock attacks on the Navy task force operating off the eastern seaboard. The "Brown Cradle" B-66B flew jamming escort in support of the F-100s, while the RB-66C monitored the ships' radar frequencies. TAC was very successful. The B-66B provided enough jamming coverage so the F-100s could attack their naval targets. As it turned out the great effort to perform well came to naught because, at the end of the exercises, TAC was unable to find funds to purchase additional jammers.[45] Re-equipping other parts of the tactical air forces with modern fighters, coupled with an unwillingness to modify any more B-66s that were scheduled to leave the Air Force inventory in the next few years, also contributed to the decision. TAC also monitored developments in electronic miniaturization. TAC hoped that individual fighters eventually could be fitted with jammer pods rugged enough to sustain the gravitational forces and other shocks and stresses associated with fighter aircraft maneuvers.

Since the 363rd TRW at Shaw did not need a jammer in peacetime, and since PACAF was phasing out its entire RB-66 force in 1960, the B-66B "Brown Cradle" briefly joined the 47th Bomb Wing at RAF Sculthorpe before moving to the 42nd TRS at RAF Chelveston at the conclusion of the WEXVAL test series. USAFE did have a wartime tactical nuclear mission and the B-66B "Brown Cradles" were employed to escort strike aircraft behind the iron curtain in event of war.[46]

The 363rd Wing at Shaw trained EWOs for TAC, USAFE, and PACAF in the late fifties and sixties. In order to provide realistic practical training, regular jamming exercises were flown against Air Defense Command (ADC) students at Tyndall AFB under project "Big Blast."[47] This allowed both EWOs and ADC radar operators to encounter actual electronic interference. Several new tracks in the southeastern United

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[44] August Seefluth, "The Other Jammer" (Arlington, VA: Air Force Association, *Air Force Magazine*, March 1992), 75.
[45] Price, 249-50.
[46] 42nd Tactical Reconnaissance Sq., *History, 1 July 1957 to 31 December 1957*, RAF Chelveston, UK, 3.
[47] 363rd Tactical Reconnaissance Wing, *History 1 July 1962 to 31 December 1962*, Shaw AFB, 5.

States were also developed to provide the maximum number of potential intercepts for students engaged in electronic reconnaissance training. This ECM training (jamming) was conducted in concert with Army Nike battalions located within these tracks.[48] The wing also provided participants for all major exercises in the United States and Alaska. In addition, NORAD used the jamming capability of the RB-66C to test regional responsiveness to jamming measures that might be encountered under wartime conditions.

Shaw became the technical center for the RB-66 fleet worldwide, with all of the CONUS based aircraft assigned there. The RB-66Cs served as trainers for EWOs, with an instructor seated with three students in the EWO compartment. These positions were all equipped with downward firing ejection seats. During one flight over Miami, a student fired his seat inadvertently and parachuted to the top of hotel on the Miami beachfront. He returned to Shaw a day later to resume his training after enjoying his additional field trip. Needless to say, the instructor received additional training to preclude further incidents.[49] Most corrective measures to keep the aircraft flying were tested and implemented at Shaw Such measures focused on a problem with the drogue chute, leaking fuel tanks, and the actual modification of reconnaissance equipment.[50] In addition, all USAF training for RB-66 personnel was done there.

Seeking to emerge from the shadow of SAC, TAC organized a Composite Air Strike Force (CSAF) to move tactical air forces overseas for crisis response. The CSAF was a combat-ready, mobile, tailored force consisting of a command element with a variable number of squadrons. Its composition would depend upon the forces and skills required to meet a particular situation. In 1958 the USAF sent the CSAF to Turkey in response to the upheavals in Iraq and Lebanon. However, while Shaw was programmed to supply the RB-66C reconnaissance assets, the 42nd TRS then based in Spangdahlem AB, Germany went instead. This reduced tanker sorties required to transport CSAF assets across the Atlantic Ocean. In 1962 the CSAF was also used in the Pacific to reinforce Taiwan during the crisis over the islands of Matsu and Quemoy. The RB-66s at Shaw again remained home as KB-50 tankers were unavailable for support.[51]

Training new EWOs in 363rd TRW had been difficult since the arrival of the RB-66Cs. The southeastern United States did not have a dedicated electronic warfare range, and, in order to train crews in the RB-66C, civilian airport radars and U.S. Army Nike radars were used for training purposes. These stationary U.S. radar systems could not simulate enemy radar, especially the newer Soviet systems. Also missing from the 363rd training scenario were mobile systems. Enemy air defense radar systems were expected to move within six hours and RB-66C crews needed exposure to battlefield mobility

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[48] 3 S-band and 3 X-Band jammers were used against the Nike sites--especially against command and control nodes. 363rd Wing, *History, July – December 1959*. Chaff was also used to blanket Nike radar sites, 363rd Wing, *History, January – June 1962*. For frequency band information see pages 54 and 65 in Air Vice Marshal J.P.R. Browne, *Electronic Warfare* (London: Brassey's, 1998). For a detailed description of chaff see pages 264-72 in Browne, *Electronic Warfare*.

[49] Telephone interview with Judge John Mitchell (Captain, USAF Ret) 8 March 2000, Stockton, California.

[50] Used to brake the aircraft and shorten the landing roll.

[51] 363rd Tactical Reconnaissance Wing, *History,1 January to 30 June 1960*, Shaw AFB, SC, 8.

operations in peacetime. Plotting of such mobile systems was considered vital to future air operations. In 1959, because of these dissatisfactions with ELINT training opportunities in the southeastern United States, the Wing Staff developed a new concept of operations, codename "Swamp Fox."[52]

The plan called for two RB-66Cs and two crews from 363rd TRW to deploy with the 42nd TRS at RAF Chelveston and later to Toul-Rosieres AB, France for sixty days and fly peripheral reconnaissance missions along the East German, Czechoslovakian, and Polish borders. The deployed aircrews gained valuable experience identifying and analyzing actual foreign radars, training not possible in the United States. The deployments were felt to be beneficial and continued until the outbreak of the Vietnam War. The deployed aircraft and personnel were integrated into the 42nd TRS that was part of 10th Tactical Reconnaissance Wing (TRW), the USAFE theater reconnaissance wing.

On 21 October 1962 the 363rd TRW at Shaw deployed to MacDill AFB, Florida as part of the USAF response to the Cuban missile crisis. Two RB-66Cs on deployment to the 42nd TRS at Toul-Rosieres AB on a "Swamp Fox" rotation in France were recalled and sent to MacDill AFB. The downing of a U-2 on 24 October 1962 by an SA-2 highlighted the importance of obtaining electronic intelligence on the operational status of the Soviet systems. On 26 October 1962 the RB-66Cs flew their first mission. These sorties consisted of two RB-66Cs circumnavigating Cuba to determine the operational patterns for deployed Soviet radars. However, it soon became evident that once the SAM systems became operational a "real-time" collection and warning capability would be needed to warn aircraft operating within Cuban airspace. During these sorties against the SA-2 system and the new Soviet radars that were deployed to Cuba, the EWOs on board the RB-66Cs reported numerous interference problems and also noted that some Soviet radars were operating at the edge of the frequency bands they could monitor. TAC realized it had to modify the electronic detection equipment on board the RB-66Cs. After the withdrawal of offensive Soviet military equipment from Cuba, this requirement was never resurfaced, even though the RB-66Cs continued to fly peripheral missions.[53] The 363rd TRW redeployed to Shaw on 15 December 1962 but continued until July 1963 to conduct electronic reconnaissance missions around Cuba using MacDill AFB as a forward operating base.[54]

Between the Cuban missile crisis in 1962 and the start of air operations over North Vietnam, the 363rd TRW improved its operating procedures and upgraded its equipment. By streamlining the procedures used to intercept, locate, and analyze radar signals, EWOs could work with ten to twelve signals an hour. Previously, EWOs worked only an average six to eight signals per hour. EWOS also perfected in-flight plotting procedures and improved the analysis and reporting process as well. These actions together allowed the crew to plot out threat systems. Reports could now be sent out via

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[52] 42nd Tactical Reconnaissance Squadron, *History, 1 January 1960 to 30 June 1960*, RAF Chelveston, UK, 2.

[53] Code-named "Cold Cream" and "Easter Egg." 363rd Tactical Reconnaissance Wing, *History January-June 1963*, Shaw AFB, SC, 5.

[54] 363rd Tactical Reconnaissance Wing, *History 1 July 1962 to 31 December 1962*, Shaw AFB SC, 7, 23.

the aircraft radios allowing for rapid dissemination of data. However, the RB-66C still only had unsecured radios which meant that in wartime information would have to be manually encrypted by the crew, a time consuming process. As an alternative, crews could use a series of daily codes to verbally transmit threat data. The most significant improvement to the equipment was the relocation of jammer controls from the gunner's panel in the forward part of the aircraft to the EWO compartment. The EWOs could now conduct tunable selective jamming. Prior to this change, the aircraft had only been capable of barrage jamming, the control just being an on/off switch.[55]

TAC became involved in the growing operations in Southeast Asia. Starting in 1965 the command sent RB-66Cs as the sole tactical electronic intelligence collection aircraft for the Air Force. Navy collection aircraft operated in the Gulf of Tonkin, but carrier space was limited. Larger aircraft like the EC-121K "Warning Star" operated from Da Nang AB, South Vietnam after 1967. The RB-66C jamming capability was also used against the North Vietnamese air defense system. In fact, tactical electronic reconnaissance efforts in support of USAF operations over North Vietnam were limited to the RB-66C. C-130B-II variants carried out a limited number of ELINT/COMINT collection missions, but, due to survivability concerns, they could not enter North Vietnamese air space.[56] Although EB-57s assigned to Air Defense Command carried jamming gear to act as radar targets for fighters and radar sites stateside, they were not deployed to Vietnam. SAC assets were also off limits to tactical conflicts because they still had a strategic mission to perform and because the Johnson Administration did not want to give the appearance of using strategic assets in a tactical Third World conflict. SAC also wanted to preserve its force structure and conceal its ECM capabilities from potential threat.[57]

The USAF deployed aircraft from Shaw to provide PACAF an electronic intelligence capability over Vietnam because the RB-66C squadron in PACAF at Yokota AB, Japan had been deactivated. Worldwide RB-66C assets still consisted of only 36 aircraft. Shaw's 9th TRS deployed RB-66Cs to Tan Son Nhut AB, South Vietnam and later to Takhli where the RB-66C efforts would be concentrated.

With the need to streamline USAF operations in the United States as a result of the growing Southeast Asian conflict, the 363rd TRW absorbed other units. While the 363rd TRW had conducted aircrew, pilot, and navigator training for the RB-66C fleet, it now absorbed the EWO training mission from the 4411th Combat Crew Training Group in 1966. This reorganization meant that the 363rd TRW now trained all crewmembers for the RB-66C.[58] Crew output increased from 42 to 96 crews per year.[59] Additionally, since

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[55] Major Robert Moraski, *B-66 Electronic Warfare Operations* (Colorado Springs, CO: Ninth Annual NORAD Electronic Warfare Conference Briefing, 23 July 1992), 8.

[56] EC-130s were based at Yokota AB, Japan with the 556th Reconnaissance Squadron and codenamed "Silver Dawn."

[57] SAC RB-47Es and later RC-135s flew missions over the Gulf of Tonkin and Laos for SAC, *not* Seventh Air Force.

[58] 363rd Tactical Reconnaissance Wing, *History, 1 January 1966-30 June 1966; 1 July 1966-31 December 1966,* Shaw AFB, SC.

[59] TAC Command, *History 1 July 1966 – 31 Dec 1966*, Langley AFB, VA, 603.

early July 1966, preparations were made at Shaw to receive the 19th TRS which was redeploying from France as a result of President DeGaulle's decision to remove NATO forces from French soil. This squadron assumed the replacement training unit (RTU) role for the 363rd TRW. The 4417th CCTS, already based at Shaw, was equipped with 14 aircraft, but soon would lose some to depot-level maintenance. The 19th Tactical Electronic Warfare Squadron (TEWS) was renamed from the 19th TRS on 15 October 1967 and had ten aircraft.

The 4416th Test Squadron at Shaw undertook development work for electronic warfare components. It was activated to support the growing electronic warfare effort in Southeast Asia. One of the many developments brought to the EB-66 fleet was the carrying of double or triple loads of ALQ-71 ECM pods under wing pylons. Throughout the Vietnam conflict equipment and tactics were continually updated. Because of experience gained in Southeast Asia the first change to the training syllabus was to add more night-time air refueling which had been found wanting in the theater.

By 1966 continued aircraft and personnel deployments to Thailand led to problems at Shaw. EWO training for Southeast Asian operations suffered due to the lack of training aircraft. The unit based a maximum of three RB-66Cs at Shaw, limiting training opportunities throughout the war. Poor serviceability rates lowered that number further.[60] Inspect, repair as necessary (IRAN), and modification programs would leave the training squadron with less than the optimal number of aircraft. While pilots and navigators could be trained in other RB-66 variants, the EWOs had to be trained in RB-66C aircraft, since this was the only aircraft which was configured for an instructor and students. Other ECM trainers in the USAF were owned by Air Training Command at Mather and Kessler AFBs. These EC-54s and ET-29s were used for initial training of all EWOs and thus could not be sent to Shaw. Also the equipment configurations on board the EC-54 and ET-29 aircraft did not match those of the RB-66C. In addition, the lack of a flight simulator for the EWOs in the early years of the Vietnam War years meant the 363rd TRW could only graduate minimally trained EWOs. The remainder of their training had to then be accomplished in the air war over North Vietnam. But training personnel on operational sorties within a combat zone was not conducive to flight safety and achieving optimal mission results. The units in Thailand soon devised an in-country training program which did not impede combat operations, but it did mean that some newly arrived EWOs were not operationally ready for longer periods.[61]

In 1966 the USAF redesignated its aircraft. Planes whose primary function was electronic support got an "E" prefix, while those primarily engaged in reconnaissance work received an "R" prefix. The RB-66C became an EB-66C, the "Brown Cradle" jammer B-66B became an EB-66B, and the RB-66B former photo-reconnaissance aircraft which had been converted into jammers became the EB-66E.

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[60] Telephone interview with Judge Mitchell, Stockton, Calif.

[61] 363rd Tactical Reconnaissance Wing, *History, 1 January 1966-30 June 1966; 1 July 1966-31 December 1966,* Shaw AFB, SC.

A further drain on limited EB-66C resources came early in 1968. In January Shaw deployed six aircraft to South Korea as part of the contingency operation conducted after the seizure of the USS *Pueblo*. Two aircraft returned to Shaw, but the other four aircraft remained in Japan and formed Det 1 363rd TRW. Most of the personnel were from the 4417th CCTS, the training unit at Shaw. Det 1, 363rd TRW was reassigned to the 19th TEWS in 1969, effectively removing the aircraft and personnel from Shaw.[62]

The 363rd at Shaw frantically sought ways to meet its training and replacement aircrew needs. The tour-length for EB-66 aircrews in Vietnam was one year, which required constant replacement training in the U.S. to keep the Thai-based units supplied with manpower. As crew training began to falter TAC asked the Air Staff to retrieve RB-66 photo-reconnaissance variants from storage and modify them. The Air Staff rejected the request because of the high cost involved in modifying the photo-reconnaissance airframes to the electronic version. Meanwhile, since the total world-wide requirement for EB-66s far exceeded the number of aircraft available, the other commands also had problems. Because PACAF desperately needed a continuous flow of crew replacements for Vietnam, it was the first to recommend in March 1968 that aircraft programmed for Southeast Asia be temporarily diverted to assist Shaw in training replacement aircrews. [63]

EB-66 Replacement Proposals

The future of tactical ELINT in the tactical air forces had never been clear. Back in February 1961, TAC recommended that the Air Force establish a single manager for electronic intelligence. Electronic intelligence was divided among various service organizations. The National Security Agency (NSA) at Ft Meade directed the total effort. NSA was charged with controlling all ELINT and electronic warfare efforts. The services had resisted this consolidation until 1968 when NSA eventually succeeded.[64] In fact, each overseas command (PACOM and EUCOM) maintained its own theater ELINT/COMINT capability, until that time, through the use of both transport and RB-57 aircraft. The theater commands tried to keep their aircraft up to date and equipped with the most current intercept gear, with procurement handled outside of TAC channels. SAC maintained its own ELINT structure using RB-47 aircraft. TAC maintained that a single agency needed to assume leadership for the ELINT mission and thus could provide electronic intelligence for the entire Air Force superior to that of the fragmented command efforts. The Tactical Air Reconnaissance Center at Shaw insisted that: "ELINT is a major problem confronting tactical reconnaissance today."[65]

TAC had planned since 1960 to replace the RB-66C in the tactical electronic reconnaissance squadrons. The first replacement proposal was a reconnaissance version of the F-105 designated as the RF-105 and later the RB-105. When OSD forced TAC to cut F-105 procurement and accept the F-4, the RF-4C was programmed as the long

[62] 363rd Tactical Reconnaissance Wing, *History, 1 July 1968 – 31 December 1968*, Shaw AFB, 22.
[63] TAC Command, *History 1 July 1968 – 31 Dec 1968*, Langley AFB, VA, 589.
[64] Price, 222.
[65] TAC Command, *History Jan-Dec 1965*, Langley AFB, VA, 664.

awaited replacement aircraft for the RB-66, with conversion of units programmed to begin in 1965. The overall force structure and planning for tactical reconnaissance between 1961 and 1966 had projected gradual replacement of the RB-66C. An electronic intelligence collection sensor contained in a pod had been planned but not funded for development for the RF-4C. The failure to incorporate an ELINT capability into the RF-4C mandated the continued use of the relatively obsolete RB-66C aircraft.[66]

The cancellation of the ELINT pod development was not viewed as a major setback at Langley AFB, TAC HQ, since a new fighter-bomber was being built, the General Dynamics F-111. OSD had spent years convincing Congress that the new F-111 fighter-bomber could serve both as a reconnaissance and jammer asset with a removable pallet in the bomb bay. The RF-111A/D, as this new airframe was designated, had never flown due to funding cuts in the overall F-111 program. The RF-111 variants were cancelled. TAC resurfaced the pod concept for RF-4C aircraft and loosened the specifications, but it would not be until the end of the Vietnam War that a useable ELINT pod for the RF-4C emerged.[67]

So long as the USAF was involved in Vietnam it had to continue to rely on the EB-66 fleet for electronic reconnaissance and jamming. Demands for more EB-66s were constrained by a lack of funding[68] and the Office of the Secretary of Defense (OSD) resorted to the continued modification of "outdated" airframes. Weary of spending any funds on the EB-66 while fighting for restoration of RF-111 funds, OSD directed the Air Staff to maintain the EB-66 force at its current level. This edict did not stop the Air Force from repeatedly requesting that RB-66 airframes in desert storage be converted to expand the fleet of EB-66 aircraft. OSD was certain it would eventually obtain RF-111 funding from Congress and did not want to jeopardize future procurements, even though the importance of the EB-66s had been validated during operations over North Vietnam.

Return to Germany

The loss of the EB-66B "Brown Cradle" jammers and EB-66C reconnaissance aircraft to Southeast Asia operations in 1966-67 left USAFE and NATO without any tactical electronic warfare (EW) capability. This loss also affected the NATO alliance that had no comparable aircraft within NATO that could replace the EB-66. In February 1966 Generals Gabiel P. Disosway (TAC), Hunter Harris Jr. (PACAF), and Bruce K. Holloway (USAFE) expressed dissatisfaction with tactical electronic warfare programs to HQ USAF.[69] The Southeast Asian war had depleted every command of its own EW assets and with growing threats each of these commands required an EW force to carry out its wartime missions. The generals urged the Air Staff to convert remaining RB-66

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[66] TAC Command, *History Jan-Dec 1965*, Langley AFB, VA, 786.
[67] Anthony M. Thornborough, *USAF Phantoms* (New York, NY: Arms & Armour Press, 1988), 135-36.
[68] Funding and other budgetary priorities caused the Air Staff to repeatedly turn down this suggestion. Remaining airframes were used as attrition and battle damage replacements. Parts were frequently removed to keep the remaining EB-66 fleet flying.
[69] TAC Command, *History, 1 January 1968 to 30 June 1968*, Volume I, Langley AFB, VA, 57.

(photo) and WB-66 (weather) aircraft, then in storage at Davis-Monthan, into jamming and electronic reconnaissance assets.[70]

As an interim measure, 15th Air Defense Command (ADC) EB-57s[71] used for air defense training were to be reconfigured to carry out the jamming mission for USAFE.[72] The commitment of the EB-57 assets was to last until the USAFE ECM force was reconstituted either by the return of assets from Southeast Asia or the arrival of new "Brown Cradle" jammer-modified aircraft in the theater. Under the operational codename "College Caper," the EB-57s were to periodically deploy to Europe, rather than be assigned there. The plan was to hold the EB-57 force in CONUS in standby status, ready for deployment in 72 hours.[73] ADC argued with the Air Staff and succeeded in convincing the leaders that it could not afford to give up the EB-57 aircraft. USAFE thus could not provide any ECM aircraft to alert forces, meaning that any attempt to enter Warsaw Pact airspace during hostilities would have resulted in higher than expected aircraft losses.[74] Other aircraft operating along the border of Warsaw Pact countries provided ELINT reconnaissance in peacetime.[75] It was the wartime requirement to have an escort-capable jammer aircraft to accompany NATO attack forces.

The one clear lesson from Vietnam that applied to Europe was that strike aircraft need ECM support to survive in a hostile air defense environment. But NATO was in a serious dilemma. Southeast Asian requirements had effectively deprived USAFE of the certainty of ECM protection for its assets. While the integrated air defense network in the Warsaw Pact countries had grown faster than that of North Vietnam and certainly had better and more capable systems, USAFE and the NATO alliance relied on deterrence, based on the ability to strike with nuclear weapons at targets in Eastern Europe, to preclude the Soviet Union from initiating hostilities. The removal of the ECM force from USAFE had been done in an underhanded way. The NATO Council had never been informed, and the aircrews were told they were being "temporarily" deployed to Thailand. The U.S. thus had a "credibility" problem since NATO members knew that American nuclear deterrence of the Soviet bloc would be weakened without some kind of an ECM force in place. The NATO continued to press the U.S. to demonstrate its commitment to the alliance with a redeployment of ECM assets.[76]

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[70] Soviet and North Korean SAM deployments made tactical nuclear strikes without any EW protection difficult and potentially costly. Middle East developments after the 1967 Arab-Israeli war and the War of Attrition (1969) had shown how sophisticated SAMs and integrated air defenses had evolved.

[71] The EB-57 emerged after redesign with 10 jammers in the bomb bay, chaff pods, a communications jamming capability, an X-Band countermeasure capability (for air-to-air radar work), and excellent evasive capabilities to become the premier airborne EW platform in Air Defense Command.

[72] The collection of electronic signals was being carried out by other USAFE aircraft such as the C-130B-II and EB-57F of the 7406CSS and 7407CSS. Other NATO allies also collected ELINT data for countermeasures programming.

[73] United States Air Forces in Europe, *History, 1 January 1968 to 30 June 1968*, Ramstein AB, GE, 242.

[74] Quick Reaction Alert (QRA) was a term for fighter-bombers with a nuclear strike mission held on immediate alert in NATO countries.

[75] EB-57, C-130B-II, EC-97s, and NATO assets such as "Atlantic," "Noratlas," and "Comet."

[76] TAC Command, *History, 1 January 1968 to 30 June 1968,* Langley AFB, VA, 59.

Since the issue of a USAFE owned and operated ECM force was now a diplomatic problem, other proposals were discussed. TAC proposed a dual basing scheme whereby assets from the 363rd Wing at Shaw, particularly the 4417th CCTS equipped with 12 EB-66s, would be based at Ramstein AB, West Germany for short annual exercises but remain home-based at Shaw. Under "Combat Caper," Shaw was to make three deployments a year lasting for 15 days each. Although the wing developed a plan, it was rejected prior to final approval by the Air Staff, TAC, and USAFE. The Office of the Secretary of Defense decided instead to permanently station a squadron of sixteen EB-66s in Germany by June 1969. This decision was in no small part due to the lobbying done by the joint force EUCOM commander and the NATO allies who wanted an effective ECM force in Europe.

TAC was now forced to take assets from the 363rd TRW at Shaw and deploy them to Spangdahlem AB, Germany. This meant that training of EB-66 replacement aircrew, pilots, navigators, and electronic warfare officers had to be scaled back. TAC had believed that the conflict in Southeast Asia would decrease in intensity, thus reducing the overall training burden. But when this did not occur, the deployment to Germany went ahead without additional aircraft being added to the inventory. The EB-66C fleet was spread thinner than ever before. The introduction of new surface-to-air missile systems[77] in East Germany in the mid sixties lent urgency to the EUCOM and NATO request.[78] The new European EB-66 squadron was activated as the 39th TEWS on 1 April 1969[79] and became part of the 36th TFW at Bitburg AB until the 52nd Wing was able to initiate operations at Spangdahlem AB.

The 39th TEWS had three missions: provide electronic warfare support to include jamming and threat warnings required by SACEUR and CINCEUR Strike Forces; provide an electronic order of battle for Eastern Europe; and provide ECM and ECCM training for NATO and U.S. air defense forces. Under "Combat Caper," two EB-66Cs, and four EB-66Es, were in place when squadron operations began. The unit was programmed to grow to twenty aircraft but never got past seventeen (four Cs and thirteen

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[77] SA-3 "Goa," SA-4 "Ganef," and SA-6 "Gainful" were all deployed with Soviet Forces in East Germany (see table below for further details).

[78] 39th Tactical Electronic Warfare Squadron, *History, 1 April to 30 June 1969*, Spangdahlem AB, GE, 1. This table shows the approximate introduction of SAM systems which the EB-66s were expected to neutralize through electronic jamming operations.

System	GSFG/CGF (Soviets)	East German Forces	Czech Forces
SA-2	1958	1961	1960
SA-3	1961	1970	1970
SA-4	1969	1970	1970
SA-5	1983	1983	1983
SA-6	1971	1972	1973
SA-7	?	?	?
SA-8	1976	1980	1982
SA-9	1970	1975	1976
SA-13	1981	1985	1985

GSFG = Group of Soviet Forces in Germany CGF = Central Group of Forces (Soviets in Czechoslovakia) from *Jane's All the World's Missiles 1977, 1983, 1988.*

[79] 39th Tactical Electronic Warfare Squadron, *History, 1 April to 30 June 1969*, Spangdahlem AB, GE, 3.

Es). Accidents and continued depot-level modification work at the Douglas plant in Tulsa, OK limited the number of operational aircraft. Using returning Southeast Asia personnel, the experience level in the squadron was high, but there were changes since aircraft had last been in theater.

The general complexity of the flying situation in the European area required extensive schooling and training. Borders and buffer zones abounded and all those who previously flew the EB-66 aircraft were surprised at the increase in general air traffic. On 10 March 1964 a RB-66B, the photo-reconnaissance version of the B-66, had been shot down by Soviet MiG-19s over Gardeleben near Magdeburg in East Germany. The crew of three was detained for 10 days and then released. USAF investigators determined that a malfunctioning compass and poor instructor pilot procedures had led to the overflight. A rash of similar overflights then led USAFE to impose a buffer zone along the inter-German frontier in order to prevent a reoccurrence of such incidents. Very strict aircrew requirements tended to hinder normal operations but had to be tolerated within theater. Since EB-66 crews had caused an international incident, the squadron members felt a particular responsibility to insure that there would no future violation. [80]

There was also an additional problem with tanker support. With the bulk of the KC-135 tanker fleet supporting Southeast Asian operations and the remainder of the KC-135 fleet earmarked for nuclear alert missions in the United States and overseas, only Air National Guard KC-97 tankers were available in the European Theater. Early KC-97 refuelings had been conducted at Shaw and had always been done in a descent mode to match the differing air speeds of the two aircraft. However, air space restrictions in Western Europe in the seventies prevented similar maneuvers. The EB-66 was never cleared for KC-97 air-to-air refuelings in theater and thus operated in Europe without tanker support limiting aircraft endurance. Refueling training and operations could thus not be carried out in Europe and pilots were rotated to Shaw to maintain proficiency.[81] Since in-flight refueling was a major component of successful air operations over North Vietnam, pilot proficiency was required so pilots from the 39th TEWS could reinforce aircrews in Thailand. The 39th TEWS was also frequently tasked to send personnel to Southeast Asia to make up for aircrew shortages.

The USAFE EB-66s flew NATO training sorties under the codename "Creek Girl." These were similar to air defense training missions known as "Dancing Girl"[82] and were flown thoughout Europe and the Mediterranean regions.[83] "Creek Girl" missions provided ECM training to fighters and radar operators. Both U.S. and NATO countries participated in these missions, which were highly successful since they allowed personnel to train in realistic ECM environments. The EB-66Es would lay chaff corridors as they did over North Vietnam and use internal jamming equipment to blanket radar screens and radar equipment on board opposing fighter aircraft.

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[80] 39th TEWS, *Unit History, April 1969-30 June 1969*, Spangdahlem AB, Germany, B-5-61. Additional information is in Commander's Summary.
[81] Ltr Request for Guidance, dated 25 August 1969 from 36 TFW/DO to USAFE/DO.
[82] See Chapter 5.
[83] 52nd TFW, *Unit History,1 July 1972-31 December 1972*, Spangdahlem AB, Germany, 13.

Other electronic jamming training sorties operated from Athinai AB, Greece where a combined RF-4C/EB-66C mission was conducted in February 1972 for CINCSOUTH to monitor Soviet ship movements. Other deployments in 1972 operated from Souda Bay, Crete and Torrejon AB, Spain. Simulating TU-16 Badgers, a Soviet naval attack bomber, the EB-66Es conducted mock strikes against the US Navy's Sixth Fleet. At least 40 sorties a month were flown against NATO air defense installations from Norway to Turkey, allowing controllers and aircraft to experience jamming operations on a first hand basis.

The operational pace of these activities could not be sustained, however, because lack of spare engines and hydraulic system components frequently grounded the aircraft. The EB-66 fleet in Europe suffered from the same maintenance problems encountered in Thailand. In addition, aircraft and personnel demands by the 42nd TEWS in Southeast Asia kept the unit from achieving operational ready status and soon personnel were being sent back to Thailand to support operations in that theater. Increased doubts as to whether escort or stand-off jamming would be available to support USAFE's alert force also contributed to TAC's decision to inactivate the 39th TEWS on 31 January 1973.[84]

The integrated air defense environment in East Germany had become so dense with overlapping radar coverage in all frequency bands, that Air Force planners began to wonder if the EB-66 force would be able to blind even a small portion of that formidable radar network. Operations over North Vietnam had shown that a combination of tactics, such as dropping chaff and making numerous aircraft orbits, could disrupt hostile radar systems. Still the question remained as to whether such defenses could be overwhelmed in Europe. Supporting two theaters simultaneously, however, was simply beyond the capability of the depleted EB-66 fleet. The 39th TEWS had been repeatedly tasked to send aircrews and maintenance personnel to Southeast Asia. Aircraft had also been sent as the North Vietnamese launched its 1972 Easter offensive requiring electronic assets to protect U.S. aircraft. With the Air Staff repeatedly denying requests to activate more aircraft from storage at Davis-Monthan, TAC saw no alternative but to close the 39th TEWS in West Germany. The Air Force also believed that the jamming pods, then being used over North Vietnam to protect tactical aircraft from terminal threats close to their targets, would be made available later to USAFE and could provide sufficient protection for the alert force. Although deactivated in Europe, the 39th reappeared in January 1973 as the 39th Tactical Electronic Warfare Training Squadron (TEWTS) when the 4417th CCTS was redesignated as the 39th TEWTS at Shaw.[85]

Operations at Shaw AFB 1969 – 1974

Activities at Shaw became more demanding as the Vietnam War continued. Deployments around the globe decreased the already small number of available aircraft. In 1969 relief was briefly in sight with a decrease in flying activities in Southeast Asia.

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[84] 39th TEWS, *Unit History, 1 July 1972 - 31 December 1972*, Spangdahlem AB, Germany, 22 and Commander's Summary.
[85] TAC History, *1 July 1972 - 31 December 1972,* Langley AFB, VA, 733.

TAC hoped that some of its resources would be returned allowing maintenance and flying activities to be reduced. Although scheduled to phase out around 1970, the EB-66C's operational life was again extended. Still, like other EB-66s (B/E jammer models), the aircraft would no longer be modernized and would have to be maintained through standard maintenance procedures. This meant that Shaw's maintenance capabilities were taxed to conduct frequent overhauls to keep the airframe and electronic components in an operational status.

Meanwhile, the command found it difficult to support the Spangdahlem squadron, the 39th TEWS. TAC again asked for additional airframes to increase the EB-66 fleet. Since the request was turned down again, TAC reiterated that contingency support commitments to Europe and Korea would have to be scaled back. Both the Air Staff and OSD refused to make funding available to allow more EB-66s to be added to the inventory, primarily because Vietnam and the F-111 project were consuming a larger portion of the TAC budget than anticipated.

The war in Southeast Asia however took another turn in October and November 1970. TAC sent seven EB-66s from Shaw to Korat to the 42st TEWS. These jammer aircraft supported increased air operations over Cambodia and Laos. North Vietnamese forces were also moving radar-guided air defenses to their troops inside South Vietnam, and Seventh Air Force at Tan Son Nhut needed additional reconnaissance assets to track movements. The deployment of these aircraft forced the 39th TEWTS at Shaw to suspend the flying portion of the electronic warfare officer classes. The unit deployed an additional four EB-66s in March 1971 to Thailand, adding to the training delays encountered. In June 1971 the four EB-66s returned from Southeast Asia and the squadron was able to gain a further five aircraft from depot maintenance in Tulsa to enhance its training mission.

In mid-1971, as a cost-savings move and in preparation for the final phase out of the aircraft, TAC planned to reduce combat crew training on the EB-66 and to end it completely one year later. In the interim PACAF would handle the training of EB-66C crews until TAC received the aircraft which were being returned from the 39th TEWS at Spangdahlem, Germany. TAC would then resume training of EB-66C and E personnel, and assume the responsibility for contingency operations. The Air Staff and TAC both believed that the EB-66s would not have to be sent back to Southeast Asia. However, maintenance problems in Thailand, and continued B-52 commitments over Laos and South Vietnam, forced TAC to send two EB-66Cs in November 1971. "Linebacker" operations in 1972 then required an even larger number of aircraft to support those activities.

The continued deployment of 363rd TRW resources to Southeast Asia had a dramatic impact as the war continued. On 4 April 1972 TAC suspended flying training for EWOs after the last EB-66C at Shaw was transferred to Korat. Simulators were used to make up some of the lost training. A heavy burden fell to the 42nd TEWS in theater, however, because EWOs were only able to receive their 11 training sorties in a combat

environment. On 5 April 1972 eight EB-66E jammers from Shaw were deployed to Korat to meet the growing demand for Linebacker and "Arc Light" operations.

The discovery of extensive internal corrosion in most EB-66 aircraft increased the level of maintenance operations at Shaw beginning in 1973. Repair of the corroded airframes was deemed to be uneconomical and too manpower-intensive. A swap-out of airframes began between Shaw and those in storage at Davis-Monthan. The refitting of stored airframes at Shaw added to the strain on the maintenance manpower and reduced the number for the operational fleet. Other B-66 airframes, former bombers and photo-reconnaissance variants, pulled from Davis-Monthan required modification to EB-66E Standard at the Douglas Tulsa facility. This trading of corroded for stored airframes, without increasing the overall number in the Air Force, was initiated to sustain the EB-66 fleet at its authorized level. Shaw also began overhauling the returning Southeast Asia aircraft in order to boost the number of operationally ready aircraft. Cannibalization of aircraft became an operational necessity at Shaw in 1971. [86]

Extended well past their projected service life and increasingly uneconomical and expensive to maintain, the EB-66s continued to fly with 363rd TRW at Shaw and in Southeast Asia. TAC shifted to a RF-4C reconnaissance force and believed that ELINT sensors for the RF-4C, under development, would soon be ready for production. The command had to wait until the air war in Southeast Asia completely ended before disposing of the EB-66 force since it still lacked any other ELINT collector and jammer. Future fighters under development were now programmed to carry either internal electronic countermeasures, jamming gear, or rely on a new family of pods, which could effectively jam enemy radars.

Training sorties at Shaw and missions over Southeast Asia continued until 1973. On 15 March 1974, with American forces now gone from Vietnam, Laos, and Cambodia, TAC retired the last Air Force EB-66, a C model at Shaw. With the retirement of the EB-66 the USAF was bereft of tactical electronic warfare assets for jamming or collection operations.[87]

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[86] 363rd Tactical Reconnaissance Wing, *History, 1 July 1971 – 31 December 1971*, Shaw AFB, 7.
[87] 363rd Tactical Reconnaissance Wing, *History, 1 January 1974 – 31 July 1974*, Shaw AFB, 1, 14.

5. The Perspective from the Pacific and Europe (1956 – 1965)

The overseas based tactical air forces, Far East Air Forces (FEAF) later renamed Pacific Air Forces (PACAF) and United States Air Forces in Europe (USAFE), needed electronic reconnaissance aircraft that, in peacetime, could fly peripheral missions close to communist countries' borders. In wartime the mission would change to overflying the battlefield and gathering data on enemy radars which challenged strike aircraft, as well as escorting American forces to their targets.

PACAF

In 1957 PACAF assigned twelve RB-66Cs to the 11th Tactical Reconnaissance Squadron (TRS), part of the 67th Tactical Reconnaissance Wing (TRW) stationed at Yokota Air Base, Japan.[88] Its function was to patrol along the east and west coasts of Korea, watching North Korean radar deployments and monitoring any truce violations. With the arrival of the more capable RB-66C, the mission expanded to include peripheral reconnaissance of the Soviet Pacific coast and the Chinese Yellow Sea coast.[89] The 11th TRS flew its first RB-66C mission on 30 January 1958 along the Soviet coast. These missions had previously been flown at night for security reasons and to give the piston engined RB-26 some protection from Soviet interceptors. The first daylight mission by the RB-66C proved uneventful, but, on subsequent missions, Soviet air activity increased. Soviet MiG-17s would come within fifty feet of the RB-66C trying to observe and photograph the aircraft.[90] Collected data allowed PACAF, which had also established an ELINT evaluation center at Yokota AB, to keep tabs on radar developments in the Soviet Union and China.

Interesting missions were attempts by the Air Force to gain reconnaissance data on Soviet aircraft transiting Japanese airfields. On 21 May 1958, two RB-66Cs conducted a sensitive reconnaissance mission against two Tu-104s at Tokyo International airport. The Tu-104 "Camel" was the civil transport derivative of the Tu-16 Badger medium bomber. It had a new fuselage and was used by the Soviet Air Force for VIP transport. The similarities between the bomber and transport were close enough that the US tried to learn everything it could about these two Soviet aircraft.[91] Unfortunately not much was learned during these and other missions against transiting Soviet aircraft landing in Japan.

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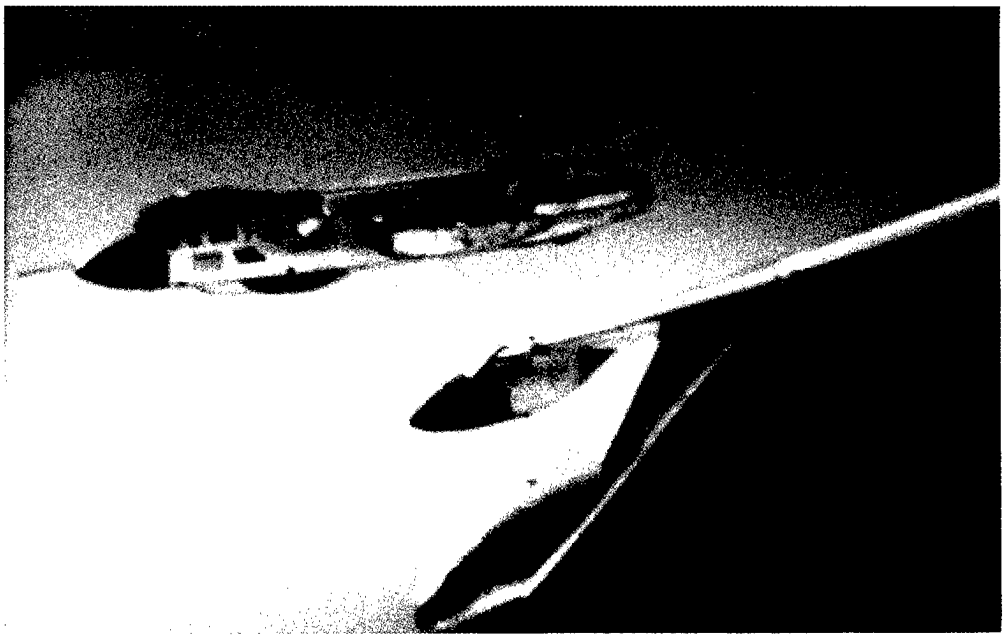
[88] 11th Tactical Reconnaissance Squadron (E&W), *History, 1 July 1957-31 December 1957*, Yokota AB, Japan, 13.
[89] Pacific Air Forces, *History, 1 July 1957-31 December 1957,* Hickam AFB, HI, 105-106.
[90] Lusk, 66.
[91] 11th Tactical Reconnaissance Squadron (E&W), *History, 1 January 1958-30 June 1958*, Yokota AB, Japan, 33.



Courtesy of Colonel K. Taylor, USAF Ret.

Figure 3. Two RB-66Cs based with the 11th TRS Yokota AB, Japan on an operational training sortie.

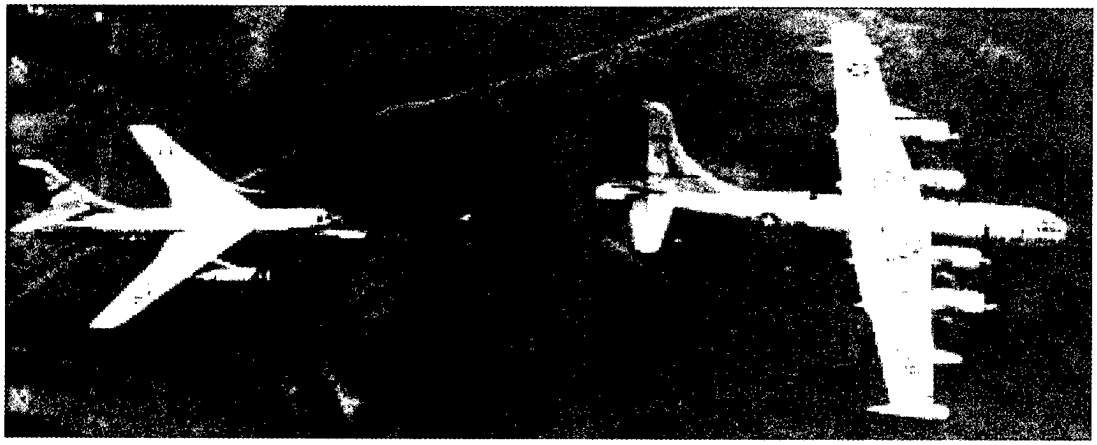
Daytime missions did not provide the electronic reconnaissance data that was hoped for. Soviet and Chinese radar operators turned off their systems in daylight hours and may have been alerted to the presence of the RB-66C aircraft. Then nighttime sorties were scheduled in order to increase collection times and to provide greater operational range. Silent night rendezvous with KB-50J tankers were conducted.[92] Silent night rendezvous were mid-air refuelings in which neither the receiver nor the tanker used radios, or beacons to find each other and thus alert the enemy. In addition neither aircraft used external lights and the hookups were done in the dark. The RB-66C operated from different Japanese bases such as Kadena, Misawa, and Itzauke to improve its collection opportunities against Chinese and Soviet targets. Tanker support allowed operations to range in the western Pacific as far south as Vietnam. As a result, the squadron conducted regular patrolling from the Kamchatka peninsula to the Gulf of Tonkin gathering electronic intelligence.

Operations were not without risk. Missing a tanker rendezvous in the Yellow Sea proved fatal for one RB-66C on 15 November 1959. Another, diverting to Osan Air Base, Korea, after missing its KB-50J tanker, crashed on approach killing three of the seven crewmen on board. There were also close calls:

[92] 11th Tactical Reconnaissance Squadron (E&W), *History, 1 January 1958-30 June 1958*, Yokota AB, Japan, 42.

We normally used the tail drogue of the KB-50.[93] Before a positioning flight from Clark AB to Kadena AB I learned that a KB-50 would be on a test-flight over northern Luzon and we coordinated a practice refueling from a wing drogue. I found that when refueling that soon after takeoff we were so heavy that normal refueling airspeed, 210 knots at 20,000 feet put us behind the power curve. I had to call for him to start a 500 feet a minute descent in order to refuel.

On another mission from Yokota AB to Clark AB with refueling west of Kadena AB I elected to use a wing drogue on the KB-50. Refueling went smooth but before we were abeam of Hong Kong I had a severe headache from carbon monoxide introduced into our cabin air from the wing jet on the KB-50. By the time for approach to Clark AB I was so ill that I declared an emergency and asked that a Flight Surgeon meet us. I flew a normal overhead approach, pitched out to downwind, lowered the gear and flaps and was in the final turn when the aircraft starting dropping. I applied full power, reduced the bank and gave the tower a close buzz on the missed approach. It was apparent that the flaps did not come down. We circled to downwind as I instructed the navigator to get unstrapped and prepare for a manual lowering of the flaps. The crew was warned that once the flaps were manually lowered we were committed to land. We touched down for a normal roll. We must have looked weird to the crash rescue crew and medical team when seven aircrew exited what appeared to be a three man aircraft. A strong shot of codeine got me through the debrief. When I went to operations [the next day] to file an incident report about the perils of refueling from a wing drogue, I received an emergency tech order change advising all B-66 operators to add an item to their in-flight refueling checklist: "Instruct aircrew to go to 100% oxygen."[94]



USAF Picture

Figure 4. A B-66B "Brown Cradle" being refueled by a KB-50 over the United Kingdom.

These aerial reconnaissance missions continued until the squadron was deactivated on 8 March 1960 and the RB-66Cs returned to the United States.[95] The deactivation left PACAF both in Korea (Fifth Air Force) and the Philippines (Thirteenth

[93] KB-50s were equipped with three drogues one--under each wing and one from the tail. Jet engines were added to the propeller-driven aircraft to give them more speed and allow for heavier takeoffs.
[94] E-mail from Colonel Arthur Taylor USAF (Ret) 26 October 1999.
[95] 67th Tactical Reconnaissance Wing, *History, 1 January 1960 –30 June 1960*, Yokota AB, Japan, 9.

Air Force)[96] without any tactical electronic reconnaissance units. The removal of the RB-66C from Japan can be explained in a variety of ways. SAC, eager to obtain its own electronic intelligence data, flew RB-47Es out of Yokota. Competition between SAC and tactical air forces was intense after the Korean War with each trying to claim a larger portion of the shrinking aircraft budget. The RB-66Cs and RB-47Es had the same electronics capability, but due to the size of the aircraft and location of the receiver antennas, the RB-47E had better electronic mapping capabilities.[97] Other factors such as range limitations and the need for in-flight refueling by the RB-66Cs played a role in the decision. The planned retirement of the RB-66C fleet from the entire Air Force inventory also helped to expedite the phase-out of PACAF's RB-66Cs. Making that decision easier was the availability of another Fifth Air Force asset, the RB-50G.[98] This platform carried more personnel and was considered more stable than the B-66, however it is impossible to make any comparison since the "intelligence take" of both platforms is still classified.

USAFE

In Europe, as in the Pacific theater, a large tactical air force faced the Soviet Union and its client states. To keep tabs on deployments, developments, and force dispositions the U.S. launched a comprehensive multi-service reconnaissance effort along the borders of the Soviet satellites in Europe. The 42nd Tactical Reconnaissance Squadron of the 10th Tactical Reconnaissance Wing stationed at Spangdahlem, AB Germany flew these tactical electronic reconnaissance missions. In 1956 the first RB-66C arrived replacing the RB-26s in squadron service.[99] A lack of qualified pilots, however, curtailed flying the jets until 1957. By 31 December 1957 the squadron received its full complement of twelve RB-66Cs and began conducting missions along the East German and Czechoslovakian borders, with most attention devoted to signals considered new or of unusual nature. The aircraft also deployed to Italy to conduct missions along the borders of Albania and Yugoslavia.[100]

In 1959 President DeGaulle of France declared as "unwelcome" US aircraft with nuclear capability on French soil. The resulting USAFE force shifts sent the 10th TRW to the United Kingdom where it occupied a three-base complex in East Anglia.[101] The 42nd TRS with the RB-66Cs went to RAF Chelveston. The increased distance to the Warsaw Pact borders and air traffic control procedures over England only allowed for one hour of actual reconnaissance out of a three-hour mission. To increase sortie time,

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[96] Missions against mainland China (People's Republic of China) were conducted under the auspices of Thirteenth Air Force headquartered at Clark AB, Philippines, using nationalist Chinese (Taiwan) air force assets. The RB-57, U-2, and an assortment of other aircraft were used to conduct reconnaissance over China.

[97] Price, 179.

[98] These aircraft were credited with a COMINT/ELINT capability See Martin Streetly, *All the World's Electronic Warfare Aircraft* 1988.

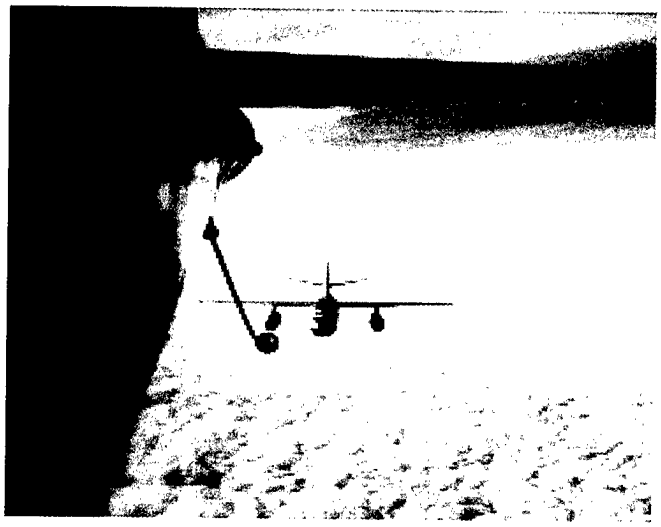
[99] 42nd Tactical Reconnaissance Squadron, *History, 1 April 1957-30 June 1957*, Spangdahlem, Germany, 5.

[100] 42nd Tactical Reconnaissance Squadron, *History, 1 October 1957-31 December 1957*, Spangdahlem, Germany, 4-6.

[101] The Wing HQ and one squadron were at RAF Alconbury, and one squadron went to RAF Buntingthorpe and one to RAF Chevelston.

the airmen employed KB-50 refueling beginning in October 1959.[102] Weather and maintenance problems with the tankers plagued these refueling missions forcing numerous cancellations.

With KB-50 refueling plans problematic USAFE started using advanced bases to extend endurance. The 42nd TRS began landing at Toul-Rosieres AB, France starting on 20 Oct 1960. This break in the mission increased on-station times by 2 hours.[103] The round-robin operation continued until July 1962 when the 42nd TRS permanently moved to Toul-Rosiers AB.[104] The reassignment increased mission times further. The squadron again moved on 1 July 1965 to Chambley AB, France where it also changed wing assignments to the 25th TRW.[105] On 1 April 1967 President DeGaulle ordered out of France all U.S. and NATO forces. By this time the 42nd TRS had been depleted of aircraft and personnel for the Southeast Asia conflict.[106] It was no surprise that, on 20 August 1967, the squadron was deactivated in place and the remaining personnel sent to Shaw.[107]



USAF Picture

Figure 5. A B-66 approaches a KB-50 over the North Sea for aerial refueling.

[102] 42nd Tactical Reconnaissance Squadron, *History, 1 January 1960-30 June 1960,* RAF Chelveston, UK, 2.
[103] 42nd Tactical Reconnaissance Squadron, *History, 1 July 1960-31 December 1960,* RAF Chelveston, UK, 2.
[104] 42nd Tactical Reconnaissance Squadron, *History, 1 January 1965-30 June 1965,* Toul-Rosieres AB, France, 2.
[105] 42nd Tactical Reconnaissance Squadron, *History, 1 July 1965-31 December 1965*, Chambley AB, France, Foreword.
[106] 25th Tactical Reconnaissance Wing, *History, 1 January 1966-30 June 1966*, Chambley AB, France, Introduction.
[107] 25th Tactical Reconnaissance Wing, H*istory, 1 July 1966-15 October 1966*, Chambley AB, France, 5.

USAFE also conducted some unique electronic warfare activities with RB-66B photo-reconnaissance aircraft. To test the ability of U.S. and allied air and air defense[108] forces to function in an electronic countermeasures environment, RB-66Bs, originally configured for photo-reconnaissance missions, were re-equipped with electronic countermeasures gear. An ECM tailcone replaced the tail gun turret. The USAF purchased these tailcones to increase the self-protection capabilities of any variant of the B/RB-66. It contained two jammers and a chaff discharge hopper. The modification also aided aircraft performance, increasing the speed of a RB-66B by 15 knots and range by 115 nautical miles.[109] The aircraft could create an electronic curtain or wall with jamming transmitters and chaff, making it difficult for air defense fighters and radar operators to accurately locate their target. After initial operations with the Luftwaffe, other NATO allies wanted their fighters and radar crews tested. The project was codenamed "Dancing Girl."[110] The official purpose according to the 10th TRW history was to familiarize aircrews, and exercise and evaluate friendly air forces in a simulated wartime environment.

This project grew each year. The US Sixth Fleet based in the Mediterranean used the RB-66B jamming capabilities, as did non-NATO countries, such as Spain and CENTO nations.[111] These operations led to problems when RB-66B navigators did not properly factor in wind speed and direction prior to chaff drops. Chaff drifted across international borders, in one case blinding airport radars in Zurich, Switzerland. Most air forces were enthusiastic about the training, which improved electronic warfare capabilities of the NATO alliance. These exercises, especially those in West Germany, were observed by the Soviets in East Germany. Monitoring electronic warfare exercises gave them an idea of NATO and USAF capabilities and may have served as a deterrent towards Soviet aggression and/or spurred on electronic warfare developments in the Soviet Union. The "Dancing Girl" program had ended in 1965 when the RB-66 photo-reconnaissance aircraft carrying the ECM tailcone were withdrawn in preparation for RF-4C replacement. By 1966 there were no RB-66 assets in Europe.

USAFE flew the special jammer variant of the B-66, the B-66B "Brown Cradle" jammer.[112] These aircraft were not given an RB designation because they were still part of the tactical bombing force. The change in designation only came in 1967 when the Air Force redesignated assets by the primary mission performed. The 13 B-66B "Brown Cradle" jammers were assigned to the 47th Bomber Wing[113] at RAF Sculthorpe, but moved to the 42nd TRS at RAF Chelveston in 1959. The jammers gave the wing the capability to escort USAFE fighter-bombers. In order to make use of this new capability some of the aircraft were placed on 15 minute "Echo" alert at the forward base in Toul-Rosieres AB, France. Their wartime mission was to escort nuclear bomb carrying

[108] In the 1960s NATO USAFE provided the bulk of the strike aircraft (fighter-bombers) while the NATO allies, who were still building up, provided most of the air defense assets of the alliance.
[109] Seefluth, 76.
[110] Personal interview with Col (USAF Ret) Willi Bruenner.
[111] CENTO was made up of Turkey, Pakistan, Iran, Iraq, and Great Britain, with the US as an observer.
[112] See Chapter 4, "The Perspectives from Shaw AFB," on development of the B-66B "Brown Cradle."
[113] The only B-66 bomber wing, retired in 1959 due to slow speed, was replaced by the F-105 in a fighter-bomber role.

fighters stationed in West Germany behind the Iron Curtain and jam any radar that could track the fighters.

Testing the jammer was a challenge. As there was no way to test the twenty-three jammers on board a B-66B "Brown Cradle" without disrupting every radar in the area, technicians devised a system of airborne testing using the RB-66C as the test-set. Before an aircraft went on alert, all jammers were preset to known Soviet frequencies. This was done on the ground as there was no way to tune jammers in the air. The B-66B accompanied by a RB-66C would fly at least 200 miles away from the British Isles. Each jammer was turned on one by one, while the RB-66C checked the jammer output and antenna pattern by intercepting the signal and flying around the "Brown Cradle" aircraft. Test completed, the B-66B would fly to Toul-Rosiers AB for alert duty.

When air operations over North Vietnam began in 1965 PACAF had no tactical electronic warfare assets. After TAC had sent its deployable assets from Shaw, USAFE was ordered to send its reconnaissance and jammer aircraft. The 42nd TRS aircraft, B-66B "Brown Cradle" and RB-66Cs, were deployed against the desires of USAFE and EUCOM.[114] Both commands opposed withdrawing any asset from Europe while the Soviet Union and Warsaw Pact continued to improve and expand their force posture in Central Europe. USAFE also believed a dangerous precedent would be set if one geographic command could withdraw assets from another, even with Joint Staff concurrence. The fact that the NATO alliance was never formally informed of the withdrawal action also led USAFE to fear that alliance partners would withdraw assets from the overall NATO command structure.

The redeployment of the B-66B "Brown Cradles" was so sensitive that five aircraft were sent in the first wave followed by the other eight, all operations conducted at night, and aircrews not told about the redeployment to Southeast Asia until they reached the United States.[115] USAFE maintained that the "Brown Cradle" aircraft would return soon, and actually operated a TDY structure in Thailand until 1966. It was designated Det 1, 25th TRW. PACAF, however, had no intention of releasing these valuable aircraft and simply integrated them into the 41st Tactical Reconnaissance Squadron. The thirteen B-66B "Brown Cradles" were the only true tactical jammers in the entire Air Force inventory at that time. With their departure USAFE and the NATO allies had nothing equivalent to put forth. While HQ USAF offered ET-29 and EC-54[116] aircraft in exchange for the RB-66C and B-66B "Brown Cradle," these were hopelessly inadequate to escort wartime strike missions.

[114] EUCOM= European Command, the joint US commander in Europe.
[115] Letter from Lt Col (Ret) Joseph Swiney, 7 February 2000, Bluff City, Tennessee.
[116] Both these aircraft were used in training EWOs in CONUS and could have preformed a limited reconnaissance function.

6. Rolling Thunder 1965-1968

The Pacific Theater commander, CINCPAC, made a number of requests for electronic warfare aircraft. An earlier request in 1964 to send RB-47Hs, a SAC strategic electronic reconnaissance aircraft, was denied, as noted in chapter 2, because of the implications of employing a strategic bomber in a "brush war."[117] As American air operations in Vietnam increased in 1964, CINCPAC asked the JCS to deploy RB-66Cs to Clark AB, Philippines. Then in April 1965 with the commencement of "Rolling Thunder" operations over North Vietnam, the Air Force sent two RB-66Cs from the 9th TRS at Shaw to Tan Son Nhut AB, outside of Saigon, South Vietnam. In May 1965 the USAF moved two RB-66Cs at Tan Son Nhut plus four more RB-66Cs sent from Shaw to Takhli. In September 1965 three more RB-66Cs arrived. These nine RB-66Cs formed the 41st TRS that provided the initial electronic intelligence gathering and jamming coverage for F-105 fighter-bombers striking at North Vietnam.[118] This deployment also exhausted the pool of deployable C models in the United States. The remaining C models in the USAF inventory were used for training at Shaw, remained in long-term depot maintenance, or belonged to USAFE's 42nd TRS.

In March 1965 the newly redesignated EB-66Cs[119] joined strike aircraft flying into "the most sophisticated defense system the United States has ever flown against."[120] In April 1965, as air strikes got underway, photo-reconnaissance detected two SA-2 SAM sites under construction near Hanoi. By June 1965 the Vietnamese had almost completely encircled Hanoi with a defensive SAM system. By mid July electronic intelligence collected by an EB-66C identified a "Spoon Rest" SA-2 search radar, and on 23 July 65 an EB-66C intercepted "Fan Song" missile guidance radar emissions in the Hanoi area. The following day a SA-2 shot down an F-4C.[121] This was the infamous SA-2 codenamed "Guideline." The Vietnamese organized the SAMs into batteries composed of six launchers with one missile per launcher with 2 or 3 ready reloads held on the site. The sites had earthen revetments and a system of roadways that gave a "Star of David" pattern. Radars in the SA-2 system included a Fan Song E-Band fire control radar, a P-12 Spoon Rest A-Band Acquisition radar, a P-15 "Flat Face" long-range search radar, and a PRV-11 "Side Net" height finder radar. The Fan Song fire control and acquisition radars were the minimum required to operate a site. However, the other radars helped refine the air picture and provided better and more precise data to SA-2 batteries allowing for a

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[117] LtCol Robert Burch CHECO Report, *Tactical Electronic Warfare Operations in SEA 1962-1968*, 10 Feb 1969, 27.

[118] Moore, 19-20.

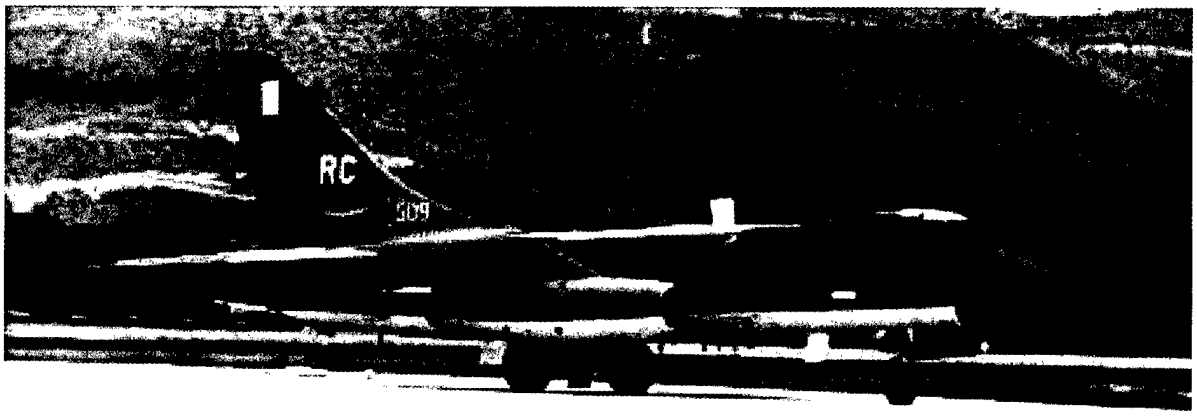
[119] In order to avert some confusion the Air Force redesignated its reconnaissance assets in 1966. The R prefix now encompassed photo or infrared reconnaissance aircraft, while aircraft engaged in electronic activity were given the E prefix, hence the RB-66C became an EB-66C and the B-66B "Brown Cradle" jammers became EB-66Bs. Later modifications of about thirty-six B/RB-66s already in storage at Davis Monthan AFB would become EB-66E. Some WB-66D weather reconnaissance aircraft were also modified to jammer configuration. These became EB-66Es but some Air Force records also carry them as EB-66Ds.

[120] CHECO Report, *Tactical Electronic Warfare Operations in SEA*, 1962-1968, 18.

[121] CHECO Report, *Tactical Electronic Warfare Operations in SEA*, 1962-1968, 19.

better fire control solution and thus were deployed with each SA-2 battery. The missile had a maximum effective range of 20 miles.[122]

The growth of the North Vietnamese radar system was documented by the EB-66C fleet deployed in Thailand with the 41st TRS. The North Vietnamese built a layered, in-depth integrated air defense system (IADS) in a relatively short time. On 31 August 1964, only six fire control radars had been confirmed in North Vietnam, with an additional seven suspected. By September 1965, a year later, there were 96 confirmed radars including 56 early warning and 28 fire control radars with eighteen others of various types suspected. By August 1966, the North Vietnamese air defense network was made up of 271 radars of all types. In 1967 the system included 450 radars and provided complete early warning coverage of North Vietnam and peripheral areas. Ground Control Intercept radar coverage used to guide MiG fighters had steadily improved and then encompassed most of North Vietnam.[123]

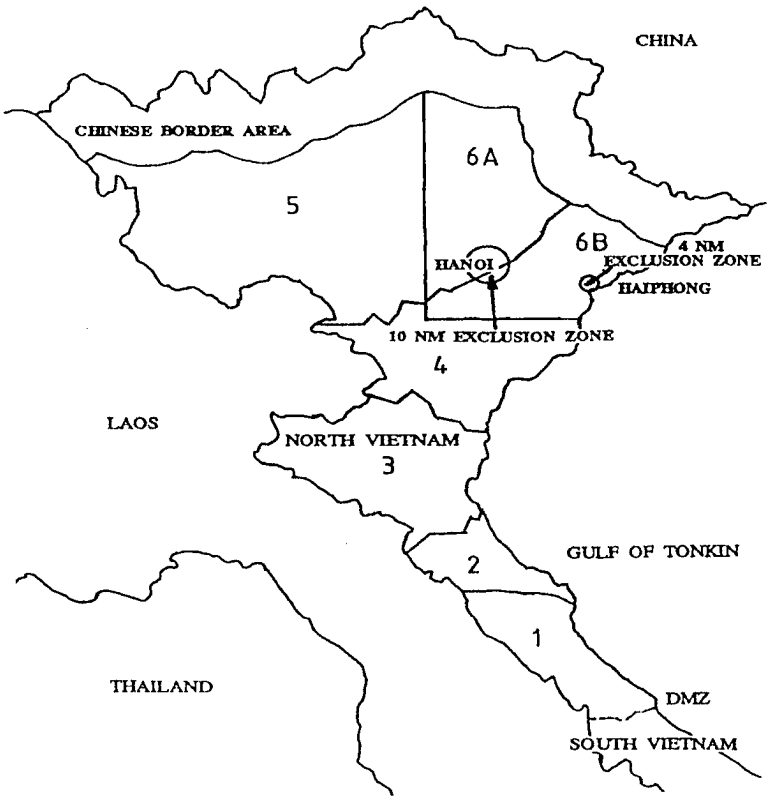


Courtesy of Lt Col Jack Sullivan, USAF Ret

Figure 6. An EB-66E taxing after landing at Korat RTAFB. The antennas below the fuselage were used by the on-board jammers.

[122] Steven J. Zaloga, *Soviet Air Defence Missiles. Design, Development and Tactics* (Alexandria, VA: Jane's Information Group, 1989), 55-57.

[123] 41st Tactical Reconnaissance Squadron, *History, 1 January 1966-30 June 1966, 1 July 1966-18 September 1966, 18 September 1966-31 December 1967, 1 January 1967-30 June 1967, 1 July 1967-30 September 1967, 1 October 1967-31 December 1967*, Takhli AB, Thailand.



AU Map Collection

Figure 7. This map shows the route packages that divided North Vietnam.

In addition to the SA-2 system, U.S. aircraft faced anti-aircraft guns that ranged in caliber from 12.7 mm to the huge 130mm. The radar fire control systems associated with large caliber anti-aircraft artillery (AAA) provided coverage over most of North Vietnam including the Demilitarized Zone (DMZ).[124] The AAA was a major threat to US fighters at low and medium altitudes. The SAM system also degraded air operations. It presented a threat at medium and high altitudes, which forced strike aircraft to lower altitudes where they faced intense automatic and small arms fire. This, in turn, degraded bombing accuracy and seriously impeded reconnaissance efforts. Air operations in SAM defended areas were restricted to visual flight conditions to allow a pilot to see a missile launch. Visual detection and evasive maneuvers rather than electronic detection were the order of the day. This proliferation of radar-controlled SAMs and heavy caliber AAA made it obvious that tactical electronic warfare aircraft were required to support air operations.

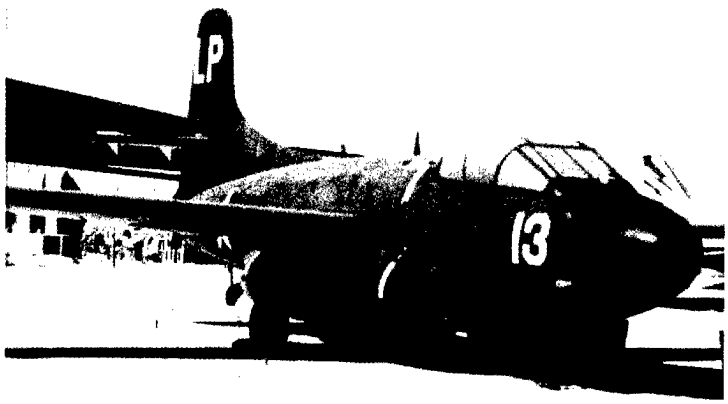
In response to communist radar deployments, initially Marine Corps and Navy aircraft conducted the bulk of the radar jamming missions until the USAF EB-66Bs arrived at Takhli in October 1965.[125] The EB-66Cs carried out reconnaissance missions in 1964-65. Each of the three carriers in the Gulf of Tonkin carried a 4-plane electronic

[124] 23mm and larger caliber had radar gun-laying radars usually a Fire Can radar.

[125] Designation of the B-66B "Brown Cradle" aircraft assigned to 42nd TRS in France and moved to Thailand.

warfare detachment, equipped with either the EA-3B Skywarrior,[126] the Navy version of the B-66, or the EA-1B Skyraider, a single-engine piston-driven aircraft.[127]

The Marines provided electronic warfare support to air operations over North Vietnam from Da Nang AB, South Vietnam with the EF-10 "Skyknight," that had seen service in Korea.[128] During the spring and summer of 1965, the EF-10B[129] usually laid down jamming barrages for Air Force strikes against the North.[130]



Author's Photo

Figure 8. An EF-10 on display at the Pima Air Museum. A two-seat night-fighter, it carried out jamming over North Vietnam at the start of Rolling Thunder.

The Skyknight had two spot jamming[131] transmitters in the fuselage and carried an external pod with four noise[132] and deception[133] jammers; it also carried an external

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[126] The EKA-3Bs, Tanker, Countermeasures or Strike (TACOS), were the most effective jammers in 1967 due to their steerable antennas, which, being highly directional, concentrated jamming support to a specific area. EB-66Cs were not able to do this until modified.

[127] John T. Smith, *Rolling Thunder. The American Strategic Bombing Campaign Against North Vietnam 1964-1968* (St. Paul, MN: Phalanx Publishing Co. 1994), 295-96.

[128] As a night fighter it was retired from the Navy but went on to serve in the Marine Corps in Vietnam until the arrival of the EA-6A in VMCJ-1.

[129] Ten aircraft assigned to the squadron VCMJ-1. On an average day five aircraft would be required for sorties over the Gulf of Tonkin.

[130] Smith, *Rolling Thunder*, 72.

[131] Spot jamming involves knowing the exact enemy operating frequency before the start of a mission, which is where ELINT (the collection and analysis of radar signals) is employed. Alternatively, spot jamming uses a receiver and signal processor to detect the signal, then tunes the jammer to its frequency and jams it, causing the radar operater's screen to go blank. Swept-spot jamming occurs when the jammer scans through a band of enemy frequencies and then jams according to threat priority or EWO's input.

[132] Radar signals use a lot of energy in the process of travelling to and reflecting from, the target, so it is a relatively simple matter to drown them out with artificially created noise. Some noise jammers are set to operate on a single frequency used by the hostile radar, while others spread out their energy over a band of frequencies in a technique known as barrage jamming.

[133] Deception jamming provides hostile radar with false target data. This involves receiving the signal from the radar, processing it in some way, then re-transmitting it in an attempt to persuade the radar to accept the false signal and derive false range and bearing information from it. It will cause the enemy's radar to lose its lock on a target.

fuel tank and chaff dispenser. The old Marine aircraft had limited effectiveness, since it lacked the jamming power of even an EB-66C and the speed and maneuverability of newer jet aircraft. The Skyknights were forced away from land and into the Gulf of Tonkin by fall 1965 due to growth of the SA-2 threat in the Red River delta region. But this orbit was too far from inland targets for effective jamming. The EB-66Bs and Cs had several advantages over the Skyknights. They were air refuelable and carried more jamming transmitters: nine in the C model and twenty-three in the B model. Compared to the Marine Skyknight the EB-66C also had extensive intelligence gathering equipment.

The original mission of the EB-66C was in performance of the classic electronic reconnaissance role. It gathered ELINT data for the identification, analysis, and location of radars making up the enemy order of battle. However, as SAM sites proliferated and the threat to strike aircraft multiplied, emphasis was diverted from ELINT to real-time electronic reconnaissance in support of strike sorties. In May 1965, the North Vietnamese air defense network was still in an embryonic phase and tactical electronic reconnaissance aircraft operated over most of the country with relative impunity. Penetration and peripheral reconnaissance were performed in a continuing effort to monitor the growth of the radar order of battle in the ensuring months. When performing ELINT collection missions, as prescribed by flight planners, hostile radar emissions were located and recorded for subsequent analysis. When a radar emission was intercepted, the EWO responsible for the frequency band in which it was operating took a series of relative bearings to the transmitter site. The converging bearings were later manually plotted to determine the site location. The time required to acquire the necessary data for location and analysis was primarily a function of aircraft speed and distance to the site. Normally, it varied from six to ten minutes for the EB-66C. Other variables such as EWO operator technique and ground site transmission patterns also affected the data collection times. The ELINT gathering task retained its traditional primacy during the early operational phase of the EB-66C in Southeast Asia.[134]

On a typical mission a pair of EB-66Cs took off from Takhli, topped off fuel tanks from a KC-135, and then rendezvoused with the strike force. The two aircraft accompanied the fighter-bomber strike force to the vicinity of their target, then entered an elliptical orbit near the target at 25,000 to 30,000 feet, beyond the reach of the 37mm and 57mm AAA guns. These AAA sites were usually organized with six guns in individual emplacements arranged in a circle around a radar, called a "Fire Can," which helped gunners lay their fire on fast moving fighter aircraft. The EB-66C EWOs jammed the Fire Can radars, which guided the AAA, while listening for Fan Song SA-2 related signals. If they detected the doubling of the Fan Song pulse repetition frequency or SA-2 guidance signal, it indicated that a SA-2 battery was firing a SA-2 missile. In this case the chief EWO, called "Raven-1," alerted the strike force by radio and then joined the other EWOs in jamming the SA-2 signals.[135] This technique proved very successful and more than compensated for the fighter's lack of sufficient radar homing and warning (RHAW) gear or on-board jammers. Unfortunately, the EB-66 did not have the speed, agility, or EW self-protection it needed to survive in dense SAM or MiG environments. By August

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[134] Moore, 24-25.

[135] *EB-66C Tactics Manual for SEA EB-66*, 355TFW, Takhli AB, Thailand 22 February 1968, 2-5.

1965, it too was forced to withdraw from the target area to serve only as a standoff jammer.

The EB-66B

In October 1965 the improved ECM aircraft, the EB-66B "Brown Cradle," joined the EW force. This addition greatly upgraded U.S. capabilities, as the B model was capable of overwhelming all threat radars in the North Vietnamese inventory. The drawback was that its jammers interfered with its radar-warning receiver.[136] Due to this fact, the C and B models had to work together. The EB-66B assumed escort-jamming missions flying with attack packages while the EB-66C monitored the effects of jamming and served as a gap-filler from its standoff locations. Because of the necessity for precise placement of the jamming strobe over the Fan Song (SA-2) radar, the EB-66C constantly monitored the beam which the B model was generating. The broader and stronger jamming barrage laid down by the EB-66B afforded it better protection against the SA-2. This allowed the EB-66C to remain well beyond the range of the SA-2 missile. In practice, therefore, while one or two EB-66Bs orbited within 15 nautical miles of the target, an EB-66C remained safely beyond the 17 nautical mile SA-2 missile range, providing SAM warning and ensuring that jamming barrages blanketed those frequencies the North Vietnamese were using. Mission planners had to take into account that electronic noise did not radiate from fixed antennas in a uniform, concentric pattern. Indeed, antenna locations caused the jamming coverage to resemble a sort of butterfly, with the aircraft at the center and the strongest signals radiating perpendicular to the flight path. For this reason mission planners tried to assign the EB-66Bs in pairs, arranging the orbit so that one of the aircraft was always oriented broad side to the hostile radar. Planners also developed jamming packages, instructions telling the EWO what frequencies to jam, when to transmit, and when to release chaff. Chaff, a World War II invention, was thin aluminum strips cut to match the frequency that was to be jammed. Chaff was either dropped in bundles that separated in flight or in containers that were retarded by parachute and had delay fuses to blow them open after a specified amount of time. To obtain the best possible coverage from the jamming package, the aircraft flew a standardized orbit designed for a particular task, such as protection of drones or B-52s, or helping strike fighters with their ingress or egress from the target area.[137]

The job of nullifying radar systems was not easy. The North Vietnamese acquired at least twenty different radar types, thus ensuring that the whole system could not be nullified. Therefore, a single aircraft deployed against a single radar ceased to be effective. Ground Control Intercept radars (GCI) gave the North Vietnamese defenders an advantage over US fighters from 1965 till 1967. The GCI could alert MiGs to the American air presence and direct them behind the U.S. aircraft. This GCI net was difficult to jam. Typically the North Vietnamese reacted to jamming by concentrating

[136] This meant that the aircraft was "deaf" while it was jamming and had no awareness that an enemy radar was locking onto it.

[137] Chapters 6 and 7 in *EB-66C Tactics Manual for SEA EB-66*, 355TFW, Takhli AB, 22 February 1968 and CHECO Report, *Tactical Electronic Warfare Operations in SEA 1962-1968*, 10 Feb 1969.

radar activities in bands not jammed at a particular time, and by constantly changing frequencies to evade jamming.[138] American electronic tactics used a combination of jamming, chaff, and crossing tracks of several EB-66 aircraft. Simultaneous jamming by two EB-66 aircraft reduced Fan Song effectiveness, but did not degrade it completely. Rapid integration of the North Vietnamese air defense network, and its expansion of SAM sites put the EB-66 fleet in front of an insurmountable task. They simply could not blind enough radars to allow USAF F-105s and F-4s to penetrate these defensive barriers. The integration of SAM and MiG interceptors further compromised mission effectiveness.[139]

Throughout the Rolling Thunder campaign from 1965 to 1968, EB-66 jamming involved a compromise between effective jammer coverage and EB-66 survival. Although the effectiveness of jammers decreased as distance from the target increased, distance protected the EB-66s from hostile fire. The noise barrage gave the best protection when attacking fighter-bombers were between the jamming orbit and target. The North Vietnamese, however, soon started to shift weapons to prevent the EB-66 from assuming this ideal station. As late as February 1966, aircraft were reasonably safe if they flew high enough to avoid most of the light anti-aircraft guns and flew outside of the lethal radius of missile defenses that ringed Hanoi and Haiphong. To support strikes in this heavily defended region, they flew orbits over the Gulf of Tonkin and inland above the mountains northwest of the Red River delta. Together, these two stations provided excellent coverage, for they bracketed the area where the North Vietnamese had concentrated their radar-controlled defenses.[140]

For the F-105s based in Thailand the EB-66s' inland orbit was particularly valuable. In order to find concealment from enemy radar, the Thunderchiefs hugged a ridgeline that pointed southeastward from the barren highlands toward the Hanoi-Haiphong area, a geographic feature that came to be called Thud Ridge. When the Thailand based F-105s attacked in the Red River Delta, EB-66s manned an orbit from which they could transmit directly along Thud Ridge keeping the strike force between the jamming source and the target during ingress and egress.

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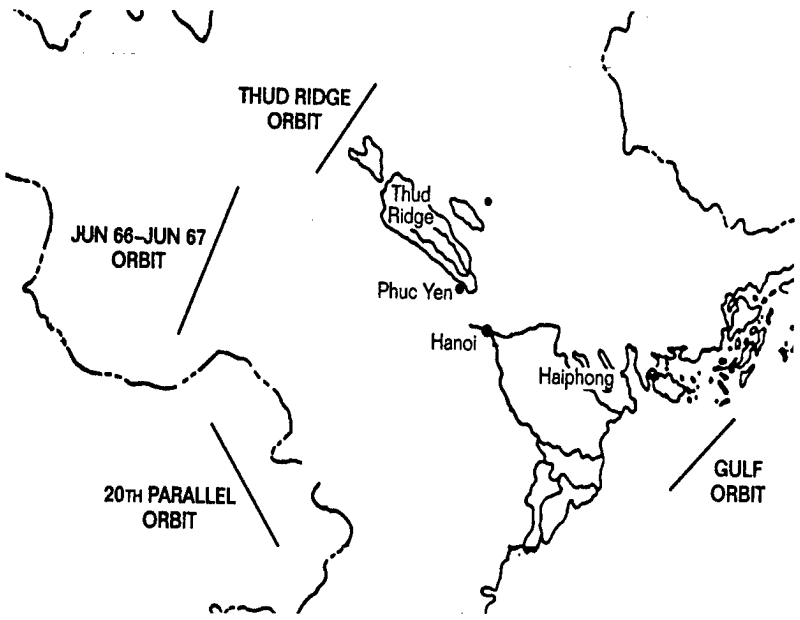
[138] Jamming energy radiated directly into a tracking radar beam is much more effective than jamming into the side-lobes or the rear of the side-lobes of the tracking beam. Orbiting EB-66s could not maintain constant main lobe jamming and were thus unable to deny the ground radar target tracking information. Many of the North Vietnamese tracking radars swept their beams in the direction of EB-66 orbits and would then lock on to the strike force denying the EB-66s the chance to jam the main lobes effectively.

[139] Smith, *Rolling Thunder*, 66.

[140] Wayne Thompson, *Rebound. The Air War over North Vietnam 1966-1973* (Draft, Air Force History and Museums Program, January 1998), 108.



AU Map Collection

Figure 9. This map shows EB-66 orbit location shifts over North Vietnam during the early years of Rolling Thunder. The 20th parallel orbit is over Laos.

The freedom of operation enjoyed by the EB-66s came to an abrupt end in February 1966 when an EB-66C was shot down by a SA-2 near Vinh, 140 nautical miles south of Hanoi.[141] The action started when the crew picked up the Fan Song signal and commenced jamming. Next came the pre-launch surge in the Fan Song pulse repetition frequency that persisted despite continued jamming and an evasive turn. The guidance signal then alerted the crew that the missile was on the way, but, before they could maneuver, the warhead exploded crippling the aircraft. The crew parachuted into the Gulf, where the US Navy picked up all but one of the crew. The destruction of this aircraft marked the beginning of a southward and westward extension of North Vietnam's SAM defenses.[142] On 3 and 5 November 1966 there were unsuccessful attacks by MiG-21s on EB-66s near Thud Ridge. In each case F-4Cs repulsed the attackers. However, these attacks reflected the effectiveness of the EB-66 jamming because it showed the priority the North Vietnamese air defense forces placed on eliminating the EB-66s. These attacks indicate that the North Vietnamese wanted their radar network unobstructed during US raids so that they could guide fighters and SAMs towards the US fighters.

The appearance of new missile sites forced the EB-66s to change orbit, though EB-66Cs would still periodically challenge SAM batteries to get more ELINT data. In October 1966, for example, an EB-66C spent 15 minutes cruising above an area defended by an SA-2 site, trying unsuccessfully to lure the North Vietnamese operators into using a

[141] Burch, 34.

[142] *Out-Country Air Operations, Southeast Asia, 1 January 1965-31 March 1968*, Project Corona Harvest, Maxwell AFB, AL, July 1973, 63.

Fan Song transmitter so that an F-105 orbiting nearby could attack with a "Shrike," an anti-radiation missile.[143] SAMs first appeared in northwestern North Vietnam in mid-1966. This shift forced the EB-66s to move south and west from the original Thud Ridge orbit, increasing both the distance to Hanoi-Haiphong and the angle formed by the jamming source, the target area, and the course flown by the Thailand based fighter-bombers.

One engagement, on 5 November 1966, made it into Esquire magazine in 1967. "Opal Flight," consisting of two F-4Cs was escorting an EB-66 from its orbit north of Hanoi at 30,000 feet altitude when the EWOs on board detected the MiG "identification friend or foe" (IFF) signal behind the EB-66. The EB-66 pilot radioed the warning to the Opal flight lead. The MiG-21 pair maneuvered in behind the EB-66, ignoring the F-4Cs, and shot an "Atoll" air-to-air missile at the EB-66. Opal 1 saw the Atoll launched and told the EB-66 to "break right," which the EB-66 pilot, Major Arthur Kibby Taylor, did, diving to 9,000 feet. The F-4Cs engaged the MiG-21s with the help of the EB-66 that reversed its turn to allow the F-4Cs to get a better shot. Both MiG-21s were downed. The engagement lasted about 90 seconds, with all of the EB-66's jammers off line due to G-loading. Still in an area with high AAA concentration, the EB-66 climbed back to altitude and proceeded back to Takhli, Thailand.[144]

The SAM evasive maneuver, which had proven effective for fighters, could not be safely performed by the EB-66. A quote from the EB-66 tactics manual shows the structural limits of the EB-66 airframe:

> The air combat tactics proposal submitted early in September omitted the use of the split S and high speed spiraling turns for the B-66 because the aircraft frame and sensor equipment might not be equal to the stress. The 120 degree coordinated roll and two G pull though was considered the most effective evasive action the B-66 could safely fly.[145]

The B-66 was thus being displaced from its optimal jamming orbits and consequently decreased the effectiveness of its operations.

The EB-66E

On 30 August 1967 a new jammer variant, the EB-66E,[146] reached Thailand.[147] This latest variant of the EB-66 had twenty-one rather than twenty-three jammers of earlier aircraft. This reduction in jammers facilitated a larger power output in existing jammers, which increased the EB-66E's ability to overwhelm hostile radar systems. Its jamming transmitters were also tunable, enabling the electronic warfare officer to change

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[143] These missiles were built to home in on the radar signal that a fire control radar emits when guiding its missiles or tracking aircraft. They are effective if radar transmitters are in operation long enough for the anti-radiation missile to acquire the signal and follow it to its source. Intermittent use of the radar by trained operators can increase its survivability.

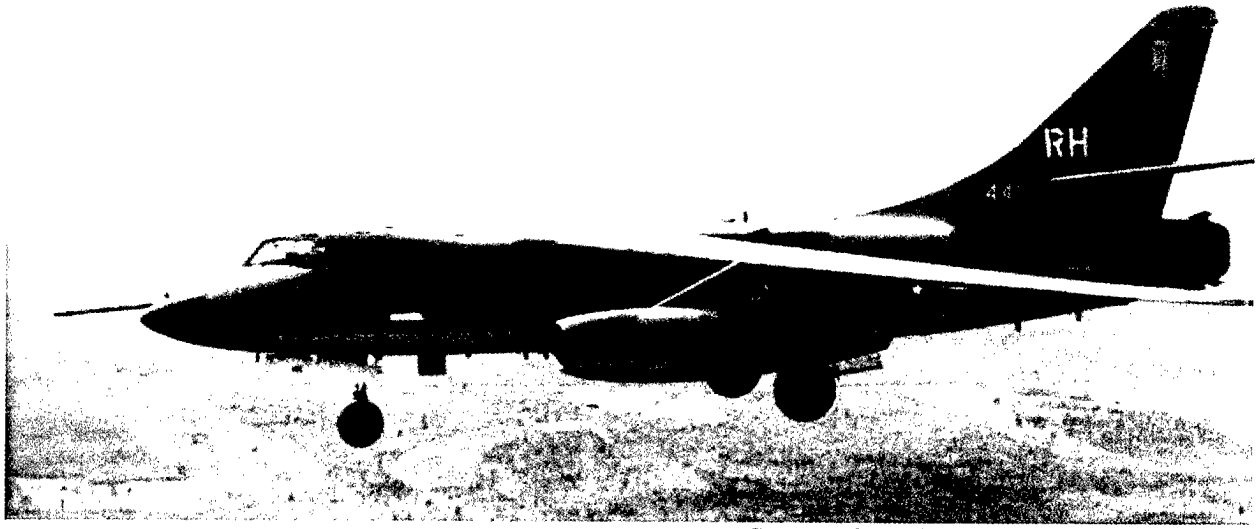
[144] E-mail from Colonel Arthur Taylor (USAF, Ret.) 3 November 1999.

[145] *Tactic Bulletin PACAF*, December 1964.

[146] Converted B/RB-66 from Davis-Monthan AFB's desert storage. A total of fifty-one were converted.

[147] 355TFW, *Unit History, 1 July 1967- 1 September 1967*, Takhli AB, Thailand, Volume 1, 119.

frequencies during flight and jam different types of radars simultaneously. It also had greater frequency coverage than the EB-66B. In contrast the EB-66B carried only one adjustable transmitter which limited the choice to three predetermined frequencies. In addition the EB-66C received steerable antennas. This change was implemented in the spring of 1968, enabling electronic warfare officers to focus the EB-66C jamming energy against a specific radar transmitter. During 1967 the EB-66s attempted to jam the MiG identification equipment utilized by North Vietnamese ground controllers to control aircraft on their radars, but the closest orbit was some seventy-five nautical miles from the aerial battlefield, too far for jamming to be effective. Once again enemy defenses frustrated the EB-66s.



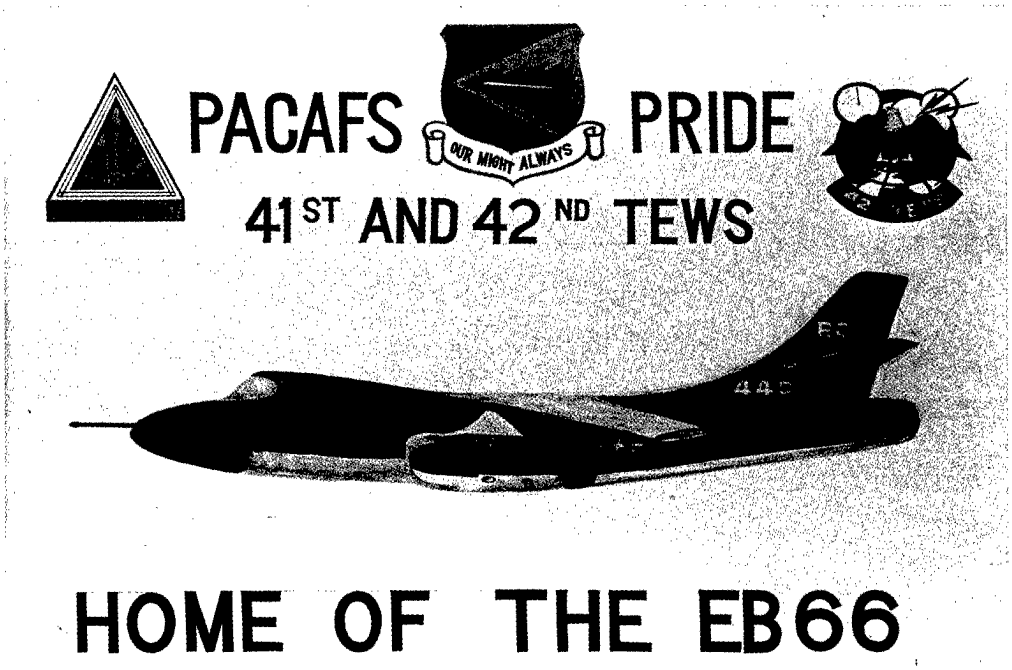
Courtesy of Lt Col Jack Sullivan, USAF

Figure 10. EB-66E on final to Takhli AB, Thailand, after a three and one half-hour mission.

Tactical Electronic Warfare Organization in Thailand

As the air war over North Vietnam intensified, more electronic warfare aircraft were moved into theater. Tactical electronic reconnaissance platforms had always been in short supply, but the war ultimately siphoned off all of USAFE's ECM and ELINT assets as the North Vietnamese air defense system grew in sophistication. Five 42nd TRS EB-66B "Brown Cradle" ECM aircraft based at Chambley AB, France were brought to Takhili AB, Thailand in the spring of 1966, operating as Det 1, 25th TRW, under the operational control of the 41st TRS. In May 1966, the 42nd was deactivated at Chambley AB, and the remaining eight EB-66Bs there were brought to Takhili, where they joined five existing EB-66Bs to form the 6460th TRS in June 1966.

The 6460th TRS was redesignated the 42nd Tactical Electronic Warfare Squadron (TEWS) in September 1966, and the 41st TRS became the 41st TEWS. In December 1967 the 41st and 42nd TEWS redistributed their aircraft[148] so that the 41st TEWS owned fourteen EB-66B/E and six EB-66C aircraft and the 42nd fifteen EB-66B/E and six EB-66C aircraft. Both units became components of the Takhli-based 355th Tactical Fighter Wing (TFW) in August 1967.[149]



Courtesy of Lt Col Jack Sullivan USAF Ret

Figure 11. The Squadrons sign at Takhli AB, Thailand

By the summer of 1967 a typical operational day called for two or three EB-66s to orbit near the intersection of the twentieth parallel and the Laotian border, seventy-five miles southwest of Hanoi, while a like number orbited over the Gulf of Tonkin. These jammers would mask the ingress and egress routes of the attacking strike fighters. While it was impossible to blind the North Vietnamese radars to the fact that large strikes were being conducted, EB-66s could degrade their reception long enough so that North Vietnamese ground controllers could not detect the size and probable target of the strike. The number of enemy radar units operating in a wide range of frequencies and the number of U.S. aircraft involved in the two daily "pushes" made it impossible to blank out North Vietnamese radar screens. The EB-66s also operated with one other handicap, U.S. radar operators would frequently complain that their radars and communications links were being jammed by "friendlies," either Navy jammers or the EB-66. Thus,

[148] Newly modified EB-66Es were entering the inventory making this split possible. Prior to the arrival of the EB-66E, the 41st TEWS held all collection assets (the EB-66C) while the 6460th (later the 42nd TEWS) held all the jammers (EB-66B).

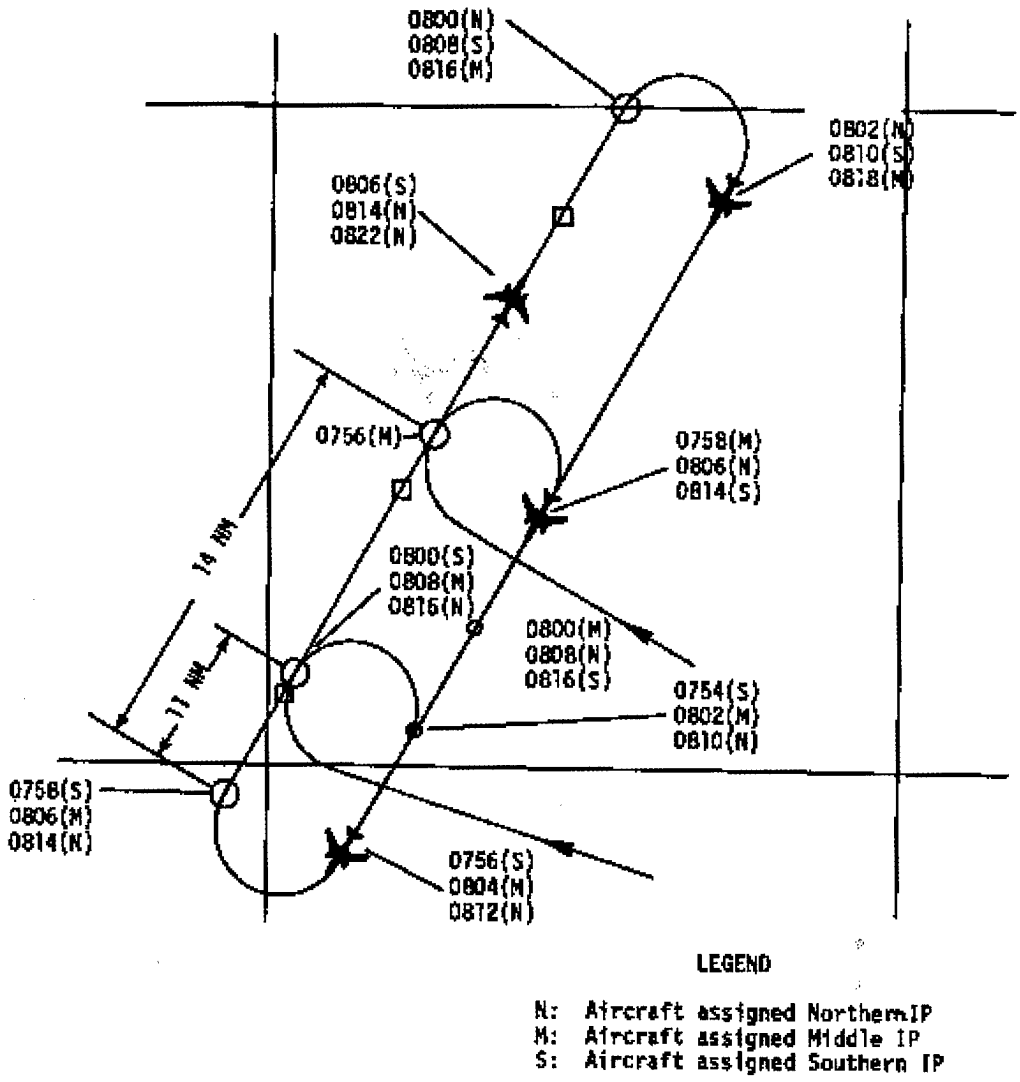
[149] 355 TFW, *Unit History, 1 October 1967-31 December 1967*, Takhli AB, Thailand; Volume 1, 5 – 19; also discussed in introduction.

restrictions were placed on EB-66 jamming operations by Seventh Air Force. While the jamming may have appeared to be marginally effective, the speed of the strike force meant that it would be over its target in seven to ten minutes. This meant that if North Vietnamese radar were blank for one or two minutes this would significantly aid the strike force on its way to and from the target.

On November 15, 1967, Seventh AF sent two EB-66s north of Thud Ridge for the first time since 1966. This move was encouraged by the fact that SAM launchers had been observed moving away from the ridge southeast into Hanoi and the panhandle. But the EB-66s were vulnerable to MiG attack, especially because their jamming transmitters interfered with communications from fighter escorts and the broadcast warning from the EC-121 "College Eye" airborne early warning aircraft.[150] A new radio installed in mid 1967 fixed this problem, so two EB-66s resumed flying long abandoned orbits without difficulty.[151]

On November 20, 1967, however, a pair of MiG-21s, one diving and one climbing, attacked a lone EB-66, orbiting north of Thud Ridge, from the rear. Two F-4 fighters flying the MIGCAP protection mission, weaving behind the EB-66 saw the MiGs and warned the EB-66 to break into a downward spiral just in time to evade a heat-seeking Atoll fired by the climbing MiG. Although the EB-66 and its F-4 escorts escaped unharmed, F-4 crews were upset at weaving behind an EB-66 to accommodate its slower speed. This position and low speed did not allow them to maneuver into optimal dog-fighting position. These renewed MiG attacks indicated that EB-66 jamming was frustrating North Vietnamese radar operators, but Seventh AF pulled the EB-66s south. Studies conducted in theater and in the United States by the Air Force Security Service, as well as post-war analysis, clearly show that the North Vietnamese MiGs were being sent after the EB-66s. This type of deliberate targeting was the best indicator that EB-66 jamming was effective. Seventh Air Force felt the limited number of EB-66s made them too valuable to risk. Dropping chaff to protect the ingressing strike force and themselves, the EB-66s degraded North Vietnamese radar coverage of the strike sorties.[152]

[150] Or from U.S. Navy EC-121 "Big Look" aircraft flying from DaNang.
[151] Marshall L. Michel III, *Clashes: Air Combat over North Vietnam 1965-1972* (Annapolis, MD: Naval Institute Press, 1997), 127.
[152] Michel, 144.



From EB-66 TACTICS Manual Vol. 3

Figure 12. This sketch shows how three EB-66s would be positioned with a scheduled "in place" time of 0800. This "super" orbit was successfully used throughout the Vietnam War. Four aircraft are depicted to show proper positioning.

During 1967, the EB-66s began flying a different orbit on their northeast corner missions over the Gulf of Tonkin in support of strikes in the Hanoi area. This super orbit consisted of one C model and two B or E models flying together. By spacing themselves at various points along the 70 mile orbit and controlling the turning times, two aircraft were always straight and level while the third aircraft was turning, thus providing maximum jamming output at all times.[153] This was the only feasible way to increase their effective transmitted power output. Until 22 March 1967, the maximum number of EB-

[153] 355TFW, *Unit History, 1 July 1967- 1 September 1967*, Takhli AB, Thailand, Volume 1, 119.

66s committed to support a strike had been five. But, on 26 March 1967, seven EB-66s, six B models and one C model, were used in support of the strike force. These aircraft flew three separate orbits, west-northwest, south-southwest, and east-southwest of the target area. Jammer output was the maximum to date and the most notable result was that a large number of North Vietnamese low frequency radars went down during the strike which would have provided range and bearing information on the strike force. During the next month Seventh AF tried to improve jamming coverage by increasing to fourteen the number of EB-66s operating during a strike.

Hurt by the jamming, the North Vietnamese reacted quickly to attack the EB-66 air operations over North Vietnam. The North Vietnamese sought to force the EB-66s from their orbits in western North Vietnam by placing new SA-2 missile batteries along Route Pack 6 as far west as 104 degrees longitude.[154] This movement forced the EB-66s to relocate further west. Almost simultaneously with the North Vietnam SAM shifts, Seventh Air Force elected to use the F-4s as bombers and to withdraw the MIGCAP from the EB-66s. The net result was to move the EB-66 orbits south of 20 degrees latitude on the western side of North Vietnam. Because the Navy supplied CAP for the EB-66s over the Gulf of Tonkin no adjustments were necessary for that orbit. The effectiveness of jamming, which is inversely proportional to the distance from the radars being jammed, was drastically reduced, particularly in the western sector. This was mainly due to the orientation of the orbits and the increased distance from the Hanoi target area. Seventh Air Force was aware of the decrease and wanted to use more aircraft to strike at North Vietnamese targets, but did not possess the aircraft necessary to increase strikes and provide fighter coverage to support aircraft such as the EB-66.[155]

[154] 355 TFW, *Unit History, 1 October 1967-31 December 1967*, Takhli AB, Thailand, Volume 1, 29.
[155] 355 TFW, *Unit History, 1 January 1967-31 March 1967, 1 April 1967-30 June 1967,* Takhli AB, Thailand, 10,18.

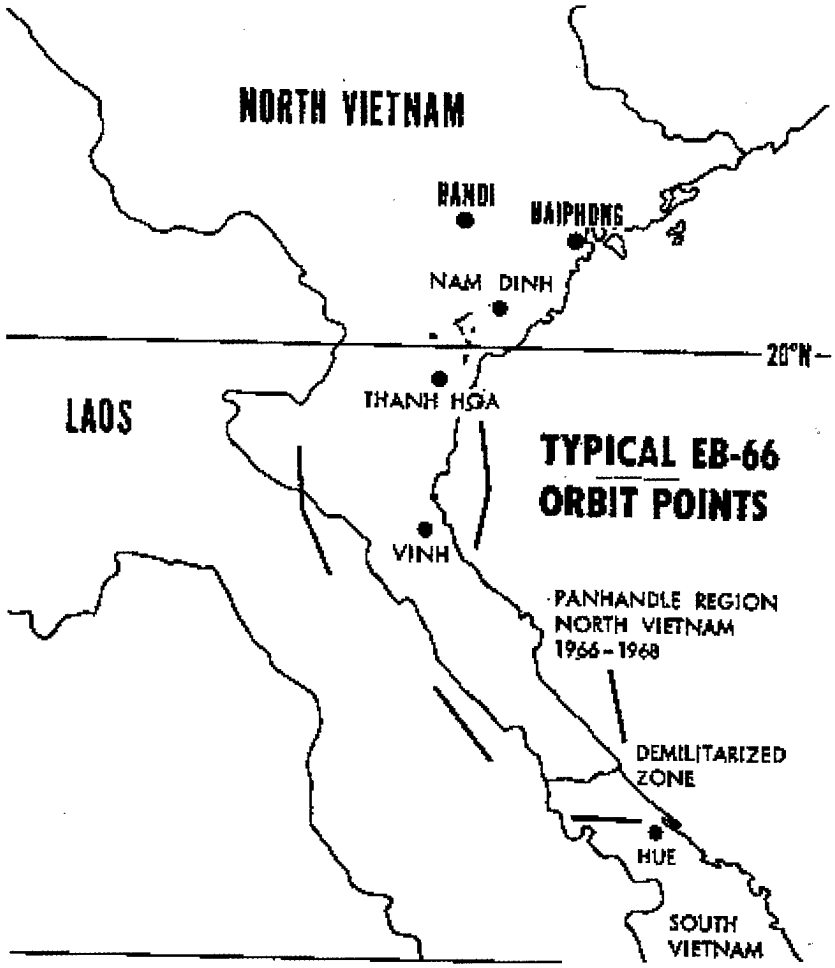


Figure 13. This map details the other EB-66 orbits used when the EB-66s were forced south or when they were supporting air operations in the southern half of North Vietnam.

Tactics now changed rapidly. ECM pods were the only electronic protection the fighter-bombers had to defeat the fire control radars as the EB-66s flew their new orbits. The EB-66s concentrated on neutralizing the early-warning, GCI, and acquisition radars from their new orbit locations. North Vietnamese early warning radars could "see" an approaching force about 250 to 300 miles away and alert defenses such as fighters, guns, and missile batteries. Ground Control Intercept (GCI) radars were used to direct fighters towards their targets from ground based command posts, and acquisition radars gave precise range, bearing, and height data to batteries attempting to shoot down aircraft. Rather than combating a part of the North Vietnamese integrated air defense system, EB-66s were now able to electronically attack the entire net.[156] Seventh Air Force directed that the western orbits be moved up to 21 degrees north latitude on the border of North Vietnam and Laos. In November 1967 intelligence noted a significant shift in enemy missile deployment. The North Vietnamese defenses were being concentrated around the

[156] Michel, *Clashes*, 124.

Hanoi area against the intensified air attacks. That made it possible to move the EB-66s closer to orbit above the northwestern extremity of Thud Ridge, but only under fighter cover. However, an attack on an EB-66C on 20 November 67 by North Vietnamese MiGs, and destruction of an EB-66C on 14 January 1968 by an SA-2, again pushed the orbit south of the 21st parallel.[157]

In December 1967 Seventh Air Force introduced new EB-66 tactics to improve the overall effectiveness of the tactical electronic warfare force. These included the use of preplanned routes, specific jammer-on/off points (telling the EWO when to turn his equipment on and off for maximum effectiveness), crossing tracks by EB-66B and E models, and a World War II relic, parachute retarded chaff to hide the strike force. Preplanned routes allowed for standardization. For example, an orbit over Laos could defeat a certain number of early warning radars inside North Vietnam thereby allowing fighters to get closer to their targets before they were detected. By presetting jammers to geographic points where the jamming equipment was operated at maximum capacity, an enemy site would go blind or could not detect the approaching strike force. Crossing tracks confused the North Vietnamese since they were not able to tell what EB-66s were protecting.[158]

Throughout 1967 various changes to the North Vietnamese radar capabilities were noted. In response to EB-66 standoff jamming, some radars were deactivated or frequencies changed. During other missions several types of radar would be activated at the same time in an attempt to maintain airspace surveillance. These North Vietnamese reactions showed that some jamming was effective in hiding the strike force from North Vietnamese threat systems, but other Soviet supplied systems were able to look through jamming and enabled a significant number of shoot-downs to be achieved.[159]

The EB-66s assumed an additional task in April 1967 when they began flying pre-strike electronic reconnaissance for B-52 aircraft under the codename "Tiny Tim." The mobility of the SA-2 system, which made it possible to set-up a site in less than six hours, meant that all of North Vietnam was a potential threat. It also placed B-52 operations in the DMZ and border areas of North Vietnam within range of a SAM attack. In April 1967, the 41st TEWS was directed to conduct electronic reconnaissance in SAM threat areas prior to a B-52 strike. The EB-66C flew the B-52 route to detect unidentified SAM sites prior to passage of the bombers. Electronic jamming was always scheduled when B-52 "Arc Light" missions entered areas requiring the use of ECM, usually north of 16 degrees north latitude. A minimum of two EB-66s were scheduled to provide support. An airborne back-up was maintained if possible and a ground back-up was on ready status at Takhli to insure that two EB-66s were always on station. When the EB-66s could not provide this level of support B-52 missions had to be cancelled or diverted to safer areas.

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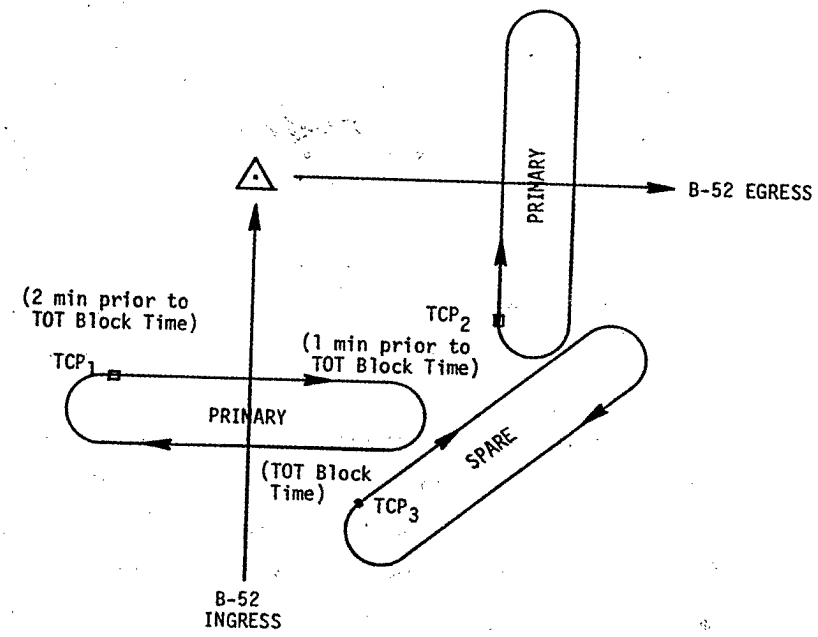
[157] Major William Reder, *EB-66 Operations in SEA, 1967*, CHECO draft report, 26 November 1968, 34.
[158] LtCol Robert Burch, CHECO report, *Tactical Electronic Warfare Operations in Southeast Asia 1962-1968,* 10 Feb 1969.
[159] Michel, *Clashes*, 199.



From EB-66 Tactics Manual

Figure 14. This sketch shows Tiny Tim support by three EB-66s to a B-52 strike.

SAC complained through PACAF that its bombers operating over Southeast Asia were vulnerable to SAMs because the bomber's jamming systems were not optimized for flight restrictions encountered in Vietnam. In order for B-52 strikes to proceed, theater assets were thus tasked to protect the bomber strikes. Seventh Air Force ordered the EB-66s to provide optimum protection for the B-52 cell (usually three bombers) while inbound to the target, and during the post release turn when the B-52 was most vulnerable to SAM threats. Because of the limited jamming capability of the EB-66C, the normal use of the C model in an ESM/ECM role was to provide threat warnings to the force supported and to selectively jam threat radar signals. When assigned to support Arc Light missions the role of the C model was to warn the B-52 strike force of Fan Song (SA-2 acquisition radar) activity, and to provide warnings in event of a SAM launch. EB-66Cs frequently diverted B-52 strikes to avoid SA-2 sites.

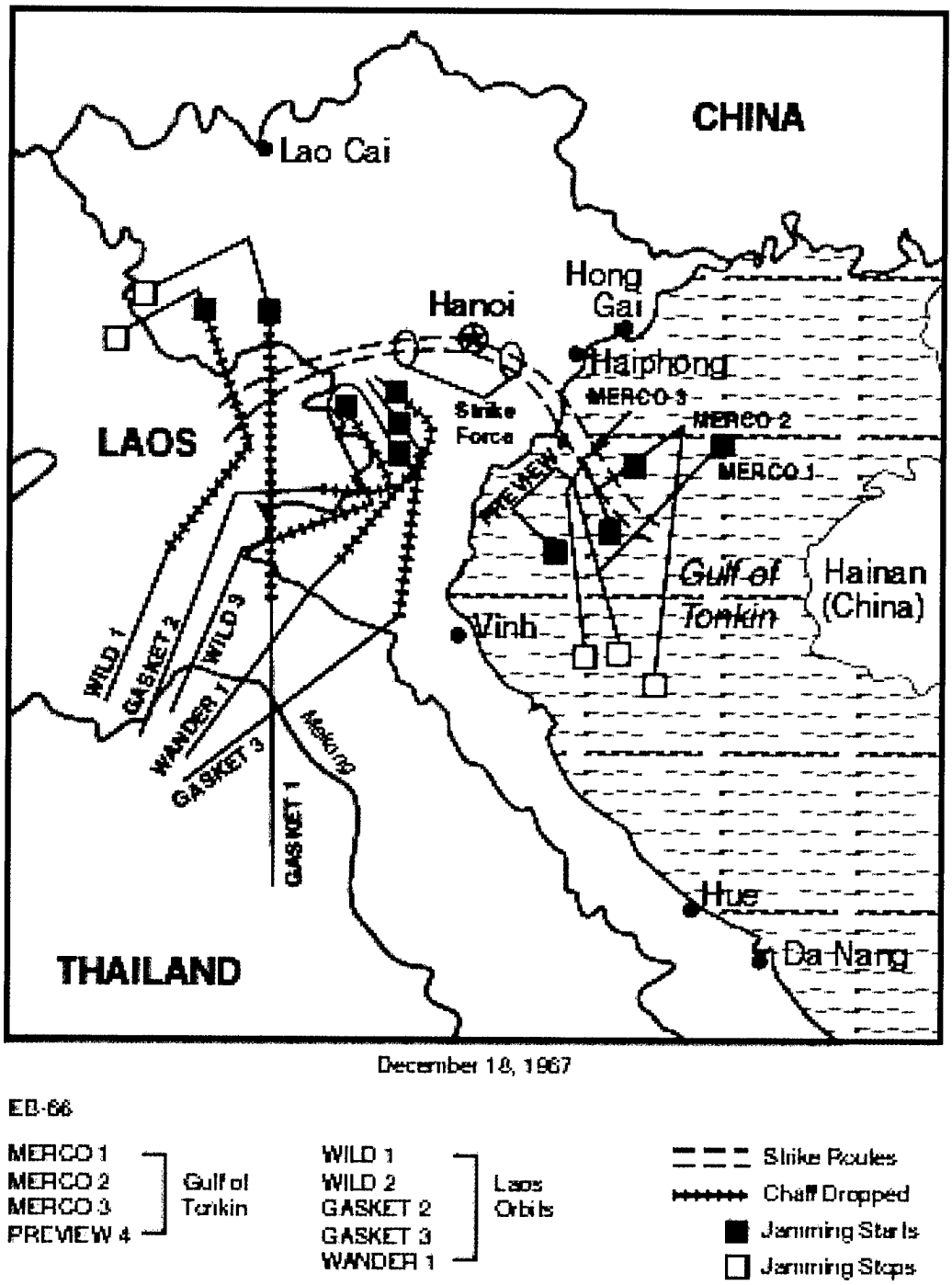


Figure 15. This map of 18 December 1967, an example of EB-66 operations, shows individual EB-66s by call signs.

The magnitude of EB-66 flight operations that accompanied Rolling Thunder strike packages can be illustrated by a typical mission. At 0430Z, 18 December 1967, three EB-66B aircraft orbited near Haiphong (refer to map figure 15) and initiated jamming at an altitude of 30,000 feet. An additional EB-66 began jamming at 0432Z.

Strike forces entered North Vietnam from the Gulf of Tonkin and passed through the EB-66 orbit at 0442Z. In orbit area 1 at 0410Z five EB-66s began dropping chaff from an altitude of 29,000 feet. It was ejected from the aircraft with a seven to eleven second delayed opening parachute. Prior to the chaff drops the North Vietnamese most likely were able to identify and track the EB-66. The EB-66s were lost in the clutter once chaff clouds started to form and drift towards the ground at a rate of 200 feet per minute. At 0431Z the strike force passed under the orbits of the EB-66 in orbit area 1. Jamming to degrade the North Vietnamese radar picture then commenced and continued until 0515Z. Enemy radars shut down and remained off for the remainder of the strike. The effectiveness of the mission can be judged by the fact that the strike force suffered no losses. This amount of flying required mid-air refueling, not only for the strike force, but also for the support aircraft. With operations on both sides of North Vietnam the EB-66 required fuel from SAC's KC-135 tankers. The complexity of the operation is aptly described by an EB-66 pilot:

> refueling was required for all route pack 6a and 6b missions [see map, p 37], missions in the Tonkin Gulf off Hanoi and Haiphong and one night mission that required a long orbit on the Gulf side of route pack 1 or 2. The route pack 6 missions were fragged for an EB-66C and EB-66E in the same orbit. We tried to control our turns so at least one aircraft was in level flight at all times. Jammer effects were degraded while the wings were banked. A flight of four F-4s were fragged for fighter cover for the EB-66s on these missions. We had one EB-66C that was out of rig or something. Pilots who tried to refuel with that aircraft consistently reported problems maintaining position on the tanker. I had that aircraft on my night refueling check out on the long orbit in the Gulf that required two refuelings. I had such a hard time refueling that the instructor and I changed seats and he did not do much better. We switched back and continued the mission intending to recover for fuel at Danang but as we left orbit I tried one last desperate attempt and managed to get 6,000 pounds so we could get back to Takhli.[160]

Tactics shifted yet again in 1967. A new tactic tried in 1967 was in close support of a strike against an isolated[161] SAM site inside North Vietnam. In this case, the EB-66C flew a racetrack pattern approximately thirty miles from the target, perpendicular to the axis of attack of the strike force. From this racetrack shaped orbit the EB-66C would direct the jamming pattern of an accompanying EB-66B or E. The ideal situation was to position the EB-66B or E jammer over, as opposed to perpendicular to, the proposed axis of attack. In addition to the vital function of providing positional information and jamming assessment of the EB-66B, the EB-66C also provided missile launch warning and used its own jammers to augment the EB-66B or E. This tactic was soon abandoned when the North Vietnamese deployed anti-aircraft guns near the SA-2 sites, increasing the vulnerability of both EB-66 aircraft and strike aircraft.

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[160] E-mail from Colonel Taylor (USAF Ret.). "Fragged" is an aviators' term that comes from "fragmentary air tasking order" and tells air crew where and how an aircraft sortie will be flown.

[161] Isolated is a relative term. The North Vietnam SAM SA-2 sites were always protected by 37mm or 57mm AAA batteries (6 guns) and thus always posed a threat. During 1965-66 there had been coordination problems among the various assets, but by 1967 they had ended and the North Vietnam air defense system became very lethal.

USAF Picture

Figure 16. A KC-135 refueling an EB-66C. Notice the drogue couplings.

Another tactic provided standoff support for strike aircraft penetrating high-threat areas of overlapping anti-aircraft systems. The EB-66C again provided positional information to the jammer aircraft and augmented its jamming. Since the EB-66C was the only aircraft capable of listening and judging the effectiveness of jamming with the help of the four on-board EWOs, the EB-66Cs could not be used in its intended ELINT gathering role. This also pointed out one of the shortfalls in the jammer fleet of EB-66B/Es. They were not equipped to measure their own effectiveness on enemy systems being jammed. The EB-66C reconnaissance aircraft was the only aircraft then equipped for that task and there were not enough EB-66Cs in the inventory to fly both ELINT and EW support missions.

Over a six-month period, July to December 1967, the 41st TEWS reduced pure reconnaissance sorties by 50% compared to the previous six months. It averaged only thirty-nine EB-66C ELINT sorties per month.[162] This meant that the ELINT data-gathering missions needed to collect information on the North Vietnamese air defense systems was transferred to other aircraft. While data exchanges existed in theater, most ELINT data had to be processed in Japan and Hawaii before the product was returned to Southeast Asia for use by tactical air forces. The data required was gathered by other sources such as SAC's RC-135C/M or PACAF's C-130 B-II assets (that operated out of

[162] 41st TEWS, *History*, 3.

South Vietnam or Kadena AB, Okinawa) and Navy assets based in Da Nang, South Vietnam. Real-time EW support to strike aircraft became the primary role of the EB-66C.

With the steady growth of the MiG and SAM threat, Seventh Air Force planners attempted to strike a balance between the EB-66s' vulnerability and their protective value to the striking force. By late 1967, the EB-66s entered the high-threat areas only on rare missions and then with extensive SAM suppression aircraft and a protective escort, or MIGCAP. The results were worthwhile. One raid, on 15 November 1967, demonstrated that "the proper orbit orientation, coupled with the opportunity to get close to the terminal threat, had an effect on the defensive system of a magnitude unacceptable to the enemy."[163] EB-66s could still defeat the Soviet supplied anti-aircraft defenses.

The last EB-66C shootdown during Rolling Thunder 1968

On January 14, 1968 five EB-66s were in orbit supporting strikes in route package five. A pair of MiG-21 Fishbeds from Phuc Yen flew south and then turned west and attacked an unescorted EB-66 orbiting near the Laotian border. A heat-seeking Atoll air-to-air missile stuck the right wing of the EB-66, the seven crew members ejected, three crew members were rescued, the other four spent the rest of the war as POWs.[164] The EB-66's inability to provide effective jamming of MiG ground control intercept communications was partially rectified by the introduction of EC-121s (College Eye) which could guide US fighters in airspace over North Vietnam. Seventh Air Force reacted to the 14 January 1968 shoot down by prohibiting EB-66 overflights of North Vietnam and maintaining a barrier patrol of F-4s to screen the EB-66s from MiG attack.[165] EB-66s continued to provide dedicated ECM support, even through their vulnerability restricted their missions to a standoff role unless sufficient fighter escort could accompany them into high threat areas. These policies remained in effect until the bombing ended in the Red River Delta on 1 April 1968. Tactics never changed until the bombing halt by President Johnson on 31 October 1968, when the EB-66 supported attacks on North Vietnam by orbiting over Laos and the Gulf of Tonkin.

An interesting encounter took place on 10 July 1968 when two US Navy F-4s intercepted a flight of four MiG-21s in southern North Vietnam. Three ECM aircraft in the vicinity, a US Navy EKA-3D, a US Marine Corps EA-6A, plus an USAF EB-66E jammed both radars and ground control intercept communications frequencies enabling the F-4s to kill two of the MiGs. It was later assessed that "ECM had a vital contributing role to the success of the mission."[166]

Throughout the war the EB-66s were particularly effective against low frequency early warning and acquisition radars.[167] The North Vietnamese countered the EB-66s by deploying a new radar codenamed "Bar Lock" in 1966/67. The EB-66 jamming was less

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[163] Reder, 42.
[164] Thompson, *Rebound.*
[165] 41st Tactical Electronic Warfare Sq., *History, 1 January 1968-30 June 1968*, Takhli AB, Thailand, 3.
[166] USAF Fighter Weapons Center, *Red Baron II,* January 1973, p. I-38.
[167] "Knife Rest" and "Spoon Rest."

impressive against this radar due to Bar Lock's multiple beam operation.[168] One Bar Lock in western North Vietnam provided coverage at least 90 miles into Laos, covering the refueling tracks of US aircraft coming from Thailand. Another near Haiphong covered "Yankee Station" (the US Navy carriers) and could see at least 180 miles into the Gulf of Tonkin. Narrow beam, high-powered height finder radars, such as the "Side Net," were also less vulnerable to EB-66 jamming. By the end of 1966, the North Vietnamese had introduced low frequency radars that were capable of operating outside the jamming coverage of the EB-66s.[169] Thus, the enemy could detect and track the strike forces throughout their course to the target and provide terminal defenses with range, track, altitude, and airspeed information, in addition to alerting specific defenses. In other words, the terminal defenses had all the information necessary to solve the firing problem for both missiles and AAA. This meant that the terminal defense radars were not required to transmit until the last minute, and even then, only to verify information already provided. Once again the changing electronic battlefield over North Vietnam had turned against the EB-66 force.

Pathfinder Operations

The onset of adverse operational weather for USAF aircraft strikes against North Vietnam in 1966 rejuvenated a bombing method originated during World War II. This technique was called (as it was in World War II) "Pathfinder" and utilized the EB-66B "Brown Cradle" aircraft as the vehicle to provide "radar eyes" for F-105, F-4C, and B-57 strikes against North Vietnam. This mission, also referred to as "buddy" bombing, was a corollary to the EB-66B's primary mission in Southeast Asia, suppression of enemy threat radars with ECM. Heavy low clouds cover most of North Vietnam during the monsoon months of November through January, thus reducing the number of days for visual bombing. Seventh Air Force required all-weather bombing capability, but did not have any strike aircraft fitted with the necessary equipment. The EB-66B K-5 radar bombing equipment had such a capability. In order to conduct an interdiction campaign against North Vietnamese resupply links, the EB-66Bs were pressed into service.

Pathfinder missions averaged approximately five hours in duration and some required three air-to-air refuelings. These sorties were slightly longer than normal EB-66 sorties, and the complexity of flying up to four different formations during one sortie made the flights more taxing on the crew. The EB-66B made up to four target runs with a total of forty-eight aircraft, including F-105s, F-4Cs, and B-57s. EB-66B pilots were responsible for directing the rendezvous with the attack aircraft and leading the formation throughout the bomb run. The navigator-bombardier on board the EB-66B used the K-5 radar bombing system to make the precision radar bomb drops which often produced circular errors of less than 200 feet.[170]

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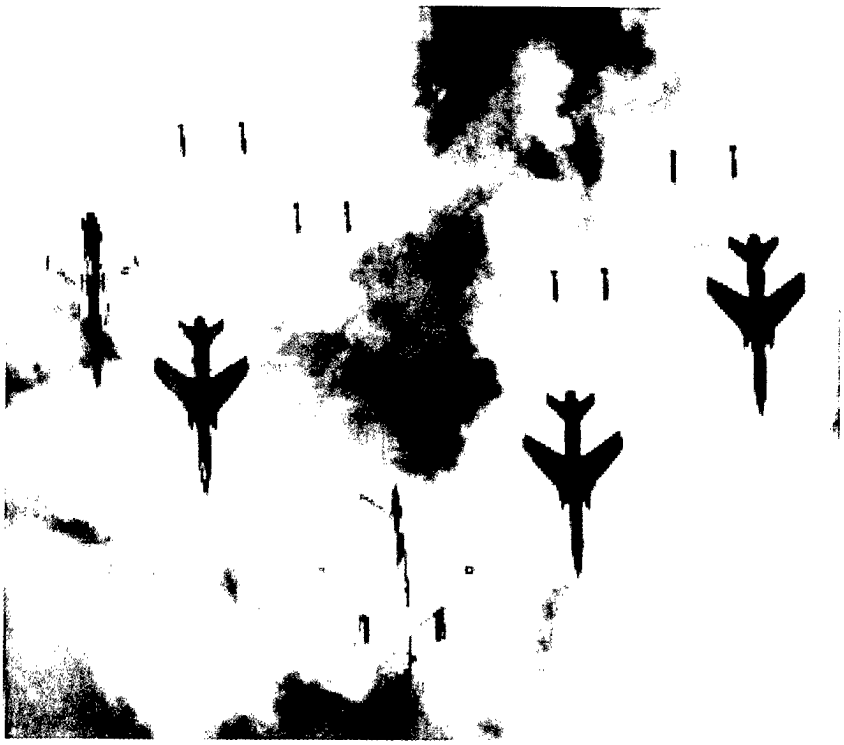
[168] Other sources state the Bar Lock was "relatively immune" to EB-66 jamming.
[169] Michel , *Clashes*, 44.
[170] Steven Pace, "Birds of a Feather," *Air Power*, March 1992, 20.

The EB-66B's K-5 bombing-navigation system was a remnant from the aircraft's original bomber equipment. The K-5 was the first system of its kind without vacuum tubes and the first electronic bombing-navigation system installed successfully in a production type aircraft. The K-5 system could track all targets up to 40 miles away in any direction, using short-range integrated radar and optics. The system used a 10 inch radar scope, or periscope when visibility permitted visual sighting. When used as a Pathfinder, the K-5 system directed the EB-66B to a release point and then sent a tone to the accompanying aircraft to drop their bombs. The system could adjust to variations of 50 knots true air speed or 5000 feet altitude without affecting bombing accuracy.[171] The EB-66B had an additional advantage. The EWO monitored the radar-warning receiver and activated ECM equipment against enemy radars. Pathfinder techniques included the protection of all formation aircraft from enemy radar controlled defenses.

After a test of the concept in Thailand, the EB-66s flew six bombing missions, from March to May 1966, along two highway segments located on the North Vietnamese-Laotian frontier. This was part of the Ho Chi Minh Trail, a logistical pipeline that supported North Vietnamese and Viet Cong operations in South Vietnam. Four F-105s with an EB-66B bombed from 20,000 feet and interdicted both lines of communications. Three strikes were flown against Nape Pass and three others against Mu Gia Pass. These six missions were to destroy stockpiles of equipment that were being transshipped via Laos into South Vietnam. The pathfinder technique was further adapted when the accompanying fighter-bombers broke away from the EB-66B escort, following the bomb drop. They descended to strike targets of opportunity in clear areas, conducting armed reconnaissance usually within 40 miles of the radar target. While the fighter-bombers operated at lower altitudes and within easy reach of radar controlled AAA, the EB-66B orbited the target area to provide electronic jamming degrading the capabilities of the radar-controlled guns. The EB-66B was extremely successful in counteracting the "Fire Can" radar, the primary guidance of radar controlled AAA. In addition to Fire Can jamming, the EB-66B crew monitored the electronic audio detection and warning system, the APS-54, for signs of SAM and airborne interceptor activity in the target area. While the EB-66B in the Pathfinder role was not tasked to strike in areas defended by SAMs or interceptors, it provided comprehensive protection for the strike force.

[171] Alling, 13.



USAF Photo

Figure 17. An EB-66B leading a flight of four F-105s on K-5 bombing system guided strike over North Vietnam.

If the EB-66B detected SAM activity the crew warned the strike aircraft and provided electronic jamming and chaff. If airborne intercept radar activity was detected, the Pathfinder crew again warned of the threat. During the Monsoon season the EB-66Bs were heavily committed to the Pathfinder bombing role.[172] On 18 November 1967[173] radar bombing ceased due to a lack of targets and the fact that SAMs were still downing aircraft. The unit history of the 42nd TEWS states that the situation was such that radar bombing was not tactically sound for such a defense environment. When aircraft were operating over cloud cover SA-2 missiles could come up through the clouds without warning, too late for evasive action to be taken. It was also necessary for aircraft to fly straight and level for thirty miles before dropping their bombs, making them vulnerable to the North Vietnamese air defense systems.

Drone Support Operations

EB-66s also furnished jamming for the frequent drone reconnaissance missions[174] over the northern provinces of North Vietnam. Two to four EB-66s usually took part in

[172] Col Robert Scott, USAF, *PACAF Tactics and Techniques Bulletin, #40,* 5 May 66, 1-3.
[173] Pathfinder bombing totals were: 1741 sorties, 3981 tons of ordnance dropped on 37 targets. (USAFE history), AFHRA.
[174] Operated by SAC's OL-20 from Bien Hoa under the code names "Blue Spring" and "Bumpy Action."

this jamming, depending upon such factors as weather, the area to be reconnoitered, and North Vietnamese defenses. When the drones were flying at low altitude into the SAM defenses protecting Hanoi and Haiphong, the EB-66s aligned themselves with the programmed flight path so that the most dangerous of the North Vietnamese acquisition and missile system radars would be transmitting directly into the jamming beam. The EB-66C was assigned to this duty since its steerable antennas concentrated jamming at greater signal strength than the omnidirectional E model antennas.

The EB-66E support to drone operations used a variety of jamming packages to provide across-the-board jamming against enemy early-warning, acquisition, ground control intercept, SAM, and fire control radars. The best jamming position for the EB-66E was when the drone was between the radar and EB-66 aircraft. For missions in the Hanoi-Haiphong area, the orbit was immediately offshore. In lower route packages EB-66Es were positioned either on the east or west side of North Vietnam or on both sides to cover opposing look angles. A key to successful support of drone operations was knowing the location of the drone in relation to the primary threat radars. Until 1969 the EB-66s and DC-130 drone director aircraft lacked secure in-flight communications which hindered even the most effective positioning of the jammer aircraft.

As the drone passed beyond the SAM sites, the Fan Song fire control radars tracking the drone would look away from the EB-66 orbit and were largely unaffected by its jamming barrage. In contrast the Spoon Rest acquisition radar remained susceptible to jamming even though the noise source, the EB-66 jammer, was behind it. Interference with Spoon Rest usually enabled the drone to survive the SAM defenses and escape to some lightly defended area of North Vietnam. In addition the EB-66 tried to jam the new Bar Lock radars which were being used by ground control intercept operators to vector MiG fighters toward the drones. They also jammed the VHF communications between the ground controllers and MiG pilots.[175] Other specialized missions supported by the EB-66s in 1966 to 1968 were "Frantic Goat" (C-130 leaflet drops), "Bumpy Action" (photo reconnaissance drones), and RF-4C reconnaissance flights.[176]

The 1968 *USS Pueblo* Crisis and Korean Commitments

The North Korea seizure of an intelligence collection vessel, the *USS Pueblo*, on 23 January 1968 forced the Joint Staff in Washington to make hard choices regarding the EB-66 fleet. Fifth Air Force, the numbered Air Force responsible for the Korean peninsula, notified the Joint Staff that it possessed no ECM or ELINT capability to cover retaliation strikes or war with North Korea. All Air Force tactical electronic warfare assets were concentrated either in Thailand, tasked to support operations in Vietnam, or at Shaw engaged in training activities. In order to prepare for retaliatory air strikes, the JCS was forced to pull aircraft and aircrews from the training establishment at Shaw and from the two squadrons engaged in the air war from Thailand. Later additional tasking

[175] Burch, 47.
[176] Burch, 46.

would be levied on the Thailand based EB-66 organizations, forcing aircrew to fly in combat operations and support another theater with the same assets.

On 29 January 1968 the Joint Staff directed the 363rd TRW at Shaw to deploy four EB-66Es and two EB-66Cs to Kunsan AB, South Korea.[177] The aircraft arrived in three days. TAC objected to the deployment, as it had already pointed out in the previous year to the Air Staff that any plan to use Shaw assets would seriously affect the training of electronic warfare officer replacements. The loss of the EB-66E jammers from Shaw was not that critical for EB-66 pilots and navigators who could be trained in other B-66 variants still available with the 363rd TRW. However, the deployment of two EB-66C aircraft on 29 January 1968 forced TAC to notify PACAF and Seventh Air Force in South Vietnam that further cuts in EWO training would occur.[178] With a limited number of EB-66Cs available, the Joint Staff had to make decisions as to which theater commander would get the aircraft. This shortage of tactical electronic warfare assets, especially for electronic intelligence gathering, dramatically demonstrated that the Air Force was in no position to support more than one overseas contingency.

The Korean deployment had a permanent effect on the stateside training squadron. In 18 February 1968 the two C models returned to Shaw, and, to relieve airfield congestion on the Korea peninsula, the four EB-66Es moved to Itazuke AB, Japan.[179] This unit was known as Det 1, 363rd TRW. Manning for these four aircraft for the remainder of 1968 was provided by Shaw using the instructor pool at the 4417th CCTS and by the 41st and 42nd TEWS at Takhli. The 41st and 42nd had to send aircrew required for air operations over North Vietnam.[180] Additionally, an EB-66C from Takhli was tasked on a monthly basis by Fifth Air Force, under the codename "Commando Cousin," to fly ELINT missions to update the Korean electronic order of battle. The need to pull aircraft and personnel from a combat theater, Vietnam, to support a crisis in another theater, Korea, graphically illustrates how vital and scarce the EB-66 assets had become to theater commanders. But it also showed that with the losses over North Vietnam the pool of 36 EB-66Cs was rapidly exhausted when two theaters required the same assets at the same time.

To give the Korean deployment personnel stability, and because tensions on the Korean peninsula remained high, realignments in the EB-66 force structure became necessary. On 1 January 1969 Det 1, 363rd TRW was redesignated as the 19th TEWS and the squadron was relieved of its assignment to PACAF and reassigned to the 18th TFW at Kadena.[181] TDY commitments by Shaw and the squadrons at Takhli ceased, as permanent personnel were assigned. The EB-66C ELINT reconnaissance missions by Takhli continued since the 19th TEWS did not gain a collection capability, although it still was a jammer force. On 31 March 1969 the squadron moved again, this time to Kadena.

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[177] 363rd Tactical Reconnaissance Wing, *History, 1 Jan 1968-30 June 1968*, Shaw AFB, SC, 33.
[178] 363rd Tactical Reconnaissance Wing, *History, 1 Jan 1968-30 June 1968*, Shaw AFB, SC, 20.
[179] 363rd Tactical Reconnaissance Wing, *History, 1 July 1968-30 December 1968*, Shaw AFB, SC, 23.
[180] 41st Tactical Electronic Warfare Squadron, *History, 1 July 1968-30 December 1968*, Takhli AB Thailand, 4.
[181] 18th TFW, *History, 1 Jan 69 – 31 Mar 69*, Kadena AB, Japan, 25.

The number of aircraft in the 19th TEWS rose to eight EB-66Es that arrived between 21 October 1969 and 4 November 1969. The mission of the 19th TEWS was "to provide the ECM support necessary to permit strike, CAP,[182] and SAR forces to execute their tasks with minimum threat from enemy detection, interception, anti-aircraft, and SAM system capabilities."[183] Just as in Vietnam the EB-66Es were to escort strike fighters to their targets and jam radar and SAM systems.

Most aircraft modification work for the 19th TEWS was carried out at Takhli. With two squadrons assigned, it acted as the center for EB-66 operations in PACAF. During operations in Japan, the 19th TEWS was plagued by persistent maintenance problems. Fuel leaks in the wings required aircraft to be returned to the depot at Warner-Robins AFB. Other maintenance difficulties included conducting 300-hour engine overhauls, acquiring spare engines, and troubleshooting interference problems between the jamming equipment and the aircraft's radios and navigation aids. The interference problem stemmed from the fact that new jamming systems were procured in isolation and not tested as part of the overall EB-66 system prior to deployment. Field units in the U.S. and Asia, both in Japan and Thailand, had to troubleshoot and develop work-arounds to have the electronic gear fully integrated and operational. Unit histories all point out that the lack of system testing led to the expenditure of numerous man hours, in one case over 3000 hours, on a single electrical problem.

After another potential Korean crisis, brought on by the shootdown of a Navy EC-121 on 16 April 1969, abated, and, in order "to streamline military forces, reduce personnel and cut overseas spending," DOD directed that the squadron was to deactivate on 31 August 1970. The unit's EB-66Es flew to Shaw ending the Korean deployment of the EB-66s.[184]

Rolling Thunder Summary

In 1966 tactical electronic reconnaissance in Southeast Asia was limited at best.[185] The only Air Force capability in theater was represented by the EB-66C, which was ineffective for pinpointing emitter locations with the accuracy required for strike planning. One of the chief limitations was collection. Manual collection duties were shared among four electronic warfare officers (EWOs), each of whom had access to one of four frequency bands. Each EWO could collect emitter data of type and location on six to ten signals per hour. However, only one of the four EWOs had sufficient radio frequency coverage to collect intelligence information on priority radars that became the prime limiting factor on subsystem performance. The manual direction-finding systems caused errors in emitter location; the plotting could be off by ten percent. In Southeast Asia, the average emitter error was 10 to 20 nautical miles. Processing of raw ELINT data was normally done manually on the ground as a post flight procedure. Priority signal

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[182] Combat Air Patrol.
[183] Det 1, 363rd TRW, *OPPLAN 36-60*, Itazuke AB, Japan, 1968, 1.
[184] HQ PACAF msg dated 27 July 1970 to 19th TEWS/CC.
[185] TAC's role was regarded largely in terms of quick reaction alert, nuclear delivery by a single penetrator. Its forces had not prepared to fight the kind of war over North Vietnam that evolved in 1965/66.

processing was accomplished in flight, but at the cost of further enlarging what was already an unacceptable emitter location error. Dissemination of airborne data was limited to voice transmissions. Electronic intelligence data collected was manually plotted on maps by emitter type and direction. Multiple plots were then necessary to determine location.

The EB-66C aircraft was not adequate to survive in enemy environments likely to be encountered during tactical air operations in the late sixties. The requirement of identifying and accurately locating enemy radar sites for the purpose of destroying them was recognized in early 1953. Actions were then initiated to provide this capability in the EB-66C fleet. Thirteen years later, this aircraft, with modified equipment, provided the only tactical electronic reconnaissance capability for the Air Force. The system was well past its prime, but it was all that the USAF had.

The effectiveness of EB-66 jamming operations can be evaluated by using data collected in the "Project Red Baron" studies carried out by both the Navy and Air Force on air-to-air encounters during Vietnam. All air-to-air engagements by the North Vietnamese against EB-66s involved the MiG-21 and, while shooting the jammers down was the ultimate goal, most attempts at engagement had the effect of disrupting the jamming patterns by the EB-66s. As the North Vietnamese grew more aggressive the EB-66 orbits had to be moved and this allowed the North Vietnamese radar network to regain its air picture and to direct aircraft, missiles, and gunfire at American aircraft. The orbit locations near Thud Ridge must have disrupted the North Vietnamese IADS, since the most intercepts were attempted in the 1966-68 period whenever the EB-66s ventured into these orbit locations.

The EB-66 had certain inherent weaknesses, most of which stemmed from the fact that the aircraft was not originally designed for the job that it was required to do. The aircraft engineers who modified the basic RB-66 for electronic warfare increased its weight with no corresponding increase in engine power. As a result the aircraft performed sluggishly and, in Thailand's hot and humid weather, clung tenaciously to the runway during takeoff. In order to reduce the long run needed to coax fully loaded EB-66s into the air, the aircraft took off with fuel tanks partially full and topped off from aerial tankers. Even so, veterans say that the failure of one engine during take-off meant that a crash was inevitable, unless the landing gear was retracted and the indicated airspeed read at least 180 knots.[186]

Mission planners soon devised jamming packages, with instructions telling EWOs what frequencies to jam, when to transmit, and when to release chaff. These provided jamming support countermeasures for the kind of mission the EB-66s were required to support. Since personnel tours were only one year in Southeast Asia, the Air Force standardized operations in order to maintain effective jamming techniques and procedures. To obtain the best possible coverage from the package, the aircraft flew a standardized orbit designed for a particular task. For example, the orbit for the

[186] *Tactics Manual For SEA, EB-66*, 355th TFW, 22 Feb 1968, p. 5-3, Change 1.

reconnaissance drone was different from the orbit for the B-52. Individual EWOs might argue that this standardization told the enemy what sort of mission to expect.

An important aircraft modification was the installation of steerable antennas in the EB-66Cs. Staff EWOs implemented this change in the spring of 1968, enabling aircrew to focus an aircraft's jamming energy against a specific radar transmitter. The EB-66E never carried a steerable antenna, probably because the modification would have required the further installation of direction finding equipment to tell the operators where to aim the new antenna. During 1967 the EB-66s tried to jam the MiG identification friend or foe system which the North Vietnamese ground controllers relied on, but the closest orbit was some 75 nautical miles from the aerial battlefield, too far for a jamming signal.

EB-66s continued to fly electronic reconnaissance missions. Unfortunately, these missions were generally flown when the environment was not being stimulated by attack aircraft activity, resulting in few new finds.[187] More ELINT information was intercepted on active jamming missions which led to the conclusion that the frequent reconnaissance sorties should have been flown in conjunction with major strikes, not when the North Vietnamese air defense system was inactive. In order to acquire electronic order of battle information, jamming missions had to be combined with passive detection sorties. Since the crew of an EB-66C was usually very busy during an active jamming sortie, the intercepted signals and the originating points were not accurate in location.

As 1968 came to an end there still was no replacement for the EB-66C, B, or E. With the bombing shifting in North Vietnam, reconnaissance and jamming missions were required every day for strike packages. As Rolling Thunder drew to a close the North Vietnamese radar net expanded. The EB-66C brought back the first evidence that Soviet supplied radars, such as "Barlock" and "Spongecake," integrated Laotian and Thai airspace into their radar net. This meant that early warning systems in North Vietnam could be alerted as soon as Air Force aircraft went "wheels-up" in Thailand.

Rolling Thunder was over, but the war continued on other fronts and the 41st and 42nd TEWS with the EB-66s would again be called upon to provide critical support. There was no respite from the intense airborne electronic warfare for the aircrews and aircraft in Thailand.

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[187] Tape recordings of new electronic signals were analyzed on the ground and at the PACOM ELINT center to determine operating characteristics and countermeasures. Usually a 15-minute recording is required to gather enough data, but smaller tape cuts could be joined for analysis.

7. The Intermission of The Vietnam War 1969-1971 and Linebacker Operations In 1972

After the end of the Rolling Thunder campaign in 1968, the pace of air operations slowed so that fewer electronic warfare aircraft were required for missions over North Vietnam. The EB-66 strength in Thailand diminished accordingly. On 31 October 1969 the 41st TEWS disbanded. The number of EB-66s fell from a maximum of 38 aircraft in Southeast Asia, to 20.[188] The 42nd TEWS, the only Air Force tactical electronic warfare squadron in theater, had 6 EB-66Cs and 14 EB-66Es.[189] The veteran EB-66Bs all went into retirement at Davis-Monthan while the excess EB-66E aircraft were assigned to the 19th TEWS at Kadena.[190]

A further draw-down in the autumn of 1970 occurred during the "Vietnamization" phase of the war.[191] Along with troop withdrawals from South Vietnam, the Thai government required that U.S. forces on its territory be cut accordingly. In an attempt to meet that goal the 42nd TEWS relocated from Takhli to Korat on 30 September 1970, and it became a part of the 388th Tactical Fighter Wing (TFW). As part of the relocation, the Air Force transferred six EB-66 aircraft (one EB-66C and five EB-66Es) to Shaw, leaving eight EB-66Es and five EB-66Cs at Korat.[192] The reduction of one EB-66C would have a major impact on Southeast Asia reconnaissance operations[193] since the C models were the only tactical Seventh Air Force assets capable of gathering ELINT data.[194] The overall war took a different turn with the invasion of Cambodia in 1970 and the South Vietnamese interdiction campaigns into Laos. Air Force units in theater had to be augmented from the United States to support these operations to include the electronic warfare force. By May 1971 the 42nd TEWS gained a total of nine additional EB-66s from Shaw in support of the "Commando Hunt" and "Lam Son 719 Northeast Monsoon" interdiction campaigns in Laos.[195] The unit was then tasked to verify the 1972 "peace" agreement, and to identify new hostile radars in Southeast Asia, especially with regard to the movement southward of AAA and SAM radars.

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[188] 41st Tactical Electronic Warfare Squadron, *History, 1 July 1969 - 31 October 1969,* Takhli AB.
[189] 42nd Tactical Electronic Warfare Squadron, *History, 1 October 1969 - 31 December 1969,* Takhli AB.
[190] 42nd Tactical Electronic Warfare Squadron, *History, 1 October 1969 - 31 December 1969,* Takhli AB.
[191] This was a political move by the Nixon Administration to turn U.S. equipment over to South Vietnamese so that the U.S. personnel could be withdrawn from the war. Ground operations were turned over first, followed by in-country air operations. This allowed the USAF to down-size its South-East Asian commitment dramatically.
[192] 42nd Tactical Electronic Warfare Squadron, *History 1 July 1970 - 31 December 1970,* Korat AB.
[193] Capt Robert Colwell, *USAF Tactical Reconnaissance in Southeast Asia July 1969-June 1971* (Maxwell AFB, Corona Harvest, 23 November 1971), 7.
[194] The C model losses had the most impact on Thai-based operations because they conducted the bulk of the reconnaissance operations in theater. These losses also impacted operations at Shaw AFB since they were needed to train new EWOs.
[195] Colwell, 43-44.

From January till March 1969, EB-66C electronic reconnaissance missions attempted to learn whether or not the North Vietnamese had extended their SAM and radar guided AAA coverage beyond their borders into Laos and Cambodia. Such a move was anticipated to protect troop concentrations and logistical support lines leading into South Vietnam. In addition EB-66s maintained almost 24-hour continuous ECM coverage for air operations not terminated by President Johnson's bombing halt. The EB-66 continued to be the only Air Force aircraft engaged in stand-off jamming as the war continued through 1968 into 1969. However, by October 1969, the number of sorties being "fragged" by Seventh Air Force dropped to less than 12 sorties a day. Maintaining combat aircrew proficiency became difficult, and for the first time in Southeast Asia local proficiency flying was required to maintain readiness requirements for EB-66 aircrews.[196]

Laos

In Laos the primary mission of tactical electronic reconnaissance was to support the interdiction campaigns. EB-66C patrolled Laos watching for enemy fire control radars. The EB-66 sorties were supplemented by SAC's RC-135C "Combat Apple"[197] aircraft that flew high priority missions such as the Lam Son 719 operation of February – March 1971.[198] The five EB-66Cs of the 42nd TEWS constituted the primary tactical electronic reconnaissance force available to Seventh AF for Commando Hunt. These aircraft provided the capability for three sorties or approximately eight hours of coverage each day. Navy and Marine Corps[199] assets helped to give Commando Hunt the 24-hour ELINT support it required.[200] This experience underscored the critical nature of the USAF's diminishing ELINT force. Limited photo-reconnaissance due to the monsoon weather meant that electronic reconnaissance was vitally important to locating enemy forces and detecting the movement of North Vietnamese units through the jungle and along the Ho Chi Minh trail network.

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[196] Lt Col Robert W. Childs, *End of Tour Report* (Maxwell AFB, Project Corona Harvest, 9 Dec 1969), 8.

[197] "Burning Pipe" RC-135C and "Combat Apple" RC-135M were COMINT/ELINT sorties flown by SAC out of Kadena, thus the collected data were considered strategic and not passed directly to the 42nd TEWS. See *Vietnam Air War Debrief,* 100. Similiar missions were also flown in the early Rolling Thunder years by SAC RB-47H aircraft codenamed "Box Top." Strategic reconnaissance remained under the jurisdiction of SAC, Eighth Air Force in the SEA theater. Missions were usually 12 hours long in 1967. There were as many as 50 sorties a month, but this later dropped to 30 sorties a month.

[198] *Vietnam Air War Debrief*, 100.

[199] EP-3E, EA-3D, and EC-121 (Big Look) operating from DaNang in Captain Robert F. Colwell, *USAF Tactical Reconnaissance in SEA,* Project CHECO Report, 23 November 1971, 19.

[200] Captain Robert F. Colwell, *USAF Tactical Reconnaissance in SEA July 1969 – June 1971* (Maxwell AFB, CHECO Report, November 1969), 44.

AU Map Collection

Figure 18. This map shows the three critical passes from North Vietnam into Laos that were bombed by B-52s with EB-66 support.

In addition to aircraft shortages, the "Commando Hunt" experience demonstrated that the Air Force badly needed a newer tactical electronic warfare support platform. Also the time delays in data processing from EB-66 collection flights pointed to the need for a near-real time in-flight relay capability. Even more serious was the fact that the EB-66 was itself antiquated and that many of its sensors reflected the "state of the art" of the

early 1950s. A critical shortcoming was the inability of the EB-66's direction finding equipment to accurately locate enemy radar sites. At best, the DF and navigation equipment of the EB-66 was capable of placing a radar within a circle with a radius of approximately 10 nautical miles[201] which was inadequate for targeting these sites. The equipment limitations were compounded by the enemy's transmission discipline; short transmission bursts[202] by enemy radar frequently permitted only a single line bearing on the transmitter locations. This information was unfortunately not good enough to dispatch F-4 or other tactical aircraft to bomb these sites. The EB-66C could not cope with these intermittent transmission techniques. Its manual collection system was too slow and the electronic reconnaissance data it collected was not suited for rapid exploitation.[203]

B-52 Support Operations

Some 12 months before the end of Rolling Thunder the North Vietnamese began shifting SA-2 SAM sites to deal with B-52 strikes on the Ban Karai and Mu Gia passes into Laos and in the area immediately south of the DMZ (see map on page 68).[204] The North Vietnamese set up SA-2s just inside their own territory that could reach B-52s as far as 15 nautical miles south of the DMZ. To counter this threat, EB-66s escorted the bombers and provided stand-off jamming. On a typical mission one or more EB-66s closed to about 10 nautical miles from the target but remained outside of North Vietnamese airspace. Radar jamming began at that point. Electronic warfare officers on board the B-52s, also watching for hostile radar activity, turning on their own jammers to reinforce the EB-66 barrage, should the North Vietnamese begin transmitting.

The EB-66C was vulnerable during jamming missions against SA-2s. Crews compensated by ensuring it never over-flew any known or suspected SAM sites. In reality, however, this could not be avoided as downing of an EB-66C in 1972 demonstrated. With threat considerations in mind, the EWOs and navigators planned their routes to provide optimum jamming support for the B-52 support missions. Optimal support for any aircraft being protected by the EB-66 had to address the SAM threat. On frequent occasions forces being afforded jamming protection flew within known SAM site threat rings. This prevented the EB-66s from supplying maximum jamming coverage to the supported aircraft since they were restricted from flying within these areas. Between 1965 and 1967 the EB-66s afforded both altitude and azimuth jamming, but, with the aging airframe and the multitude of antennas and external equipment that had been added to the airframe, the EB-66 could no longer attain the altitudes desirable for

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[201] *USAF Tactical Reconnaissance in SEA July 1969 – June 1971* (Maxwell AFB, CHECO Report), 44.

[202] A form of transmission security. Radars are kept off the air until ready to fire the SAM or AAA gun. Other radars not normally associated with the weapon system are used to monitor aircraft movements and provide altitude, speed, and direction information to the weapon system.

[203] *USAF Tactical Reconnaissance in SEA July 1969-June 1971*, 45.

[204] These two passes from North Vietnam into Laos were the primary resupply routes of the North Vietnamese regular army fighting inside South Vietnam, Cambodia, and Laos. The passes were the only places where trails converged forcing the North Vietnamese supply troops to store equipment and supplies in depots which could be hit from the air.

optimum support. Regardless of the number of EB-66s used, a combination of jamming equipment and techniques were employed to cover all enemy frequencies.

To improve jamming, the staff at Takhli prepared EWO instructions that provided emphasis on specific radar types. Thus, different EB-66E jammers within the same jamming orbit would target different radar frequencies relying on power output and frequency band coverage to "blind" hostile systems. Although the orbit locations remained static, the jamming package used in each orbit were varied in an effort to prevent the enemy from countering repetitive jamming operations.

The EB-66s flew at tactical altitudes of 23,000 to 27,000 feet. This became a problem as the B-52s flew ten thousand feet higher. To compensate for the lack of altitude coverage, multiple jamming platforms were used to insure jamming from several azimuths, thus achieving a more complete degradation of the enemy's defense systems. The concern was not so much fire control radar degradation, but rather with the degradation of enemy early warning radars, the ones that feed initial acquisition information to the SAM and AAA fire control radars. By denying the enemy initial acquisition, a time advantage was gained and time, even a few seconds, could be critical in the success or failure of a SAM against a B-52.[205] The impact of the EB-66 jammers combined with those on B-52s seriously hampered enemy air defense capabilities.

Just as in previous years, there were other types of support being flown by the 42nd TEWS. In 1971-72 the unit assisted fighter strike, photo-reconnaissance, AC-130 gunship, psychological warfare (leaflet drop), and search and rescue (SAR) missions. Orbiting near the AC-130 gunships or SAR forces, both C and E models would jam and provide warning of SAM/AAA radar activations in the area of operations.[206] The "Grey Creeper" mission was a C-130 photo-mapping survey of northern Laos. Two EB-66Es would be fragged to provide jamming support. One EB-66E had to be wing level at all times and within 15 nautical miles of the RC-130. This required excellent flying skills on the part of the EB-66 pilot since the minimum airspeeds for an EB-66 and RC-130 were quite different. To compensate, the EB-66s had to weave behind and above the RC-130.

Until May 1969, the EB-66 bore exclusive responsibility for stand-off jamming to screen drone reconnaissance flights over North Vietnam. During that month Marine Corps EA-6As[207] began sharing that burden. Both the Marine Corp's new EA-6A and the Navy's EA-6B "Prowler" variants produced more jamming power and could better align their signals towards the radars being jammed.[208] When the North Vietnamese changed the operating frequency of the Fan Song missile guidance radar for the SA-2 to a higher frequency, I-Band, the EA-6A was the only system in theater capable of monitoring that bandwidth. The EB-66 was later modified to reach this new frequency band.

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[205] Colwell, 43.
[206] Lt Col Childs, 10.
[207] Based at Da Nang South Vietnam with VCMJ-1. They took the place of the Skyknight EF-10.
[208] Air Vice Marshal J.P.R. Browne, *Electronic Warfare (London:* Brassey's Vol. 4, 1998), 32.

Operational security was easier to maintain for the Navy since EA-6A aircraft routinely protected US Navy carriers operating in the Gulf of Tonkin. Operational security for EB-66 drone support was a problem that had to be addressed in 1969. The USAF Security Service noted that normal EB-66 supporting procedures were a factor in alerting North Vietnamese air defenses to drone launches.[209] Since few EB-66s flew north over the Gulf of Tonkin, the North Vietnamese were able to determine that a launch was imminent when an EB-66 proceeded in that direction. After September 1969 diversionary flights were scheduled and some random fragged missions helped to mask the actual drone launches.[210]

Tactics

The rigid orthodoxy associated with EB-66 tactics continued in 1972. The number of EB-66s and KC-135s, and the repeated use of the same strike routes, altitudes, and times for major strikes and corresponding stereotypical orbit patterns, all provided clues to B-52 targets. Personnel turnover still forced a standardization of jamming missions along specific routes. Call-sign and strike-time changes helped to somewhat vary standard routines air operations after 1969.

The EB-66s also increased the use of chaff. When dispensing chaff, the aircraft avoided SAM infested areas and relied on the wind to carry the radar reflectors over the target. The EB-66 orbits were either figure-eight or elliptical and covered an area measuring 4 by 40 nautical miles. The orbit locations were based on up-to-date weather forecasts. On board each aircraft were two hoppers, each carrying 348 chaff bundles. The EB-66 might drop its first bundle 3 hours or more before the strike it was helping to screen, depending on wind velocity and direction and distance to target. These factors also determined the rate at which chaff was dropped, usually 12 bundles per minute from each of the two hoppers.[211]

As they had in earlier years, the EB-66s continued to try jamming radio communications between ground controllers and MiGs. Results varied according to the distance the jamming signal had to travel and the angle formed by the orbiting EB-66, the radio transmitter, and the interceptor formation. The shorter the distance and narrower the angle, the better the results. The aircraft also continued to engage in long distance electronic radar jamming. On most missions, they focused upon target acquisition, early warning, and ground control intercept sets, through the EB-66E sometimes jammed Fan Song transmitters located near the center of the area protected by SAMs. On a Fan Song mission, an EB-66C usually accompanied the EB-66E to detect signals from AAA radars, such as Fire Can, and alert the E model which could then direct a noise barrage against them. Jamming acquisition and early warning radars also had indirect results, forcing fire

[209] "Bumpy Action" was a drone photo-reconnaissance mission.
[210] EB-66 Manual, 22-25.
[211] EB-66 Manual, 3-3, Change 4.

control radars to acquire the approaching aircraft, thus presenting themselves as targets for anti-radiation missiles fired by F-105Gs.[212]

In an attempt to provide a greater level of jamming coverage the 42nd TEWS received support from the Navy's new EA-6B Prowler. These operations, prior to the cease fire of 1971, helped to create more extensive jamming coverage and also confused the North Vietnamese, who were blinded to such an extent that they could not determine the direction or strength of an approaching strike force. This cooperation only lasted for a short time and was not repeated until the Linebacker I and II raids in 1972. The biggest obstacle to increased cooperation was the lack of a "joint commander" in Vietnam who could direct the air activities of both Air Force aircraft and the Navy carrier-based aircraft. Coordination with carrier-based EA-6B and Thailand-based EB-66s was complicated by command arrangements and the distances involved. Joint planning worked slightly better with U.S. Navy assets stationed at Da Nang AB, South Vietnam.

A new jamming protection package, developed by the 42nd TEWS EWOs, provided greater versatility and protection of the strike force. New jamming protection packages were difficult to create as a multiplicity of factors had to be considered, such as knowing enemy emitter ranges (EB-66C determined these parameters) and the capabilities of the jammers themselves including ease of operation and physical location within the EB-66E. The new package allowed the EWO to transition from acquisition jamming to jamming of enemy GCI radars for self-protection by only realigning six transmitters during a mission.[213] With the older packages most of the twenty-one transmitters had to be realigned. This new package improved jamming performance and gave the strike force more protection.

Jamming tactics in 1969-1971 varied depending upon the specific support mission to be accomplished. In general, however, jamming was initiated upon entering the North Vietnamese early warning/GCI net. Upon reaching the target area, SAM, AAA, and their associated acquisition radars received priority. The EB-66E used jamming packages (jamming transmitters set to cover selected frequencies) designed to counter AAA and SAM threats, and to blanket early-warning, ground control intercept, and acquisition radars. The jamming packages were designed to provide maximum jamming coverage for aircraft supported by the EB-66. Pure noise barrage jamming was used to supplement the self-protection pods carried by the strike aircraft. The EB-66E packages were designed to meet changing mission requirements and available resources. These included variations in threat environment, in the particular mission, and in the number and type of jamming support aircraft available for a given mission. Therefore, the packages were specialized in design to provide optimum coverage of specific radars. A given package was thus appropriate only under a certain set of circumstances. A limited number of jammers were allocated to cover the total frequency bandwidth for a specific radar. The remaining jammers were allocated against the radar's intercept frequencies. Built-in

[212] *Tactics of Electronic Warfare*, Project CHECO Report, July 1974, 23.
[213] *Tactics of Electronic Warfare*, Project CHECO Report, July 1974, 43.

redundancy and overlapping coverage minimized the effects of possible system malfunctions.[214]

On 26 December 1971, Operation "Proud Deep Alpha" began, an air campaign designed to bomb the logistics infrastructure and air defense installations in southern North Vietnam. The build-up of North Vietnamese forces in this area had not gone unnoticed.[215] The EB-66s figured prominently in the five-day, 1000-sortie operation, flying 182 sorties. The North Vietnamese had learned a great deal about the EB-66s since Rolling Thunder and now would salvo numerous SA-2s in the direction of jamming sources hoping to down or at least disrupt the jamming patterns of the EB-66s. The following accounts show under what conditions the EB-66 crews fought in the second half of the Vietnam War.

On 29 December 1971 a SAM site protecting Quan Lang airfield engaged an EB-66E flown by Lt Col Frank Wink. The EWO detected a Fan Song radar in high pulse frequency repetition, meaning the radar had acquired Wink's EB-66E, and then the launch signal. He warned the pilot, who saw the missile in time to make a hard diving turn to the left. As this SAM exploded harmlessly high above the aircraft, the EWO reported another launch and then a third. Eluding both missiles, the EB-66E got clear of the battery that had just salvoed the SA-2s. On that same day, another EB-66E under Lt Col Jack E. Tullett escorted 34 F-4D Phantoms to their targets deep inside North Vietnam. Lt Col Tullett's EB-66E was leading another EB-66E and an EB-66C. The latter managed to pinpoint every one of the new SA-2 Fan Song radars near the Mu Gia Pass, that the EB-66Es jammed.[216]

With the EB-66 force shrinking further due to maintenance problems, aircraft usage was modified. The EB-66E still served as the primary jammer between 1969-1971, due to the limited number of transmitters installed in the EB-66C, except when maintenance required the substitution of a EB-66C for an EB-66E or it was desirable to employ the steerable integrated tactical antenna subsystem (ITAS)[217] against specific radar signals that posed a threat to the supported forces. The primary mission of the C model continued to be the collection of new signals and the analysis of jamming operations on North Vietnamese radar sites. The EB-66E provided broad frequency coverage usually concentrating on EW/GCI frequency bands. If the threat radar sites and frequencies outnumbered the transmitters available, which was usually the case, barrage jamming frequency widths were widened, and the EB-66C ITAS antennas were pointed to cover the maximum number of threat radar sites possible. This two-dimensional jamming problem (frequency and direction) required considerable forethought and planning to be successful.

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[214] *Tactics Manual for SEA, EB-66*, 355th TFW, 1969.

[215] The North Vietnamese believed that the US would leave South Vietnam, so they built up arms dumps in South Vietnam in preparation for a ground campaign in 1972. USAF and USN reconnaissance assets had observed the build-up and, after reconnaissance aircraft had been fired upon, a series of strikes were set up to hit logistics lines inside Laos and southern North Vietnam at the transshipment points.

[216] *Air Force Operations over North Vietnam*, Project Corona Harvest Report, PACAF, September 1972.

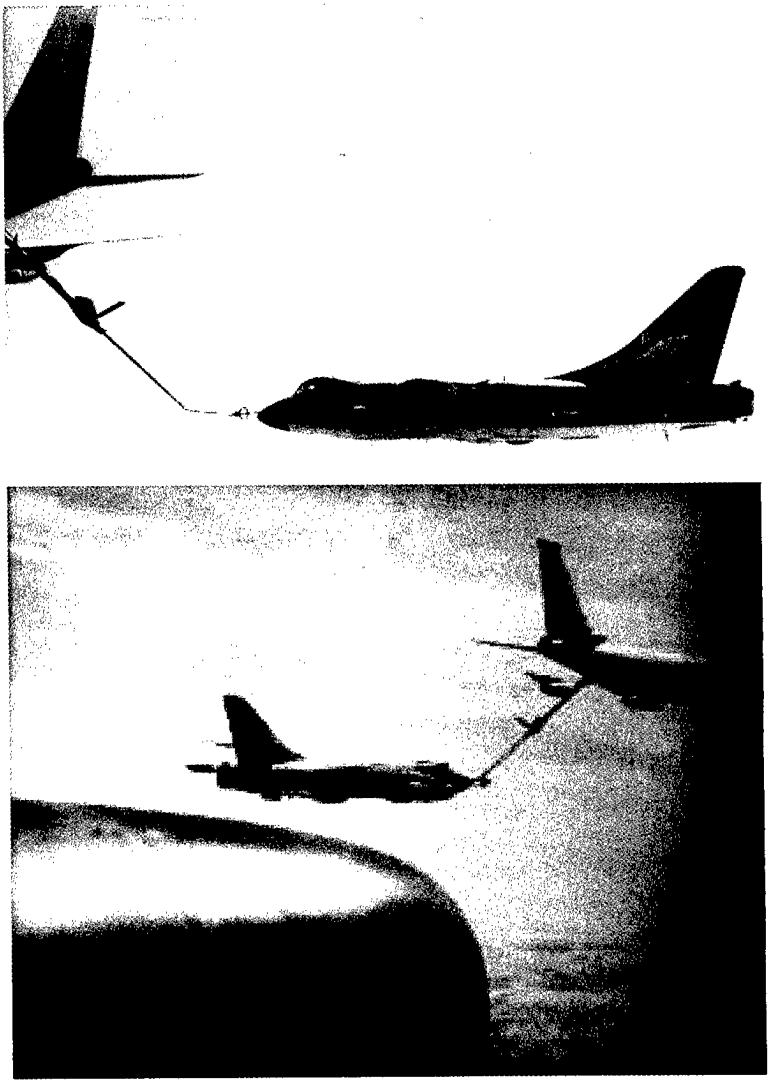
[217] The EB-66 had five steerable ALA-32 antennas, with each antenna connected to an individual jammer.

Fuel Limitations

Air refueling support was the prime factor determining mission duration. It also limited any variation in tactics, diversionary tracks, chaff drops, and jamming techniques. Tanker support was required but frequently was either not available or cancelled. Exact percentages are not available, but the problem was directly related to the number of KC-135s available to Seventh Air Force. Heavy tanker usage by fighters or B-52s meant that there was little or no tanker support left for the EB-66s. This resulted in mission cancellations. The EB-66's probe and drogue refueling method required the KC-135[218] tanker to be specially configured with a hose attached to the boom. This hose rendered the KC-135 unusable to all other USAF aircraft in theater. This refueling system dated back to the birth of the EB-66 fleet, when TAC and SAC used different refueling methods for their respective aircraft. Seventh Air Force had removed all other Air Force probe-only aircraft such as the F-100s and F-104s from the theater, that could not be refueled by SAC's boom-equipped KC-135 tanker force. The EB-66 fleet, however, could not be removed or replaced, nor was the Air Force willing to spend additional funds to equip the EB-66 with a boom receptacle. Thus, refueling became a major limiting factor in EB-66 operations.

The impact on EB-66 operations was dramatic. The EB-66E model aircraft could provide jamming support for only short periods without aerial refueling. The EB-66C aircraft was unable to provide even limited jamming support or ELINT collection without refueling. To avoid using excessive numbers of dedicated tankers for EB-66 operations, which otherwise could be used for strike forces, every effort was made by the planning staff in the 42nd TEWS to combine EB-66C/E refueling requirements into the fewest number of tanker sorties. The duration of a mission was based upon arriving at the jamming orbit start point with adequate fuel for the orbit and the required reserve for landing at Takhli, including fuel reserves to an alternate field. The normal duration of an EB-66E unrefueled mission was one hour fifty minutes, and that of the EB-66C was one hour. The EB-66E took off with approximately a 22,000 pound fuel load, and the EB-66C with approximately 16,000 pounds.[219] The 6,000 pound difference in the EB-66C was a built in safety factor for the four EWOs in the aft crew compartment. If required, both pre-strike and mid-strike air refueling were conducted, adding to overall sortie duration. Jamming support was thus just not possible without air-to-air refueling. The crews flying over the Gulf of Tonkin did have other refueling sources. U.S. Navy tankers would in an emergency situation give an EB-66 enough fuel to return to base. Most personal accounts state that the KC-130F that operated out of Da Nang was used, as was the KA-3D. While not used on a daily basis the Navy tankers did provide a margin of safety during the flights over the Gulf of Tonkin.

[218] Strategic Air Command KC-135 tankers were built with a boom to provide rapid pressurized refueling to B-52 bombers on nuclear missions. All other fixed wing USAF aircraft in Southeast Asia could be refueled from the boom save the EB-66 fleet, which had been built when TAC used KB-50s as its tankers.
[219] Francillon and Roth, 6-7.



Photos courtesy of Lt Col Jack Sullivan, USAF Ret

Figure 19. The top photo is of an EB-66E (notice the antenna farm on the belly of the aircraft). The bottom picture shows an EB-66C being refueled (notice the pods on the wingtips).

EWO Training

Another problem faced by the EB-66 community was training. The situation reached crisis proportions in 1971 when there were not enough aircraft to allow comprehensive EWO crew training at Shaw.[220] This was due to aircraft availability and logistics problems including the number of aircraft in an "inspect and repair as necessary" (IRAN) status, a form of depot-level maintenance. As a result, new EWOs arrived in Southeast Asia in 1970 without having flown in the aircraft. Experienced EWOs coming from other aircraft, like the B-52, were also affected, but since they had flown before they were used in the 42nd TEWS to maintain the experience level. Under AFM 51-66, the Air Force manual governing aircrew training, combat-ready EWOs were required to have completed six sorties in Phase I and five missions in Phase II of their training before they arrived in theater.[221] Without airframes at Shaw, this simply was not happening.

The training squadrons at Shaw attempted to fill the void by using ECM simulators. The EB-66C EWOs used an old RB-47 simulator that was effective in teaching the use of the equipment but had one major limitation since it was only a two-man simulator.[222] This forced the trainers to combine positions resulting in a lack of crew coordination training. The "E" model EWOs had better training equipment. Their simulator was a modified B-52 T-4 simulator that incorporated very accurate layout of the EB-66E.

With the continued shortage of C models in Thailand, the training situation deteriorated further. Previously, when a new EWO arrived to the 42nd TEWS in Thailand he was given eleven flights in the EB-66C under the supervision of an EWO instructor. These theater flights allowed the new EWO to understand the mechanics of the EB-66C and learn how to intercept actual North Vietnamese radar emissions. Now the new EWOs had to fly actual sorties and learn the "business" while supporting on-going operations. These missions were flown in the combat zone and were, by a strict interpretation of AFM 51-66, not a proper method of training. However, with no other options and due to the relatively small number of "experienced" EWOs coming to Southeast Asia, this training program was the best compromise available to meet mission requirements.

Starting in April 1972 when the EB-66E became the primary electronic warfare aircraft. Logistical problems with the engines began to emerge and the EB-66C engines were cannibalized in order to support the EB-66E. This drastically cut down the number of EB-66C sorties and hence slowed the EWO checkout program creating a backlog of non-combat ready EWOs. Temporary duty EWO support from Shaw and Germany became necessary to cover the EB-66C mission assignments. It became very apparent

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[220] In November 1970 the 39th TEWTS sent six EB-66s to Korat during "Coronet West," forcing TAC to suspend the flying portion of EWO training until the aircraft returned from their deployment. (363th TRW, *History, 1 July –31 December 1970,* Shaw AFB, SC, Vol. 1.)

[221] *AFM 51-66,* Bolling, AFB Washington, DC, dated March 1967.

[222] 363rd TRW, *History 1 July to 31 December 1968*, Shaw AFB, SC, 35.

that immediate action was required to insure a more timely upgrading of EWOs to combat ready status in order to meet the heavy operational flying commitments.

After the cease-fire in 1971 flight training was increased to keep crews at peak efficiency. Most EB-66E flights were for training purposes and pilots were able to obtain additional flying time to practice air refuelings. While the EB-66C was heavily tasked with ELINT sorties, training was also conducted during these sorties. An instructor rode in the gunner's seat to supervise pilots and navigators on these sorties.[223] With four positions in the EWO compartment, EWO training was continued. This allowed the unit to recover from personnel shortfalls and prepare for the next stage of the Vietnam conflict.

Maintenance

The aircraft had been performing tirelessly, but the advanced age of the EB-66 fleet and the climate in which they operated began to take its toll. A lack of new aircraft engines and the limited number of spares in Thailand led to cannibalization to obtain engines and parts. After two accidents at Shaw in 1969, the depot at Warner-Robins AFB determined that the engines required a shorter overhaul cycle. An immediate program for overhaul of 64 J-71 engines in the 42nd TEWS started in May 1969 and was completed in July 1969.[224] The number of operational accidents rose as engine components simply failed due to age and wear. By 1972, maintenance issues dominated monthly and quarterly squadron reporting.[225] A 1972 squadron report made it clear:

> The EB-66 is an old aircraft, and parts have not been made for years. In addition, since the Air Force has been planning to retire the aircraft for a number of years, they (sic) are reluctant to authorize money to manufacture long lead-time items and make necessary modifications and improvements.[226]

The J-71-13 engines were the biggest problem. After a number of catastrophic failures such as engine blowups, the number of engines and aircraft able to fly was significantly reduced.[227] To support the E model in 1972, EB-66Cs were cannibalized for engines. This limited ELINT activity.[228] The depot recommended a 1200-hour limit on all engines. This left the unit with only enough engines available for 12 of the 27 aircraft on hand, plus three spare engines.

In addition to the 1200-hour limit, that temporarily grounded many of the EB-66s, take-off fuel loads for all missions were reduced to provide a safe minimum level single-

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[223] 363rd TRW, *History, 1 July to 31 December 1968*, Shaw AFB, SC, 18.
[224] 363rd TRW, *History, 1 July to 31 December 1972*, Shaw AFB, SC, 44.
[225] 42nd Tactical Electronic Warfare Squadron, *History, 1 July to 31 December 1972,* Takhili AB, Thailand, 1–11.
[226] 42nd Tactical Electronic Warfare Squadron, *History, 1 July to 31 December 1972,* Takhili AB, Thailand, 3.
[227] Fatigue failure of a compressor rotor blade in the fourth stage compressor destroyed an engine.
[228] Lt Col Hurst, *End of Tour Report,* Maxwell AFHRA, 4 April 1973.

engine performance.[229] This required all sorties to be air refueled. The most serious problem confronting EB-66 crews during the late sixties and seventies was engine wear. In April 1969 an Allison J-71 engine failed on take-off and an EB-66E crashed killing three on board. Inspection of the wreckage disclosed a failure in the fourth stage compressor. Thereafter the Air Force grounded the entire EB-66 fleet while the mechanics examined the engines. The mechanics discovered that cracks were common in those engines with more than 1200 hours. After inspections at Takhli, slightly more than a third of the aircraft were found to require engine replacements, a job that took two months. Although the immediate crisis ended in June 1969, engine wear was a recurring problem during the remainder of the war.

Another serious problem requiring maintenance involved multiple fuel cell leaks. The EB-66 is a wet-wing aircraft, which consequently requires a sealant to be used on all seams in the wing skin. Extended service and the tempo of operations in Southeast Asia led to sealant cracks and resulted in major JP-4 leaks near the wing roots where the greatest stresses occur. While dangerous, a few sorties were launched from Takhli, and later Korat, with fuel leaks because not enough other aircraft were available for the sorties required by Seventh Air Force.[230] After initiating a set of interim corrective measures which themselves took weeks to complete, it became evident that the only alternative was to completely reseal the aircraft which kept them grounded for months as the ground crew stripped, prepared, applied, and cured the sealant.

Because of these problems, PACAF requested that HQ USAF provide some relief. As there were no replacements for the EB-66, PACAF felt that new engines such as the Navy's J-57 could be provided to return a large portion of the EB-66 fleet to the air. On 8 May 1969 the Air Staff rejected any modernization program and instead directed that the EB-66 force be maintained as a viable force through normal maintenance and modification processes. Mechanical problems persisted throughout 1972. The 42nd TEWS was hard pressed to fly the required 15 sorties per day with an average of 19 EB-66s available. In September the shortage of engines caused the number of daily sorties to decline to eight, while the leaking fuel tanks reduced the number to six sorties a day.

Both operation and maintenance woes took their toll in 1972 as the Vietnam War continued. The 42nd TEWS was left with thirteen aircraft, eight E models and five C models, but the Air Staff denied attempts to increase the unit strength to 20 aircraft (13 E models and 7 C models). This denial was based on planning guidance in the Pentagon that the aircraft would be retired in fiscal year 1973. In November 1972 when it looked like a cease-fire for Vietnam would go into effect, PACAF decided to start a planned phase-out of the EB-66 fleet.

The criterion used by PACAF for removing EB-66s from the inventory at Korat was based solely on the number of airframe hours, not necessarily the best measurement as the engines were the real problem. Many of the aircraft chosen for retention had not

[229] 42nd TEWS, *History, 1 January – 30 June 1973*, Korat AB, Thailand, 8.
[230] E-mail from Mr. Glen Adams, USAF Ret., 6 March 2000.

flown in months due to fuel cell or engine problems.[231] In fact, the airframes with the highest number of flight hours were the aircraft that could fly and thus were better suited to remain in the inventory. This type of criterion imposed by headquarters in Hawaii had unfortunate consequences. An emergency meeting in Hawaii in 1972 about the composition and retention of the EB-66 fleet in the theater revamped PACAF's selection process for the retirement of EB-66 assets, but not before another critical EB-66C had been sent to Davis-Monthan.[232] Since the being of the war the EB-66Cs had been in short supply. No more that the original 36 had been built and there had been no conversions of desert storage aircraft to the C configuration. The jammer E model fleet could always be expanded since these airframes were all conversions from existing aircraft in storage. Operational and combat losses had cut into the number of C airframes. These losses severely curtailed ELINT gathering and EWO training missions. Collection of new signals and observation of North Vietnamese radar deployments became the hallmark of the C models after Linebacker, since Seventh Air force used them to verify compliance with the Paris peace accords.

BAT 21

A dramatic demonstration of EB-66 vulnerability took place on 2 April 1972, in an area just south of the DMZ where the presence of SAMs was suspected but not yet confirmed. Both an EB-66C and EB-66E were supporting a three ship B-52 strike. The North Vietnamese fired four SA-2 SAM missiles at the B-52s package that missed. A second volley of three SA-2s probably aimed at the jamming source brought down the EB-66C.[233] The loss forced Seventh Air Force to ban the EB-66C, which generated less jamming power that the E models, from areas where SAMs were suspected.[234] During Linebacker II, however, all restrictions involving the EB-66s were waived, allowing three EB-66Es to orbit 40 nautical miles west of Hanoi. Their jamming fields were disrupted when MiGs and SA-2s forced the aircraft to maneuver to avoid these threats. The EB-66Cs also flew sorties during Linebacker I and II. The only aircraft lost was an E model that crashed at Korat due to an engine failure killing all three crewmembers.[235]

On 29 March 1972 North Vietnam began its long awaited invasion of South Vietnam directly across the DMZ. The South Vietnamese army proved unable to stop North Vietnamese armor while air power was grounded due to the monsoon cloud cover. USAF assets had been so depleted by the draw-down of forces under President Nixon's initiatives that a series of deployments under the code-name "Constant Guard"[236] were required to get air power back into theater. On 7 April 1972 eight EB-66s from the 39th TEWTS at Shaw arrived at Korat.[237] These aircraft gave Seventh Air Force some badly

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[231] Lt Col John F. Hurst, *End of Tour Report.*
[232] 42nd TEWS, *History, 1 January – 30 June 1973*, Korat AB, Thailand, 4.
[233] Lt Col Iceal "Gene" Hamilton, the only survivor, would evade capture for eleven days.
[234] *Tactics of Electronic Warfare*, Project CHECO Report, 23.
[235] *Tactics of Electronic Warfare*, Project CHECO Report, 30.
[236] A series of deployments had been planned during the withdrawal of US forces. Thus two TFWs and a Marine Air Group returned to Southeast Asia to attempt to stop the North Vietnamese invasion.
[237] *TAC Programming Plan 25-73*, Shaw AFB, SC (30 November 1973).

needed electronic warfare assets, since the North Vietnamese were moving their SA-2 systems with them as they advanced into South Vietnam. This in turn was creating a very dynamic air defense environment which affected close air support and interdiction missions by tactical fighter aircraft.

Linebacker

The lull in the air war had given the North Vietnamese an extended opportunity to improve their capabilities, tactics, and training for the final air campaigns of the Vietnam War. Thus, when full-scale air attacks on North Vietnam resumed in May 1972, the North Vietnamese had rebuilt their air defense system, adding radars that extended coverage deeper into Laos and South Vietnam.[238] Other refinements included more SA-2s, MiGs, and anti-aircraft guns. North Vietnam also integrated signals intelligence into its air defense system.[239] North Vietnam was capable of monitoring American communications in Thailand and South Vietnam and relaying information of U.S. strikes to radar and air defense sites around the country.[240] The improved capabilities created new and different electronic warfare challenges that the EB-66s had not previously encountered in the past over North Vietnam.

The Air Force used a complete and sophisticated package of ECM and SAM suppression aircraft to protect the B-52s during Linebacker I and II. Activities among the various support and suppression aircraft were carefully orchestrated. Up to 85 aircraft would accompany the bombers during their nightly raids. F-4s and EB-66s dispersed a wide corridor of chaff to blind North Vietnamese early-warning and acquisition radars. Other EB-66s and EA-6Bs jammed North Vietnamese GCI radars in an effort to prevent the entire air defense system from receiving early warnings of the attack. On 18 December 1972, with the Linebacker II resumption of bombing over Hanoi, the 42nd TEWS provided extensive coverage for B-52s.[241] The North Vietnamese, however, employed standard and well executed electronic countermeasure tactics such as band switching and frequency changes to make it more difficult for the EB-66s to jam North Vietnamese signals. On this occasion, the risk to the EB-66s seemed justified. It was a case of vulnerability "be damned." Three EB-66Es assumed an orbit just 40 nautical miles west of Hanoi. While these aircraft jammed the radar controlled defenses of Hanoi, a flight of MiG-21s closed to within five nautical miles before F-4s intervened and scattered the MiGs away before they could intercept. The EB-66Es were also forced to dodge SAMs, temporarily disrupting their jamming patterns. The North Vietnamese fired

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[238] *Air War Vietnam* with an introduction by Drew Middleton, (New York, NY: The Bobbs-Merrill Co, Inc, 1978), 141.

[239] American SIGINT on the other hand was collected by a variety of sources but kept from aircrews because they did not possess high enough security clearances. Attempts by senior Air Force officers to solve this problem met with resistance. A site codenamed "Teaball" was established at Nakhon Phanon Thailand but never managed to win the confidence of US aircrews see *Clashes. Air Combat over North Vietnam 1965-1972* by Marshall Michel.

[240] Michel, 190.

[241] With EB-66 jamming from both Laos and the Gulf of Tonkin, the first and second waves each had 3 EB-66Es operating over North Vietnam near Hanoi, the third wave was escorted by 5 US Navy EKA-3Bs.

at jamming sources validating that EB-66 jamming was indeed effective. SAM sites were being relocated at night and this was making the job of the EB-66s more challenging. In addition, the North Vietnamese had perfected existing techniques such as quickly shutting the radar off to prevent the EB-66s from learning the transmission capabilities of the radars. The EB-66s provided the best support they could in light of the circumstances. Overwhelming North Vietnamese defenses with jamming was not possible, thus the B-52s suffered losses, but the EB-66s did not.

As the North Vietnamese began to acquire air defense radars that operated in the I-band range, upgrades to the EB-66 jamming equipment were initiated. The EB-66s needed to keep pace with developing threat systems. This measure took on increased urgency as the SA-3[242] and its associated tracking radar "Low Blow" operated in the I-Band. This was the next SAM system acquired by the North Vietnamese from the Soviet Union.[243] Its operating characteristics were vastly improved over those of the SA-2[244] and, if used in combat over North Vietnam, would have severely curtailed EB-66 operations. At the conclusion of Linebacker II, the EB-66s resumed "Tiny Tim" B-52 support operations over Laos and northern South Vietnam.

Finis

The conclusion of Linebacker II on 31 December 1972 came none too soon for the EB-66s due to the criticality of the maintenance situation. Spare parts supplies were exhausted, all spare engines had been used, and the last useable forward fuel tank had been salvaged at Davis-Monthan The 42nd TEWS continued to fight logistical and maintenance difficulties until March, when the flying schedule eased and parts arrived from the U.S. The remainder of 1973 was spent verifying North Vietnamese compliance with accords reached in Paris and in supporting B-52 operations. When bombing ceased over Cambodia on 14 August 1973, only electronic surveillance missions were flown.

The end of the Vietnam War also marked the end of the EB-66 in the service of the USAF. On 24 December 1973 the EB-66C flew its last electronic reconnaissance mission in Southeast Asia. On 26 December, Thirteenth Air Force cancelled all further

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[242] An SA-3 may have shot down a USMC F-4B but this is still under dispute. SA-3s were not deployed in any great numbers until 1974/75. See Steven J. Zaloga, *Soviet Air Defence Missiles. Design, Development and Tactics* (Alexandria, VA: Jane's Information Group, 1989).

[243] Zaloga, 92.

[244] The technological coup de grace for the SA-2 SAM system came during Vietnam. The USSR supplied AAA and associated radars in 1965 and also agreed to supply SA-2s. The SA-2 was designed to hit high flying bombers, and thus could not hit small, fast, and low targets. The PVO (Soviet air defense forces) estimated it would take two SA-2s to down an opposing aircraft. By 1966 the average in Vietnam was 30 per aircraft The average increased as the USAF added sophisticated ECM and improved its tactics. While a new tactical SAM was not available in 1966 it is also doubtful if the USSR would have deployed it. By 1974 the average number of SA-2s required to down an aircraft was 55. Nevertheless the Soviet Union and its client states continued to improve the SA-2, and today it still provides an air defense capability for many ex-Soviet client nations.

EB-66 sorties. Deactivation activities now moved at a rapid pace. On 2 January 1974 all remaining EB-66s were flown to Clark AB, Philippines for salvage. None would ever fly back to Davis-Monthan as they were scrapped in the Philippines. The USAF would also deactivate the training establishment at Shaw in 1974, leaving the Air Force without a tactical electronic warfare aircraft.

8. EB-66 Vietnam War Era Summary

The EB-66 force proved to be too small in number relative to the requirements levied against it. It was already quite small to begin with in 1964, and had to be shifted between theaters as crises and contingencies arose. When the USS *Pueblo* was seized in 1968, EB-66s operating in the Vietnam War had to be dispatched to South Korea. Additional aircraft were pulled from the stateside training establishment causing training problems. This graphically demonstrated an over committed EB-66 fleet. Meanwhile commanders in Europe wanted ECM aircraft. The growth of systems in East Germany in both size and sophistication, combined with data learned about Soviet air defense systems from Arab-Israeli wars, prompted USAFE to request and receive its own share of what came to be considered as a precious asset. But the demands for EB-66s in the "hot" war in Vietnam forced both the Korea and Germany based squadrons to be deactivated. No TAC assets were left to cover the ELINT gathering and potential wartime jamming missions in the European and Korean theaters once activities escalated in Vietnam.

Before jamming was possible, data had to be gathered on the new communist systems being fielded by the North Vietnamese. In early 1965 the EB-66C was deployed to South Vietnam and then to Thailand. It provided the sole Air Force tactical jamming and electronic intelligence capabilities for two years. Flying in an escort role to the strike fighters, the EB-66C concentrated its jamming on terminal threats such as SA-2 SAM system and AAA radars. It also gathered most of the intelligence data on the Fan Song B fire control radar which would later prove to the greatest threat to American aircraft over North Vietnam.

In spite of active jamming the new SA-2 system took its toll on aircraft. Aware that it had a very limited number of electronic warfare assets, Seventh Air Force was forced to restrict operations in light of emerging North Vietnamese threats. From late 1965 until 1967, the growing SAM threat made incursions into North Vietnamese airspace increasingly risky. The EB-66B "Brown Cradle" jammer arrived in theater in 1965, and EB-66Bs operated with the EB-66Cs against the SAM threat. A stand-off jamming posture was assumed to cover strike aircraft during their approach to the target. The stand-off tactics jammed only acquisition, early-warning, and height-finding radars. The distance to the targets from the stand-off jamming orbits, and the limited jammer power output by the EB-66s, did not allow terminal threat systems to be jammed. Strike aircraft carried jammer pods designed for that purpose.

In addition to electronic jamming, another countermeasure involved the use of chaff which had its origin in World War II. Release tactics were developed by the two tactical electronic warfare squadrons in theater to simulate additional aircraft returns on North Vietnamese radarscopes and thereby mask strike forces. These techniques became very sophisticated with the use of parachute retarded chaff that would blow across Vietnam further confusing the enemy. By carefully studying wind data and drop rates of

chaff, aircrews were able to create "curtains" behind which aircraft could hide. However, there were problems caused by chaff drifting over the Gulf of Tonkin which upset the Navy by blinding its radars, including one radar cruiser called "Red Crown" which observed activities up the Red River Delta. The North Vietnamese did adjust their radar frequencies to counter chaff and often fired through the chaff with SAMs or guns which allowed them to some score hits on U.S. aircraft.

EB-66s launched daily to thwart the defensive systems in North Vietnam. However, constant movements, refinements in techniques, and new tactics created a very dynamic air defense picture that the aircrews could not always defeat. As North Vietnamese missile coverage continued to grow, EB-66 orbits were pushed further away from North Vietnamese airspace, limiting jamming effectiveness. Introduction of the MiG-21 in North Vietnam, targeted against the EB-66s, forced Seventh Air Force to provide MIGCAP. When this protective cover was needed elsewhere, the EB-66s had to move even further away from North Vietnamese airspace. Following the bombing halt of 1 April 1968 the Air Force reduced the EB-66 force by retiring aircraft. Operations shifted to B-52 support in Laos and Cambodia and support of drone operations until resumption of bombing in North Vietnam.

Mechanical problems dogged the EB-66 fleet during its entire service life. Despite a multitude of mechanical ailments, under-powered engines, and leaking fuel tanks, the EB-66 force managed to conduct operations from 1964 till 1974. Air aborts from loss of pressurization increased as windowpanes cracked from the thermal and mechanical stresses on the airframe. As the aircraft equipment was continuously modified to detect and jam evolving enemy systems, the lack of system integration and engineering support required field units to work untold hours, troubleshooting and modifying the equipment. At one point in 1970 three-man hours of maintenance were required for every hour of flying time. This was considered excessive since aircraft older than the EB-66 fleet could be maintained with less dedicated support.

Maintenance statistics for the EB-66s found in squadron histories are not easy to interpret. There are two basic maintenance related criteria used by the Air Force of the fifties and sixties which attempt to explain why aircraft were not available for duty. "Not operationally ready, maintenance" (NORM) was the category which described an aircraft which has not been repaired. "Not operationally ready, supply" (NORS) states that the aircraft was waiting for parts. In Thailand, for example, this meant the part often had to be shipped from the United States. The dominant factor accounting for unsatisfactory operational readiness rates was the NORM rating. The EB-66C consistently demonstrated a high NORM rating throughout its Air Force career due to fuel cell, electronic subsystem, hydraulic system, and engine problems. This caused a disproportionate maintenance workload per flying hour. During the height of the engine crisis in 1969/70 up to 320 man-hours per airframe a month were devoted to airframe maintenance, notwithstanding the time spent on troubleshooting and repairing the electronic subsystems.

The downward trend in maintenance reliability, especially after 1969, in Takhli with the 42nd TEWS was a result of an untenable logistics support situation. The NORS rating surpassed the NORM rating during this time. Due to the planned and partially begun phaseout in 1965, there were inadequate supply stocks for the remaining EB-66Cs. With no other source for spare parts, the Air Force began to cannibalize aircraft stored at Davis-Monthan. Manufacture of new parts was handled by the depot for EB-66 aircraft at Warner-Robins. The procurement of parts from non-production line operations in small quantities became an increasingly expensive expedient when the parts stock from Davis-Monthan was exhausted. This high cost of parts contributed to the decision to not put more stored airframes into the inventory since restoring them to a flyable condition would have added enormously to this already increasing maintenance cost.

Most problems encountered by the EB-66 were the result of obsolescence and the phase-out of the EB-66 weapon system, which was later deferred midway to permit deployments to Southeast Asia in 1965. The overall shortage of aircraft was the greatest factor affecting their effectiveness. The inability of the Air Staff to find the funding required to operationalize more stored airframes resulted in EB-66 force personnel having to modify and maintain their aging airframes as best they could. The probe and drogue refueling system, and the fact that a mission could not be successfully flown without mid-air refueling, provided the EB-66 crews a few additional challenges, but by planning and adjusting orbits the EB-66s were able to carry out their missions.

The reliance on the EB-66C for tactical electronic collection capability gave this aircraft a special place among the EB-66s. The B and E jammer models required the Cs' data in order to conduct jamming operations. Since these aircraft were also the EWO trainers, competing demands were placed on these airframes. Because of their small number any losses were keenly felt by the tactical electronic warfare squadrons abroad and in the U.S. Each C model removed from service, especially in the post Rolling Thunder phase of the war, reduced the capability for electronic intelligence collection and indirectly the capability of jammer aircraft as well. The C model fleet was not enlarged from stored airframes because of the high price associated with electronics and antenna installation.

Electronic warfare, by its very nature, is dynamic. For every development, there is a countermeasure. Therefore, electronic warfare is never constant and establishing an effectiveness rate is difficult at best. During the Vietnam War, however, the USAF Security Service was tasked by the Chief of Staff in 1967 to produce an electronic warfare study that examined the effectiveness of electronic warfare, including jamming, over North Vietnam.[245] But since so much jamming occurred simultaneously, from USAF EB-66s and pods and the Navy, the Security Service was not able to establish the extent to which each individual system had contributed to the total effort. It was nevertheless recognized in the study that electronic warfare had saved aircraft from

[245] Code-named "Comfy Coat," it was to "develop the capability for comprehensive evaluation of USAF EW effectiveness in SEA combat operations." (Lt Col Burch, *Tactical Electronic Warfare Operations in SEA 1962-1968,* Project CHECO, 10 Feb 1969, 48.)

enemy air defense threats and was thus considered the cornerstone of any future air operations.

The legacy of the EB-66 force is that it did its job. It ensured that friendly losses were kept to a minimum and that North Vietnamese radars were degraded so that strike forces could carry out their raids. Tactics developed by the EB-66 community, especially stand-off jamming with powerful jammers to blind enemy radars, were subsequently reflected in the EF-111 design which was finally delivered in 1981.

9. Post-Vietnam Tactical Electronic Warfare

As the Vietnam War came to an end in 1974, and the last EB-66C/Es were retired by the 39th TEWTS at Shaw, the USAF had to face the future without any tactical electronic warfare platforms. The long hoped for RF-111A/D[246] variants did not survive the congressional budget battles of the early seventies. Other proposals such as the EF-105 and EF-4C also never materialized, and Air Force had previously stated that it did not want the Navy's EA-6B.

TAC's commander, General William "Spike" Momeyer, and other Air Force officers[247] spent an inordinate amount of time urging the USAF not to buy the EA-6B, which they considered to be inferior to the EB-66 in speed, range, and jamming ability. In a 25 March 1969 letter to the then Air Force Chief of Staff, General John McConnell, General Momeyer wrote:

> It appears to me that if we don't upgrade the EB-66, we may be forced into acquiring the EA-6B to perform the Air Force support jamming role. This aircraft is much less desirable from a performance standpoint and considerably less capable from a systems standpoint than the EB-66 for this mission. The EA-6B program has already cost the Navy considerably more than the cost we are talking about for ITEWS. [Improved Tactical Electronic Warfare System, was to give the EB-66 improved and updated electronic equipment to improve the jamming and reconnaissance capabilities]

With the retirement of the EB-66 fleet in 1974, however, the US Navy's EA-6B was the most capable electronic warfare platform in the U.S. inventory. Different operational requirements and memories of the great inter-service bureaucratic struggles over the F-111 dampened any plans to buy the EA-6B for Air Force service.

The Air Staff and TAC had wanted since 1968 to develop and produce an airframe that combined the reconnaissance and jammer function in one platform. This new electronic warfare aircraft would be capable of escorting strike fighters through modern integrated air defense systems (IADS) to their targets. But lacking funding to develop such a platform, the Air Staff sought to modify older F-111A airframes for this task. The project was named the Tactical Jammer System (TJS). The need to pass near real-time information to a commander became the principal requirement. This would also lead the Air Force to redistribute the electronic warfare mission (radar jamming, reconnaissance, deception, communications jamming) to multiple platforms rather than

---

[246] Referred to as TFX-R in General Dynamics product information. The RF-111A was cancelled in 1968 during budget cuts. Originally 110 reconnaissance-configured RF-111As were to equip six squadrons. Sixty RF-111Ds were proposed in 1967 but these were also cancelled. The conversion of 46 F-111As to RF-111s was cancelled in 1970. These cancellations left the Air Force with no reconnaissance or electronic warfare F-111 variant until 1981.

[247] General Momyer's correspondence as TAC Commander, illustrate his concerns with the tactical electronic warfare mission and the proposed follow-on aircraft.

concentrating on one airframe. The sophistication of the multi-tiered, mutually supporting IADS being designed by the Soviet Union validated this requirement.

Until a new dedicated electronic warfare aircraft could be developed, the USAF believed that pod jammers, carried by the fighters themselves, would provide adequate protection. During the Vietnam War pod protection had improved with each new electronic development, however, North Vietnamese air defenses used an older type radar acquisition system than the newer Soviet systems. The pod protection approach proved ineffective during the Arab-Israeli 1973 Yom Kippur War, when older U.S. designed pods failed to jam the SA-6 "Gainful" SAMs. The SA-6s radars operated in a portion of the frequency spectrum never used before by the Soviets. Israeli Air Force pilots attempted to compensate for their lack of jamming capability by flying lower to get under the SA-6's radar coverage. This tactic placed them into the heart of the ZSU-23-4 (a mobile AAA gun) threat envelope and accounted for high Israeli losses. After an emergency airlift of U.S. ALQ-101/119 pods programmed to counter the SA-6 radar, the Israeli Air Force was able to reestablish air superiority.[248]

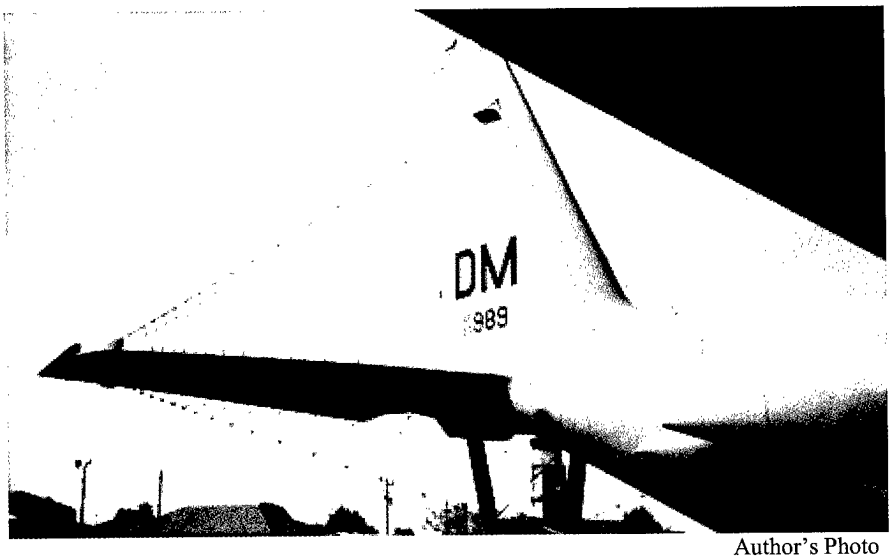
At the conclusion of the 1973 Arab-Israeli War, the USAF entered into a period of doctrinal realignments. During the Vietnam War a series of modified fighters had been developed which could acquire the emission of SAM and AAA radars and launch guided weapons at these sites. In the seventies the Air Force believed that these aircraft, called Wild Weasels, could precede strike aircraft to their targets. [249] This concept was known as suppression of enemy air defenses (SEAD). The Wild Weasel would destroy or, at the very least, suppress enemy radar systems allowing strike fighters to reach their targets. However, USAFE faced a bigger challenge as the U.S. military focus shifted back to the Central Front in West Germany after the Vietnam War. The Soviet Union had emplaced an integrated air defense system of such magnitude that, for SEAD to work, a part of the radar network would have to be jammed. Before it could be jammed the radars had to mapped and catalogued. PACAF faced a similar challenge in Korea. The first priority was therefore to obtain some type of ELINT collector.

The Air Force conceived the Tactical Electronic Reconnaissance Sensor (TEREC) equipped RF-4 in 1970, but the sensor system did not arrive in USAFE and PACAF until 1975. [250] This was one of many electronic warfare programs started during the Vietnam War, based on theater requirements, that did not enter service until the mid-seventies. This sensor solved only the tactical passive detection ELINT problem since it could not conduct any operations jamming. The ALQ-125 pod determined the precise nature of an enemy's electronic order of battle and had the capability for automatic detection, classification, and location of hostile ground based emitters such as the highly mobile radars used to control SAM/AAA. It was pre-programmed to search for those systems deemed to represent the highest threat. Once a radar had been identified, tracking

[248] Anthony H. Cordesman and Abraham R. Wagner, *The Lessons of Modern War. Volume 1 The Arab-Israeli Conflicts 1973-1989* (Boulder, Co: Westview Press, 1990), 20-25.
[249] F-105, F-4G.
[250] Anthony M. Thornborough and Peter E. Davies, *The Phantom Story* (New York, NY: Arms and Armour Press, 1994), 241-42.

continued just long enough to permit its precise location to be determined. A real-time data link sent relevant information to ground based intelligence facilities.[251] Only 24 of the TEREC pods were deployed to USAFE and PACAF on RF-4Cs.[252] As the RF-4Cs left the inventory, their mission and that of the TEREC pods was not replaced. The U-2R (TR-1) precision location strike system (PLSS) was briefly in operation in Europe before the collapse of the Soviet Union.[253] It had passive detection capabilities and real-time data links. This capability is still used by the USAF in other ongoing contingencies.

While the EB-66s had tried to jam communications between radar sites and SAM launchers, and also between MiGs and their ground controllers, the 1973 Arab-Israeli War provided the impetus for a new Air Force system, the EC-130H "Compass Call," to do essentially the same mission. Using a C-130 transport aircraft to carry large amounts of complex computer and electronic equipment as well as operators, Compass Call gathers electronic signals through antennas placed on its fuselage in front of the wings. It then transmits its powerful jamming signals from an antenna array behind the wings. The most visible is the "cheese cutter" array mounted on the tail that gives the aircraft its distinctive look. Using on-board computers and powerful algorithms, the aircraft can prevent jamming itself or friendly frequencies. The EC-130H carries a specialist crew who can monitor, update, and refine jamming parameters while the aircraft is in flight, thus giving the platform "man-in-the-loop" versatility in conducting electronic warfare.



Author's Photo

Figure 20. Antenna array on an EC-130H Compass Call, the "cheese grater."

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[251] *World's Greatest Stealth and Reconnaissance Aircraft* (New York: Aerospace Publishing, 1991), 56-59.
[252] *Jane's All the World's Weapons Systems 1987-88* (London: Jane's Information Group, 1987), 918.
[253] The U-2Rs (now called TR-1s) were based at RAF Alconbury and flew reconnaissance missions over Central Europe. Data were relayed to a hardened intelligence site in Germany where imagery and signals intelligence data were correlated and reported to USAF and allied agencies. The system was relocated to CONUS after the collapse of the Soviet Union. It has been modified and now is operational at Beale AFB. The U-2s were also relocated to Beale AFB.

These sixteen aircraft serve to disrupt communications between integrated air defense system nodes.[254] The EC-130H allows a very complex and interdependent system to be broken up into smaller pieces that can be destroyed or disrupted, clearing a path for strike aircraft. It conducts spot jamming of selected frequencies, not broad band barrage jamming, and it allows the crew on board the platform to judge the effectiveness of its jamming operations. Because of its power and frequency range, the EC-130H has remained the undisputed heavyweight of communications jamming. While the EB-66 force had tried to handle all these electronic warfare tasks from one platform, the Air Force now saw the value in having different platforms to accomplish specific tasks.

Development on the EF-111 "Raven" jammer did not start until 1974. The delay in starting the EF-111 work was due to congressional concerns with the F-111 airframe that still suffered from structural and reliability problems. Since the F-111 production line was closed, TAC had to give up existing F-111 airframes from flying squadrons to have them modified for electronic warfare duty. To cut down development time and technological risk, the Grumman contractor used the same electronic jamming subsystems found on the EA-6B (Prowler). This saved some production time, but escalating costs from system redesign of the EF-111 brought congressional scrutiny of the program.[255] In 1981 the first Raven was delivered to Mountain Home AFB, eight years after the last EB-66 had left the inventory.[256] They were deployed in shockingly small numbers considering the worldwide tasks they were tasked to perform. Forty-two were assigned to the 388th TFW at Mountain Home and the 20th TFW at RAF Upper Heyford.[257] USAFE was now able to interconnect multiple EW systems, as it also operated the EC-130H squadron in West Germany, to provide a comprehensive electronic warfare capability.[258] The Air Force could thus listen, jam, surpress, and disrupt integrated enemy air defenses.

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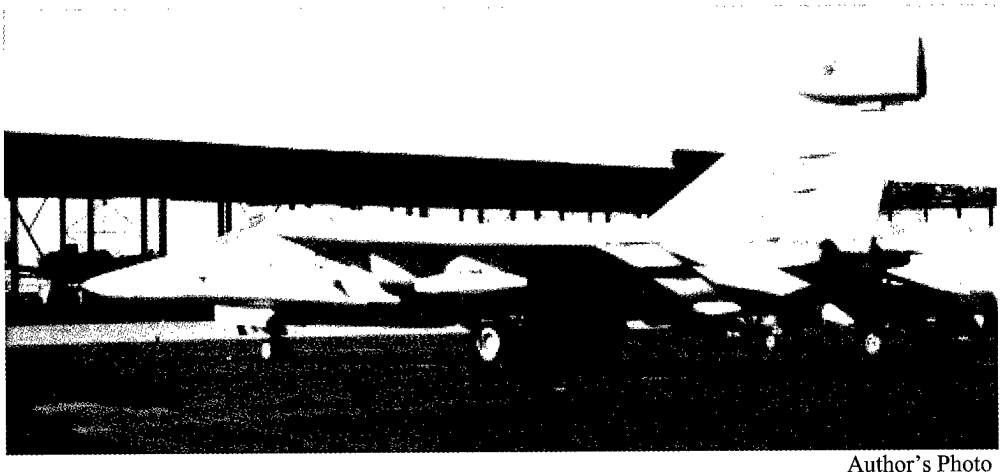
[254] There are six Block 20 aircraft in the 43rd Electronic Combat Squadron (ECS) ("Bats") and seven Block 30 aircraft in the 41st ECS ("Scorpions") at Davis-Monthan AFB.

[255] Anthony M. Thornborough and Peter E. Davies, *F-111, Success in Action* (New York, NY: Arms and Armour Press Ltd, 1989), 85.

[256] 390th Electronic Combat Squadron (ECS).

[257] 42nd Electronic Combat Squadron (ECS).

[258] USAFE established the 65th Air Division to deal with theater EW issues. Subordinate to it was a Wing Headquaters, the 66th ECW at Sembach AB, West Germany. Assigned to the wing were the 42nd ECS with 11-13 EF-111s; F-4G Wild Weasels at Spangdahlem in the 52nd TFW; 6 EC-130Hs with the 43rd ECS at Sembach AB; and the 6910th USAF Electronic Security Wing (USAF Security Service, later Electronic Security Service). In addition, the 38th TRS at Zweibrucken with TEREC pods was tasked from the air division headquarters. This very compact organization was disbanded at the end of the Cold War and has never been reestablished.



Author's Photo

Figure 21. EF-111 at Davis-Monthan AFB awaiting processing into the AMARC, July 1999.

With the growth of stealth technology in the mid eighties, the Air Force believed this to be a better way to get an aircraft to its target. Instead of jamming an integrated air defense system, and thus alerting an enemy to the presence of an attacking aircraft, stealth technology would allow the undetected penetration of hostile airspace. As funding of existing and projected aircraft became tighter with the end of the Cold War, the USAF was forced to make a number of difficult decisions. The F-4G Wild Weasel was retired in 1992 and replaced by a less capable system, the F-16CJ with HTS (HARM Targeting System). The F-16CJ was planned to be an interim system, but funding and force structure cuts required the Air Force to improve and rely on the F-16CJ. Next to leave the inventory was the EF-111. It saw action in Libya in 1986 and Desert Storm in 1991, and continued to patrol the Southern and Northern No-Fly-Zones over Iraq until 1998 when the last dozen aircraft were retired. The EF-111 retirement was also influenced by the fact that the F-111 airframes from which the EF was converted were over 38 years old, and the fact that all other F-111 models had long since left the Air Force.

Current Airborne Electronic Warfare

The retirement of the EF-111 forced the USAF and USN to pool their electronic warfare resources on the EA-6B Prowler which had been rejected by the USAF at the end of the Vietnam War.[259] Post-Desert Storm operations in Iraq and Yugoslavia demonstrated that Third World countries using air defense weapons similar to those employed by the North Vietnamese from 1965-1973 can down U.S. aircraft or adversely

[259] This consolidation occurred at a time when many in Congress were questioning why the US had four air forces, and in order to save money if one or more could not be eliminated. Congress settled for an OSD promise to minimize and cut duplications of missions. The Prowler dual use concept fit neatly into this "cost cutting" move.

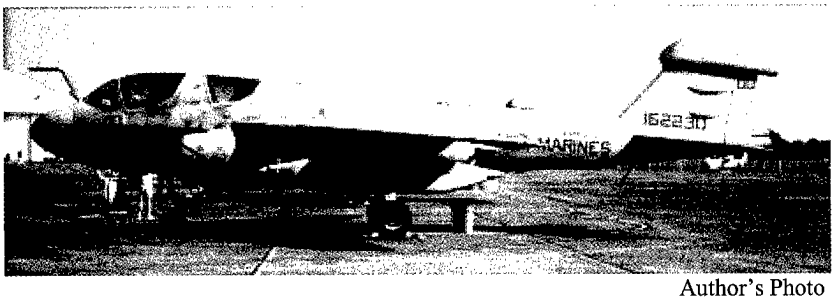
affect air operations.[260] Defense cuts and defense structure reviews by Congress and the Office of the Secretary of Defense gave the appearance that this joint use of the EA-6B would save both resources and funding. The Air Force, which would have preferred to have its own escort capable jammer, was left with no alternative but to accept the EA-6B since Congress wanted to eliminate duplication among the services

To understand the current predicament of airborne electronic warfare, an overview of the EA-6B Prowler is required. During the Vietnam War, while the EB-66s were flying missions, the Navy moved quickly to develop new carrier-based jammers. The piston engine EA-1F was superceded by the EKA-3, which was a further development of the Navy's A-3D, the predecessor of the USAF EB-66. This aircraft was big and used considerable deck space. In order to eliminate differing types of aircraft, the Navy sought an electronic combat version of the A-6 "Intruder" bomber. The first variant to emerge was the two-seat EA-6A flown by the USMC from DaNang. While the EA-6A was adequate for its mission, only twenty-seven were produced. The Navy wanted more capability and thus elongated the A-6 airframe in order to accommodate two additional EWOs. This new four seat electronic warfare version was designated the EA-6B Prowler and flew combat missions over North Vietnam in 1972.[261] The aircraft, which was produced through small production buys throughout the eighties, was continuously updated to maintain the currency of its electronic equipment suite. Thus, the current fleet of electronic warfare aircraft dates back to the Vietnam War era.

When the EF-111s were phased out of service in 1998, four new "purple" (joint) USN/USAF-manned Prowler squadrons picked up the Air Force electronic warfare mission. Basically the Air Force traded twenty-four EF-111s for sixteen EA-6Bs. The EF-111 fleet had already been reduced in the late eighties from forty-two to twenty-four aircraft. In addition, four USMC EA-6B squadrons were declared expeditionary making them a part of forward deployment rotations. In theory, three forward deployment sites could be covered by these eight squadrons: Atsugi, Japan; Incirlik, Turkey; and Prince Sultan AB, Saudi Arabia. After the commencement of air operations over the Balkans the USAF added Aviano AB, Italy to the list of forward deployment sites. This would have led to a six-month rotation for the eight expeditionary designated squadrons. Such an operational tempo could not be maintained under current DOD policy, so other squadrons were used to fill deployments and some sites were left "gapped," i.e., there were no EA-6Bs on station.

[260] Iraq and Yugoslavia (Serbia today) have air defense systems based around the SA-2 and SA-3 and use mobile systems such as the SA-6 to fill in gaps. USAF losses have been to the SA-6 and SA-3 in recent years.

[261] 720 combat sorties were logged by EA-6B Prowlers from 1972 until 1975.



Author's Photo

Figure 22. A USMC VMAQ-4 EA-6B at Maxwell AFB, September 1999.

As operational requirements increased, more Navy assets were tasked for electronic warfare missions around the globe. The Navy soon complained since deployments of the carrier EA-6B squadrons were affecting cruise work-up preparations which were periodically conducted at their home base in Whitbey Island NAS or at Fallon NAS in the U.S. Carrier air wings work and train together prior to sailing. Complaints arose that electronic warfare assets were not available and other air wing aircraft could not train with the Prowlers. The USMC EA-6B squadrons were also overtasked by commitments since they became national assets. The Marine Prowlers are scheduled to train with Marine assets, but the MAGTF has lost operational control of the Prowlers to the Joint Staff in the Pentagon.[262] Marine Corps EA-6B squadrons have two service-unique features that have made them valuable in an expeditionary role: a deployable, intermediate-level maintenance capability, and the Tactical Electronic Reconnaissance Processing and Evaluating System (TERPES). TERPES is a deployable interpretation facility that allows the electronic reconnaissance product of the EA-6B to be used at the tactical level without the lengthy national intelligence exploitation process.

The calculated assumptions guiding deployment of the EA-6B force was that ten carrier squadrons could support three deployed carriers, and that nine land-based squadrons (four expeditionary Navy, one Reserve, and four Marine) could provide three squadrons for forward based deployments. There are currently twenty active and reserve Navy and Marine Corps squadrons, each with four aircraft, including the four jointly manned squadrons.[263] This force was stretched thin during the Kosovo air campaign when a total of ten and a half squadrons were deployed. Six flew from Aviano AB, Italy and two were based on carriers. The half squadron was a two-aircraft detachment from the USN Reserve's VAQ-209. Two additional squadrons, one flying from Saudi Arabia and one from Turkey, enforced the no-fly-zones over Iraq. A Marine Corps squadron was stationed in Japan in case of hostilities on the Korea peninsula. The increased need for electronic warfare assets has served to highlight the overall EA-6B shortages.

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[262] Marine aviation is also suffering from the loss of the RF-4B which carried reconnaissance sensors, and the Hawk SAM system. The Corps relies on other services to provide these capabilities.

[263] 10 Carrier squadrons: VAQ-128, 130, 133, 134, 135, 136, 138, 139, 140, 141
4 Land-based squadrons (USAF/USN manned): VAQ-132, 133, 137, 142
1 Naval Reserve squadron: VAQ –209
1 Readiness squadron: VAQ-129 (transition training)
4 USMC squadrons: VMAQ-1, 2, 3, 4

Of the 124[264] Prowlers in the Navy and Marine Corps inventory today, only 82[265] are currently deployable to support world-wide operations. The others are being used for training or undergoing depot-level maintenance.[266] The ECM force is scheduled to number 120 deployable EA-6Bs by 2015. In order to achieve this figure all airframes stored with the Navy and Northrup-Grumman will have to be used. The production line for the EA-6B closed in 1988. In the aftermath of Kosovo the Navy scrounged together one more squadron in 2000 by removing two EA-6Bs from Point Mugu, California, where they were used in test programs, and added a heavily modified EA-6B nicknamed "Frankenprowler" due to its non-standard modifications, from Patuxent River NAS.

The EA-6B fleet is currently suffering the same maintenance and airframe problems the EB-66s had during the Vietnam War. The airframes are at least seventeen years old, and production of the EA-6B and its spare parts ceased in 1991. Engine repairs are a chronic problem, and airframe stresses cause parts breakage requiring expensive manufacturing in small lots to provide new parts. Because most of the electronic subsystems are of a 1970s vintage, the EA-6B lacks the newer technology necessary to perform its electronic warfare mission. Its radar jammers cannot reach newer bands; its communications system cannot receive data from modern day reconnaissance systems, including the space-based systems; and it lacks night-vision equipment, which is vital for a military that conducts extensive night operations. Currently the Prowler fleet is being equipped with Improved Capability 3 (ICAP-3) which modifies the internal systems on board the aircraft. The electronic systems will soon require Band 9/10 jammers, to jam advanced double-digit Russian SAM systems such as the SA-10 and SA-12. [267] These modifications are being funded in the aftermath of Kosovo air operations. Lacking any ECM aircraft of its own, the Air Force is forced to rely on a Navy aircraft, which in turn must meet the requirements of a carrier force, to perform its tactical electronic warfare mission.

In the aftermath of the Operation Allied Force over Kosovo in 1999, OSD initiated studies to explore augmenting the EA-6B. Since these aircraft had to support virtually every flight over Yugoslavia, the question is whether the Air Force should buy back into a support jamming role with its own specialized aircraft or buy into a Navy or UAV program for that purpose. The fear among defense planners is that something else may have to be sacrificed, recalling that the Air Force removed the EF-111 fleet primarily because it could not afford it. There is presently no resolution to the problem on how to acquire a new jammer.

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[264] Loren B. Thompson, "The Future of Airborne Electronic Warfare," *Sea Power*, March 2000, 40.

[265] Of the 124 available, forty-two are out of service due to maintenance; eighty-two are available in nineteen squadrons, eleven of which are carrier based, four assigned to US Navy expeditionary squadrons, and four to US Marine Corps squadrons.

[266] Carrier based operations have proved to be exceedingly hard on the wings, thus many Prowlers are currently in depot awaiting new wing sets. These sets in turn are manufactured in small lots and have increased the overall cost of Prowler operations.

[267] For a frequency band chart see D. Curtis Schleher, *Introduction to Electronic Warfare* (Dedham, MA: Artech House, 1986), 26-27.

Current options being studied include the F-18G "Growler" (Super Hornet), the EB-1 (a jammer version of the B-1), the JSF, and the EF-22. More exotic proposals have called for the use of a commercial airframe, which could carry more jamming equipment higher, faster, and further than the proposed military airframes and conduct very powerful stand-off jamming, but it could not escort a strike package into hostile airspace. Another issue being studied is whether an active jammer is indeed required to protect the new low-observable technology (stealth-like) aircraft such as the F-22 and JSF. If the new low-observable technologies work, there may be no need for an escort jammer. Stand-off jammers in the future may be required to orbit up to 125 miles from Russian-made S-400 SAM batteries. This necessitates a different approach to electronic warfare.

Either way, the current situation mirrors that of the Vietnam War. The EB-66 was deployed in small numbers with no available successor. Today the Air Force and Navy have fielded a limited asset that must be deployed around the world in increasingly larger numbers with no way to expand the overall number of airframes available. In 1968 the *USS Pueblo* crisis forced a combat theater to give up EB-66 assets to another theater. Today EA-6Bs are being moved like chess pieces from hotspot to hotspot to protect US combat aircraft. With airborne electronic warfare the cornerstone of any U.S. military operation, and digital technology moving forward at an unprecedented rate, modernizing electronic warfare capabilities must be a priority if the U.S. wants to maintain its warfighting edge. Aircraft survivability in the future against a technologically advanced enemy is at stake

APPENDIX A

EB/RB-66s Displayed in Museums

RB-66B
Air Force Museum, Wright-Patterson AFB, OH
Dyess Linear Air Park, Texas

EB-66C
Shaw AFB, SC

WB-66D
Lackland AFB, TX
Warner-Robins AFB, GA
Pima and Space Museum, Tucson, AZ

APPENDIX B

Aircraft Numbers of EB-66C/B/E airframes

EB-66C (RB-66C when built)

36 54-0447 to 476 (30 airframes) 55-0384 to 389 (6 airframes)

EB-66B (B-66B when built) [Brown Cradle Conversations]

55-0482, 484, 485, 486, 487, 489, 491, 492, 493, 495, 496, 497, 498 (13 conversions)

EB-66E (built as B/RB/WB-66) 50 airframes numbers found (perhaps even more)

53- 0479, 0480
54-0417, 0419, 0420, 0423, 0424, 0426, 0427, 0429, 0431, 0434, 0435, 0438, 0439, 0440, 0441, 0442, 0443, 0445, 0446, 0506, 0507, 0508, 0509, 0510, 0511, 0514, 0515, 0516, 0519, 0520, 0521, 0522, 0523, 0524, 0525, 0526, 0527, 0528, 0529, 0531, 0532, 0533, 0534, 0536, 0537, 0539, 0540, 0542, 0546

APPENDIX C

Vietnam War Losses

Combat Losses

DATE	*TYPE*	*SERIAL NUMBER*	*CALL SIGN*	*CAUSE*	*LOCATION/ REMARKS*
22 Oct 1965	RB-66B			SA-2	14 15'/107 38'
25 Feb 1966	EB-66C	54-457	Gull 01	SA-2	18 07'/107 18'
20 Jul 1966	EB-66C	54-464	Devil 01	SA-2	22 00'/105 25'
4 Feb 1967	EB-66C	55-387	Harpoon 01	SA-2	
14 Jan 1968	EB-66C	55-388	Preview 01	Atoll/MiG-21	
2 Apr 1972	EB-66C	55-466	Bat21	SA-2	5 out of 6 killed

Operational Losses

17 Nov 1967	EB-66C	54-473			5 of 7 killed
6 Dec 1967	EB-66C	54-462			3 killed
5 Mar 1968	EB-66E	54-524			
19 Jul 1968	EB-66B	54-491			
17 Apr 1969	EB-66B	54-498			
24 Oct 1970	EB-66C	55-384			
10 Mar 1971	EB-66C	55-389			
23 Dec 1971	EB-66E	54-529		Hunt02	3 killed
1971	Unknown	?	?		

The Author

Captain Gilles Van Nederveen is the Associate Editor of the *Aerospace Power Journal* at Maxwell AFB. A career intelligence officer, his previous assignments have included RC-135, E-8, and EC-130 flying tours. In addition to having served as an airborne intelligence officer, he has also served as a political-military affairs officer, signals and imagery analyst, and test engineer.

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Air University

Lance W. Lord, Lt Gen, USAF, Commander

College of Aerospace Doctrine, Research and Education

James L. Ruttler, Jr., Col, USAF, Commander

Airpower Research Institute

James R.W. Titus, PhD, Dean of Research, Air University
Allan W. Howey, Col, USAF, Director